



KCGM HSSE DEPARTMENT, CLOSURE

KCGM Mine Closure Plan 2022 (v1) Volume 3 of 3

Mineral Field 26

Part B

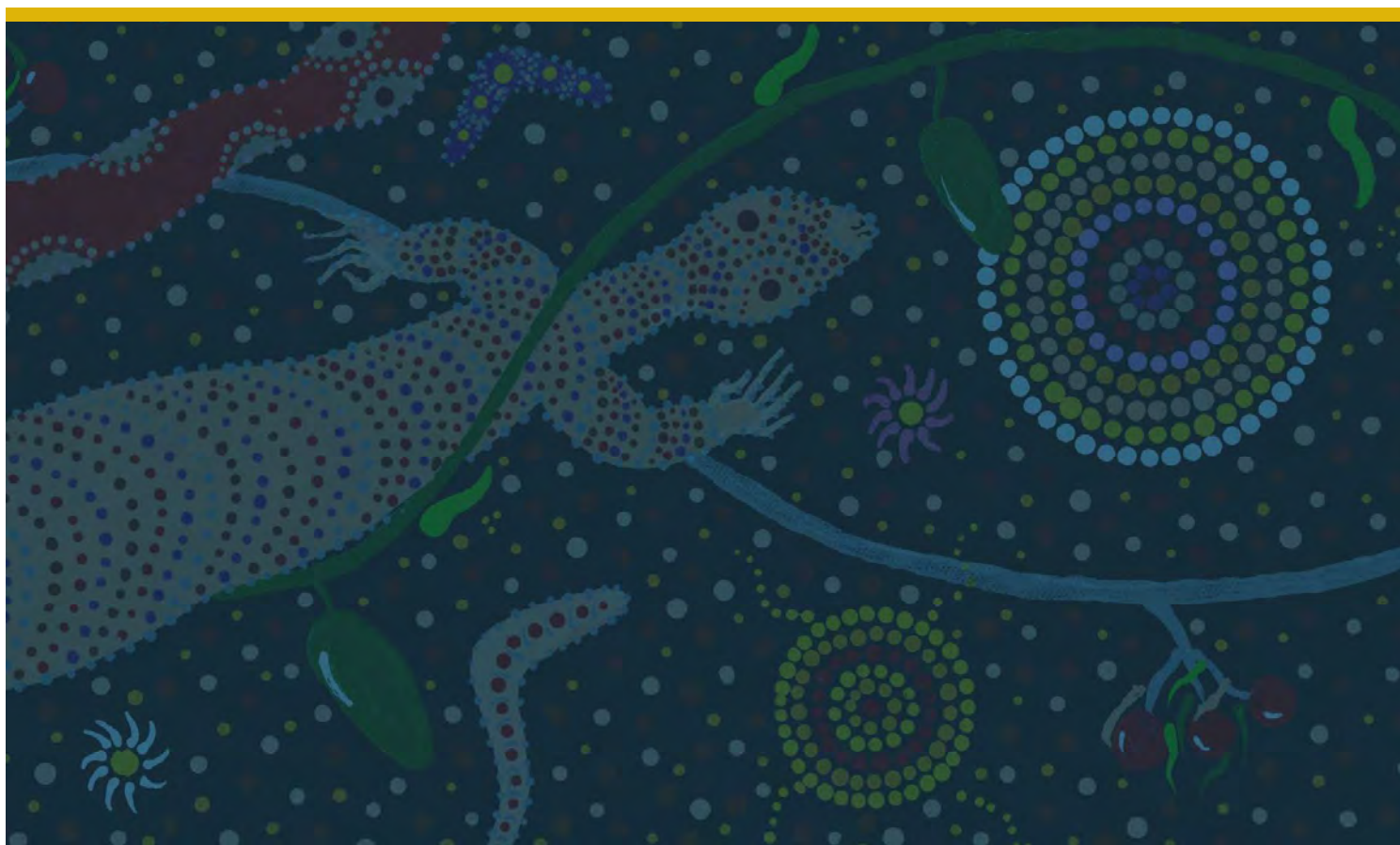


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GEOCHEMICAL ASSESSMENT OF HISTORICAL/LEGACY TAILINGS AT KCGM

PREPARED FOR:

**KALGOORLIE CONSOLIDATED GOLD MINES PTY
LTD**



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PREPARED BY:

Martinick Bosch Sell Pty Ltd
4 Cook Street
West Perth WA 6005
Ph: (08) 9226 3166
Fax: (08) 9226 3177
Email: info@mbsenvironmental.com.au
Web: www.mbsenvironmental.com.au

MBS
ENVIRONMENTAL

MINE CLOSURE PLANNING GEOCHEMICAL ASSESSMENT OF HISTORICAL/LEGACY TAILINGS

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Company	Contact name	Copies	Date
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1. INTRODUCTION AND SCOPE

As part of ongoing investigations to inform mine closure planning, Kalgoorlie Consolidated Gold Mines (KCGM) has requested MBS Environmental (MBS) provide a geochemical assessment of tailings samples collected by KCGM between November 2015 and October 2016 from historical/legacy Tailings Storage Facilities (TSFs) in the area around Fimiston Super Pit and Fimiston Mill, the Mt Percy TSF as well the hand constructed Mullingar TSF approximately 5.5 km to the northwest of the Fimiston Operations. This work was identified as a knowledge gap in a recent review of geochemical characteristics of KCGM tailings conducted by MBS (MBS 2016) as well as in hydrochemical modelling of the Fimiston Super Pit (Schlumberger 2016).

This report provides an assessment of laboratory data for 15 samples of tailings solids collected from historical TSFs and submitted to Intertek Genalysis laboratories by KCGM in November 2015 (eight samples) and October 2016 (seven samples).

The objectives of this assessment were to:

- Describe the geochemical characteristics, including classification of their potential to generate acid metalliferous drainage (AMD), of 15 samples of tailings from historical/legacy TSF's (pre KCGM ownership in 1989) to further inform mine closure planning and strategies.
- Determine the risk of any potential for seepage from tailings materials to be contaminated by acid, salts, metals or metalloids

2. SAMPLE DESCRIPTIONS

KCGM staff collected 15 samples of tailings from seven historical TSF's for analysis by Intertek Genalysis laboratories. The samples were identified as follows:

- Paringa TSF (1).
- Paringa TSF (2).
- Balgold Oroya TSF (Behind Workshop Area).
- Morrison (Calcine) TSF.
- Mt Percy.
- Old Croesus (Fim I).
- Croesus (Pit Shell).
- Mullingar (eight samples identified as MULL1 to MULL8).

The location of the above sampling sites in relation to the current overlying KCGM Fimiston operations is illustrated in Figure 1 (sample locations marked in red). Photographs of various sample locations are shown in Appendix 1. The Mt Percy TSF and Mullingar TSF's are located approximately 5.5 km to the north and northwest respectively of Fimiston operations area and not shown on Figure 1. Samples for the current assessment were taken from near surface (0 to 0.2 m) depth. The sample from the exposed portion of the Balgold Oroya TSF (refer photographs Appendix 1) was taken based on accessibility but it is known that this area (marked as Oroya, Balgold and Galconda in Figure 1) is highly variable in nature and contains many former facilities including leach pads. Therefore this single sample should not be considered representative of this entire area.

In particular it should be noted that the Morrison (Calcine) TSF (shown as 'Calcine' in Figure 1) and Croesus TSF store calcined tailings (tailings that have undergone a high temperature roast to oxidise sulfides) and are deep red in colour as a result (refer photographs at end of report). The remaining tailings samples assessed and current Fimiston tailings are not calcined.

Future management options for Croesus (Pit Shell) material may be limited by safe access as much of this TSF lies within the zone of instability of the pit. The small volume of Morrison (Calcine) TSF material is within an area of proposed southern cutback (Morrison cutback) pit extension and therefore KCGM is considering management options for this material.



Figure 1: Sample Locations Layout (Source KCGM)

3. METHODOLOGY

3.1 ACID BASE ACCOUNTING

Acid Base Accounting (ABA) was used to classify tailings samples as Potentially Acid Forming (PAF), Non Acid Forming (NAF), Acid Consuming (AC) or 'Uncertain' using procedures similar to those used in earlier studies of KCGM mine waste (e.g. MBS 2016). ABA for this assessment involves:

- Measurement of "oxidisable" or "non-sulfate-sulfur" as the difference between total sulfur and sulfate-sulfur provided by an acid extraction procedure.
- Calculation of Acid Potential (AP) by multiplying the "oxidisable" sulfur concentration by 30.6, reported with units of kg H₂SO₄/t.
- Measurement of Acid Neutralising Capacity (ANC), also reported with units of kg H₂SO₄/t.
- Calculation of Net Acid Production Potential (NAPP), defined as the difference between AP and ANC.
- Measurement of NAG pH, which is the pH of a solution obtained by oxidation of a finely ground sample with hydrogen peroxide under conditions of the Net Acid Generation (NAG) laboratory test.
- Classification of mine waste based on NAPP and NAG pH values according to the criteria presented in Table 1.
- Calculation of the neutralisation potential ratio (NPR), defined as ANC divided by AP, where a ratio greater than two indicates a significant excess of neutralisation capacity versus potential for acid generation (MEND 2009).

The samples were also analysed for total carbon. The corresponding acid neutralising capacity (kg H₂SO₄/t) attributed to the carbonate minerals, designated as Carb-NP, was calculated by multiplying the reported result (%C) by 81.7. This calculation assumes all of the total carbon is present as reactive calcium and magnesium carbonate minerals such as calcite (CaCO₃), dolomite (CaMg(CO₃)₂) and low iron ankerite ((Ca,Mg,Fe)CO₃).

Table 1: Combined AMIRA NAPP and NAG Classification of Acid Rock Drainage¹

Primary Geochemical Waste Type Class	NAPP Value kg H ₂ SO ₄ /t	NAG pH	Sulfur Content*
Potentially Acid Forming – High Capacity (PAF-HC)	≥ 10	< 4.5	≥ 0.3%
Potentially Acid Forming – Low Capacity (PAF-LC)	0 to 10	< 4.5	0.16 to 0.3%
Uncertain possibly NAF	0 to 5	> 4.5	Not important
Uncertain possibly PAF	-10 to 0	< 4.5	Not important
Non Acid Forming (NAF)	-100 to 0	> 4.5	Not important
Acid Consuming (AC)	< -100	> 4.5	Not important

¹ Table 1 is based on the Australian Government's Guidelines on Managing Acidic and Metalliferous Drainage (DFAT 2016) and is in turn based on an earlier classification system included within the AMIRA ARD Test Handbook (AMIRA 2002), which is advocated by the Global Acid Rock Drainage Guidelines (GARD) published by the International Network for Acid Prevention (INAP 2009).

*Total sulfur analysis by combustion or XRF analysis.

3.2 ELEMENTAL CONCENTRATIONS AND GEOCHEMICAL ENRICHMENT

Based on existing knowledge of the mineralogy of ore and the geological setting at KCGM, the following elements were considered to be potentially geochemically and/or environmentally significant for the tailings samples or major elements required for general characterisation: gold (Au), silver (Ag), aluminium (Al), arsenic (As), barium (Ba), bismuth (Bi), calcium (Ca), cadmium (Cd), cobalt (Co), chromium (Cr), copper (Cu), iron (Fe), mercury (Hg), potassium (K), magnesium (Mg), manganese (Mn), molybdenum (Mo), sodium (Na), nickel (Ni), lead (Pb), sulfur (S), antimony (Sb), selenium (Se), tellurium (Te), uranium (U), vanadium (V) and zinc (Zn).

All of these elements were measured simultaneously by inductively coupled plasma – atomic emission spectroscopy (ICP-AES) and ICP-MS following digestion of a finely ground sample with the 'four acid' or 'A' digest method by Intertek Genalysis laboratories. Mercury was measured by an alternate low temperature digestion to avoid loss of volatile mercury.

From this data, the global abundance index (GAI) for each element was calculated by comparison to the average earth crustal abundance (AIMM 2001). The main purpose of the GAI is to provide an indication of any elemental enrichment that could be of environmental significance. The GAI (based on a log-2 scale) is expressed in integer increments from zero to six (GARD Guide). A GAI of zero indicates that the content of the element is less than or up to three times the average crustal abundance; a GAI of one corresponds to a 3 to 6 fold enrichment; a GAI of two corresponds to a 6 to 12 fold enrichment and so forth, up to a GAI of six, which corresponds to a 96-fold, or greater, enrichment above average crustal abundances. A GAI of three or more is generally considered significant and may warrant further investigation.

3.3 WATER LEACHATE ANALYSIS

All tailings samples were subjected to a water leach at a sample to solution ratio of 1:5 (weight/volume) using deionised water as typically applied for assessments of soils which represents the typical subsurface saturated water concentrations. A 1:20 ratio as defined in Australian Standards Leaching Procedure (ASLP) 4439.3 is sometimes often used for assessment of potential concentrations in seepage but this can also be estimated by adjustment of results (division by four) from the 1:5 extraction ratio applied in this investigation. A 1:5 extraction ratio allows for better reporting limits of trace metals and is more indicative of porewater type concentrations.

Water leachates were analysed for final extract pH and electrical conductivity (EC), major ions, alkalinity, fluoride (F), boron (B), and the metals and metalloids listed in Section 3.2.

3.4 ACETIC ACID LEACHATE ANALYSIS

Tailings samples were also extracted using dilute acetic acid as the leaching fluid (initial pH 2.9) according to ASLP 4439.3 specification. Analytical finish of the filtered (0.45 µm) extract was via ICP-OES or ICP-MS finish, as necessary, for a range of elements as listed in Section 3.2. This test provides an indication of the nature of acid neutralising materials present and metals and metalloids that are likely to be leached should acid conditions prevail; either by oxidation of sulfide minerals in the tailings being assessed or by co-storage with other sources of PAF mine waste or contact with acidic water.

4. RESULTS AND DISCUSSION

Results for analysis of the historical tailings solids from KCGM leases are presented in Tables A1 to A5 in Appendix 2.

4.1 STATIC ACID BASE ACCOUNTING

Results for pH, EC, total sulfur, sulfate sulfur, ANC, total carbon, NAG and NAG pH are presented in Table A1 of Appendix 2. Calculated parameters, AP, NAPP and Carb-NP, as well as the classification based on criteria presented in Table 1, are also presented.

All samples examined had moderate levels of total sulfur, ranging from 0.55% to 2.37%. Sulfate-sulfur (non-oxidisable form), however, was a significant proportion of total sulfur in most of the samples analysed — in particular for Morrison TSF and Croesus (Pit Shell) (approximately 75%). The latter is consistent with those tailings having undergone a roasting process, which would oxidise contained sulfides to sulfates. Mt Percy tailings had a lower proportion (8%) of sulfate-sulfur as estimated from the acetic acid ASLP (Section 4.3.4). Estimates of sulfate-sulfur are also likely underestimated due to the mild extraction conditions and insoluble forms of sulfate such as barium or strontium sulfates. As a result of the generally high proportions of sulfate-sulfur, the calculated AP values of the samples were low to moderate (8.4 to 58 kg H₂SO₄/t).

Tailings samples had moderate to very high ANC, with values ranging from 37 (Croesus Pit Shell) to 200 kg H₂SO₄/t (Mt Percy). ANC and Carb-NP values were similar for most samples, indicating that the ANC is present in readily available acid neutralising carbonate forms. Carb-NP was just slightly higher than ANC in eight of the 15 tailings samples indicating the presence of carbon in forms which do not contribute to net acid neutralisation — these may include graphitic carbon (from carbonaceous ore including Black Flag Shales) or iron carbonate minerals such as high-iron ankerite ((Ca,Mg,Fe)(CO₃)₂) or siderite (FeCO₃).

As a result of low to moderate AP values and moderate to high ANC, all historical tailings samples were classified as NAF, with negative NAPP values and alkaline NAG pH values of 8 to 9.6. Nine of the 15 samples (Table A1 of Appendix 2) were further classified as acid consuming (AC). The NAF classifications according to Table 1 are illustrated in Chart 1. Chart 2 illustrates all samples have NPR values of greater than two.

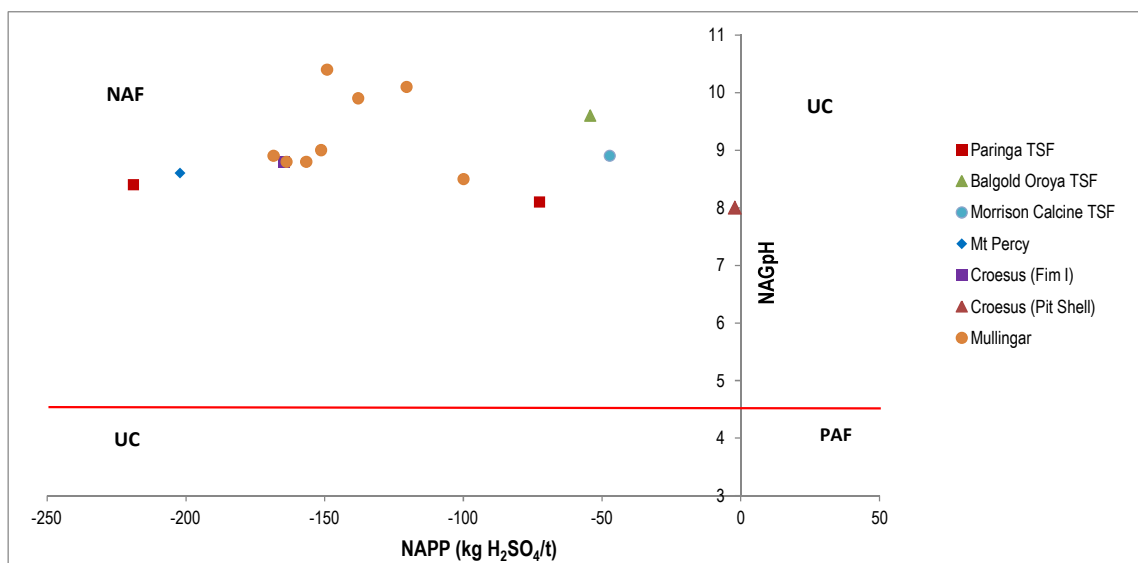


Chart 1: ABA Classification Cross Plot

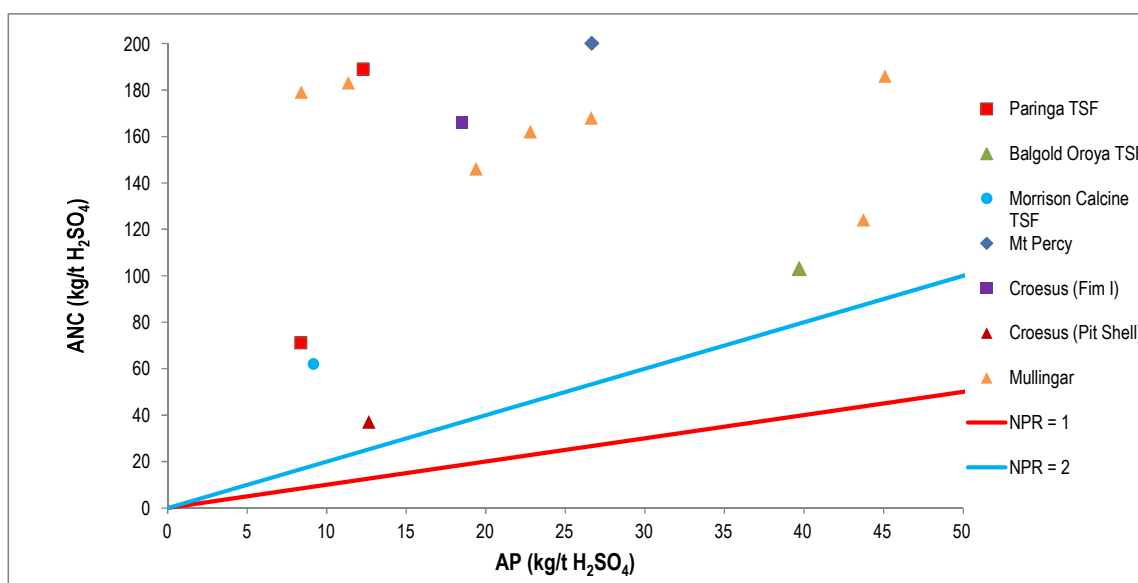


Chart 2: Historical/Legacy Tailings NPR Plot

4.2 ELEMENTAL CONCENTRATIONS AND GEOCHEMICAL ENRICHMENT

Results for analysis of the tailings solids for 26 environmentally significant metals and metalloids are presented in Table A2 of Appendix 2. Calculated GAI values are presented in Table A3 of Appendix 2, with values equal to greater than three highlighted by yellow shading.

Examination of results indicates:

- All samples were substantially enriched in gold, with the two calcined tailings (Morrison TSF and Croesus (Pit Shell), having ore grade levels of approximately 3.2 mg/kg (3.2 g/t) versus the global crustal average of 0.005 mg/kg. The eight Mullingar samples were not analysed for gold. All samples analysed had calculated GAI values of six for gold.
- The associated metal silver was also significantly enriched in all samples except Mt Percy and Mullingar, with highest concentrations of 26 mg/kg and 15 mg/kg being found in Morrison TSF and Croesus (Pit Shell) (GAI 6 versus the global average of 0.07 mg/kg).
- All samples were substantially enriched in the metalloid antimony with GAI values of 3 to 6, corresponding to concentrations of antimony of 3.3 to 86 mg/kg versus the global average of 0.2 mg/kg.
- Although selenium is usually associated with the presence of antimony, selenium was only considered enriched in the Morrison TSF and Croesus (Pit Shell) samples with a GAI of 3.
- Tellurium was significantly enriched in all samples with concentrations of 1.2 to 13.9 mg/kg versus a very low crustal average of 0.001 mg/kg. Samples from Morrison TSF and Croesus (Pit Shell) with elevated gold, silver and tellurium suggest the tellurium is present in the form of telluride minerals calaverite (AuTe₂) and sylvanite (Ag,Au)Te₂, which are known to occur in the Golden Mile deposit and are insoluble under normal conditions.
- Mercury was enriched (1.1 mg/kg, GAI 3) in the Balgold Oroya TSF sample exposed behind the workshop. As per other KCGM investigations, higher concentrations of both mercury and tellurium at this site (13.9 mg/kg tellurium) suggest the presence of coloradoite (HgTe), which is also insoluble under normal conditions. Marginal mercury enrichment was also observed for two Mullingar samples (MULL1 and MULL8, GAI 3).

- Morrison TSF and Croesus (Pit Shell) samples were also significantly enriched in arsenic (maximum 2,615 mg/kg, GAI 6), cobalt (maximum 369 mg/kg, GAI 3), copper (maximum 764 mg/kg, GAI 3) and molybdenum (maximum 124 mg/kg, GAI 6). The similarity and nature of these tailings materials is consistent with a different pre-treatment of the ore (sulfide flotation and calcining prior to gold extraction) compared to other historical tailings samples. Molybdenum was also marginally enriched (GAI 3) in the Old Croesus (FIM I) sample, and significantly enriched (GAI 4) in all Mullingar samples.
- The Croesus (Pit Shell) sample was also found to be marginally enriched in lead (117 mg/kg, GAI 3), as were two Mullingar samples (110 and 149 mg/kg for samples MULL4 and MULL8, respectively). The source of elevated lead concentrations in these tailings may result from the presence of lead sulfide minerals (galena, PbS) in the source ore, or use of lead nitrate added during cyanidation.
- No historical tailings samples were enriched in barium, bismuth, nickel, chromium, cadmium, manganese, uranium, vanadium, zinc or the common rock-forming elements (aluminium, calcium, magnesium sodium and potassium).

These results clearly demonstrate all tailings samples are enriched in gold, silver, antimony and tellurium. This combination of elements is considered to be associated with the particular nature of the gold/gold telluride deposit. Morrison TSF and Croesus (Pit Shell) tailings samples are more metalliferous than the other samples, also being enriched with environmentally significant elements arsenic, cobalt, copper, molybdenum and lead (Croesus Pit Shell only). In addition to gold, silver, antimony and tellurium, the historical Balgold Oroya TSF and two of the Mullingar samples was the only samples enriched in mercury – likely in the form of coloradoite.

4.3 WATER LEACHATE ANALYSIS

Results for analysis of water leachates of the tailings solids are presented in Table A4 of Appendix 2. Included for comparison purposes are livestock drinking water guidelines (ANZECC 2000) which are commonly applied for comparison of general water quality, although it should be noted that the only the major beneficial users of groundwater in the Goldfields region are for mine process water as groundwater is too saline for livestock use.

4.3.1 pH

Water leachates of all samples were circum-neutral to moderately alkaline, with pH values ranging from 7.2 to 9.1. The highest pH was recorded for the calcined Croesus (Pit Shell) sample.

As all samples were classified as NAF and contained an excess of calcium and magnesium carbonate minerals (Section 4.1), tailings porewater and TSF seepage from rainfall leaching are predicted to remain slightly alkaline in perpetuity.

4.3.2 Salinity and Major Ions

Water leachates of tailings solids were brackish to saline, as indicated by EC values ranging from 1.7 to 20.4 mS/cm. Croesus (Pit Shell) in particular, but also Morrison TSF and Paringa TSF (1), were more saline with calculated total dissolved solids (TDS) concentrations of 8,400 to 13,600 mg/L on a 1:5 solid/liquid basis, compared to a livestock drinking water guideline of 5,000 mg/L for cattle.

Major ion composition was variable with Paringa TSF (1) and Croesus (Pit Shell) leachates being dominated by sodium and chloride ions, while other samples contained increasing amounts of sulfate ions. The 1:5 solid/liquid extracts for Paringa TSF, Morrison TSF, Balgold Oroya and Croesus (Pit Shell) were also saturated or supersaturated with respect to gypsum. Although tailings samples assessed in the current work are not expected to be placed on slopes, the higher concentrations of calcium, magnesium and brackish to saline EC values suggests the tailings materials should not in any event be dispersive. Salinity in the tailings materials is expected to remain for some time after closure due to capillary action - particularly if final placement involves overlying waste rock cover. Residual salinity in the oldest and fully exposed Mullingar TSF samples is evidence of this.

Fluoride concentrations were very low in all samples, ranging from <0.1 to 0.8 mg/L. As these concentrations are well below the livestock drinking water guideline of 2 mg/L, fluoride is not considered a contaminant of potential concern (CoPC) in these historic KCGM tailings.

4.3.3 Metals and Metalloids

Despite enrichment in several metals and metalloids, water leachates of the tailings samples for the Paringa, Balgold Oroya, Mt Percy and Old Croesus (Fim I) TSFs did not contain significant concentrations of any metals or metalloids tested due to the insoluble nature of the minerals or elements under neutral conditions. Although geochemically enriched, mercury, tellurium, selenium, antimony, copper, lead and silver in all water extracts were present at very low or less than detectable (e.g. tellurium) concentrations and all were well below livestock drinking water guidelines (ANZECC 2000) and WA Department of Health non-potable groundwater use guidelines (DoH 2014).

The following metal and metalloid concentrations in Morrison TSF and Croesus (Pit Shell) leachate samples were above livestock drinking water guidelines (on a 1:5 extract basis):

- Arsenic (2.52 and 1.75 mg/L respectively) versus a livestock guideline of 0.5 mg/L.
- Cobalt in Croesus (Pit Shell) of 9.0 mg/L versus a livestock guideline of 1 mg/L.
- Molybdenum (0.70 and 0.81 mg/L respectively) versus a livestock guideline of 0.15 mg/L.

With the exception of arsenic in the Croesus (Pit Shell) sample, all above results also marginally exceed the livestock drinking water guideline if compared on a 1:20 extract basis (division of results by four). The 1:20 dilution ratio would be more typical for any potential seepage.

Slightly elevated (>0.01 mg/L, above non-potable groundwater re-use guidelines) concentrations of mercury were recorded in three Mullingar samples (MULL1, MULL3 and MULL8, maximum 0.025 mg/L in MULL1). No samples exceeded the non-potable groundwater use guideline of 0.01 mg/L if adjusted for a 1:20 ratio extraction. Three samples also reported molybdenum (maximum 0.40 mg/L) concentrations above the livestock drinking water guideline.

Chart 3 shows the fractions, as percentages, of the total concentrations of arsenic, cobalt, molybdenum and mercury that are soluble in water. Mercury is the most soluble for particular (not consistent) samples – especially Mullingar. As above the concentrations of soluble mercury are still relatively low and total mercury also low as evidenced by only marginal enrichment (maximum concentration 1.1 mg/kg in MULL1). Molybdenum is the next most soluble, as expected, given its normal presence as the molybdate oxyanion and the alkaline nature of the water extract. Cobalt was found to be particularly soluble (essentially at saturation levels given the alkaline pH) in the Croesus (Pit Shell) sample with 12.2% of the total cobalt being water soluble – perhaps as the cobalt (II) tetrachloride complex which is stable at higher chloride concentrations. Approximately 0.5% of the arsenic present in Morrison TSF and Croesus (Pit Shell) samples was soluble, despite the higher iron content of these two samples (>33% Fe) versus other samples. Arsenate/arsenite oxyanions present from previous oxidation of arsenopyrite are likely being displaced from the surface of the iron oxides by the higher salinity and pH also associated with these samples.

Concentrations of soluble aluminium, boron, barium, bismuth, iron, chromium, manganese, nickel, uranium, vanadium and zinc were very low and therefore considered to be of no environmental consequence.

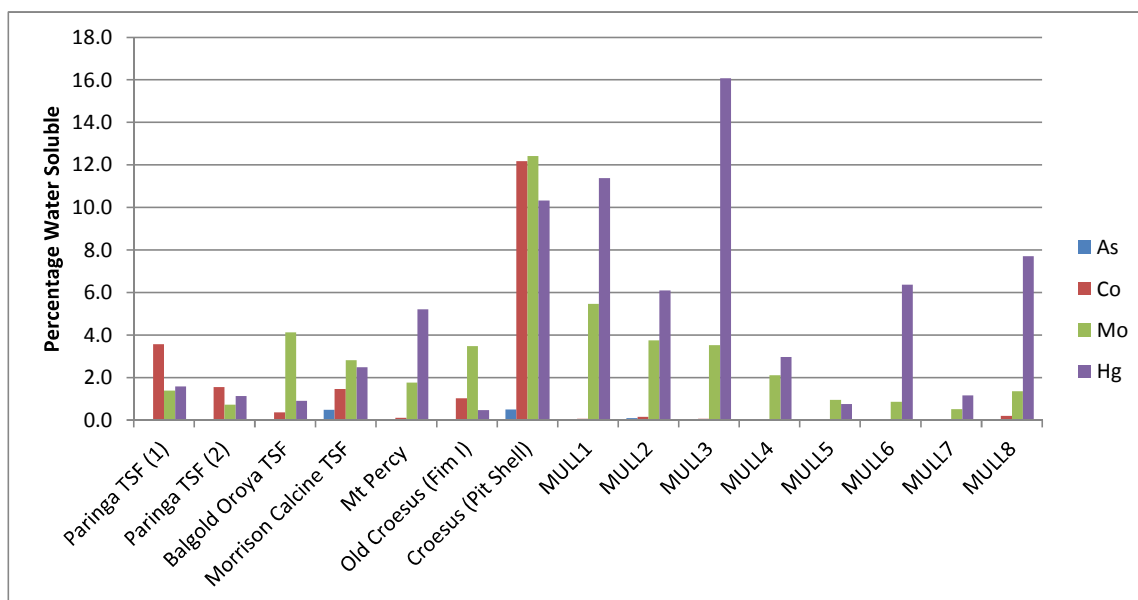


Chart 3: Solubility of Arsenic, Cobalt, Molybdenum and Mercury as Percentages of Total Concentrations

4.3.4 Acetic Acid Leachate Analysis

Results for analysis of acetic acid leachates of the tailings solids are presented in Table A5 of Appendix 2. Comparison of water leachate concentrations presented in Table A4 of Appendix 2 was made with acetic acid leachate concentrations. It should be noted that water leachate was provided by a 1:5 sample to solution leach, while the acid leachate was provided by a 1:20 leach. Comparison on this basis indicates:

- Higher concentrations of calcium and magnesium and iron in acetic acid leachates - a result of partial dissolution of calcium and magnesium carbonates and iron hydroxides or carbonates (e.g. siderite) by acetic acid.
- Higher concentrations of manganese from dissolution of manganese oxides or carbonates by acetic acid.
- Slightly higher concentrations of aluminium, barium, copper, cadmium, nickel and uranium, which reflects the higher concentrations of oxide, hydroxide and carbonate minerals of these elements, all of which are soluble under acidic conditions.
- Generally similar concentrations of mercury, antimony, selenium and tellurium, although tellurium did become slightly more soluble (maximum 0.019 mg/L at 1:20) in the Croesus (Pit Shell) sample under the acidic leachate conditions.
- Only slightly higher concentrations of arsenic in acetic acid leachates, likely from partial dissolution of iron hydroxides and release of the adsorbed oxyanions.
- Significantly lower concentrations of soluble molybdenum and lower concentrations of cobalt in the Croesus (Pit Shell) sample in particular.
- All Mullingar samples contained detectable concentrations of soluble mercury, ranging from 0.002 mg/L to 0.007 mg/L in sample MULL4. There was no significant relationship between water-soluble mercury (Section 4.3.3) and acetic acid soluble mercury; the highest water-soluble concentration was 0.025 mg/L for sample MULL1, whereas the acetic acid solution concentration for this sample was 0.003 mg/L (0.012 mg/L if adjusted to the same 1:5 ratio). These observations suggest that mercury is expected to occur in different mineral forms, ranging from insoluble minerals such as coloradoite to salts of the mercuric (Hg^{2+}) ion.

5. CONCLUSIONS AND IMPLICATIONS FOR MINE CLOSURE

5.1 ALL HISTORICAL TAILINGS

Based on analysis of 15 samples of historical tailings facilities at various surface locations on the KCGM Fimiston lease area the following conclusions can be made:

- The tailings samples had low to moderate theoretical acid production potential and correspondingly moderate to high levels of ANC, with a significant portion of sulfur in most samples being in the already oxidised form (sulfate). As a result all samples were classified as NAF, with Paringa TSF (2), Mt Percy, Old Croesus (Fim I) and six Mullingar samples being further classified as acid consuming.
- Leachate and hence any potential for seepage (depending on closure design) from these tailings is predicted to be alkaline and brackish to moderately saline in perpetuity. Mt Percy TSF, Old Croesus (Fim I) and the Balgould Oroya TSF were lower in salinity (brackish leachate), while Paringa TSF, Morrison TSF and Croesus (Pit Shell) TSFs were approximately four fold more saline. Variable levels of salinity were recorded for the eight Mullingar samples.
- All tailings samples were found to be geochemically enriched in gold, silver, antimony and tellurium as a result of the nature of the particular gold mineralisation, but none of these elements were found to be soluble in water extracts or dilute acetic acid extracts to any extent considered to be of environmental concern post-closure when covered.
- The Balgould Oroya TSF sample was also found to be marginally enriched in mercury (1.1 mg/kg) along with a higher concentration of tellurium (13.9 mg/kg). Mullingar samples were also marginally enriched in mercury and, to a lesser degree, tellurium. Tellurium was highly insoluble and mercury in Balgould Oroya TSF also highly insoluble. Mercury from Mullingar tailings was marginally more soluble than other samples but remained below the non potable groundwater use guideline of 0.01 mg/L if adjusted to a 1:20 ratio extraction. In addition, the net rate of leaching (as evidence from retained salinity) and total concentrations of mercury are low (maximum 1.1 mg/kg). Again, as these elements were found to have low solubility in water extracts they are not considered to pose a risk to the environment when covered with waste rock to prevent water and wind erosion.
- The Paringa, Mt Percy, Mullingar and Old Croesus TSFs are therefore considered to contain geochemically benign tailings, with only moderate levels of salinity in leachates and/or potential seepage, which will remain alkaline. The sample of exposed Balgould Oroya tailings material assessed in this work is also geochemically benign but as previously noted, other materials within the Balgould, Oroya and Galconda operations area is expected to be significantly different and variable in nature.
- Geochemical assessment indicates that for materials other than Morrison and Croesus (Pit Shell) TSF material, a suitably designed waste rock cover to prevent wind and water erosion will be sufficient post-closure to prevent negative impacts on the surrounding environment.

5.2 MORRISON (CALCINE) TSF AND CROESUS (PIT SHELL) TSF

Analysis of the two samples of calcined tailings from Morrison (Calcine) TSF and Croesus (Pit Shell) indicates properties which are somewhat different to the other historical samples - summarised as follows:

- Tailings samples from these historical TSFs were similar in nature and also geochemically enriched in arsenic, cobalt, copper, molybdenum, selenium and lead (Croesus (Pit Shell) only). This difference relates to the different nature of treatment for the production of these tailings.
- Lead and copper in these samples were not found to be soluble under the alkaline conditions expected to prevail post-closure and these elements, despite enrichment, are not considered to pose a risk to the environment.

- Concentrations of arsenic (0.63 mg/L on a 1:20 basis) and molybdenum (0.175 mg/L on a 1:20 basis) in water leachate for the Morrison TSF sample marginally exceeded the livestock drinking water guidelines of 0.5 mg/L and 0.15 mg/L, respectively.
- Concentrations of cobalt (2.25 mg/L on a 1:20 basis), molybdenum (0.202 mg/L on a 1:20 basis) and selenium (0.022 mg/L on a 1:20 basis) in water leachate for the Croesus (Pit Shell) sample were found to marginally exceed the livestock drinking water guidelines of 1 mg/L, 0.15 mg/L and 0.02 mg/L, respectively.
- Any potential post-closure seepage from Croesus (Pit Shell) would eventually report to the Fimiston pit lake and it is noted that this TSF also lies within the zone of instability of the pit. Any potential post closure seepage from the Morrison (Calcine) TSF would report to the underlying groundwater and from there to the pit lake or down gradient palaeochannel aquifer (Schlumberger 2016). Although the potential for impact from both is considered very low given expected seepage rates from finely divided and tightly packed tailings, dilution and receiving environment, the total concentration and solubility of arsenic in both these TSF landforms is sufficient to be classified as Class (III) landfill according to DER landfill waste classifications and waste definitions (DER 2009).

Given these conclusions, it is recommended that KCGM consider the following closure management options for Croesus (Pit Shell) and Morrison TSF tailings:

- Remove and stockpile (as safe access permits) the tailings while the potential for end of mine life or external toll treatment re-processing is investigated based on the measured gold content (up to 3.2 g/t measured in this study).
- Remove tailings and, if not to be re-processed for gold extraction at end of mine, placed within a WRD as a rolled and compacted layer (water shedding), ideally on a sub-base of underlying NAF waste rock (Golden Mile dolerite or Paringa basalt) and covered by at least two metres of additional NAF waste rock or oxide. This may be appropriate for the Morrison TSF tailings in particular but less suitable for Croesus (Pit Shell) TSF given its location and stability.
- Temporarily remove and stockpile Morrison TSF tailings for later placement/backfill within the pit shell along with the Croesus TSF tailings and then cover with a layer of waste rock and (post closure) the pit lake water itself. As the pit lake will remain a groundwater sink in perpetuity (Schlumberger 2016) with no risk of overtopping, there will be no migration of metals and metalloids outside the boundary of the hypersaline (saturated salt) pit lake for the relatively limited metals and metalloid dissolution.

6. REFERENCES

AIMM 2001. Field Geologists' Manual. Australasian Institute of Mining and Metallurgy Monograph 9. Fourth Edition. Carlton, Victoria.

AMIRA 2002. ARD Test Handbook: Project 387A Prediction and Kinetic Control of Acid Mine Drainage. Australian Minerals Industry Research Association, Ian Wark Research Institute and Environmental Geochemistry International Pty Ltd, May 2002.

ANZECC 2000. National Water Quality Management Strategy, Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand.

DER 2009. Landfill Waste Classifications and Waste Definitions 1996 as amended 2009. Department of Environment Regulation (previously Department of Environment). 17 December 2009

DoH 2014. *Contaminated Sites Ground and Surface Water Chemical Screening Guidelines*, Department of Health, Government of Western Australia, December 2014.

DFAT 2016. Preventing Acid and Metalliferous Drainage (Department of Foreign Affairs and Trade September 2016).

MBS Environmental 2016. Tailings Geochemistry Overview. Report prepared for KCGM October 2016.

MEND 2009. Prediction Manual for Drainage Chemistry from Sulphidic Geologic Materials, MEND Report 1.20.1. CANMET Mining and Mineral Sciences Laboratories for the MEND (Mine Environmental Neutral Drainage) programme, December 2009.

INAP 2009. Global Acid Rock Drainage (GARD) Guide. International Network for Acid Prevention, <http://www.gardguide.com> (accessed 25 November 2016).

Schlumberger 2016. KCGM site-wide closure water and hydrochemical model. Report prepared for KCGM February 19 2016 by Schlumberger Water Services.

APPENDICES

APPENDIX 1: SAMPLE LOCATION PHOTOGRAPHS

SAMPLE LOCATION PHOTOGRAPHS

KCGM NOVEMBER 2016

Balgold Oroya TSF



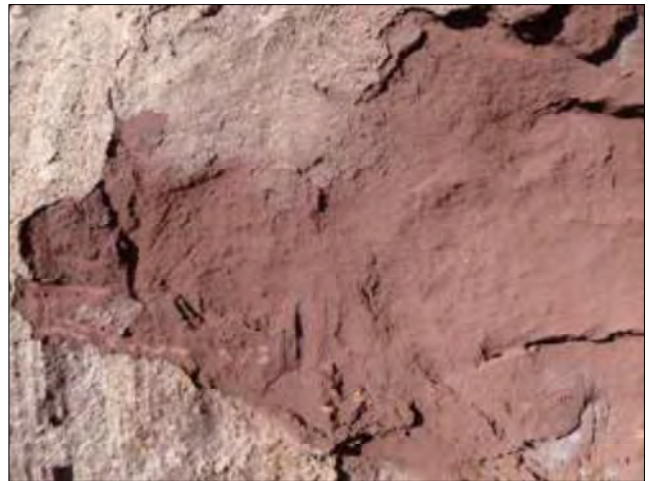
Morrison (Calcine) TSF



Morrison (Calcine) TSF



Croesus (Pit Shell)



Croesus (Pit Shell)



APPENDIX 2: COLLATED DATA TABLES

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Table A2-1: Tailings Samples Acid Base Accounting

Sample	pH	EC	Total-S	Sulfate-S*	Total C	AP	ANC	Carb-NP	NAPP	NAG	NPR	NAG pH	Classification
	pH units	µS/cm	%	%	%			kg H ₂ SO ₄ /tonne			(ANC/API)	pH units	
Paringa TSF (1)	8.1	13,270	0.55	0.28*	0.99	8	71	81	-63	0	8.5	8.1	NAF
Paringa TSF (2)	8.3	6,150	0.60	0.20*	2.83	12	189	231	-177	0	15	8.4	AC
Balgold Oroya TSF	8.4	3,430	1.88	0.58*	1.15	40	103	94	-63	0	3.0	9.6	NAF
Morrison (Calcine) TSF	8.6	12,590	1.20	0.90*	0.69	9	62	56	-53	0	6.8	8.9	NAF
4 Mt Percy RAMP	7.9	2,500	0.95	0.08*	2.80	27	200	229	-173	0	7.5	8.6	AC
Old Croesus (Fim I)	8.0	2,920	0.87	0.26*	2.24	19	166	183	-147	0	9.0	8.8	AC
Croesus (Pit Shell)	9.1	2,0360	1.56	1.15*	0.18	13	37	15	-24	0	2.9	8.0	NAF
MULL1	8.4	12,300	1.52	0.89	1.46	19	146	119	-127	0	7.5	8.5	AC
MULL2	7.7	15,400	1.19	0.91	2.02	8	179	165	-171	0	21	8.8	AC
MULL3	7.2	8,200	0.92	0.55	2.20	11	183	180	-172	0	16	8.9	AC
MULL4	8.5	4,200	1.81	0.34	2.24	45	186	183	-141	0	4.1	9.9	AC
MULL5	7.9	1,700	2.37	0.49	2.18	58	153	178	-95	0	2.7	10.1	NAF
MULL6	8.5	6,200	1.35	0.48	2.33	27	168	190	-141	0	6.3	8.8	AC
MULL7	8.5	2,600	1.77	0.34	2.36	44	124	193	-80	0	2.8	10.4	NAF
MULL8	8.1	11,400	1.39	0.64	2.13	23	162	174	-139	0	7.1	9	AC

* Estimate only from acetic acid ASLP not a true (4M HCl) sulfate sulfur determination.

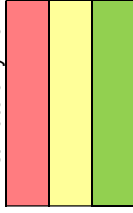


Table A2-2: Tailings Samples Elemental Composition

Sample	Au	Ag	Al	As	Ba	Bi	Ca	Cd	Co	Cr	Cu	Fe	Hg
	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	%	mg/kg
Paringa TSF (1)	0.39	0.80	70,954	151	295	0.12	19,261	0.24	69	134	198	11	0.16
Paringa TSF (2)	0.67	0.76	50,130	126	155	0.05	46,985	0.23	37	58	66	9.9	0.22
Balgold Oroya TSF	0.79	1.7	50,374	156	165	0.11	41,816	0.22	42	72	81	13	1.1
Morrison (Calcine) TSF	3.2	26	24,320	2,615	83	0.19	24,403	0.34	323	9	484	34	0.20
4 Mt Percy RAMP	0.36	0.24	5,6660	154	252	0.09	44,441	0.50	54	645	73	7.0	0.05
Old Croesus (Fim I)	0.56	1.5	55,690	109	236	0.65	41,667	0.25	38	158	83	8.5	0.54
Croesus (Pit Shell)	3.2	15	23,280	1,771	73	0.3	21,571	0.73	369	16	764	33	0.34
MULL1	N/A	0.30	49,415	79	45	0.03	52,460	0.06	57	6	87	11	1.1
MULL2	N/A	0.23	57,036	36	81	0.03	54,738	0.15	36	10	70	11	0.66
MULL3	N/A	0.16	50,828	58	52	0.03	56,143	0.12	49	7	91	11	0.34
MULL4	N/A	0.37	52,819	101	77	0.05	52,688	0.12	57	8	128	11	0.67
MULL5	N/A	0.54	45,505	112	81	0.03	48,262	0.12	53	6	117	10	0.67
MULL6	N/A	0.32	49,076	67	84	0.03	52,588	0.12	42	5	114	9.7	0.39
MULL7	N/A	0.49	48,154	92	82	0.03	52,663	0.13	52	<5	114	11	0.43
MULL8	N/A	0.28	55,318	64	111	0.04	48,751	0.11	38	8	76	9.8	0.78

N/A denotes Not Analysed.

Table A2-3: Tailings Samples Elemental Composition Continued

Sample	K	Mg	Mn	Mo	Na	Ni	Pb	Sb	Se	Te	U	V	Zn
	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Paringa TSF (1)	16,349	10,980	1,044	3.8	20,489	113	10	12	0.9	7.2	0.38	322	153
Paringa TSF (2)	12,805	20,502	1,659	12	16,330	38	7.4	9.6	<0.5	7.1	0.38	260	173
Balgold Oroya TSF	13,857	12,400	1,399	5.3	12,777	52	45	14	0.9	14	0.43	427	211
Morrison (Calcline) TSF	8,178	10,747	604	124	14,688	133	39	86	3.2	9.9	0.20	232	277
4 Mt Percy RAMP	8,784	30,547	1,244	2.4	10,337	282	11	3.3	0.6	1.2	0.40	158	288
Old Croesus (Fim I)	15,518	24,253	1,368	15	12,479	198	24	11	0.9	5.3	0.58	274	144
Croesus (Pit Shell)	7,682	11,301	553	33	24,477	188	117	80	2.7	11	0.31	197	505
MULL1	4,082	21,374	1,443	37	21,549	12	4.7	4.6	0.8	2.1	0.10	492	122
MULL2	9,657	25,617	1,363	47	23,514	17	21	3.4	<0.5	1.8	0.07	606	212
MULL3	6,539	22,286	1,572	32	19,674	18	56	3.6	0.7	1.5	0.09	541	138
MULL4	9,426	20,051	1,457	32	14,184	26	110	4.7	0.8	2.0	0.18	618	141
MULL5	10,790	16,383	1,318	34	9,185	21	79	6.6	0.9	1.8	0.12	533	105
MULL6	10,519	19,283	1,358	37	14,577	19	81	5.6	0.7	1.4	0.10	545	110
MULL7	10,219	18,351	1,454	43	10,843	20	102	8.5	0.8	1.5	0.10	534	113
MULL8	14,631	18,930	1,321	41	15,221	16	149	5.0	0.6	1.6	0.11	572	147

Table A2-4: Tailings Samples Global Abundance Index

Sample	Au	Ag	Al	As	Ba	Bi	Ca	Cd	Co	Cr	Cu	Fe	Hg
Paringa TSF (1)	6	3	0	2	0	0	0	0	1	0	1	1	0
Paringa TSF (2)	6	3	0	2	0	0	0	0	0	0	0	1	1
Balgold Oroya TSF	6	4	0	2	0	0	0	0	0	0	0	1	3
Morrison (Calcine) TSF	6	6	0	6	0	0	0	0	3	0	3	2	1
4 Mt Percy RAMP	6	1	0	2	0	0	0	1	1	2	0	0	0
Old Croesus (Fim I)	6	4	0	2	0	1	0	0	0	0	0	0	2
Croesus (Pit Shell)	6	6	0	6	0	0	0	1	3	0	3	2	1
MULL1	N/A	2	0	1	0	0	0	0	1	0	0	1	3
MULL2	N/A	1	0	0	0	0	0	0	0	0	0	1	2
MULL3	N/A	1	0	1	0	0	0	0	0	0	0	1	2
MULL4	N/A	2	0	1	0	0	0	0	1	0	1	1	2
MULL5	N/A	2	0	2	0	0	0	0	0	0	1	1	2
MULL6	N/A	2	0	1	0	0	0	0	0	0	0	1	2
MULL7	N/A	2	0	1	0	0	0	0	0	0	0	1	2
MULL8	N/A	1	0	1	0	0	0	0	0	0	0	1	3

 Denotes GAI values greater than or equal to 3

Table A2-5: Tailings Samples Global Abundance Index Continued

Sample	K	Mg	Mn	Mo	Na	Ni	Pb	Sb	Se	Te	U	V	Zn
Paringa TSF (1)	0	0	0	1	0	0	0	5	2	6	0	1	1
Paringa TSF (2)	0	0	0	2	0	0	0	5	0	6	0	0	1
Balgold Oroya TSF	0	0	0	1	0	0	1	5	2	6	0	1	1
Morrison (Calcine) TSF	0	0	0	6	0	0	1	6	3	6	0	0	1
4 Mt Percy RAMP	0	0	0	0	0	1	0	3	1	6	0	0	1
Old Croesus (Fim I)	0	0	0	3	0	1	0	5	2	6	0	0	0
Croesus (Pit Shell)	0	0	0	4	0	1	3	6	3	6	0	0	2
MULL1	0	0	0	4	0	0	0	4	1	6	0	1	0
MULL2	0	0	0	4	0	0	0	4	0	6	0	2	1
MULL3	0	0	0	4	0	0	2	4	1	6	0	1	0
MULL4	0	0	0	4	0	0	3	4	1	6	0	2	0
MULL5	0	0	0	4	0	0	2	4	2	6	0	1	0
MULL6	0	0	0	4	0	0	2	4	1	6	0	1	0
MULL7	0	0	0	4	0	0	2	5	1	6	0	1	0
MULL8	0	0	0	4	0	0	3	4	1	6	0	1	0

Denotes GAI values greater than or equal to 3

Table A2-6: Tailings Samples Water Leachate Concentrations

Sample	pH	EC	TDS	Na	K	Ca	Mg	Cl	SO ₄	F	Total Alkalinity	HCO ₃	CO ₃	SAR
	pH units	mS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg CaCO ₃ /L			ratio
Paringa TSF (1)	8.1	13	8,891	2,304	44	403	383	4,259	1,728	0.8	18	18	<1	20
Paringa TSF (2)	8.3	6.2	4,121	781	15	508	188	1,383	1,755	<0.1	15	13	3	7.5
Balgold Oroya TSF	8.4	3.4	2,298	267	11	657	54	464	1,714	0.5	12	9	3	2.7
Morrison (Calpine) TSF	8.6	13	8,435	2,125	32	876	248	3,984	2,308	0.4	13	5	8	16
4 Mt Percy RAMP	7.9	2.5	1,675	318	5	137	44	595	407	0.2	16	16	<1	6.0
Old Croesus (Fim I)	8.0	2.9	1,956	199	17	490	88	219	1,649	<0.1	15	15	<1	2.2
Croesus (Pit Shell)	9.1	20.4	13,641	3,688	71	1,042	782	7,615	3,174	0.5	30	<1	29	21
MULL1	8.4	12	8,241	2,157	21	249	516	3,988	1,584	<0.1	23	21	<1	18
MULL2	7.7	15	10,318	2,773	27	311	685	5,176	2,070	<0.1	36	36	<1	20
MULL3	7.2	8.2	5,494	1,461	16	156	251	2,623	738	<0.1	40	40	<1	17
MULL4	8.5	4.2	2,814	626	10	146	115	1,139	531	<0.1	19	9	11	9.4
MULL5	7.9	1.7	1,139	100	22	250	47	173	699	<0.1	47	47	<1	1.5
MULL6	8.5	6.2	4,154	987	13	194	227	1,817	882	<0.1	23	13	10	11
MULL7	8.5	2.6	1,742	385	7	146	55	634	432	<0.1	22	20	<1	6.8
MULL8	8.1	11	7,638	2,111	21	196	362	3,829	1,035	<0.1	28	28	<1	21
Livestock			5,000			1,000			1,000	2				
Non Potable Groundwater								250	1,000	15				

Table A2-7: Tailings Samples Water Leachate Concentrations Continued

Sample	Au	Ag	Al	As	B	Ba	Bi	Cd	Co	Cr	Cu	Fe	Hg
	µg/L	mg/L	mg/L	mg/L	mg/L	mg/L	µg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Paringa TSF (1)	2.4	0.007	<0.1	0.003	0.1	0.042	<0.05	<0.0002	0.495	<0.1	<0.1	<0.1	<0.001
Paringa TSF (2)	1.8	0.023	<0.1	<0.001	<0.1	0.016	<0.05	<0.0002	0.115	<0.1	<0.1	<0.1	<0.001
Balgold Oroya TSF	11	0.0012	<0.1	0.006	0.2	0.007	<0.05	<0.0002	0.031	<0.1	<0.1	0.1	0.002
Morrison (Calcine) TSF	45	0.264	<0.1	2.5	0.6	0.022	<0.05	<0.0002	0.948	<0.1	<0.1	0.1	0.001
4 Mt Percy RAMP	2.2	0.0004	<0.1	0.005	0.1	0.008	<0.05	<0.0002	0.011	<0.1	<0.1	<0.1	<0.001
Old Croesus (Fim I)	18	<0.0001	<0.1	0.002	0.1	0.016	<0.05	<0.0002	0.079	<0.1	<0.1	0.1	<0.001
Croesus (Pit Shell)	32	0.291	<0.1	1.75	0.2	0.028	<0.05	<0.0002	8.99	<0.1	<0.1	<0.1	0.007
MULL1	N/A	0.0023	0.2	0.008	N/A	0.003	<0.1	<0.0005	0.008	<0.1	<0.1	0.9	0.025
MULL2	N/A	<0.0002	<0.1	0.007	N/A	0.019	<0.1	<0.0005	0.011	<0.1	<0.1	0.6	0.008
MULL3	N/A	0.0008	<0.1	0.004	N/A	0.003	<0.1	<0.0005	0.007	<0.1	<0.1	1.4	0.011
MULL4	N/A	0.0004	<0.1	<0.002	N/A	0.001	<0.1	<0.0005	0.006	<0.1	<0.1	1	0.004
MULL5	N/A	<0.0002	<0.1	<0.002	N/A	0.006	<0.1	<0.0005	<0.002	<0.1	<0.1	0.6	<0.002
MULL6	N/A	0.0014	<0.1	0.002	N/A	0.002	<0.1	<0.0005	0.005	<0.1	<0.1	1.2	0.005
MULL7	N/A	0.0002	<0.1	<0.002	N/A	<0.001	<0.1	<0.0005	0.003	<0.1	<0.1	1.3	<0.002
MULL8	N/A	0.0046	<0.1	<0.002	N/A	0.004	<0.1	<0.0005	0.015	<0.1	<0.1	1.4	0.012
Livestock		1	5	0.5	5			0.01	1	1	1		0.002
Non Potable Groundwater		1	0.2	0.1	40	20		0.02		0.5 (CrVI)	20	0.3	0.01

Denotes a result in 1:5 extract above the Livestock drinking water guideline or Non Potable Groundwater use guideline

Table A2-8: Tailings Samples Water Leachate (1:5) Concentrations Continued

Sample	Mn	Mo	Ni	Pb	Sb	Se	Te	U	V	Zn
	mg/L	mg/L	mg/L	mg/L	µg/L	mg/L	µg/L	µg/L	mg/L	mg/L
Paringa TSF (1)	<0.1	0.01	<0.1	<0.005	0.5	<0.005	<1	<0.05	<0.1	<0.1
Paringa TSF (2)	<0.1	0.02	<0.1	<0.005	0.2	<0.005	<1	<0.05	<0.1	<0.1
Balgold Oroya TSF	<0.1	0.04	<0.1	<0.005	0.9	<0.005	<1	<0.05	<0.1	<0.1
Morrison (Calcine) TSF	<0.1	0.70	0.1	<0.005	5.1	0.07	<1	<0.05	<0.1	<0.1
4 Mt Percy RAMP	<0.1	0.009	<0.1	<0.005	0.2	<0.005	<1	<0.05	<0.1	<0.1
Old Croesus (Fim I)	<0.1	0.10	<0.1	<0.005	0.7	0.009	<1	<0.05	<0.1	<0.1
Croesus (Pit Shell)	<0.1	0.81	<0.1	<0.005	24	0.09	<1	<0.05	<0.1	<0.1
MULL1	<0.1	0.40	<0.1	<0.01	0.4	<0.01	<2	<0.1	<0.1	<0.1
MULL2	<0.1	0.35	<0.1	<0.01	2.4	<0.01	<2	<0.1	<0.1	<0.1
MULL3	<0.1	0.22	<0.1	<0.01	0.3	<0.01	<2	<0.1	<0.1	<0.1
MULL4	<0.1	0.13	<0.1	<0.01	<0.2	<0.01	<2	<0.1	<0.1	<0.1
MULL5	<0.1	0.07	<0.1	<0.01	1.2	<0.01	<2	<0.1	<0.1	<0.1
MULL6	<0.1	0.06	<0.1	<0.01	0.3	<0.01	<2	<0.1	<0.1	<0.1
MULL7	<0.1	0.04	<0.1	<0.01	0.5	<0.01	<2	<0.1	<0.1	<0.1
MULL8	<0.1	0.11	<0.1	0.01	0.3	<0.01	<2	<0.1	<0.1	<0.1
Livestock		0.15	1	0.1		0.02		200		20
Non Potable Groundwater	5	0.5	0.2	0.1	30	0.1		170		3

Denotes a result in 1:5 extract above the Livestock drinking water guideline or Non Potable Groundwater use guideline

Table A2-9: Tailings Samples Acetic Acid Leachate (1:20) Concentrations

Sample	pH	Au	Ag	Al	As	B	Ba	Bi	Ca	Cd	Co	Cr	Cu	Fe	Hg
	pH units	µg/L	mg/L	mg/L	mg/L	mg/L	mg/L	µg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Paringa TSF (1)	4.3	0.7	0.0025	3.9	<0.001	0.3	0.13	<0.05	405	0.003	0.43	<0.1	0.2	78	<0.001
Paringa TSF (2)	4.6	0.5	<0.0001	0.2	<0.001	0.1	0.07	<0.05	582	0.003	0.09	<0.1	<0.1	149	<0.001
Balgold Oroya TSF	4.6	2.3	<0.0001	4.1	0.003	0.3	0.07	<0.05	1,113	0.002	0.04	<0.1	0.2	12	<0.001
Morrison (Calcine) TSF	4.3	8.4	0.03	3.1	2.0	0.6	0.07	<0.05	719	0.003	0.71	<0.1	1.6	46	<0.001
4 Mt Percy RAMP	4.3	1.1	0.0001	0.5	0.004	0.1	0.04	<0.05	342	0.004	0.22	<0.1	<0.1	90	<0.001
Old Croesus (Fim I)	4.8	3.7	<0.0001	0.9	<0.001	0.2	0.09	<0.05	577	0.003	0.10	<0.1	0.2	100	<0.001
Croesus (Pit Shell)	4.1	6.7	0.0955	6.2	3.9	0.3	0.04	<0.05	718	0.01	1.3	<0.1	3.7	2.4	0.002
MULL1	5.1	NA	<0.0001	<0.1	0.001	NA	0.03	<0.05	1,734	0.002	0.24	<0.1	0.1	12	0.003
MULL2	5.3	NA	<0.0001	<0.1	<0.001	NA	0.05	<0.05	1,792	0.003	0.17	<0.1	<0.1	39	0.003
MULL3	5.4	NA	0.0001	<0.1	<0.001	NA	0.04	<0.05	1,533	0.003	0.16	<0.1	<0.1	15	0.004
MULL4	5.3	NA	<0.0001	<0.1	<0.001	NA	0.02	<0.05	1,418	0.004	0.08	<0.1	<0.1	47	0.007
MULL5	5.2	NA	<0.0001	<0.1	<0.001	NA	0.03	<0.05	1,256	0.003	0.10	<0.1	<0.1	192	0.002
MULL6	5.3	NA	<0.0001	<0.1	<0.001	NA	0.02	<0.05	1,376	0.004	0.08	<0.1	<0.1	98	0.002
MULL7	5.3	NA	<0.0001	<0.1	<0.001	NA	0.02	<0.05	1,334	0.003	0.08	<0.1	<0.1	111	0.002
MULL8	5.4	NA	<0.0001	<0.1	<0.001	NA	0.02	<0.05	1,369	0.004	0.12	<0.1	<0.1	53	0.006

Table A2-10: Tailings Samples Acetic Acid Leachate (1:20) Concentrations Continued

Sample	K	Mg	Mn	Mo	Na	Ni	Pb	S	Sb	Se	Te	U	V	Zn
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	µg/L	mg/L	µg/L	µg/L	mg/L	mg/L
Paringa TSF (1)	16	233	13	<0.5	630	0.2	<0.005	138	<0.1	<0.005	<1	1.3	<0.1	1.0
Paringa TSF (2)	3	221	16	<0.5	181	0.2	<0.005	99	<0.1	<0.005	<1	0.7	<0.1	2.6
Balgold Oroya TSF	5	135	7.1	<0.5	74	<0.1	<0.005	291	0.8	<0.005	4	1.6	<0.1	1.1
Morrison (Calcine) TSF	8	280	9.2	15	556	0.2	<0.005	450	8.8	0.03	7	0.3	<0.1	4.0
4 Mt Percy RAMP	<1	148	8.4	<0.5	90	0.4	<0.005	39	0.2	<0.005	<1	0.4	<0.1	1.2
Old Croesus (Fim I)	7	164	12	<0.5	55	0.5	<0.005	132	0.2	<0.005	<1	1.4	<0.1	0.8
Croesus (Pit Shell)	19	409	6.6	8.0	1,043	0.1	0.034	573	16	0.02	19	0.7	<0.1	4.2
MULL1	6	211	19	<0.5	562	<0.1	<0.005	407	<0.1	<0.005	<1	0.2	<0.1	0.4
MULL2	9	312	23	<0.5	689	<0.1	<0.005	440	<0.1	<0.005	<1	0.3	<0.1	1.2
MULL3	6	200	23	<0.5	384	<0.1	<0.005	154	<0.1	<0.005	<1	0.08	<0.1	0.3
MULL4	3	216	21	<0.5	190	<0.1	<0.005	167	<0.1	<0.005	<1	0.1	<0.1	0.3
MULL5	3	218	20	<0.5	46	<0.1	<0.005	238	<0.1	<0.005	<1	0.1	<0.1	0.4
MULL6	3	255	19	<0.5	250	<0.1	<0.005	253	<0.1	<0.005	<1	0.1	<0.1	0.3
MULL7	3	206	21	<0.5	99	<0.1	<0.005	168	<0.1	<0.005	<1	0.1	<0.1	0.2
MULL8	6	370	21	<0.5	455	<0.1	<0.005	302	<0.1	<0.005	<1	0.2	<0.1	0.3

5.9 Appendix 5.9: MT CHARLOTTE Hydrological Predictions



Peter Clifton & Associates
Consulting Hydrogeologists
A division of Saguario Holdings Pty Ltd
ACN 073 231 295; ABN 33 216 640 980

Postal Address: PO Box 186, Floreat WA 6014
Telephone: (08) 9388 9191
Facsimile: (08) 9388 7171
Mobile: 0408 929 964
E-mail: pca@saguario.com.au

25 March 2021

Kalgoorlie Consolidated Gold Mines Pty Ltd
Private Mail Bag 27
Kalgoorlie WA 6433

Attn: Ms Janine Cameron, Senior Environmental Coordinator

Ref: Mt Charlotte Underground Mine Flooding Predictions

The Mt Charlotte Underground Mine was initially developed to depths of around 130 m prior to the 1930s. The mine was re-opened in 1963, and has since been developed to a depth of around 1.2 km. Current plans are to continue mining until around 2018 and then the mine will be closed.

The mine is accessed either via the Sam Pearce Decline or the Cassidy Shaft. The portal of the Sam Pearce Decline is at the northern end of the Fimiston Open Pit, about 2.5 km SE of the Cassidy Shaft headframe. The decline tracks northwest and joins the main underground workings of Mt Charlotte on the 9 Level (9L). Elevations of these points are:

- Surface at Cassidy Shaft: 390 mAHD
- Portal of Sam Pearce Decline: 316 mAHD
- Intersection of Sam Pearce Decline and 9L: 134 mAHD

There is a small-scale dewatering operation at Mt Charlotte. Water produced by these operations is mostly a mixture of groundwater seepage and water introduced for operating machinery. After dewatering ceases and the mine is closed, the underground voids will slowly fill with water and the level of water in the mine will rise.

A mine flooding model for the Mt Charlotte Underground Mine has been developed to predict the rate of water level rise and likely equilibrium water level in the mine. The flooding model is based on a mine void model which has been developed independently, and inflows from various sources. The flooding model updates earlier predictions of void flooding at Mt Charlotte by Rockwater (2001).

The void model is based on a block model of the mine stopes and other developments produced from data provided by KCGM, and includes all current and proposed mine voids to the end of mining in 2018. The void model is used to estimate the volume of voids between a particular elevation and the base of the mine sump.

The flooding model calculates the incremental volume of water added to the mine from several sources for a given time interval. The level of water in the mine is then determined from the mine void model and the cumulative volume of water in the mine.

Sources of inflow considered by the model are:

- Observed groundwater seepages (maximum 356 kL/day)
- Additional groundwater seepage equivalent to the present discharge of water vapour from the mine ventilation system (average maximum 241 kL/day)
- Additional groundwater seepage equivalent to the rate that water is removed from the mine in wet ore (average 55 kL/day)
- Additional groundwater seepage equivalent to the rate that water is being used for dust suppression (25 kL/day)
- Surface water runoff (average 17 kL/day)

The most significant observed groundwater seepages in the underground are associated with four major steeply dipping structures at depths between -22 mAHD and -540 mAHD.

The flooding model can account for the groundwater inflow components as being either head dependent or head independent. The ambient groundwater level used in head dependent inflow calculations is 335 mAHD, and is based on nearby observations.

Three simulations of the Mt Charlotte mine flooding model have been run:

- Seepage from all inflow components, with head dependent groundwater inflow, and final flood level equal to the ambient groundwater level
- Seepage from all inflow components with no head dependency, and final flood level equal to the ambient groundwater level
- Seepage from all inflow components, with head dependent groundwater inflow, and final flood level equal to the level of the Sam Pearce Decline portal

The first simulation allows groundwater inflow rates to decrease as the flood level rises. This simulation predicts the final equilibrium water level will occur 105 years after closure.

The second simulation assumes seepage rates from all sources remain constant, which is a conservative assumption. The predicted time to flood the mine under these conditions is 34 years after closure.

The third simulation allows flood water to overflow into the Fimiston Pit when the level of water in the mine reaches the portal of the Sam Pearce Decline. This is the most likely of the three scenarios considered, and predicts the final equilibrium flood level will occur 99 years after closure. The predicted inflow rate at this level is 33 kL/day. This is the estimated rate of overflow from the Mt Charlotte Underground into the lake that eventually will develop in the Fimiston Pit after closure of those operations.

Yours faithfully
Peter Clifton & Associates

P M Clifton
9505_L108.DOCX

5.10 Appendix 5.10: MT CHARLOTTE Waste Characterisation

MT CHARLOTTE UNDERGROUND WASTE ROCK GEOCHEMICAL CHARACTERISATION

PREPARED FOR:

**KALGOORLIE CONSOLIDATED GOLD MINES PTY
LTD**



JANUARY 2018

PREPARED BY:

Martinick Bosch Sell Pty Ltd
4 Cook Street
West Perth WA 6005
Ph: (08) 9226 3166
Fax: (08) 9226 3177
Email: info@mbsenvironmental.com.au
Web: www.mbsenvironmental.com.au

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MT CHARLOTTE UNDERGROUND WASTE ROCK GEOCHEMICAL CHARACTERISATION

Distribution List:

Company	Contact name	Copies	Date
KCGM Pty. Ltd.	Janine Cameron – Senior Environmental Coordinator	[01]	12 January 2018
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1. INTRODUCTION

1.1 BACKGROUND

Kalgoorlie Consolidated Gold Mines Pty Ltd (KCGM) operates the Fimiston Open Pit, Mt Charlotte underground mine and the Fimiston and Gidji Processing Plants located adjacent to the City of Kalgoorlie-Boulder approximately 600 km east of Perth, Western Australia (Figure 1).

Mining and mineral processing has occurred in this area, known as the Golden Mile, since gold was first discovered in 1893. The Golden Mile is one of the world's richest gold-bearing reefs and gave rise to a multitude of mining operations. In 1989, all mines, processing plants and leases along the Golden Mile were merged into one integrated operation, KCGM.

Ore for gold production at KCGM is today sourced from two primary mining locations; the Fimiston Open Pit (commonly known as the Super Pit) and the Mt Charlotte underground mine approximately 2 km north of the Fimiston Open Pit (Figure 1). The Fimiston Open Pit mining rate is approximately 69 million tonnes per annum (Mt/a) (comprising ore and waste), of which approximately 12 Mt/a is processed at the Fimiston Mill.

In addition to the above mining locations, development at the Mt Charlotte underground is currently progressing towards two new ore sources:

- Northern Orebody (NOB), a geological extension of the fault line mineralisation seen in the Fimiston Pit.
- Lower Hidden Secret Orebody (LHSO), located approximately 400 m east of Mt Charlotte and within the steeply dipping western limb of the Kalgoorlie Anticline. Mining for LHSO will be between 215 and 440 m underground.

Waste rock generated from NOB and LHSO development will be backfilled to underground mine voids, as has historically been the practice at Mt Charlotte. Waste material will be placed both above and below the final post mining groundwater level.

Waste rock from the NOB extension will comprise almost entirely Golden Mile dolerite (GMD) with minor Black Flag shale lithologies, similar to Fimiston Pit. There is a significant amount of assay data and comprehensive waste characterisation for GMD in particular, as well as Black Flag shale from the Fimiston Pit (MBS 2016, MBS 2017). NOB waste rock is expected to be very similar in nature to these previous samples from Fimiston Pit.

The LHSO development will intercept four fresh rock lithologies: Devons Consol basalt (DCB), Williamstown dolerite (WD), Porphyry (POR) and Kapai slate (KS). The lithology identified as Hannans Lake serpentinite (HLS), which is also in the fresh rock zone, lies below the LHSO and is not part of currently proposed mining. These lithologies are not encountered to any significant degree (only minor Kapai slate is intercepted) in Fimiston Pit and as such, no previous waste characterisation data (if any has been performed), is currently available to support mine closure planning. High sulfur assays recorded for Kapai slate during drilling programs have also indicated this lithology presents a risk of generating acidic and metalliferous drainage (AMD). Although KCGM proposes to backfill waste materials from NOB and LHSO to underground mine voids, additional waste characterisation is required to assess potential impacts to the surrounding environment, particularly post closure leaching of environmentally significant metals and metalloids to the groundwater.



Figure 1: KCGM Fimiston Open Pit and Key Mine Waste Landforms

1.2 OBJECTIVE AND SCOPE OF WORK

The objectives and scope of work for the additional waste rock characterisation were to:

- Liaise with KCGM personnel for provision of drill log data including lithology, sulfur assays (percentage sulfur) and depth for a representative selection of Mt Charlotte underground waste rock types.
- Review the above data to select approximately 24 samples across the fresh waste rock lithologies relevant to Mt Charlotte underground LHSO and NOB orebodies. This includes Kapaï slate, Devons Consol basalt, Hannans Lake serpentinite and Williamstown dolerite for the LHSO and the U8 and U9 sequences of Golden Mile dolerite for NOB.
- Visit the Mt Charlotte mine to collect the above samples of drill core, discuss the geology, mine waste planning, available assay results and predicted post-closure groundwater levels.
- Submit samples to a laboratory for determination of the following acid base accounting (ABA) parameters:
 - Total sulfur, sulfate sulfur and (for shale and slate lithologies) chromium reducible sulfur (CRS).
 - Acid Neutralising Capacity (ANC).
 - Total carbon.
 - Net Acid Generation (NAG) test on samples containing >0.2% total sulfur.
- Submit selected samples to the laboratory for the following:
 - Elemental analysis of four acid digest solutions (Ag, Al, As, B, Ba, Ca, Cd, Co, Cu, Cr, Fe, K, Mg, Mn, Mo, Na, Ni, Pb, Sb, Se, Sn, Te, Th, U, V and Zn) and mercury (separate digestion required).
 - Analysis of water and dilute acid leachates of selected samples (based on expected AMD results) for pH, EC, alkalinity/acidity, major ions (Ca, Mg, Na, K, Cl, sulfate) and soluble metals and metalloids (Ag, Al, As, B, Ba, Be, Ca, Cd, Co, Cu, Cr, Fe, K, Hg, Li, Mg, Mn, Mo, Na, Ni, Nb, Pb, Sb, Se, Sn, Ta, U, V and Zn).
 - Mineralogy by X-Ray Diffraction (XRD) (one for each lithology).
- Preparation of a concise geochemical report outlining the properties of the waste rock lithologies and discussing similarities to Fimiston Pit wastes. This does not include an assessment of potential for asbestiform minerals.
- Assessment of the relative risk of neutral and acid drainage potential within waste rock from Mt Charlotte based on available information and current/intended mine practices.

2. PROJECT GEOLOGY AND HYDROLOGY

2.1 MT CHARLOTTE UNDERGROUND GEOLOGY

The Kalgoorlie-Boulder stratigraphy lies within the Archaean aged Norseman-Wiluna Greenstone Belt of WA. Intruded mafic to ultramafic sills contain gold-bearing lodes. Most gold mineralisation in the Golden Mile Deposit (including the NOB extension and Fimiston Pit) is hosted within one of these sills; the Golden Mile dolerite. The Fimiston deposit is dominated by the large Kalgoorlie Anticline/Syncline system which caused deformation of the original stratigraphic sequence. The Golden Mile Fault is the main fault occurring in this system and is directly associated with GMD (KCGM 2014). The GMD layer consisting of mafic-ultramafic rocks is further divided into ten units (designated U1 to U10) which differentiate between mineral concentration and texture of GMD.

The Central Lease area geology, which includes the LHSO deposit, is complex due to multiple overprinting folding events and later crosscutting faults. The general profile of the Central Lease deposits consists of a lower mafic-ultramafic volcanic sequence with sub volcanic sills overlain by a thick sequence of sedimentary and intermediate to felsic volcanoclastic rocks. The lower GMD stratigraphy hosts the LHSO deposit, which also holds the main Mt Charlotte-based Fimiston Deposit, and has expressions in the southern portion of the greenstone belt (Figure 2). Figure 3 is a mine cross-sectional view looking north of Mt Charlotte underground and the LHSO deposit showing drill holes for LHSO which were selected for the current study.

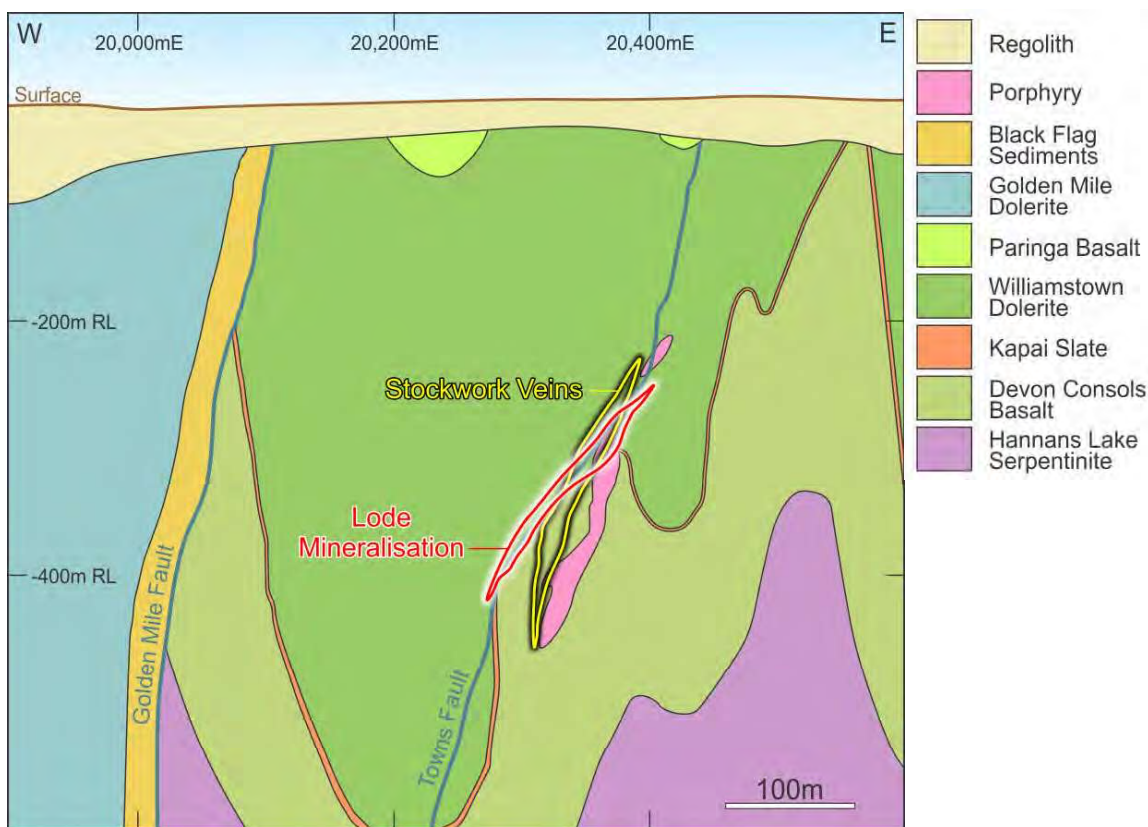


Figure 2: Lower Hidden Secret Orebody Cross-Sectional Geology Schematic

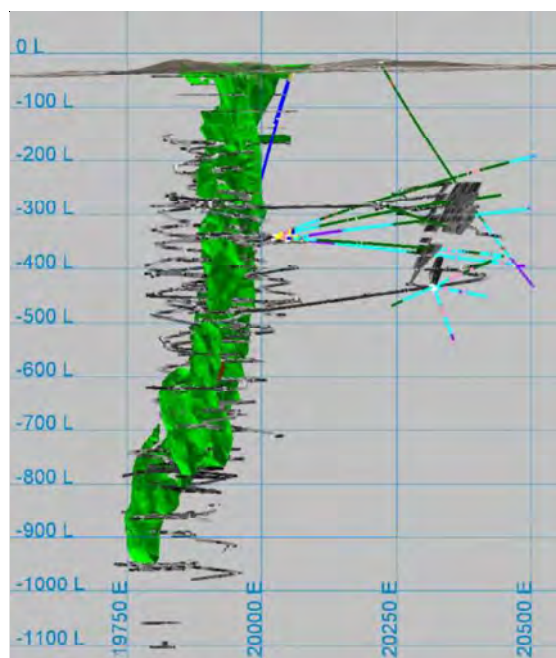


Figure 3: Cross-Sectional View of Mt Charlotte Underground/LHSO Looking North

The mineralising event on the Golden Mile has led to an overall geochemical enrichment in arsenic (As), tellurium (Te), mercury (Hg), lead (Pb), vanadium (V) and boron (B). This enrichment is largely confined to the main lode systems with lower levels of enrichment in the surrounding host BF shales and significantly lower enrichment in the host GMD and Paringa basalt. Gold mineralisation in the LHSO is associated with silver, tellurium, mercury, zinc and copper minerals with a significant presence of hessite (Ag_2Te) in particular (Fitzgerald and Nixon 2016 and references therein).

Estimated waste rock tonnages by lithology for each deposit are given in Table 1.

Table 1: Mt Charlotte Waste Rock Breakdown by Lithology (KCGM Block Model)

Deposit	Lithology (Abbreviation)	Tonnes	Percentage of Total Waste
NOB	Golden Mile dolerite (GMD)	1,961,250	98.7
	Black Flag shale (BF)	26,046	1.3
	Total	1,987,296	100
LHSO	Williamstown dolerite (WD)	388,727	64
	Devons Consul basalt (DCB)	135,043	22
	Porphyry (POR)	76,694	13
	Kapai slate (KS)	7,469	1.2
	Total	607,932	100

2.2 REGIONAL AND LOCAL HYDROGEOLOGY

2.2.1 Regional Hydrogeology

There are three major groundwater systems which have been defined during extensive drilling and testing in the vicinity of KCGM:

- The shallow ferricrete and alluvial sedimentary system, an accumulation of sand, gravel and fractured ferricrete within clays, occurring typically from 4 to 40 m depth, which is present in lower elevation areas of the surface water catchments;
- The palaeochannel systems, an extensive network of Tertiary alluvial sands occurring at around 60 m depth in buried river channels. This aquifer system is well understood and is utilised by KCGM and by other mining operations as the primary source of process water supply; and
- The bedrock system hosted primarily within GMD and Paringa basalt, where groundwater flow occurs in fractured and weathered zones within the basement rocks at depth (the primary aquifer for Fimiston Open Pit).

There is no known potable groundwater in the vicinity of Kalgoorlie-Boulder (and by extension, KCGM) within the above systems. Groundwater quality ranges from brackish (1,000 to 3,000 mg/L Total Dissolved Solids (TDS)) in shallow groundwater, to brines approximately five to six times more saline than seawater in paleochannels (up to 200,000 mg/L TDS). The primary influence on the wide variation in TDS concentrations is the topographical location and groundwater age rather than rock type hosting the groundwater system.

2.2.2 Local Hydrogeology

The Mt Charlotte underground mine is not connected to the extensive underground water systems along Kalgoorlie's Golden Mile, which lie beneath the Fimiston Open Pit. Dewatering from Mt Charlotte underground is directed to surface where it is pumped to Fimiston Mill. Minimal (if any) dewatering will need to be carried out at LHSO as a result of dewatering at Mt Charlotte underground (Peter Clifton & Associates 2014) and the observed lack of groundwater flow in mine workings in the area.

Post-closure flood modelling for the Mt Charlotte underground mine was undertaken by Peter Clifton & Associates (2014) to predict long term changes in groundwater levels as the system adjusted to the cessation of mine dewatering. Water entering Mt Charlotte underground post closure will be sourced from a combination of mine surface water runoff (including through the former Glory Hole mine) and underground groundwater from various faults (Charlotte, Flanagan, Neptune and Golden Mile). The natural groundwater level in the area was estimated to be at 335 m Australian height datum (AHD, m above sea level), surface level is approximately 390 m AHD). The most likely modelled scenario considered allowed for flooded mine water in Mt Charlotte underground to reach equilibrium and overflow into the Fimiston Open Pit when the flood level reaches the portal of the Sam Pearce decline at 316 m AHD. This was predicted to occur 99 years after closure of the Mt Charlotte underground mine. The predicted flow rate into Fimiston Pit area (including infiltration into the mine ramp) at the Sam Pearce decline after this time was 33 kL/day.

3. GEOCHEMICAL CHARACTERISATION METHODS

3.1 ACID FORMING WASTE CLASSIFICATION METHODOLOGY

There is no simple method to define whether mine waste containing small quantities of sulfur will produce sulfuric acid. Sulfide minerals are variable in their behaviour under oxidising conditions and not all forms will produce sulfuric acid (H_2SO_4). Instead, a combination of approaches is often applied to more accurately classify mine waste. These approaches are listed below in order of increasing data requirements (and therefore increased reliability):

- The “Analysis Concept”, which only requires data for total sulfur content. Its adoption is based on long term experience of wastes from Western Australian mine sites in arid and semi-arid conditions. Experience has shown that waste rock containing very low sulfur contents (less than 0.2 to 0.3%) rarely produces significant amounts of acidic seepage.
- The “Ratio Concept”, which compares the relative proportions of acid neutralising minerals (measured by the Acid Neutralising Capacity (ANC)) to acid generating minerals (measured by the Maximum Potential Acidity (MPA)). Experience has shown that the risk of generating acidic seepage is generally low when this ratio (the Neutralisation Potential Ratio – NPR) is above a value of two.
- Acid-Base Accounting, in which the calculated value for Nett Acid Producing Potential (NAPP) is used to classify the acid generating potential of mine waste. NAPP is equal to the MPA minus the ANC.
- Procedures recommended by AMIRA (2002), which take into consideration measured values provided by the Nett Acid Generation (NAG) test and calculated NAPP values.
- Kinetic leaching column test data, which provides information for the relative rates of acid generation under controlled laboratory conditions, intended to simulate those within a waste rock dump (WRD) or tailings storage facility (TSF).

A sound knowledge of geological and geochemical processes must also be employed in the application of the above methods.

Classification of wastes in this report uses procedures recommended by AMIRA (2002) based on NAPP and NAGpH results. However, results are also compared to the Analysis Concept (total sulfur) and Ratio Concept models and a modification of the AMIRA procedure by determination of the following:

- Analysis for total sulfur (Tot_S) and sulfate sulfur ($\text{SO}_4\text{-S}$), both reported as sulfur, as a measure of oxidisable sulfur. Alternatively, Chromium Reducible Sulfur (CRS) can be used as a direct measure of oxidisable sulfur and is potentially a better method for lithologies with significant organic carbon such as shales and slates.
- Analysis for ANC (quoted in $\text{kg H}_2\text{SO}_4/\text{t}$).
- Calculation of carbonate neutralising potential (CarbNP) (quoted in $\text{kg H}_2\text{SO}_4/\text{t}$) from measured concentrations of carbon.
- Calculation of Acid Production Potential (AP) = $[(\text{Tot_S} - \text{SO}_4\text{-S}) * 30.6]$ $\text{kg H}_2\text{SO}_4/\text{t}$. Chromium Reducible Sulfur (CRS) can be used in place of total sulfur minus sulfate sulfur in this calculation of AP.
- Calculation of NAPP = $[\text{AP} - \text{ANC}]$ $\text{kg H}_2\text{SO}_4/\text{t}$.
- Calculation of Effective NAPP = $[\text{AP} - \text{CarbNP}]$ $\text{kg H}_2\text{SO}_4/\text{t}$.
- Analysis for NAG (quoted in $\text{kg H}_2\text{SO}_4/\text{t}$).
- Analysis for NAGpH.
- Calculation of NPR = ANC/AP .

This AMIRA approach is more conservative than either the Analysis Concept or the Ratio Concept alone, but assumes the absence of sulfur present as barium sulfate. The AMIRA approach of using NAG testing is particularly useful for PAF-LC materials or where there is very low ANC in the host rock. A combined acid generation classification scheme based on NAPP and NAG determinations is presented in Table 2.

Table 2: Waste Classification Criteria

Primary Geochemical Waste Type Class	NAPP Value kg H ₂ SO ₄ /t	NAGpH	Sulfide S Content
Potentially Acid Forming (PAF)	≥10	< 4.5	≥ 0.3%
Potentially Acid Forming – Low Capacity (PAF-LC)	0 to 10	< 4.5	0.16 to 0.3%
Uncertain (UC)	0 to 5	> 4.5	Not important
Uncertain (UC)	-10 to 0	< 4.5	Not important
Non Acid Forming (NAF)	-100 to 0	> 4.5	Not important
Acid Consuming (AC)	< -100	> 4.5	Not important

Table 2 is based on the Australian Government's Guidelines on Managing Acidic and Metalliferous Drainage (DIIS 2016) and is in turn based on an earlier classification system included within the AMIRA ARD Test Handbook (AMIRA 2002), which is advocated by the Global Acid Rock Drainage Guidelines (GARD) published by the International Network for Acid Prevention (INAP 2009). This classification system, based on static acid base accounting procedures and used in conjunction with geological, geochemical and mineralogical analysis can still leave materials classified as 'uncertain' where there is conflicting NAGpH and NAPP results. Uncertain materials demonstrating a NAGpH above 4.5 may be tentatively assigned as potentially NAF and those below pH 4.5 as potentially PAF – however in such cases, further assessment, such as the use of kinetic leaching columns may be required to provide a definitive classification.

3.2 LABORATORY METHODS

Representative samples from NOB and LHSO were collected by MBS and submitted to Intertek Genalysis which holds accreditation with the National Association of Testing Authorities (NATA). Collated results of all analysis are presented in Appendix 1 and original lab reports attached in Appendix 2.

3.2.1 Acid Base Accounting

All samples collected were screened for total sulfur and carbon as well as ANC. Full ABA analysis (namely sulfate-sulfur and NAG analysis) was only conducted on samples containing greater than or equal to 0.2% total sulfur (Analysis Concept).

ANC was measured by a modified Sobek procedure (AMIRA 2002), which involves addition of dilute hydrochloric acid to the sample, followed by gentle simmering (two hours) to complete the reaction. The ABA scheme relies on measurement of oxidisable sulfur. The value of this fraction of sulfur in mine waste samples is calculated as the difference between total sulfur and sulfate-sulfur, which is present in a fully oxidised form and therefore not capable of generating additional acidity. Sulfate-sulfur content was determined by a heated hydrochloric acid extraction and Inductively Coupled Plasma – Optical Emission Spectrometry (ICP-OES) finish. CRS was also measured on selected samples (Kapai slate) in conjunction with total sulfur and sulfate-sulfur. CRS provides a direct measurement of sulfide-sulfur (instead of calculation of total oxidisable sulfur (TOS) as the difference between total sulfur and sulfate sulfur). Kapai Slate samples are expected to contain organic sulfur forms which do not generate acid upon oxidation. CRS measurement therefore can provide a more accurate prediction of sulfide sulfur and hence acid generation potential compared to calculation of TOS.

When assessing data for the MPA and NAPP, it must be noted that both parameters are based on the assumption that all sulfur contained in the sample is acid producing (sourced from pyrite (FeS_2) and other iron sulfide minerals). However, this represents a worst case scenario as not all minerals containing sulfur will result in acid production. Conversely, the NAPP calculation also assumes that the acid neutralising material measured in ANC is rapid-acting. In practice, some neutralising capacity is supplied by silicate and aluminosilicate minerals which can be much slower to react. Further still, iron carbonate minerals such as siderite (FeCO_3) have limited or no capacity to neutralise acidity due to acid producing reactions resulting from oxidation of the dissolved ferrous iron component. Despite these assumptions, NAPP remains a suitable conservative prediction of potential acid generation when used in conjunction with mineralogical data.

The NAG test involves the addition of hydrogen peroxide, a strong oxidising agent, to a sample of mine waste to oxidise reactive sulfides. After cooling the sample pH is measured (NAGpH) and any acidity generated measured by back titrating with sodium hydroxide solution to a pH of 4.5 (NAG to pH 4.5) and pH 7 (NAG to pH 7). NAG is expressed in units of $\text{kg H}_2\text{SO}_4/\text{t}$. A significant NAG result (i.e. final NAGpH less than 4.5) generally indicates that the sample is PAF (Table 2) and the test provides a direct measure of the NAG potential. A NAGpH of 4.5 or more generally indicates that the sample is NAF, but may still be capable of generating metalliferous drainage following oxidation of the sulfide minerals. Results for titrations of aliquots of the NAG solution to endpoint pH values of 4.5 and 7.0 allow estimation by the difference between these results of the relative amounts of non-acid producing base metal (such as copper) and iron sulfides in the sample.

3.2.2 Water and Dilute Acid Extractable Leach

Selected samples were subjected to a water extraction (deionised, 1:5 extraction ratio) to assess potentially soluble species from waste rock. The Australian Standard Leaching Procedure (ASLP, 1:20 ratio) was also performed on selected samples using dilute acetic acid (pH 2.9) as the extraction fluid. This test was performed to simulate seepage quality expected under mild acidic conditions which may be achieved by severe oxidation of sulfide minerals.

3.2.3 Elemental Composition

Environmentally significant metals and metalloids were measured following digestion of a finely ground sample with a mixture of four acids (hydrochloric, nitric, perchloric and hydrofluoric acids) which is a near total determination for the elements measured.

From this data, the global abundance index (GAI) for each element was calculated by comparison to the average earth crustal abundance (Bowen 1979 and AIMM 2001). The main purpose of the GAI is to provide an indication of any elemental enrichment that could be of environmental significance. The GAI (based on a log-2 scale) is expressed in integer increments from zero to six (GARD Guide). A GAI of zero indicates that the content of the element is less than or up to three times the average crustal abundance; a GAI of one corresponds to a three to six fold enrichment; a GAI of two corresponds to a six to 12 fold enrichment and so forth, up to a GAI of six which corresponds to a 96-fold, or greater, enrichment above average crustal abundances. A GAI of more than three is considered significant and may warrant further investigation. Results have been truncated to show no more than a GAI of six.

3.2.4 Mineralogy

Six samples in total, from both NOB and LHSO, representing each of the fresh lithological units (Williamstown dolerite, Porphyry, Devons Consol basalt, Kapai slate, Hannans Lake serpentinite and Golden Mile dolerite) were chosen for mineralogical determination. These samples were submitted to Intertek Genalysis Laboratory Services for a quantitative powder XRD of the crystalline and amorphous contents. Samples were further ground to a very fine powder in an agate mortar and pestle and subsampled for analysis with and without addition of zinc oxide (solid dilution 10% by weight) to determine amorphous content. XRD patterns were then collected on PANalytical Cubix wavelength dispersive XRD with quantitative analysis performed using an automated Rietveld method of correction. Full experimental details are provided in the mineralogical laboratory report presented in Appendix 2

4. PREVIOUS STUDIES ON GMD AND BF SHALE

GMD and BF shale in NOB occur as part of the same mineralisation event present in Fimiston Pit and results of previous geochemical characterisations for these lithologies within Fimiston Pit are therefore relevant to this study. A summary of previous findings for GMD and BF shale is given below.

4.1 GOLDEN MILE DOLERITE

A review of three previous Fimiston Pit geochemical studies (MBS 2016) and assay data for the GMD lithology (MBS 2017) indicated GMD is geochemically benign. A summary of previous findings for this lithology in Fimiston Pit is provided below:

- Assay data from 101,751 samples indicated the majority (54%) contained total sulfur concentrations of less than 0.3%. The median was 0.26% and 90th percentile 1.81%.
- Calculated MPA based on 90th percentile concentration (1.81%) was 50 kg H₂SO₄/t, which was significantly less than the average ANC of 171 kg H₂SO₄/t measured from 27 samples.
- Mineralogical analysis by XRD identified trace/accessory levels of pyrite in four samples and significant concentrations of ankerite as the dominant carbonate mineral able to provide substantial ANC consistent with the results above.
- All GMD samples were classified as NAF, with the majority being further classified as acid consuming due to low sulfur content and high ANC. Neutral to mildly alkaline pH and low to moderate salinity levels will therefore result in any seepage water generated.
- Environmentally significant metals and metalloids were very low; with enrichment noted for gold, silver, antimony and some samples for mercury. Given the local geology, tellurium was also expected to be enriched, although it was not included in the analysis suite for these studies. Concentrations and expected solubilities of metals and metalloids were not considered a risk to the receiving environment.
- GMD was considered suitable for rock armouring or construction purposes, given its benign geochemical nature and physical competence. Results also indicated it would be suitable for PAF encapsulation on an above ground waste landform given its high ANC content.

4.2 BLACK FLAG SHALE

A review of three previous Fimiston Pit geochemical studies (MBS 2016) and additional characterisation work for the BF shale lithology (MBS 2017) indicated variable total sulfur contents, generally dependant on the material's position within the shale seam. This position therefore determines the AMD properties of this minor lithology which comprises 1.3% of the NOB waste material. A summary of findings for the BF shale lithology in Fimiston Pit is provided below:

- Assay data from 2,687 samples indicated a median sulfur content of 1.98% and 90th percentile sulfur content of 5.49%.
- Due to the presence of organic sulfur, total sulfur concentrations tend to overestimate the amount of oxidisable sulfur and CRS was found to be a better measure of oxidisable sulfur. The proportion of CRS to total sulfur was however relatively consistent for the 15 fresh rock samples assessed for CRS at an average of 84% of total sulfur.
- The ratio of oxidisable sulfur (in the form of pyrite) to ANC (in the form of ankerite) was generally dependant on the material's position within the BF Shale bed. The central six metres of the BF Shale bed was found to be the dominant sulfide/lower ANC zone, but 'fingers' of sulfides and carbonates occurred outside this zone as well. Siderite (iron carbonate) was also present in various samples, but this mineral does not contribute to ANC.

- Due to the spatial and compositional variability of the BF Shale material, some inherent variability in the potential to oxidise and generate AMD was observed across all studies. This included bulk container field trials over 11 years at KCGM.
- Overall, based on estimations from total sulfur content and measured NAGpH, it is predicted that BF shale waste with between 2 and 4% sulfur may be classified as PAF. This represents between 19 and 50% of BF shale waste which, under worst case scenario exposure conditions, may generate AMD.
- BF shale was enriched in various metals and metalloids (Au, Ag, Hg, Te, Sb, Se, Cd, Cu, Zn in particular) at levels significantly higher than present in the surrounding GMD and Paringa basalt. Concentrations were consistent with those expected for material within or approaching the lode zone. Samples of fresh rock BF shale contained low concentrations of soluble metals and metalloids and leachates were circum-neutral to alkaline, with low to moderate salinity. Extreme weathering under worst case exposure conditions of PAF-HC material still did not release soluble Hg, Te or Sb. Primary metals released with acid formation were Al, Mn, Fe, Cu, Ni, Co and Zn.
- Sulfide oxidation rates were very slow, resulting in a significant lag period before acid generation occurs. There was also significant ANC within the host rock, such that net acid generation and associated metals leaching should only be possible after very prolonged exposure.

Operating guidelines at KCGM have been implemented to treat all BF shale as PAF and ensure correct placement and encapsulation within surrounding mafic waste rock within the WRDs. Given this, prolonged exposure of BF Shale leading to acid generation is considered unlikely.

5. REVIEW OF LHSO ASSAY DATA BY LITHOLOGY

LHSO sulfur assay data measured by X-Ray Fluorescence (XRF) during drilling programs were provided to MBS for review as part of this report. A summary of this data for waste rock by lithology is outlined in Table 3. A histogram of sulfur content for key example lithologies of WD and KS are shown in Chart 1 and Chart 2, respectively. Key points noted are as follows:

- GMD assay data was very similar to or slightly lower than previous results from Fimiston Pit (Section 4.1, MBS 2017) which again indicates a low risk of AMD formation, assuming similar levels of ANC.
- HLS (logged in drilling, but not part of waste rock for LHSO) was very low in sulfur with 71% of samples recording concentrations at or below the 0.3% sulfur content (Table 3) stipulated by the 'Analysis Concept'. These samples therefore pose a very low risk of generating AMD.
- WD, DCB and POR, which are the major waste rock lithologies for LHSO, contained similar, relatively low concentrations of sulfur. Approximately 66% of WD samples, for example, contained less than or equal to 0.3 % sulfur. This lithology represents 64% of LHSO waste rock by tonnage.
- Sulfur in KS (Chart 2) was more variable with significantly higher average and 90th percentile concentrations. Although a minor lithology (1.2% of LHSO waste tonnage), this material clearly has significant potential for acid formation.

Table 3: Sulfur (%) Summary for LHSO Drilling Assays

Lithology	# Samples	Average	Median	90th Percentile	Maximum	% At or Below 0.3 %S of Analysis Concept
WD	11,609	0.66	0.11	1.69	36	66
DCB	11,828	0.83	0.13	2.00	58	61
POR	2,918	0.85	0.46	2.03	30	44
KS	601	7.39	6.73	17.9	35	31
HLS	433	0.37	0.08	1.0	5.7	71
GMD	3,395	0.46	0.05	1.3	22	76

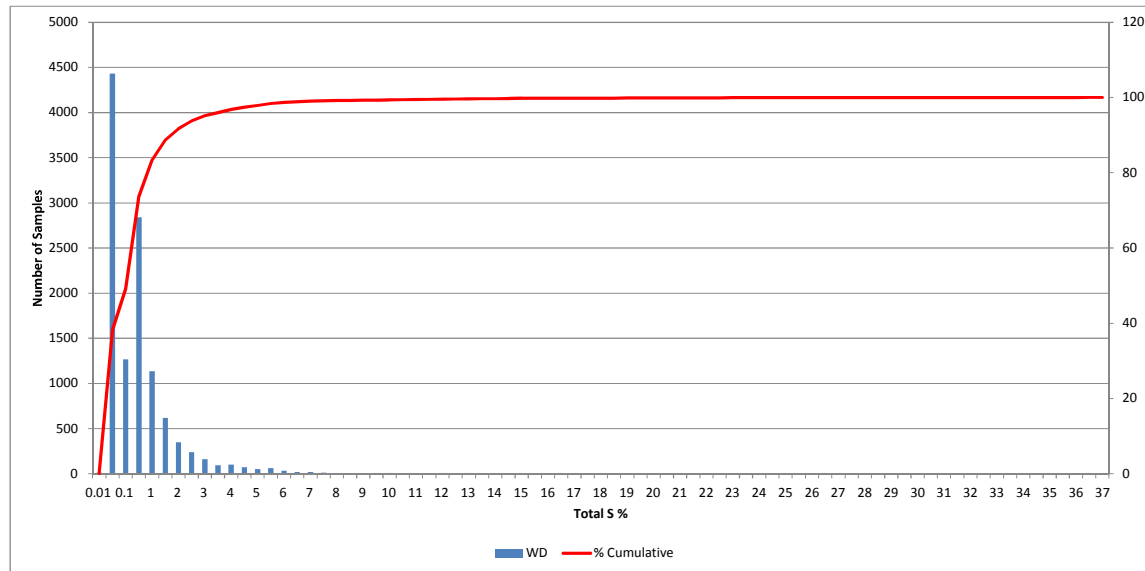


Chart 1: Frequency Histogram of Total Sulfur in WD Assay Samples

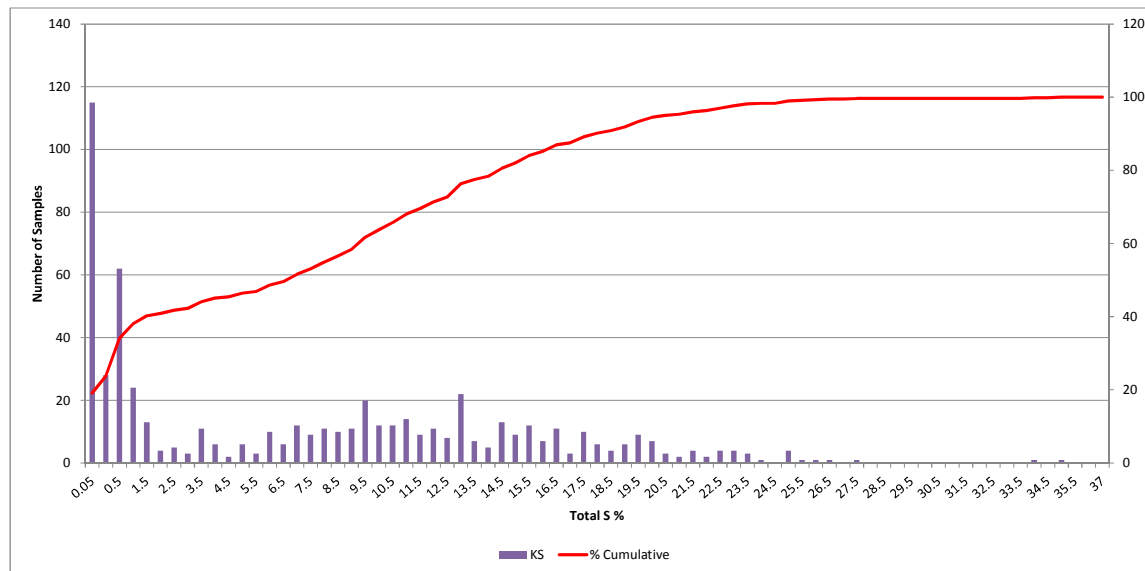


Chart 2: Frequency Histogram of Total Sulfur in KS Assay Samples

6. DESCRIPTION OF SAMPLES

Following a desktop review of available drill log and assay data provided by KCGM personnel, MBS collected 27 representative core samples representing various waste lithologies associated with the LHSO and NOB orebodies at the Mt Charlotte underground mine. Hannans Lake serpentinite, although outside current planned mining zones, was also sampled so as to include all lithologies in the area. NOB waste rock consists entirely of GMD and minor (1.3%) BF shale and is considered geochemically similar to waste rock from Fimiston Pit, properties of which were outlined in Section 4. Consideration of these previous study results thus influenced sampling for current Mt Charlotte waste characterisation with only four samples of GMD from the NOB extension sampled in order to confirm consistency of properties with Fimiston Pit studies. One of these samples (NOBREG), represented weathered regolith – all other samples for the study of NOB and LHSO were of fresh rock consistent with the proposed mining zone. Samples were selected across the range of mining depths, lithologies and sulfur contents considered to be representative of waste rock. A summary of samples collected from the LHSO and NOB by lithology is given in Table 4. Full descriptions are provided in Table A1-1 of Appendix 1.

Table 4: Sample Descriptions

Lithology	Depth Range (m)	Total Samples Collected
Lower Hidden Secret Orebody (LHSO)		
Williamstown dolerite (WD)	28 to 373	5
Porphyry (POR)	55 to 398	4
Devons Consol basalt (DCB)	31 to 330	5
Kapai slate (KS)	70.5 to 502	5
Hannans Lake serpentinite (HLS)	52 to 481	4
Total samples collected from LHSO		23
Northern Orebody (NOB)		
Golden Mile dolerite (GMD)	12 to 230	4
Total samples collected from NOB		4

7. RESULTS AND DISCUSSION

7.1 ACID BASE ACCOUNTING

Laboratory results for total sulfur, CRS, ANC, NAG testing and calculated acid base accounting parameters of the NOB and LHSO samples are collated in Table A1-2 of Appendix 1. The original laboratory reports are included in Appendix 2.

7.1.1 Sulfur Forms

A summary of results for the three sulfur forms assessed is provided in Table 5.

Table 5: Sulfur (%) Forms Summary

Lithology	# Samples	SO ₄ _S Range	SO ₄ _S Mean	Total S Range	Total S Mean	CRS Mean*
WD	5	<0.01 to 0.01	<0.01	0.13 to 3.6	1.1	N/A
DCB	5	<0.01	<0.01	0.55 to 1.4	1.1	N/A
POR	4	<0.01	<0.01	0.12 to 1.4	0.80	N/A
KS	5	0.03 to 0.15	0.07	6.2 to 21.6	12.6	10.0
HLS	4	<0.01	<0.01	0.24 to 1.1	0.50	N/A
NOB GMD	4	<0.01 to 0.02	<0.01	0.02 to 1.09	0.40	N/A

*N/A Indicates not analysed.

As CRS is considered a better indicator of oxidisable sulfide content for KS samples, the ABA parameters AP and NAPP were calculated from CRS for these samples rather than as total sulfur minus sulfate sulfur in Table A1-2.

Based on the data in Table 5, and Tables A1-1 and A1-2 (Appendix 1), the following are noted as key points:

- CRS, on average, accounted for 79% of the total sulfur present in KS, which was very similar to the 84% observed in BF shale samples (MBS 2017). Total sulfur in these samples includes organic sulfur which does not oxidise to form acid and can therefore result in misleading ABA parameters (high bias).
- Consistent with samples being from the fresh rock zone (apart from NOB REG), levels of sulfate were generally very low to non-detectable.
- Levels of total sulfur were approximately consistent with the overall trends seen from assay analysis (Section 5), with KS having significantly higher total sulfur contents and noted field reactivity versus the others which was reflected in higher sulfate levels for these samples.

7.1.2 Acid Neutralisation Capacity

ANC was measured directly by acid addition, heating and back-titration. Results are provided in Table 6 together with acid production potentials for each lithology, calculated from overall mean sulfur assays (Table 3). Carb-NP results (calculated from the measured total carbon analysis), are given in Table A1-2 (Appendix 1).

Table 6: ANC Versus Mean AP From Total Sulfur Assays (kg H₂SO₄/t)

Lithology	# Samples	ANC Minimum	ANC Maximum	ANC Mean	AP Mean
WD	5	204	422	299	20
DCB	4	216	419	310	16
POR	5	74	179	104	26
KS	5	10	145	84	226
HLS	4	243	480	350	11
NOB GMD	4	21	228	132	14

Based on the data in Table 6, and Table A1-2 (Appendix 1), the following are noted as key points:

- ANC levels were high to very high in all samples from all lithologies, but in particular WD, DCB and HLS. WD and DCB are the dominant waste lithologies by tonnage from LHSO (Table 1).
- KS had the lowest levels of ANC and was the only lithology to have mean ANC levels below the calculated AP from sulfur assay data. For other lithologies, the mean ANC of samples from this work were between 4 and 32 times the level of AP calculated from sulfur assays in the KCGM database.
- For most samples there was very good agreement between the measured ANC and the calculated Carb-NP, which is consistent with readily available carbonates contributing to the ANC. The KS lithology showed marginally more variation which is considered to be due to the presence of organic carbon.

7.1.3 Acid Drainage Classification

AMD classifications based on criteria in Table 2 are outlined in Table A1-2 of Appendix 1. Classifications for samples with more than 0.2% sulfur are represented as a plot of NAPP (CRS used for KS) versus NAGpH for the samples grouped by lithology in Chart 3. The four quadrants are labelled as NAF, PAF and two UC (uncertain) according to the classification criteria in Table 2.

Based on examination of these results, the following can be noted:

- All lithologies other than KS (and BF shale which was previously discussed in section 4.2), from Mt Charlotte were classified as NAF with measured NAGpH values of greater than 4.5 for those measured (more than 0.2% total sulfur). In addition due, to the very high levels of ANC relative to oxidisable sulfur, many were further classified as 'acid consuming' (AC). All samples of WD, DCB and HLS were thus classified as AC. Two of the three fresh rock GMD samples and one of the four POR samples were also classified as AC.
- Four out of the five KS samples were classified as PAF – high capacity. This was a result of high levels of oxidisable sulfur and somewhat lower levels of ANC. One KS sample (KS 2), had a conflicting slightly positive NAPP (35 kg H₂SO₄/t), but a reported NAGpH value of 7.4, resulting in an uncertain classification (UC). As indicated previously, the reactive nature of KS was noted in oxidation and visible acid formation in the drill core trays exposed at KCGM.

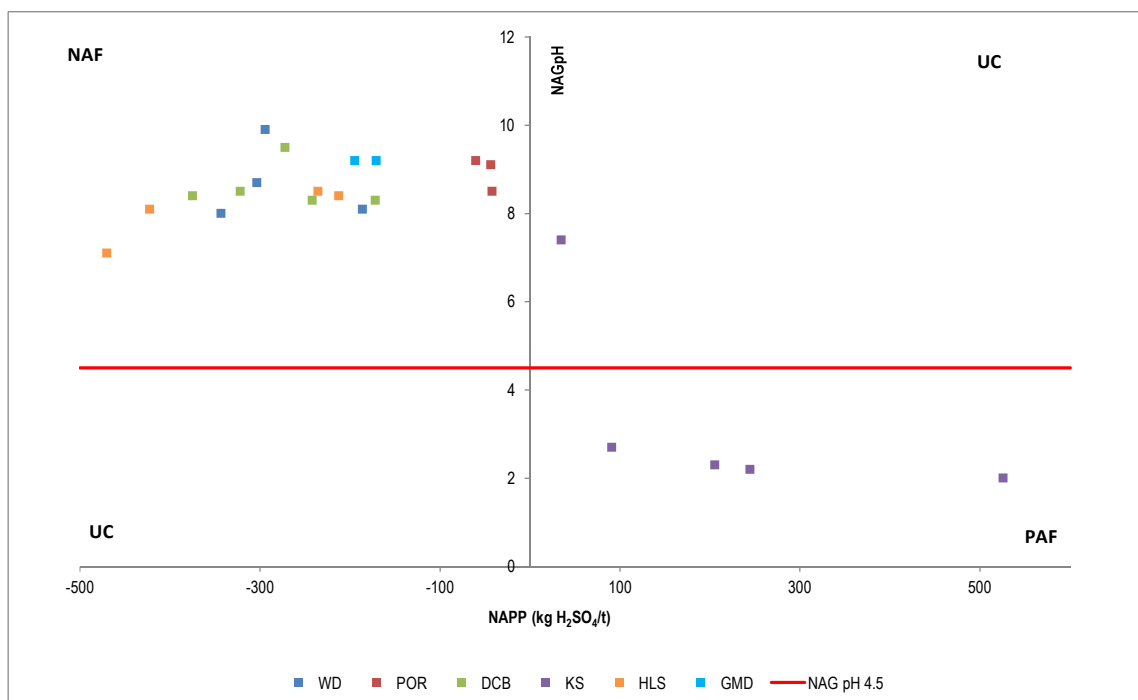


Chart 3: AMD Plot Classifications of Mt Charlotte Lithologies

7.2 ELEMENTAL COMPOSITION

Total elemental composition of selected (, Mt Charlotte waste rock samples (four of each lithology) is presented in Table A1-3 of Appendix 1. Tables A1-4 of Appendix 1 presents calculated GAI values for these samples, as outlined in Section 3.2.3. A summary of results for enriched (GAI of three or more) samples is provided in Table 7.

Key points noted are as follows:

- Consistent with previously discussed observations regarding LHSO mineralisation (Section 2.1), silver, tellurium and antimony were found to be generally enriched across most to all samples. Hessite (Ag_2Te), which is a key mineral associated with gold mineralisation in LHSO (Section 2.1), accounts for the enrichment in silver and tellurium. Gold was not assessed in the current work and lode zone samples were not targeted, but it is expected that concentrations of these and other elements would also be correlated with gold concentration and increase with proximity to the lode zone.
- Mercury, zinc and copper were not found to be enriched within LHSO waste lithologies, indicating these elements are closely associated with the mineralisation event versus the host rock.
- KS was enriched in a number of elements at concentrations generally similar to those observed for BF shale in Fimiston Pit studies. This included arsenic (one sample), cadmium, copper, mercury, selenium and tin. Mercury in BF shale and Fimiston ore is present primarily as coloradoite (HgTe) which is highly insoluble (CSIRO 2013). Coloradoite is also expected to be the dominant form of mercury in KS.
- Consistent with the mafic lithology, chromium and nickel were marginally enriched in HLS samples. Chromium was also elevated in two of the four WD samples (WD 2 and WD 3) and one DCB sample (DCB 2). Cadmium was also enriched in sample WD 1.

Overall, all waste lithologies were generally enriched in silver, tellurium and antimony. KS was geochemically enriched in a similar series of elements to BF shale. With the exception of the KS lithology and minor enrichment in chromium for mafic lithologies, enrichment in other metals and metalloids is closely associated with proximity to mineralisation. As an example, copper and zinc are almost absent in waste rock other than KS.

Table 7: Mt Charlotte Enriched Metals and Metalloids

Metal	Maximum Concentration (mg/kg)	Maximum GAI	Enriched Lithology
Silver	6.9	6	All except HLS
Arsenic	487	4	KS (1 sample)
Cadmium	16	6 (3 in WD)	KS and WD (1 sample)
Chromium	1,889	4	WD, DCB, HLS
Copper	2,524	5	KS
Mercury	23	3	KS
Nickel	1,030	3	HLS
Antimony	17	6	All
Selenium	17	6	KS
Tin	17	3	KS
Tellurium	5.9		All
Zinc	7,256	6	KS and WD

7.3 WATER LEACHATE CHARACTERISATION

7.3.1 Soluble Salts, Alkalinity and pH

Results for pH, EC, alkalinity and major ions in the 1:5 water extracts of selected samples are given in Table A1-5 of Appendix 1. Results for 1:5 extract pH and EC of all samples are also shown in Table A1-2 of Appendix 1.

Samples of fresh waste rock from Mt Charlotte underground were found to have:

- Generally alkaline pH values, ranging from 8.6 to 9.4 in 1:5 extracts of fresh rock. The only exceptions were samples of partially oxidised KS, where pH values ranged from 4.9 to 8.3.
- Moderate to high levels of soluble alkalinity in most samples, with DCB having the highest levels (up to 128 mg/L as CaCO₃). Again, the only exception was KS, which contained low concentrations (3 to 30 mg/L as CaCO₃).
- Relatively low levels of salinity and soluble salts in fresh rock waste samples with most samples having 1:5 EC values below 200 µS/cm.
- Slightly higher levels of salinity were found in the sample of weathered GMD (GMD REG) with 434 µS/cm and KS 1 and KS 2 (maximum 578 µS/cm), both of which had visible signs of oxidation from field exposure.
- Sulfate was the dominant anion rather than chloride, with significant calcium and magnesium as well as sodium present as the dominant cations.

Overall, results suggest that with the exception of isolated pockets of minor KS lithology, the salinity of waste rock placed underground post mining will remain low and any leachate will be alkaline in nature.

7.3.2 Soluble Metals and Metalloids

Results for water soluble metals and metalloids in the 1:5 extracts of samples are given in Table A1-6 of Appendix 1. ANZECC livestock drinking water guidelines (cattle) are provided for comparison, although it is noted that groundwater is far too saline for use other than as process water.

Key observations are summarised below.

- Despite geochemical enrichment in a variety of elements, no metal or metalloid concentrations in the 1:5 extracts of fresh (non-oxidised) waste rock samples exceeded livestock drinking water guidelines. Concentrations of silver and tellurium which were enriched in the waste rock samples, but have no livestock drinking water guideline, were also very low or not detectable.
- Only low concentrations of antimony were noted in 1:5 extracts (maximum 12 µg/L), despite geochemical enrichment of this element of most samples. There is no corresponding guideline for antimony, but it has a similar or slightly higher toxicity than arsenic, for which the livestock guideline is 500 µg/L. Measured concentrations therefore are not considered to pose any risk to the receiving environment.
- Sample KS 1 which was already partially oxidised by field exposure in the core yard for several years recorded a pH of 4.9 and the 1:5 extract slightly exceeded the ANZECC livestock drinking water guidelines for cadmium (23.6 µg/L) and zinc (28.7 mg/L). However these results:
 - Would not exceed guidelines of 10 µg/L (cadmium) and 20 mg/L (zinc) using the ASLP dilution ratio of 1:20 instead of 1:5. The 1:5 dilution ratio is commonly used to provide better sensitivity for minor elemental concentrations, but obviously magnifies results.
 - Represent samples after several years of exposure to weathering. Such conditions are unlikely to be replicated for such periods of time in the Mt Charlotte underground.
 - Do not reflect placement conditions in the Mt Charlotte underground where surrounding high ANC rock will control pH, generating more alkaline conditions and hence limit solubility of cadmium in particular.

Overall, minimising the rate of oxidation of the minor volume of KS waste rock by placement underground, in conjunction with the high ANC waste rock of other LHSO lithologies, should control any risk to receiving groundwater of soluble metals and metalloids.

7.4 DILUTE ACID LEACHATE CHARACTERISATION

Dilute acetic acid leachate tests provide an indication of the acid neutralising minerals and metals which may be released if management measures for control of oxidation of sulfides and acid formation were not applied. Results for selected samples of Mt Charlotte waste rock are presented in Table A1-7 of Appendix 1.

Under the acidic conditions of this test (starting pH 2.9, final pH 4.1 to 5.2) the following was noted:

- Calcium, iron and magnesium were the major cations solubilised by contact with acid which is consistent with the presence of reactive carbonate minerals such as ankerite, dolomite and calcite. Calcite and ankerite are often observed to be slightly more reactive than dolomite under laboratory conditions and hence will be the first to react to neutralise acid.
- Despite geochemical enrichment in various elements and the acidic conditions of the extract, soluble concentrations of all metals and metalloids of environmental concern were very low. All concentrations were below the livestock drinking water guidelines with the exception of lead in sample KS 2 (148 µg/L versus livestock guideline of 100 µg/L).
- Lead (148 µg/L) and antimony (14 µg/L) in KS 2 were the main notably elevated elements for the acetic acid leachates of samples. However, such concentrations from isolated amounts of KS are considered unlikely given the underground disposal regime, limited exposure to oxygen and buffering capacity of surrounding rock.

Results suggest the most significant metals and metalloids which may be released as a result of uncontrolled oxidation without neutralisation of KS waste rock will be lead, zinc, cadmium and antimony. Mercury was not significantly soluble which is consistent with observations from BF shale (MBS 2017). It is important to reiterate the fact that elemental concentrations presented in Table A1-7 are not a prediction of net expected concentrations

of actual seepage, but an indication of acid neutralisation reactions and species that may be solubilised under acid conditions prior to any neutralisation and precipitation by interactions with surrounding rock.

7.5 MINERALOGICAL ASSESSMENT

Results for the mineralogical assessment of the crystalline and amorphous content of six samples from the fresh rock zone are summarised in Table 8. The quantitative X-ray diffraction analysis report is provided in Appendix 2.

Results indicate the following key points:

- Pyrite was the only acid forming mineral present which confirms the validity of AP calculations based on oxidisable sulfur contents.
- Very high amounts of readily available acid neutralising carbonate minerals were present, namely as ankerite, ferroan magnesite, dolomite and calcite, depending on the lithology (refer Glossary Section 10). With the exception of KS, quantities of these carbonate materials far exceeded the pyrite content which is consistent with the NAF and often acid consuming classification of WD, POR, DCB, HLS and GMD lithologies.
- Other minerals present in significant concentrations included quartz, plagioclase and chlorite which are either non-reactive or mildly acid neutralising (chlorite).

Table 8: Mineralogical Summary

Sample	AMD Class	Mineral Content (%)
WD 3	NAF (AC)	Quartz (29), ferroan magnesite (35), sodium calcium plagioclase (10), chlorite (6), ankerite (13), pyrite (4), illite/muscovite (1), potassium feldspar (1). Amorphous content 3%
POR 1	NAF	Quartz (29), sodium calcium plagioclase (35), dolomite (7), pyrite (2), illite/muscovite (24). Amorphous content 2%
DCB 2	NAF (AC)	Quartz (28), ferroan magnesite (40), sodium calcium plagioclase (9), chlorite (3), dolomite (12), pyrite (2), illite/muscovite (4), potassium feldspar (1). Amorphous content 1%
KS 2	UC	Quartz (67), sodium calcium plagioclase (2), ankerite (14), siderite (4), pyrite (9). Amorphous content 4%
HLS 3	NAF (AC)	Quartz (24), sodium calcium plagioclase (1), chlorite (14), ankerite (27), pyrite (2), paragonite (12), illite/muscovite (7). Amorphous content 12%
NOB GMD 3	NAF (AC)	Quartz (25), sodium calcium plagioclase (17), chlorite (25), calcite (10), ankerite (4), pyrite (1), ilmenite (2). Amorphous content 17%

8. CONCLUSIONS

Results of geochemical characterisation and a review of sulfur assay data for Mt Charlotte underground waste rock lithologies indicated:

- Total sulfur concentrations measured in LHSO samples selected for geochemical characterisation were consistent with those measured by XRF during drilling programs, indicating that samples selected were representative of waste rock to be mined at the site.
- Fresh mafic rock lithologies GMD, WD, DCB, POR and HLS are all classified as NAF with alkaline pH, moderate levels of soluble alkalinity and low salinity levels. WD, DCB, HLS and two of the four GMD samples were further classified as being acid consuming, with very high levels of readily reactive carbonate based ANC relative, to oxidisable sulfur concentrations.
- A general enrichment in silver, tellurium and antimony, which is typical of Golden Mile mineralisation and/or the presence of minerals like hessite within LHSO mineralisation. Fresh mafic rock lithologies GMD, WD, DCB, POR and HLS were low in most environmentally significant metals and metalloids and produced very low concentrations of soluble metals and metalloids in both water and acidic leachates. These materials are considered geochemically benign and seepage from them does not pose a risk to the receiving hypersaline groundwater at KCGM.
- Fresh mafic rock lithologies GMD, WD, DCB and POR are considered suitable for use in construction or rock armouring purposes, given the benign geochemical nature and physical competence of this material. The acid consuming nature of the dominant lithologies of LHSO (WD and DCB) which together account for 86% of LHSO waste rock by mass, is also of note when co-disposed underground as backfill with KS.
- Although a minor lithology (1.2% of LHSO waste mass), KS waste rock contained significant levels of oxidisable sulfur and slightly lower levels of ANC and as such was classified as PAF – high capacity (one sample was uncertain). Levels of CRS KS (5.3 to 17.5%) were significantly higher than those in BF shale from Fimiston Pit (0.51 to 10.7 %), although the proportion of oxidisable sulfur to total sulfur was similar for both (approximately 80%).
- KS was the most geochemically enriched Mt Charlotte waste lithology with enrichment in silver, tellurium, antimony (as for mafics), but also mercury, copper, arsenic, selenium, tin, cadmium and zinc. The concentrations and distribution of enriched elements was broadly similar to BF shale from previous studies (MBS 2017). Despite this enrichment, levels of soluble species released during leaching with both water and weak acid were still comparatively low – likely due to insoluble mineral forms being present such as tellurides. It is noted that extreme weathering of geochemically similar PAF BF shale enriched in mercury, tellurium and antimony still did not release soluble fractions of these three elements.
- Overall, co-disposal of the minor portion of KS lithology (1.2% of LHSO waste mass) with surrounding high ANC lithologies from LHSO underground is considered to pose negligible risk of significant oxidation and metals release to groundwater. The potential for surface oxidation of KS material during the operational phase of mining will likely be constrained by limited air flow in backfilled underground stopes away from active ventilation areas and be readily neutralised by the much larger proportion of highly reactive acid consuming waste rock with moderate to high levels of soluble alkalinity. All oxidation potential will cease after cessation of mining and the recovery of the water table which is expected to cover all such underground waste rock.

9. REFERENCES

- AIMM 2001. Field Geologists' Manual. Australasian Institute of Mining and Metallurgy Monograph 9. Fourth Edition. Carlton, Victoria.
- AMIRA 2002. *ARD Test Handbook: Project 387A Prediction and Kinetic Control of Acid Mine Drainage*. Australian Minerals Industry Research Association, Ian Wark Research Institute and Environmental Geochemistry International Pty Ltd, May 2002.
- Bowen, H.J.M. 1979. Environmental Chemistry of the Elements. Academic Press, London; New York.
- DIIS 2016. Preventing Acid and Metalliferous Drainage (Department of Industry, Innovation and Science) September 2016.
- INAP 2009. Global Acid Rock Drainage (GARD) Guide. International Network for Acid Prevention, <http://www.gardguide.com> (accessed 21 June 2017).
- Kalgoorlie Consolidated Gold Mines (KCGM) (2014). *DMP Mining Proposal: KCGM Hidden Secret Project*.
- Fitzgerald, M. and Nixon, D.G. (2016). *The Exploration and Geology of the Hidden Secret Au-Ag Lode Orebody, Mount Charlotte, Kalgoorlie – Abstract for 'Brownfields Exploration: Deep and Meaningful' symposium July 2016, Kalgoorlie*.
- MBS 2016. *Waste Rock Geochemistry Overview (Super Pit Project)*. Report prepared for KCGM August 2016 by MBS Environmental.
- MBS 2017. Fresh Rock Waste Geochemical Characterisation for Fimiston Open Pit. Report prepared for KCGM August 2017 by MBS Environmental.
- Peter Clifton & Associates (2014). *Review of Water Production and Water Quality Data 2013, Mt Charlotte Underground Mine, Kalgoorlie*. Report prepared for KCGM, February 2014.

10. GLOSSARY OF TECHNICAL TERMS

Term	Explanation
AC	Acid consuming material.
ANC	Acid Neutralising Capacity. A process where a sample is reacted with excess 0.5 m HCl at a pH of about 1.5, for 2-3 hours at 80-90°C followed by back-titration to pH=7 with sodium hydroxide. This determines the acid consumed by soluble materials in the sample.
ankerite	A calcium, iron, magnesium, manganese carbonate mineral of general formula $\text{Ca(Fe,Mg,Mn)(CO}_3)_2$. In composition it is closely related to dolomite, but differs from this in having magnesium replaced by varying amounts of iron(II) (ferroan ankerite) and manganese(II).
AP	Acid Potential. Similar to MPA, but only is based on the amount of sulfide-sulfur (calculated as the difference between total sulfur and sulfate-sulfur ($\text{SO}_4\text{-S}$), or directly as CRS) rather than total sulfur. $\text{AP (kg H}_2\text{SO}_4\text{/t) = (Total S - SO}_4\text{-S) x 30.6}$
Basalt	A dark coloured fine grained mafic extrusive igneous rock composed chiefly of calcium plagioclase and pyroxene. Extrusive equivalent of gabbro, underlies the ocean basins and comprises oceanic crust.
Carb NP	Carbon Neutralising Potential. The amount of ANC provided by carbonate minerals. $\text{Carb NP (kg H}_2\text{SO}_4\text{/t) = TIC (\%) x 81.7}$
CIL	Carbon in Leach – the process of extracting gold from crushed rock by extraction with sodium cyanide solution and adsorption onto activated charcoal.
Circum-neutral pH	pH value near 7.
CRS	Chromium Reducible Sulfur. A measurement of reactive sulfide sulfur normally applied to acid sulfate soils using reaction with metallic chromium and hydrochloric acid to liberate hydrogen sulfide gas which is trapped and then measured by iodometric titration. For certain sample types, it is considered to be a more accurate estimate of oxidisable sulfur for iron sulfides than the difference between total sulfur and sulfate-sulfur ($\text{SO}_4\text{-S}$) for calculating Acid potential (AP).
Dolerite	A mafic, holocrystalline, subvolcanic rock equivalent to volcanic basalt or plutonic gabbro
dolomite	Calcium magnesium carbonate $\text{CaMg(CO}_3)_2$.
EC	Electrical conductivity. A measurement of solution salinity. Conversion: $1000 \mu\text{S/cm} = 1 \text{ dS/m} = 1 \text{ mS/cm}$
felsic	Silicate minerals, magma, and rocks which are enriched in the lighter elements such as silicon, oxygen, aluminium, sodium, and potassium.
mafic	Descriptive of igneous rock containing a high content of ferromagnesian silicate minerals, but less than those present in ultramafic rocks. Common mafic rocks include basalt, dolerite and gabbro.
magnesite	Magnesium carbonate ($\text{Mg(CO}_3)_2$) or magnesium iron carbonate ($\text{Mg, Fe(CO}_3)_2$), the latter is termed ferroan magnesite.
MPA	Maximum Potential Acidity. A calculation where the total sulfur in the sample is assumed to all be present as pyrite. This value is multiplied by 30.6 to produce a value known as the Maximum Potential Acidity reported in units of $\text{kg H}_2\text{SO}_4\text{/t}$. MPA should include only the non-sulfate sulfur to avoid over-estimation of acid production in which case it may be referred to as AP.
NAF	Non Acid Forming

Term	Explanation
NAG	Net Acid Generation. A process where a sample is reacted with 15% hydrogen peroxide solution at pH = 4.5 to oxidise all sulfides and then time allowed for the solution to react with acid soluble materials. This is a direct measure of the acid generating capacity of the sample but can be affected by the presence of organic materials.
NAPP	Net Acid Producing Potential. $NAPP (kg H_2SO_4/t) = AP - ANC$. $NAPP (kg H_2SO_4/t) = AP - ANC$
effective NAPP	NAPP calculated using CarbNP rather than traditional ANC. Effective NAPP $(kg H_2SO_4/t) = AP - CarbNP$
PAF	Potentially Acid Forming. A sample is classified as PAF if the NAGpH is less than 4.5 and NAPP is positive (i.e. AP is greater than ANC).
PAF-LC	Potentially Acid Forming – Low Capacity. Waste rock classification for samples with NAPP values less than or equal to 10 kg H ₂ SO ₄ /t.
PAF-HC	Potentially Acid Forming – High Capacity. Waste rock classification for samples with NAPP values greater than 10 kg H ₂ SO ₄ /t.
pyrite	Iron (II) sulfide, FeS ₂ . Pyrite is the most common sulfide minerals and the major acid forming mineral oxidising to produce sulfuric acid.
siderite	Iron (II) carbonate FeCO ₃ . Siderite reacts with acid to release ferrous ions (pale green) which then oxidise to ferric (brown) and this in turn generates acidity equal to the initial acid consumption by carbonate. It therefore does not overall contribute to ANC.
TIC	Total Inorganic Carbon.
XRD	X-Ray Diffraction. A laboratory technique used to identify and quantify crystalline mineral phases in geological materials measuring diffraction angles and patterns from a finely ground sample.
XRF	X-Ray Fluorescence. An analytical technique that measures elemental composition by the detection of fluorescent (or secondary) X-rays emitted from the elements after irradiation by an X-ray source.

APPENDICES

APPENDIX 1: COLLATED RESULTS

LIST OF APPENDIX TABLES

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Table A1-1: Sample Descriptions

Sample ID	Orebody	Lithology	Grouping	Drill Hole ID	Depth (m)
WD 1	LHSO	Williamstown Dolerite	WD	UGHS144	28-30
WD 2	LHSO	Williamstown Dolerite	WD	UGHS012	280-282
WD 3	LHSO	Williamstown Dolerite	WD	UGHS154	87-89
WD 4	LHSO	Williamstown Dolerite	WD	UGHS007	325-327
WD 5	LHSO	Williamstown Dolerite	WD	UGHS012	371-373
POR 1	LHSO	Porphyry	POR	UGHS012	330-333
POR 2	LHSO	Porphyry	POR	UGHS140	55-57
POR 3	LHSO	Porphyry	POR	UGHS132	56-58
POR 4	LHSO	Porphyry	POR	UGHS010	395-398
DCB 1	LHSO	Devon Consols Basalt	DCB	UGHS012	313-316
DCB 2	LHSO	Devon Consols Basalt	DCB	UNGD010	329-330
DCB 3	LHSO	Devon Consols Basalt	DCB	UGHS140	31-33
DCB 4	LHSO	Devon Consols Basalt	DCB	UGHS140	66-69
DCB 5	LHSO	Devon Consols Basalt	DCB	UGHS132	92-94
KS 1	LHSO	Kapai Slate	KS	UGHS012	356-358
KS 2	LHSO	Kapai Slate	KS	UGHS092	151-154
KS 3	LHSO	Kapai Slate	KS	UGHS010	90-92
KS 4	LHSO	Kapai Slate	KS	UGHS010	500-502
KS 5	LHSO	Kapai Slate	KS	UGHS144	70.5-72
HLS 1	LHSO	Hannans Lake Serpentinite	HLS	UGHS038A	432-434
HLS 2	LHSO	Hannans Lake Serpentinite	HLS	UGHS039	52-54

Sample ID	Orebody	Lithology	Grouping	Drill Hole ID	Depth (m)
HLS 3	LHSO	Hannans Lake Serpentinite	HLS	UGHS039	74-77
HLS 4	LHSO	Hannans Lake Serpentinite	HLS	CKD13m	474-481
GMD REG	NOB	Golden Mile Dolerite Regolith (Transition)	GMD	MC044273	12-13
GMD 1	NOB	Golden Mile Dolerite	GMD	MC04272	40-45
GMD 2	NOB	Golden Mile Dolerite	GMD	MC04273	201-206
GMD 3	NOB	Golden Mile Dolerite	GMD	MC04273	225-230

Table A1-2: Acid Base Accounting

Sample	pH (1:5)	EC (1:5)	Total C	Total-S	CRS	SO ₄ -S	AP	ANC	NAPP	Carb NP	NAG _{pH4.5}	NAG _{pH7}	NAGpH	NPR Ratio	Classification
	pH Units	µS/cm	%	%	%	%			kg H ₂ SO ₄ /t				pH units		
WD 1	9.4	82	2.61	0.75	N/A	<0.01	23	209	-186	213	0	0	8.1	9	NAF (AC)
WD 2	9.4	129	1.86	0.13	N/A	N/A	4.0	204	-200	152	N/A	N/A	N/A	51	NAF (AC)
WD 3	9.2	87	5.7	2.57	N/A	0.01	78	422	-343	466	0	0	8.0	5	NAF (AC)
WD 4	9.1	159	4.6	0.77	N/A	<0.01	23	318	-294	376	0	0	9.9	13	NAF (AC)
WD 5	9.1	143	4.46	1.29	N/A	<0.01	39	343	-304	364	0	0	8.7	9	NAF (AC)
POR 1	9.3	115	1.18	1.43	N/A	<0.01	44	86	-42	96	0	0	8.5	2	NAF
POR 2	9.2	134	1.15	0.45	N/A	<0.01	14	74	-60	94	0	0	9.2	5	NAF
POR 3	8.6	800	2.33	0.12	N/A	N/A	3.7	179	-175	190	N/A	N/A	N/A	49	NAF (AC)
POR 4	9.0	146	1.1	1.13	N/A	<0.01	34	78	-43	90	0	0	9.1	2	NAF
DCB 1	9.0	187	3.36	1.44	N/A	<0.01	44	216	-172	275	0	0	8.3	5	NAF (AC)
DCB 2	9.2	117	6.06	1.44	N/A	<0.01	44	419	-375	495	0	0	8.4	10	NAF (AC)
DCB 3	9.2	146	4.11	0.55	N/A	<0.01	17	289	-272	336	0	0	9.5	17	NAF (AC)
DCB 4	9.1	139	4.4	1.11	N/A	<0.01	34	276	-242	359	0	0	8.3	8	NAF (AC)
DCB 5	9.1	181	4.88	0.91	N/A	<0.01	28	350	-322	399	0	0	8.5	13	NAF (AC)
KS 1	4.9	578	0.36	21.6	17.5	0.15	536	10	526	29	337	412	2.0	0.0	PAF-HC
KS 2	8.3	114	2.24	6.19	5.32	0.03	163	128	35	183	0	0	7.4	0.7	UC
KS 3	8.3	291	2.49	10.1	7.71	0.03	236	145	91	203	72	102	2.7	0.5	PAF-HC
KS 4	7.6	562	1.54	11.9	8.44	0.11	258	53	205	126	185	232	2.3	0.1	PAF-HC
KS 5	8.1	292	1.62	13.4	10.8	0.04	330	86	244	132	218	242	2.2	0.2	PAF-HC
HLS 1	9.0	206	6.09	0.32	N/A	<0.01	9.6	480	-470	498	0	0	7.1	49	NAF (AC)
HLS 2	9.2	196	3.92	0.24	N/A	<0.01	7.2	243	-236	320	0	0	8.5	33	NAF (AC)

Sample	pH (1:5)	EC (1:5)	Total C	Total-S	CRS	SO4-S	AP	ANC	NAPP	Carb NP	NAG _{ph4.5}	NAG _{ph7}	NAGpH	NPR Ratio	Classification
	pH Units	µS/cm	%	%	%	%					kg H ₂ SO ₄ /t			pH units	
HLS 3	9.1	172	3.53	1.10	N/A	<0.01	34	246	-212	288	0	0	8.4	7	NAF (AC)
HLS 4	9.2	151	5.42	0.27	N/A	<0.01	8.1	431	-423	443	0	0	8.1	52	NAF (AC)
GMD REG	9.6	434	0.05	0.02	N/A	N/A	0.6	21	-20	4	N/A	N/A	N/A	34	NAF
GMD 1	9.0	198	2.91	1.09	N/A	<0.01	33	228	-195	238	0	0	9.2	7	NAF (AC)
GMD 2	9.3	159	1.02	0.06	N/A	N/A	1.8	100	-98	83	N/A	N/A	N/A	54	NAF
GMD 3	8.9	86	2.12	0.30	N/A	<0.01	9.0	180	-171	173	0	0	9.2	20	NAF (AC)

*As NAGpH is equal to the original pH this samples is already fully oxidised.

N/A denotes Not Analysed

Denotes PAF classification

Denotes Uncertain classification

Denotes NAF/AC classification

Table A1-3: Total Metals and Metalloids

Sample	Ag	Al	As	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	Hg	K
	mg/kg	%	mg/kg	mg/kg	mg/kg	%	mg/kg	mg/kg	mg/kg	mg/kg	%	mg/kg	%
WD 1	0.36	6.9	7.2	278	0.31	4.5	1.3	59	379	95	8.7	0.1	0.1
WD 2	0.27	4.0	1.7	199	0.50	3.2	0.06	62	1,270	99	7.3	<0.1	1.5
WD 3	5.4	2.4	23	572	1.3	3.0	0.16	57	906	117	6.8	0.1	0.2
WD 4	0.28	7.0	5.1	207	0.66	8.3	0.13	35	348	48	5.0	<0.1	3.8
POR 1	1.2	7.6	22	1,272	1.6	2.1	0.16	7.3	23	88	2.5	0.3	1.9
POR 2	0.15	8.1	4.1	1,183	1.5	2.0	0.07	7.6	22	4	2.4	<0.1	2.2
POR 3	<0.05	7.4	4.0	1,121	1.5	4.2	0.06	28	61	11	4.9	<0.1	1.6
POR 4	1.4	7.8	5.5	1,238	2.2	1.9	0.23	10	37	28	2.3	<0.1	2.4
DCB 1	6.9	7.1	71	227	0.72	4.0	0.65	52	428	61	5.6	0.1	1.9
DCB 2	2.1	2.5	3.5	137	1.2	3.1	0.06	55	1,098	44	6.5	<0.1	0.7
DCB 3	0.24	6.4	1.8	123	0.62	7.0	0.06	48	367	37	7.0	<0.1	1.9
DCB 4	0.47	6.5	9.4	380	0.87	6.2	0.29	45	324	85	6.4	<0.1	2.9
KS 1	1.4	3.9	487	121	0.42	0.2	16	150	119	2,062	23	1.1	1.0
KS 2	1.4	0.2	38	10	0.25	3.2	0.56	11	83	407	9.2	0.6	0.03
KS 4	2.6	5.7	166	234	0.65	1.4	9.6	153	205	2,524	19	1.0	2.2
KS 5	1.9	4.3	179	409	0.97	2.0	2.2	76	184	458	14.9	0.5	2.1
HLS 1	0.13	3.3	67	48	0.15	7.2	0.22	59	1,143	47	6.3	<0.1	0.6
HLS 2	<0.05	7.4	7.7	148	0.46	6.8	0.09	25	157	68	5.2	<0.1	1.2
HLS 3	0.13	7.2	36	189	0.31	6.1	0.13	53	308	100	7.7	<0.1	1.3
HLS 4	0.06	3.6	36	22	0.16	6.0	0.05	75	1,889	32	6.8	<0.1	0.2
GMD REG	<0.05	9.4	20	9.3	0.27	2.8	0.08	50	46	104	7.9	<0.1	0.02
GMD 1	0.13	7.5	24	12	0.31	6.3	0.12	42	28	89	8.8	<0.1	0.3
GMD 2	0.6	7.2	4.7	42	0.53	3.5	0.06	39	29	27	10	<0.1	0.1

Sample	Ag	Al	As	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	Hg	K
	mg/kg	%	mg/kg	mg/kg	mg/kg	%	mg/kg	mg/kg	mg/kg	mg/kg	%	mg/kg	%
GMD 3	0.08	6.0	3.8	12	0.52	6.1	0.07	39	15	36	12	<0.1	0.03
Crustal Average	0.07	8.2	25	425	2.8	4.1	0.11	20	100	50	4.1	0.08	2.1

Table A1-3: Total Metals and Metalloids, continued

Sample	Mg	Mn	Mo	Na	Ni	Pb	Sb	Se	Sn	Te	Th	U	V	Zn
	%	mg/kg	mg/kg	%	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
WD 1	4.3	2,139	0.5	2.7	150	12	1.8	0.6	0.1	<0.2	0.60	0.15	175	671
WD 2	10.8	1,338	0.3	0.2	291	2.1	0.80	<0.5	0.3	0.3	0.99	0.23	118	60
WD 3	10.2	1,207	0.2	1.0	279	3.0	1.0	0.9	<0.1	5.9	0.78	0.18	126	54
WD 4	3.5	1,151	0.4	0.1	105	3.3	1.2	<0.5	0.3	1.1	1.2	0.27	127	50
POR 1	1.0	316	1.6	3.1	10	13	5.7	<0.5	0.8	0.7	8.9	2.2	60	77
POR 2	0.8	337	0.3	3.1	8	6.5	2.2	<0.5	0.7	<0.2	9.3	2.1	53	64
POR 3	2.7	559	0.1	2.8	69	4.6	2.7	<0.5	0.7	<0.2	6.7	1.4	133	47
POR 4	0.9	343	1.2	2.7	7	21	2.9	<0.5	0.8	0.4	9.7	2.3	52	75
DCB 1	4.0	2,067	0.5	2.1	220	33	4.2	<0.5	1.8	5.6	0.62	0.16	193	304
DCB 2	10.0	1,251	0.2	0.9	257	2.4	1.4	0.5	0.1	2.9	0.81	0.19	106	50
DCB 3	4.3	1,125	0.2	0.8	159	4.2	3.0	<0.5	0.3	<0.2	0.49	0.11	159	55
DCB 4	4.0	1,599	0.6	0.7	170	7.6	3.5	<0.5	0.3	<0.2	0.48	0.13	171	208
KS 1	1.0	511	6.7	0.2	210	99	14	17	12	3.1	4.8	1.3	53	7,256
KS 2	1.5	441	1.9	0.1	11	19	14	4.5	0.3	1.5	0.23	0.07	6	221
KS 4	1.1	708	5.0	0.2	182	45	12	15.1	17	4.5	4.6	1.3	100	4789
KS 5	1.2	452	4.3	0.1	140	33	17	7.2	2.2	4.4	4.2	1.2	69	994
HLS 1	9.8	1,159	0.2	0.1	702	3.3	0.76	<0.5	<0.1	<0.2	0.15	0.05	107	141
HLS 2	2.3	1,227	0.5	1.3	55	3.8	3.4	<0.5	0.7	<0.2	0.63	0.18	201	67
HLS 3	3.9	2,083	0.4	0.6	126	5.3	1.7	0.7	0.3	0.3	0.53	0.15	189	90
HLS 4	11.0	1,129	<0.1	0.04	1,030	0.8	0.44	<0.5	<0.1	<0.2	0.14	0.03	117	68
GMD REG	3.0	1,557	0.1	2.6	55	<0.5	3.5	<0.5	0.2	<0.2	0.26	0.04	247	63
GMD 1	3.3	1,431	0.3	2.3	50	3	4.3	<0.5	0.2	<0.2	0.20	0.05	281	71
GMD 2	3.2	1,468	0.6	2.4	36	1.1	0.61	<0.5	0.2	<0.2	0.56	0.11	326	95

Sample	Mg	Mn	Mo	Na	Ni	Pb	Sb	Se	Sn	Te	Th	U	V	Zn
	%	mg/kg	mg/kg	%	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
GMD 3	2.5	1,819	0.7	1.7	24	1.1	0.76	<0.5	1.4	<0.2	0.57	0.14	358	90
Crustal Average	2.3	950	1.5	2.3	75	14	0.2	0.2	2	0.001	10	2.7	135	70

Table A1-4: Global Abundance Index (GAI)

Sample	Ag	Al	As	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	Hg	K
WD 1	2	0	0	0	0	0	3	1	1	0	1	0	0
WD 2	1	0	0	0	0	0	0	1	3	0	0	0	0
WD 3	6	0	0	0	0	0	0	1	3	1	0	0	0
WD 4	1	0	0	0	0	0	0	0	1	0	0	0	0
POR 1	4	0	0	1	0	0	0	0	0	0	0	1	0
POR 2	1	0	0	1	0	0	0	0	0	0	0	0	0
POR 3	0	0	0	1	0	0	0	0	0	0	0	0	0
POR 4	4	0	0	1	0	0	0	0	0	0	0	0	0
DCB 1	6	0	1	0	0	0	2	1	2	0	0	0	0
DCB 2	4	0	0	0	0	0	0	1	3	0	0	0	0
DCB 3	1	0	0	0	0	0	0	1	1	0	0	0	0
DCB 4	2	0	0	0	0	0	1	1	1	0	0	0	0
KS 1	4	0	4	0	0	0	6	2	0	5	2	3	0
KS 2	4	0	0	0	0	0	2	0	0	2	1	2	0
KS 4	5	0	2	0	0	0	6	2	0	5	2	3	0
KS 5	4	0	2	0	0	0	4	1	0	3	1	2	0
HLS 1	0	0	1	0	0	0	0	1	3	0	0	0	0
HLS 2	0	0	0	0	0	0	0	0	0	0	0	0	0
HLS 3	0	0	0	0	0	0	0	1	1	0	0	0	0
HLS 4	0	0	0	0	0	0	0	1	4	0	0	0	0
GMD REG	0	0	0	0	0	0	0	1	0	0	0	0	0
GMD 1	0	0	0	0	0	0	0	0	0	0	1	0	0
GMD 2	3	0	0	0	0	0	0	0	0	0	1	0	0
GMD 3	0	0	0	0	0	0	0	0	0	0	1	0	0

Table A1-4: Global Abundance Index (GAI) continued

Sample	Mg	Mn	Mo	Na	Ni	Pb	Sb	Se	Sn	Te	Th	U	V	Zn
WD 1	0	1	0	0	0	0	3	1	0	6	0	0	0	3
WD 2	2	0	0	0	1	0	1	1	0	6	0	0	0	0
WD 3	2	0	0	0	1	0	2	2	0	6	0	0	0	0
WD 4	0	0	0	0	0	0	2	1	0	6	0	0	0	0
POR 1	0	0	0	0	0	0	4	1	0	6	0	0	0	0
POR 2	0	0	0	0	0	0	3	1	0	6	0	0	0	0
POR 3	0	0	0	0	0	0	3	1	0	6	0	0	0	0
POR 4	0	0	0	0	0	0	3	1	0	6	0	0	0	0
DCB 1	0	1	0	0	1	1	4	1	0	6	0	0	0	1
DCB 2	2	0	0	0	1	0	2	1	0	6	0	0	0	0
DCB 3	0	0	0	0	0	0	3	1	0	6	0	0	0	0
DCB 4	0	0	0	0	1	0	4	1	0	6	0	0	0	1
KS 1	0	0	2	0	1	2	6	6	2	6	0	0	0	6
KS 2	0	0	0	0	0	0	6	4	0	6	0	0	0	1
KS 4	0	0	1	0	1	1	5	6	3	6	0	0	0	5
KS 5	0	0	1	0	0	1	6	5	0	6	0	0	0	3
HLS 1	2	0	0	0	3	0	1	1	0	6	0	0	0	0
HLS 2	0	0	0	0	0	0	3	1	0	6	0	0	0	0
HLS 3	0	1	0	0	0	0	2	1	0	6	0	0	0	0
HLS 4	2	0	0	0	3	0	1	1	0	6	0	0	0	0
GMD REG	0	0	0	0	0	0	4	1	0	6	0	0	0	0
GMD 1	0	0	0	0	0	0	4	1	0	6	0	0	0	0
GMD 2	0	0	0	0	0	0	1	1	0	6	0	0	1	0
GMD 3	0	0	0	0	0	0	1	1	0	6	0	0	1	0

Table A1-5: Water Leachate (1:5), Major Ions

Sample	pH	EC	Ca	Mg	Na	K	Cl	SO ₄	Total Alkalinity	HCO ₃ Alkalinity	CO ₃ Alkalinity
		mS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg CaCO ₃ /L		
WD 1	9.4	82	11	4.4	3.2	0.3	4	9.8	34	8	26
WD 3	9.2	87	5.7	7.5	1.7	1.2	2	22	28	5	23
POR 1	9.3	115	13	4.9	7.6	4.9	8	22	65	39	26
DCB 2	9.2	117	6.9	8.1	5.0	2.8	8	20	128	102	26
DCB 4	9.1	139	12	6.1	3.7	8	5	14	114	88	26
KS 1	4.9	578	50	21	7.9	2.8	32	265	3	3	<1
KS 2	8.3	114	17	7.0	1.6	0.4	10	34	30	30	<1
HLS 3	9.1	172	12	5.5	15	5.4	8	19	62	34	28
GMD 3	8.9	86	10	2.7	5.6	0.4	<2	5.0	40	25	15

Table A1-6: Water Leachate (1:5), Metals and Metalloids

Sample	Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg	Li
	µg/L	mg/L	µg/L	mg/L	µg/L	µg/L	µg/L	µg/L	mg/L	mg/L	mg/L	µg/L	µg/L
WD 1	0.03	0.27	0.3	0.12	7.9	<0.1	<0.02	<0.1	<0.01	<0.01	<0.01	<0.1	1.1
WD 3	0.06	0.06	8.7	0.11	175	<0.1	<0.02	<0.1	<0.01	<0.01	<0.01	<0.1	1.1
POR 1	<0.01	0.36	3.0	0.12	9.5	<0.1	<0.02	<0.1	<0.01	<0.01	<0.01	<0.1	1.9
DCB 2	0.02	0.13	1.2	0.11	183	<0.1	<0.02	<0.1	<0.01	<0.01	<0.01	<0.1	1.7
DCB 4	0.01	0.36	2.9	0.12	24	<0.1	<0.02	<0.1	<0.01	<0.01	<0.01	<0.1	2.0
KS 1	<0.01	0.41	7.8	0.14	6.2	0.2	23.6	35	<0.01	0.17	29	<0.1	5.8
KS 2	0.10	<0.01	0.2	0.12	0.90	<0.1	<0.02	<0.1	<0.01	<0.01	<0.01	<0.1	1.0
HLS 3	<0.01	0.43	1.7	0.14	0.93	<0.1	<0.02	<0.1	<0.01	<0.01	<0.01	<0.1	2.7
GMD 3	0.07	0.47	0.4	0.11	0.68	<0.1	<0.02	<0.1	<0.01	<0.01	<0.01	<0.1	0.55
Livestock (ANZECC 2000)	N/G	5	500	5	N/G	N/G	10	1000	1	1	N/G	2	N/G

N/G No guideline

Table A1-6: Water Leachate, Metals and Metalloids, continued

Sample	Mn	Mo	Nb	Ni	Pb	Sb	Se	Sn	Ta	Te	Th	U	V	Zn
	mg/L	µg/L	µg/L	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	mg/L	mg/L
WD 1	0.009	0.21	<0.005	<0.01	<0.5	2.6	<0.5	<0.1	0.002	<0.1	<0.005	<0.005	<0.01	<0.01
WD 3	0.001	0.12	<0.005	<0.01	<0.5	2.8	0.6	<0.1	0.002	<0.1	<0.005	<0.005	<0.01	<0.01
POR 1	0.004	2.4	<0.005	<0.01	<0.5	9.2	<0.5	<0.1	0.002	<0.1	<0.005	0.11	<0.01	<0.01
DCB 2	0.001	0.28	<0.005	<0.01	<0.5	4.8	<0.5	<0.1	0.002	<0.1	<0.005	<0.005	<0.01	<0.01
DCB 4	0.002	0.29	<0.005	<0.01	<0.5	6.9	<0.5	<0.1	0.002	<0.1	<0.005	<0.005	<0.01	<0.01
KS 1	1.9	<0.05	<0.005	0.17	11	0.02	3.1	<0.1	0.002	<0.1	<0.005	0.19	<0.01	28.7
KS 2	0.004	1.3	<0.005	<0.01	<0.5	12	1.7	<0.1	0.002	<0.1	<0.005	0.01	<0.01	<0.01
HLS 3	0.004	0.49	<0.005	<0.01	<0.5	3.6	0.5	<0.1	0.003	<0.1	<0.005	<0.005	<0.01	<0.01
GMD 3	0.008	2.6	<0.005	<0.01	<0.5	0.64	<0.5	<0.1	0.003	<0.1	<0.005	<0.005	<0.01	<0.01
Livestock (ANZECC 2000)	N/G	150	N/G	1	100	N/G	20	N/G	N/G	N/G	N/G	200	N/G	20

Table A1-7: Dilute Acid (1:20 Acetic) Leachate, Major Ions, Metals and Metalloids

Sample	pH	Ag	Al	As	B	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	Hg	K	Li
	pH units	µg/L	mg/L	µg/L	mg/L	µg/L	µg/L	mg/L	µg/L	µg/L	mg/L	mg/L	mg/L	µg/L	mg/L	µg/L
WD 1	4.4	<0.01	2.8	1.7	0.02	112	1.1	372	3.5	32	0.07	<0.01	144	<0.1	0.20	8.7
WD 3	4.3	0.28	0.79	11	0.03	1528	4.0	284	1.2	17	0.14	0.02	49	<0.1	1.1	4.2
POR 1	4.1	0.03	2.0	2.3	0.02	210	1.3	234	0.42	9.3	0.01	0.01	90	<0.1	2.3	3.6
DCB 2	4.3	0.05	1.1	2.2	0.02	847	2.4	280	0.58	25	0.11	<0.01	48	<0.1	1.5	3.2
DCB 4	4.5	0.12	2.0	2.1	0.01	383	3.0	412	1.0	62	0.03	<0.01	136	<0.1	3.8	8.0
KS 2	4.2	0.04	0.29	7.5	0.02	18	1.8	239	1.0	2.4	0.05	0.06	108	<0.1	0.20	3.3
HLS 3	4.5	0.31	2.7	1.0	0.03	37	0.7	401	0.68	37	0.04	<0.01	157	<0.1	2.2	10
GMD 3	5.2	0.03	0.73	0.3	0.02	15	1.1	1,441	1.7	8.1	<0.01	<0.01	58	<0.1	0.20	3.4

Table A1-7: Dilute Acid (1:20 Acetic) Leachate, Major Ions, Metals and Metalloids, continued

Sample	Mg	Mn	Mo	Na	Nb	Ni	Pb	S	Sb	Se	Sn	Ta	Te	Th	U	V	Zn
	mg/L	mg/L	µg/L	mg/L	µg/L	mg/L	µg/L	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	mg/L	mg/L
WD 1	141	16	<0.05	1.6	<0.005	0.04	87	0.55	0.73	<0.5	<0.1	<0.001	<0.1	0.098	0.19	<0.01	0.37
WD 3	180	6.0	0.12	0.7	<0.005	0.11	13	1.8	1.3	0.7	<0.1	0.001	2.6	0.182	0.11	<0.01	0.04
POR 1	96	3.6	0.58	2.3	<0.005	0.01	49	1.0	2.3	0.7	<0.1	<0.001	0.3	0.33	0.55	0.02	0.32
DCB 2	182	4.2	0.14	5.4	<0.005	0.11	11	1.5	1.4	<0.5	<0.1	<0.001	0.8	0.104	0.12	<0.01	0.14
DCB 4	185	8.8	<0.05	1.2	<0.005	0.15	19	0.75	1.2	0.6	<0.1	<0.001	<0.1	0.06	0.05	<0.01	0.30
KS 2	98	2.4	0.6	0.8	<0.005	<0.01	148	2.2	14	0.7	<0.1	<0.001	0.8	0.18	0.06	<0.01	0.60
HLS 3	159	12	<0.05	3.8	<0.005	0.04	3.4	0.62	0.53	0.8	<0.1	<0.001	<0.1	0.072	0.08	<0.01	0.23
GMD 3	19	24	<0.05	1.9	<0.005	<0.01	1.9	0.36	0.19	3.8	<0.1	<0.001	<0.1	<0.005	0.01	<0.01	0.03

APPENDIX 2: LABORATORY REPORTS

QUANTITATIVE X-RAY DIFFRACTION ANALYSIS

REPORT PREPARED FOR	MARTINICK BOSCH SELL PTY LTD M. NORTH
CLIENT CODE	
JOB CODE	1710818
No. of SAMPLES	6
CLIENT O/N	M. NORTH
SAMPLE SUBMISSION No.	N/A
PROJECT	KCGM MT CHARLOTTE KCGMMCG
STATE	PULPS
DATE RECEIVED	21/08/2017
DATE COMPLETED	13/09/2017
DATE WRITTEN	13/09/2017
WRITTEN BY	Dr Sharon Ness
ANALYSING LABORATORY	Perth

SAMPLE DETAILS

DISCLAIMER

This report relates specifically to the sample(s) that were drawn and/or provided by the client or their nominated third party. The reported results(s) provide no warranty or verification on the sample(s) representing any specific goods and/or shipment and only relate to the sample(s) as received and tested. This report is prepared solely for the use of the client named in this report. Intertek accepts no responsibility for any loss, damage or liability suffered by a third party as a result of any reliance upon or use of this report.

The results provided are not intended for commercial settlement purposes.

SIGNIFICANT FIGURES

The method detection limit is approximately 1 wt% for most phases.

Uncertainty in the analysis should reflect errors (absolute) of no greater than: +/- 10% for phases 50-95%, +/- 5% for phases 10-50% and +/- 2% for phases 3-10%. Phases of < 3% are approaching detection limit and normally no refinements are made on these.

Please note that results are rounded off to integer values

LEGEND

ND Not Detected

JOB INFORMATION

PREPARATION

XRD16 (dry 50C, mill < 60um, micronised)

ANALYTICAL METHOD

XRDQUANT02 - Quantitative analysis, crystalline and amorphous content, double scan

SAMPLING

Sample(s) coned and quartered, then grab(s) taken

AMORPHOUS CONTENT DETERMINATION

Internal standard double scan

ADDITIONS

Internal standard ZnO (zincite)

SAMPLE PRESENTATION

Sample(s) packed and presented as unoriented powder mount(s) of the total sample

JOB INFORMATION

INSTRUMENTATION AND PARAMETERS

INSTRUMENT: PANalytical Cubix³ XRD
Copper radiation (operating at 45 kV and 40 mA)
Graphite monochromator (diffracted beam)

PARAMETERS:

Parameter	Setting
Start angle (deg 2 θ)	4
End angle (deg 2 θ)	65
Step size (deg 2 θ)	0.02
Time/active length (secs)	150
Active length (deg 2 θ)	4.01

SOFTWARE:

Qualitative analysis: Bruker Diffrac.EVA 4.2 Search/Match
ICDD PDF-2 (2015) database

Quantitative analysis: SIROQUANT Version 4

RESULTS

The quantitative analysis of the crystalline and amorphous content of each sample is given in the file, **282.00_1710818 XRD RESULTS.xlsx**, attached to the report email.

Calculation of the phase abundances has been based on the Brindley contrast corrections using a particle diameter of 4 μm .

NOTES

NONE

QUALITY CONTROL

NIST STANDARD REFERENCE MATERIAL (SRM) 656

This standard is used for quality control on the instrument and software.

The standard reference material is a powder which consists of sub-micrometer, equi-axial, non-aggregated grains that do not display the effects of absorption contrast, extinction or preferred orientation.

An aliquot of this SRM, spiked with 10% Al₂O₃ (SRM 676a) for the amorphous content determination, was prepared as un-oriented powder mount of the total sample and the pattern analysed with SIROQUANT™.

Sample ID α 656 (High α Phase Powder)

		1710818	method std dev	SRM certified	SRM uncert
Phase	Formula	wt%	wt%	wt%	wt%
Amorphous content		10.0	0.6	9.5	0.61
Si ₃ N ₄ , alpha	Si ₃ N ₄	87.0	0.6	87.5	0.59
Si ₃ N ₄ , beta	Si ₃ N ₄	3.0	0.1	3.0	0.05

Each interval defined by the certified value and its uncertainty is a 95% confidence interval for the true value of the mean in the absence of systematic error.

METHOD DESCRIPTION

Quantification is determined from the chosen software package: this uses the full-profile Rietveld method of refining the profile of the calculated XRD pattern against the profile of the measured XRD pattern. The total calculated pattern is the sum of the calculated patterns of the individual phases.

Results are given as weight % of the total crystalline phases and amorphous content.

The amorphous content quantifies the amorphous material and unknown minerals or known minerals for which there is not a suitable crystal structure.

Corrections are incorporated into the process that allows for a more accurate description of the mineral's contribution to the measured pattern and to allow for variation due to atomic substitution, layer disordering, preferred orientation, and other factors that affect the acquisition of the XRD scan.

The limitations of qualitative XRD analysis are as follows:

There is a limit of detection of approximately 1 wt% on the crystalline phases.

The detection of a phase may be dependent on its crystallinity.

Where there exist multiple phases, overlap of diffracted reflections can occur, thus rendering some ambiguity into the interpretation.

Overlapping reflections of a major phase can mask the presence of minor or trace phases.

Some phases cannot be unambiguously identified as they are present in minor or trace amounts.

The limitations of quantitative XRD analysis by a full-profile Rietveld method are as follows:

The limitations for qualitative XRD analysis apply.

The method as described is standardless: it relies solely on the published crystallographic data available for each phase. Some data may not exactly describe the phases present.

Particle size is important with respect to the absorption of the X-rays by the sample. Micronising reduces the particle size to that more suitable for quantitative analysis.

The accuracy of the analysis is dependent on sampling and sample preparation in addition to the calculated profiles being exactly representative of the chemistry of the component phases and their crystallinity. Some preferred orientation effects and reflection overlaps may occur which cannot be adequately resolved.

AMORPHOUS CONTENT

INTERNAL STANDARD METHOD

Single scan (SIROQUANT™ and TOPAS)

The amorphous content is determined from the addition of a known spike of a well-crystalline internal standard to each sample.

When amorphous material is present, the weight percentage of the spike found is larger than actually weighed out. The amount of amorphous material that causes the difference in the spike weight percentages is then calculated and all weight percentages are normalised to include the amorphous content.

Double scan (SIROQUANT only)

SIROQUANT™ also allows the choice of using the spiked pattern completely, or combining the run with a previous unspiked pattern result. This choice is given because the weight percentages from an unspiked pattern are more accurate since the intensities are not diluted by the spike addition. The percentages from the unspiked sample are normalised to the amorphous content calculated from the spiked sample pattern.

EXTERNAL STANDARD METHOD

The amorphous content is determined from the external standard method¹.

The normalisation constant is determined from the external standard which allows the calculated weight fractions to be placed on an absolute scale.

Reference:

1. O'Connor, B.H., and Raven, M.D., "Application of the Rietveld refinement procedure in assaying powdered mixtures", Powder Diffraction 3(1), (1988), 2-6.

Modelling

A pattern representing a poorly crystalline form of silica is used in the SIROQUANT program.²

Reference:

2. Ward, C.R. and French, D., "Determination of glass content and estimation of glass composition in fly ash using quantitative X-ray diffractometry." Fuel 85 (2006), 2268-2277.

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MINERALS TEST REPORT

CLIENT

MARTINICK BOSCH SELL PTY LTD
4 Cook Street
WEST PERTH, W.A. 6005
AUSTRALIA

JOB INFORMATION

JOB CODE : 282.0/1709783
NO. SAMPLES : 27
NO. ELEMENTS : 49
CLIENT ORDER NO. : M. NORTH (Job 1 of 0)
SAMPLE SUBMISSION NO. :
PROJECT : KCGM MT CHARLOTTE KCGMMCG
DATE RECEIVED : 13/07/2017
DATE REPORTED : 27/09/2017
DATE PRINTED : 27/09/2017

REPORT NOTES

TESTED BY

Intertek
15 Davison Street, Maddington 6109, Western Australia
PO Box 144, Gosnells 6990, Western Australia
Tel: +61 8 9251 8100
Email: min.aus.per@intertek.com

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SIGNIFICANT FIGURES

It is common practice to report data derived from analytical instrumentation to a maximum of two or three significant figures. Some data reported herein may show more figures than this. The reporting of more than two or three figures in no way implies that figures beyond the least significant digit have significance.

For more information on the uncertainty on individual reported values, please contact the laboratory.

SAMPLE STORAGE

All solid samples (assay pulps, bulk pulps and residues) will be stored for 60 days without charge. Following this, samples will be stored at a daily rate until clients' written advice regarding return, collection or disposal is received. If storage information is not supplied on the submission, or arranged with the laboratory in writing, the default will be to store the samples with the applicable charges. Storage is charged at \$4.00 per m³ per day, expenses related to the return or disposal of samples will be charged at cost. Current disposal cost is charged at \$150.00 per m³.

Samples received as liquids, waters or solutions will be held for 60 days free of charge then disposed of, unless written advice for return or collection is received.

LEGEND	X	= Less than Detection Limit	NA	= Not Analysed
	SNR	= Sample Not Received	UA	= Unable to Assay
	*	= Result Checked	>	= Value beyond Limit of Method
	DTF	= Result still to come	+	= Extra Sample Received Not Listed
	IS	= Insufficient Sample for Analysis		



ELEMENTS	Ag	Ag	Al	Al	ANC	As
UNITS	ppm	ug/l	ppm	mg/l	kgH2SO4/t	ppm
DETECTION LIMIT	0.05	0.01	50	0.01	1	0.5
DIGEST	4A/	Ws/	4A/	Ws/	ANCx/	4A/
ANALYTICAL FINISH	MS	MS	OE	OE	VOL	MS
SAMPLE NUMBERS						
0001 WD1 UGHS144 28-30m	0.36	0.03	6.91%	0.27	209	7.2
0002 WD2 UGHS012 280-282m	0.27		4.04%		204	1.7
0003 WD3 UGHS154 87-89m	5.44	0.06	2.41%	0.06	422	23.2
0004 WD4 UGHS007 325-327m	0.28		7.02%		318	5.1
0005 WD5- UGHS012 371-373m					343	
0006 POR1 - UGHS012 330-333m	1.20	X	7.62%	0.36	86	21.8
0007 POR2 UGHS140 55-57m	0.15		8.13%		74	4.1
0008 POR3 UGHS132 56-58m	X		7.44%		179	4.0
0009 POR4 UGHS010 395-398m	1.37		7.83%		78	5.5
0010 DCB1 UGHS012 313-316m	6.90		7.10%		216	70.6
0011 DCB2 UNGD010 329-330m	2.05	0.02	2.55%	0.13	419	3.5
0012 DCB3 UGHS140 31-33m	0.24		6.37%		289	1.8
0013 DCB4 UGHS140 66-69m	0.47	0.01	6.50%	0.36	276	9.4
0014 DCB5 UGHS132 92-94m					350	
0015 KS1 UGHS012 356-358m	1.43	X	3.90%	0.41	10	487.0
0016 KS2 UGHS092 151-154m	1.37	0.10	2299	X	128	38.3
0017 KS3 UGHS010 90-92m					145	
0018 KS4 UGHS010 500-502m	2.64		5.67%		53	166.0
0019 KS5 UGHS144 70.5-72m	1.92		4.33%		86	179.2
0020 HLS1 UGHS038A 432-434m	0.13		3.26%		480	66.7
0021 HLS2 UGHS039 52-54m	X		7.41%		243	7.7
0022 HLS3 UGHS039 74-77m	0.13	X	7.18%	0.43	246	36.0
0023 HLS4 CKD13 474-481m	0.06		3.65%		431	36.3
0024 NOB REG MC044273 12-13m	X		9.43%		21	20.0
0025 NOB GMD1 MC04272 40-45m	0.13		7.50%		228	23.8
0026 NOB GMD2 MC04273 201-206m	0.60		7.16%		100	4.7
0027 NOB GMD3 MC04273 225-230m	0.08	0.07	6.00%	0.47	180	3.8

STANDARDS

0001 DS-1						
0002 OREAS 502b						
0003 OREAS 905	0.55		7.68%			34.9
0004 NAG Std 3						

BLANKS

0001 Control Blank	X	X	X	X	0	X
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ELEMENTS	As	B	Ba	Ba	Be	Be
UNITS	ug/l	mg/l	ppm	ug/l	ppm	ug/l
DETECTION LIMIT	0.1	0.01	0.1	0.05	0.05	0.1
DIGEST	Ws/	Ws/	4A/	Ws/	4A/	Ws/
ANALYTICAL FINISH	MS	OE	MS	MS	MS	MS
SAMPLE NUMBERS						
0001 WD1 UGHS144 28-30m	0.3	0.12	277.5	7.93	0.31	X
0002 WD2 UGHS012 280-282m			199.4		0.50	
0003 WD3 UGHS154 87-89m	8.7	0.11	572.4	175.18	1.31	X
0004 WD4 UGHS007 325-327m			206.7		0.66	
0005 WD5- UGHS012 371-373m						
0006 POR1 - UGHS012 330-333m	3.0	0.12	1272.2	9.47	1.57	X
0007 POR2 UGHS140 55-57m			1183.0		1.51	
0008 POR3 UGHS132 56-58m			1120.8		1.49	
0009 POR4 UGHS010 395-398m			1238.0		2.20	
0010 DCB1 UGHS012 313-316m			227.3		0.72	
0011 DCB2 UNGD010 329-330m	1.2	0.11	136.9	182.61	1.15	X
0012 DCB3 UGHS140 31-33m			123.2		0.62	
0013 DCB4 UGHS140 66-69m	2.9	0.12	380.1	23.84	0.87	X
0014 DCB5 UGHS132 92-94m						
0015 KS1 UGHS012 356-358m	7.8	0.14	121.2	6.15	0.42	0.2
0016 KS2 UGHS092 151-154m	0.2	0.12	10.3	0.90	0.25	X
0017 KS3 UGHS010 90-92m						
0018 KS4 UGHS010 500-502m			233.6		0.65	
0019 KS5 UGHS144 70.5-72m			409.0		0.97	
0020 HLS1 UGHS038A 432-434m			48.2		0.15	
0021 HLS2 UGHS039 52-54m			147.9		0.46	
0022 HLS3 UGHS039 74-77m	1.7	0.14	188.6	0.93	0.31	X
0023 HLS4 CKD13 474-481m			21.6		0.16	
0024 NOB REG MC044273 12-13m			9.3		0.27	
0025 NOB GMD1 MC04272 40-45m			11.5		0.31	
0026 NOB GMD2 MC04273 201-206m			41.7		0.53	
0027 NOB GMD3 MC04273 225-230m	0.4	0.11	12.0	0.68	0.52	X
STANDARDS						
0001 DS-1						
0002 OREAS 502b						
0003 OREAS 905			2841.6		3.12	
0004 NAG Std 3						
BLANKS						
0001 Control Blank	X	0.06	X	X	X	X



ELEMENTS	C	CO3	Ca	Ca	Cd	Cd
UNITS	%	mgCaCO3/L	ppm	mg/l	ppm	ug/l
DETECTION LIMIT	0.01	1	50	0.01	0.02	0.02
DIGEST		Ws/	4A/	Ws/	4A/	Ws/
ANALYTICAL FINISH	/CSA	VOL	OE	OE	MS	MS
SAMPLE NUMBERS						
0001 WD1 UGHS144 28-30m	2.61	26	4.48%	11.27	1.32	X
0002 WD2 UGHS012 280-282m	1.86		3.18%		0.06	
0003 WD3 UGHS154 87-89m	5.70	23	3.02%	5.74	0.16	X
0004 WD4 UGHS007 325-327m	4.60		8.35%		0.13	
0005 WD5- UGHS012 371-373m	4.46					
0006 POR1 - UGHS012 330-333m	1.18	26	2.10%	12.57	0.16	X
0007 POR2 UGHS140 55-57m	1.15		2.01%		0.07	
0008 POR3 UGHS132 56-58m	2.33		4.21%		0.06	
0009 POR4 UGHS010 395-398m	1.10		1.95%		0.23	
0010 DCB1 UGHS012 313-316m	3.36		4.01%		0.65	
0011 DCB2 UNGD010 329-330m	6.06	26	3.07%	6.85	0.06	X
0012 DCB3 UGHS140 31-33m	4.11		6.96%		0.06	
0013 DCB4 UGHS140 66-69m	4.40	26	6.24%	11.83	0.29	X
0014 DCB5 UGHS132 92-94m	4.88					
0015 KS1 UGHS012 356-358m	0.36	X	1500	49.59	15.83	23.61
0016 KS2 UGHS092 151-154m	2.24	X	3.17%	17.46	0.56	X
0017 KS3 UGHS010 90-92m	2.49					
0018 KS4 UGHS010 500-502m	1.54		1.37%		9.57	
0019 KS5 UGHS144 70.5-72m	1.62		2.04%		2.16	
0020 HLS1 UGHS038A 432-434m	6.09		7.23%		0.22	
0021 HLS2 UGHS039 52-54m	3.92		6.81%		0.09	
0022 HLS3 UGHS039 74-77m	3.53	28	6.08%	12.12	0.13	X
0023 HLS4 CKD13 474-481m	5.42		6.03%		0.05	
0024 NOB REG MC044273 12-13m	0.05		2.85%		0.08	
0025 NOB GMD1 MC04272 40-45m	2.91		6.33%		0.12	
0026 NOB GMD2 MC04273 201-206m	1.02		3.51%		0.06	
0027 NOB GMD3 MC04273 225-230m	2.12	15	6.08%	10.38	0.07	X
STANDARDS						
0001 DS-1	3.21					
0002 OREAS 502b						
0003 OREAS 905			6018		0.37	
0004 NAG Std 3						
BLANKS						
0001 Control Blank	X	X	X	X	X	X



ELEMENTS	Cl	Co	CoolourChange	Cr	Cr	
UNITS	mg/l	ppm	ug/l	NONE	ppm	mg/l
DETECTION LIMIT	2	0.1	0.1	0	5	0.01
DIGEST	Ws/	4A/	Ws/	ANCx/	4A/	Ws/
ANALYTICAL FINISH	COL	MS	MS	QUAL	OE	OE
SAMPLE NUMBERS						
0001 WD1 UGHS144 28-30m	4	58.6	X	Yes	379	X
0002 WD2 UGHS012 280-282m		61.8		Yes	1270	
0003 WD3 UGHS154 87-89m	2	57.4	X	Yes	906	X
0004 WD4 UGHS007 325-327m		34.9		Yes	348	
0005 WD5- UGHS012 371-373m				Yes		
0006 POR1 - UGHS012 330-333m	8	7.3	X	Yes	23	X
0007 POR2 UGHS140 55-57m		7.6		Yes	22	
0008 POR3 UGHS132 56-58m		28.4		Yes	61	
0009 POR4 UGHS010 395-398m		10.3		Yes	37	
0010 DCB1 UGHS012 313-316m		52.1		Yes	428	
0011 DCB2 UNGD010 329-330m	8	55.1	X	Yes	1098	X
0012 DCB3 UGHS140 31-33m		47.6		Yes	367	
0013 DCB4 UGHS140 66-69m	5	44.9	X	Yes	324	X
0014 DCB5 UGHS132 92-94m				Yes		
0015 KS1 UGHS012 356-358m	32	150.0	34.6	Yes	119	X
0016 KS2 UGHS092 151-154m	10	11.1	X	No	83	X
0017 KS3 UGHS010 90-92m				Yes		
0018 KS4 UGHS010 500-502m		153.2		Yes	205	
0019 KS5 UGHS144 70.5-72m		75.6		No	184	
0020 HLS1 UGHS038A 432-434m		58.5		Yes	1143	
0021 HLS2 UGHS039 52-54m		25.1		Yes	157	
0022 HLS3 UGHS039 74-77m	8	53.2	X	Yes	308	X
0023 HLS4 CKD13 474-481m		75.1		Yes	1889	
0024 NOB REG MC044273 12-13m		50.0		No	46	
0025 NOB GMD1 MC04272 40-45m		42.0		Yes	28	
0026 NOB GMD2 MC04273 201-206m		38.5		Yes	29	
0027 NOB GMD3 MC04273 225-230m	X	39.2	X	Yes	15	X

STANDARDS

0001 DS-1						
0002 OREAS 502b						
0003 OREAS 905		15.2			26	
0004 NAG Std 3						

BLANKS

0001 Control Blank	X	X	X		X	X
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ELEMENTS	Cu	Cu	EC	Fe	Fe	Final-pH
UNITS	ppm	mg/l	uS/cm	%	mg/l	NONE
DETECTION LIMIT	1	0.01	10	0.01	0.01	0.1
DIGEST	4A/	Ws/	Ws/	4A/	Ws/	ANCx/
ANALYTICAL FINISH	OE	OE	MTR	OE	OE	MTR
SAMPLE NUMBERS						
0001 WD1 UGHS144 28-30m	95	X	82	8.71	X	1.6
0002 WD2 UGHS012 280-282m	99		129	7.25		1.2
0003 WD3 UGHS154 87-89m	117	X	87	6.79	X	0.3
0004 WD4 UGHS007 325-327m	48		159	5.03		1.4
0005 WD5- UGHS012 371-373m			143			1.7
0006 POR1 - UGHS012 330-333m	88	X	115	2.51	X	1.3
0007 POR2 UGHS140 55-57m	4		134	2.42		1.3
0008 POR3 UGHS132 56-58m	11		800	4.93		1.1
0009 POR4 UGHS010 395-398m	28		146	2.34		1.3
0010 DCB1 UGHS012 313-316m	61		187	5.55		1.2
0011 DCB2 UNGD010 329-330m	44	X	117	6.46	X	0.3
0012 DCB3 UGHS140 31-33m	37		146	6.97		1.5
0013 DCB4 UGHS140 66-69m	85	X	139	6.39	X	1.4
0014 DCB5 UGHS132 92-94m			181			0.3
0015 KS1 UGHS012 356-358m	2062	0.17	578	23.18	28.70	1.4
0016 KS2 UGHS092 151-154m	407	X	114	9.19	X	0.9
0017 KS3 UGHS010 90-92m			291			1.3
0018 KS4 UGHS010 500-502m	2524		562	19.15		1.1
0019 KS5 UGHS144 70.5-72m	458		292	14.94		1.4
0020 HLS1 UGHS038A 432-434m	47		206	6.34		0.3
0021 HLS2 UGHS039 52-54m	68		196	5.15		1.3
0022 HLS3 UGHS039 74-77m	100	X	172	7.66	X	1.4
0023 HLS4 CKD13 474-481m	32		151	6.79		0.3
0024 NOB REG MC044273 12-13m	104		434	7.94		1.7
0025 NOB GMD1 MC04272 40-45m	89		198	8.75		1.3
0026 NOB GMD2 MC04273 201-206m	27		159	10.42		1.6
0027 NOB GMD3 MC04273 225-230m	36	X	86	11.87	X	1.2

STANDARDS

0001 DS-1						
0002 OREAS 502b						
0003 OREAS 905	1510			4.30		
0004 NAG Std 3						

BLANKS

0001 Control Blank	X	X	X	X	X	
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ELEMENTS	Fizz-Rate	HCO3	Hg	Hg	K	K
UNITS	NONE	mgCaCO3/L	ppm	ug/l	ppm	mg/l
DETECTION LIMIT	1	2	0.1	0.1	20	0.1
DIGEST	ANCx/	Ws/	AR1/	Ws/	4A/	Ws/
ANALYTICAL FINISH	QUAL	VOL	MS	MS	OE	OE
SAMPLE NUMBERS						
0001 WD1 UGHS144 28-30m	2	8	0.1	X	695	0.3
0002 WD2 UGHS012 280-282m	2		X		1.49%	
0003 WD3 UGHS154 87-89m	2	5	0.1	X	2457	1.2
0004 WD4 UGHS007 325-327m	2		X		3.75%	
0005 WD5- UGHS012 371-373m	3					
0006 POR1 - UGHS012 330-333m	3	39	0.3	X	1.95%	4.9
0007 POR2 UGHS140 55-57m	2		X		2.22%	
0008 POR3 UGHS132 56-58m	2		X		1.63%	
0009 POR4 UGHS010 395-398m	2		X		2.41%	
0010 DCB1 UGHS012 313-316m	2		0.1		1.88%	
0011 DCB2 UNGD010 329-330m	3	102	X	X	7234	2.8
0012 DCB3 UGHS140 31-33m	3		X		1.86%	
0013 DCB4 UGHS140 66-69m	2	88	X	X	2.93%	8.0
0014 DCB5 UGHS132 92-94m	3					
0015 KS1 UGHS012 356-358m	1	3	1.1	X	1.02%	2.8
0016 KS2 UGHS092 151-154m	3	30	0.6	X	328	0.4
0017 KS3 UGHS010 90-92m	3					
0018 KS4 UGHS010 500-502m	3		1.0		2.19%	
0019 KS5 UGHS144 70.5-72m	3		0.5		2.13%	
0020 HLS1 UGHS038A 432-434m	3		X		6088	
0021 HLS2 UGHS039 52-54m	3		X		1.16%	
0022 HLS3 UGHS039 74-77m	3	34	X	X	1.28%	5.4
0023 HLS4 CKD13 474-481m	3		X		2006	
0024 NOB REG MC044273 12-13m	X		X		234	
0025 NOB GMD1 MC04272 40-45m	3		X		2569	
0026 NOB GMD2 MC04273 201-206m	3		X		871	
0027 NOB GMD3 MC04273 225-230m	3	25	X	X	275	0.4
STANDARDS						
0001 DS-1						
0002 OREAS 502b			X			
0003 OREAS 905					3.05%	
0004 NAG Std 3						
BLANKS						
0001 Control Blank		4	X	X	X	X



ELEMENTS	Li	Mg	Mg	Mn	Mn	Mo
UNITS	ug/l	ppm	mg/l	ppm	mg/l	ppm
DETECTION LIMIT	0.05	20	0.01	1	0.001	0.1
DIGEST	Ws/	4A/	Ws/	4A/	Ws/	4A/
ANALYTICAL FINISH	MS	OE	OE	OE	OE	MS
SAMPLE NUMBERS						
0001 WD1 UGHS144 28-30m	1.05	4.30%	4.41	2139	0.009	0.5
0002 WD2 UGHS012 280-282m		10.82%		1338		0.3
0003 WD3 UGHS154 87-89m	1.13	10.22%	7.52	1207	0.001	0.2
0004 WD4 UGHS007 325-327m		3.55%		1151		0.4
0005 WD5- UGHS012 371-373m						
0006 POR1 - UGHS012 330-333m	1.94	9593	4.89	316	0.004	1.6
0007 POR2 UGHS140 55-57m		8294		337		0.3
0008 POR3 UGHS132 56-58m		2.66%		559		0.1
0009 POR4 UGHS010 395-398m		8552		343		1.2
0010 DCB1 UGHS012 313-316m		4.02%		2067		0.5
0011 DCB2 UNGD010 329-330m	1.70	10.00%	8.14	1251	0.001	0.2
0012 DCB3 UGHS140 31-33m		4.28%		1125		0.2
0013 DCB4 UGHS140 66-69m	2.01	4.05%	6.14	1599	0.002	0.6
0014 DCB5 UGHS132 92-94m						
0015 KS1 UGHS012 356-358m	5.75	9611	20.75	511	1.938	6.7
0016 KS2 UGHS092 151-154m	0.96	1.50%	6.95	441	0.004	1.9
0017 KS3 UGHS010 90-92m						
0018 KS4 UGHS010 500-502m		1.06%		708		5.0
0019 KS5 UGHS144 70.5-72m		1.23%		452		4.3
0020 HLS1 UGHS038A 432-434m		9.81%		1159		0.2
0021 HLS2 UGHS039 52-54m		2.29%		1227		0.5
0022 HLS3 UGHS039 74-77m	2.73	3.92%	5.54	2083	0.004	0.4
0023 HLS4 CKD13 474-481m		10.99%		1129		X
0024 NOB REG MC044273 12-13m		2.96%		1557		0.1
0025 NOB GMD1 MC04272 40-45m		3.32%		1431		0.3
0026 NOB GMD2 MC04273 201-206m		3.25%		1468		0.6
0027 NOB GMD3 MC04273 225-230m	0.55	2.47%	2.73	1819	0.008	0.7
STANDARDS						
0001 DS-1						
0002 OREAS 502b						
0003 OREAS 905		2878		392		3.3
0004 NAG Std 3						
BLANKS						
0001 Control Blank	0.08	X	X	X	X	X



ELEMENTS	Mo	Na	Na	NAG	NAGpH	NAG(4.5)
UNITS	ug/l	ppm	mg/l	kgH2SO4/t	NONE	kgH2SO4/t
DETECTION LIMIT	0.05	20	0.1	1	0.1	1
DIGEST	Ws/	4A/	Ws/	NAGx/	NAGx/	NAGx/
ANALYTICAL FINISH	MS	OE	OE	VOL	MTR	VOL
SAMPLE NUMBERS						
0001 WD1 UGHS144 28-30m	0.21	2.75%	3.2	0	8.1	0
0002 WD2 UGHS012 280-282m		1579				
0003 WD3 UGHS154 87-89m	0.12	9969	1.7	0	8.0	0
0004 WD4 UGHS007 325-327m		943		0	9.9	0
0005 WD5- UGHS012 371-373m				0	8.7	0
0006 POR1 - UGHS012 330-333m	2.37	3.10%	7.6	0	8.5	0
0007 POR2 UGHS140 55-57m		3.12%		0	9.2	0
0008 POR3 UGHS132 56-58m		2.81%				
0009 POR4 UGHS010 395-398m		2.67%		0	9.1	0
0010 DCB1 UGHS012 313-316m		2.11%		0	8.3	0
0011 DCB2 UNGD010 329-330m	0.28	9213	5.0	0	8.4	0
0012 DCB3 UGHS140 31-33m		8464		0	9.5	0
0013 DCB4 UGHS140 66-69m	0.29	6705	3.7	0	8.3	0
0014 DCB5 UGHS132 92-94m				0	8.5	0
0015 KS1 UGHS012 356-358m	X	1591	7.9	412	2.0	337
0016 KS2 UGHS092 151-154m	1.26	1277	1.6	0	7.4	0
0017 KS3 UGHS010 90-92m				102	2.7	72
0018 KS4 UGHS010 500-502m		1979		232	2.3	185
0019 KS5 UGHS144 70.5-72m		875		242	2.2	218
0020 HLS1 UGHS038A 432-434m		931		0	7.1	0
0021 HLS2 UGHS039 52-54m		1.34%		0	8.5	0
0022 HLS3 UGHS039 74-77m	0.49	6325	15.4	0	8.4	0
0023 HLS4 CKD13 474-481m		357		0	8.1	0
0024 NOB REG MC044273 12-13m		2.57%				
0025 NOB GMD1 MC04272 40-45m		2.28%		0	9.2	0
0026 NOB GMD2 MC04273 201-206m		2.36%				
0027 NOB GMD3 MC04273 225-230m	2.63	1.69%	5.6	0	9.2	0

STANDARDS

0001 DS-1						
0002 OREAS 502b						
0003 OREAS 905		2.44%				
0004 NAG Std 3				22	2.5	19

BLANKS

0001 Control Blank	X	X	X	6	4.4	0
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ELEMENTS	Nb	Ni	Ni	OH	Pb	Pb
UNITS	ug/l	ppm	mg/l	mgCaCO3/L	ppm	ug/l
DETECTION LIMIT	0.005	1	0.01	0	0.5	0.5
DIGEST	Ws/	4A/	Ws/	Ws/	4A/	Ws/
ANALYTICAL FINISH	MS	OE	OE	VOL	MS	MS
SAMPLE NUMBERS						
0001 WD1 UGHS144 28-30m	X	150	X	0.0000000	12.2	X
0002 WD2 UGHS012 280-282m		291			2.1	
0003 WD3 UGHS154 87-89m	X	279	X	0.0000000	3.0	X
0004 WD4 UGHS007 325-327m		105			3.3	
0005 WD5- UGHS012 371-373m						
0006 POR1 - UGHS012 330-333m	X	10	X	0.0000000	13.3	X
0007 POR2 UGHS140 55-57m		8			6.5	
0008 POR3 UGHS132 56-58m		69			4.6	
0009 POR4 UGHS010 395-398m		7			20.9	
0010 DCB1 UGHS012 313-316m		220			33.0	
0011 DCB2 UNGD010 329-330m	X	257	X	0.0000000	2.4	X
0012 DCB3 UGHS140 31-33m		159			4.2	
0013 DCB4 UGHS140 66-69m	X	170	X	0.0000000	7.6	X
0014 DCB5 UGHS132 92-94m						
0015 KS1 UGHS012 356-358m	X	210	0.17	0.0000000	98.8	10.6
0016 KS2 UGHS092 151-154m	X	11	X	0.0000000	18.7	X
0017 KS3 UGHS010 90-92m						
0018 KS4 UGHS010 500-502m		182			45.3	
0019 KS5 UGHS144 70.5-72m		140			32.5	
0020 HLS1 UGHS038A 432-434m		702			3.3	
0021 HLS2 UGHS039 52-54m		55			3.8	
0022 HLS3 UGHS039 74-77m	X	126	X	0.0000000	5.3	X
0023 HLS4 CKD13 474-481m		1030			0.8	
0024 NOB REG MC044273 12-13m		55			X	
0025 NOB GMD1 MC04272 40-45m		50			3.0	
0026 NOB GMD2 MC04273 201-206m		36			1.1	
0027 NOB GMD3 MC04273 225-230m	X	24	X	0.0000000	1.1	X
STANDARDS						
0001 DS-1						
0002 OREAS 502b						
0003 OREAS 905		10			30.7	
0004 NAG Std 3						
BLANKS						
0001 Control Blank	X	1	X	0.0000000	X	X



ELEMENTS	pH	pH Drop	S	S	S	S
UNITS	NONE	NONE	%	mg/l	%	%
DETECTION LIMIT	0.1	0.1	0.01	0.05	0.01	0.02
DIGEST	Ws/	ANCx/		Ws/	SHCl/	SCR/
ANALYTICAL FINISH	MTR	MTR	/CSA	OE	OE	VOL
SAMPLE NUMBERS						
0001 WD1 UGHS144 28-30m	9.4	3.1	0.75	3.27	X	
0002 WD2 UGHS012 280-282m	9.4	3.3	0.13			
0003 WD3 UGHS154 87-89m	9.2	3.0	2.57	7.38	0.01	
0004 WD4 UGHS007 325-327m	9.1	3.1	0.77		X	
0005 WD5- UGHS012 371-373m	9.1	3.2	1.29		X	
0006 POR1 - UGHS012 330-333m	9.3	3.4	1.43	7.44	X	
0007 POR2 UGHS140 55-57m	9.2	3.4	0.45		X	
0008 POR3 UGHS132 56-58m	8.6	3.1	0.12			
0009 POR4 UGHS010 395-398m	9.0	3.5	1.13		X	
0010 DCB1 UGHS012 313-316m	9.0	3.0	1.44		X	
0011 DCB2 UNGD010 329-330m	9.2	2.9	1.44	6.51	X	
0012 DCB3 UGHS140 31-33m	9.2	3.1	0.55		X	
0013 DCB4 UGHS140 66-69m	9.1	3.0	1.11	4.77	X	
0014 DCB5 UGHS132 92-94m	9.1	3.0	0.91		X	
0015 KS1 UGHS012 356-358m	4.9	2.8	21.59	88.20	0.15	17.50
0016 KS2 UGHS092 151-154m	8.3	2.9	6.19	11.47	0.03	5.32
0017 KS3 UGHS010 90-92m	8.3	3.0	10.08		0.03	7.71
0018 KS4 UGHS010 500-502m	7.6	2.8	11.87		0.11	8.44
0019 KS5 UGHS144 70.5-72m	8.1	3.1	13.39		0.04	10.80
0020 HLS1 UGHS038A 432-434m	9.0	3.0	0.32		X	
0021 HLS2 UGHS039 52-54m	9.2	3.1	0.24		X	
0022 HLS3 UGHS039 74-77m	9.1	3.1	1.10	6.33	X	
0023 HLS4 CKD13 474-481m	9.2	3.0	0.27		X	
0024 NOB REG MC044273 12-13m	9.6	2.9	0.02			
0025 NOB GMD1 MC04272 40-45m	9.0	3.1	1.09		X	
0026 NOB GMD2 MC04273 201-206m	9.3	3.4	0.06			
0027 NOB GMD3 MC04273 225-230m	8.9	3.1	0.30	1.67	X	

STANDARDS

0001 DS-1	2.53
0002 OREAS 502b	
0003 OREAS 905	
0004 NAG Std 3	

BLANKS

0001 Control Blank	7.1	X	X	X
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ELEMENTS	SO4	Sb	Sb	Se	Se	Sn
UNITS	%	ppm	ug/l	ppm	ug/l	ppm
DETECTION LIMIT	0.03	0.05	0.01	0.5	0.5	0.1
DIGEST		4A/	Ws/	4A/	Ws/	4A/
ANALYTICAL FINISH	/CALC	MS	MS	MS	MS	MS
SAMPLE NUMBERS						
0001 WD1 UGHS144 28-30m	2.25	1.78	2.61	0.6	X	0.1
0002 WD2 UGHS012 280-282m	0.40	0.80		X		0.3
0003 WD3 UGHS154 87-89m	7.71	1.00	2.79	0.9	0.6	X
0004 WD4 UGHS007 325-327m	2.31	1.15		X		0.3
0005 WD5- UGHS012 371-373m	3.86					
0006 POR1 - UGHS012 330-333m	4.27	5.67	9.17	X	X	0.8
0007 POR2 UGHS140 55-57m	1.36	2.19		X		0.7
0008 POR3 UGHS132 56-58m	0.35	2.73		X		0.7
0009 POR4 UGHS010 395-398m	3.40	2.90		X		0.8
0010 DCB1 UGHS012 313-316m	4.31	4.17		X		1.8
0011 DCB2 UNGD010 329-330m	4.33	1.36	4.78	0.5	X	0.1
0012 DCB3 UGHS140 31-33m	1.65	3.00		X		0.3
0013 DCB4 UGHS140 66-69m	3.33	3.52	6.94	X	X	0.3
0014 DCB5 UGHS132 92-94m	2.73					
0015 KS1 UGHS012 356-358m	64.67	13.88	0.02	17.0	3.1	12.4
0016 KS2 UGHS092 151-154m	18.54	14.22	12.40	4.5	1.7	0.3
0017 KS3 UGHS010 90-92m	30.19					
0018 KS4 UGHS010 500-502m	35.56	12.06		15.1		17.1
0019 KS5 UGHS144 70.5-72m	40.12	16.60		7.2		2.2
0020 HLS1 UGHS038A 432-434m	0.97	0.76		X		X
0021 HLS2 UGHS039 52-54m	0.73	3.39		X		0.7
0022 HLS3 UGHS039 74-77m	3.29	1.65	3.62	0.7	0.5	0.3
0023 HLS4 CKD13 474-481m	0.82	0.44		X		X
0024 NOB REG MC044273 12-13m	0.05	3.52		X		0.2
0025 NOB GMD1 MC04272 40-45m	3.25	4.32		X		0.2
0026 NOB GMD2 MC04273 201-206m	0.17	0.61		X		0.2
0027 NOB GMD3 MC04273 225-230m	0.89	0.76	0.64	X	X	1.4
STANDARDS						
0001 DS-1	7.58					
0002 OREAS 502b						
0003 OREAS 905		2.10		2.9		4.0
0004 NAG Std 3						
BLANKS						
0001 Control Blank	X	X	X	X	X	X



ELEMENTS	Sn	Ta	Te	Te	Th	Th
UNITS	ug/l	ug/l	ppm	ug/l	ppm	ug/l
DETECTION LIMIT	0.1	0.001	0.2	0.1	0.01	0.005
DIGEST	Ws/	Ws/	4A/	Ws/	4A/	Ws/
ANALYTICAL FINISH	MS	MS	MS	MS	MS	MS
SAMPLE NUMBERS						
0001 WD1 UGHS144 28-30m	X	0.002	X	X	0.60	X
0002 WD2 UGHS012 280-282m			0.3		0.99	
0003 WD3 UGHS154 87-89m	X	0.002	5.9	X	0.78	X
0004 WD4 UGHS007 325-327m			1.1		1.17	
0005 WD5- UGHS012 371-373m						
0006 POR1 - UGHS012 330-333m	X	0.002	0.7	X	8.91	X
0007 POR2 UGHS140 55-57m			X		9.29	
0008 POR3 UGHS132 56-58m			X		6.69	
0009 POR4 UGHS010 395-398m			0.4		9.74	
0010 DCB1 UGHS012 313-316m			5.6		0.62	
0011 DCB2 UNGD010 329-330m	X	0.002	2.9	X	0.81	X
0012 DCB3 UGHS140 31-33m			X		0.49	
0013 DCB4 UGHS140 66-69m	X	0.002	X	X	0.48	X
0014 DCB5 UGHS132 92-94m						
0015 KS1 UGHS012 356-358m	X	0.002	3.1	X	4.80	X
0016 KS2 UGHS092 151-154m	X	0.002	1.5	X	0.23	X
0017 KS3 UGHS010 90-92m						
0018 KS4 UGHS010 500-502m			4.5		4.60	
0019 KS5 UGHS144 70.5-72m			4.4		4.15	
0020 HLS1 UGHS038A 432-434m			X		0.15	
0021 HLS2 UGHS039 52-54m			X		0.63	
0022 HLS3 UGHS039 74-77m	X	0.003	0.3	X	0.53	X
0023 HLS4 CKD13 474-481m			X		0.14	
0024 NOB REG MC044273 12-13m			X		0.26	
0025 NOB GMD1 MC04272 40-45m			X		0.20	
0026 NOB GMD2 MC04273 201-206m			X		0.56	
0027 NOB GMD3 MC04273 225-230m	X	0.003	X	X	0.57	X
STANDARDS						
0001 DS-1						
0002 OREAS 502b						
0003 OREAS 905			X		15.07	
0004 NAG Std 3						
BLANKS						
0001 Control Blank	X	0.002	X	X	X	X



ELEMENTS	TotAlk	U	U	V	V	Zn
UNITS	mgCaCO3/L	ppm	ug/l	ppm	mg/l	ppm
DETECTION LIMIT	2	0.01	0.005	1	0.01	1
DIGEST		4A/	Ws/	4A/	Ws/	4A/
ANALYTICAL FINISH	/CALC	MS	MS	OE	OE	OE
SAMPLE NUMBERS						
0001 WD1 UGHS144 28-30m	34	0.15	X	175	X	671
0002 WD2 UGHS012 280-282m		0.23		118		60
0003 WD3 UGHS154 87-89m	28	0.18	X	126	X	54
0004 WD4 UGHS007 325-327m		0.27		127		50
0005 WD5- UGHS012 371-373m						
0006 POR1 - UGHS012 330-333m	65	2.16	0.109	60	X	77
0007 POR2 UGHS140 55-57m		2.12		53		64
0008 POR3 UGHS132 56-58m		1.40		133		47
0009 POR4 UGHS010 395-398m		2.27		52		75
0010 DCB1 UGHS012 313-316m		0.16		193		304
0011 DCB2 UNGD010 329-330m	128	0.19	X	106	X	50
0012 DCB3 UGHS140 31-33m		0.11		159		55
0013 DCB4 UGHS140 66-69m	114	0.13	X	171	X	208
0014 DCB5 UGHS132 92-94m						
0015 KS1 UGHS012 356-358m	3	1.25	0.189	53	X	7256
0016 KS2 UGHS092 151-154m	30	0.07	0.006	6	X	221
0017 KS3 UGHS010 90-92m						
0018 KS4 UGHS010 500-502m		1.33		100		4789
0019 KS5 UGHS144 70.5-72m		1.17		69		994
0020 HLS1 UGHS038A 432-434m		0.05		107		141
0021 HLS2 UGHS039 52-54m		0.18		201		67
0022 HLS3 UGHS039 74-77m	62	0.15	X	189	X	90
0023 HLS4 CKD13 474-481m		0.03		117		68
0024 NOB REG MC044273 12-13m		0.04		247		63
0025 NOB GMD1 MC04272 40-45m		0.05		281		71
0026 NOB GMD2 MC04273 201-206m		0.11		326		95
0027 NOB GMD3 MC04273 225-230m	40	0.14	X	358	X	90
STANDARDS						
0001 DS-1						
0002 OREAS 502b						
0003 OREAS 905		5.14		10		139
0004 NAG Std 3						
BLANKS						
0001 Control Blank	4	X	X	X	X	X



ELEMENTS	Zn
UNITS	mg/l
DETECTION LIMIT	0.01
DIGEST	Ws/
ANALYTICAL FINISH	OE
SAMPLE NUMBERS	
0001 WD1 UGHS144 28-30m	X
0002 WD2 UGHS012 280-282m	
0003 WD3 UGHS154 87-89m	X
0004 WD4 UGHS007 325-327m	
0005 WD5- UGHS012 371-373m	
0006 POR1 - UGHS012 330-333m	X
0007 POR2 UGHS140 55-57m	
0008 POR3 UGHS132 56-58m	
0009 POR4 UGHS010 395-398m	
0010 DCB1 UGHS012 313-316m	
0011 DCB2 UNGD010 329-330m	X
0012 DCB3 UGHS140 31-33m	
0013 DCB4 UGHS140 66-69m	X
0014 DCB5 UGHS132 92-94m	
0015 KS1 UGHS012 356-358m	28.74
0016 KS2 UGHS092 151-154m	X
0017 KS3 UGHS010 90-92m	
0018 KS4 UGHS010 500-502m	
0019 KS5 UGHS144 70.5-72m	
0020 HLS1 UGHS038A 432-434m	
0021 HLS2 UGHS039 52-54m	
0022 HLS3 UGHS039 74-77m	X
0023 HLS4 CKD13 474-481m	
0024 NOB REG MC044273 12-13m	
0025 NOB GMD1 MC04272 40-45m	
0026 NOB GMD2 MC04273 201-206m	
0027 NOB GMD3 MC04273 225-230m	X
STANDARDS	
0001 DS-1	
0002 OREAS 502b	
0003 OREAS 905	
0004 NAG Std 3	
BLANKS	
0001 Control Blank	X



METHOD CODE DESCRIPTION

Method Code	Analysing Laboratory NATA Laboratory Accreditation	NATA Scope of Accreditation
/CALC	Intertek Genalysis Perth 3244 3237 No digestion or other pre-treatment undertaken. Results Determined by calculation from other reported data.	
/CSA	Intertek Genalysis Perth 3244 3237 Induction Furnace Analysed by Infrared Spectrometry	MPL_W043, CSA : MPL_W043
4A/MS	Intertek Genalysis Perth 3244 3237 Multi-acid digest including Hydrofluoric, Nitric, Perchloric and Hydrochloric acids in Teflon Tubes. Analysed by Inductively Coupled Plasma Mass Spectrometry.	4A/ : MPL_W002, MS : ICP_W003
4A/OE	Intertek Genalysis Perth 3244 3237 Multi-acid digest including Hydrofluoric, Nitric, Perchloric and Hydrochloric acids in Teflon Tubes. Analysed by Inductively Coupled Plasma Optical (Atomic) Emission Spectrometry.	4A/ : MPL_W002, OE : ICP_W004
ANCx/MTR	Intertek Genalysis Perth 3244 3237 Acid Neutralizing Capacity Digestion Procedure. Analysed with Electronic Meter Measurement	
ANCx/QUAL	Intertek Genalysis Perth 3244 3237 Acid Neutralizing Capacity Digestion Procedure. Analysed by Qualitative Inspection	
ANCx/VOL	Intertek Genalysis Perth 3244 3237 Acid Neutralizing Capacity Digestion Procedure. Analysed by Volumetric Technique.	
AR1/MS	Intertek Genalysis Perth 3244 3237 1g Aqua-Regia digest. Analysed by Inductively Coupled Plasma Mass Spectrometry.	

METHOD CODE DESCRIPTION

Method Code	Analysing Laboratory NATA Laboratory Accreditation	NATA Scope of Accreditation
NAGx/MTR	Intertek Genalysis Perth 3244 3237 Net Acid Generation Extraction of samples with H2O2 Analysed with Electronic Meter Measurement	
NAGx/VOL	Intertek Genalysis Perth 3244 3237 Net Acid Generation Extraction of samples with H2O2 Analysed by Volumetric Technique.	
SCR/VOL	Intertek Genalysis Perth 3244 3237 Chromium Reducible Sulphur Analysed by Volumetric Technique.	
SHCI/OE	Intertek Genalysis Perth 3244 3237 Acid Soluble soil. Analysed by Inductively Coupled Plasma Optical (Atomic) Emission Spectrometry.	
Ws/COL	Intertek Genalysis Perth 3244 3237 Water Extraction using a sample:water ratio of 1:5 or to client request. Analysed by UV-Visible Spectrometry.	
Ws/MS	Intertek Genalysis Perth 3244 3237 Water Extraction using a sample:water ratio of 1:5 or to client request. Analysed by Inductively Coupled Plasma Mass Spectrometry.	
Ws/MTR	Intertek Genalysis Perth 3244 3237 Water Extraction using a sample:water ratio of 1:5 or to client request. Analysed with Electronic Meter Measurement	
Ws/OE	Intertek Genalysis Perth 3244 3237 Water Extraction using a sample:water ratio of 1:5 or to client request. Analysed by Inductively Coupled Plasma Optical (Atomic) Emission Spectrometry.	

METHOD CODE DESCRIPTION

Method Code	Analysing Laboratory NATA Laboratory Accreditation	NATA Scope of Accreditation
Ws/VOL	Intertek Genalysis Perth 3244 3237 Water Extraction using a sample:water ratio of 1:5 or to client request. Analysed by Volumetric Technique.	

MINERALS TEST REPORT

CLIENT

MARTINICK BOSCH SELL PTY LTD
4 Cook Street
WEST PERTH, W.A. 6005
AUSTRALIA

JOB INFORMATION

JOB CODE : 282.0/1710554
NO. SAMPLES : 8
NO. ELEMENTS : 33
CLIENT ORDER NO. : M. NORTH (Job 1 of 1)
SAMPLE SUBMISSION NO. :
PROJECT : KCGM MT CHARLOTTE KCGMMCG
DATE RECEIVED : 13/07/2017
DATE REPORTED : 27/09/2017
DATE PRINTED : 27/09/2017

REPORT NOTES

1. Amended Report - This report replaces the previously issued results

TESTED BY

Intertek
15 Davison Street, Maddington 6109, Western Australia
PO Box 144, Gosnells 6990, Western Australia
Tel: +61 8 9251 8100
Email: min.aus.per@intertek.com

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SIGNIFICANT FIGURES

It is common practice to report data derived from analytical instrumentation to a maximum of two or three significant figures. Some data reported herein may show more figures than this. The reporting of more than two or three figures in no way implies that figures beyond the least significant digit have significance.

For more information on the uncertainty on individual reported values, please contact the laboratory.

SAMPLE STORAGE

All solid samples (assay pulps, bulk pulps and residues) will be stored for 60 days without charge. Following this, samples will be stored at a daily rate until clients' written advice regarding return, collection or disposal is received. If storage information is not supplied on the submission, or arranged with the laboratory in writing, the default will be to store the samples with the applicable charges. Storage is charged at \$4.00 per m³ per day, expenses related to the return or disposal of samples will be charged at cost. Current disposal cost is charged at \$150.00 per m³.

Samples received as liquids, waters or solutions will be held for 60 days free of charge then disposed of, unless written advice for return or collection is received.

LEGEND	X	= Less than Detection Limit	NA	= Not Analysed
	SNR	= Sample Not Received	UA	= Unable to Assay
	*	= Result Checked	>	= Value beyond Limit of Method
	DTF	= Result still to come	+	= Extra Sample Received Not Listed
	IS	= Insufficient Sample for Analysis		



ELEMENTS	Ag	Al	As	B	Ba	Be
UNITS	ug/l	mg/l	ug/l	mg/l	ug/l	ug/l
DETECTION LIMIT	0.01	0.01	0.1	0.01	0.05	0.1
DIGEST	ASLP/	ASLP/	ASLP/	ASLP/	ASLP/	ASLP/
ANALYTICAL FINISH	MS	OE	MS	OE	MS	MS
SAMPLE NUMBERS						
0001 WD1 UGHS144 28-30m	X	2.78	1.7	0.02	112.14	1.1
0002 WD3 UGHS154 87-89m	0.28	0.79	10.6	0.03	1528.30	4.0
0003 POR1 - UGHS012 330-333m	0.03	1.95	2.3	0.02	209.89	1.3
0004 DCB2 UNGD010 329-330m	0.05	1.05	2.2	0.02	847.16	2.4
0005 DCB4 UGHS140 66-69m	0.12	1.95	2.1	0.01	383.31	3.0
0006 KS2 UGHS092 151-154m	0.04	0.29	7.5	0.02	17.99	1.8
0007 HLS3 UGHS039 74-77m	0.31	2.72	1.0	0.03	37.01	0.7
0008 NOB GMD3 MC04273 225-230m	0.03	0.73	0.3	0.02	14.90	1.1
CHECKS						
0001 WD1 UGHS144 28-30m	0.02	2.85	2.1	X	125.16	1.0
STANDARDS						
0001 TMDW	1.94		79.8		52.18	20.5
BLANKS						
0001 Control Blank	X	X	X	0.01	X	X



ELEMENTS	Ca	Cd	Co	Cr	Cu	Fe
UNITS	mg/l	ug/l	ug/l	mg/l	mg/l	mg/l
DETECTION LIMIT	0.01	0.02	0.1	0.01	0.01	0.01
DIGEST	ASLP/	ASLP/	ASLP/	ASLP/	ASLP/	ASLP/
ANALYTICAL FINISH	OE	MS	MS	OE	OE	OE
SAMPLE NUMBERS						
0001 WD1 UGHS144 28-30m	372.41	3.49	31.5	0.07	X	144.11
0002 WD3 UGHS154 87-89m	283.99	1.23	16.8	0.14	0.02	48.59
0003 POR1 - UGHS012 330-333m	234.19	0.42	9.3	0.01	0.01	89.92
0004 DCB2 UNGD010 329-330m	279.94	0.58	24.6	0.11	X	47.97
0005 DCB4 UGHS140 66-69m	411.68	1.04	61.8	0.03	X	136.34
0006 KS2 UGHS092 151-154m	238.75	1.02	2.4	0.05	0.06	107.87
0007 HLS3 UGHS039 74-77m	401.19	0.68	36.6	0.04	X	157.13
0008 NOB GMD3 MC04273 225-230m	1440.61	1.66	8.1	X	X	57.67
CHECKS						
0001 WD1 UGHS144 28-30m	370.62	3.48	34.4	0.07	X	145.31
STANDARDS						
0001 TMDW		10.17	25.4			
BLANKS						
0001 Control Blank	X	X	X	X	X	X



ELEMENTS	Hg	K	Li	Mg	Mn	Mo
UNITS	ug/l	mg/l	ug/l	mg/l	mg/l	ug/l
DETECTION LIMIT	0.1	0.1	0.05	0.01	0.001	0.05
DIGEST	ASLP/	ASLP/	ASLP/	ASLP/	ASLP/	ASLP/
ANALYTICAL FINISH	MS	OE	MS	OE	OE	MS
SAMPLE NUMBERS						
0001 WD1 UGHS144 28-30m	X	0.2	8.74	140.87	15.670	X
0002 WD3 UGHS154 87-89m	X	1.1	4.24	179.59	5.993	0.12
0003 POR1 - UGHS012 330-333m	X	2.3	3.62	96.35	3.601	0.58
0004 DCB2 UNGD010 329-330m	X	1.5	3.17	182.19	4.215	0.14
0005 DCB4 UGHS140 66-69m	X	3.8	8.00	185.05	8.781	X
0006 KS2 UGHS092 151-154m	X	0.2	3.33	98.41	2.393	0.60
0007 HLS3 UGHS039 74-77m	X	2.2	10.11	158.54	12.355	X
0008 NOB GMD3 MC04273 225-230m	X	0.2	3.40	18.52	23.639	X
CHECKS						
0001 WD1 UGHS144 28-30m	X	0.3	9.14	144.90	16.578	X
STANDARDS						
0001 TMDW	X		20.08			101.08
BLANKS						
0001 Control Blank	X	X	X	X	0.002	X



ELEMENTS	Na	Nb	Ni	Pb	pH	S
UNITS	mg/l	ug/l	mg/l	ug/l	NONE	mg/l
DETECTION LIMIT	0.1	0.005	0.01	0.5	0.1	0.05
DIGEST	ASLP/	ASLP/	ASLP/	ASLP/	ASLP/	ASLP/
ANALYTICAL FINISH	OE	MS	OE	MS	MTR	OE
SAMPLE NUMBERS						
0001 WD1 UGHS144 28-30m	1.6	X	0.04	86.9	4.4	0.55
0002 WD3 UGHS154 87-89m	0.7	X	0.11	12.5	4.3	1.80
0003 POR1 - UGHS012 330-333m	2.3	X	0.01	49.1	4.1	0.99
0004 DCB2 UNGD010 329-330m	5.4	X	0.11	10.9	4.3	1.47
0005 DCB4 UGHS140 66-69m	1.2	X	0.15	19.0	4.5	0.75
0006 KS2 UGHS092 151-154m	0.8	X	X	147.5	4.2	2.22
0007 HLS3 UGHS039 74-77m	3.8	X	0.04	3.4	4.5	0.62
0008 NOB GMD3 MC04273 225-230m	1.9	X	X	1.9	5.2	0.36
CHECKS						
0001 WD1 UGHS144 28-30m	1.7	X	0.04	89.6	4.4	0.60
STANDARDS						
0001 TMDW		0.013		38.9		
BLANKS						
0001 Control Blank	X	X	X	X	2.9	X



ELEMENTS	Sb	Se	Sn	Ta	Te	Th
UNITS	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l
DETECTION LIMIT	0.01	0.5	0.1	0.001	0.1	0.005
DIGEST	ASLP/	ASLP/	ASLP/	ASLP/	ASLP/	ASLP/
ANALYTICAL FINISH	MS	MS	MS	MS	MS	MS
SAMPLE NUMBERS						
0001 WD1 UGHS144 28-30m	0.73	X	X	X	X	0.098
0002 WD3 UGHS154 87-89m	1.34	0.7	X	0.001	2.6	0.182
0003 POR1 - UGHS012 330-333m	2.28	0.7	X	X	0.3	0.330
0004 DCB2 UNGD010 329-330m	1.44	X	X	X	0.8	0.104
0005 DCB4 UGHS140 66-69m	1.17	0.6	X	X	X	0.060
0006 KS2 UGHS092 151-154m	13.89	0.7	X	X	0.8	0.180
0007 HLS3 UGHS039 74-77m	0.53	0.8	X	X	X	0.072
0008 NOB GMD3 MC04273 225-230m	0.19	3.8	X	X	X	X
CHECKS						
0001 WD1 UGHS144 28-30m	0.90	0.5	X	X	X	0.089
STANDARDS						
0001 TMDW	9.99	9.9	X	0.041	3.3	0.015
BLANKS						
0001 Control Blank	X	X	X	X	X	X



ELEMENTS	U	V	Zn
UNITS	ug/l	mg/l	mg/l
DETECTION LIMIT	0.005	0.01	0.01
DIGEST	ASLP/	ASLP/	ASLP/
ANALYTICAL FINISH	MS	OE	OE
SAMPLE NUMBERS			
0001 WD1 UGHS144 28-30m	0.187	X	0.37
0002 WD3 UGHS154 87-89m	0.113	X	0.04
0003 POR1 - UGHS012 330-333m	0.549	0.02	0.32
0004 DCB2 UNGD010 329-330m	0.115	X	0.14
0005 DCB4 UGHS140 66-69m	0.048	X	0.30
0006 KS2 UGHS092 151-154m	0.057	X	0.60
0007 HLS3 UGHS039 74-77m	0.077	X	0.23
0008 NOB GMD3 MC04273 225-230m	0.014	X	0.03
CHECKS			
0001 WD1 UGHS144 28-30m	0.195	X	0.39
STANDARDS			
0001 TMDW	9.958		
BLANKS			
0001 Control Blank	X	X	X



METHOD CODE DESCRIPTION

Method Code	Analysing Laboratory NATA Laboratory Accreditation	NATA Scope of Accreditation
ASLP/MS	Intertek Genalysis Perth 3244 3237 AS4439.3-1997: Australian Standard Leachates Protocol for Wastes, Sediments & Contaminated Soils. Analysed by Inductively Coupled Plasma Mass Spectrometry.	ASLP/ : ENV_W037, MS : ICP_W003
ASLP/MTR	Intertek Genalysis Perth 3244 3237 AS4439.3-1997: Australian Standard Leachates Protocol for Wastes, Sediments & Contaminated Soils. Analysed with Electronic Meter Measurement	
ASLP/OE	Intertek Genalysis Perth 3244 3237 AS4439.3-1997: Australian Standard Leachates Protocol for Wastes, Sediments & Contaminated Soils. Analysed by Inductively Coupled Plasma Optical (Atomic) Emission Spectrometry.	ASLP/ : ENV_W037, OE : ICP_W004

5.11 Appendix 5.11: GIDJI Gidji I Tailings Geochemistry

MEMORANDUM

Attention:	Janine Cameron	From:	Dr Thomas Robson
Company:	Kalgoorlie Consolidated Gold Mines	Date:	5 February 2021
Subject:	Gidji 1 Tailings Geochemistry	Project:	Gidji 3 TSF

1. BACKGROUND

Kalgoorlie Consolidated Gold Mine (KCGM) are currently looking to extend the Gidji Tailings Storage Facility (TSF), located around 20 km north of Kalgoorlie, Western Australia. The intention is to construct a third tailings cell, referred to as Gidji 3, and KCGM have submitted an application for the development under Section 45c of the *Environmental Protection Act*.

The s45c application includes provision to use tailings from the first cell of the Gidji TSF (Gidji 1) to construct embankments for Gidji 3. The tailings contained in Gidji 1 were produced using a calcine (roaster) process to enhance recovery of refractory (sulfidic) gold concentrates prior to 2001, after which an ultra-fine grind (UFG) process was adopted to eventually replace the Gidji roaster. Deposition into Gidji 1 ceased in April 2012 with deposition between early 2002 and April 2012 comprising a mixture of calcine and UFG tailings. The embankments of the second, lined, TSF cell (Gidji 2) and subsequent raises were constructed using Gidji 1 tailings. Tailings deposited within Gidji 2 (and proposed Gidji 3) are and will be produced entirely from the UFG process.

The UFG and calcine tailings have some contrasting geochemical properties; most significantly, the UFG tailings contain a high proportion of sulfide (20-25% as total S) whereas the calcine tailings contain very little sulfide and moderate amounts of sulfur (2 to 2.5%) present as gypsum (calcium sulfate). Consequently, the UFG tailings are potentially acid forming (PAF), whilst the calcine tailings forming the majority of Gidji 1 are non-acid forming (NAF).

The Department of Water and Environmental Regulation (DWER) presented KCGM with a request for further information (RFI) in response to the s45c application. The RFI indicates that no information has been provided in relation to the suitability of the Gidji 1 tailings for embankment construction. The department has specifically asked for information around the potential for cyanide and other contaminants of potential concern (CoPCs) to be leached from the material and potential for acidification. The department has also requested information on the geotechnical suitability and stability of the material from Golder Associates (KCGM's Engineers of Record), which is provided in a separate memo.

KCGM has asked MBS Environmental (MBS) to review and collate all relevant information for Gidji 1 calcine tailings and to provide an assessment to address some of the knowledge gaps highlighted by DWER.

The scope of work for the Gidji 1 tailings review is as follows:

- Review technical reports and data provided by KCGM relating to Gidji tailings and construction of the Gidji TSF.
- Collate all relevant geochemical data.

- Assess the data in relation to the suitability of the Gidji 1 tailings for construction of the Gidji 3 embankments.
- Prepare a concise technical memorandum to address the geochemical aspects of the DWER RFI, noting that KCGM has separately commissioned a certified tailings engineer to address geotechnical knowledge gaps identified in the RFI.

2. INFORMATION SOURCES

All available technical reports of relevance to the Gidji TSF or Gidji tailings were reviewed by MBS. Geochemical information and testing results were drawn from two reports, as summarised in Table 1. The details of the analytical test work are provided in the body of the technical reports.

Table 1: Summary of Information Sources and Data

Document	Data Extracted
Gidji Roaster Geochemical Characterisation of Profile-Samples from Tailings-Bed (GCA 2003)	• Acid base accounting (ABA) • Electrical conductivity (EC) and pH • Acid-Base Characteristic Curves (ABCC)
Assessment of Geochemical Behaviour of Mercury in Mine Tailings for the Kalgoorlie Gold Mine (Earth Systems 2014)	• Bottle leach aqueous geochemistry • Elemental composition

The data drawn from the studies (Table 1) are considered to be relevant to this assessment on the basis that:

- The laboratory test procedures and interpretation used in each study are consistent with current good practice and the analytical determinations were undertaken by laboratories accredited by the National Association of Testing Authorities (NATA), except for ABCC testing undertaken using in-house laboratory facilities (GCA 2003).
- The sample assessed by Graeme Campbell and Associates (sample GCA4668) reflected 100% calcine tailings, and therefore the acid base accounting results from GCA (2003) represent the residual (remaining) tailings from the Gidji 1 TSF cell. Whilst ABA testing has been undertaken as part of subsequent studies (Earth Systems 2014, MBS 2018), these reflected the influence of UFG tailings, which have a much higher acid formation risk than the calcine tailings.
- Whilst the tailings assessed by Earth Systems (2014) as part of an investigation into mercury geochemistry (referred to as 'GID' in the report) reflect a mixture of 80% calcine tailings and 20% UFG tailings, the results are considered conservatively representative of calcine tailings. Some key aspects considered were:
 - Solubility of CoPCs would typically be greater in UFG tailings compared with calcine tailings due to the higher potential for sulfide oxidation and associated oxidative-dissolution in the UFG tailings.
 - Both tailings were produced using cyanide extraction and both contain residual cyanide species, which can form variably stable soluble complexes with some metals and metalloids (e.g. cobalt, copper, mercury). The basic (alkaline) pH of unoxidised UFG tailings (pH 8), as well as the water leachate salinity and chloride content were consistent with results for calcine tailings - reflective of process water. As such, the geochemical parameters exerting most control on CoPC solubility are similar in both materials.
 - Mercury present in mercury telluride minerals like coloradoite (HgTe) is preserved in the UFG tailings, whereas much of the mercury was volatilised by the Gidji roaster process and lost from the calcine tailings. By extrapolation between the mercury concentration of mixed tailings (20% UFG, 80% calcine) and pure UFG tailings (Earth Systems 2014), it is estimated that the pure calcine tailings contain approximately 0.2 mg/kg mercury.

- Excepting volatile elements like mercury, both calcine and UFG tailings were produced from ore of the same provenance. Therefore the concentrations of most elements are expected to be relatively consistent between materials.

3. DATA ASSESSMENT APPROACH

3.1 ACID FORMATION RISK

MBS uses a combined acid generation risk classification scheme (Table 2) based on NAPP (net acid production potential) and NAG pH (net acid generation test pH) determinations to classify waste rock materials for acid generation risk, which is consistent with guidance set out in AMIRA (2002) and the equivalent Federal guidelines (DIIS 2016).

Table 2: Acid Formation Risk Classification Criteria

Primary Geochemical Waste Type Class	NAPP Value kg H ₂ SO ₄ /t	NAG pH
Potentially Acid Forming (PAF)	≥10	< 4.5
Potentially Acid Forming – Low Capacity (PAF-LC)	0 to 10	< 4.5
Uncertain (UC)	Positive	> 4.5
	Negative	< 4.5
Non-Acid Forming (NAF)	Negative	> 4.5 or sulfur <0.2%*
Acid Consuming (AC)	< -100	>4.5
Barren	≤2 and sulfur < 0.05%	-

* Application of 0.2% sulfur cut-off as a screening tool for the need for determination of NAG pH for classification may be applied on a site specific basis in conjunction with assessment of ANC and NPR). This uses a ratio analysis approach for low risk samples based on Western Australian conditions where extensive experience has indicated no potential for samples with less than 0.2% sulfur to generate net acidity in arid conditions for waste rock from hard rock mines. A negative NAPP and NPR of more than 4 (DIIS 2016) indicates no considered risk of acid generation in such instances.

3.2 ELEMENTAL ENRICHMENT

MBS uses the global abundance index (GAI) approach to compare elemental concentrations in waste rock materials with the average earth crustal abundance (AusIMM 2001, Smith and Huyck 1999). Where concentrations of any given element fall below the laboratory limit of reporting (LOR), an indicative value equal to the respective LOR is used to calculate GAI or the GAI is assigned as zero. The main purpose of the GAI is to provide an indication of any elemental enrichment that could be of environmental significance. The GAI (based on a log-2 scale) is expressed in integer increments from 0 to 6 (INAP 2009). A GAI of 0 indicates that the content of the element is less than or up to three times the average crustal abundance; a GAI of 1 corresponds to a three-to-six-fold enrichment; a GAI of 2 corresponds to a six-to-12-fold enrichment and so forth, up to a GAI of 6, which corresponds to a 96-fold, or greater, enrichment above average crustal abundances. A GAI of 3 or more is generally considered 'significant' and may warrant further investigation.

3.3 SALINE AND METALLIFEROUS SEEPAGE

The potential for tailings to generate potentially harmful seepage/runoff was assessed by comparison of leachate (water bottle roll extraction, Earth Systems (2014)) concentrations against relevant water quality guideline values, typically those set out in the *Australian and New Zealand Guidelines for Fresh & Marine Water Quality* (ANZG 2018). These guideline values included:

- ANZG Livestock drinking water default guideline values (DGVs).
- Non-potable groundwater use (NPUG, DER 2014) trigger values.

- USEPA Maximum Contaminant Level (MCL) for thallium. Note that the current freshwater ecosystem ANZG DGV for thallium is considered unreliable, hence the application of the USEPA value.

4. SUMMARY OF GEOCHEMICAL CHARACTERISTICS

The laboratory testwork results relied upon for this review are collated in Attachment 1. The key geochemical characteristics of the Gidji 1 tailings are as follows:

- Gidji 1 tailings are non-acid forming (NAF):
 - Sulfur speciation indicated that of the total sulfur (2.3%) in the sample, almost all (2%) was present as sulfate, which has no potential to generate additional acidity. This is consistent with the calcination of the material, which would have oxidised or volatilised the majority of the sulfur in the original ore, leaving a minor proportion of oxidised sulfur (sulfates) compounds (e.g. gypsum) and possibly traces of oxidisable sulfur (pyrite).
 - The acid neutralising capacity (ANC) of the sample (26 $\text{H}_2\text{SO}_4/\text{t}$) is greater than the acid production potential (AP, 9.2 $\text{H}_2\text{SO}_4/\text{t}$), yielding a negative NAPP value (-17 $\text{kg H}_2\text{SO}_4/\text{t}$). This assumes all insoluble sulfur is present as oxidisable pyrite. In reality, it should also be noted that oxidised sulfate minerals such as jarosite (from pyrite oxidation) are poorly soluble and may lead to sulfate results being less than total sulfur and hence overestimation of the AP.
 - The effective NAPP, which is based on the carbonate content of the sample (0.25%) is also negative (-11 $\text{H}_2\text{SO}_4/\text{t}$). Effective NAPP is a more conservative predictor of the potential of mine wastes to generate net acidic seepage because only ANC representing readily reactive carbonates is considered in the calculation, as opposed to less reactive ANC provided by silicate dissolution.
 - Acid consumption curves (ABCC) suggest, very conservatively, a carbonate buffering capacity in the order of 12 $\text{H}_2\text{SO}_4/\text{t}$ (to pH 4.5), consistent with ANC provided by ankerite (Ca-Mg-Fe carbonates). Cautiously calculating an Effective NAPP from this value also yields a negative result (-3 $\text{H}_2\text{SO}_4/\text{t}$) despite a potentially elevated predicted AP. This indicates that the risk of the tailings producing net acidic seepage is very low even using the most conservative assessment assumptions.
- Based on screening by GAI, the Gidji 1 tailings are significantly enriched in several environmentally significant metals and metalloids:
 - Silver (Ag) based on a total concentration of 1.8 mg/kg versus a crustal average of 0.07 mg/kg.
 - Arsenic (As), given the tailings sample contained 1,740 mg/kg arsenic relative to 25 mg/kg typically found in crustal rocks and soils. Antimony, commonly associated with arsenic, was also present at 39 mg/kg compared with a typical value of 0.2 mg/kg.
 - Chloride (Cl) based on the tailings containing 0.73% chlorine compared with 0.013% in typical crustal rocks. This is a result of the saline process water.
 - Cobalt (Co), which was present at 295 mg/kg in the tailings versus a crustal average of 25 mg/kg.
 - Copper (Cu) based on the tailings containing 826 mg/kg relative to a typical abundance of 60 mg/kg.
 - Mercury (Hg) as the tailings concentration (1 mg/kg) was over ten times the average crustal abundance (0.08 mg/kg).
 - Molybdenum (Mo) due to the tailings containing 26 mg/kg compared with the average of 2 mg/kg.
 - Lead (Pb) given the tailings contained 238 mg/kg versus 16 mg/kg in average crustal rocks.
 - Selenium (Se) due to the sample containing 2 mg/kg compared with the average crustal abundance of 0.2 mg/kg.
 - Tellurium (Te) based on a total concentration of 31 mg/kg versus a crustal average of 0.001 mg/kg.
- Water leach extraction (1 kg dry weight tailings extracted with 1 L deionised water, rolled for at least 8 hours) indicated that runoff or seepage from the Gidji 1 tailings is likely to be neutral to basic (pH 8.5), of

brackish salinity (4,480 mg/L total dissolved solids, TDS) and to contain sulfate concentrations at around the livestock drinking water DGV (1,000 mg/L). Given the environmental context and low acid formation risk and low potential for further oxidation of the material, the tailings are unlikely to generate harmfully saline or acidic seepage.

- Detectable concentrations of cyanide were present in the 1:1 extract of Gidji 1 tailings (porewater ratio). This included 3.3 mg/L total cyanide, including weak-acid dissociable (WAD, 1.4 mg/L) and free cyanide (1.1 mg/L). Whilst these concentrations are not considered to be particularly high (given high porewater type extraction ratio), the presence of these species is likely associated with the formation of soluble cyanide-metal complexes, which may increase the environmental mobility of some CoPCs. It should also be noted that cyanide breaks down once exposed to ultraviolet light and the atmosphere; hence the presence of cyanide and metal complexes would be expected to further diminish over time if Gidji 1 tailings were used to construct embankments. Furthermore, assessment results are from 2014 and further aging of the tailings on site since this time suggest that the material proposed for embankment construction would contain less cyanide than the freshly produced tailings characterised by Earth Systems (2014).
- Water leach extraction also indicated that some but not all of the enriched chemical species (see above) are likely to be soluble to the extent where consideration of potential environmental risk is warranted:
 - Whilst the tailings are enriched in silver, lead, selenium and antimony, water leachable concentrations of these species were below the analytical limit of reporting (LOR). Water leachable molybdenum (0.08 mg/L) was below the livestock drinking water DGV (0.15 mg/L). The solubility of these species in terms of rainfall runoff and percolation/seepage is unlikely to be environmentally significant.
 - Whilst arsenic was leached at around the NPUG trigger level (0.12 mg/L versus 0.1 mg/L), the concentration was below the corresponding livestock DGV (5 mg/L) and, at this concentration, arsenic oxyanions (e.g. arsenate) are expected to be effectively adsorbed or co-precipitated with iron oxyhydroxides present in the soils and regolith of the surrounding environment. The overall risk from arsenic leachability is considered to be low. The extraction ratio (1:1, porewater) is also noted to be substantially higher than typical used for assessments against these trigger values - a more typical extraction ratio for such comparison (1:10 or 1:20 ratio extract) would be expected to produce concentrations in the order of 0.01 mg/L (1/10th) and hence below the NPUG value.
 - Cobalt, copper and mercury were leached from the tailings at concentrations exceeding broadly applicable water quality screening values. Cobalt (3.2 mg/L) and copper (1.5 mg/L) marginally exceeded the livestock drinking water DGVs of 1 mg/L, whilst mercury (0.02 mg/L) exceeded the corresponding DGV of 0.002 mg/L by one order of magnitude. These findings are consistent with the formation of soluble cyanide-metal complexes. These complexes will likely decrease in solubility over time with cyanide decomposition (aging), and again noting the high extraction ratio used for these tests.

5. RISK ASSESSMENT

A qualitative risk assessment was undertaken to examine the potential environmental risks resulting from replicating the embankment design used for Gidji 2 (i.e. using Gidji 1 tailings to construct raises) for the proposed Gidji 3 cell(s). The assessment approach is discussed in the following subsections and the outcomes of the assessment are summarised in Table 6.

5.1 RISK PATHWAYS CONSIDERED

The potential impacts assessed in relation to use of Gidji 1 tailings to construct embankment raises of the proposed Gidji 3 tailings cell(s) were:

- Acidification of Gidji 1 tailings embankment materials due to *in situ* sulfide oxidation.
- Acidification of Gidji 1 tailings embankment materials due to interaction with acidic seepage from UFG tailings to be contained in lined Gidji 3 cell(s).

- Degradation of groundwater quality due to contributions of seepage or runoff from Gidji 1 tailings, produced by percolating rainwater.
- Degradation of surface water quality due to contributions of seepage or runoff from Gidji 1 tailings, produced by percolating rainwater.
- Degradation of surface water quality due to erosion and dispersal of Gidji 1 tailings from Gidji 3 embankment.
- Degradation of soil quality due to release of rainfall runoff including salts from Gidji 1 tailings.
- Degradation of soil quality due to erosion and dispersal of Gidji 1 tailings from the Gidji 3 embankments.

5.2 METHODOLOGY

The assessment was completed with consideration of the International Standard ISO 31000:2018 - 'Risk Management – Guidelines' (ISO 2018). Risk was determined based on an assessment of the consequence and likelihood of a potential impact using procedures summarised below:

- Identify key CoPCs, environmental values (e.g. beneficial uses of groundwater, ability of soils to support native vegetation) and release scenarios to identify those combinations critical to avoiding unacceptable environmental outcomes.
- Establish 'base case' setting for each risk pathway assessed. These conditions typically relate to design specifications of infrastructure, aspects of the Mine Closure Plan and existing environmental conditions.
- Undertake assessment of inherent risks, based on base case conditions, for each scenario.
- Identify appropriate mitigation measures for control of unacceptable inherent risks and assess residual risk.
- Recommend alternative potential mitigation measures and identify requirements for further investigation to address any unacceptable residual risks if necessary.

Contributors to the risk assessment were Thomas Robson (Senior Environmental Geochemist, MBS Environmental), Michael North (Principal Environmental Geochemist, MBS Environmental) and Janine Cameron (Closure Specialist, KCGM).

5.2.1 Consequence Scale

Several aspects were considered in determining the consequence of each potential impact, including:

- Type of impact (direct or indirect).
- Geographic extent, size, and scale.
- Duration, frequency, and reversibility of the potential impact.
- Whether the potential impacts are from planned or unplanned events.
- Sensitivity of the receptor/resource and the value of the receptor/resource.

The consequence ratings for impacts varied from Insignificant, through to Catastrophic as defined in Table 3.

Table 3: Risk Assessment Consequence Scale

Descriptor	Explanation
Insignificant	Negligible changes to water and/or soil quality. Minimal contamination within immediate vicinity of operation, easily treatable in short term and does not result in additional adverse impacts on associated environmental values (e.g. ability of soils to support native vegetation).
Minor	Contained, low impact to soil and water quality of project area. Minimal contamination, which is localised and treatable in medium term, with no subsequent additional impact on environmental values (e.g. ability of soils to support native vegetation).
Moderate	Uncontained impact to soil and water quality, amenable to remediation in the short term. Localised, low level land contamination that results in additional adverse impacts on associated environmental values (e.g. ability of soils to support native vegetation) in the short to medium term.
Major	Extensive hazardous impact to soil and water quality that will require long-term remedial works. Includes low level contamination on a regional scale resulting in additional adverse impacts on associated environmental values requiring medium to long term management.
Catastrophic	Uncontained hazardous impact to soil and water quality with long term residual effects. Moderate to severe contamination on a regional scale resulting in permanent damage with severe environmental and socioeconomic disruption.

5.2.2 Likelihood Scale

Likelihood reflects the probability of exposure to CoPCs resulting in potential harm (i.e. consequence) to environmental values. Where practicable, likelihood was determined using quantitative information or data. Definitions for likelihood are presented in Table 4.

Table 4: Risk Assessment Likelihood Scale

Descriptor	Explanation
Rare	Highly unlikely, but it may occur in exceptional circumstances
Unlikely	Not expected, but there is a slight possibility it may occur at some time
Possible	The event might occur at some time as there is a history of occurrence at similar projects.
Likely	There is a strong possibility the event will occur as there is a history of frequent occurrence at similar projects.
Almost Certain	Very likely. The event is expected to occur in most circumstances as there is a history of regular occurrence at similar projects.

5.2.3 Risk Rating

Inherent and residual risk ratings were determined by assessing the likelihood and consequence of an impact before and after the application of mitigation or management measures. The level of risk was determined using the matrix shown in Table 5.

Table 5: Risk Level Matrix

Likelihood	Consequences				
	Insignificant	Minor	Moderate	Major	Catastrophic
Rare	Low	Low	Medium	Medium	High
Unlikely	Low	Low	Medium	High	High
Possible	Low	Low	Medium	High	Extreme
Likely	Low	Medium	High	Extreme	Extreme
Almost Certain	Medium	Medium	High	Extreme	Extreme

Table 6: Qualitative Risk Assessment Outcomes

Receptors	Potential Impacts	Risk Assessment (Inherent)		Comments	Risk Management Measures	Risk Assessment (Residual)	
		Likelihood	Consequence			Likelihood	Consequence
Surface water, soils and groundwater	Acidification of Gidji 1 tailings embankment due to <i>in situ</i> sulfide oxidation (with secondary impacts as below).	Rare	Minor	Low	Acid base accounting indicates a low risk of Gidji 1 tailings generating net acidic seepage. Majority of sulfur present in oxidised forms such as gypsum, which will not generate additional acidity. A toe drain will	Rare	Minor
Surface water, soils and groundwater	Acidification of Gidji 1 tailings embankment due to interaction with PAF UFG tailings contained within the Gidji 3 cell(s) (with secondary impacts as below).				As with Gidji 2, the Gidji 3 tailings impoundment will be fitted with a composite liner (compacted Gidji 1 tailings walls, overlain with welded HDPE) overlain with a seepage interception drainage system. The HDPE liner will extend to the crest of the embankment surface to effectively minimise porewater migration into the embankment as well as pipe erosion of the embankment. Gidji 3 is a downstream TSF, meaning that the embankment thickness increases with each raise, further minimising the potential for interaction with seepage from the impounded UFG tailings.		
		Possible	Minor	Low	The tailings to be deposited within the Gidji 3 cell are potentially acid forming (PAF) and surface tailings may produce acidic leachate when exposed to the atmosphere. The interaction of acidic seepage from the UFG tailings with embankments constructed using Gidji 1 tailings could hypothetically result in the generation of acidic, metalliferous drainage (AMD) due to the geochemical characteristics of the UFG tailings to be placed in Gidji 3.	Rare	Minor
Surface Water	Degraded surface water quality due to inputs of rainfall-driven seepage/runoff from the Gidji 3 embankment (i.e. interaction between rainwater and Gidji 1 calcine tailings).	Possible	Minor	Low	During operations, seepage and runoff from the outer embankment will be managed through toe bunding and a network of seepage recovery bores located downgradient of the TSF. Construction of downstream raises will result in the outer embankment being periodically covered with a fresh layer of Gidji 1 calcine tailings, which will help to maintain the integrity of the outer surface and minimise erosion.	Rare	Minor
Surface Water	Degraded surface water quality due to erosion and dispersal of Gidji 1 tailings from Gidji 3 embankment.	Unlikely	Minor	Low	Closure concepts involve sheeting the embankments with competent waste rock, which will minimise interaction of rainfall runoff with the tailings and control embankment erosion. An inward-draining design for the tailings will also limit runoff over embankments.	Unlikely	Minor

Receptors	Potential Impacts	Risk Assessment (Inherent)		Comments	Risk Management Measures	Risk Assessment (Residual)	
		Likelihood	Consequence			Likelihood	Risk Rating
Soils	Degraded soil quality due to inputs of rainfall runoff from Gidji 3 embankment (interaction with Gidji 1 calcine tailings).	Unlikely	Minor	Seepage and runoff interacting with Gidji 1 calcine tailings may contain environmentally significant concentrations of metals/metalloids (Co, Cu, Hg) and their cyanide/chloro complexes. Gidji 1 tailings are enriched in certain metals, metalloids and salts, which may be deleterious to soil quality and native vegetation.	Relatively minimal embankment erosion is anticipated during operations. Construction of downstream raises will result in the outer embankment being periodically covered with a fresh layer of Gidji 1 calcine tailings, which will help to maintain the integrity of the outer surface and minimise erosion. During operations, the embankment runoff will be captured by a toe drain reporting to a lined dam.	Unlikely	Minor
				Given the semi-arid climate and topography of the area, widespread transport of embankment runoff or eroded tailings particles is unlikely to significantly affect soils away from the immediate vicinity of the TSF (i.e. toe bunds).	At closure the embankment will be protected from erosion by a capping layer, which will minimise erosion. A crest bund will prevent rainwater from reaching the outer embankment. Current closure design is for an inward-draining store and release design for the cell.		
Groundwater	Degraded groundwater quality due to inputs of rainfall runoff from Gidji 3 embankment (interaction with Gidji 1 calcine tailings)	Unlikely	Minor	Seepage and runoff may contain environmentally significant concentrations of metals/metalloids (Co, Cu, Hg) and their cyanide/chloro complexes.	An existing network of seepage recovery bores will identify and manage seepage, in the unlikely event that it should occur. During operations, the embankment runoff will be captured by a toe drain reporting to a lined dam and the existing bores will remain be in operation.	Unlikely	Minor
				Given the semi-arid climate of the operation area, significant and uncontained inputs of seepage/runoff from the tailings embankments to groundwater is unlikely, and would be a very small contribution in relation to the Gidji 1 TSF. An existing network of seepage recovery bores will identify and manage seepage. Natural groundwater has low environmental value (naturally acidic and saline), with Mining Operations identified as the only beneficial user.	At closure the embankment will be protected by a capping layer, which will minimise erosion. A crest bund will prevent rainwater from reaching the outer embankment. Current closure design is for an inward-draining store and release design for the cell.		
					The replication of the Gidji 2 embankment construction for Gidji 3 is not expected to result in any additional impacts to groundwater, which has minimal environmental value (naturally acidic) but is monitored and managed as an ongoing concern.		

6. SUMMARY AND CONCLUSION

A review of existing geochemical testwork results was undertaken for the Gidji 1 calcine tailings. The key geochemical characteristics pertaining to potential environmental hazards were used to facilitate a qualitative risk assessment to determine the suitability of the Gidji 1 calcine tailings to construct embankment raises as part of the proposed Gidji 3 tailings storage cell(s) design. As appropriate for the knowledge gaps identified by DWER, the assessment focused on potential for cyanide and other contaminants of potential concern to be leached from the material and potential for acidification of the Gidji 1 tailings themselves.

The outcomes of this review and risk assessment indicate that the use of Gidji 1 tailings to construct lined embankment raises as part of the proposed Gidji 3 tailings storage cell(s) is unlikely to result in unacceptable environmental outcomes. This conclusion was based on the geochemical testing results presented, existing environmental conditions, the existing use of Gidji 1 tailings for embankment construction of Gidji 2, existing management infrastructure and understanding of closure planning for the Gidji TSF.

I trust that this assessment will assist in your planning and approval process for Gidji 3. Please contact me to discuss any aspect of this assessment or for additional advice.

Yours sincerely
MBS Environmental



Dr Thomas Robson
Senior Environmental Geochemist

enc.

Attachment 1: Collated Analytical Results

7. REFERENCES

AMIRA International. 2002. ARD Test Handbook: Project 387A Prediction and Kinetic Control of Acid Mine Drainage. Prepared for AMIRA International by Ian Wark Research Institute and Environmental Geochemistry International Pty Ltd. <http://www.amira.com.au/documents/downloads/P387AProtocolBooklet.pdf> (accessed 18 January 2019).

ANZG. 2018. Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Governments and Australian State and Territory Governments. www.waterquality.gov.au/anz-guidelines (accessed 30 November 2018).

AusIMM. 2001. Monograph 9: Field Geologists' Manual. Fourth Edition. Carlton VIC: Australasian Institute of Mining and Metallurgy.

DER. 2014. Assessment and Management of Contaminated Sites - Contaminated Sites Guidelines. Government of Western Australia, Perth: Department of Environment Regulation. December 2014.

DIIS. 2016. Preventing Acid and Metalliferous Drainage: Leading Practice Sustainable Development Program for the Mining Industry. Department of Industry, Innovation and Science. <https://industry.gov.au/resource/Documents/LPSDP/LPSDP-AcidHandbook.pdf> (accessed 11 April 2018).

Earth Systems. 2014. Assessment of Geochemical Behaviour of Mercury in Mine Tailings for the Kalgoorlie Gold Mine. Unpublished technical report prepared by Earth Systems Pty Ltd for Kalgoorlie Consolidated Gold Mines Pty Ltd.

GCA. 2003. Gidji Roaster Geochemical Characterisation of Profile-Samples from Tailings-Bed. Unpublished technical report prepared by Graeme Campbell and Associates Pty Ltd (GCA) for Kalgoorlie Consolidated Gold Mines Pty Ltd.

INAP. 2009. *Global Acid Rock Drainage (GARD) Guide*. International Network for Acid Prevention. <http://www.gardguide.com> (accessed 18 November 2019).

International Organization for Standardization (ISO). 2018. Risk Management – Guidelines (ISO 31000:2018). Geneva, Switzerland: ISO.

Landloch. 2020. Gidji TSF Embankment Erosion Study. Unpublished technical report prepared by Landloch Pty Ltd for Kalgoorlie Consolidated Gold Mines Pty Ltd.

MBS. 2018. Fimiston, Kaltails and Gidji Tailings Geochemistry Overview – February 2018. Unpublished technical report prepared by MBS Environmental Pty Ltd (MBS) for Kalgoorlie Consolidated Gold Mines Pty Ltd.

Price, W.A. 1997. Guidelines and Recommended Methods for the Prediction of Metal Leaching and Acid Rock Drainage at Minesites in British Columbia. British Columbia Mine Reclamation Section, Ministry of Employment and Investment, April 1997. <http://mend-nedem.org/mend-report/draft-guidelines-and-recommended-methods-for-the-prediction-of-metal-leaching-and-acid-rock-drainage-at-minesites-in-british-columbia/> (accessed November 22, 2018).

Smith, K.D. and Huyck, H.L.O. 1999. An Overview of the Abundance, Relative Mobility, Bioavailability, and Human Toxicity of Metals. In *The Environmental Geochemistry of Mineral Deposits Part A: Processes, Techniques and Health Issues*. Reviews in Economic Geology 6: 29-70.

Attachment 1: Collated Analytical Results

Table A1-1: Sample Descriptions

Sample ID	Study	Sample Depth (mbgl)	Material	Description
GID	Earth Systems (2014)	N/A	Tailings	80% caline tailings / 20% UFG tailings
TSF-2	Landloch (2020)	1	Tailings	Gidji TSF embankment sample at depth
TSF-3	Landloch (2020)	2.5	Tailings	Gidji TSF embankment sample at depth
CGA4668	GCA (2003)	N/A	Tailings	100% calcine tailings

Table A1-2: Acid Base Accounting (ABA) Summary

Paramater	Units	Result
Sample ID	CGA4668	
Study	GCA (2003)	
Description	100% calcine tailings	
pH	pH Units	8.7
EC	uS/cm	34
TDS	mg/L	22
Total S	%	2.3
SO4_S	%	2
Total C	%	0.25
Acid Insoluble C	%	<0.01
ANC	kg H ₂ SO ₄ /tonne	26
NAPP		-17
NAG pH	pH Units	N.D
NAG (pH 4.5)	kg H ₂ SO ₄ /tonne	N.D
NAG (pH 7)		N.D
MPA		70.4
AP		9.2
CC-ANC		20
Eff. NAPP (CC-ANC)		-11
NPR	Ratio	2.8
Classification	NAF	

Table A1-3: Global Abundance Indices (GAIs)

Parameter	Units	Tailings Concentration	GAI	Average Crustal Abundance
Sample ID	GID			
Study	Earth Systems (2014)			
Description	80% caline tailings / 20% UFG tailings			
Ag	mg/kg	1.8	4	0.07
Al	%	1.93	0	8
As	mg/kg	1,740	6	25
Ba	mg/kg	13	0	430
Be	mg/kg	0.2	0	3
Bi	mg/kg	0.4	0	0.2
Ca	%	2.94	0	3
Cd	mg/kg	1.3	2	0.18
Ce	mg/kg	2.2	0	45
Cl	%	0.73	5	0.013
Co	mg/kg	295	3	25
Cr	mg/kg	49	0	200
Cs	mg/kg	0.4	0	3
Cu	mg/kg	826	3	60
Fe	%	38	2	5
Ga	mg/kg	0.9	0	17
Ge	mg/kg	0.2	0	15
Hf	mg/kg	<1	0	3
Hg	mg/kg	1	3	0.08
In	mg/kg	<0.1	0	0.1
K	%	0.31	0	2.6
La	mg/kg	1	0	30
Li	mg/kg	5.3	0	30
Mg	%	0.81	0	2.1
Mn	mg/kg	480	0	900
Mo	mg/kg	26	3	2
Na	%	0.59	0	2.4
Nb	mg/kg	0.2	0	20
Ni	mg/kg	158	0	80
Pb	mg/kg	238	3	16
Rb	mg/kg	3.1	0	120
Sb	mg/kg	39	6	0.2
Se	mg/kg	2	3	0.2
Sn	mg/kg	0.3	0	2.5
Sr	mg/kg	158	0	350
Te	mg/kg	31	6	0.001
Th	mg/kg	0.2	0	10
Ti	%	1.2	1	0.5
Tl	mg/kg	0.6	0	1
U	mg/kg	0.1	0	3
V	mg/kg	26	0	150
W	mg/kg	2.8	1	1
Y	mg/kg	3.3	0	30
Zn	mg/kg	381	2	70
Zr	mg/kg	10	0	160

Values of three or higher are highlighted.

Where elemental concentrations were below laboratory limit of reporting (<LOR), a GAI of zero was assigned.

**Table A1-4: Water Bottle Leach Extraction
- Major Parameters and Ions**

Parameter	Units	Result	Livestock Drinking Water DGV (ANZECC 2000/ANZG 2018)	NPUG (DER 2014)
Sample ID	GID			
Study	Earth Systems (2014)			
Description	80% caline tailings / 20% UFG tailings			
pH	pH Units	8.5	6.5-8.5	N/G
EC	µS/cm	7,000	6,250	N/G
TDS	mg/L	4,480	4,000	N/G
Ca	mg/L	346	1,000	N/G
K	mg/L	20	N/G	N/G
Mg	mg/L	43	No limit	N/G
Na	mg/L	1,270	N/G	N/G
Sulfate	mg/L	1,080	1,000	1,000
Chloride	mg/L	1,700	N/G	250
Alkalinity	mg CaCO ₃ /L	24	N/G	N/G
Acidity	mg CaCO ₃ /L	<1	N/G	N/G
Free Cyanide	mg/L	1.1	N/G	0.8
WAD Cyanide	mg/L	1.4	N/G	N/G
Total Cyanide	mg/L	3.3	N/G	N/G
Thiocyanate	mg/L	120	N/G	N/G

N/G : No applicable guideline value.

**Table A1-5: Water Bottle Leach Results
- Metals and Metalloids**

Parameter	Units	Result	Livestock Drinking Water DGV (ANZECC 2000/ANZG 2018)	NPUG (DER 2014)	Other Guideline
Sample ID	GID				
Study	Earth Systems (2014)				
Description	80% caline tailings / 20% UFG tailings				
Ag	mg/L	<0.01	N/G	1	
Al	mg/L	<0.01	5	0.2	
As	mg/L	0.12	0.5	0.1	
B	mg/L	<0.05	5	40	
Bi	mg/L	<0.001	N/G	N/G	
Cd	mg/L	<0.0001	0.01	0.02	
Co	mg/L	3.2	1	N/G	
Cr	mg/L	0.001	1	0.5	
Cu	mg/L	1.5	1	20	
Fe	mg/L	<0.05	No limit	0.3	
Hg	mg/L	0.021	0.002	0.01	
Mn	mg/L	0.01	N/G	5	
Mo	mg/L	0.08	0.15	0.5	
Ni	mg/L	0.18	1	0.2	
Pb	mg/L	<0.001	0.1	0.1	
Sb	mg/L	0.02	N/G	0.03	
Se	mg/L	<0.01	0.02	0.1	
Sn	mg/L	<0.001	N/G	N/G	
Te	mg/L	<0.005	N/G	N/G	
Tl	mg/L	<0.001	N/G	N/G	0.002 (USEPA MCL)
U	mg/L	<0.001	0.2	0.17	
V	mg/L	0.02	N/G	N/G	
Zn	mg/L	<0.005	20	3	

N/G : No applicable guideline value.

Table A1-6: Acid Base Characteristic Curve (ABCC) Results

Replicate 1			Replicate 2		
Cumulative Acid Added (mL)	Cumulative Acid Consumption (kg H ₂ SO ₄ /t)	pH	Cumulative Acid Added (mL)	Cumulative Acid Consumption (kg H ₂ SO ₄ /t)	pH
0	0	9.3	0	0	9.6
0.4	0.2	8.8	0.4	0.2	9.1
0.8	0.4	8.6	0.8	0.4	8.8
1.2	0.6	8.4	1.2	0.6	8.6
1.6	0.8	8.3	1.6	0.8	8.4
2	1	8.2	2	1	8.4
2.8	1.4	8.2	2.8	1.4	8.2
3.2	1.6	8	3.2	1.6	8.2
3.6	1.8	8	3.6	1.8	8.1
4	2	7.8	4	2	8
4.4	2.2	7.8	4.4	2.2	8
4.8	2.4	7.7	4.8	2.4	7.9
5.2	2.6	7.6	5.2	2.6	7.9
5.6	2.8	7.6	5.6	2.8	7.8
6	3	7.5	6	3	7.7
6.4	3.2	7.5	6.4	3.2	7.7
6.8	3.4	7.4	6.8	3.4	7.6
7.2	3.6	7.3	7.2	3.6	7.6
7.6	3.8	7.4	7.6	3.8	7.5
8	4	7.3	8	4	7.5
8.4	4.2	7.3	8.4	4.2	7.4
8.8	4.4	7.2	8.8	4.4	7.4
9.2	4.6	7.2	9.2	4.6	7.3
9.6	4.8	7.2	9.6	4.8	7.3
10	5	7.1	10	5	7.2
10.4	5.2	7.1	10.4	5.2	7.2
10.8	5.4	7	10.8	5.4	7.2
11.2	5.6	7	11.2	5.6	7.1
11.6	5.8	6.9	11.6	5.8	7.1
12	6	6.9	12	6	7
12.4	6.2	6.8	12.4	6.2	7
12.8	6.4	6.7	12.8	6.4	6.9
13.2	6.6	6.6	13.2	6.6	6.9
13.6	6.8	6.5	13.6	6.8	6.8
14	7	6.4	14	7	6.8
14.4	7.2	6.4	14.4	7.2	6.7
14.8	7.4	6.2	14.8	7.4	6.7
15.2	7.6	6.1	15.2	7.6	6.6
15.6	7.8	6.1	15.6	7.8	6.5
16	8	6	16	8	6.4
16.4	8.2	5.9	16.4	8.2	6.2
16.8	8.4	5.8	16.8	8.4	6.1
17.2	8.6	5.6	17.2	8.6	6
17.6	8.8	5.5	17.6	8.8	5.9
18	9	5.4	18	9	5.7
18.4	9.2	5.3	18.4	9.2	5.6
18.8	9.4	5.2	18.8	9.4	5.5
19.2	9.6	5.1	19.2	9.6	5.4
19.6	9.8	5.1	19.6	9.8	5.2
20	10	5	20	10	5.1
20.4	10.2	5	20.4	10.2	5.1
20.8	10.4	4.9	20.8	10.4	5
21.2	10.6	4.8	21.2	10.6	4.9
21.6	10.8	4.8	21.6	10.8	4.9
22	11	4.8	22	11	4.8
22.4	11.2	4.7	22.4	11.2	4.7
22.8	11.4	4.7	22.8	11.4	4.7
23.2	11.6	4.6	23.2	11.6	4.6
23.6	11.8	4.6	23.6	11.8	4.6
24	12	4.5	24	12	4.5
24.4	12.2	4.5	24.4	12.2	4.5
24.8	12.4	4.7	24.8	12.4	4.4
25.2	12.6	4.7	25.2	12.6	4.4
25.6	12.8	4.6	25.6	12.8	4.3
26	13	4.6	26	13	4.3
26.4	13.2	4.5	26.4	13.2	4.2
26.8	13.4	4.4	26.8	13.4	4.2
27.2	13.6	4.4	27.2	13.6	4.1
27.6	13.8	4.3	27.6	13.8	4.1
28	14	4.2	28	14	4
28.4	14.2	4.2	28.4	14.2	4
28.8	14.4	4.1	28.8	14.4	3.9
29.2	14.6	4.1	29.2	14.6	3.9
29.6	14.8	4.1	29.6	14.8	3.8
30	15	4	30	15	3.8
30.4	15.2	4	30.4	15.2	3.7
30.8	15.4	3.9	30.8	15.4	3.7
31.2	15.6	3.9	31.2	15.6	3.6
31.6	15.8	3.8	31.6	15.8	3.6
32	16	3.8	32	16	3.5
32.4	16.2	3.8	32.4	16.2	3.5
32.8	16.4	3.7	32.8	16.4	3.5
33.2	16.6	3.7	33.2	16.6	3.4
33.6	16.8	3.7	33.6	16.8	3.4
34	17	3.6	34	17	3.3
34.4	17.2	3.6	34.4	17.2	3.3
34.8	17.4	3.6	34.8	17.4	3.3
35.2	17.6	3.5	35.2	17.6	3.3
35.6	17.8	3.5	35.6	17.8	3.2
36	18	3.4	36	18	3.2
36.4	18.2	3.4	36.4	18.2	3.2
36.8	18.4	3.4	36.8	18.4	3.2
37.2	18.6	3.4	37.2	18.6	3.1
37.6	18.8	3.3	37.6	18.8	3.1
38	19	3.3	38	19	3
38.4	19.2	3.3			
38.8	19.4	3.2			
39.2	19.6	3.2			
39.6	19.8	3.2			
40	20	3.1			
40.4	20.2	3.1			
40.8	20.4	3.1			
41.2	20.6	3			
41.6	20.8	3			

5.12 Appendix 5.12: GIDJI TSF Hydrological Review



KCGM

Hydrogeological Review of The Gidji TSFs



Report Status

Revision	Date	Signature
<i>Rev A (draft)</i>	<i>January 2019</i>	
<i>Rev 0 (Final)</i>	<i>January 2019</i>	<i>B. Bennett</i>



EXECUTIVE SUMMARY

Kalgoorlie Consolidated Gold Mines Pty Ltd (KCGM) manages the mining and ore processing operations at the Fimiston Gold Mine Operations, located adjacent to the City of Kalgoorlie-Boulder in the Eastern Goldfields Region of Western Australia. KCGM is the management company for the mining operations and is owned by Newmont Australia Pty Ltd and Barrick (Australia Pacific) Pty Limited. KCGM was formed in 1989 by the amalgamation of multiple individual mining leases hosting several small open pit and underground mining operations along Kalgoorlie's Mt Percy, Mt Charlotte and Golden Mile orebodies.

Gold ore from KCGM's mining operations is processed at the Fimiston Processing Plant which is located on the eastern side of the Fimiston Open Pit (Figure 1). High sulphide concentrate is processed at the Gidji Processing Plant, located around 20 km north of Kalgoorlie Boulder (Figure 1). Tailings from the Gidji Processing Plant have been deposited in the unlined Gidji I TSF, and the lined Gidji II TSF. A third facility, the Gidji III TSF is currently being designed and permitted and will include lined cells.

Monitoring and recovery of seepage from the formations below the Gidji TSFs have been undertaken since 1995. KCGM has requested that Big Dog Hydrogeology Pty Ltd (BDH) review the current performance of seepage recovery and monitoring at the Gidji TSFs and provide updated recommendations for ongoing management of the tailings storage facilities during both operations and closure. The results of the hydrogeological review and resulting recommendations for ongoing groundwater management are provided in this report.

Seepage from the unlined Gidji I TSF has been managed during the operating period by operating the Gidji Trench and up to 28 production bores to remove seepage and groundwater and to control groundwater depths around the TSF. Operation of the trench and bores at average rates up to 6 L/s has successfully managed groundwater depths outside the operational footprint of the facilities, and for the 16 monitoring bores currently defined as compliance locations, groundwater depth has been greater than the current compliance limit of 4 m from 1999 to 2018.

From 2012 to 2018 average annual total pumping has reduced from 4.2 L/s to around 0.7 L/s. This response was predicted and is due to groundwater elevations approaching the base of the transmissive portion of the ferricrete and alluvial sediment groundwater system, which significantly reduces the flow rate available from each production bore. Rising groundwater elevations around the Gidji TSFs in 2017 and 2018 are attributed to precipitation driven recharge from surface, and in particular to precipitation events occurring in February 2017, February 2018 and October 2018. The existing pumping system has been demonstrated to be capable of managing groundwater depths during ongoing draindown of the Gidji I TSF and during any future precipitation driven recharge events, which would cause the total pumping rate from the bores to be increased.

Hydrochemical monitoring data are consistent with background groundwater being present prior to TSF operation, having a naturally low pH of around 3 in most locations, having TDS concentrations around 50,000 mg/L and having negligible CN concentrations. Operation of the unlined cells in the Gidji I TSF since 1989 has resulted in seepage of decant water entering the groundwater system, with seepage influences reducing after the cells were permanently decommissioned in 2015. TDS concentrations in groundwater are most diagnostic of seepage influences as they are not expected to be affected by attenuation during flow through the groundwater system. The influence of seepage can also be discerned in groundwater pH, groundwater EC, in concentrations of total CN, WAD CN, free CN, and in filterable concentrations of Cu and Co.

As the groundwater mound beneath the Gidji I TSF continues to decline, groundwater hydraulic gradients outside the area of the production bores will act away from the TSF, and some further changes in hydrochemistry can be expected due to the migration of residual seepage emplaced during the operating period. The recent increase in TDS concentrations at MB R25, and the recent increases in CN concentrations at MB R07, MB R14 and MB R25 are attributed to this influence.

Based on the current review of monitoring data it is concluded that:

1. The groundwater monitoring regime required for compliance with licence L5946/1988/13 provides sufficient data to identify groundwater flow directions and the influences of TSF seepage on groundwater hydrochemistry and should be continued.
2. The interpretation monitoring undertaken by KCGM provides a detailed understanding of recharge processes and controls on groundwater hydrochemistry and should be continued.
3. No additions to the compliance or interpretation monitoring are required.
4. The existing pumping system is sufficient to manage groundwater depths as the groundwater mound below the Gidji I TSF continues to decay.
5. No changes to the existing monitoring regime are required to manage ongoing deposition in the Gidji II TSF.

It is recommended that during construction of the Gidji III TSF, three additional monitoring bores be installed to the northeast of the facility, for the combined purposes of 1) investigating whether a groundwater system is present in this area; 2) providing monitoring data to confirm that the lined cells in the Gidji III TSF perform as designed, and do not result in significant rates of seepage to groundwater; and 3) monitoring any potential influences of residual seepage from the Gidji I TSF if they are found to extend this far from the facility.

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Appendix A DWER licence L5946/1988/13

Appendix B Long term hydrographs

Appendix C Time series groundwater hydrochemistry

1. Introduction

1.1 Background

Kalgoorlie Consolidated Gold Mines Pty Ltd (KCGM) manages the mining and ore processing operations at the Fimiston Gold Mine Operations, located adjacent to the City of Kalgoorlie-Boulder in the Eastern Goldfields Region of Western Australia. KCGM is the management company for the mining operations and is owned by Newmont Australia Pty Ltd and Barrick (Australia Pacific) Pty Limited. KCGM was formed in 1989 by the amalgamation of multiple individual mining leases hosting several small open pit and underground mining operations along Kalgoorlie's Mt Percy, Mt Charlotte and Golden Mile orebodies.

Gold ore from KCGM's mining operations is processed at the Fimiston Processing Plant which is located on the eastern side of the Fimiston Open Pit (Figure 1). Tailings from the Fimiston Processing Plant are currently deposited in the Fimiston I, Fimiston II and Kaltails Tailings Storage Facilities (TSFs) as marked in Figure 1. High sulphide concentrate is processed at the Gidji Processing Plant, located around 20 km north of Kalgoorlie Boulder (Figure 1). When commissioned in 1989, the process in the Gidji Processing Plant included a roasting component, before extracting the gold and depositing the tailings in the Gidji I TSF (see Figure 2 for detail of the Gidji TSFs). Subsequently, as a result of the KCGM Emissions Reduction Project, roasting was discontinued and replaced with an ultrafine grinding circuit, with the resulting tailings placed in the Gidji II TSF. The proposed Gidji III TSF indicated in Figure 2 is currently being designed and permitted and will receive tailings from the ultrafine grinding circuit.

Monitoring and recovery of seepage from the formations below the Gidji TSFs have been undertaken since 1995. The performance of the seepage recovery system is regularly summarised and reported by KCGM, and an independent review of the monitoring and management of seepage was most recently undertaken in 2015 (PCA, 2015). KCGM has requested that Big Dog Hydrogeology Pty Ltd (BDH) review the current performance of seepage recovery and monitoring at the Gidji TSFs and provide updated recommendations for ongoing management of the tailings storage facilities during both operations and closure. The results of the hydrogeological review and resulting recommendations for ongoing groundwater management are provided in this report.

1.2 Licensing

The operation of the Gidji Processing Plant and associated TSFs is governed by Prescribed Premises Licence L5946/1988/13 which was most recently issued by the Department of Water and Environmental Regulation (DWER) in October 2016, and is reproduced in Appendix A. Conditions for the management and monitoring of seepage from the Gidji TSFs included in the licence are summarised as:

1. Samples must be collected annually from the Gidji Trench and the Gidji Return Dam (decant pond) and analysed for pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS), and cyanide (CN) in the forms of total, free, and Weak Acid Dissociable (WAD).
2. Depth to groundwater must be measured in compliance monitoring bores and operational area monitoring bores quarterly.
3. Depth to groundwater must be maintained greater than 4 m at compliance monitoring bores.
4. Operational area and compliance monitoring bores must be monitored six monthly for pH and EC, and annually for TDS, total CN, free CN and WAD CN.
5. Summaries of groundwater monitoring results must be provided to DWER quarterly.
6. Monitoring results must be summarised in the Annual Environmental Report (AER) submitted to DWER.

The objective of applying a compliance limit of 4 m for groundwater depth at compliance monitoring bores in licence L5946/1988/13 is to ensure that hypersaline groundwater does not rise into the potential root zone for vegetation downgradient of the TSFs.

1.3 Objectives of review

Specific objectives for the hydrogeological review of the Gidji TSFs over the remaining Life Of Mine (LOM) by BDH were agreed with KCGM to be:

1. Confirm whether groundwater elevation and groundwater chemistry monitoring data continue to support the interpretation of hydrogeological conditions compiled in 2015 (PCA, 2015).
2. Investigate whether the installed seepage pumping system remains appropriate for the management of seepage from the TSFs.
3. Identify whether the current groundwater monitoring regime remains appropriate for the definition and management of groundwater conditions around the TSFs.
4. Determine whether any changes to the monitoring regime are required for the management of the proposed Gidji III TSF.
5. Determine whether the current understanding and modelling of groundwater conditions in closure remains valid.

1.4 Relevant preceding study

The study most relevant to the understanding of the hydrogeological regime at the Gidji TSFs comprises a review undertaken in 2015 (PCA, 2015). Components of this review and key conclusions were:

1. Geological, hydrogeological, hydrochemical and operational data for the TSFs were compiled and reviewed.
2. The KCGM approach to managing seepage from the TSFs (operation of production bores) was concluded to be effective and to have sufficient capacity to continue to be effective in managing groundwater depths to ensure they remained below the compliance limit set in licence L5946/1988/13.
3. The groundwater monitoring regime was concluded to be providing appropriate data for the management of the TSFs and no changes were recommended.
4. A numerical model of groundwater responses to TSF seepage was constructed and calibrated. The model predicted a rapid decay in total pumping rates within two years of terminating deposition at Gidji I, and a continuing gradual decline in the groundwater mound to the north, east and south of the Gidji I TSF, with minor reduction in groundwater levels to the west.

The description of the Gidji TSF hydrogeology provided in the 2015 review has been used as the basis for the current study, and the available groundwater monitoring data have been reviewed to confirm that the conceptual and numerical models developed and described in the 2015 study remain valid.

2. Gidji operations and hydrogeological setting

2.1 Gidji TSF operational history

The Gidji I TSF comprises two unlined tailings storage cells (Figure 2) and was commissioned in 1989 to store tailings generated from the processing of concentrate in the Gidji Processing Plant. Tailings have been discharged to the TSF as a slurry containing around 50% by weight of finely ground rock particles. The liquid portion of the slurry comprises hypersaline water derived from remote water supply borefields and includes residual chemicals from ore processing, including lime and cyanide. Excess water within the tailings cells (decant water) has been removed from the TSF via the Gidji Return Dam and returned to the mine water management circuit.

Two new tailings storage cells, referred to as the Gidji II TSF, were constructed to the northwest of the Gidji I TSF in 2011 and 2013 (Figure 2). The Gidji II TSF was constructed with a composite HDPE and compacted clay liner below the cells, in order to minimise seepage from the saturated tailings cells into the underlying geological formations.

A further two cells are planned for construction to the northeast of the Gidji I TSF (referred to as the Gidji III TSF as indicated in Figure 2). The Gidji III TSF is planned to be constructed with a composite HDPE and compacted clay liner below the tailings storage cells, in order to minimise seepage from the saturated tailings cells into the underlying geological formations.

Since commissioning of the Gidji I TSF in 1989, tailings have been deposited to the two cells (referred to as Gidji I west and Gidji I east) on a rotational schedule, with each cell being used for several months at a time, before being left for the tailings to consolidate and dry out. Deposition into the Gidji I west cell stopped in May 2012, and deposition to the Gidji I east cell stopped in August 2013, with deposition to the Gidji II TSF commencing in 2012.

During 2015, tailings deposition was temporarily restarted in the Gidji I TSF, with deposition in that facility subsequently being permanently terminated by August 2015. Since August 2015, all tailings deposition has been to the lined Gidji II TSF.

2.2 Gidji TSF seepage recovery

Operation of the unlined cells in the Gidji I TSF has allowed some tailings water to seep into the shallow formations underlying the facility. Prior to 1999, seepage was recovered by the operation of a production bore (PB R01) and the Gidji Trench, both of which were commissioned in 1994. Subsequently the volume of seepage recovery was increased by the addition of five production bores in 1999, the addition of 13 production bores in 2000 and the addition of nine production bores in 2003. All of the production bores are equipped with low flow air displacement pumps which operate continuously to extract the maximum possible volume from each bore. A total of 28 production bores have been installed, located as marked in Figure 3, with four of those production bores subsequently decommissioned (PB R13, PB R14, PB R15 and PB R16) during the construction of the Gidji II TSF.

Groundwater depths and groundwater chemistry have been monitored in a total of 35 monitoring bores surrounding the Gidji TSFs, located as marked in Figure 3. Six of those monitoring bores (MB R04, MB R05, MB R11, MB R17, MB R18 and MB R31) have been subsequently decommissioned during the operating period.

Total annual seepage recovery volumes from 1995 to 2018 are plotted in Figure 4. These annual totals do not include flow from the Gidji Trench which is not metered. However seepage rates to the trench are low and have been estimated to be less than 0.1 L/s (PCA, 2015). Annual recovery volumes peaked at 156,000 m³ in 2006, equivalent to an average pumping rate for the year of 4.9 L/s. Recovery volumes were relatively low (equivalent to around 0.5 L/s) from 1994 to 1999 when PB R01 and the seepage trench were being operated and increased significantly in 1999 with the addition of new production bores. Annual seepage production declined from 135,000 m³ in 2012 (equivalent to 4.2 L/s) to 21,000 m³ in 2018 (equivalent to 0.7 L/s), due to lowered groundwater levels reducing the available yield from each production bore.

Figure 4 includes the estimated annual tailings deposition to the Gidji I TSF where records are available, along with annual precipitation totals measured at the Kalgoorlie Boulder airport. There appears to be no correlation between annual precipitation and seepage pumping volumes, whereas seepage pumping volumes clearly reduced rapidly in 2014 and 2016, which were the periods following tailings deposition terminating in the Gidji I TSF.

2.3 Rainfall and evaporation

Climate data recorded at the Kalgoorlie Boulder Airport Station collected by the Australian Bureau of Meteorology (BoM) provide the primary source to characterise the local climate for the Gidji facilities. The station is located around 20 km south of the Gidji operations and daily climate records are available from 1939 up to the current date. Annual rainfall at Kalgoorlie over the period of recording has ranged from 109 mm in 1940 to 531 mm in 1992, with a long term average of 268 mm. Annual evaporation greatly exceeds precipitation and averages around 2,600 mm.

Table 1 provides annual precipitation totals recorded during the period of operation of the Gidji TSFs from 1989 to 2018 and compares the annual totals against the long term average. Annual precipitation was highest in 1992 (531 mm), and lowest in 1991 (164 mm). Since the Gidji I TSF was permanently decommissioned in 2015, annual precipitation has been close to average.

Table 1: Annual precipitation totals

Year	Annual Precipitation (mm)	Compared to Long Term Average
1989	180.6	67%
1990	299.6	112%
1991	163.8	61%
1992	530.8	198%
1993	326.2	122%
1994	245	91%
1995	480	179%
1996	235.2	88%
1997	245.4	92%
1998	313.4	117%
1999	384.8	144%
2000	446	167%
2001	226	84%
2002	188.2	70%
2003	318.6	119%
2004	279.6	104%
2005	170.2	64%
2006	190.2	71%
2007	196.6	73%
2008	266.6	100%
2009	254	95%
2010	165.4	62%
2011	389.4	145%
2012	240.6	90%
2013	367.8	137%
2014	359.2	134%
2015	233.6	87%
2016	313.2	117%
2017	256.8	96%
2018	233.6	87%

2.4 Topography and surface water hydrology

Ground surface at the Gidji facilities slopes downwards to the west, towards a chain of salt lakes as indicated in Figure 1, which includes Gidji Lake. The drainage divide lies around 2 km east of the Gidji facilities. There are no defined drainage channels near the Gidji facilities, and runoff occurs as overland sheet flow following relatively rare large precipitation events.

2.5 Hydrogeology

Regional geological conditions around the Gidji site are well understood from public domain mapping and resource investigation undertaken by KCGM. Bedrock underlying the Gidji facilities is broadly mapped as sedimentary, felsic volcanic and volcanoclastic rocks. The shallow geological conditions immediately underlying the Gidji facilities are well defined from geotechnical and hydrogeological investigation drilling undertaken during the construction and management of the facilities and comprise Cainozoic sedimentary deposits overlying weathered bedrock.

There are three major groundwater transmitting systems recognised in the Eastern Goldfields region of Western Australia, which are potentially relevant to the hydrogeology of the Gidji facilities, and these comprise:

1. Palaeochannel systems; a localised but extensive network of alluvial sands of Tertiary age occurring at up to 60 m depth (referred to as the Wollubar Sandstone). As mapped in Figure 1, the Kunanalling tributary of the Yindarlgooda North palaeochannel is known to be present around 1 km to the west of the Gidji facilities. The sand unit within this channel is exploited by KCGM as a process water supply, via the Northern Borefield which is located as illustrated in Figure 1. Monitoring of the Northern Borefield has confirmed that groundwater is supplied as leakage from the formations underlying and overlying the Wollubar Sandstone as well as from storage within the sands. The Wollubar Sandstone is overlain by a stiff, plastic clay referred to as the Perkolilli Shale, which has a very low hydraulic conductivity, and results in the sands being confined prior to borefield operation. A review of the performance of the Northern Borefield using data to the end of 2017 identified that the Kunanalling tributary remains confined, (the groundwater elevation as measured in the Wollubar Sandstone is above the top of the Wollubar Sandstone) despite the operation of the Northern Borefield at total rates between 20 and 110 L/s over the period 1985 to 2017 (BDH, 2018). The extent and properties of the paleochannel groundwater system are well understood from regional groundwater exploration programs and investigations undertaken by government agencies (e.g. Commander et al, 1992).
2. The ferricrete and alluvial sediment groundwater system; comprising sand, gravel and fractured ferricrete within clay deposits, typically occurring between 5 and 40 metres below ground level in well-developed surface drainages in the Eastern Goldfields and overlying the bedrock. A thin layer of this unit is present below the Gidji TSFs and this the unit targeted by the production bores for seepage recovery.
3. The bedrock groundwater system; where groundwater flow potentially occurs in fractured and weathered zones within the basement rocks at depth. This groundwater system occurs in discrete locations in the Eastern Goldfields, usually associated with structural dislocation which occurs at the orebodies and is not expected to be present below the Gidji TSFs.

Locally the sedimentary sequence below the Gidji TSFs comprises, from surface downwards:

- A surficial layer of alluvium and colluvium up to 2 m thick, comprising red-brown clayey silt and sand, potentially including calcrete developed in some locations.
- Dense, red-brown clay and sandy clay, with a thickness of 2 to 3 m.

- A layer of clay, sand and gravel, up to 5 m thick. This unit often contains very hard bands or nodules of indurated ferricrete. This geological unit equates to the ferricrete and alluvial groundwater system as described above. Groundwater transmission typically occurs with fractures and solution cavities formed within the indurated ferricrete. This unit has been reported to be best developed along the southwest of the Gidji I TSF and is also present along the northwest of the Gidji I TSF. It is reported to be thin or absent to the east of the Gidji I TSF.
- Laminated, multicoloured clays which may contain small amounts of clay or gravel.

The hydraulic conductivity of most of the sedimentary units below the Gidji TSFs is low, however the ferricrete and alluvial sediment groundwater system has sufficient hydraulic conductivity to allow the transmission of seepage and groundwater at low rates. This unit has been identified as the only significant groundwater transmitting and producing unit near the Gidji TSFs.

The locations of the Northern Borefield production bores and monitoring bores which are closest to the Gidji TSFs are illustrated in Figure 5. Figure 6 reproduces a hydrogeological cross section constructed along the location indicated in Figure 5. Figure 6 illustrates that the shallow ferricrete and alluvial groundwater system below the Gidji TSFs is a completely separate groundwater system to the deep Wollubar Sandstone in the Northern Borefield, being offset to the east, and being vertically separated by the Perkolilli Shale which has a low hydraulic conductivity.

Production and monitoring bores in the Northern Borefield are typically screened in the Wollubar Sandstone below 35 m Below Ground Level (mBGL) (production bore G1 in Figure 5 is screened from 43 to 49 mBGL, and production bore MP1 in Figure 5 is screened from 40.3 to 49.6 mBGL). Depth to groundwater in monitoring bore GL3 in Figure 5 is currently around 20 mBGL. In contrast, production bores to the west of the Gidji I TSF are screened typically to around 20 mBGL, and monitoring bores to the west of the Gidji I TSF currently have groundwater depths around 7 mBGL.

As there are no groundwater monitoring bores that were installed at the Gidji TSFs prior to tailings deposition, it is unclear whether shallow groundwater was present prior to the operation of the Gidji I TSF, or whether the current saturation of the ferricrete and alluvial sediments has been driven primarily by seepage.

3. Review of groundwater depths and elevations

3.1 Data collection, quality control and compliance limits

The measurement of groundwater depth has been undertaken generally on a monthly basis in all monitoring bores around the Gidji TSFs, which exceeds the minimum monitoring frequency of quarterly required in licence L5946/1988/13 and provides an extensive dataset defining groundwater depth trends. The collar elevation has been accurately surveyed for all monitoring bores allowing groundwater depths to be converted to groundwater elevations. Groundwater depth is not recorded in the production bores as it is strongly influenced by the cycling of the installed pumps.

Quality control of monitoring bore groundwater depths has been achieved by comparing reported depths against the casing depth, and by plotting data against time to identify anomalous points. In general, the groundwater depth data are indicated to be suitably reliable for interpretation. A few suspect measurements have been disregarded during interpretation, and these include:

- A number of measurements made in 2005 which are anomalously shallow.
- A number of measurements made in MB R06s, where the groundwater depth was equivalent to the base of the casing. This bore is screened to 8 mBGL and is affected by the operation of adjacent production bores causing it to sometimes go dry. In some periods, groundwater depth measurements reflect a small amount of water perched in the base of the casing, and do not reflect the groundwater level in the surrounding groundwater system.
- An anomalously shallow groundwater depth in MB R24 in 2013.
- An anomalously shallow groundwater depth in MB R10 in 2006.
- Groundwater depth measurements in MB R02 and MB R03 in October 2015, which appear to have been switched between the bores.

Licence L5946/1988/13 defines a compliance limit for groundwater depth below surface of 4 m. This limit applies only to 16 monitoring bores defined as compliance bores, which are currently MB R07, MB R08, MB R13 to MB R15, MB R19 to MB R28, and MB R34.

3.2 Groundwater depth trends

Appendix B provides long term groundwater depth hydrographs for all monitoring bores over the entire monitoring period (starting in 1999), while Figures 7 to 11 provide more detail of the recent trends (from 2008 to 2018). In each case:

1. The bores have been grouped into western monitoring bores, trench monitoring bores, decant monitoring bores, and eastern monitoring bores. This grouping is included in Figure 3 and is based on previous observations that the bores in each of these areas exhibit common responses (PCA, 2015). For example the eastern monitoring bores, which are located in areas where no ferricrete is present, demonstrate larger changes in groundwater depths (90th percentile range of 4.7 m), compared to the western monitoring bores intersecting ferricrete (which have a 90th percentile range of 1.8 m). The grouping of monitoring bores in each plot allows common trends across each area to be recognised and allows discrete localised variations in groundwater depth to be discounted.
2. Monitoring data are plotted as depth below surface. As the objective of the seepage management system is to ensure that the hypersaline groundwater does not approach the potential root zone of downgradient variation, this provides a direct indication of the success of the groundwater management program.

3. For plots which include monitoring bores currently defined in licence L5946/1988/13 as compliance bores, the compliance bores are plotted using symbols for each monitoring point, while the remaining bores (defined as operational area bores) are plotted as continuous lines.
4. For plots which include compliance monitoring bores, the licence compliance limit of 4 m is plotted for comparison with depths measured in these bores.
5. Total monthly average pumping rates are included in each plot, to investigate the relationship between groundwater depths and borefield operation.
6. Monthly precipitation totals measured at the Kalgoorlie Boulder airport are included to investigate any relationship between recharge events and groundwater depths.
7. Key milestones for changes in tailings deposition at the Gidji I TSF are annotated in the plots for reference and comparison.

Observations from the groundwater depth hydrographs in Appendix B and Figures 7 to 11 are:

- For all of the compliance monitoring bores, groundwater depth has been below the current licence compliance limit of 4 mBGL throughout the monitoring period from 1991 to present. In November 2018, the shallowest groundwater depth in any compliance bore was 6.53 m at MB R26.
- The trends discussed in the 2015 review (PCA, 2015) remain apparent, and include:
 - ▶ Shallow groundwater depths when monitoring commenced in 1999.
 - ▶ Increasing groundwater depths from 1999 to 2003 associated with total pumping being increased from 0.5 L/s to around 5 L/s.
 - ▶ Gradually increasing groundwater depths from 2003 to 2008, and slightly decreasing groundwater depths from 2008 to 2013, in response to the overall balance between tailings deposition, seepage and total pumping.
 - ▶ Short term cycling of groundwater depth related to deposition cycles in the Gidji I TSF cells or to the operation of nearby production bores.
 - ▶ No strong correlation between short term changes in groundwater depths and precipitation patterns prior to 2017.
 - ▶ Much larger changes in groundwater depths in the eastern monitoring bores compared to the western monitoring bores.
- Trends in groundwater depths and pumping rates since 2013 which are evident from the data to 2018 (Figures 7 to 11) are:
 - ▶ Monthly total pumping reduced by around 50% during the 12 months following stopping tailings deposition in the Gidji I TSF in 2013, remained stable for the 12 months following restarting deposition in 2014, and reduced by a further 50% in the 12 months following final decommissioning of the Gidji I TSF in 2015. These trends confirm a direct link between total pumping and deposition in the Gidji I TSF. In the period of tailings deposition in the Gidji II TSF from 2016 to 2018, total pumping has averaged 0.8 L/s, due to the increasing groundwater depths around the production bores.
 - ▶ For the trench monitoring bores and decant monitoring bores, strongly increasing groundwater depths are observed from 2013 to 2018, with the largest increases in groundwater depths being 6 m at MB R09 and 8 m at MB R10.
 - ▶ For the western monitoring bores, groundwater depths increased from 2013 to January 2017, decreased in early 2017, and then increased again to 2018.
 - ▶ For the eastern monitoring bores, groundwater depths increased to January 2017, and then decreased on average from 2017 to 2018.

- ▶ Nearly all of the monitoring bores appear to show changes in groundwater depths due to recharge associated with precipitation events in February 2017, February 2018 and October 2018. This response is unusual compared to the responses prior to 2017. However the responses are consistent with observations from other KCGM borefields, which confirm that the magnitude and spacing of individual precipitation events in the Kalgoorlie region in those periods was conducive to unusually high rates of recharge. In February 2017, this resulted from several close spaced daily precipitation totals of around 30 mm, which resulted in 158 mm of precipitation occurring over two weeks. In February 2018, this resulted from multiple small daily events which resulted in around 95 mm of precipitation occurring over a six week period. In October 2018, this resulted from multiple small daily events which resulted in 133 mm of precipitation occurring over a six week period.
- ▶ As a result of the combined influences of tailings deposition in the Gidji I TSF to 2013, terminating deposition in 2013 and 2015, and the three significant recharge events, in most of the monitoring bores it is noted that:
 - Groundwater depths were close to their lowest (ie groundwater elevations were close to highest) in August 2013.
 - Groundwater depths were close to their greatest (ie groundwater elevations were close to their lowest) in January 2017.
 - Groundwater depths had recovered slightly (ie groundwater elevations had risen slightly) in November 2018.

3.3 Groundwater depth in 2018

Figure 12 provides a colour shaded contour map of depth to groundwater from surface in November 2018, using data available from the monitoring bores. Interpolation of groundwater depth has been achieved by:

1. Converting the groundwater depth at each bore to a groundwater elevation.
2. Contouring a smoothly varying groundwater elevation surface between the bores (Figure 13).
3. Subtracting the groundwater elevation surface from the current topographic surface defined from survey data provided by KCGM.
4. Contouring the differences between the two surfaces.

This approach provides the most reliable interpretation of groundwater depth, as it takes account of any depressions or hills in the natural surface that occur between the monitoring bores. Figure 12 illustrates that groundwater is generally around 6 to 8 m below surface to the west and southwest of the Gidji TSFs, increasing to more than 15 m below surface to the east and north. The shallowest groundwater occurs within the operational area for the TSFs, in the eastern corner of the Gidji I TSF. Locally slightly shallower groundwater is indicated near MB R32 to the northwest of the Gidji II TSF, and near the production bores to the south of the Gidji I TSF. In each case these local variations result from natural depressions in the ground surface defined from the ground survey data. In all locations outside the operational footprint, groundwater remained safely below the compliance limit of 4 mBGL in November 2018.

3.4 Groundwater elevations

Groundwater depths measured in the monitoring bores in November 2018 have been converted to groundwater elevation using the surveyed bore collar and have been contoured in Figure 13. Groundwater elevations range from 342 mAHD close to the Gidji I TSF in the east, to 337 mAHD in the west, and to 330 mAHD in the south, east and north. Residual mounding associated with TSF seepage is clearly evident in the contours which illustrate a radial pattern around the Gidji I TSF. Relatively steep hydraulic gradients are indicated by the close spaced contours to the north, east and south of the Gidji TSFs, while low hydraulic gradients are contoured to the west, consistent with higher hydraulic conductivity conditions in the west. These trends are consistent with groundwater elevations contoured throughout the operating periods for the Gidji TSFs, and the low hydraulic gradients to the west correlate with the presence of higher hydraulic conductivity ferricrete within the ferricrete and alluvial sediment groundwater system.

Figures 14 and 15 provide groundwater elevation contours for August 2013 (highest groundwater elevations in recent years) and for January 2017 (lowest groundwater elevations in recent years). In each case the shape of the contours is very similar to those for November 2018, demonstrating the influence of groundwater mounding near the Gidji I TSF, and confirming that low hydraulic gradients consistently are observed to the west. However the actual groundwater elevations are generally higher in 2013 compared to 2018, and slightly lower in 2017 compared to 2018.

3.5 Recent changes in groundwater elevations

Groundwater elevations were at their highest in recent years in August 2013 and at their lowest in January 2017. The change in groundwater elevations between these dates has been interpolated by subtracting the contours in Figure 15 from those in Figure 14. The resulting change in groundwater elevations is presented in Figure 16. Blue and green shaded areas reflect a lowering of groundwater elevations, while yellow and red shading reflects a rise in groundwater elevations. In all locations where monitoring bores are available to control the interpretation, groundwater elevations reduced from 2013 to 2017. The magnitude of the change was around 0.5 to 1 m in the west, and around 2 to 5 m in the north, east and south. These significant changes in groundwater elevations, despite a reduction in total pumping, reflect the rapid response of the groundwater system to terminating tailings deposition in the Gidji I TSF.

Figure 17 provides colour shaded contours for the changes in groundwater elevations from 2013 to 2018. In the areas where monitoring bores are available to control the interpretation, groundwater elevations also reduced between 2013 and 2018. In the west, the magnitude of the reduction was comparable with that in 2017. In the north, east and south, the reduction in groundwater elevations was smaller compared to those in 2017.

Figure 18 investigates the changes in groundwater elevations between January 2017 and November 2018. In locations close to the Gidji TSFs, and near the production bores, groundwater elevations mostly reduced from 2017 to 2018 (green shading). More distant from the Gidji TSFs, groundwater elevations rose by around 0.2 m in the west, and by between 1 and 3 m in the north, east and south (yellow and orange shading). This distribution of responses, with large changes distant from the Gidji TSFs, and slight reductions near the Gidji TSFs, confirms that the changes from 2017 to 2018 are related to precipitation recharge, and not to the occurrence of TSF seepage.

3.6 Conclusions regarding groundwater depth management

Seepage from the unlined Gidji I TSF has been managed during the operating period by operating the Gidji Trench and up to 28 production bores to remove seepage and groundwater and to control groundwater depths around the TSF. Operation of the trench and bores at monthly average total rates up to 6 L/s has successfully managed groundwater depths outside the operational footprint of the facilities, and for the 16 monitoring bores currently defined as compliance locations, groundwater depth has been greater than the current compliance limit of 4 m from 1999 to 2018.

From 2014 to 2018 total annual average pumping has reduced from around 4 L/s to around 0.5 L/s. This response was expected and predicted (PCA, 2015), and is due to groundwater elevations approaching the base of the transmissive portion of the ferricrete and alluvial sediment groundwater system, which significantly reduces the flow rate available from each production bore. The lowering of groundwater elevations is a direct response to the termination of tailings deposition in the Gidji I TSF, with all deposition now occurring in the lined Gidji II TSF. Contouring of groundwater elevations confirms that groundwater mounding remains present around the Gidji I TSF, and this mound will continue to be removed by ongoing pumping at low rates.

Rising groundwater elevations around the Gidji TSFs in 2017 and 2018 are attributed to precipitation driven recharge from surface, and in particular to precipitation events occurring in February 2017, February 2018 and October 2018. This inferred source is confirmed by the distribution of the observed changes in groundwater elevations, which are larger distant from the TSFs and smaller close to the TSFs.

The existing pumping system has been demonstrated to be capable of managing groundwater depths during ongoing draindown of the Gidji I TSF and during any future precipitation driven recharge events, which would cause the total pumping rate from the bores to be increased.

4. Review of groundwater chemistry

4.1 Data collection and quality control

As described in Section 1.2, the minimum requirements for hydrochemical data collection are defined in licence L5946/1988/13 and include the collection of samples from the Gidji Trench, the Gidji Return Dam, the operational area bores and the compliance monitoring bores, with samples analysed for pH, EC, TDS, WAD CN, total CN and free CN.

In addition, KCGM have undertaken in the past and in some cases continue to undertake interpretation hydrochemical monitoring, including:

- Field measurement of pH and EC in production bores and monitoring bores.
- Periodically sampling production bores and analysing for a range of major ions and metals.
- Periodically sampling all monitoring bores for a variable range of parameters.
- Annual sampling of compliance monitoring bores for a comprehensive suite of major ions, CN species, and filterable metals concentrations. These annual samples have been collected since the 1990s and continue to be collected.

Detailed investigations into hydrochemical data quality have not been undertaken, however time series plots of all parameters have been reviewed, and anomalous points have been investigated. These investigations have identified that the hydrochemical data are of suitable quality for interpretation, although the following data anomalies should be considered during interpretation:

- Laboratory determined TDS concentrations in some periods appear to bias very high, in particular for production bore samples in April 2008, and also on some other sampling occasions in 2006 and 2008 at both production bores and monitoring bores. These samples did not have unusually high EC or chloride concentrations, and the elevated TDS concentrations reported by the laboratory are considered suspect. These observations are consistent with monitoring data from other KCGM facilities which have identified that laboratory TDS may occasionally significantly over-report concentrations for hypersaline groundwater.
- Laboratory EC values for a number of sampling locations vary by three orders of magnitude, and it is apparent that EC units have been incorrectly converted for some samples.

4.2 Time series hydrochemical trends

4.2.1 Background

As a screening approach to investigating all available hydrochemical data, Appendix C provides time series plots for all hydrochemical analytes available from the KCGM database. Details of the plots are:

- All production bores, operational area and compliance monitoring bores have been included in the plots.
- All production bores have been combined in the same plot to allow consistent trends to be correlated. Composite plots for monitoring bores have been compiled using the same bore grouping as was identified from groundwater depth trends (western, trench, decant and eastern bores).
- The date when tailings deposition was first stopped in the Gidji TSF is marked on each graph, as this was the event which caused the greatest changes in groundwater elevations and may potentially have an influence on groundwater chemistry.
- Total monthly average pumping rates are included in each plot to investigate any correlation with hydrochemistry.

- Monthly precipitation data are included on each plot to investigate whether the influence of inferred recharge events can be discerned in groundwater chemistry.
- Laboratory results below detection have been plotted as the detection limit. Due to the long history of monitoring, and the changes in detection limits which have occurred, this may introduce some artificial variation to some plots.
- Where necessary, concentrations have been plotted at log scale to provide more detail on the changes in low concentrations.

4.2.2 Gidji I TSF decant

The Gidji Return Dam receives decant water recovered from the tailings cells in the Gidji I and Gidji II TSFs. This dam therefore provides the best indication of the hydrochemistry of seepage from the unlined Gidji I TSF cells. Under licence L5946/1988/13 the Gidji Return Dam is required to be monitored annually for TDS, pH, EC, WAD CN, total CN and free CN. Average values for these analytes calculated from data collected prior to 2014 (in the period when deposition was occurring to the Gidji I TSF) are summarised in Table 2. A spot sample was collected from the Gidji II decant water in November 2015 and was analysed for a range of filterable metals (MBS, 2016). These results are also included in Table 2 for reference. The 2015 sample from the Gidji II TSF has similar hydrochemistry to the averages for the Return Water Dam and confirms recent decant water hydrochemistry is consistent with the remainder of the operating period.

Decant water at the Gidji TSFs which potentially contributes to seepage from the unlined cells in the Gidji I TSF is characterised as having:

- High TDS concentrations, greater than 100,000 mg/L, and dominated by Na and Cl, with a significant contribution from sulphate.
- An alkaline pH averaging 9.
- Elevated EC due to the high TDS concentrations, averaging 105,000 uS/cm.
- High cyanide concentrations, averaging for 1,140 mg/L total CN, 704 mg/L for WAD CN, and 272 mg/L for free CN.
- Elevated concentrations of Co, Cu, and Fe.

Table 2: Gidji Return Dam hydrochemistry

Sample type Location	Unit	Average Gidji Return Dam 1995 to 2013	Spot Sample Gidji II TSF Decant Nov-15
Date			
pH		9	8.4
EC	uS/cm	106000	114000
TDS	mg/L	107000	NA
Ca	mg/L	1325	1095
Mg	mg/L	459	1515
Na	mg/L	32557	32280
K	mg/L	848	486
Cl	mg/L	48813	37400
Sulphate	mg/L	10273	18851
Bicarbonate	mg/L	940	1210
Nitrate	mg/L	30	NA
Total CN	mg/L	1140	1082
WAD CN	mg/L	704	555
Free CN	mg/L	272	78
Filterable Al	mg/L	0.56	<1
Filterable As	mg/L	0.90	0.08
Filterable Cd	mg/L	0.05	<0.002
Filterable Co	mg/L	171	129.28
Filterable Cu	mg/L	426	523.8
Filterable Fe	mg/L	16	184.1
Filterable Hg	mg/L	0.10	<0.01
Filterable Mn	mg/L	0.11	<0.1
Filterable Ni	mg/L	10	18.1
Filterable Pb	mg/L	0.03	<0.05
Filterable Sb	mg/L	0.32	0.07
Filterable Se	mg/L	0.36	0.26
Filterable Zn	mg/L	0.28	<0.1

Note: NA Not analysed

4.2.3 pH

Laboratory and field measurements of pH in production bores and monitoring bores are plotted in Figures C1 to C10 in Appendix C. Comparing the equivalent plots for these parameters indicates that trends are consistent between field pH and laboratory pH, and on average laboratory pH is 0.2 to 0.5 units higher than field pH, which is consistent with changes in the level of dissolved CO₂ in the samples during transport and handling.

pH is variable with both location and time, over a large range of 3 to 8. There appears to be a trend of higher pH close to the Gidji I TSF (pH 4 to 6 at MB R06d, MB R04, MB R01), and lower pH distant from the TSF (pH 3 to 4 in most other monitoring bores), which would be consistent with the influence of high pH seepage from the TSF, however an exception is noted at MB R23 which is distant from the TSF and mostly has a neutral (high) pH.

Low groundwater pH in the range 3 to 4 is not unusual in the ferricrete and alluvial sediment groundwater system and is consistently observed at the Fimiston I and II TSFs, at the Kaltails TSF and in the Morrisons Flats area near the KCGM facilities. The low pH has been interpreted to be a natural background effect, and to result from long term ferrolysis reactions between the groundwater and the host geology.

4.2.4 TDS and EC

Figures C11 to C25 provide all the available data on field measured EC, laboratory measured EC, and laboratory determined TDS by evaporation concentrations. TDS concentrations appear to potentially be diagnostic of seepage influences and the TDS data are therefore reproduced as Figures 19 to 23 for reference. The errors in converting laboratory EC units described in Section 4.1 are evident in Figures C16 to C20, and the inferred errors in determining TDS concentrations are evident from the spikes in 2006 and 2008 in Figures 19 to 23, with these spikes not being replicated in the EC plots. Since around 2007, field EC and laboratory EC have been consistent, while prior to 2007 a larger scatter is evident between the field and laboratory datasets.

TDS concentrations at production bores have been in the range 80,000 to 140,000 mg/L, and have varied significantly during the monitoring period, potentially reflecting changes in decant water quality within the Gidji I TSF (TDS concentrations at the Gidji Return Dam have varied from 50,000 mg/L to 190,000 mg/L from 1995 to 2018). The decant and trench bores illustrate a clear trend of increasing TDS concentrations from 1995 to 2008 (Figures 21 and 22) with concentrations rising from 50,000 mg/L to around 130,000, and subsequently stabilising or declining slightly. These responses are consistent with the influence of seepage of high TDS decant water from the Gidji I TSF. TDS would be expected to be the analyte which is most diagnostic of TSF seepage influences, as TDS is significantly elevated in decant water, and is expected to be conserved during flow through the groundwater system, whereas metals and CN concentrations are expected to be affected by pH, and by hydrochemical and geochemical influences along the travel paths.

Some western monitoring bores display rising trends in TDS from 1995 to 2003, similar to the decant and trench bores, but most more distant monitoring bores have relatively consistent TDS concentrations, which range from around 50,000 mg/L in bores distant from the TSF (such as MB R28 located distant from the Gidji I TSF to the west plotted in Figure 20) to around 100,000 mg/L in bores near the TSF, such as MB R07, MB R12 and MB R14 plotted in Figure 20. No decline in TDS concentrations associated with either terminating deposition in the Gidji I TSF or the inferred recharge events in 2017 and 2018 can be discerned from the annual monitoring data.

4.2.5 Major ions

Figures C26 to C70 in Appendix C present all of the available data for concentrations of Ca, Mg, Na, K, Cl, nitrate, Si, bicarbonate and sulphate. For most analytes, there are insufficient data to define long term trends, however major ion concentrations appear relatively stable in most locations. Bicarbonate is an exception, varying over wide ranges and directly linked to changes in groundwater pH. Sulphate may have increased at production bores between 2001 and 2010, which would be consistent with the influence of the elevated sulphate in decant water, however this trend is only defined by one set of samples. There may be a trend of increasing Ca and Cl concentrations in some western and eastern monitoring bores since deposition in the Gidji I TSF terminated, but these changes are identified in only a few bores and are within the historical range of observed concentrations.

4.2.6 Cyanide

A large dataset is available for concentrations of WAD CN, free CN and total CN in production bores and monitoring bores, and all available data are plotted in Figures C71 to C85 in Appendix C. CN concentrations are highly variable with location and time, and the concentrations have therefore been plotted at a logarithmic scale in the figures. WAD CN concentrations appear to be potentially diagnostic of seepage influences and the WAD CN data are therefore reproduced in Figures 24 to 28 for reference. The trends in WAD CN and free CN are very similar in the plots, with the actual concentrations for WAD CN being slightly higher than free CN, when viewed at log scale. Total CN follows broadly the same trends as are identified in free CN and WAD CN but with some differences in trends, and with total CN being higher than WAD CN, as expected.

CN concentrations in production bores illustrate large changes associated with both short term and long term trends which may relate to varying contributions of seepage to the pumped flows. The trench and decant monitoring bores display similar CN trends to those identified for TDS. Relatively low concentrations were evident in 1995, and CN concentrations increased by a factor of 10 to 100 from 1995 to 2008 consistent with seepage influences, and then stabilised (Figures 26 and 27). Unlike TDS concentrations, the trench and decant bores demonstrate a consistent decline in CN concentrations following decommissioning of the Gidji I TSF, consistent with a declining influence from seepage.

CN concentrations have been mostly close to or below detection in the eastern monitoring bores since 2001, although occasional isolated spikes in total CN concentration occur. The western monitoring bores generally demonstrate significant but variable CN concentrations. At monitoring bores MB R07, MB R14 and MB R25 the log scale plots for the western monitoring bores in Figures 25, C77 and C82 indicate increasing CN concentrations from around 2015. These bores are all located in a similar area to the west of the Gidji I TSF. CN trends at these bores have been examined in more detail in Figure 29 and TDS trends are examined in more detail in Figure 30. In combination the time series plots identify that:

- While total CN has been variable in all three monitoring bores, a consistent increasing trend in concentrations is evident from 2015 at MB R07, from 2013 at MB R14 and from 2016 at MB R25.
- WAD CN and free CN concentrations have exhibited a broadly similar relationship to total CN over the monitoring period, and the recent trends appear to be related to an increase in the total CN, rather than to a change in the proportion of total CN which is present in WAD and free forms.
- At MB R25, distant from the Gidji I TSF, TDS concentrations have increased from 90,000 mg/L in 2014 to 115,000 mg/L in 2018, and the corresponding but delayed changes in total CN concentrations (from 0 mg/L in 2016 to 15 mg/L in 2017) would be consistent with the expansion of the seepage zone from the Gidji I TSF, driven by seepage which occurred prior to decommissioning the facility. pH has remained consistent at around 3.2 through this period at MB R25.
- At MB R07 and MB R14, TDS concentrations have been relatively consistent since 2015, while total CN concentrations have increased since 2015. At each of these bores, the rising trend in total CN concentrations coincides with and correlates with an increase in groundwater pH of around 0.5 units.
- The TDS and CN concentrations at MB R07, MB R14 and MB R25 remain within the range observed over the entire monitoring period in bores near the Gidji I TSF. The recent increases in CN concentrations at MB R25 potentially reflect a small expansion in the zone of seepage influence around the Gidji I TSF, driven by hydraulic gradients associated with the residual mounding around the TSF. The recent increases in CN concentrations at MB R07 and MB R14 potentially reflect rises in groundwater pH, as the stability and solubility of CN is strongly controlled by pH. The rises in groundwater pH may reflect a small increase in the influence of high pH seepage.

- Overall, the changes in TDS and CN concentrations at MB R07, MB R14 and MB R25 are consistent with small changes in the extent and pH of seepage to the west of the Gidji I TSF. That seepage is inferred to have been emplaced during the operating period and based on the locations of the bores and the timing of the trends, the hydrochemical trends are not consistent with any recent change in the seepage behaviour of the TSFs.

4.2.7 Filterable metals

Filterable concentrations of metals measured at production and monitoring bores around the Gidji I TSF are plotted in Figures C86 to C150 in Appendix A. In all cases the concentrations have been plotted at logarithmic scale to provide additional detail of the trends at low concentrations. Observations of metals distributions from the time series plots are:

- Filterable concentrations of Sb and Pb are generally low and close to the detection limit.
- Filterable Ni and Hg follow similar trends, being present at the production bores, western, trench and decant monitoring bores, but being absent in the eastern monitoring bores. Concentrations are generally low, and for Ni much lower than sampled in the decant water. No consistent trends with time or location are evident in the available data and the metals can not be correlated with seepage influences.
- A correlation is identified between filterable concentrations of Al and Zn and groundwater pH. MB R23 and MB R06d which mostly have a neutral pH have low concentrations of Al and Zn, while the monitoring bores with a pH around 3 have concentrations of filterable Al up to 200 mg/L and filterable Zn up to 1 mg/L. These concentrations are much higher than observed in decant water and reflect the interactions between low pH groundwater and the geology hosting the groundwater system.
- Filterable Cu concentrations demonstrate a correlation with CN concentrations which is consistent with Cu being present complexed with CN. Cu concentrations are highest at PB R01, MB R06d and MB R01, all of which have very high CN concentrations. The distribution of Cu in groundwater can be linked to seepage influences. However the recent Cu concentrations (mostly less than 1 mg/L) are significantly lower than in decant water and suggest significant attenuation occurs in flow through the groundwater system.
- Concentrations of filterable Co have been up to 100 mg/L in production bores and in monitoring bores close to the TSF, consistent with the influence of TSF seepage as the decant water also has high Co concentrations. Co would be expected to be complexed with CN, however the correlation between Co and CN is not as strong as observed for Cu.
- Disregarding a few points which potentially have been entered to the KCGM database with the wrong units, the time series plots for filterable As, Cd, Cr and Se indicate these metals are present at low but detectable concentrations, and the distribution of these metals in groundwater can not be correlated with seepage influences.
- Filterable Fe has been present in production bores and monitoring bores at up to 100 mg/L and filterable Mn has been present at up to 10 mg/L. No correlation is evident with distance from the TSF or CN concentrations, and these metals appear to be largely controlled by pH, redox conditions and interactions with the host geology, rather than seepage influences.

4.3 pH, TDS and CN distributions in 2018

Analytes which have been identified from the time series plots as having patterns consistent with seepage influences which are greatest close to the Gidji I TSF are pH, TDS and CN. Measurements for these parameters from both production bores and monitoring bores in October 2018 have been contoured in Figures 31 to 34. As some bores were not sampled in October 2018, in a few bores the value from the October 2017 sampling have been used in the contours.

With the exception of MB R23, which is distant from the Gidji I TSF and has a variable but mostly neutral pH, groundwater pH displays consistent regional trends in Figure 31, including 1) a background pH of around 3.1; and 2) a higher pH in the range 4 to 7 near the TSF driven by the influence of alkaline seepage (Gidji Return Dam water has an average pH of 9). The pH contours indicate a preferential seepage flowpath to the west of the Gidji I TSF through the locations of MB R07 and MB R14.

The groundwater TDS concentrations contoured in Figure 32 demonstrate patterns consistent with those identified for pH, but provide more detail on the seepage pathways, as TDS is not expected to be attenuated in flow through the groundwater system (compared to pH which is affected by buffering within the groundwater and CN which is affected by pH). The TDS concentrations are broadly consistent with background groundwater concentrations around 50,000 mg/L, and the influence of seepage from the Gidji I TSF occurring at greater than 100,000 mg/L. The inferred preferential pathway through the locations of MB R07 and MB R14 is clearly defined in the contours, and the residual influence of seepage is evident in TDS concentrations at MB R26, further to the west. The TDS concentrations also identify a preferential seepage flowpath to the northwest towards MB R29. The contoured TDS concentrations indicate a seepage influence on groundwater chemistry extending from the Gidji I TSF around 600 m to the west, around 400 m to the northwest, and around 300 m to the south, east and north.

The distributions of WAD CN and total CN in groundwater contoured in Figures 33 and 34 illustrate a similar seepage influence to pH and TDS, with preferential flowpaths to the west and northwest evident. The highest concentrations in groundwater are significantly lower than in decant water (total CN in groundwater up to 200 mg/L compared to an average of 1,140 mg/L in the Gidji Return Dam, WAD CN concentrations in groundwater up to 100 mg/L compared to an average of 700 mg/L in decant water), consistent with attenuation of CN in the low pH groundwater system. Total CN appears to provide a more reliable indication of seepage extent compared to WAD CN.

4.4 Conclusions regarding groundwater chemistry management

Although it is unknown whether groundwater was present in the ferricrete and alluvial sediments below the Gidji I TSF prior to TSF operation, the long term trends in TDS concentrations in Figures 19 to 23, and the contoured hydrochemical data in Figures 31 to 34 are consistent with background groundwater being present, having a naturally low pH of around 3 in most locations, having TDS concentrations around 50,000 mg/L and having negligible CN concentrations. These inferred conditions are consistent with observations of the natural background hydrochemistry of the ferricrete and alluvial sediment groundwater system in other locations near KCGM facilities.

Operation of the unlined cells in the Gidji I TSF since 1989 has resulted in seepage of decant water entering the groundwater system, with seepage influences reducing after the cells were permanently decommissioned in 2015. As indicated by samples from the Gidji Return Dam, seepage is expected to have a high pH, TDS above 100,000 mg/L, and elevated concentrations of CN, Co, Cu and Fe.

TDS concentrations in groundwater are most diagnostic of seepage influences as they are not expected to be affected by attenuation during flow through the groundwater system. The influence of seepage can also be discerned in groundwater pH, groundwater EC, in concentrations of total CN, WAD CN, free CN, and in filterable concentrations of Cu and Co. The groundwater hydrochemistry identifies preferential seepage flowpaths to the west and northwest, consistent with the presence of ferricrete in these areas which increases the hydraulic conductivity of the groundwater system. The production bores installed to recover seepage are predominantly located to the west and northwest of the Gidji I TSF and are therefore suitably designed to intercept these flowpaths.

As the groundwater mound beneath the Gidji I TSF continues to decline, groundwater hydraulic gradients outside the area of the production bores will act away from the TSF, and some further changes in hydrochemistry can be expected due to the migration of residual seepage emplaced during the operating period. The recent increase in TDS concentrations at MB R25, and the recent increases in CN concentrations at MB R07, MB R14 and MB R25 are attributed to this influence.

5. Conclusions and recommendations for ongoing seepage management

5.1 Suitability of current monitoring regime

Groundwater monitoring at the Gidji TSFs which is undertaken to comply with the conditions of licence L5946/1988/13 comprises:

1. Annual samples from the Gidji Trench and the Gidji Return Dam (decant pond) analysed for pH, EC, TDS, free CN, WAD CN and total CN.
2. Operational area and compliance monitoring bores monitored six monthly for pH and EC, and annually for TDS, total CN, free CN and WAD CN.
3. Depth to groundwater measured in compliance monitoring bores and operational area monitoring bores quarterly.

Additional groundwater monitoring which is undertaken by KCGM for interpretation purposes comprises:

1. Monthly records of total seepage and groundwater abstraction from production bores.
2. Monthly measurement of depth to groundwater in operational area and compliance monitoring bores.
3. Annual sampling of all production bores and compliance monitoring bores for a comprehensive suite including major ions and filterable metals.

The reviews of groundwater depth and groundwater hydrochemical data in Sections 3 and 4 have identified that:

- Since 2017 the groundwater system has been subject to recharge in response to precipitation events occurring over periods of a week to a month.
- TDS concentrations are the most diagnostic hydrochemical parameter for seepage influences, and EC provides a useful means of confirming the reliability of TDS concentrations.
- Groundwater pH is a control on metals concentrations and is inferred to have a role in the attenuation of CN.
- Total CN concentrations are useful in identifying the attenuated extent of seepage influences.
- Free CN and WAD CN concentrations are of some use in interpreting seepage influences.
- Comprehensive suite hydrochemical analyses have some value in understanding the controls on metals concentrations in groundwater.

It is therefore concluded that:

1. The groundwater monitoring regime required for compliance with licence L5946/1988/13 provides sufficient data to identify groundwater flow directions and the influences of TSF seepage on groundwater hydrochemistry and should be continued.
2. The interpretation monitoring undertaken by KCGM provides a more detailed understanding of recharge processes and controls on groundwater hydrochemistry and should be continued.
3. No additions to the compliance or interpretation monitoring are required.

5.2 Effectiveness of current seepage recovery around the Gidji I TSF

Operation of the Gidji Trench and the production bores has been demonstrated to successfully manage groundwater depths to ensure they have remained below the current compliance limit throughout the operating period for the Gidji I TSF. Currently the system operates at low total pumping rates, due to groundwater levels approaching the base of the ferricrete and alluvial groundwater system, which reduces the flow rate available from each production bore. However, the pumping systems in the bores are configured so that if groundwater levels rise in response to seepage or natural recharge, flow rates from the existing bores will increase. The existing system is therefore concluded to be sufficient to manage groundwater depths as the groundwater mound below the Gidji I TSF continues to decay.

5.3 Management of the Gidji II TSF

The lined cells in the Gidji II TSF have been utilised for tailings deposition since 2012. The reviews of groundwater depth and groundwater hydrochemistry data in Sections 3 and 4 have not identified any seepage influences from the Gidji II TSF. Based on the known geology, the interpreted hydrogeology, and the measured groundwater elevations and groundwater flow directions, the existing monitoring bores are suitably located to identify any seepage influences from the Gidji II TSF if they should occur in future. No changes to the existing monitoring regime are required to manage ongoing deposition in the Gidji II TSF.

5.4 Management of the planned Gidji III TSF

Figure 35 illustrates the planned footprint of the Gidji III TSF, which is planned to be constructed with double lined cells, comprising a compacted clay layer overlain by an HDPE membrane. The performance of the Gidji III TSF for seepage management would therefore be expected to be similar to that of the Gidji II TSF. Monitoring bores which are anticipated to be decommissioned during construction of the Gidji III TSF are highlighted in Figure 35, and comprise MB R03, MB R10, MB R21 and MB R34. This would result in the removal of all of the monitoring bores to the northeast of the Gidji I TSF which are currently being used to monitor the influence of residual seepage emplaced during the operating period.

Figure 6 illustrates that the ferricrete and alluvial sediment groundwater system is expected to pinch out to the northeast of the Gidji I TSF, and it is likely that low hydraulic conductivity conditions occur in the area of the Gidji III TSF. In order to confirm this interpretation, it is recommended that during construction of the Gidji III TSF, three additional monitoring bores be installed to the northeast of the facility, for the combined purposes of 1) investigating whether a groundwater system is present in this area; 2) providing monitoring data to confirm that the lined cells in the Gidji III TSF perform as designed, and do not result in significant rates of seepage to groundwater; and 3) monitoring any potential influences of residual seepage from the Gidji I TSF if they are found to extend this far from the facility.

Proposed locations for the monitoring bores are indicated in Figure 35, and these locations would require adjustment based on actual field conditions and the final designs for the Gidji III TSF and associated infrastructure, including access roads and powerlines. As groundwater is expected to be relatively deep in these locations, the bores would need to be drilled to a minimum of 30 m depth and may potentially extend into weathered bedrock and unweathered bedrock. Completion details would need to be determined from an assessment of any hydrogeological units encountered during drilling. Currently it is anticipated that the most suitable bore completion in each location would be single bore, fully screened from around 5 m depth to the base of the casing. This would ensure that the bore monitors any deep groundwater which is currently present and is suitably designed to identify any saturation of the shallow units which would potentially occur in the unlikely event of seepage from the lined Gidji III TSF.

5.5 Management for closure

Potential future groundwater responses during closure of the Gidji TSFs have been investigated by numerical modelling (PCA, 2015). Conclusions and predictions from the numerical model were that:

- A seepage rate of 500 kL/day (5.8 L/s) from the Gidji I TSF during the operating period was applied in the model to provide a match with the observed mounding below the TSF.
- 120,000 m³ of pore water was predicted to be released from the Gidji I TSF in the draindown period following closure.
- Total pumping was expected to decline from around 4.5 L/s prior to closure to around 1.2 L/s within two years.
- Within three years of closure, groundwater levels were predicted to decline by up to 5 m close to the eastern boundary of the Gidji I TSF, with smaller changes to the east, north and south, and much smaller changes to the west.

The observed responses of the groundwater system since decommissioning the Gidji I TSF have been generally consistent with the predictions of the model, and it is noted that:

- Total pumping has declined in a similar manner to that predicted, with average annual pumping reducing from 4.2 L/s in 2012 to 0.7 L/s in 2018.
- Changes in groundwater elevation following closure are best illustrated in Figure 16, which contours the changes prior to the recharge events in 2017 and 2018. The reduction in groundwater elevations was around 5 m to the east of the Gidji I TSF, and around 1 m to the west of the Gidji I TSF.

The primary difference between the modelled groundwater responses and the observed groundwater responses is the occurrence of the inferred recharge events in 2017 and 2018. The numerical model did not simulate natural recharge to the groundwater system, as the monitoring data available at that time indicated that seepage from the Gidji I TSF was a much larger input to the groundwater system than natural recharge.

Overall, the model predictions of groundwater responses following closure of the Gidji I TSF remain valid for use in closure planning at the Gidji facilities. However it should be considered when using the model predictions, that if further natural recharge events occur, the decay of the groundwater mound may occur over a longer period than predicted by the model.

References

BDH 2018, KCGM, *Groundwater Monitoring Review for 2017, Northern Borefield, Kalgoorlie*, Big Dog Hydrogeology Pty Ltd.

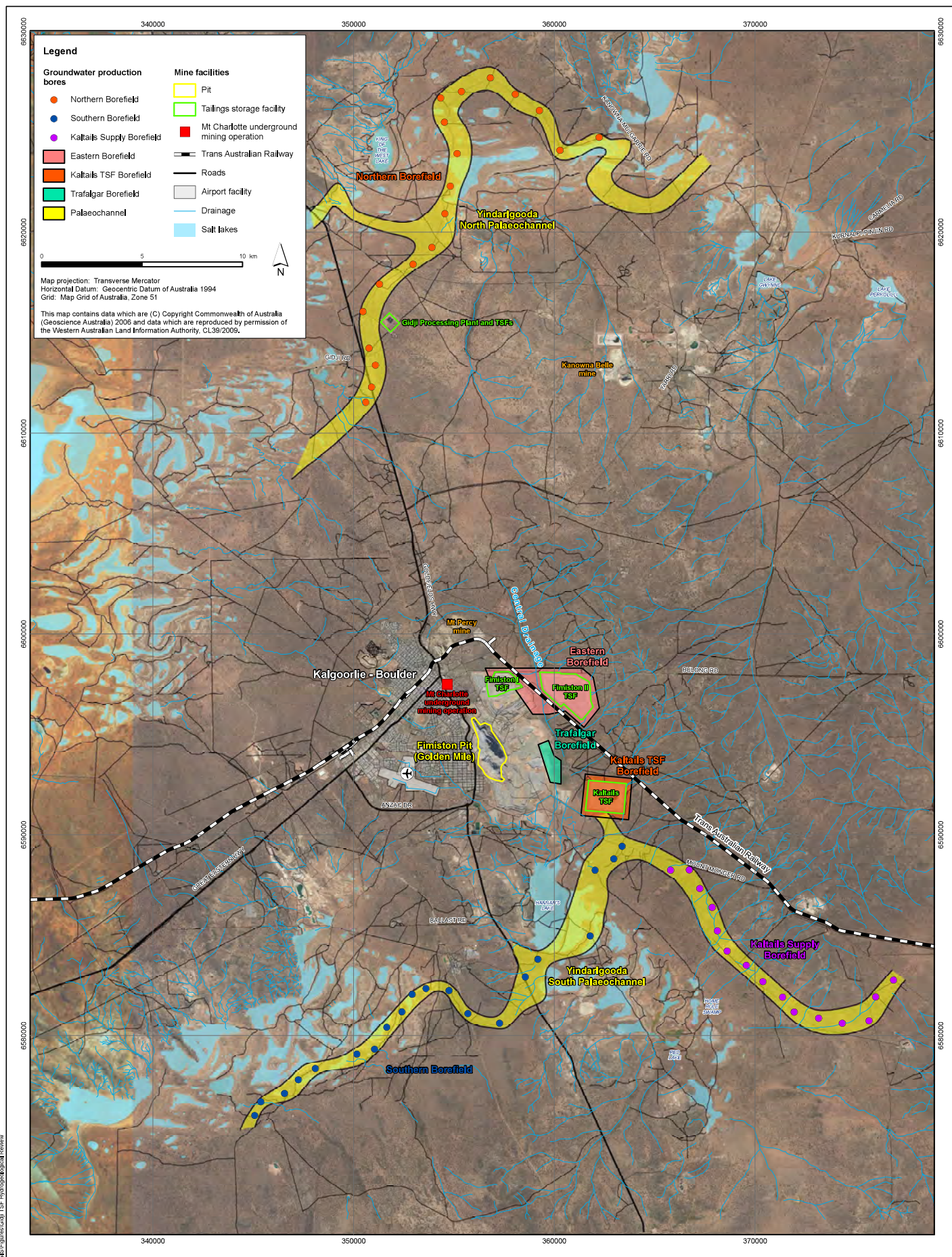
MBS 2016, *Geochemical Tailings Characterisation, Memorandum from David Allen of MBS to Janine Cameron of KCGM dated 24 March 2016*, MBS Environmental Pty Ltd.

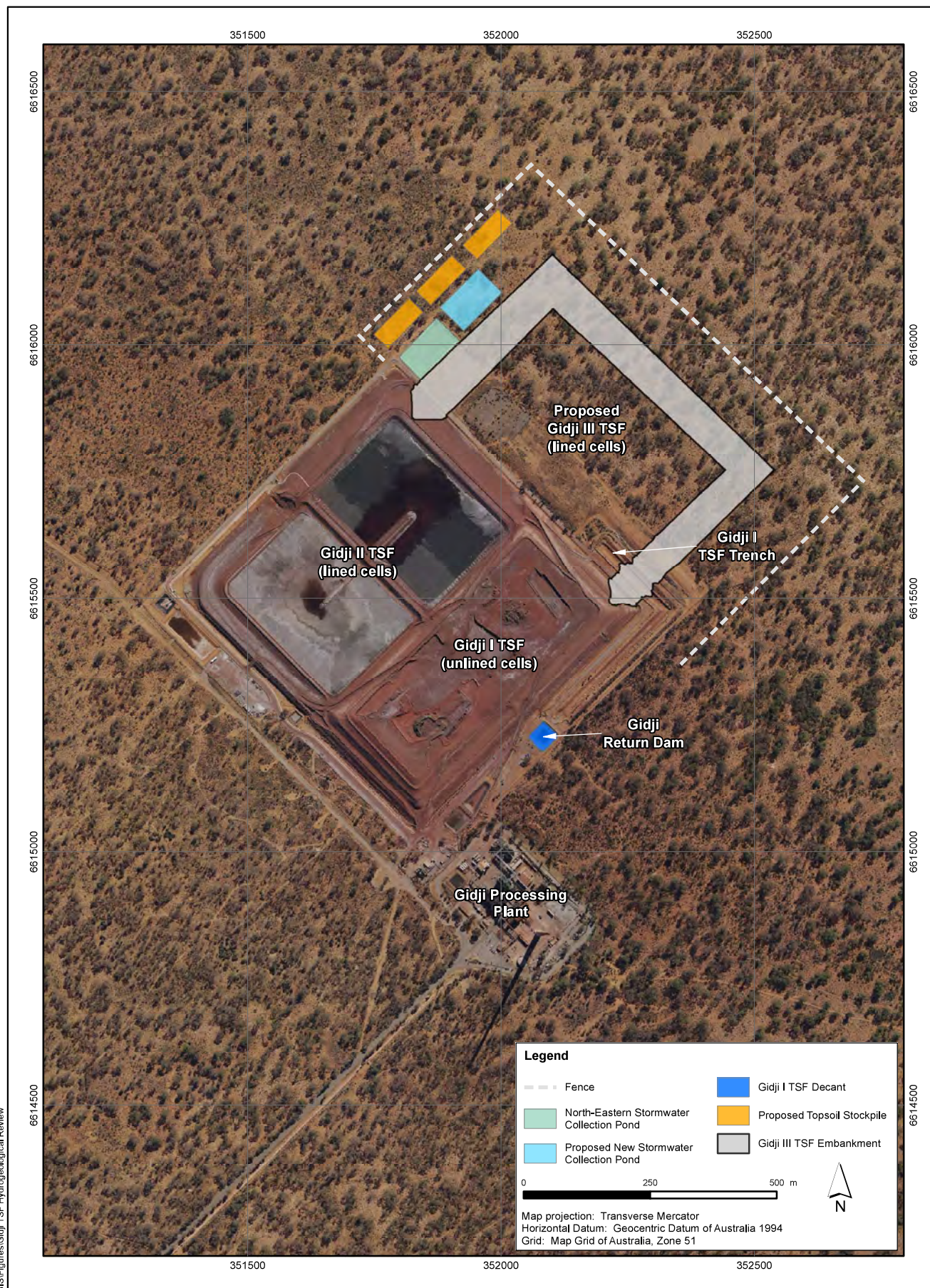
PCA 2015, *Gidji Tailings Storage Facility, Review of Hydrogeological Data and Groundwater Management.*, Peter Clifton & Associates.

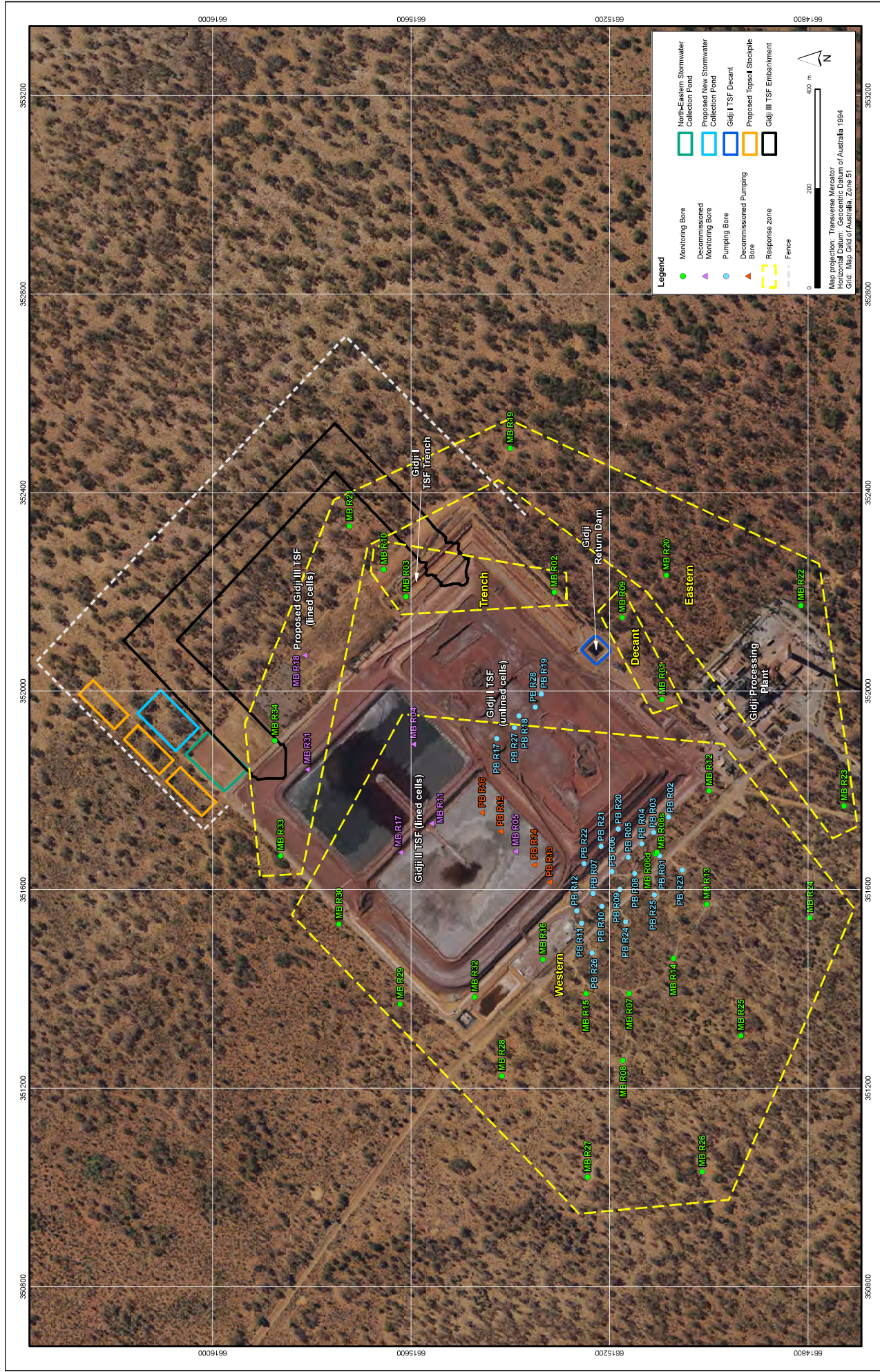
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Monitoring and pumping locations

Figure 3

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Report	Gidji TSE Hydrogeological Review

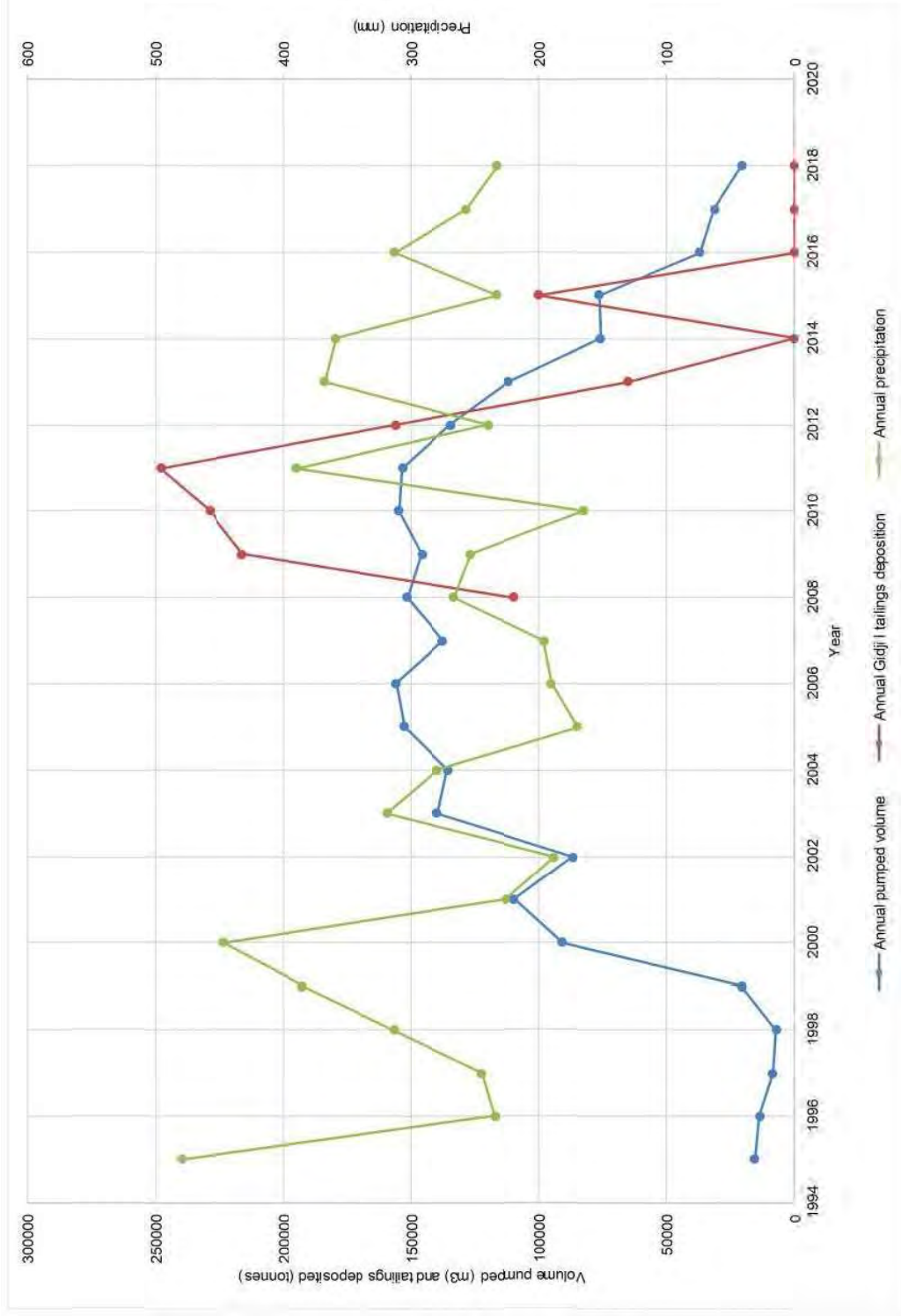
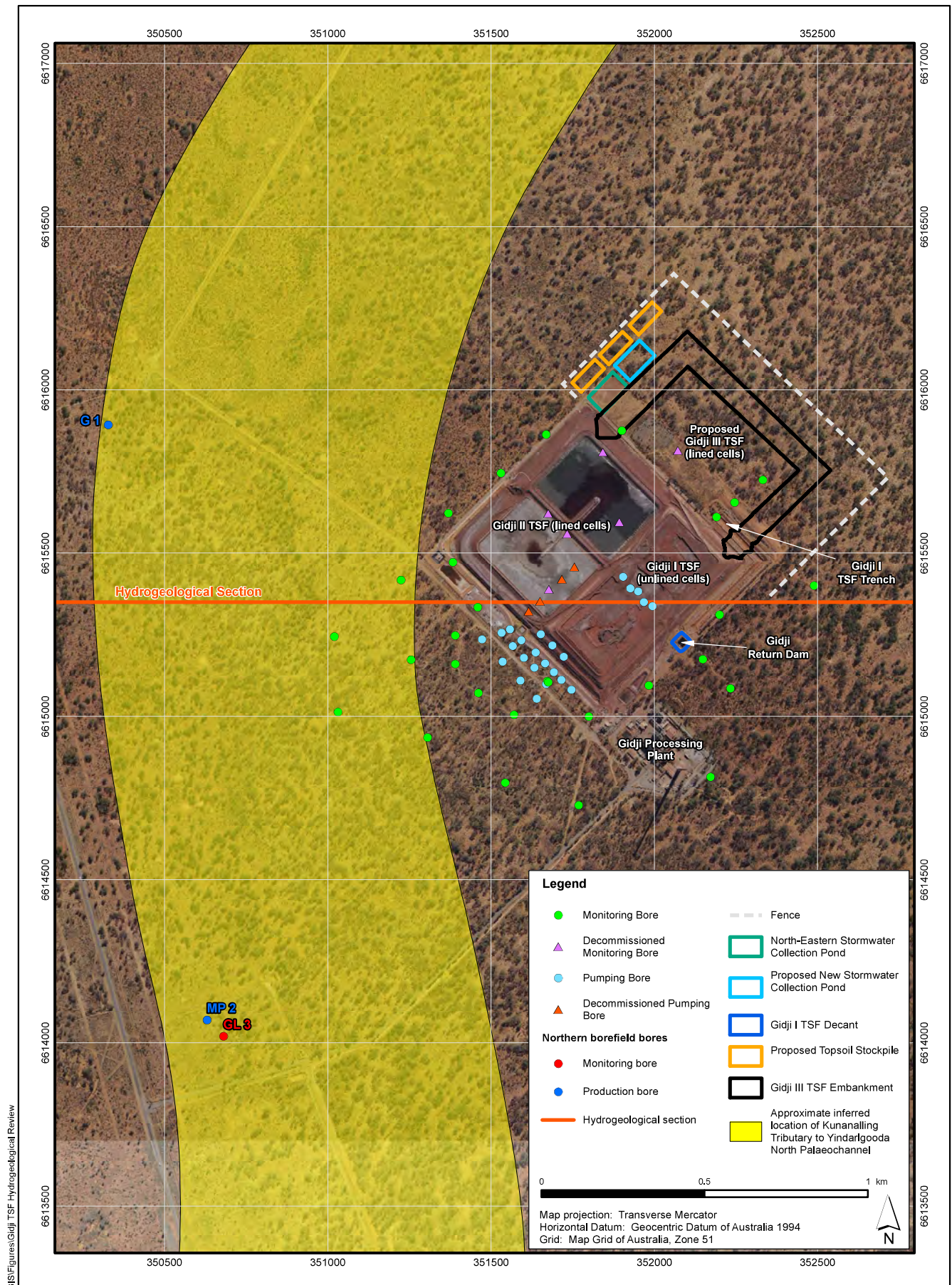


Figure 4

Date: January 2019

Report: KCGM Gidji TSF Hydrogeological Review

Annual pumping and deposition volumes



G:\Projects\BDH Projects\KGM\GIS\Figures\Gidji TSF Hydrogeological Review



Gidji facilities and Northern Borefield

Figure 5

Date: January 2019

Report: Gidji TSF
Hydrogeological Review

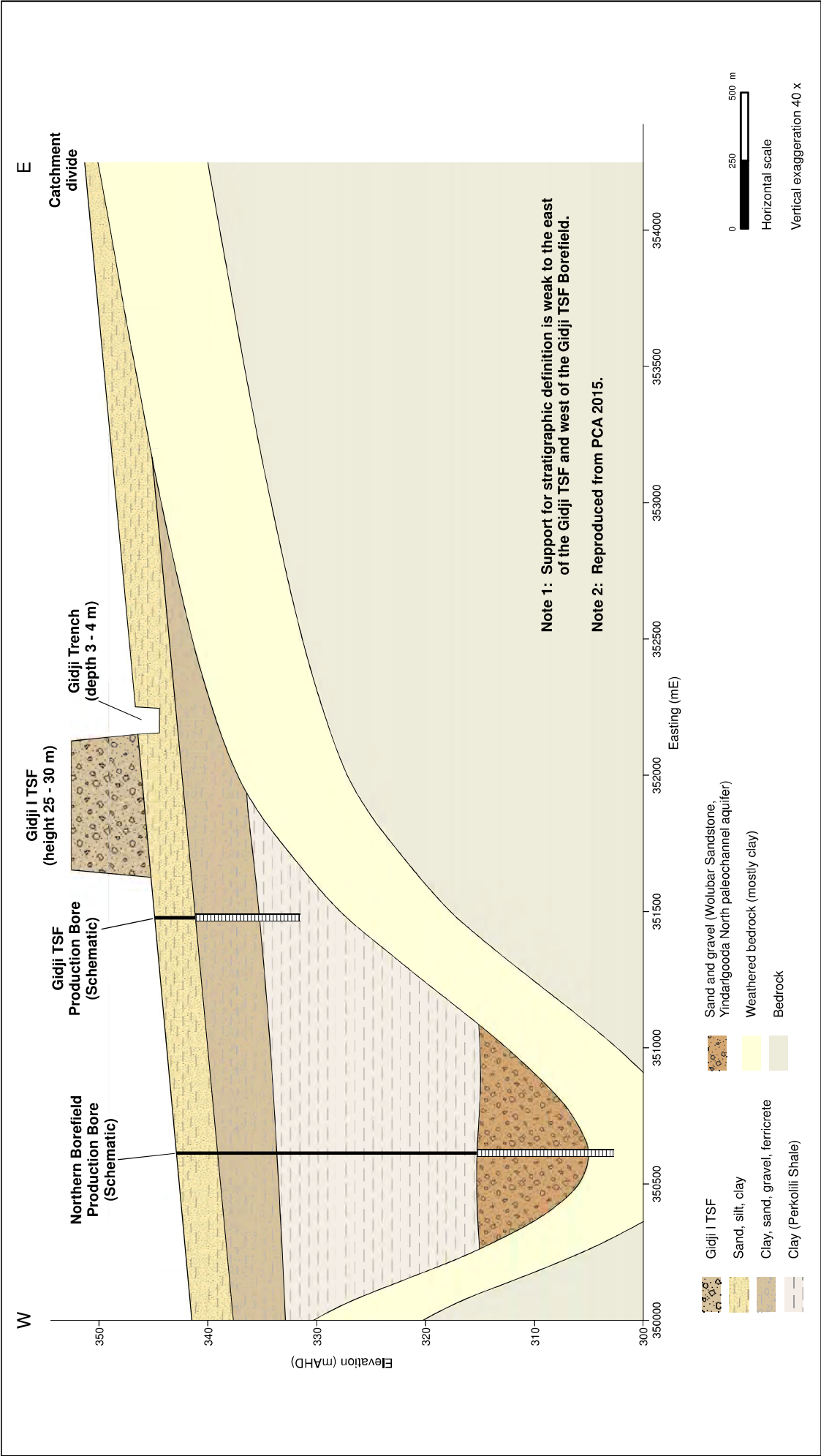


Figure 6

Date: January 2019

Report: Gidji TSF Hydrogeological Review

Hydrogeological section



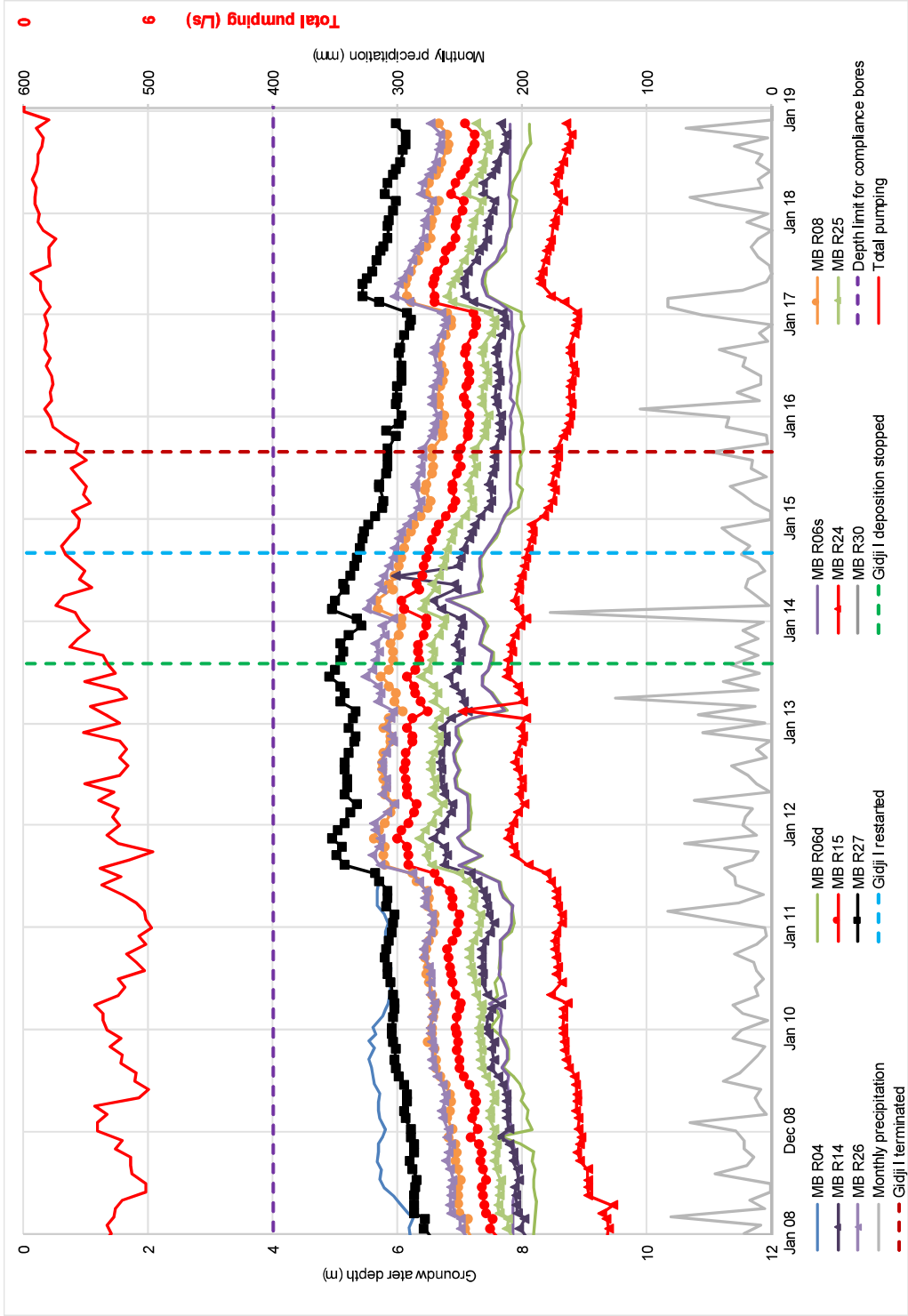


Figure 7

Recent hydrographs - western bores part 1



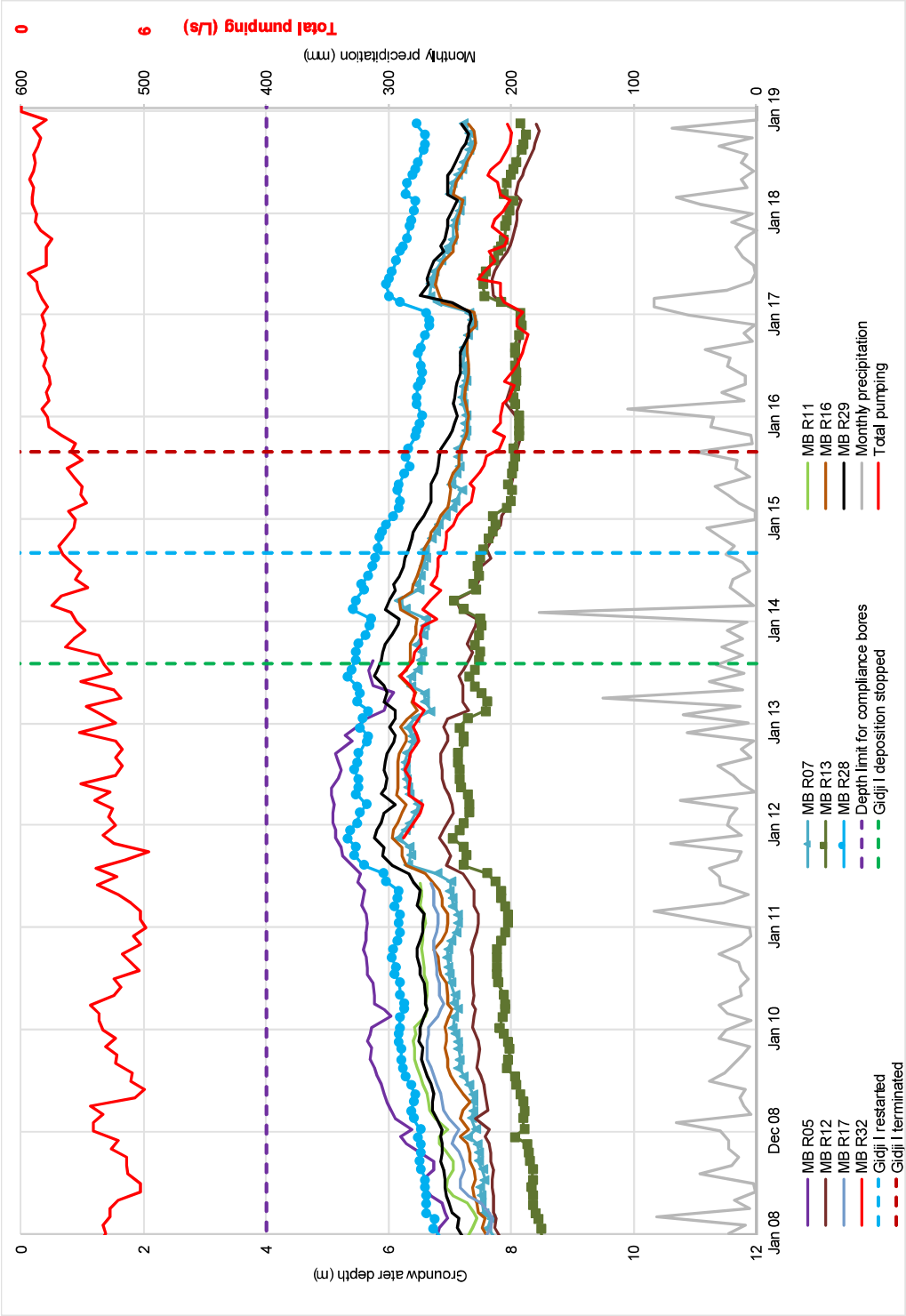
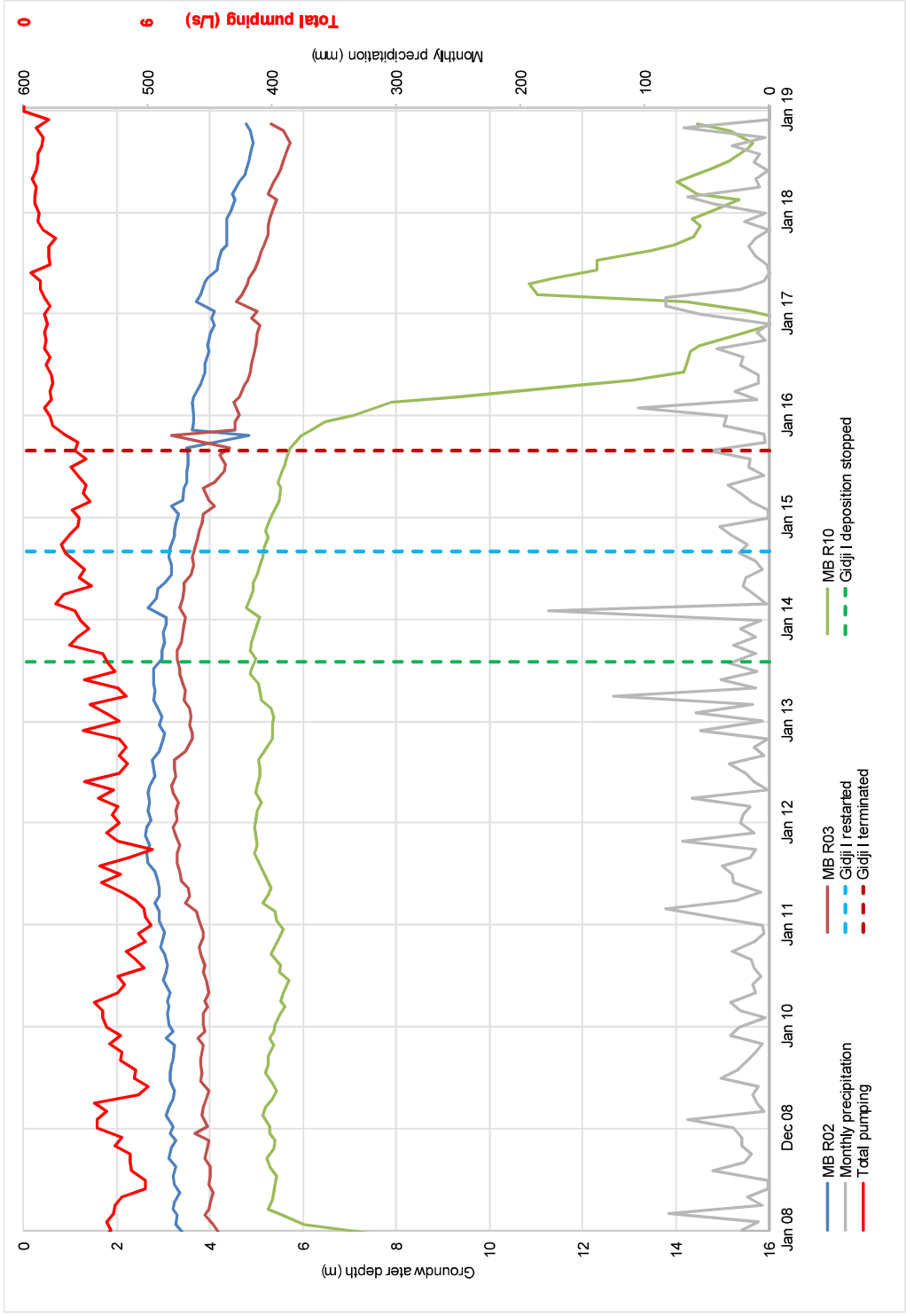


Figure 8

Recent hydrographs - western bores part 2

Date:	January 2019
Report:	KCGM Gidji TSF Hydrogeological Review





Recent hydrographs - trench bores

Figure 9

Date: January 2019

Report: KCGM Gidji TSF Hydrogeological Review

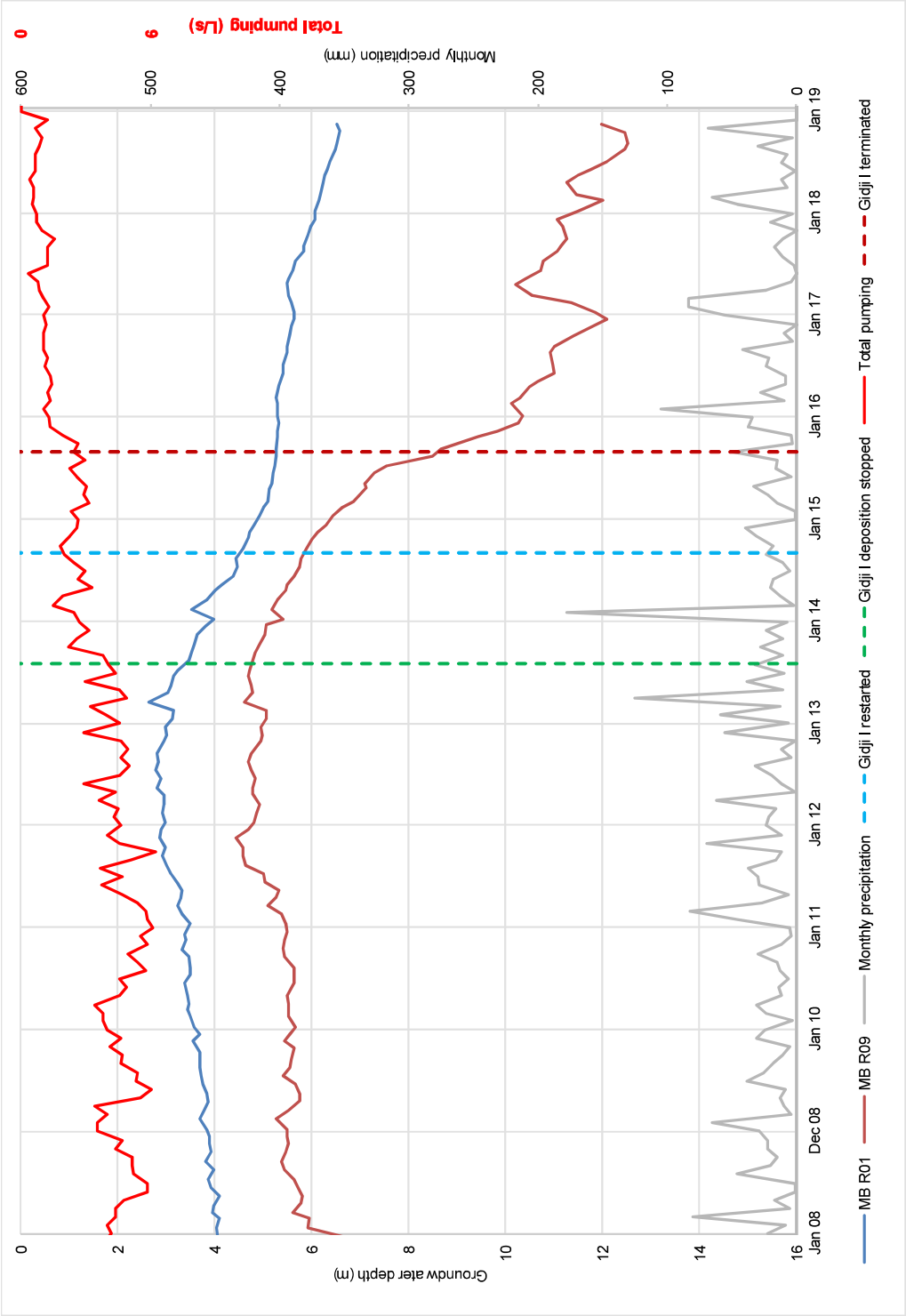


Figure 10

Recent hydrographs - decant bores



Date:	January 2019
Report:	KCGM Gidji TSF Hydrogeological Review

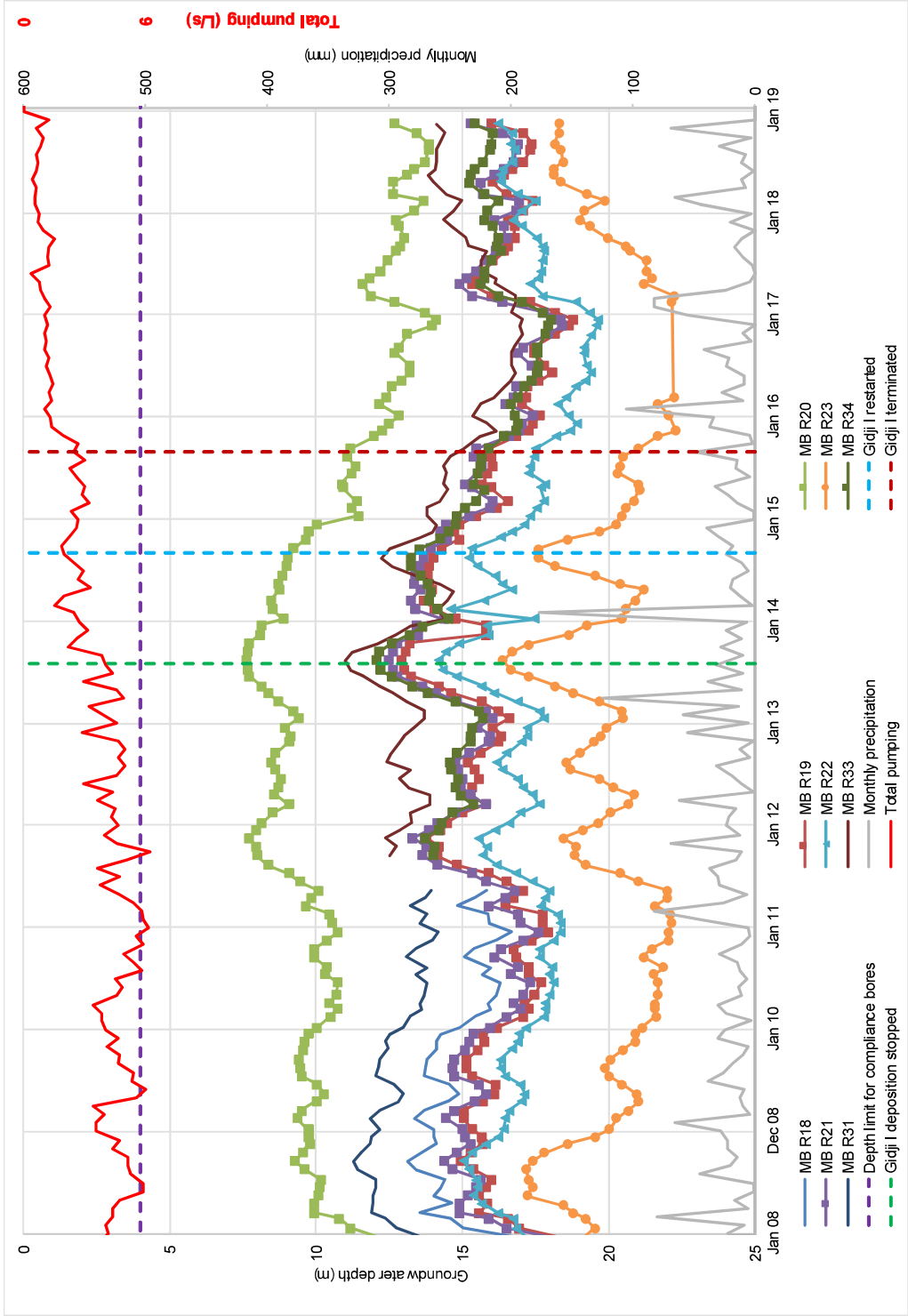
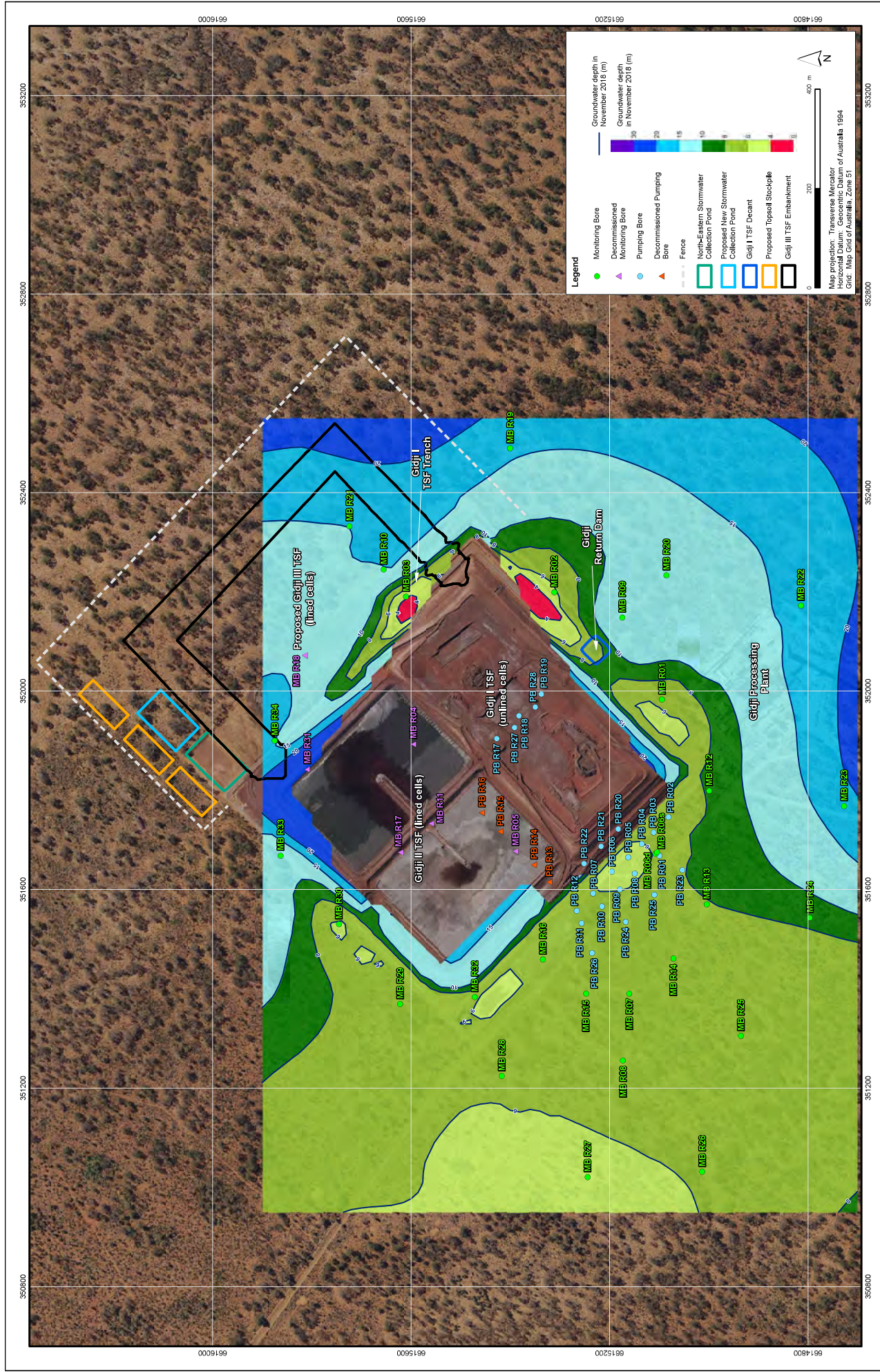


Figure 11

Recent hydrographs - eastern bores



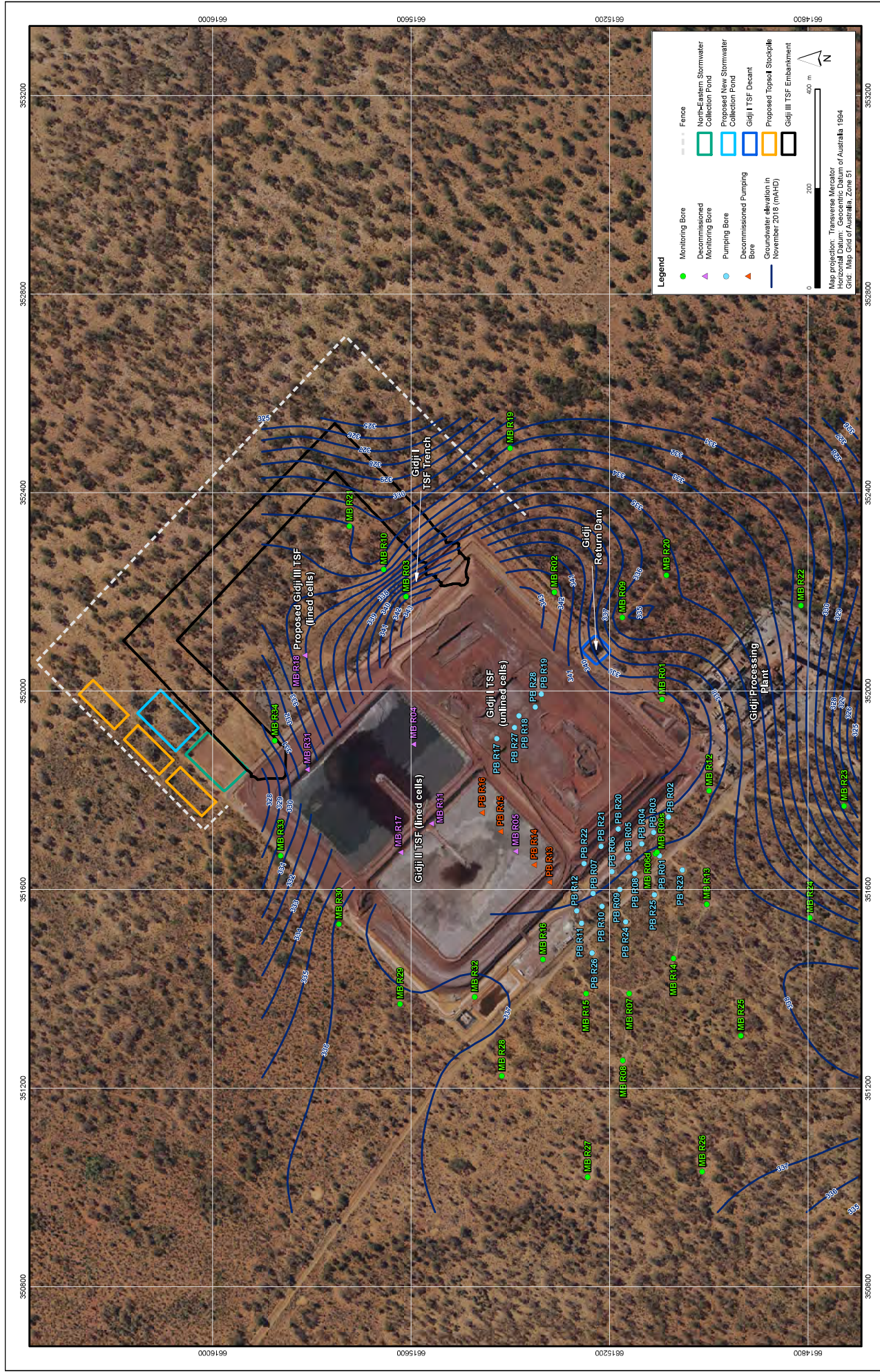
Date:	January 2019
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Groundwater depth in November 2018

Figure 12

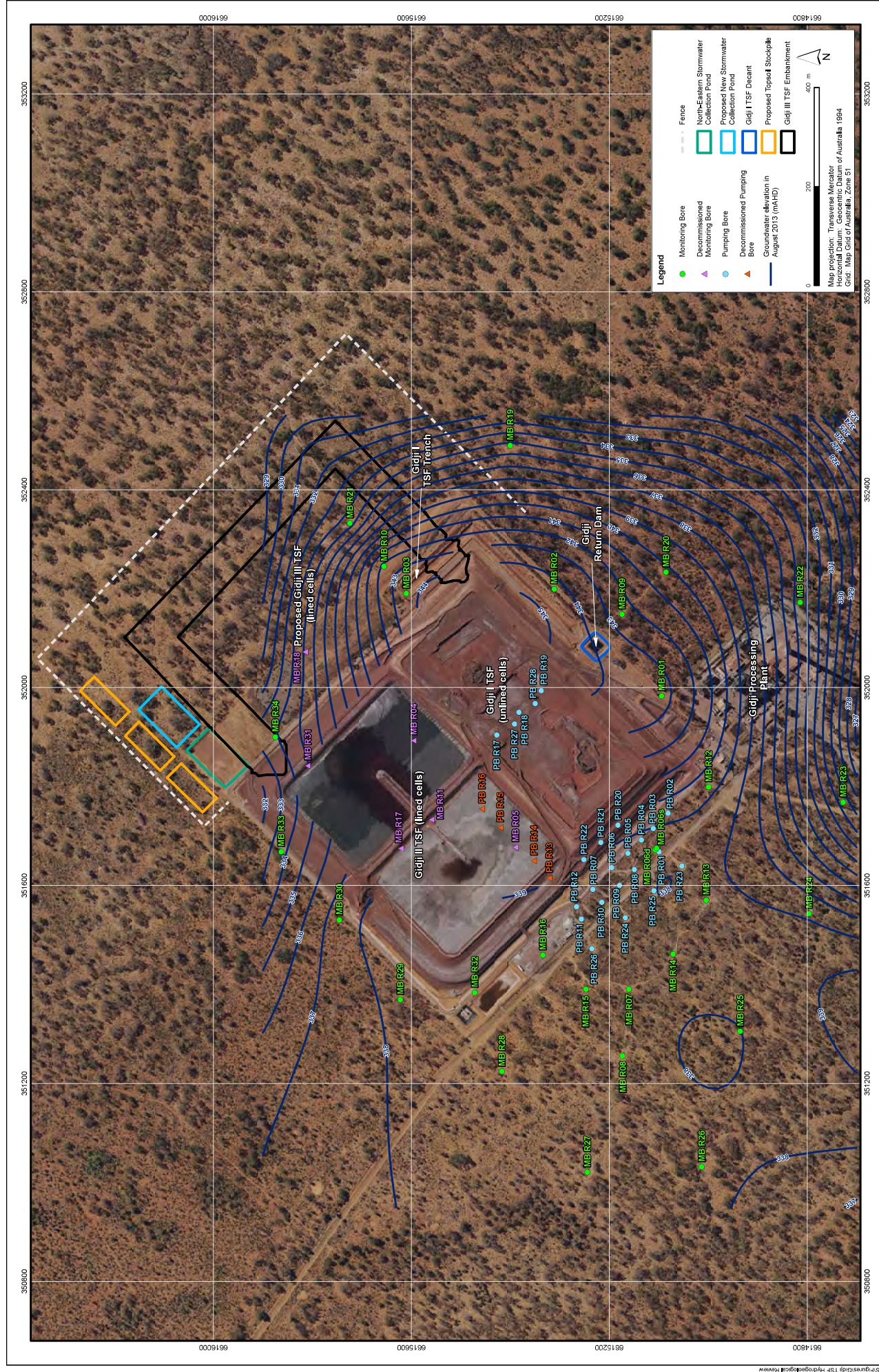
Date	January 2019
Report	Gidji TSF Hydrogeological Review



Groundwater elevations in November 2018

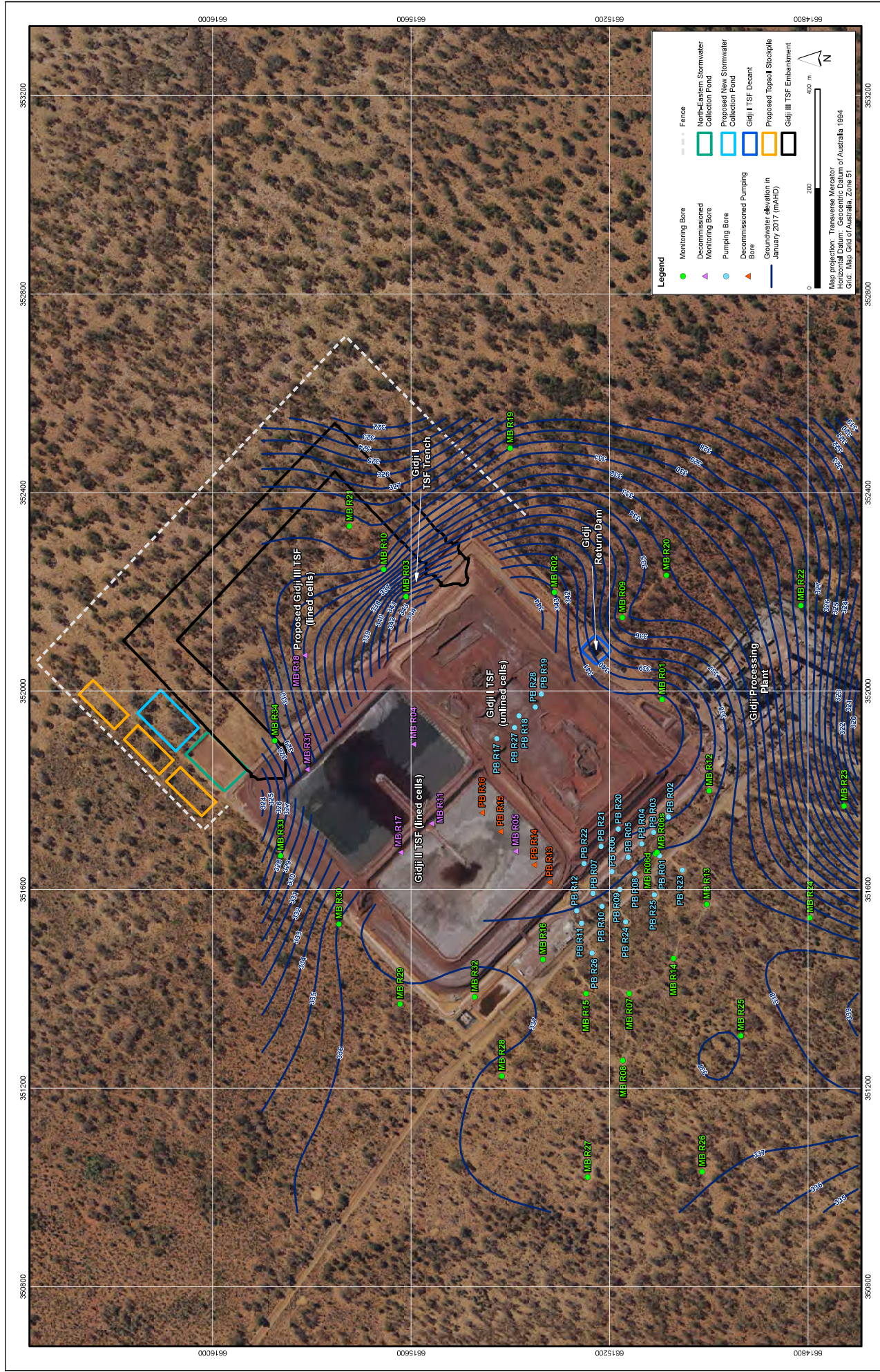
Figure 13

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Groundwater elevations in August 2013

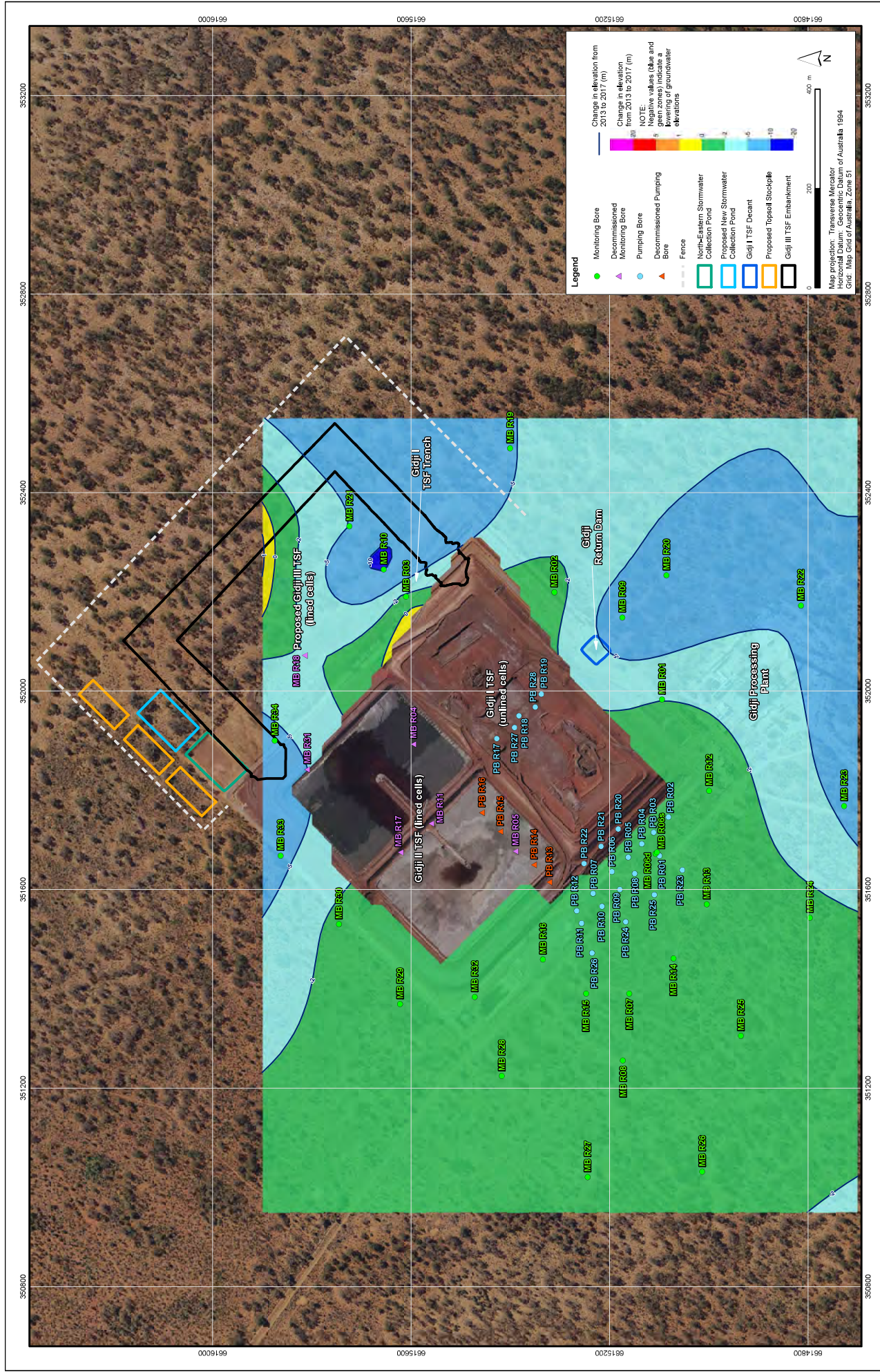
Figure 14
Date: January 2019
Report: Gidji TSF Hydrogeological Review



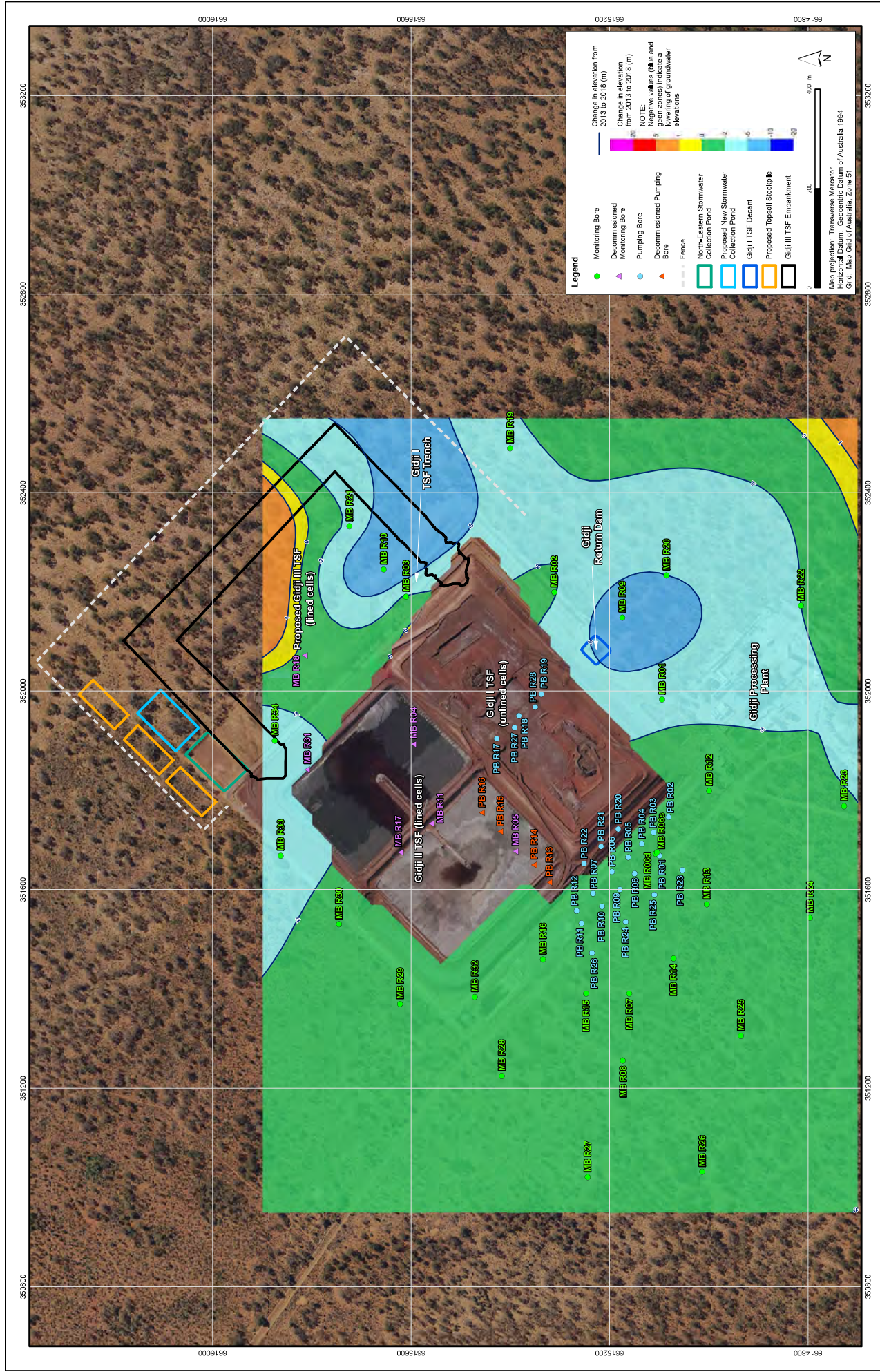
Groundwater elevations in January 2017

Figure 15

Date	January 2019
Report	Gidji TSF Hydrogeological Review



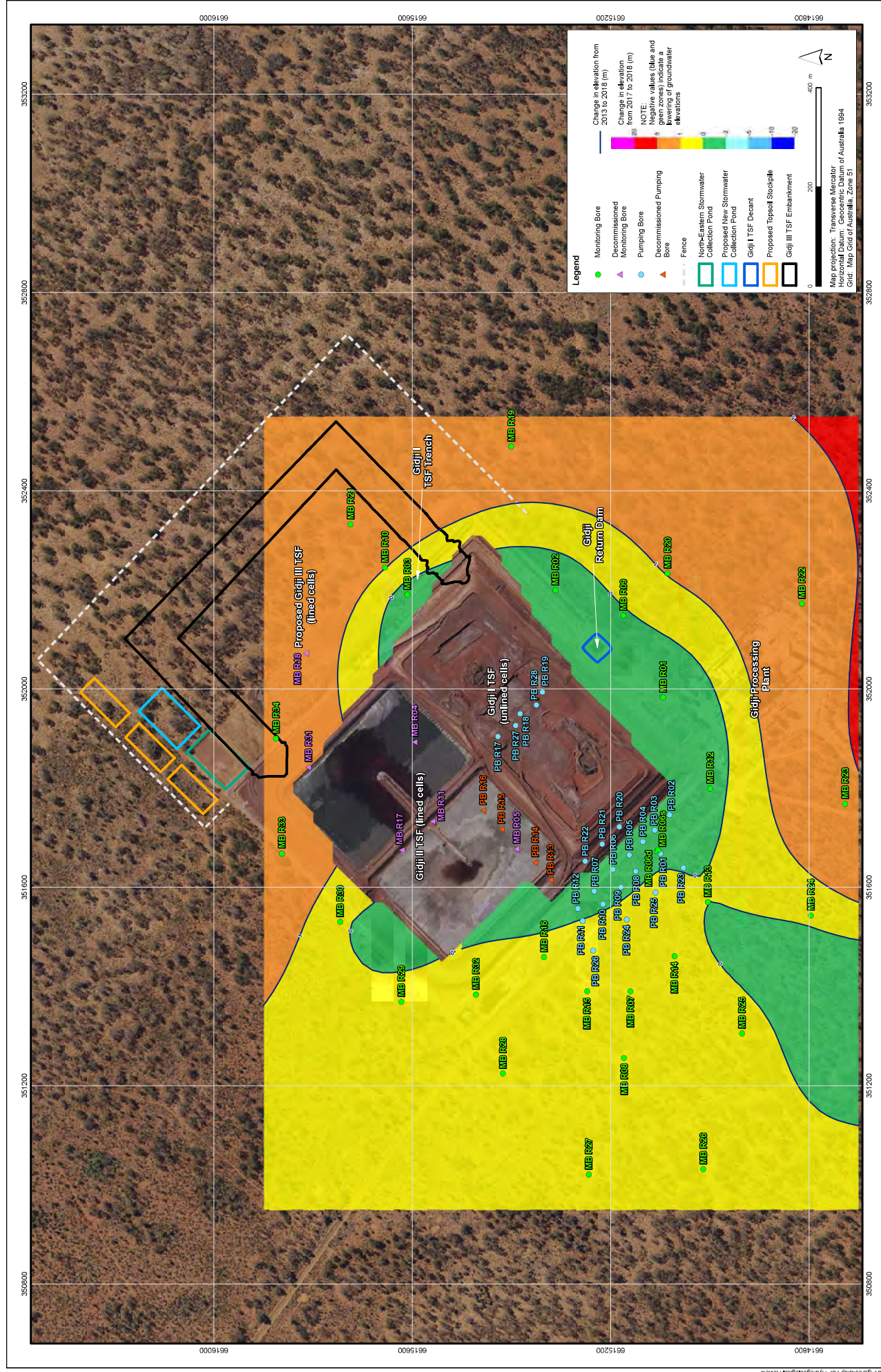
Change in elevations from 2013 to 2017



Change in elevations from 2013 to 2018

Figure 17

Date	January 2019
Report	Gidji TSF Hydrogeological Review



Change in elevations from 2017 to 2018

Figure 18

Date: January 2019

Report:	Cidili TSE
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Hydrogeological Review

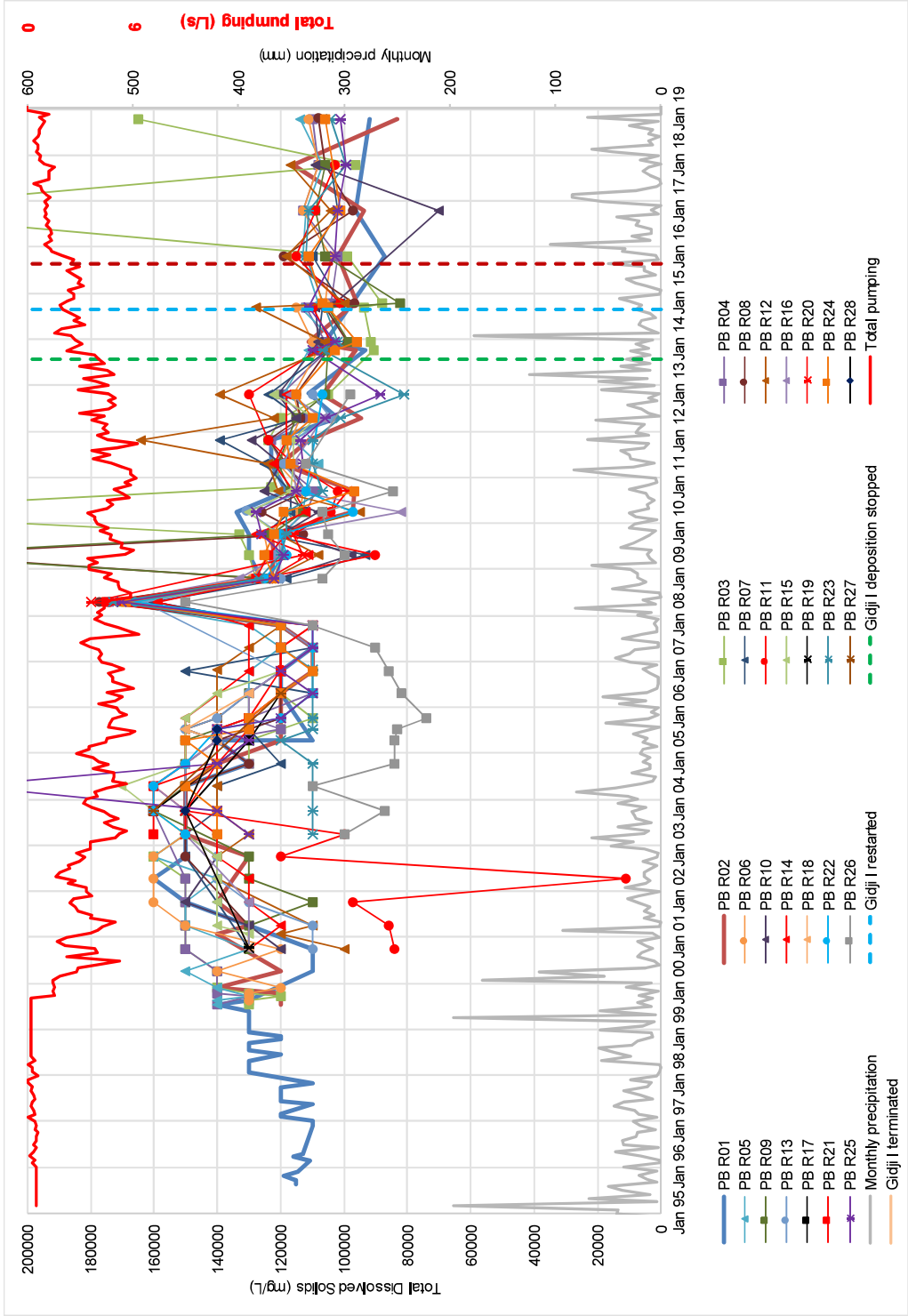


Figure 19

Date:	January 2019
Report:	KCGM Gidji TSF Hydrogeological Review

TDS - production bores



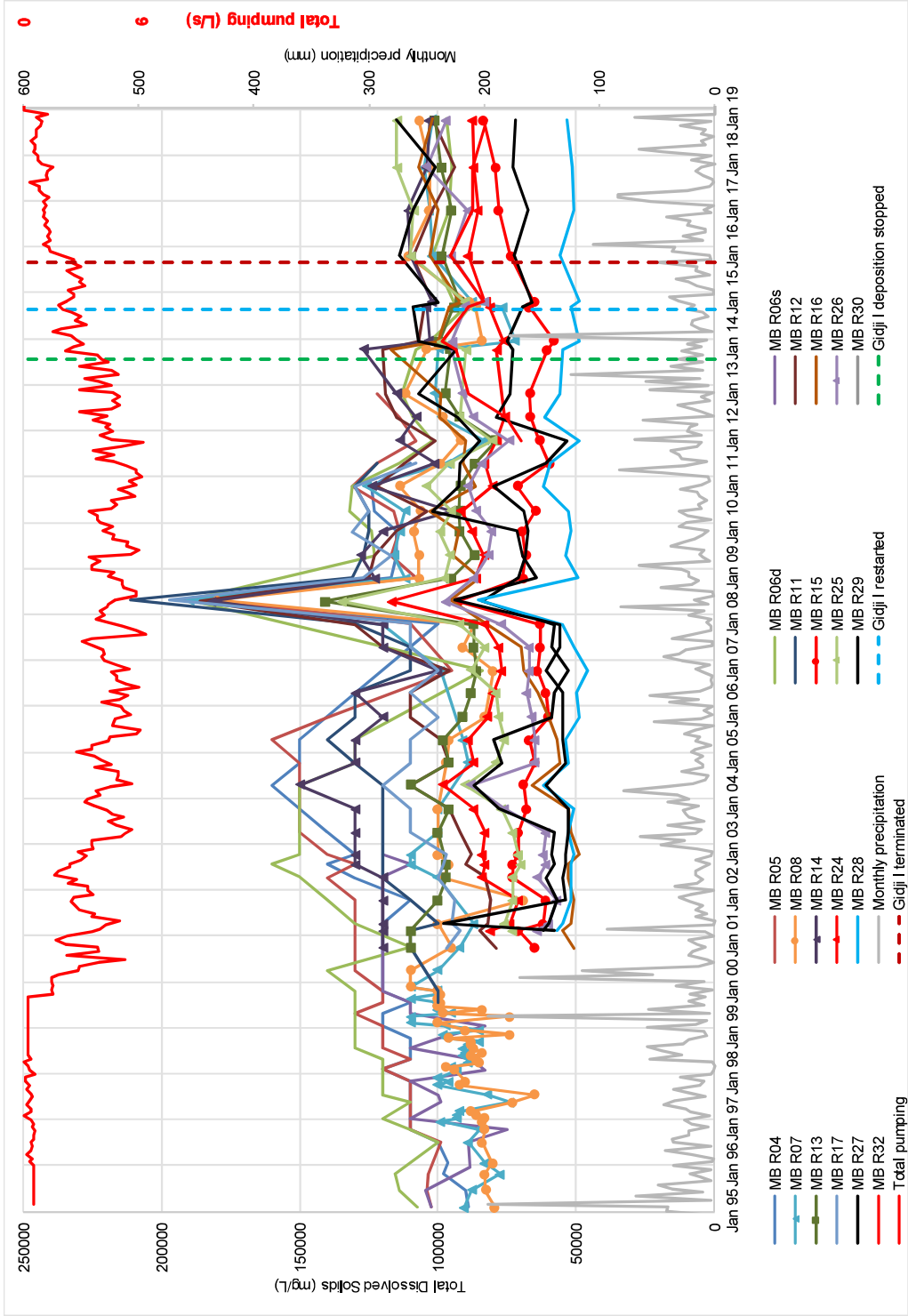


Figure 20

Date: January 2019
Report: KCGM Gidji TSF
Hydrogeological Review

TDS - western bores



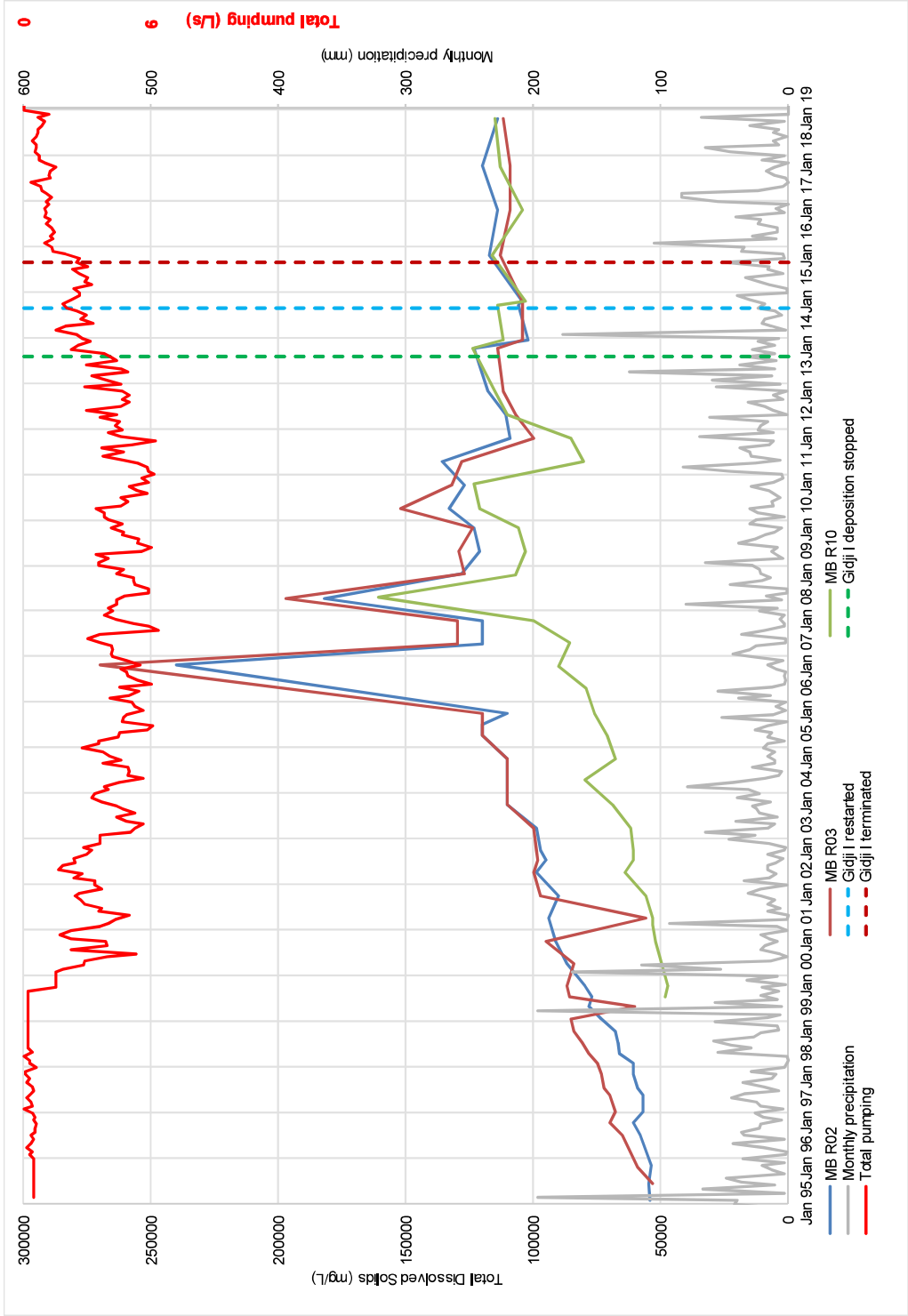


Figure 21

Date: January 2019
Report: KCGM Gidji TSF
Hydrogeological Review

TDS - trench bores



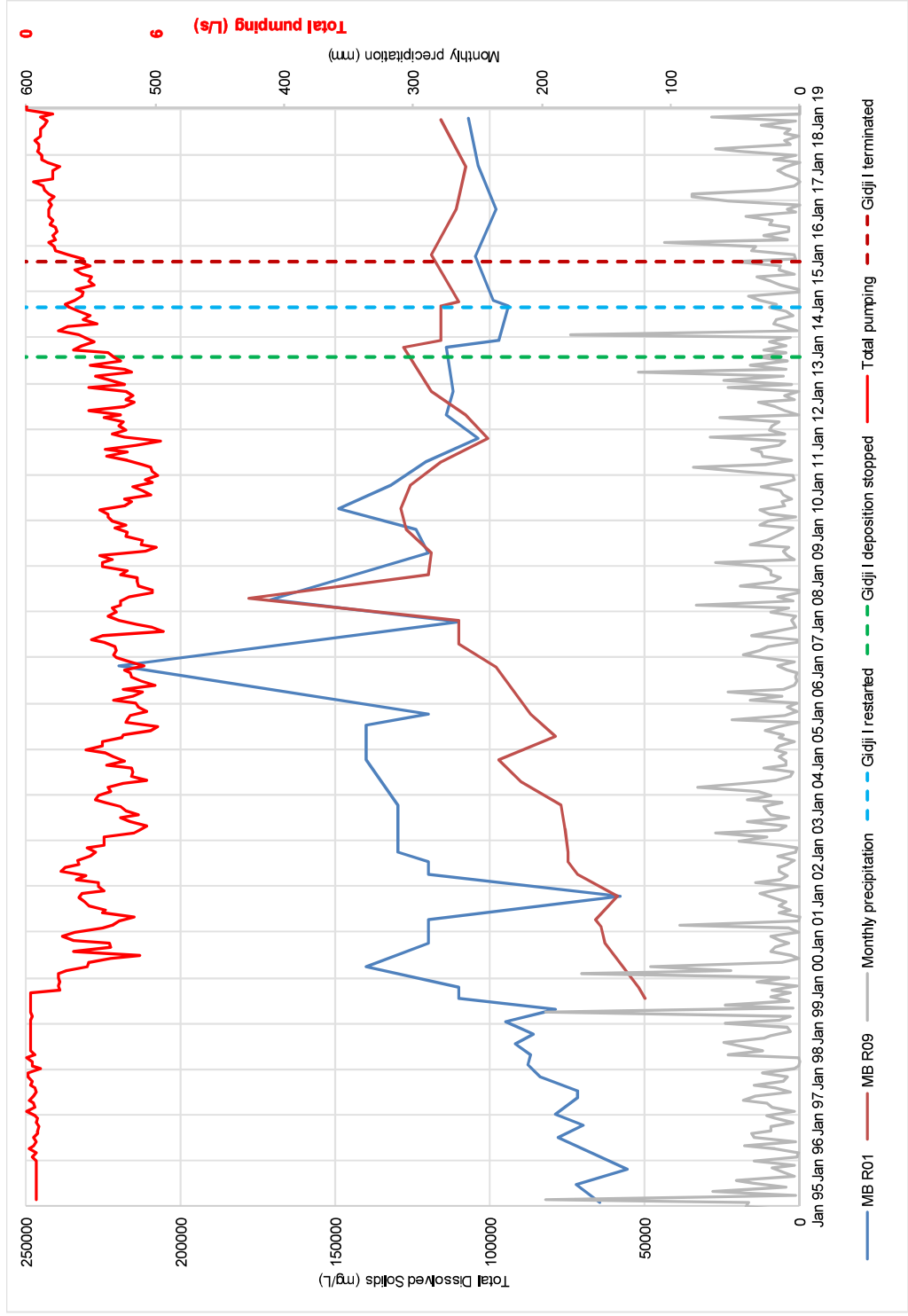


Figure 22

Date: January 2019
Report: KCGM Gidji TSF
Hydrogeological Review

TDS - decant bores



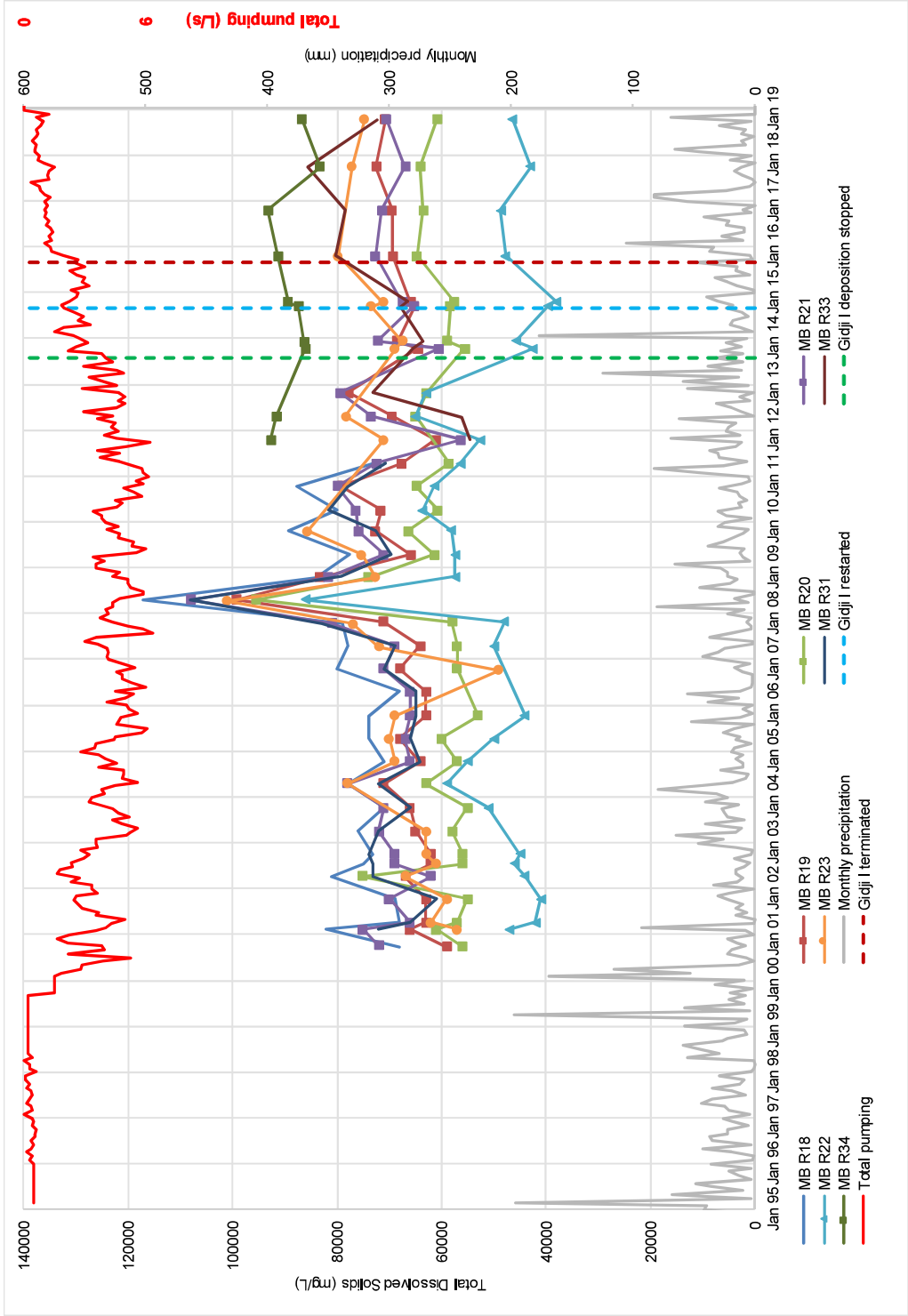


Figure 23

Date: January 2019
Report: KCGM Gidji TSF Hydrogeological Review

TDS - eastern bores



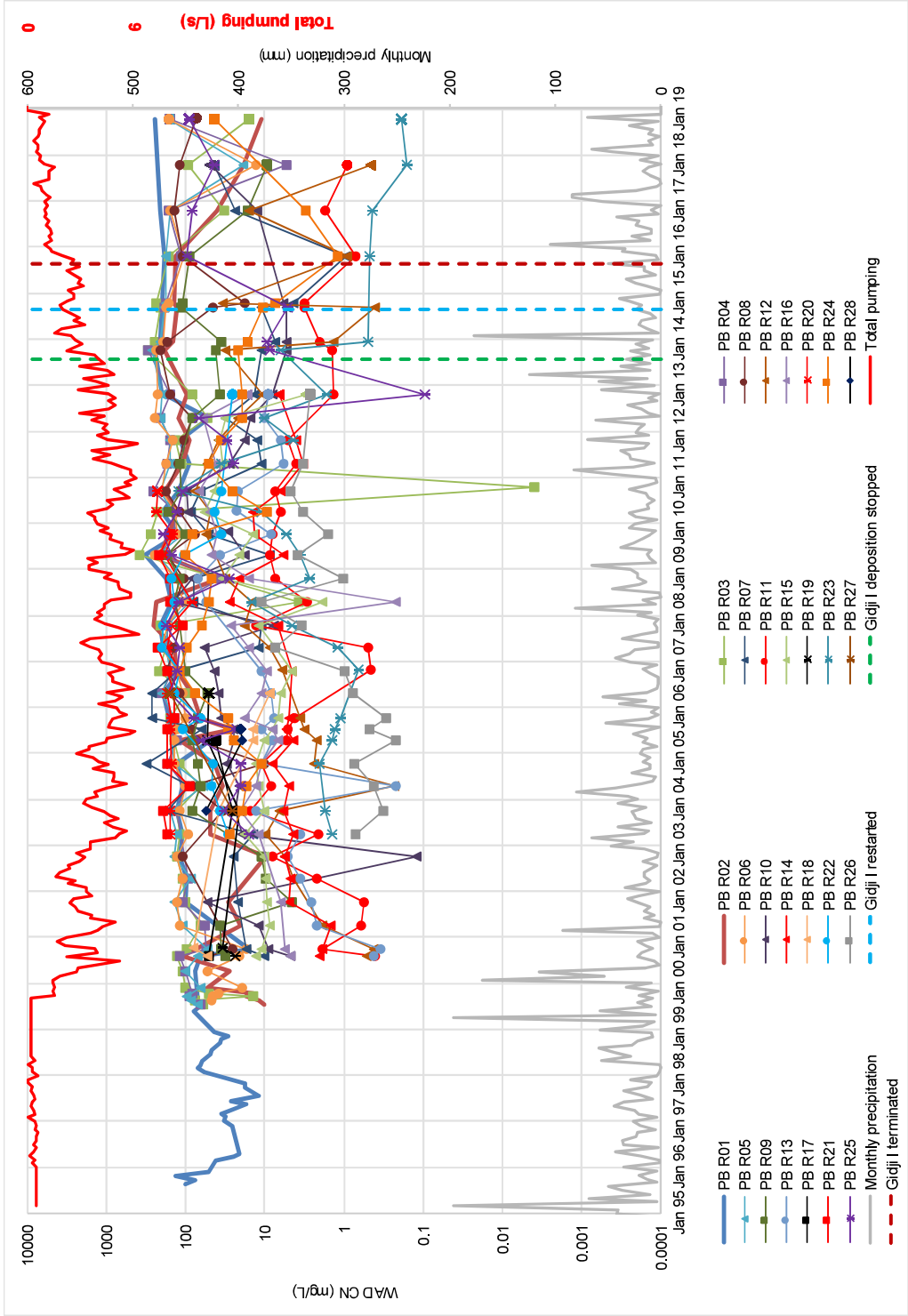


Figure 24

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WAD CN - production bores



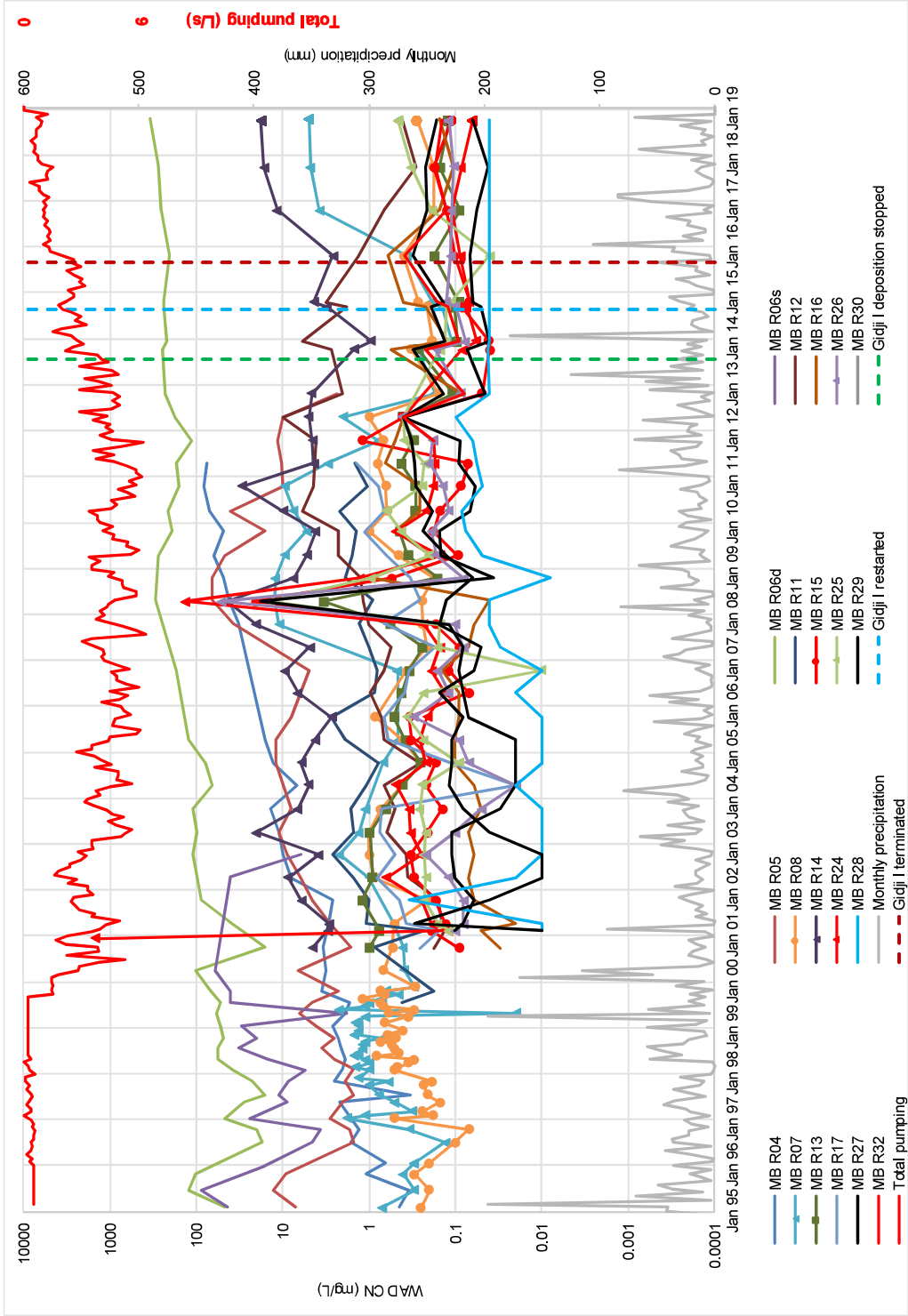


Figure 25

Date:	January 2019
Report:	KCGM Gidji TSF Hydrogeological Review

WAD CN - western bores



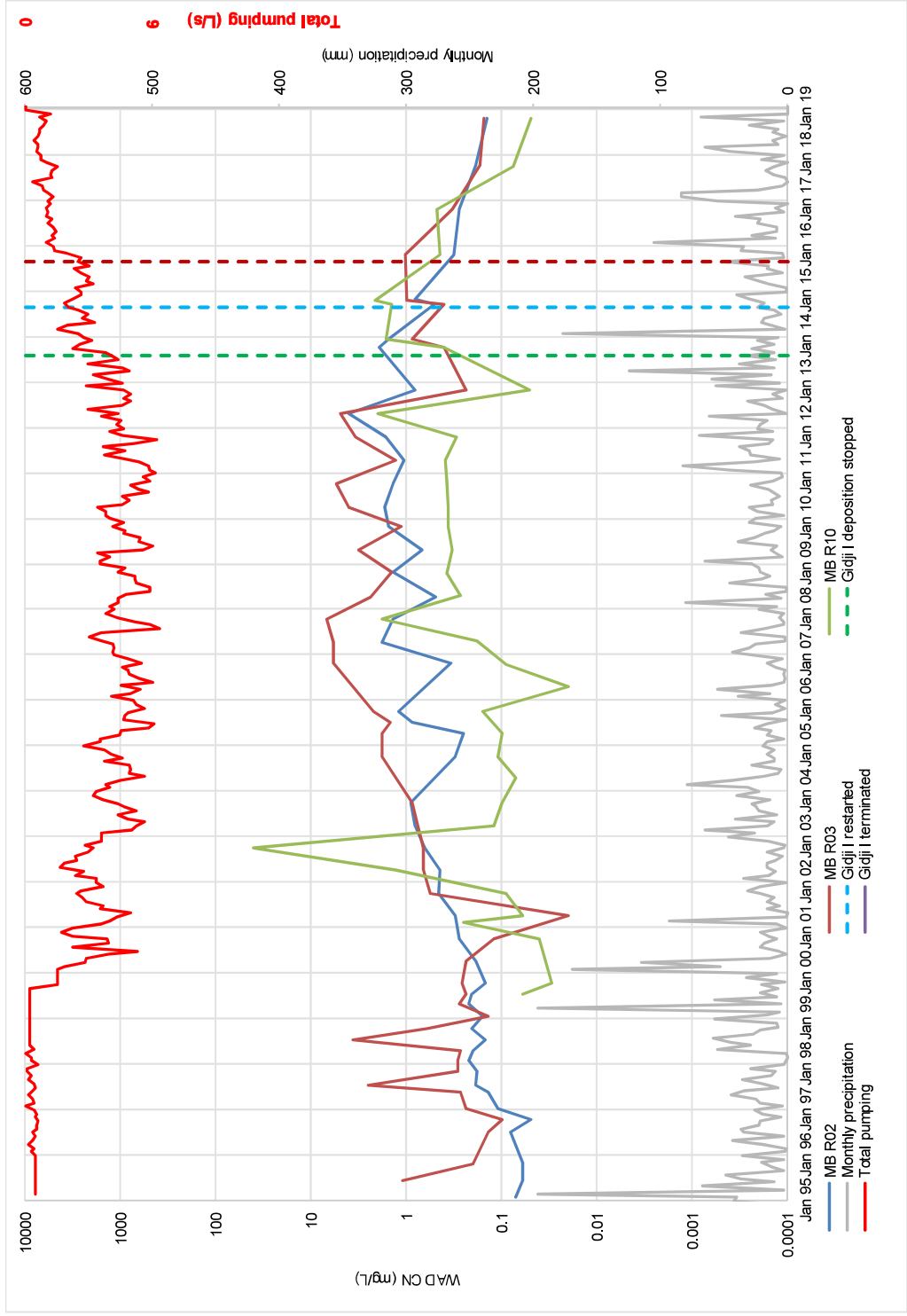


Figure 26

Date: January 2019
Report: KCGM Gidji TSF
Hydrogeological Review

WAD CN - trench bores



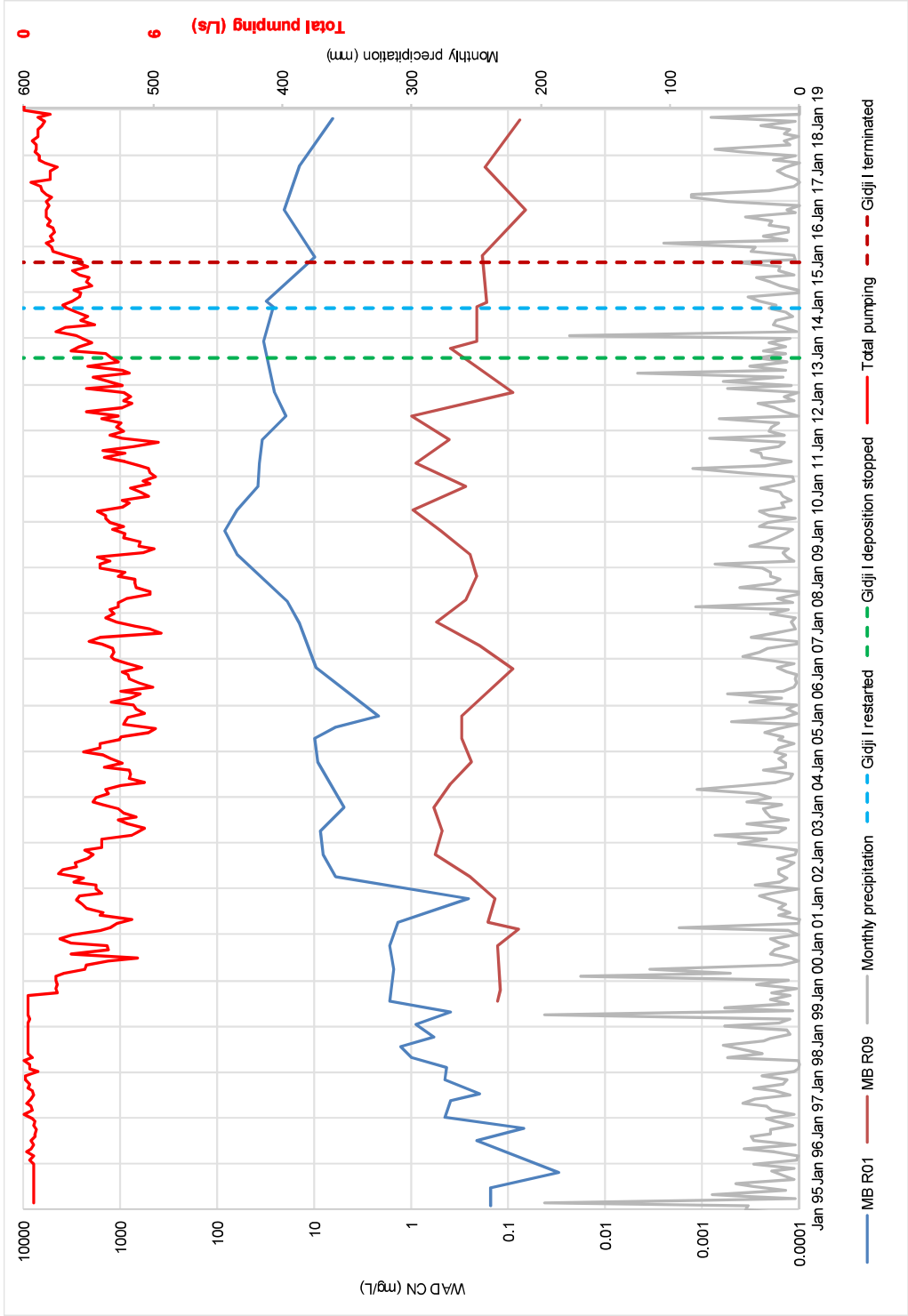


Figure 27

Date:	January 2019
Report:	KCGM Gidji TSF Hydrogeological Review

WAD CN - decant bores



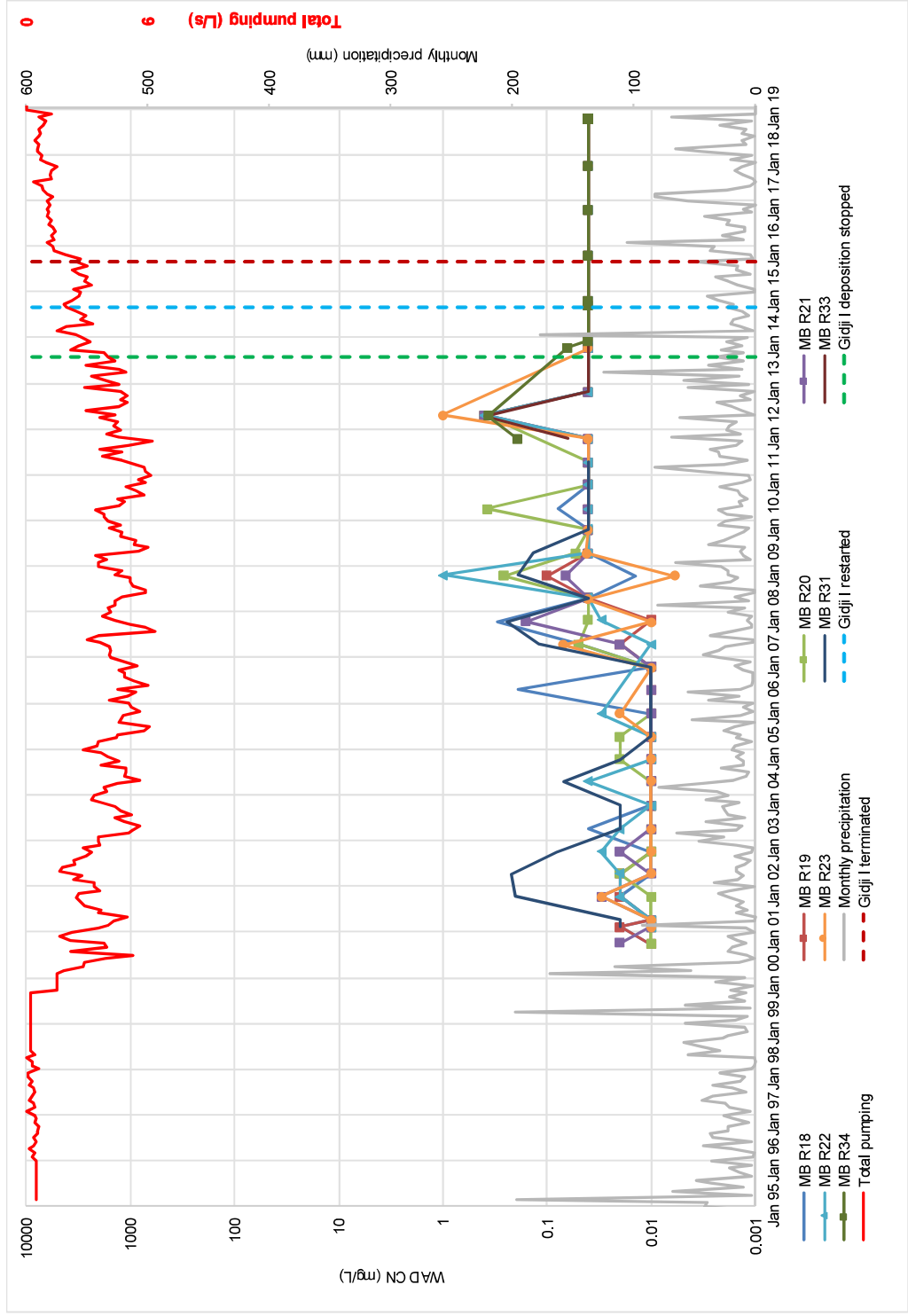


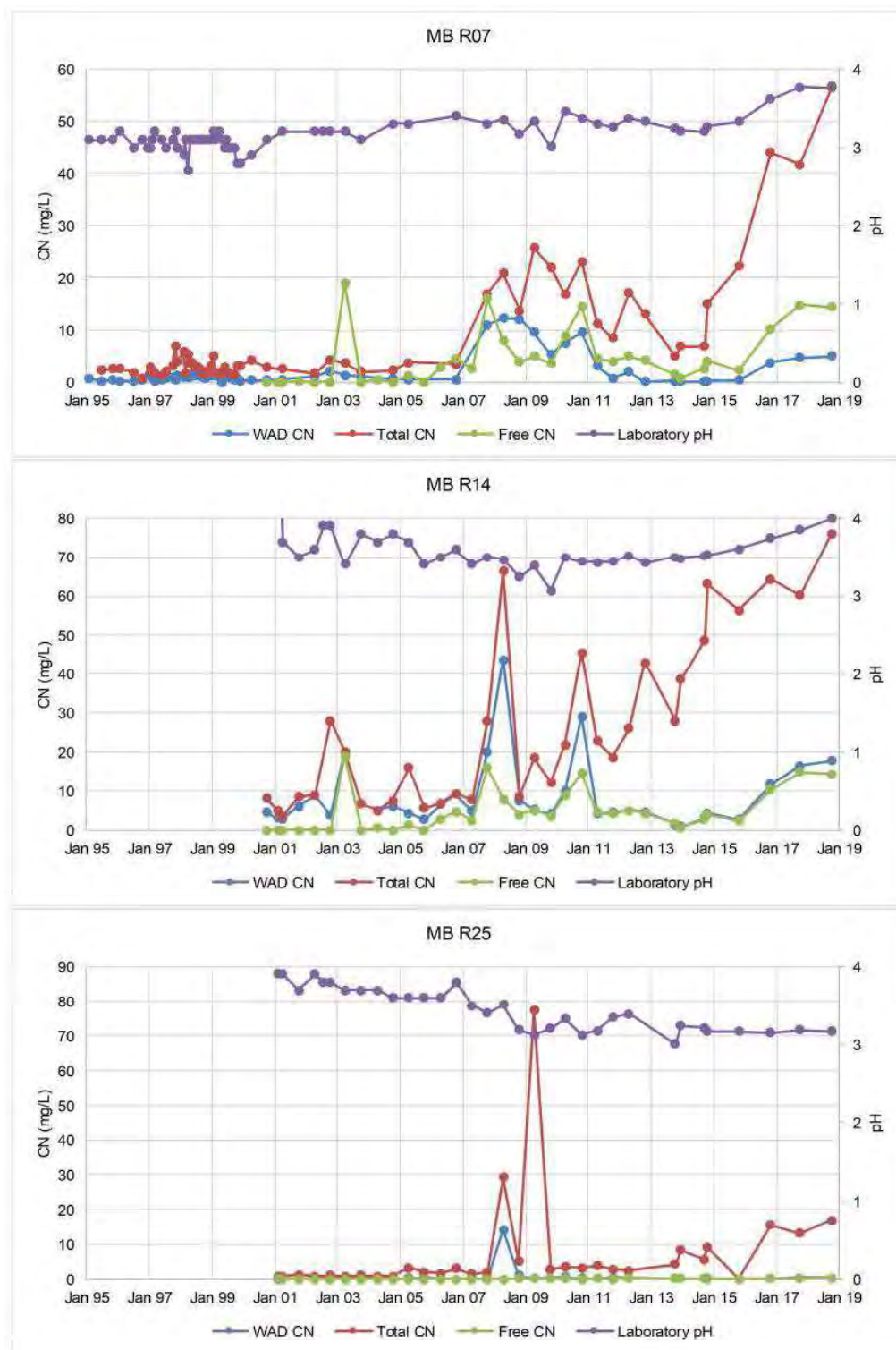
Figure 28

Date: January 2019

Report: KCGM Gidji TSF
Hydrogeological Review

WAD CN - eastern bores





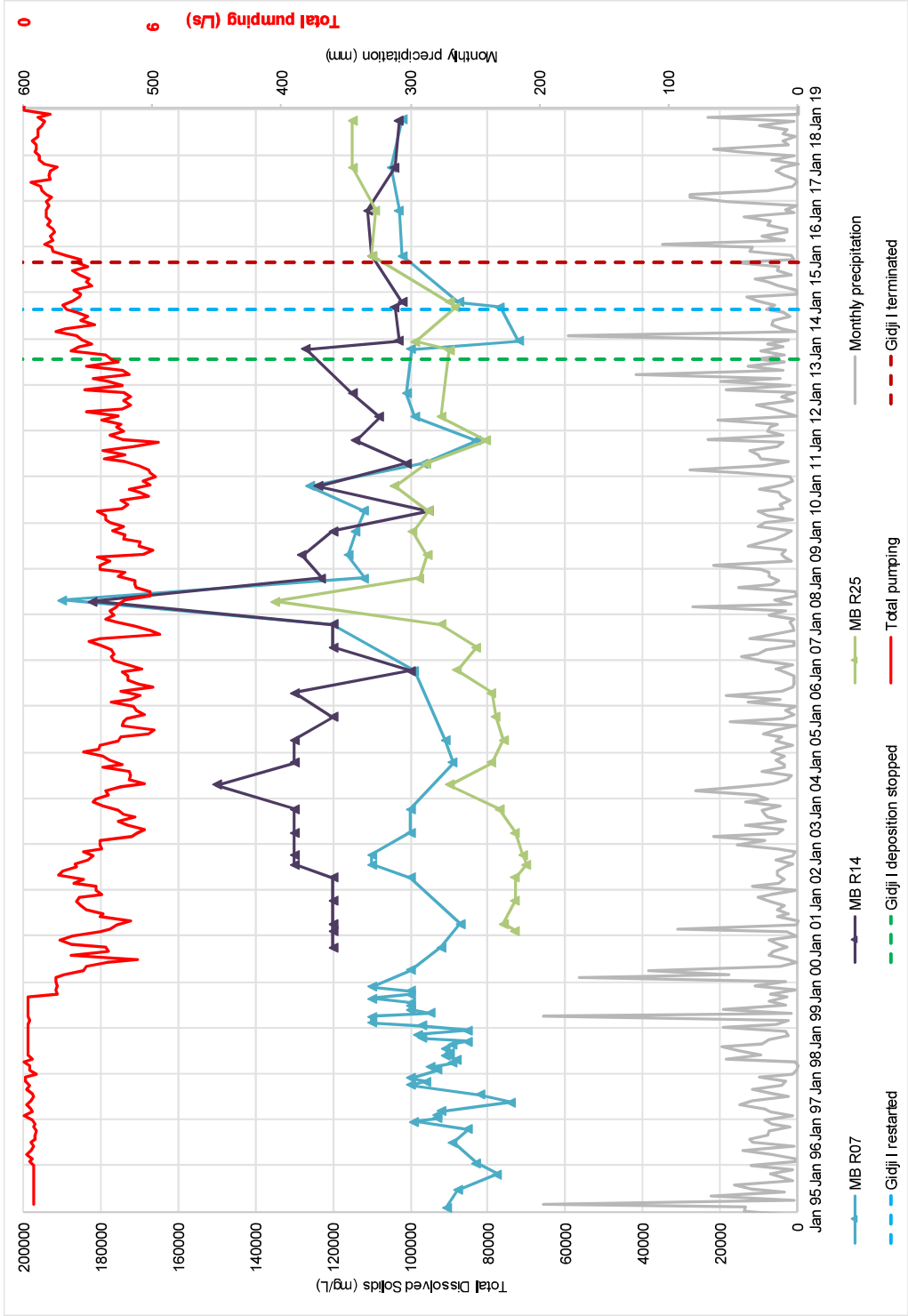
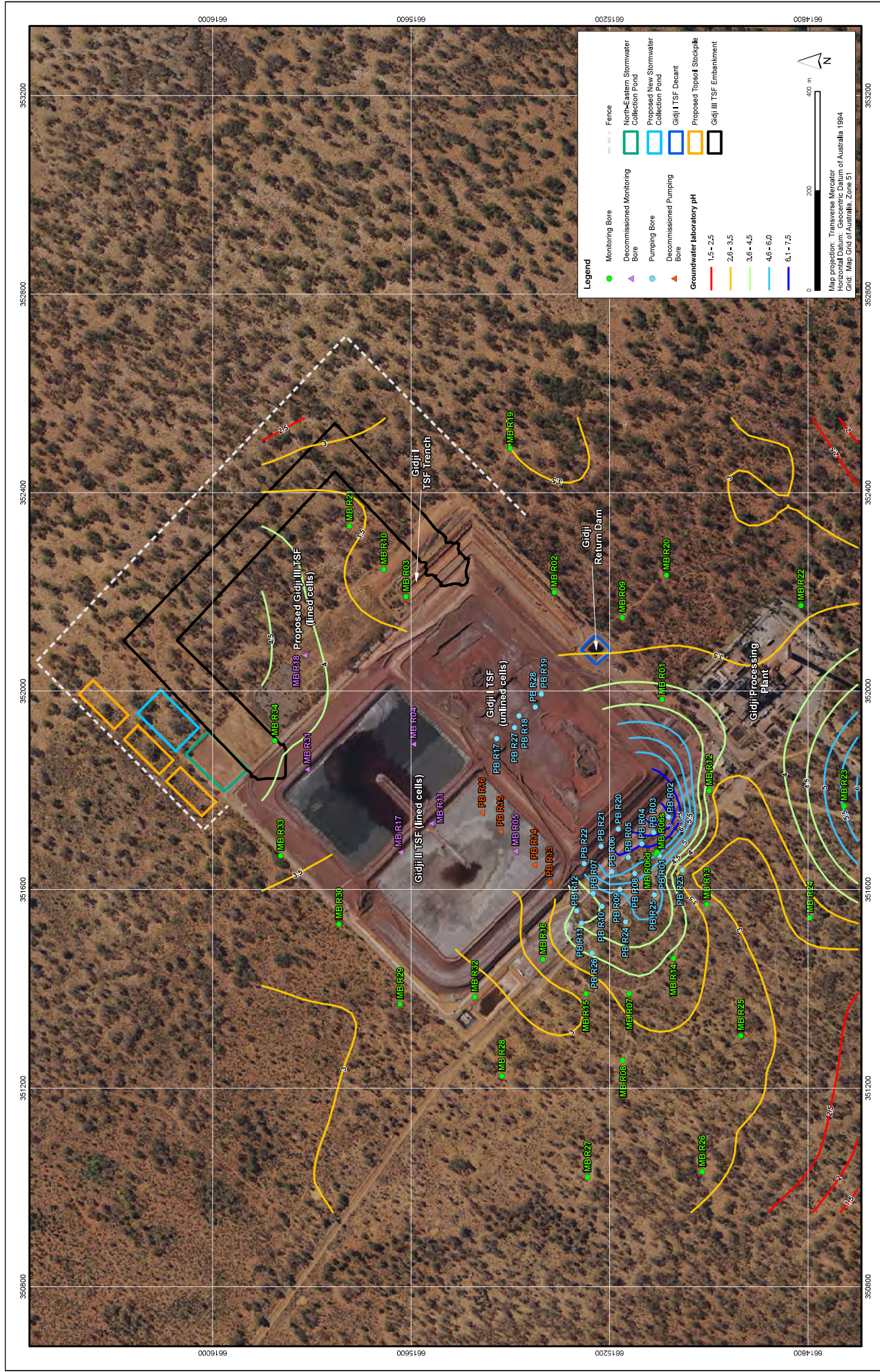


Figure 30

Date:	January 2019
Report:	KCGM Gidji TSF Hydrogeological Review

TDS trends in MB R07, MB R14 and MB R25

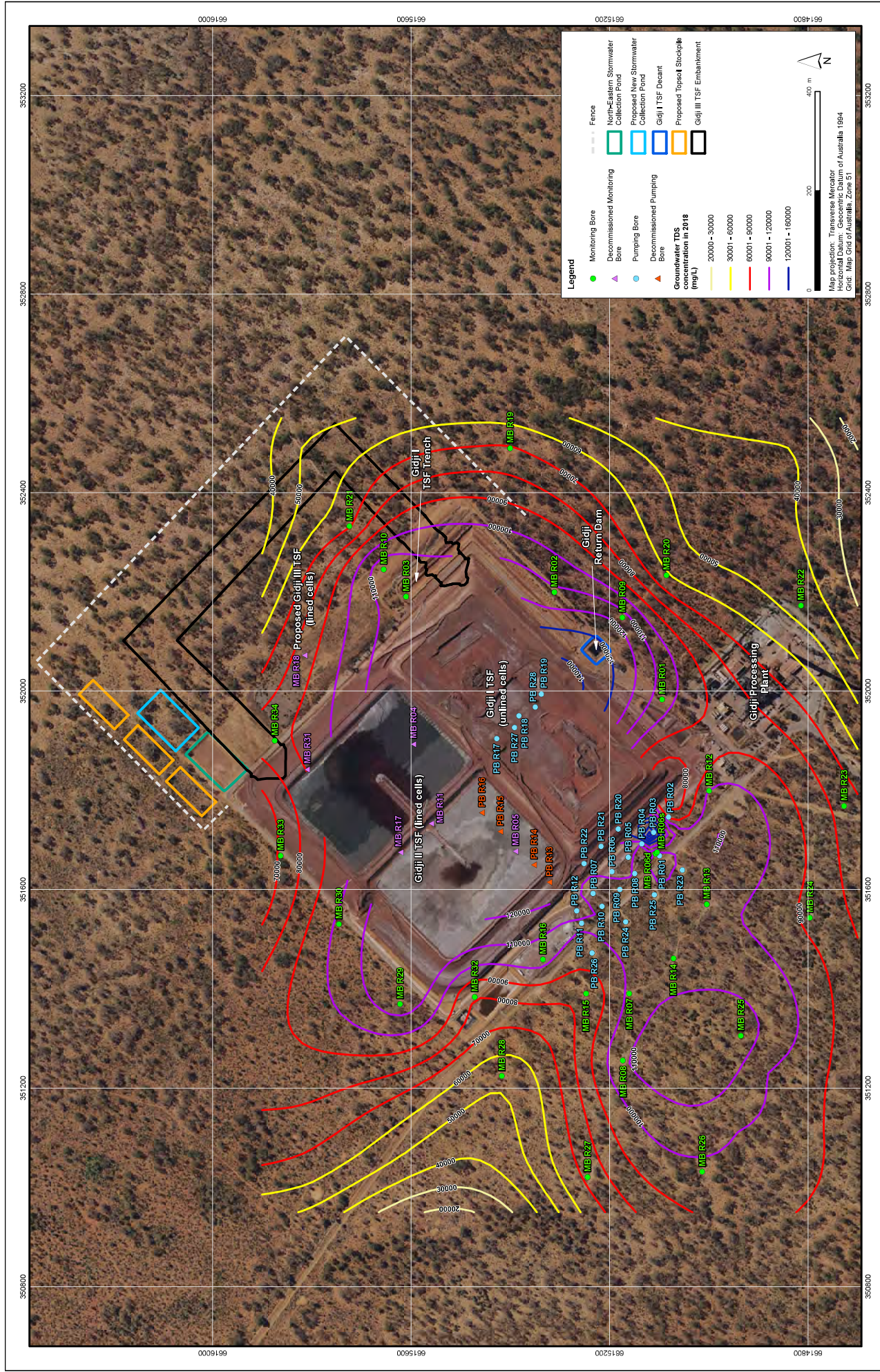




Laboratory pH distribution in 2018

Figure 31

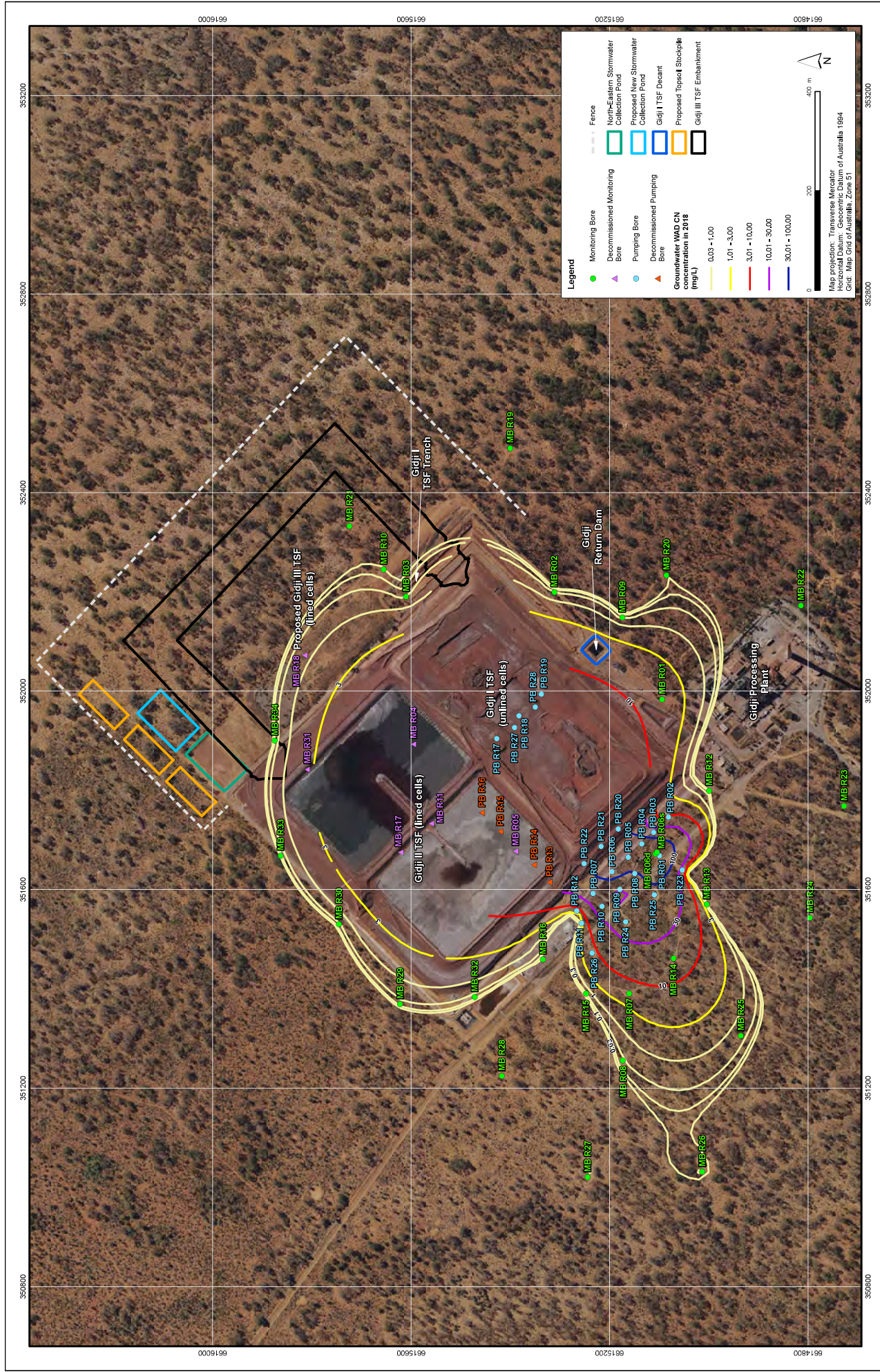
Date	January 2019
Report	Gidji TSF Hydrogeological Review



TDS distribution in 2018

Figure 32

Date	January 2019
Report	Gidji TSF Hydrogeological Review



WAD CN distribution in 2018

Figure 33

Date	January 2019
Report	Gidji TSF Hydrogeological Review

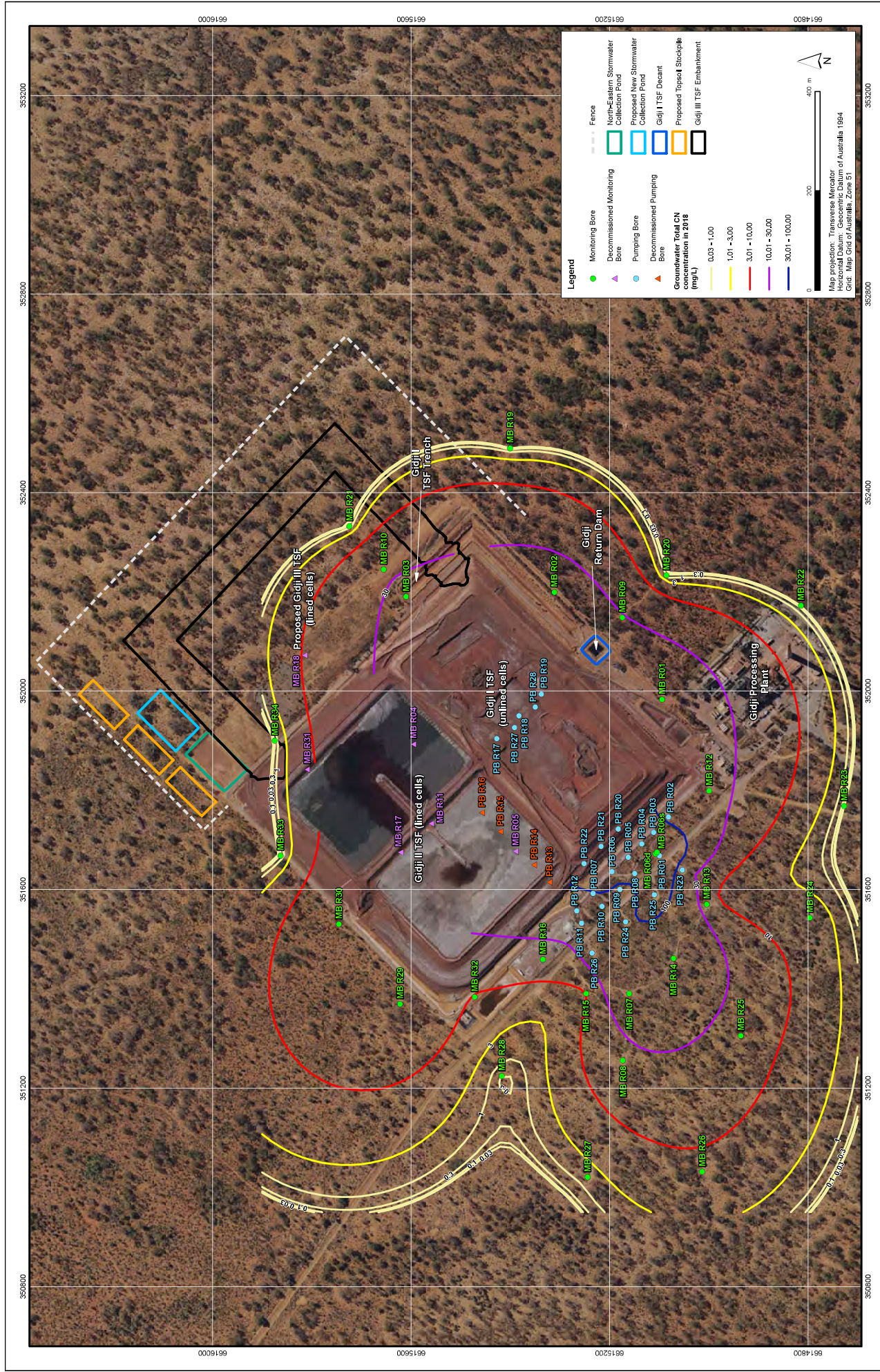
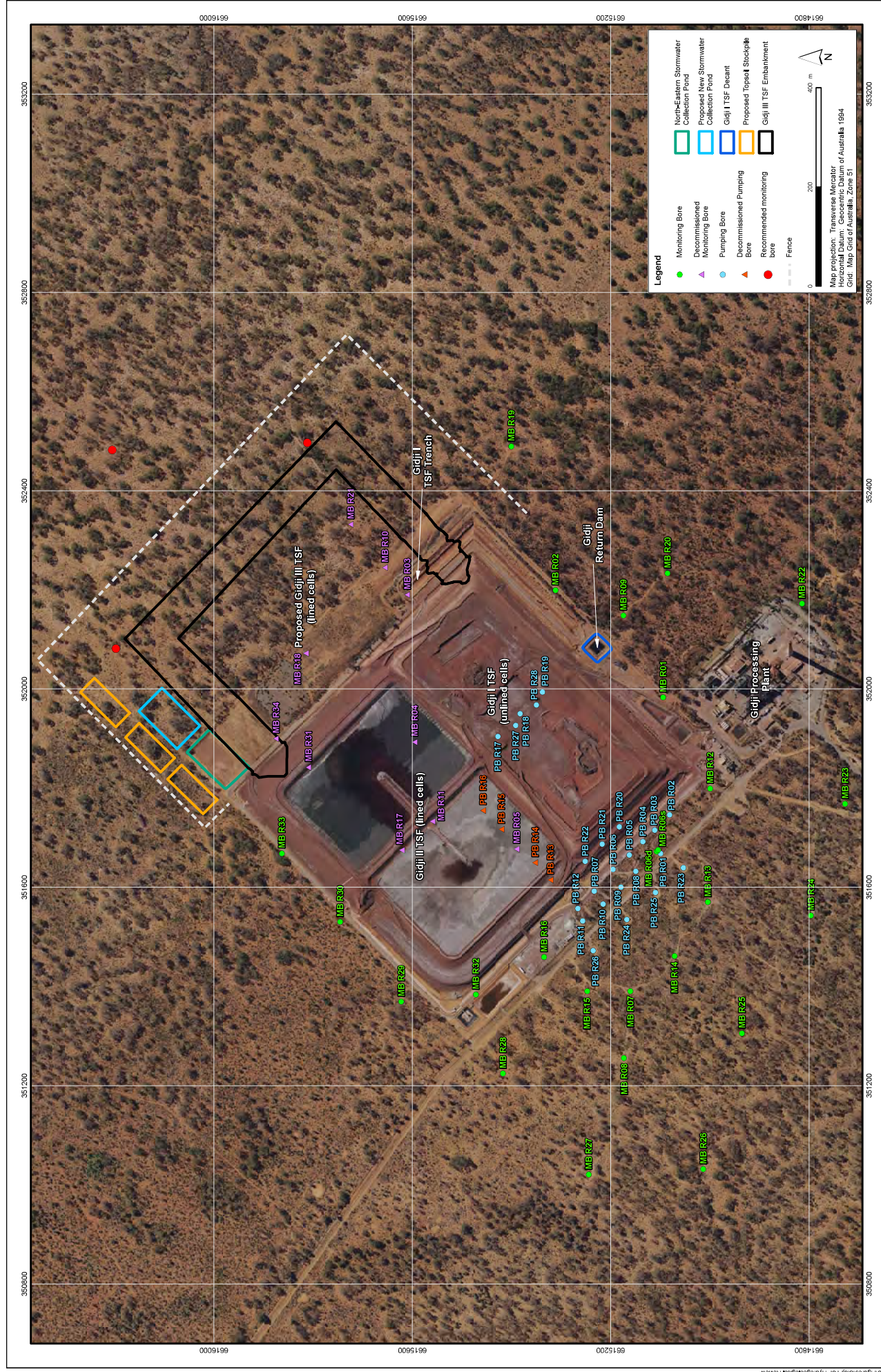


Figure 34

Date: January 2019
Report: Gidji TSF Hydrogeological Review

Total CN distribution in 2018





Recommended monitoring for Gidji III TSF

Figure 35

Date: January 2010

Report:	January 2019
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Gidji TSF
Hydrogeological Review

Appendix A

DWER licence L5946/1988/13



LIC1866

Licence Number	L5946/1988/13
Licence Holder	Kalgoorlie Consolidated Gold Mines Pty Ltd
ACN	009 377 619
Registered business address	Black Street KALGOORLIE WA 6430
Date of amendment	5 October 2016
Prescribed Premises	Category 5: Processing or beneficiation of metallic or non-metallic ore
Premises	Gidji Processing Plant Tenements G24/24-33 KALGOORLIE WA 6430

Amendment

The Chief Executive Officer (CEO) of the Department of Environment Regulation (DER) has amended the above licence in accordance with section 59 of the *Environmental Protection Act 1986* as set out in this Amendment Notice.

Jonathan Bailes

Manager Licensing (Process Industries)

an officer delegated under section 20 of the Environmental Protection Act 1986 (WA)

Amendment Notice

This notice is issued under section 59 of the *Environmental Protection Act* 1986 (EP Act) to amend the licence issued under the EP Act for a prescribed premises as set out below. This notice of amendment is given under section 59B(9) of the EP Act.

Amendment Description

Licence L5946/1988/13 was granted by DER on 26 September 2015. The licence was last amended on 21 April 2016 to remove metal smelting activities (ore roasting) which are no longer carried out. Ore roasting has been replaced by the use of Ultra-Fine Grinding (UFG) Mills commissioned in 2001 (10tph mill) and 2015 (30tph mill).

The Licence Holder has submitted an application to amend the licence in accordance with Ministerial Statement No. 1032 (MS1032) issued by the Environmental Protection Authority (EPA) on 30 June 2016. The Ministerial Statement approves an increase in production throughput from 351,000tpa to 438,000tpa.

The use of the UFG Mills has resulted in efficiency gains which enable the premises to process approximately 25% more ore using the existing infrastructure.

The amendment application also included a request to remove vegetation monitoring requirements near the premises Tailings Storage Facility as specified in condition 2.2.1. Other minor administrative amendments have also been made.

Decision

Increase in throughput capacity

The increased throughput authorised by MS1032 will result in an increased rate of discharge of tailings to the Gidji II Tailings Storage Facility (TSF). The main environmental risks associated with an increased discharge of tailings to the Gidji II TSF relate to potential increased seepage from the base and walls of the TSF and overtopping of the TSF.

These risks are mitigated by the design of the TSF which is regulated by the Department of Mines and Petroleum, and who also require an annual audit and assessment of the structural stability of the TSF. The TSF is designed using the downstream method of construction meaning that there is no requirement to allow the tailings to dry and consolidate prior to raise construction.

The Gidji II TSF has a containment capacity of 2.2Mt at a dry density of 1.6t/m³ (Golder Associates, August 2015). A revised water balance for the increase production shows that there will be an increase in supernatant return that will require treatment in the cyanide destruction plant.

The TSF will be managed according to the *Kalgoorlie Consolidated Gold Mines Gidji Tailings Storage Facilities Operating manual- October 2015 Update* (Golder Associates, November 2015).

Condition 1.2.2 of the licence requires the Licence Holder to maintain an operating freeboard of 300mm in the TSF cells and the supernatant return water dam. Condition 1.2.3 requires six-hourly visual inspections of the tailings and supernatant return water lines, ponding on the surface of the TSF, maintenance of the freeboard, and integrity of the external walls of the TSF. Where an issue is identified, corrective action is

required to be undertaken to mitigate environmental impacts.

The Gidji II TSF was constructed with a composite clay and HDPE liner with a permeability of less than 1×10^{-9} m/s. The TSF also has an over-liner drainage system to maximise the recovery of seepage within the TSF. Seepage from the TSF is also managed by the use of groundwater production bores and compliance monitoring bores that limit the extent to which ambient groundwater levels rise within the vicinity of the TSF in accordance with licence condition 1.2.4.

The Delegated Officer considers these control measures to be adequate to manage the risks associated with an increase in tailings generated as a consequence of the increased production throughput capacity.

Vegetation Monitoring

Vegetation monitoring has been conducted at the site since 1999 to determine if groundwater mounding resulting from seepage from the Gidji I TSF is causing impacts on vegetation growth. The Gidji I TSF was lined with a clay base, and a series of groundwater production bores and seepage trenches were used to manage and recover seepage from this TSF. A series of targets and limits for water quality and standing water levels were incorporated into the licence requiring management action to prevent ambient groundwater levels from reaching the root zone of vegetation. The Licence Holder has requested that vegetation monitoring is removed from the licence as current groundwater abstraction and monitoring controls have demonstrated that the impact to vegetation from seepage can be adequately managed by controlling the groundwater levels in the vicinity of the Gidji I TSF.

The Delegated Officer accepts that the use of groundwater production bores and seepage trenches has been an effective measure in mitigating environmental impacts and that the continuation of vegetation monitoring is no longer required. Furthermore, tailings deposition is no longer occurring in the Gidji I TSF, and the newly commissioned Gidji II TSF is appropriately lined and contains an over drainage layer which will significantly reduce groundwater mounding beneath the TSFs. Quarterly groundwater monitoring results since the closure of the Gidji I TSF indicate a decrease in groundwater mounding beneath the TSFs which is expected to decrease further over time.

The Delegated Officer has removed the vegetation monitoring requirements on the basis of the above and that the vegetation monitoring carried out to date has not demonstrated any impacts such as declining vegetation health over the groundwater mounding risk areas.

Administrative Amendments

The Delegated Officer has made minor administrative amendments to correct typographical errors and remove improvement condition 3.1.1 as the Dust Management Plan was submitted to DER on the 4 July 2016 and assessed as meeting the requirements of the condition.

Amendment History

Instrument	Issued	Amendment
L5946/1988/13	26/09/2014	Licence re-issue
L5946/1988/13	4/12/ 2014	Licence amendment to increase plant throughput capacity from 225,000 tonnes to 351,000 tonnes per annum and to allow for the use of Gidji I TSF.
L5946/1988/13	21/04/ 2016	Licence amendment to remove metal smelting or refining and the Gidji I TSF for deposition of tailings. The vehicle wash down bay is also removed. The licence has also been amended to extend the duration of the licence in accordance with DER's <i>Guidance Statement on Licence Duration</i> .
L5946/1988/13	5/10/2016	Amendment Notice 1 Amended to increase the approved throughput capacity, and remove the requirements for vegetation monitoring and the improvement condition requiring the submission of a dust management plan.

Amendment

- The approved licence production or design capacity is amended from 351,000 tonnes per annual period to 438,000 tonnes per annual period.
- Condition 2.1.2 of the licence is amended by the insertion of the red text shown in underline below:

2.1.2 The Licensee shall ensure that:

 - quarterly monitoring is undertaken at least 45 days apart;
 - six monthly monitoring is undertaken at least 5 months apart; and
 - annual monitoring is undertaken at least 9 months apart.
- Condition 2.2.1 of the licence is amended by the by the deletion of the text shown in strikethrough below and the insertion of the red text shown in underline below:

2.2.1 The Licensee shall undertake monitoring in ~~Tables 2.2.1 and 2.2.2~~ Table 2.2.2 according to the specifications in ~~these tables~~ that table.
- The licence is amended by the deletion of the following Table 2.2.1:

Table 2.2.1: Monitoring of vegetation			
Purpose	Monitoring Reference	Parameter	Frequency
Monitor the vegetation in the vicinity of the Gidji roaster to identify if there is any detrimental impacts on vegetation caused by seepage from the TSFs	1, 2, 6, 7, 8, 9, 12, 13, 14, 15 as shown on the map of TSF photographic monitoring locations in Schedule 1	Photographs of vegetation at monitoring points associated with monitoring bores or identifiable field markers. Photographs are to be taken at a fixed focal length and away from the TSFs to standardise information gained.	Annually (between 1 September and 30 November)

5. The licence is amended by the deletion of the following condition 3.1.1:

3.1.1 *The Licensee shall complete the improvement in Table 3.1.1 by the date of completion in Table 3.1.1.*

Table 3.1.1: Improvement program		
Improvement reference	Improvement	Date of completion
IR1	The Licensee shall submit to the CEO a Dust Management Plan (DMP) covering the management of dust onsite that may potentially cause a risk to the environment. As a minimum the DMP shall include: • A review of the adequacy of current dust management practices and provide recommendations for changes to operating procedures or monitoring if required. • Standard operational procedures (SOPs) for the identification, assessment and management actions for fugitive dust emissions; and • Identification of roles and responsibilities under the DMP. The Licensee shall implement the DMP.	31 July 2016

6. Table 4.2.1 of the licence is amended by the deletion of the text shown in strikethrough below and the insertion of the red text shown in underline below:

Table 4.2.1: Annual Environmental Report		
Condition or table (if relevant)	Parameter	Format or form ¹
-	Summary of any failure or malfunction of any pollution control equipment that has resulted in any reportable environmental incidents that have occurred during the annual period and any action taken	None specified
Table 2.2.1	TSE Photographic Vegetation Monitoring Programme including an assessment of the vegetation by a person with tertiary or post-secondary qualifications in plant ecology, botanical or environmental studies.	
4.1.3	Compliance	Annual Audit Compliance Report (AACR)
4.1.4	Complaints summary	None specified
Table 5.2.2 <u>4.2.2</u>	Reference non annual reporting data and provide a summary of the key findings and recommendations	
Table 5.3.1 <u>4.3.1</u>	Summary of any saline, alkaline or cyanide constituent spills greater than 5000L that escaped from pipeline bunding	

Note 1: Forms are in Schedule 2

7. Table 4.2.2 of the licence is amended by the by the deletion of the text shown in strikethrough below and the insertion of the red text shown in underline below:

Table 4.2.2: Non-annual reporting requirements				
Condition or table (if relevant)	Parameter	Reporting period	Reporting date (after end of the reporting period)	Format or form
2.1.3	Calibration	Available on request	14 calendar days	None specified
-	Copies of original monitoring reports submitted to the Licensee by third parties	Not Applicable	Within 14 days of the CEO's request	As received by the Licensee from third parties
Table 2.2.2	Groundwater monitoring including summary of any <u>limit</u> target exceedances	Quarterly	46 calendar days	None specified



Licence

Environmental Protection Act 1986, Part V

Licensee: Kalgoorlie Consolidated Gold Mines Pty Ltd

Licence: L5946/1988/13

Registered office: Kalgoorlie Consolidated Gold Mines Pty Ltd
Black Street
KALGOORLIE WA 6430

ACN: 009 377 619

Premises address: Gidji Processing Plant
Tenements G24/24-33
KALGOORLIE WA 6430

Issue date: Friday, 26 September 2014

Commencement date: Monday, 29 September 2014

Expiry date: Saturday, 28 September 2029

Prescribed premises category
Schedule 1 of the *Environmental Protection Regulations 1987*

Category number	Category description	Category production or design capacity	Approved Premises production or design capacity
5	Processing or beneficiation of metallic or non-metallic ore	50 000 tonnes or more per year	351,000 tonnes per annual period

438,000

Conditions

This Licence is subject to the conditions set out in the attached pages.

Jonathan Bailes
Manager Licensing (Process Industries)
Officer delegated under section 20
of the *Environmental Protection Act 1986*



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Introduction

This Introduction is not part of the Licence conditions.

DER's industry licensing role

The Department of Environment Regulation (DER) is a government department for the state of Western Australia in the portfolio of the Minister for Environment. DER's purpose is to advise on and implement strategies for a healthy environment for the benefit of all current and future Western Australians.

DER has responsibilities under Part V of the *Environmental Protection Act 1986* (the Act) for the licensing of prescribed premises. Through this process DER regulates to prevent, control and abate pollution and environmental harm to conserve and protect the environment. DER also monitors and audits compliance with works approvals and licence conditions, takes enforcement action as appropriate and develops and implements licensing and industry regulation policy.

Licence requirements

This Licence is issued under Part V of the Act. Conditions contained within the Licence relate to the prevention, reduction or control of emissions and discharges to the environment and to the monitoring and reporting of them.

Where other statutory instruments impose obligations on the Premises/Licensee the intention is not to replicate them in the licence conditions. You should therefore ensure that you are aware of all your statutory obligations under the Act and any other statutory instrument. Legislation can be accessed through the State Law Publisher website using the following link:

<http://www.slp.wa.gov.au/legislation/statutes.nsf/default.html>

For your Premises relevant statutory instruments include but are not limited to obligations under the:

- *Environmental Protection (Unauthorised Discharges) Regulations 2004* – these regulations make it an offence to discharge certain materials such as contaminated stormwater into the environment other than in the circumstances set out in the regulations.
- *Environmental Protection (Controlled Waste) Regulations 2004* - these regulations place obligations on you if you produce, accept, transport or dispose of controlled waste.
- *Environmental Protection (Noise) Regulations 1997* – these regulations require noise emissions from the Premises to comply with the assigned noise levels set out in the regulations.

You must comply with your licence. Non-compliance with your licence is an offence and strict penalties exist for those who do not comply.



Licence holders are also reminded of the requirements of section 53 of the Act which places restrictions on making certain changes to prescribed premises unless the changes are in accordance with a works approval, licence, closure notice or environmental protection notice.

Licence fees

If you have a licence that is issued for more than one year, you are required to pay an annual licence fee prior to the anniversary date of issue of your licence. Non payment of annual licence fees will result in your licence ceasing to have effect meaning that it will no longer be valid and you will need to apply for a new licence for your Premises.

Ministerial conditions

If your Premises has been assessed under Part IV of the Act you may have had conditions imposed by the Minister for Environment. You are required to comply with any conditions imposed by the Minister.

Premises description and Licence summary

Kalgoorlie Consolidated Gold Mines Ltd (KCGM) operates the Fimiston open pit, Mt Charlotte underground mine, Fimiston mill, and Gidji Processing Plant on behalf of joint venture owners Barrick Ltd (Australia Pacific) and Newmont Asia Pacific Ltd (Newmont).

The Gidji Processing Plant, located 17 kilometres north of Kalgoorlie-Boulder, treats refractory gold sulphide concentrate produced by the Fimiston mill. The purpose of this amendment is to remove metal smelting or refining from the licence. The Licensee also applied to increase the throughput of 351,000 to 438,000 tonnes per annual period however this was not assessed on the basis that this increase needs to be approved under Part IV of *The Environmental Protection Act 1986* and any approved increase reflected in Ministerial Statement Nos. 77 and 28. This Part IV amendment is delayed, and the Licensee has requested that the parts of the application which do not require amendment of the Ministerial Statement to be processed. A separate application will be made for the increased throughput following the finalisation of the Part IV process.

Historically, the sulphide ore was initially roasted to oxidate the sulphide which in turn allowed the fine gold particles to be dissolved once the ore was placed into cyanide solution. In order to reduce gaseous emissions to air, the site undertook an Emissions Reduction Project under Works Approval W5659/2014/1. This involved the replacement of the two 20 tonne per hour roasters with one 30 tonne per hour Ultrafine Grinding Mill (UFG) to process refractory ore from Fimiston. This is in addition to the existing 10 tonne per hour UFG mill, maintaining the sites 40 tonne per hour processing of refractory ore. The two roasters ceased operating on 26 January 2015 and 5 April 2015 respectively. This Licence amendment removes reference to all point source air emissions and associated monitoring requirements. Additionally ambient monitoring requirements in accordance with the *Environmental Protection (Goldfields Residential Areas) (Sulfur Dioxide) Policy 2003* are also no longer relevant to this licence.

The tailings from the cyanide leach and carbon-in-pulp adsorption process is sent to the Gidji Tailings Storage Facilities (TSFs). Currently, two cells are in operation, Gidji II (east) and Gidji II (west). These cells were commissioned in 2012 and 2014 respectively. Associated infrastructure supporting the process plant includes access tracks, borefields (production and monitoring bores), water storage ponds, transfer ponds and seepage interception trench. This amendment includes the removal of the Gidji I TSF as an approved tailing deposition area. Under a previous licence amendment (4 December 2014), DER agreed to allow the use of the use of the Gidji I TSF as an interim measure until the TSF reached its maximum capacity or until the new UFG mill was commissioned (whichever came first).

This amendment also removes reference to the vehicle wash down bays from the licence as no vehicles are washed down at the Gidji facility. This was confirmed through DER's Inspection of the premises on 25 March 2015.

Other changes have also been made to reflect administrative changes implemented within DER.



The licences and works approvals issued for the Premises since 1/10/2007 are:

Instrument log		
Instrument	Issued	Description
L5946/1988/10	1 October 2007	Licence re-issue
L5946/1988/11	29 September 2009	Licence re-issue
W4862/2011/1	4 April 2011	Works Approval for Gidji TSF extension
L5946/1988/12	1 December 2011	Licence re-issue and amendment to some condition wording
L5946/1988/12	19 April 2012	Licence amendment due to commissioning of TSF II East Cell
L5946/1988/12	12 June 2014	Licence amendment due to commissioning of TSF II West Cell
W5659/2014/1	26 June 2014	Works Approval for Emissions Reduction Program (install Ultra Fine Grinding (UFG) mill)
L5946/1988/13	26 September 2014	Licence re-issue, conversion to REFIRE format and TSF seepage and groundwater monitoring amendments
L5946/1988/13	4 December 2014	Licence amendment to increase plant throughput capacity from 225,000 tonnes to 351,000 tonnes per annum and to allow for the use of Gidji I TSF.
L5946/1988/13	21 April 2016	Licence amendment to remove metal smelting or refining and the Gidji I TSF for deposition of tailings. The vehicle wash down bay is also removed. The licence has also been amended to extend the duration of the licence in accordance with DER's <i>Guidance Statement on Licence Duration</i> .

Severance

It is the intent of these Licence conditions that they shall operate so that, if a condition or a part of a condition is beyond the power of this Licence to impose, or is otherwise *ultra vires* or invalid, that condition or part of a condition shall be severed and the remainder of these conditions shall nevertheless be valid to the extent that they are within the power of this Licence to impose and are not otherwise *ultra vires* or invalid.

END OF INTRODUCTION



Licence conditions

1 General

1.1 Interpretation

1.1.1 In the Licence, definitions from the *Environmental Protection Act 1986* apply unless the contrary intention appears.

1.1.2 For the purposes of this Licence, unless the contrary intention appears:

'Act' means the *Environmental Protection Act 1986*;

'annual' means the inclusive period from 1 January until 31 December in that year;

'AS/NZS 5667.1' means the Australian Standard AS/NZS 5667.1 *Water Quality – Sampling – Guidance of the Design of sampling programs, sampling techniques and the preservation and handling of samples*;

'AS/NZS 5667.11' means the Australian Standard AS/NZS 5667.11 *Water Quality – Sampling – Guidance on sampling of groundwaters*;

'averaging period' means the time over which a limit is measured or a monitoring result is obtained;

'CEO' means Chief Executive Officer of the Department of Environment Regulation;

'CEO' for the purpose of correspondence means:

Chief Executive Officer
Department Administering the *Environmental Protection Act 1986*
Locked Bag 33
CLOISTERS SQUARE WA 6850
Email: info@der.wa.gov.au

'CN-free' means free cyanide;

'CN-total' means total cyanide;

'CN-WAD' means weak acid dissociable cyanide;

'compliance bores' means those compliance monitoring bores listed in Table 2.2.2 and at the locations depicted in Schedule 1: Maps-Gidji operations monitoring bore location:

'environmentally hazardous material' means material (either solid or liquid raw materials, materials in the process of manufacture, manufactured products, products used in the manufacturing process, by-products and waste) which if discharged into the environment from or within the premises may cause pollution or environmental harm. Note: Environmentally hazardous materials include dangerous goods where they are stored in quantities below placard quantities. The storage of dangerous goods above placard quantities is regulated by the Department of Mines and Petroleum;

'freeboard' means the distance between the maximum water surface elevations and the top of retaining banks or structures at their lowest point;

'Licence' means this Licence numbered L5946/1998/13 and issued under the Act;



'Licensee' means the person or organisation named as Licensee on page 1 of the Licence;

'mm' means millimetre;

'mg/L' means milligrams per litre;

'NATA' means the National Association of Testing Authorities, Australia;

'NATA accredited' means in relation to the analysis of a sample that the laboratory is NATA accredited for the specified analysis at the time of the analysis;

'Premises' means the area defined in the Premises Map in Schedule 1 and listed as the Premises address on page 1 of the Licence;

'quarterly' means the 4 inclusive periods from 1 January to 31 March, 1 April to 30 June, 1 July to 30 September and 1 October to 31 December in that year;

'Schedule 1' means Schedule 1 of this Licence unless otherwise stated;

'Schedule 2' means Schedule 2 of this Licence unless otherwise stated;

'six monthly' means the 2 inclusive periods from 1 January to 30 June and 1 July to 31 December in that year;

'spot sample' means a discrete sample representative at the time and place at which the sample is taken;

'SWL' means standing water level;

'TSF' means an engineered containment pond or dam used to store tailings, i.e. a tailings storage facility;

'TDS' means total dissolved solids

'usual working day' means 0800 – 1700 hours, Monday to Friday excluding public holidays in Western Australia; and

'µS/cm' means microsiemens per centimetre.

1.1.3 Any reference to an Australian or other standard in the Licence means the relevant parts of the standard in force from time to time during the term of this Licence.

1.1.4 Any reference to a guideline or code of practice in the Licence means the version of that guideline or code of practice in force from time to time and shall include any amendments or replacements to that guideline or code of practice made during the term of this Licence.

1.2 Premises operation

1.2.1 The Licensee shall ensure that all pipelines containing environmentally hazardous materials are either:

- (a) equipped with automatic cut-outs in the event of a pipe failure; or
- (b) provided with secondary containment sufficient to contain any spill for a period equal to the time between routine inspections.

1.2.2 The Licensee shall ensure that waste material is only stored and/or treated within vessels or compounds provided with the infrastructure detailed in Table 1.2.2.



Table 1.2.2: Containment infrastructure		
Storage vessel or compound and location in map of storage locations in Schedule 1	Material	Requirements
Gidji II TSF East Cell	Tailings	HDPE lined with under drainage layer, netted during tailings deposition Minimum freeboard of 300mm
Gidji II TSF West Cell		HDPE lined with under drainage layer, netted during tailings deposition Minimum freeboard of 300mm
Production water dam Return water dam	Any substance containing saline, alkaline or cyanide constituents resulting from activities on the Premises	HDPE lined, netted Minimum freeboard of 300mm

1.2.3 The Licensee shall:

- (a) undertake inspections as detailed in Table 1.2.3;
- (b) take corrective action to mitigate adverse environmental consequences as soon as practicable, where any inspection identifies that an appropriate level of environmental protection is not being maintained; and
- (c) maintain a record of all inspections undertaken.

Table 1.2.3: Inspection of infrastructure		
Scope of inspection	Type of inspection	Frequency of inspection ¹
Tailings pipelines	Visual integrity	Every 6 hours during operations
Return water lines		
Tailings deposition	Visual	
Ponding on the surface of the TSF	Visual to confirm location of the pond	
Freeboard	Visual to confirm required freeboard capacity is available	
External wall of the TSF	Visual integrity	

Note 1: If circumstances at the scheduled time of inspection are identified as immediately hazardous to personnel the inspection should be undertaken as soon as practicable and the reason(s) recorded.

- 1.2.4 The Licensee shall install and maintain groundwater production bores to control the impact of seepage on groundwater levels such that the ambient groundwater water level limit measured in compliance monitoring bores are met.



2 Monitoring

2.1 General monitoring

2.1.1 The licensee shall ensure that:

- (a) all water samples are collected and preserved in accordance with AS/NZS 5667.1;
- (b) all groundwater sampling is conducted in accordance with AS/NZS 5667.11; and
- (c) all laboratory samples are submitted to and tested by a laboratory with current NATA accreditation for the parameters being measured.

2.1.2 The Licensee shall ensure that:

- (a) quarterly monitoring is undertaken at least 45 days apart;
- (b) six monthly monitoring is undertaken at least 5 months apart; and
- (c) **annual monitoring is undertaken at least 9 months apart.**

2.1.3 The Licensee shall ensure that all monitoring equipment used on the Premises to comply with the conditions of this Licence is calibrated in accordance with the manufacturer's specifications or any relevant and effective internal management system.

2.1.4 The Licensee shall, where the requirements for calibration cannot be practicably met, or a discrepancy exists in the interpretation of the requirements, bring these issues to the attention of the CEO accompanied with a report comprising details of any modifications to the methods.

2.2 Ambient environmental quality monitoring

2.2.1 The Licensee shall undertake monitoring in Tables 2.2.1 and 2.2.2 according to the specifications in those tables.

Table 2.2.1: Monitoring of vegetation			
Purpose	Monitoring Reference	Parameter	Frequency
Monitor the vegetation in the vicinity of the Gidji roaster to identify if there is any detrimental impacts on vegetation caused by seepage from the TSFs	1, 2, 6, 7, 8, 9, 12, 13, 14, 15 as shown on the map of TSF photographic monitoring locations in Schedule 1	Photographs of vegetation at monitoring points associated with monitoring bores or identifiable field markers. Photographs are to be taken at a fixed focal length and away from the TSFs to standardise information gained.	Annually (between 1 September and 30 November)



Table 2.2.2: Monitoring of ambient groundwater quality					
Monitoring point reference and location on map of groundwater monitoring locations in Schedule 1	Parameter	Limit	Units	Averaging period	Frequency
Gidji Trench, Gidji Return Dam	pH ¹	-	-	Spot sample	Annually
	Electrical conductivity ¹		µS/cm		
	TDS		mg/L		Annually
	CN-free				
	CN-WAD				
	CN- total				
Compliance Monitoring bores MBR7,MBR8, MBR13-MBR15, MBR19-MBR28, MBR34	Standing water level (SWL) ¹	4	mbgl	Spot sample	Quarterly
	pH ¹	-	-		Six monthly
	Electrical conductivity ¹		µS/cm		
	TDS		mg/L		Annually
	CN-free				
	CN-WAD				
	CN- total				
	Operational area monitoring bores MBR1–MBR3, MBR6d,MBR6s, MBR9,MBR10, MBR12, MBR16, MBR29,MBR30, MBR32,MBR33		Standing water level (SWL) ¹		-
pH ¹		-	Six monthly		
Electrical conductivity ¹		µS/cm			
TDS		mg/L	Annually		
CN-free					
CN-WAD					
CN- total					

Note 1: In-field non-NATA accredited sampling permitted

3 Improvements

3.1.1 The Licensee shall complete the improvement in Table 3.1.1 by the date of completion in Table 3.1.1.

Table 3.1.1: Improvement program		
Improvement reference	Improvement	Date of completion
IR1	The Licensee shall submit to the CEO a Dust Management Plan (DMP) covering the management of dust onsite that may potentially cause a risk to the environment. As a minimum the DMP shall include: • A review of the adequacy of current dust management practices and provide recommendations for changes to operating procedures or monitoring if required. • Standard operational procedures (SOPs) for the identification, assessment and management actions for fugitive dust emissions; and • Identification of roles and responsibilities under the DMP. The Licensee shall implement the DMP.	31 July 2016



4 Information

4.1 Records

- 4.1.1 All information and records required by the Licence shall:
- (a) be legible;
 - (b) if amended, be amended in such a way that the original and subsequent amendments remain legible or are capable of retrieval;
 - (c) except for records listed in 4.1.1(d) be retained for at least 6 years from the date the records were made or until the expiry of the Licence or any subsequent licence; and
 - (d) for those following records, be retained until the expiry of the Licence and any subsequent licence:
 - (i) off-site environmental effects; or
 - (ii) matters which affect the condition of the land or waters.
- 4.1.2 The Licensee shall complete an Annual Audit Compliance Report indicating the extent to which the Licensee has complied with the conditions of the Licence, and any previous licence issued under Part V of the Act for the Premises for the previous annual period.
- 4.1.3 The Licensee shall implement a complaints management system that as a minimum records the number and details of complaints received concerning the environmental impact of the activities undertaken at the Premises and any action taken in response to the complaint.

4.2 Reporting

- 4.2.1 The Licensee shall submit to the CEO an Annual Environmental Report by 31 March after the end of the annual period. The report shall contain the information listed in Table 4.2.1 in the format or form specified in that table.

Table 4.2.1: Annual Environmental Report		
Condition or table (if relevant)	Parameter	Format or form ¹
-	Summary of any failure or malfunction of any pollution control equipment that has resulted in any reportable environmental incidents that have occurred during the annual period and any action taken	None specified
Table 2.2.1	TSF Photographic Vegetation Monitoring Programme including an assessment of the vegetation by a person with tertiary or post-secondary qualifications in plant ecology, botanical or environmental studies.	
4.1.3	Compliance	Annual Audit Compliance Report (AACR)
4.1.4	Complaints summary	None specified
Table 5.2.2	Reference non annual reporting data and provide a summary of the key findings and recommendations	
Table 5.3.1	Summary of any saline, alkaline or cyanide constituent spills greater than 5000L that escaped from pipeline bunding	

Note 1: Forms are in Schedule 2

- 4.2.2 The Licensee shall ensure that the Annual Environmental Report also contains an assessment of the information contained within the report against previous monitoring results.



- 4.2.3 The Licensee shall submit the information in Table 4.2.2 to the CEO according to the specifications in that table.

Table 4.2.2: Non-annual reporting requirements				
Condition or table (if relevant)	Parameter	Reporting period	Reporting date (after end of the reporting period)	Format or form
2.1.3	Calibration	Available on request	14 calendar days	None specified
-	Copies of original monitoring reports submitted to the Licensee by third parties	Not Applicable	Within 14 days of the CEO's request	As received by the Licensee from third parties
Table 2.2.2	Groundwater monitoring including summary of any target exceedances	Quarterly	46 calendar days	None specified

4.3 Notification

- 4.3.1 The Licensee shall ensure that the parameters listed in Table 4.3.1 are notified to the CEO in accordance with the notification requirements of the table.

Table 4.3.1: Notification requirements			
Condition or table (if relevant)	Parameter	Notification requirement ¹	Format or form ²
-	Any spills of environmentally hazardous materials greater than 250L occurring in locations that may adversely impact on the environment	As soon as practicable but no later than 5pm of the next usual working day	None specified
-	Any liquid spills greater than 5000L containing saline, alkaline or cyanide constituents that escape from overland pipeline bunding		
2.1.1	Breach of any limit specified in the Licence	Part A: As soon as practicable but no later than 5pm of the next usual working day. Part B: As soon as practicable	N1
2.1.4	Calibration report	As soon as practicable.	None specified

Note 1: Notification requirements in the Licence shall not negate the requirement to comply with s72 of the Act

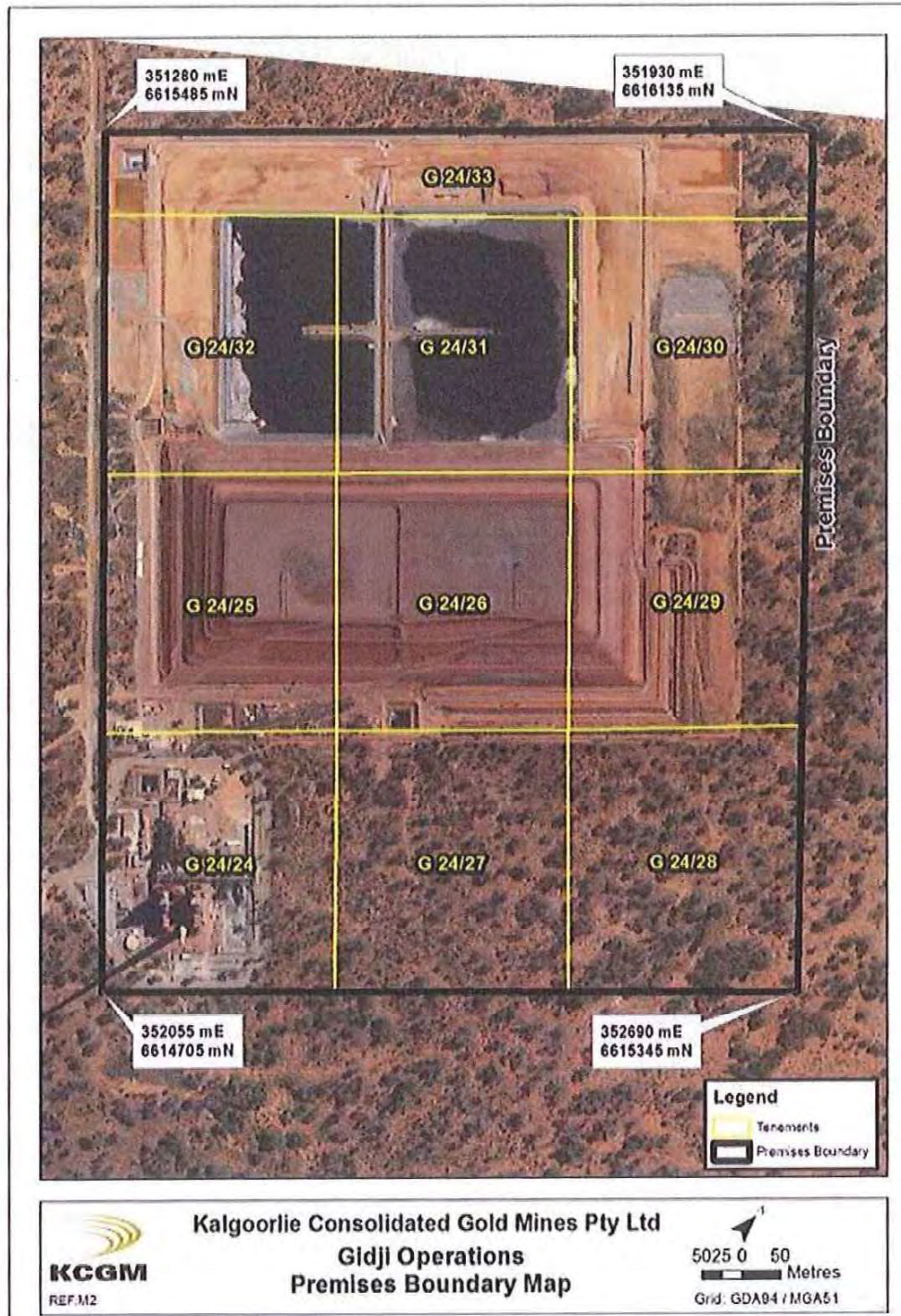
Note 2: Form N1 is located in Schedule 2



Schedule 1: Maps

Premises map

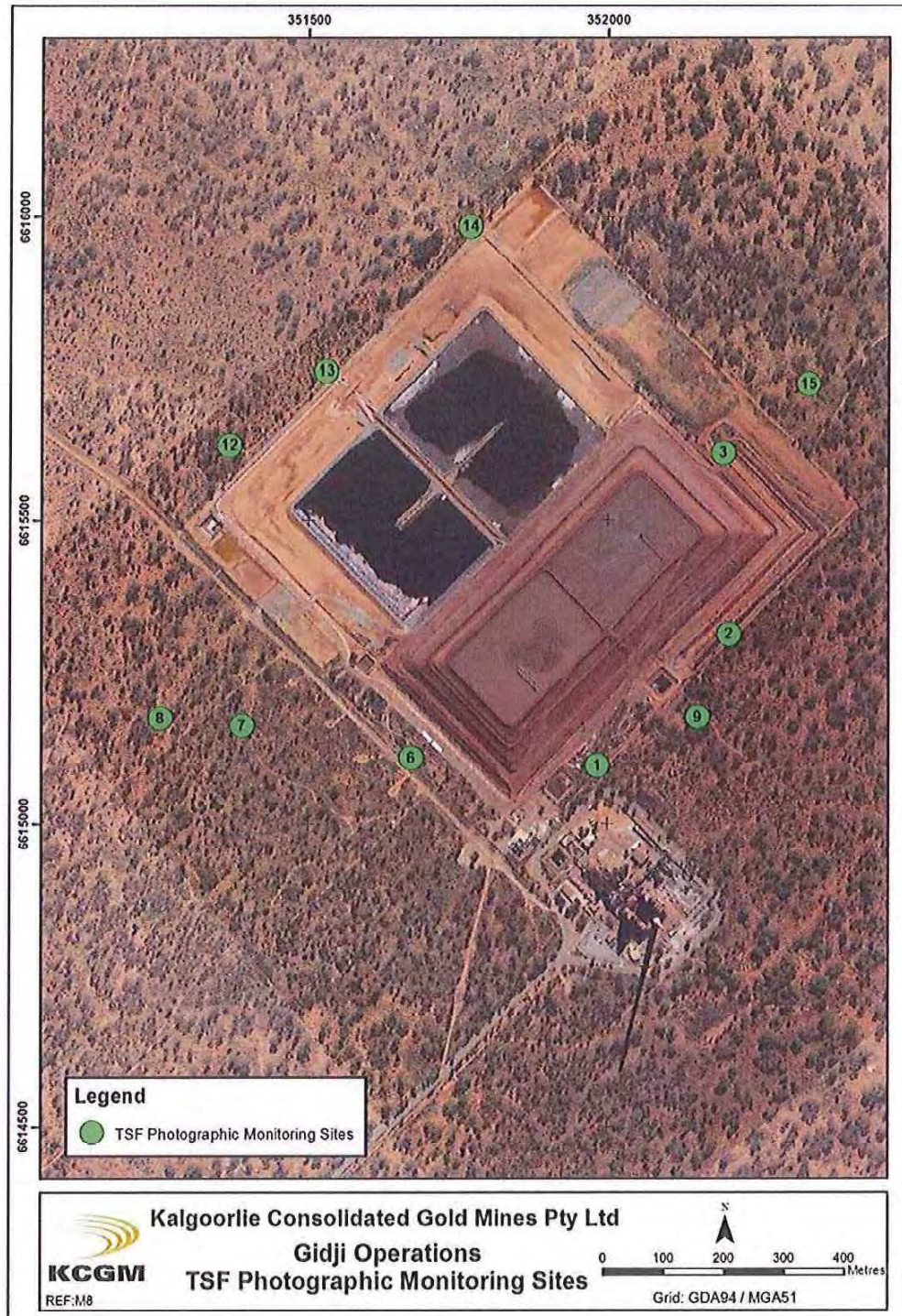
The Premises is shown in the map below. The black line depicts the Premises boundary.





Map of TSF photographic monitoring locations

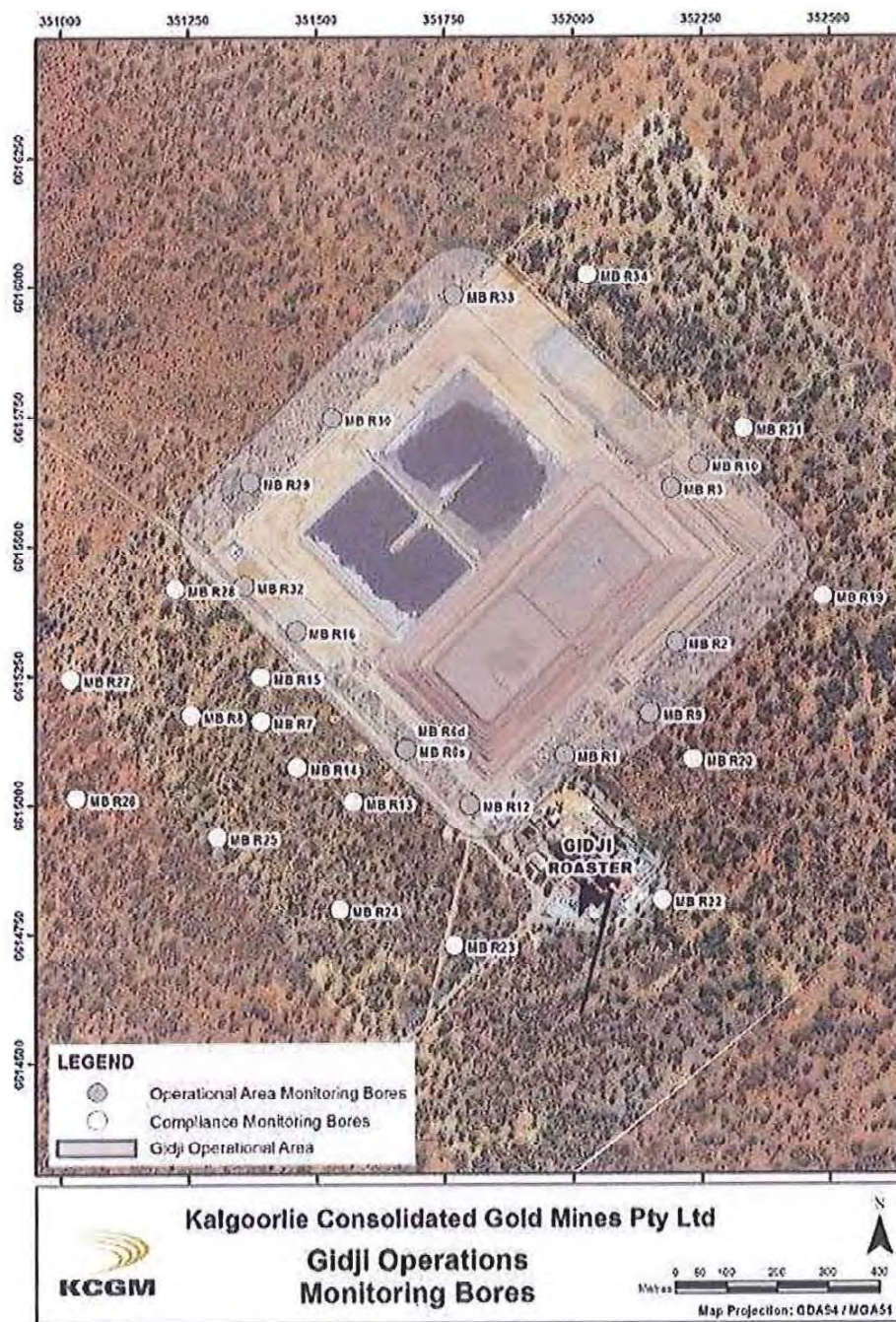
The locations of the monitoring points defined in Tables 2.2.1 are shown below.
Note: monitoring location 3 is no longer used.





Map of groundwater monitoring locations

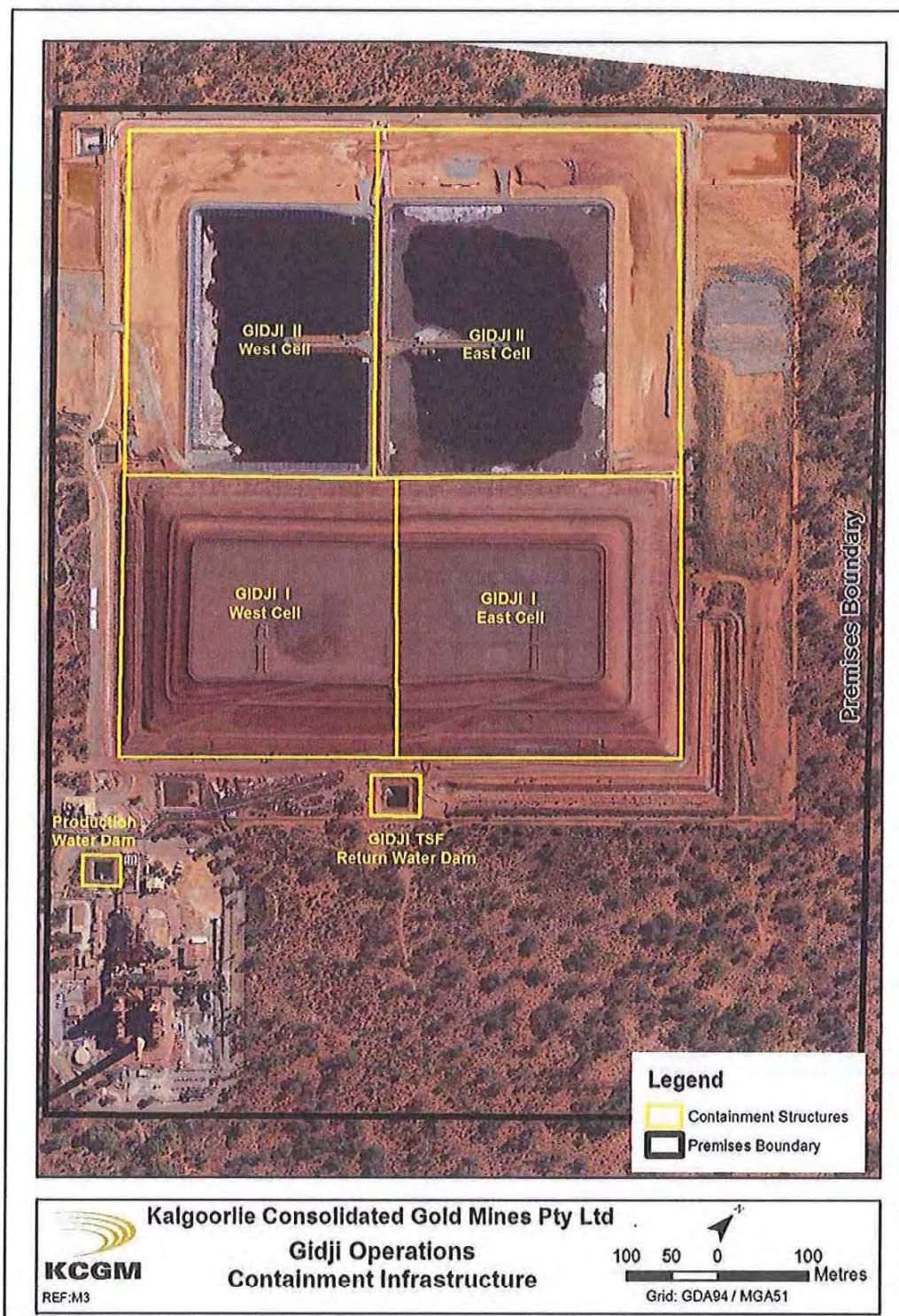
The locations of the monitoring points defined in Table 2.2.2 are shown below.





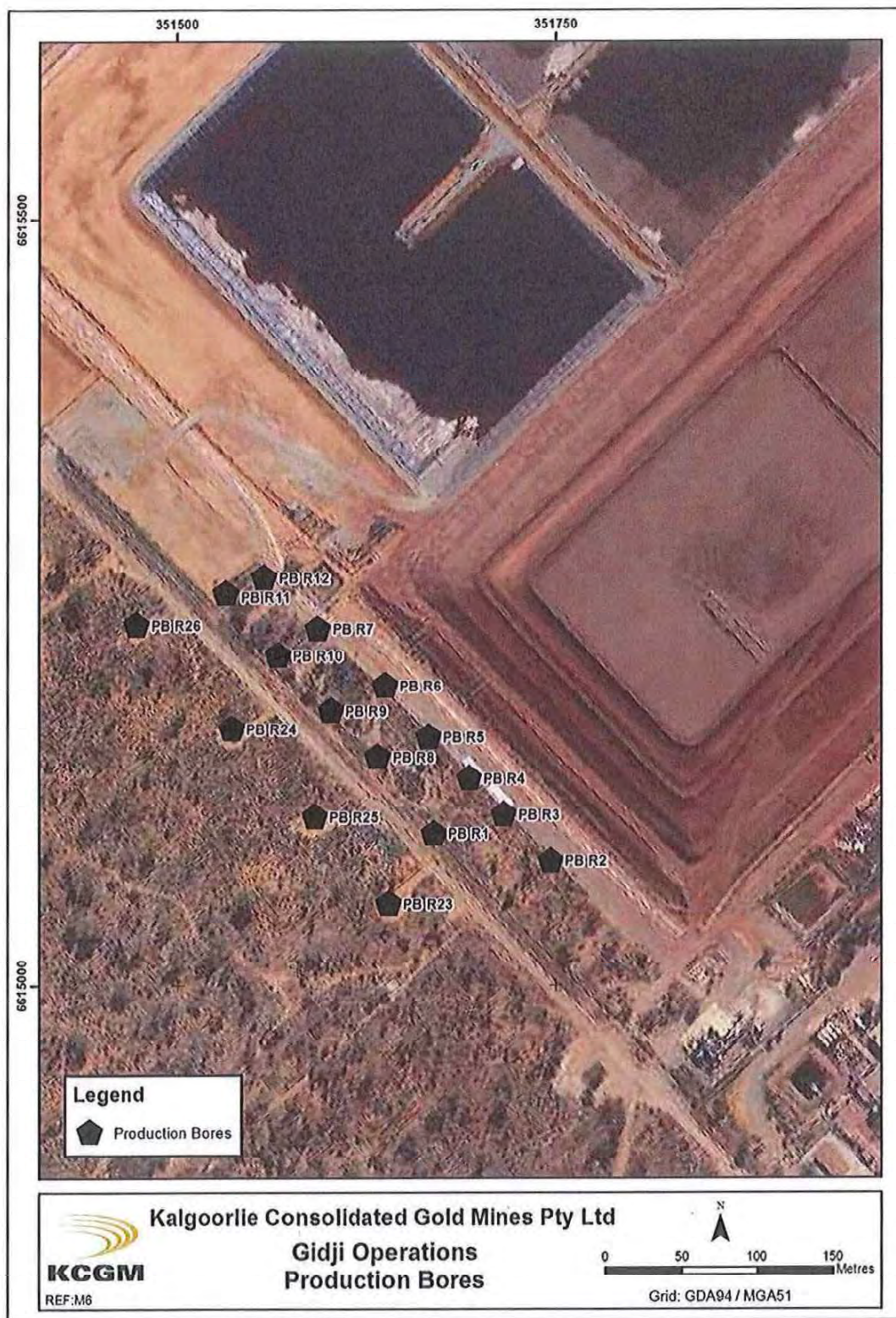
Map of storage locations

Storage locations as defined in Tables 1.3.2 are shown below.





Map of groundwater production bores





Schedule 2: Reporting & notification forms

These forms are provided for the proponent to report monitoring and other data required by the Licence. They can be requested in an electronic format.

ANNUAL AUDIT COMPLIANCE REPORT PROFORMA

SECTION A

LICENCE DETAILS

Licence Number:	Licence File Number:
Company Name:	ABN:
Trading as:	
Reporting period: _____ to _____	

STATEMENT OF COMPLIANCE WITH LICENCE CONDITIONS

1. Were all conditions of the Licence complied with within the reporting period? (please tick the appropriate box)

Yes ☐ Please proceed to Section C

No ☐ Please proceed to Section B

Each page must be initialled by the person(s) who signs Section C of this Annual Audit Compliance Report (AACR).

Initial:



SECTION B

DETAILS OF NON-COMPLIANCE WITH LICENCE CONDITION.

Please use a separate page for each Licence condition that was not complied with.

a) Licence condition not complied with:	
b) Date(s) when the non-compliance occurred, if applicable:	
c) Was this non-compliance reported to DER?:	
☐ Yes ☐ Reported to DER verbally Date _____ ☐ Reported to DER in writing Date _____	☐ No
d) Has DER taken, or finalised any action in relation to the non-compliance?:	
e) Summary of particulars of the non-compliance, and what was the environmental impact:	
f) If relevant, the precise location where the non-compliance occurred (attach map or diagram):	
g) Cause of non-compliance:	
h) Action taken, or that will be taken to mitigate any adverse effects of the non-compliance:	
i) Action taken or that will be taken to prevent recurrence of the non-compliance:	

Each page must be initialled by the person(s) who signs Section C of this AACR

Initial:



SECTION C

SIGNATURE AND CERTIFICATION

This Annual Audit Compliance Report (AACR) may only be signed by a person(s) with legal authority to sign it. The ways in which the AACR must be signed and certified, and the people who may sign the statement, are set out below.

Please tick the box next to the category that describes how this AACR is being signed. If you are uncertain about who is entitled to sign or which category to tick, please contact the licensing officer for your premises.

If the licence holder is		The Annual Audit Compliance Report must be signed and certified:
An individual	☐ ☐	by the individual licence holder, or by a person approved in writing by the Chief Executive Officer of the Department of Environment Regulation to sign on the licensee's behalf.
A firm or other unincorporated company	☐ ☐	by the principal executive officer of the licensee; or by a person with authority to sign on the licensee's behalf who is approved in writing by the Chief Executive Officer of the Department of Environment Regulation.
A corporation	☐ ☐ ☐ ☐ ☐ ☐	by affixing the common seal of the licensee in accordance with the <i>Corporations Act 2001</i> ; or by two directors of the licensee; or by a director and a company secretary of the licensee, or if the licensee is a proprietary company that has a sole director who is also the sole company secretary – by that director, or by the principal executive officer of the licensee; or by a person with authority to sign on the licensee's behalf who is approved in writing by the Chief Executive Officer of the Department of Environment Regulation.
A public authority (other than a local government)	☐ ☐	by the principal executive officer of the licensee; or by a person with authority to sign on the licensee's behalf who is approved in writing by the Chief Executive Officer of the Department of Environment Regulation.
a local government	☐ ☐	by the chief executive officer of the licensee; or by affixing the seal of the local government.

It is an offence under section 112 of the *Environmental Protection Act 1986* for a person to give information on this form that to their knowledge is false or misleading in a material particular. There is a maximum penalty of \$50,000 for an individual or body corporate.

I/We declare that the information in this annual audit compliance report is correct and not false or misleading in a material particular.

SIGNATURE: _____

NAME:
(printed) _____

POSITION: _____

DATE: ____/____/____

SEAL (if signing under seal)

SIGNATURE: _____

NAME:
(printed) _____

POSITION: _____

DATE: ____/____/____



Licence: L5946/1988/13 Licensee: Kalgoorlie Consolidated Gold Mines Pty Ltd
Form: N1 Date of breach:

Notification of detection of the breach of a limit

These pages outline the information that the operator must provide. Units of measurement used in information supplied under Part A and B requirements shall be appropriate to the circumstances of the emission. Where appropriate, a comparison should be made of actual emissions and authorised emission limits.

Part A

Licence Number	
Name of operator	
Location of Premises	
Time and date of the detection	

Notification requirements for the breach of a limit	
Emission point reference/ source	
Parameter(s)	
Limit	
Measured value	
Date and time of monitoring	
Measures taken, or intended to be taken, to stop the emission	

Part B

Any more accurate information on the matters for notification under Part A.	
Measures taken, or intended to be taken, to prevent a recurrence of the incident.	
Measures taken, or intended to be taken, to rectify, limit or prevent any pollution of the environment which has been or may be caused by the emission.	
The dates of any previous N1 notifications for the Premises in the preceding 24 months.	

Name	
Post	
Signature on behalf of Kalgoorlie Consolidated Gold Mines Pty Ltd	
Date	



Decision Document

Environmental Protection Act 1986, Part V

Proponent: Kalgoorlie Consolidated Gold Mine Pty Ltd

Licence: L5946/1988/13

Registered office: Kalgoorlie Consolidated Gold Mines Pty Ltd
Black Street
KALGOORLIE WA 6430

ACN: 099 377 619

Premises address: Gidji Processing Plant
Tenements G24/24-33
KALGOORLIE WA 6430

Issue date: Friday, 26 September 2014

Commencement date: Monday, 29 September 2014

Expiry date: Saturday, 28 September 2029

Decision

Based on the assessment detailed in this document the Department of Environment Regulation (DER) has decided to issue an amended licence. DER considers that in reaching this decision, it has taken into account all relevant considerations and legal requirements and that the Licence and its conditions will ensure that an appropriate level of environmental protection is provided.

Decision Document prepared by: Cristina Angel
Senior Licensing Officer

Decision Document authorised by: Jonathan Bailes
Delegated Officer



Contents

1	Purpose of this document	2
2	Administrative summary	3
3	Executive summary of proposal and assessment	4
4	Decision table	5
5	Advertisement and consultation table	12
6	Risk Assessment	13

1 Purpose of this document

This Decision Document explains how DER has assessed and determined the application and provides a record of DER's decision-making process and how relevant factors have been taken into account. Stakeholders should note that this document is limited to DER's assessment and decision making under Part V of the *Environmental Protection Act 1986*. Other approvals may be required for the proposal, and it is the proponent's responsibility to ensure they have all relevant approvals for their Premises.



2 Administrative summary

Administrative details		
Application type	Works Approval ☐ New Licence ☐ Licence amendment ☒ Works Approval amendment ☐	
Activities that cause the premises to become prescribed premises	Category number(s) 5	Assessed design capacity 438,000 tonnes per annual period
Application verified	Date: 20 August 2015	
Application fee paid	NA	
Works Approval has been complied with	Yes ☐ No ☐ N/A ☐	
Compliance Certificate received	Yes ☐ No ☐ N/A ☐	
Commercial-in-confidence claim	Yes ☐ No ☒	
Commercial-in-confidence claim outcome		
Is the proposal a Major Resource Project?	Yes ☒ No ☐	
Was the proposal referred to the Environmental Protection Authority (EPA) under Part IV of the <i>Environmental Protection Act 1986</i> ?	Yes ☐ No ☒	Referral decision No: Managed under Part V ☐ Assessed under Part IV ☐
Is the proposal subject to Ministerial Conditions?	Yes ☒ No ☐	Ministerial statement Nos: 28 & 77 EPA Report No:
Does the proposal involve a discharge of waste into a designated area (as defined in section 57 of the <i>Environmental Protection Act 1986</i>)?	Yes ☐ No ☒ Department of Water consulted Yes ☐ No ☒	
Is the Premises within an Environmental Protection Policy (EPP) Area Yes ☐ No ☒		
Is the Premises subject to any EPP requirements? Yes ☐ No ☒		



3 Executive summary of proposal and assessment

Kalgoorlie Consolidated Gold Mines Ltd (KCGM) operates the Fimiston open pit, Mt Charlotte underground mine, Fimiston mill and Gidji Processing Plant on behalf of joint venture owners Barrick Ltd (Australia Pacific) and Newmont Asia Pacific Ltd (Newmont).

The Gidji Processing Plant, located 17 kilometres north of Kalgoorlie-Boulder, treats refractory gold sulphide concentrate produced by the Fimiston mill. The purpose of this amendment is to remove metal smelting or refining from the licence. The Licensee also applied to increase the throughput of 351,000 to 438,000 tonnes per annual period however this was not assessed on the basis that this increase needs to be approved under Part IV of *The Environmental Protection Act 1986* and any approved increase reflected in Ministerial Statement Nos. 77 and 28. This Part IV amendment is delayed and the Licensee has requested that the parts of the application which do not require amendment of the Ministerial Statement to be processed. A separate application will be made for the increased throughput following the finalisation of the Part IV amendment.

Historically, the sulphide ore was initially roasted to oxidate the sulphide which in turn allowed the fine gold particles to be dissolved once the ore was placed into cyanide solution. In order to reduce its gaseous emissions to air, the site undertook an Emissions Reduction Project under Works Approval W5659/2014/1. This involved the replacement of the two 20 tonne per hour roasters with one 30 tonne per hour Ultrafine Grinding Mill (UFG) to process refractory ore from Fimiston. This is in addition to the existing 10 tonne per hour UFG mill, maintaining the sites 40 tonne per hour processing of refractory ore. The two roasters ceased operating on 26 January 2015 and 5 April 2015 respectively. This Licence amendment removes reference to all point source air emissions and associated monitoring requirements. Additionally, ambient monitoring requirements in accordance with the *Environmental Protection (Goldfields Residential Areas) (Sulfur Dioxide) Policy 2003* are also no longer relevant to this licence.

The tailings from the cyanide leach and carbon-in-pulp adsorption process are sent to the Gidji Tailings Storage Facilities (TSFs). Currently, two cells are in operation, Gidji II (east) and Gidji II (west). These cells were commissioned in 2012 and 2014 respectively. Associated infrastructure supporting the process plant includes access tracks, borefields (production and monitoring bores), water storage ponds, transfer ponds and seepage interception trench. This amendment includes the removal of the Gidji I TSF as an approved tailing deposition area. Under a previous licence amendment (4 December 2014), DER agreed to allow the use of the Gidji I TSF as an interim measure until the TSF reached its maximum capacity or until the new UFG mill was commissioned (whichever came first).

This amendment also removes reference to the vehicle wash down bays from the licence as no vehicles are washed down at the Gidji facility. This was confirmed through DER's Inspection of the premises on 25 March 2015. This expiry date of this Licence has also been amended to extend in accordance with DER's *Guidance Statement on Licence Duration (November 2014)*.

Other changes have also been made to reflect administrative changes implemented within DER.



4 Decision table

All applications are assessed in line with the *Environmental Protection Act 1986*, the *Environmental Protection Regulations 1987* and DER's Operational Procedure on Assessing Emissions and Discharges from Prescribed Premises. Where other references have been used in making the decision, they are detailed in the decision document.

DECISION TABLE

Works Approval / Licence section	Condition number W = Works Approval L = Licence	Justification (including risk description & decision methodology where relevant)	Reference documents
Definitions	NA	Definitions have been amended to remove reference to any terminology associated with removed conditions. Other definitions have been removed in accordance with administrative changes implemented within DER.	NA
General conditions	NA	These conditions have been removed from the previous licence in accordance with administrative changes implemented within DER: • Condition 1.2.1 has been removed as it contains explanatory text only; • Condition 1.2.2 has been removed as it is not sufficiently clear or certain; • Condition 1.2.3 and 1.2.4 have been removed as it is the occupier's responsibility to ensure that they comply with relevant legislative requirements for secondary activities such as the storage and handling of environmentally hazardous materials. Unauthorised discharges of environmentally hazardous materials are subject to the provisions of the <i>Environmental Protection (Unauthorised Discharges) Regulations 2004</i>. • Condition 1.2.5 has been removed as it is not sufficiently clear or certain. The condition does not specify what stormwater infrastructure is required to be constructed and maintained or what if any specific management actions are required. Contaminated stormwater has previously been assessed as posing a moderate risk. DER has considered whether the risk profile of the premises has significantly changed since the previous licence was granted. Significant changes have occurred at the site and although greater quantities cyanide will be used per tonne of concentrate processed, there will be no increase in on-site storage of reagents. Deliveries will increase in frequency to maintain stock levels to meet	DER public website at: www.der.wa.gov.au <i>Environmental Protection Act 1986</i> <i>Environmental Protection (Unauthorised Discharge) Regulations 2004</i>



DECISION TABLE

Works Approval / Licence section	Condition number W = Works Approval L = Licence	Justification (including risk description & decision methodology where relevant)	Reference documents
		increased throughput. On this basis, and in accordance with administrative changes, this condition has been removed as the risk can be managed through established site procedures. The substantive offences of the EP Act provide enforceable prohibitions for discharges of contaminated stormwater that result in pollution or environmental harm.	
Premises operation	L1.2.1- 1.2.4	Premises operation has been reassessed as part of this amendment. Reference to vehicle wash down bays is removed from Table 1.2.1 as no vehicles are washed down at the Gidji processing plant. References to the clay lined Gidji I TSF West Cell and the Gidji I TSF East cell are also removed from Table 1.2.1. The construction of these cells is not considered adequate to contain supernatant from tailings deposited within these cells.	<i>Environmental Protection Act 1986.</i> <i>Environmental Protection (Unauthorised Discharge) Regulations 2004</i> Amendment supporting documentation (30 June 2015; 20 August 2015) DER public website at: www.der.wa.gov.au
Emissions General	NA	Condition 2.1 in the previous version of the licence. Removal of nil condition sections of licence in accordance with administrative changes implemented by DER.	DER public website at: www.der.wa.gov.au
Point source emissions to air, surface water, groundwater and land	NA	Conditions 2.2-2.5 in the previous version of the licence. Point source air emission conditions have been removed from this licence as the site is no longer authorised to undertake metal roasting activities. Both roasters ceased to be operational on 26 January 2015 and 5 April 2015 respectively. A decommissioning plan is being developed to remove the infrastructure. Removal of nil condition sections of licence in accordance with administrative changes implemented by DER.	Amendment supporting documentation (30 June 2015; 20 August 2015) DER public website at: www.der.wa.gov.au



DECISION TABLE

Works Approval / Licence section	Condition number W = Works Approval L = Licence	Justification (including risk description & decision methodology where relevant)	Reference documents
Fugitive emissions	NA	Conditions 2.6.1- 2.6.2 in the previous version of the licence. Refer to improvements section below. Removal of nil condition sections of licence in accordance with administrative changes implemented by DER.	<i>Environmental Protection Act 1986.</i> DER public website at: www.der.wa.gov.au
Odour and Noise	NA	Conditions 2.7-2.8 in previous version of licence. Removal of nil condition sections of licence in accordance with administrative changes implemented by DER.	DER public website at: www.der.wa.gov.au
Monitoring general	NA	Condition 3.1.3 from the previous licence is removed as it is not enforceable and does not clearly state the outcome that must be achieved.	DER public website at: www.der.wa.gov.au
Monitoring of point source emissions to air	NA	Conditions 3.2.1-3.2.3 in the previous version of the licence. There are no point source emissions to air authorised under this amended licence. This section and all conditions relating to point source emissions to air have been removed.	
Monitoring of point source emissions to surface water, groundwater, land; and monitoring of inputs and outputs	NA	Conditions 3.3- L3.7 from the previous licence. Removal of nil condition sections of licence in accordance with administrative changes implemented by DER.	DER public website at: www.der.wa.gov.au



DECISION TABLE

Works Approval / Licence section	Condition number W = Works Approval L = Licence	Justification (including risk description & decision methodology where relevant)	Reference documents
Ambient environmental quality monitoring	NA	Conditions 3.8.1, 3.8.2, 3.8.3 and 3.9.1 from the previous licence. There are no point source emissions to air authorised under this amended licence. All conditions relating to ambient air quality and meteorological monitoring have been removed from this licence. The requirements to undertake ambient groundwater monitoring and vegetation monitoring are retained in this licence. Removal of nil condition sections of licence in accordance with administrative changes implemented by DER. Reference to vegetation monitoring location 3 has been removed from Table 2.1.4 as it is located in a disturbed area containing mining infrastructure with restricted access.	<i>Environmental Protection Act 1986.</i> Gidji Tailings Storage Facilities Operating Manual- October 2015 Update DER public website at: www.der.wa.gov.au Kalgoorlie Consolidated Gold Mines Annual Environment Report 2015 Email correspondence from Catherine Wharton, 8 April 2016
Improvement Condition	L3.1.1	The condition requiring the submission of a report on hydrogeological data, seepage recovery procedures, and the current groundwater monitoring programme is removed. This condition was completed and the report was received by DER on 31 March 2015. Fugitive dust emission have previously been assessed as moderate. DER has considered whether the risk profile of fugitive dust from the premises has significantly changed since the previous licence was issued. No significant changes have occurred, and therefore in accordance with administrative changes implemented within DER, generic fugitive conditions have been removed. Fugitive dust will be managed through the development of a site-specific Dust Management Plan.	Gidji Tailings Storage Facility Review of Hydrogeological Data and Groundwater Management (March 2015). <i>Environmental Protection Act 1986.</i> DER public website at: www.der.wa.gov.au



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Department of Environment Regulation

DECISION TABLE

Works Approval / Licence section	Condition number W = Works Approval L = Licence	Justification (including risk description & decision methodology where relevant)	Reference documents
		<u>Standard operation</u> <i>Emission:</i> Fugitive dust emissions from vehicle and plant movements, cleared areas, and the TSFs. Dust from TSFs will contain cyanide and other toxic metals. Gidji I TSF is not currently in use and the dust suppressing the effect of the wet tailings is not available to reduce fugitive dust emissions. Dry and high wind conditions promote dust lift off from TSFs and other surfaces. <i>Impact:</i> Dust and cyanide emissions can be harmful to human health and the environment. Elevated total suspended particulates (TSP) impact on vegetation by smothering and through abrasion to leaves. Particulate matter less than 10 (PM₁₀) or 2.5 (PM_{2.5}) microns in diameter can be inhaled deep into the lungs creating health impacts. The acute toxicity of cyanide is extremely harmful when inhaled by fauna or human receptors. <i>Controls:</i> Use of water carts and ongoing supervision by site personnel with the early identification of any potential dust issues. Cyanide is broken down by UV light. The proposed deposition of tailings on an irregular basis will assist in reducing dust generation. <u>Risk Assessment</u> <i>Consequence:</i> Moderate <i>Likelihood:</i> Possible <i>Risk rating:</i> Moderate <u>Regulatory Controls</u> Improvement condition IR1 has been added requiring the occupier to develop a Dust Management Plan to detail how the Licensee will manage the risk associated with fugitive dust emissions. <u>Residual Risk</u> <i>Likelihood:</i> Moderate <i>Consequence:</i> Unlikely <i>Risk rating:</i> Moderate Condition 5.1.2 from the previous licence version is removed as the condition is not enforceable as the conditions for compliance are unclear.	DER public website at: www.der.wa.gov.au
Information	NA		



DECISION TABLE

Works Approval / Licence section	Condition number W = Works Approval L = Licence	Justification (including risk description & decision methodology where relevant)	Reference documents
Reporting	L4.2.1	Condition 1.2.2 from the previous licence version has been removed. However, DER still requires an annual summary of reportable environmental incidents and actions taken to be provided in the Annual Environmental Report. Reporting conditions 5.2.1, 5.2.2 and 5.2.3 from the previous licence version have been changed to reflect changes to premises operations and administrative changes implemented in DER: • Condition 5.2.1 – the removal of reference to SO₂ Vegetation Monitoring Program from Table 5.2.1 as the premises no longer has point source air emissions; • Condition 5.2.2 – part (a) removal. Condition part was not enforceable and did not clearly state the outcome that must be achieved by the Licensee. • Condition 5.2.2 – part (b) removal of reference to target reporting in the Annual Environmental Report. • Condition 5.2.3- removal of reference to point source air emissions monitoring, roaster plant process monitoring, ambient SO₂ and meteorological monitoring requirements in Table 5.2.2. Updates have been made to this condition to remove reference to 'any failure or malfunction of pollution control equipment of any incident which has caused, is causing or may cause pollution' as this requirement exists in section 72 of the <i>Environmental Protection Act 1986</i>. Further information on reporting pollution obligations under s72 of the EP Act can be found at www.der.wa.gov.au/your-environment/reporting-pollution. Form N1 has been amended to reflect these changes. Conditions 6.1.1- 6.5.1 from the previous licence version have been removed. There are no point source air emissions authorised under this licence and all conditions relating to the <i>Environmental Protection (Goldfields Residential Areas) (Sulfur Dioxide) Policy 2003</i> and ambient air quality have been removed from the licence.	Amendment supporting documentation (30 June 2015; 20 August 2015) DER public website at: www.der.wa.gov.au Section 72 of <i>Environmental Protection Act 1986</i>. DER public website at: www.der.wa.gov.au Amendment supporting documentation (30 June 2015; 20 August 2015)
EPP related Requirements	NA		



Government of Western Australia
Department of Environment Regulation

DECISION TABLE

Works Approval / Licence section	Condition number W = Works Approval L = Licence	Justification (including risk description & decision methodology where relevant)	Reference documents
Schedules	N/A	As there is no point source air emissions authorised under this licence, maps and attachments referencing air emissions discharge locations, ambient air monitoring and meteorological locations, and data formatting requirements, have been removed. Form N1 has been updated.	Amendment supporting documentation (30 June 2015; 20 August 2015) DER public website at: www.der.wa.gov.au
Licence Duration	N/A	The licence duration has been amended in accordance with DER's Guidance Statement on Licence Duration. An expiry date of 28 September 2029 was determined as it is the latest date that aligns with the annual licence period and the Licensee's legal access to all the tenements included within the prescribed premises boundary.	DER's Guidance Statement on Licence Duration (November 2014).



5 Advertisement and consultation table

Date	Event	Comments received/Notes	How comments were taken into consideration
18 March 2016	Proponent sent a copy of draft amended instrument	-	-
8 April 2016	Proponents comments received via email from Catherine Wharton	Licensee requested that vegetation monitoring location 3 be removed from the licence condition Minor typographical and administrative changes recommended.	DER confirmed with aerial photography and the 2015 Annual Environmental Report that this location is within an infrastructure area and removed reference to it within vegetation monitoring condition 2.1.4. Minor typographical and administrative changes made.



6 Risk Assessment

Note: This matrix is taken from the DER Corporate Policy Statement No. 07 - Operational Risk Management

Table 1: Emissions Risk Matrix

Likelihood	Consequence				
	Insignificant	Minor	Moderate	Major	Severe
Almost Certain	Moderate	High	High	Extreme	Extreme
Likely	Moderate	Moderate	High	High	Extreme
Possible	Low	Moderate	Moderate	High	Extreme
Unlikely	Low	Moderate	Moderate	Moderate	High
Rare	Low	Low	Moderate	Moderate	High

Appendix B

Long term hydrographs

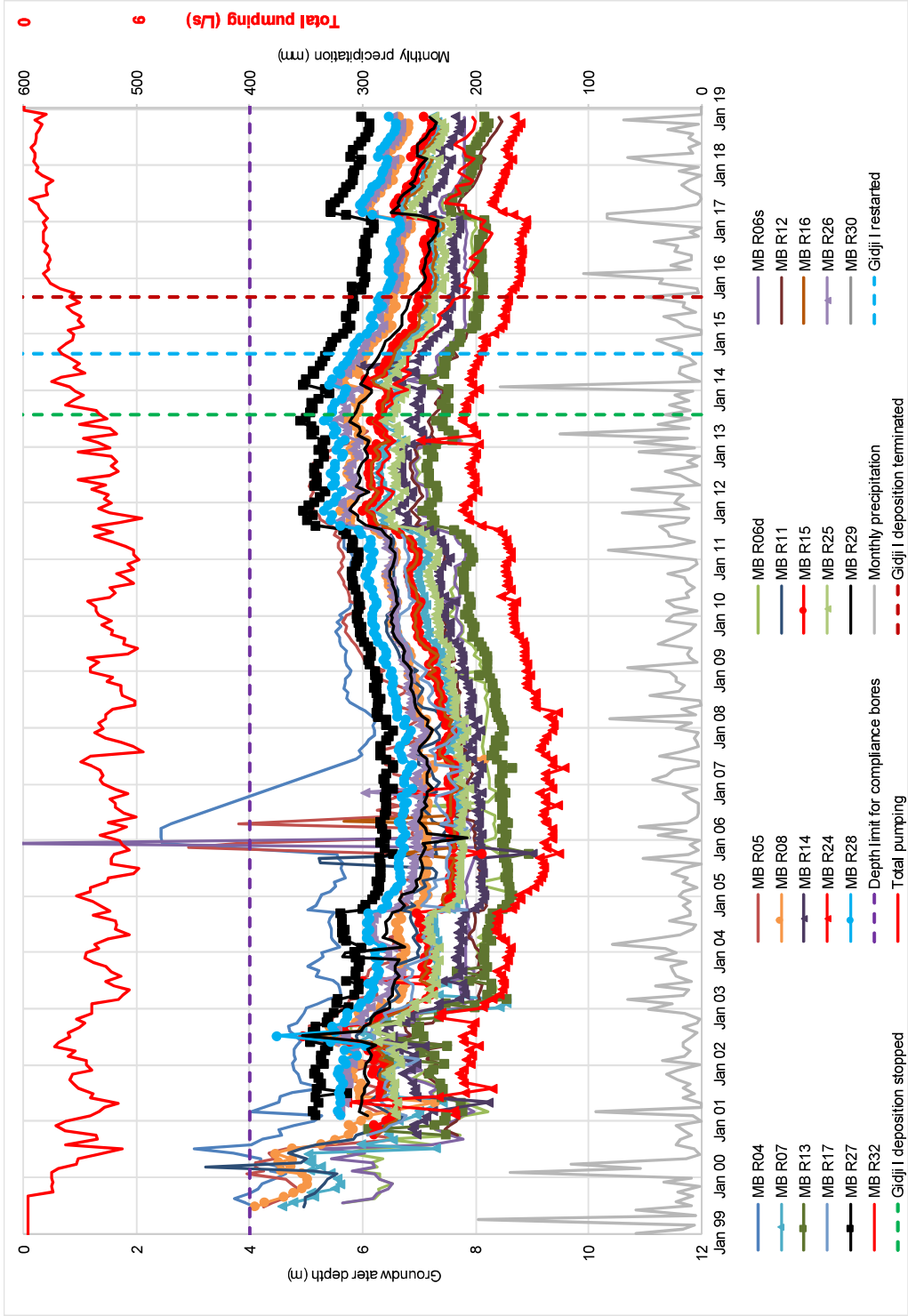
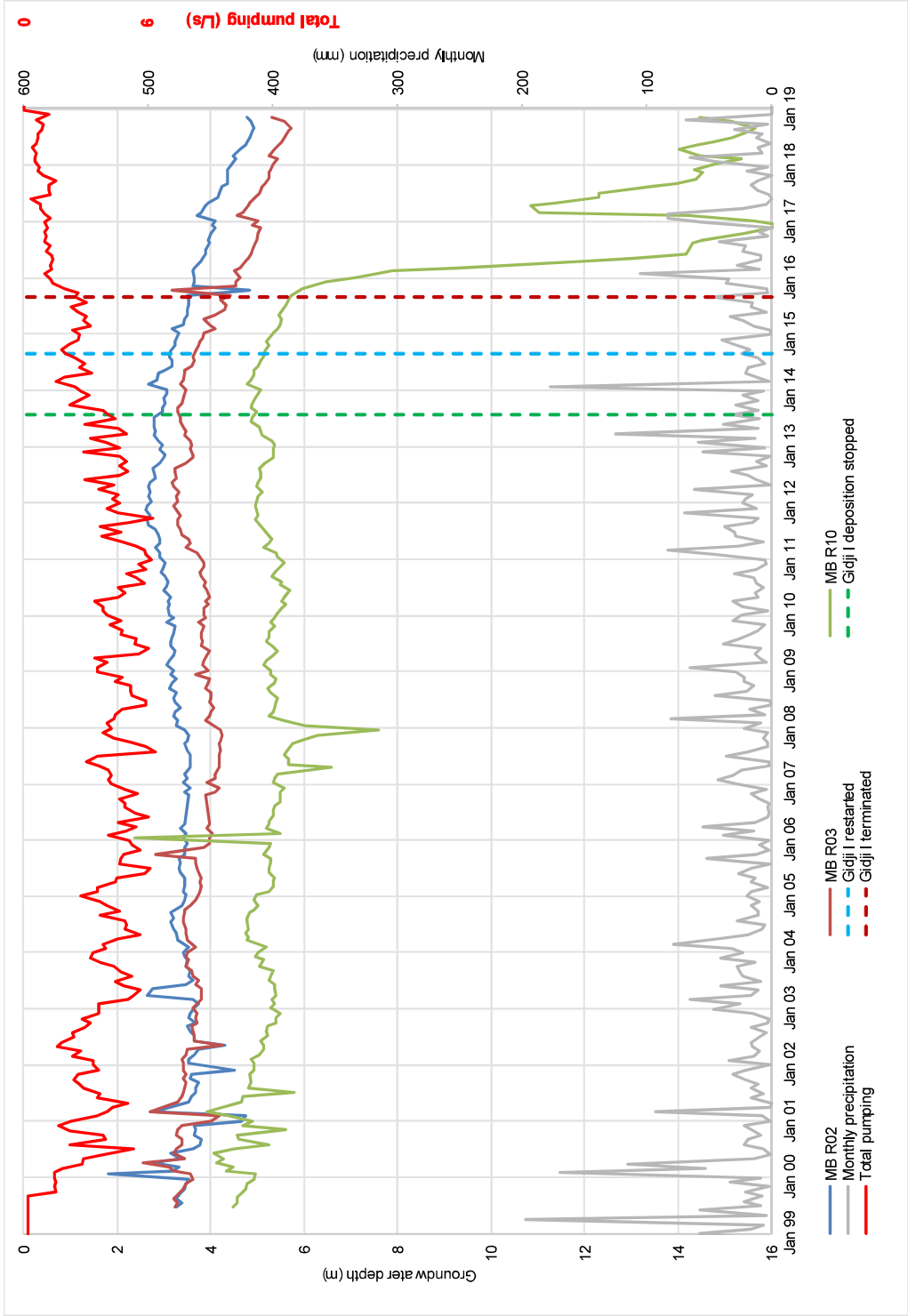


Figure B1

Long term hydrographs - western bores



Date:	January 2019
Report:	KCGM Gidji TSF Hydrogeological Review



Long term hydrographs - trench bores

Figure B2

Date:	January 2019
Report:	KCGM Gidji TSF Hydrogeological Review

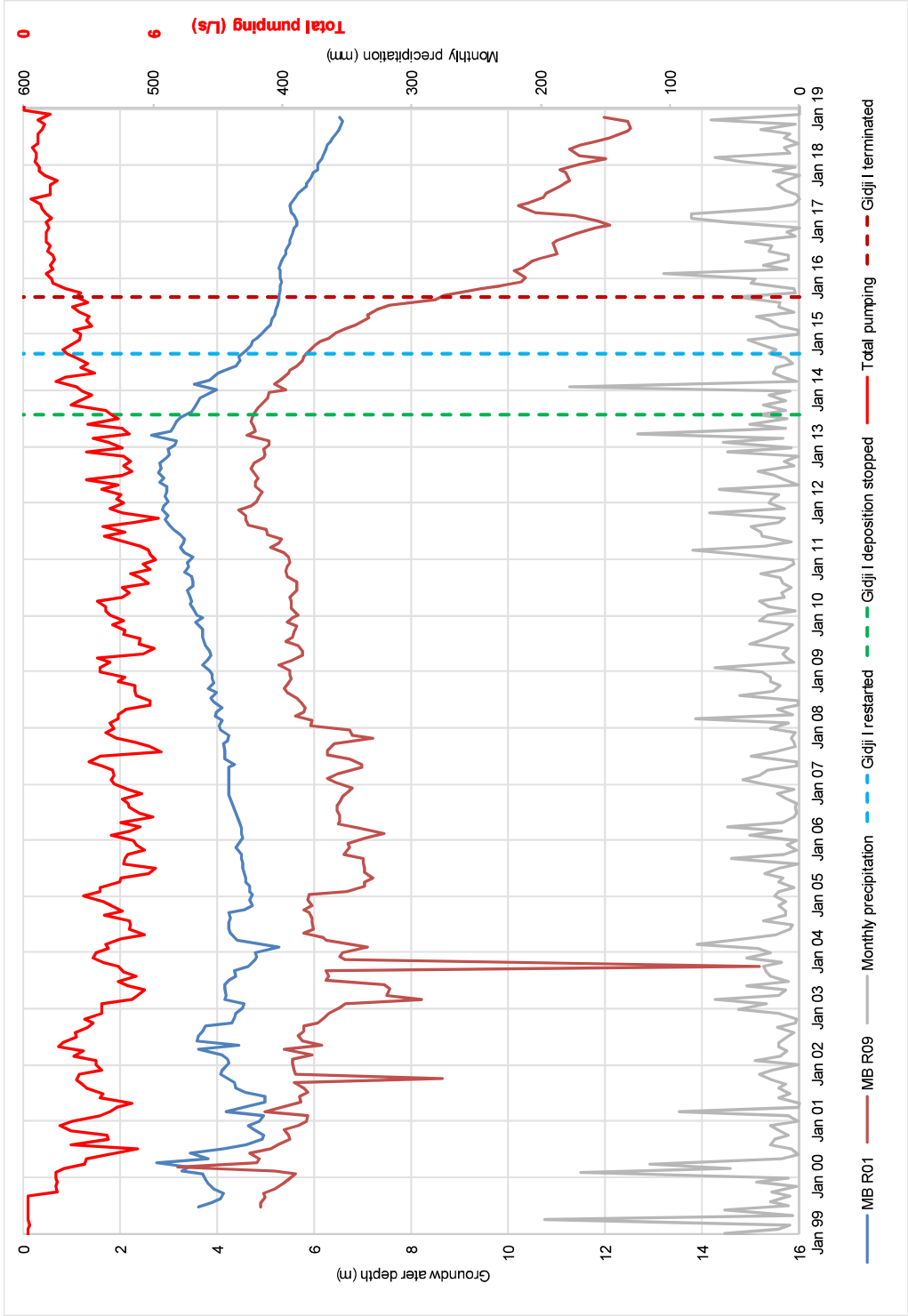
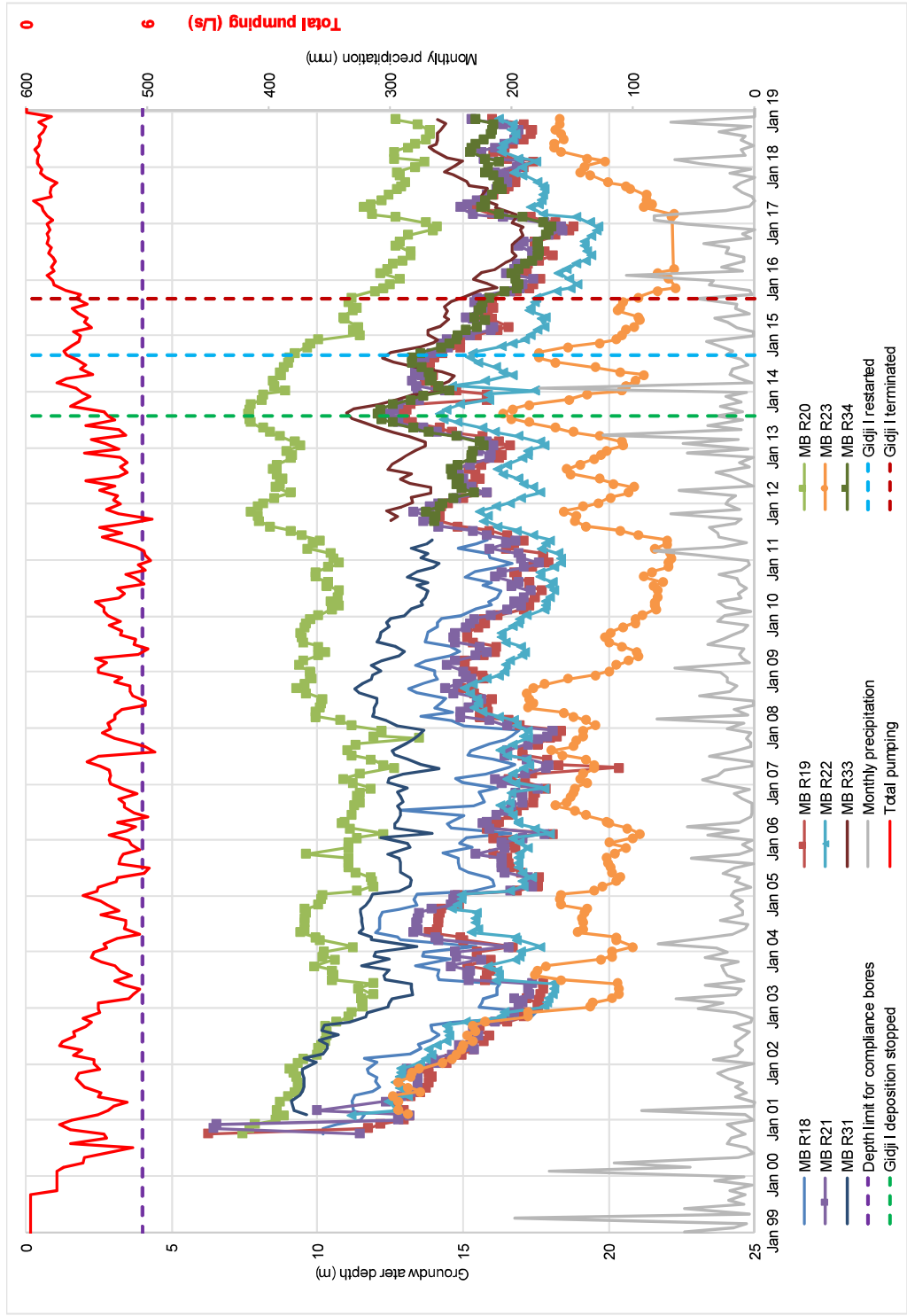


Figure B3

Date:	January 2019
Report:	KCGM Giidji TSF Hydrogeological Review

Long term hydrographs - decant bores





Appendix C

Time series groundwater hydrochemistry

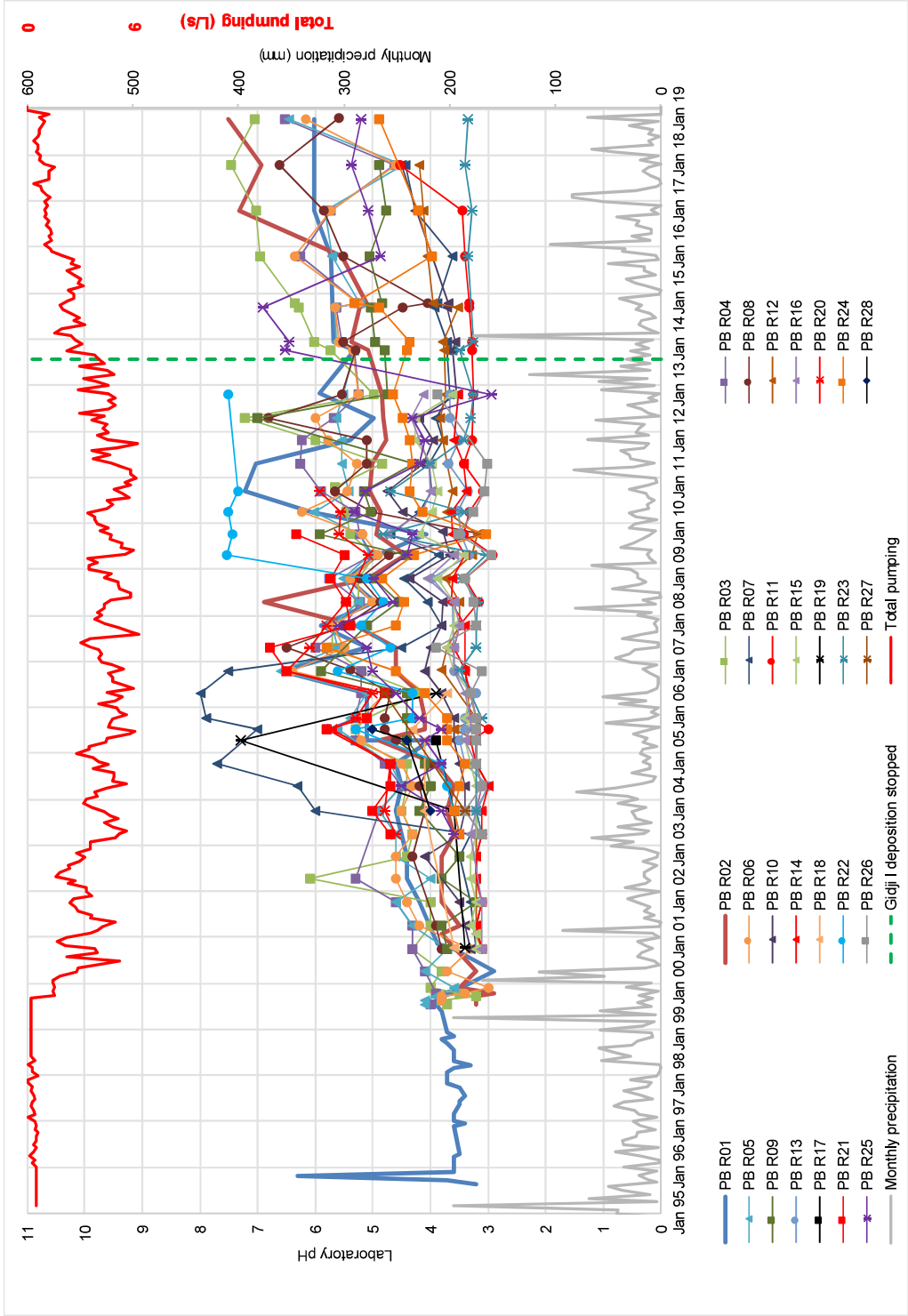
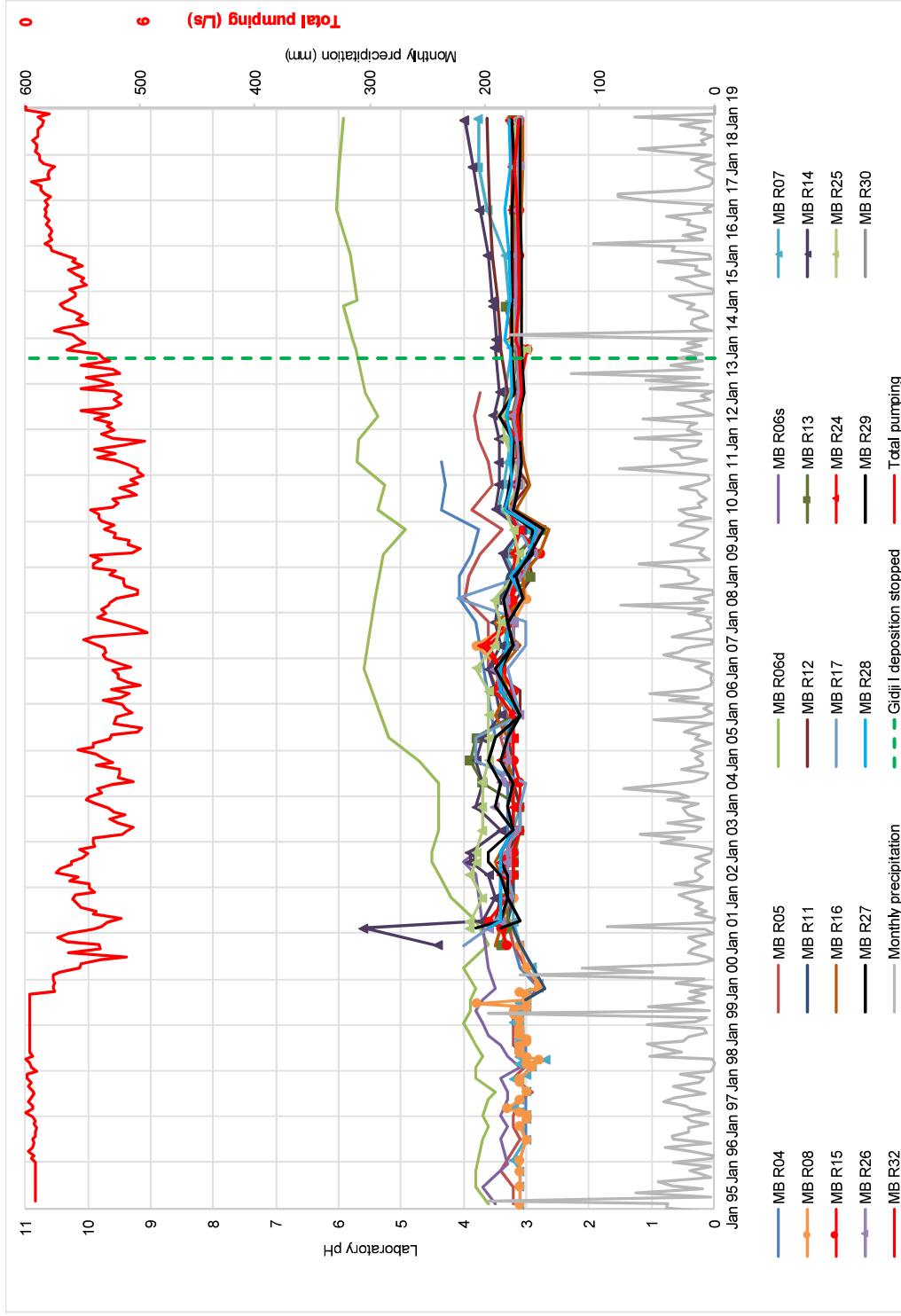


Figure C1

Date:	January 2019
Report:	KCGM Gidji TSF Hydrogeological Review

Groundwater Laboratory pH - production bores





Groundwater Laboratory pH - western bores

Figure C2

Date:	January 2019
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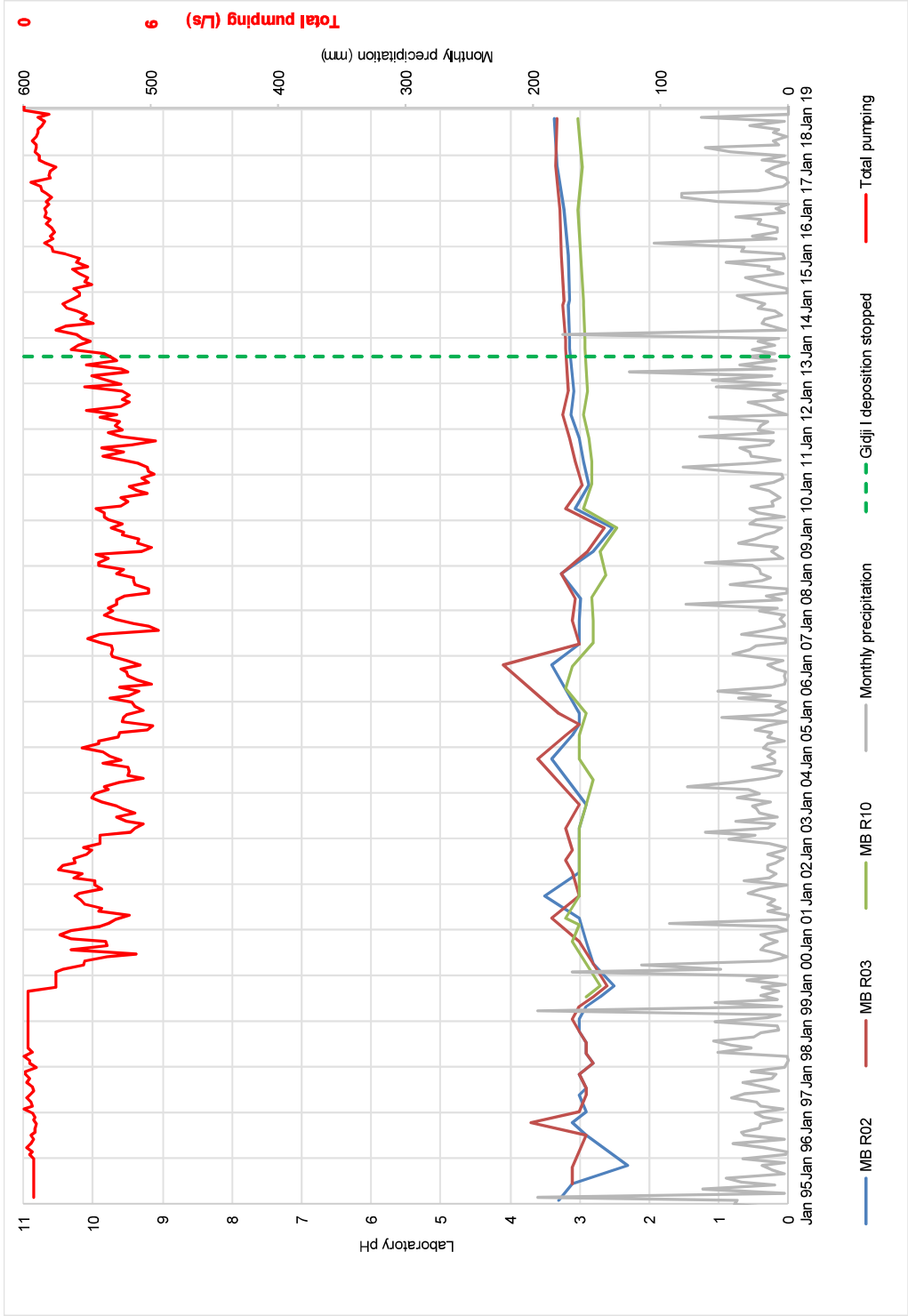
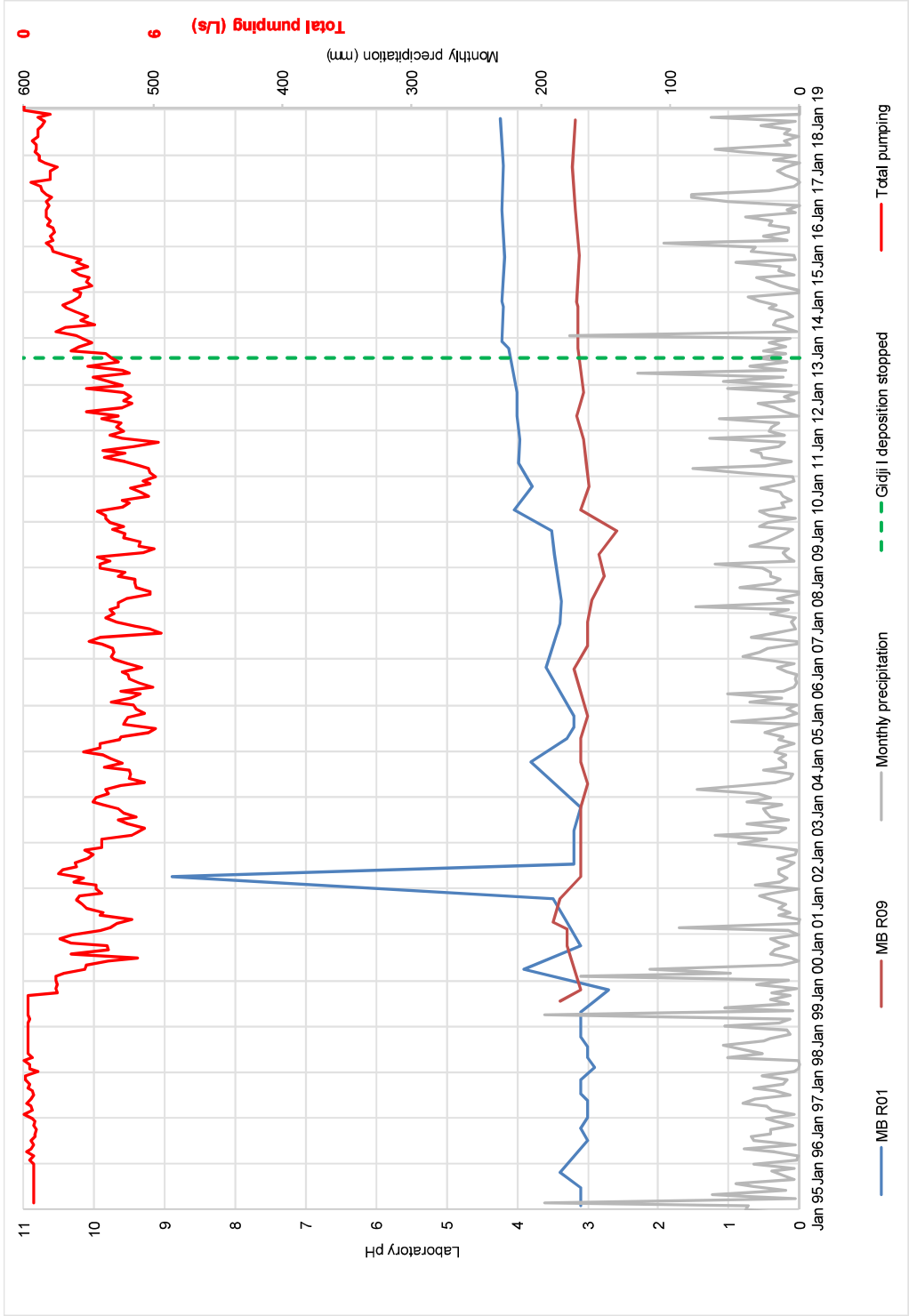


Figure C3

Groundwater Laboratory pH - trench bores



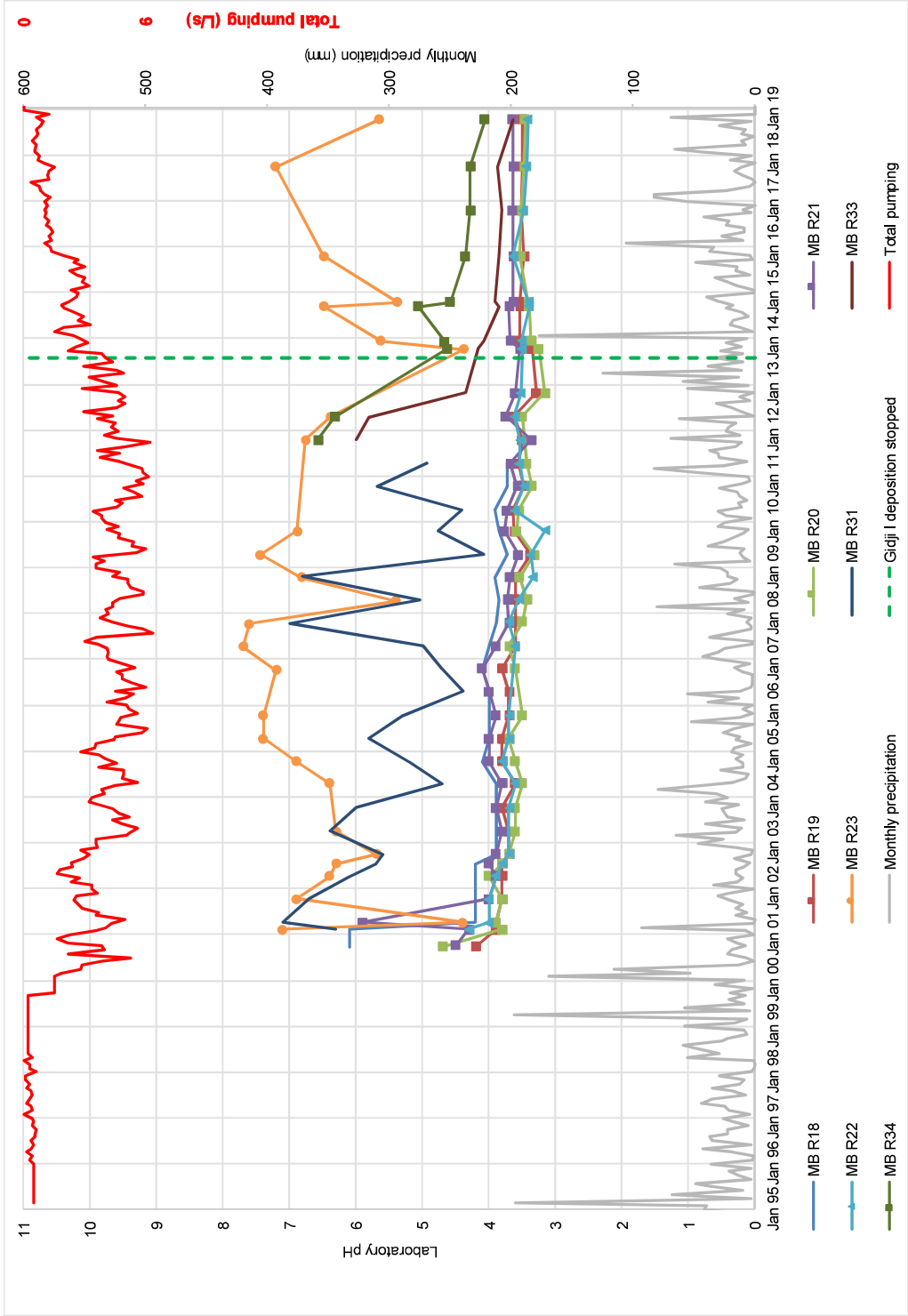
Date:	January 2019
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Groundwater Laboratory pH - decant bores

Figure C4

Date:	January 2019
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Groundwater Laboratory pH - eastern bores

Figure C5

Date:	January 2019
Report:	KCGM Gidji TSF Hydrogeological Review



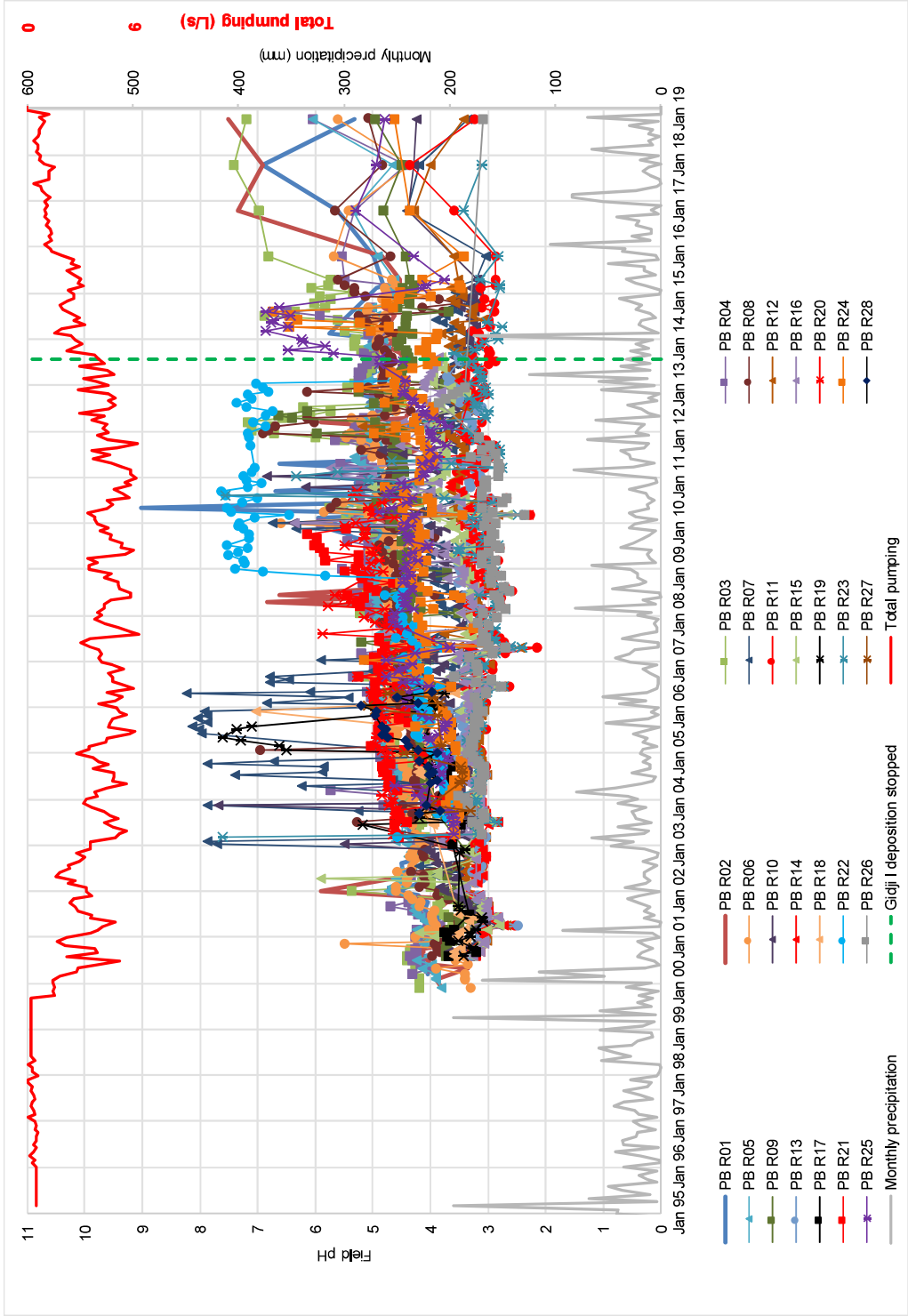


Figure C6

Date:	January 2019
Report:	KCGM Gidji TSF Hydrogeological Review

Groundwater Field pH - production bores



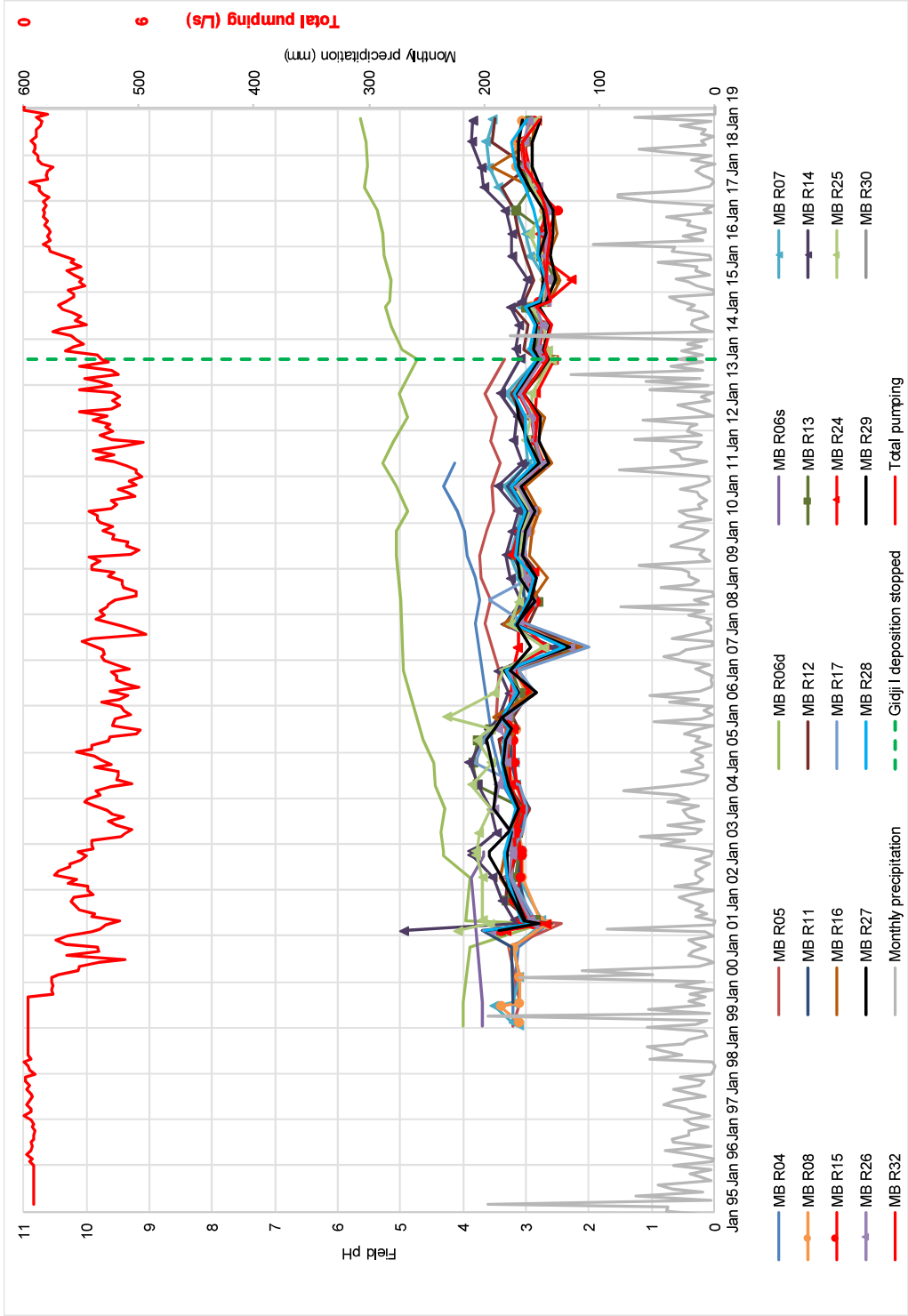
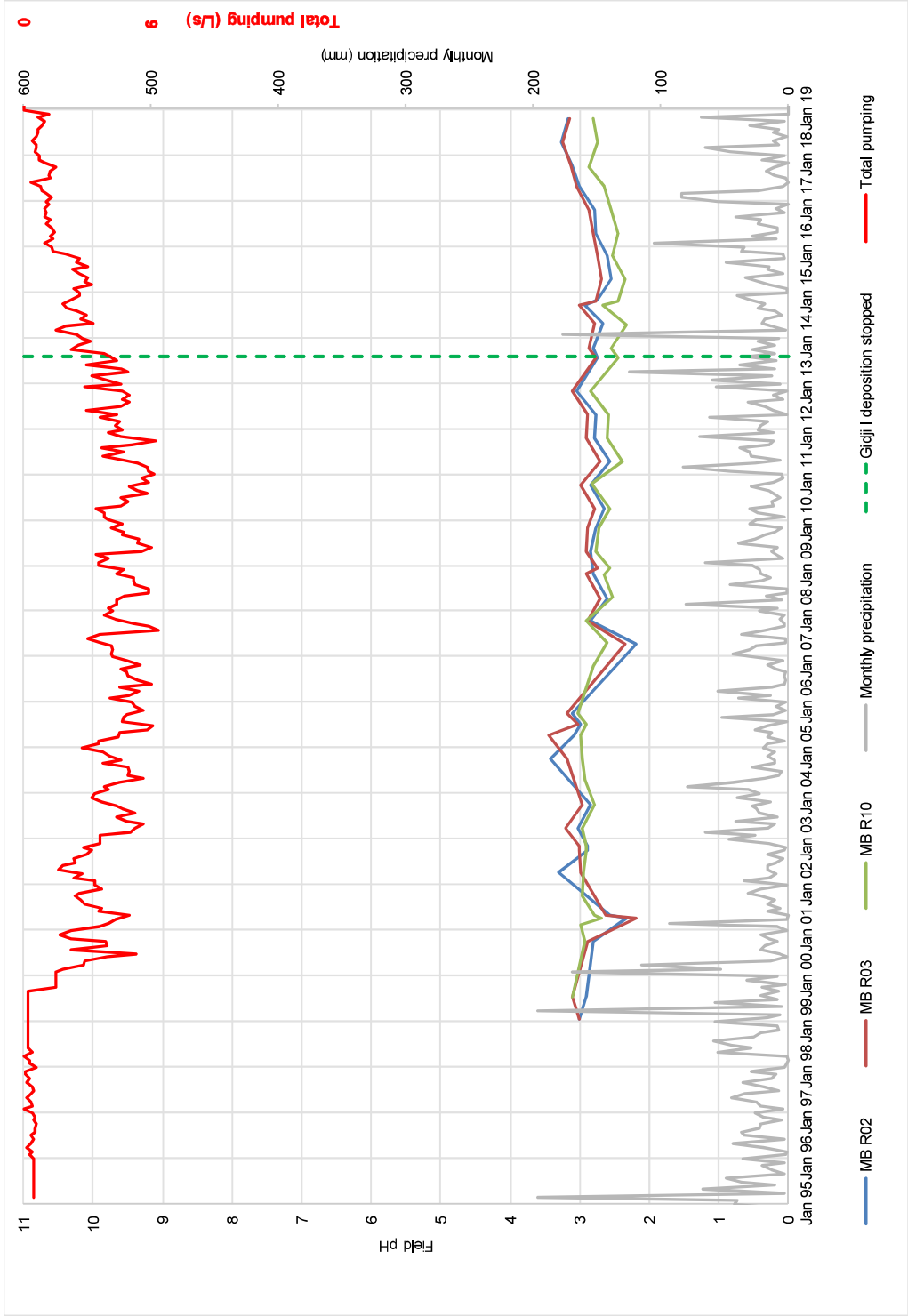


Figure C7

Date:	January 2019
Report:	KCGM Gidji TSF Hydrogeological Review

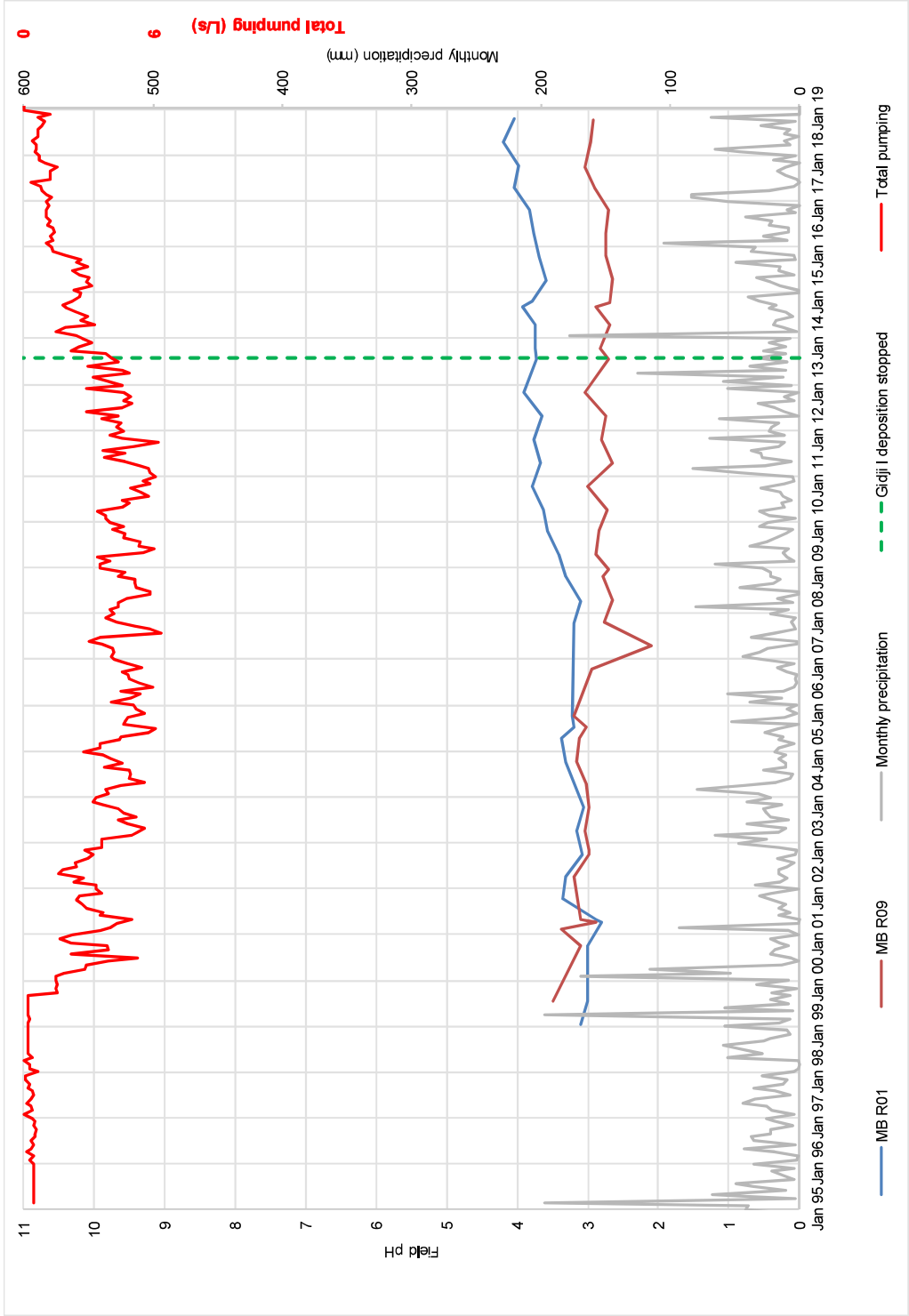
Groundwater Field pH - western bores





Groundwater Field pH - trench bores





Groundwater Field pH - decant bores

Figure C9

Date:	January 2019
Report:	KCGM Gidji TSF Hydrogeological Review

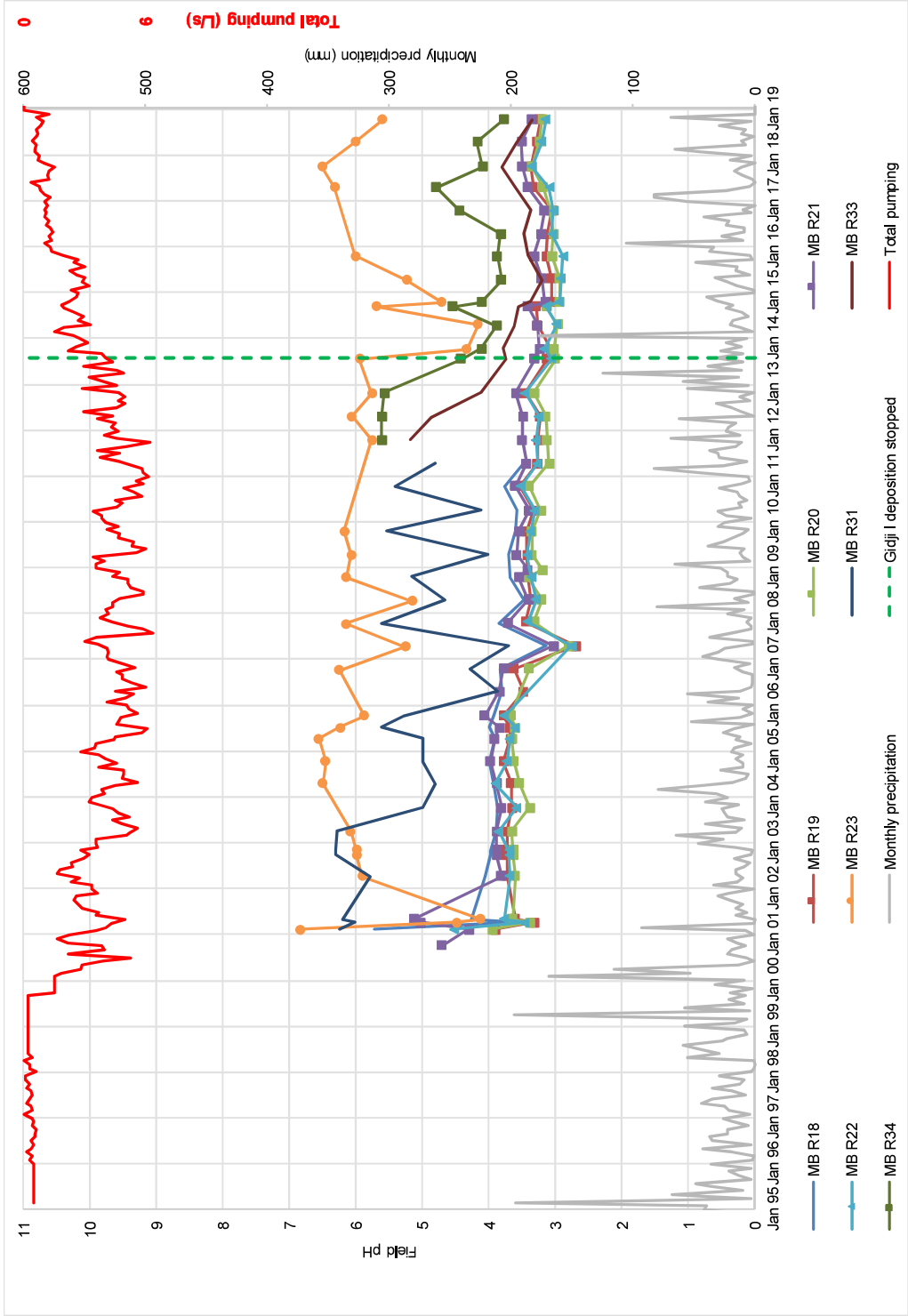
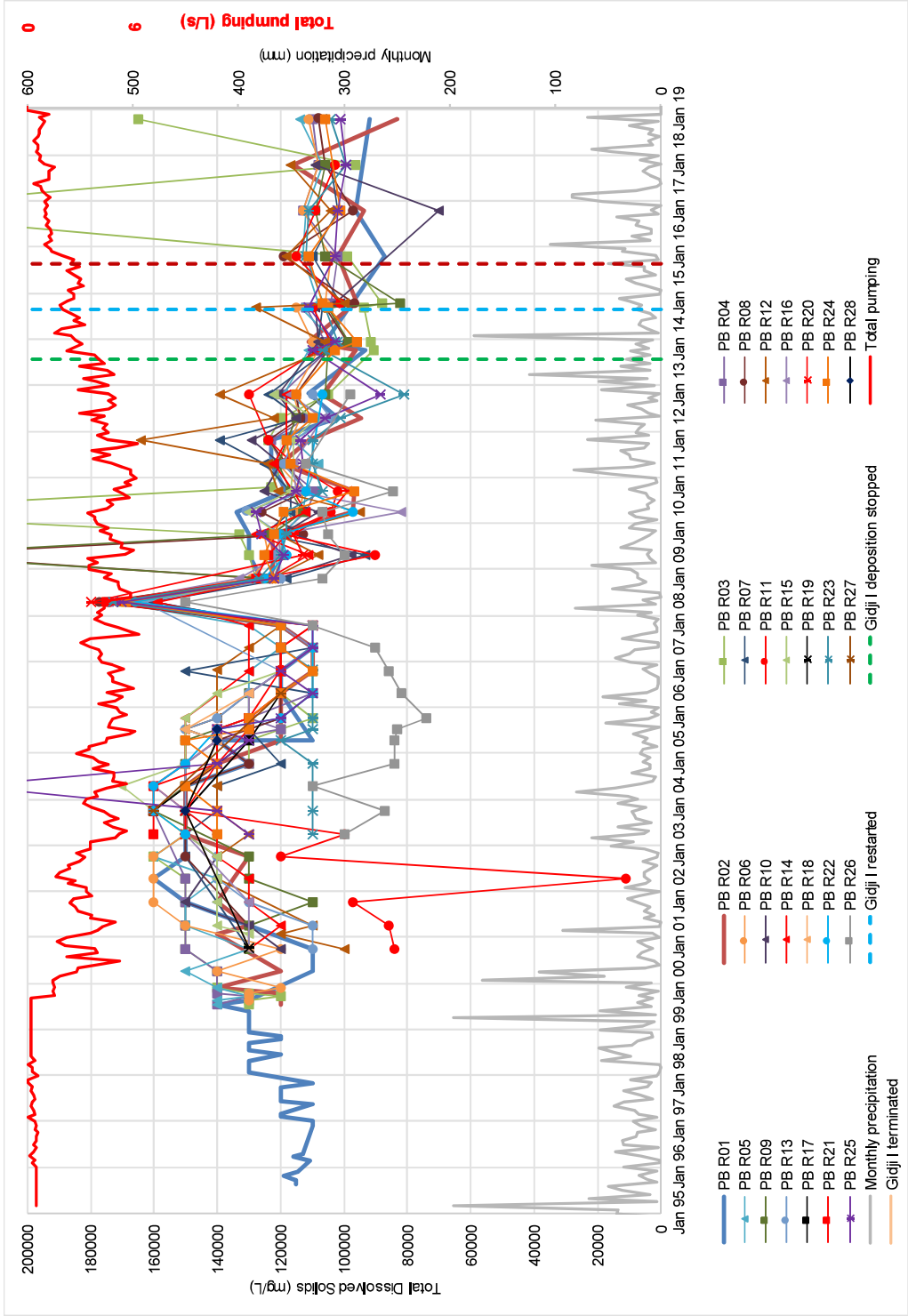


Figure C10

Date:	January 2019
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Groundwater Field pH - eastern bores





Groundwater TDS - production bores



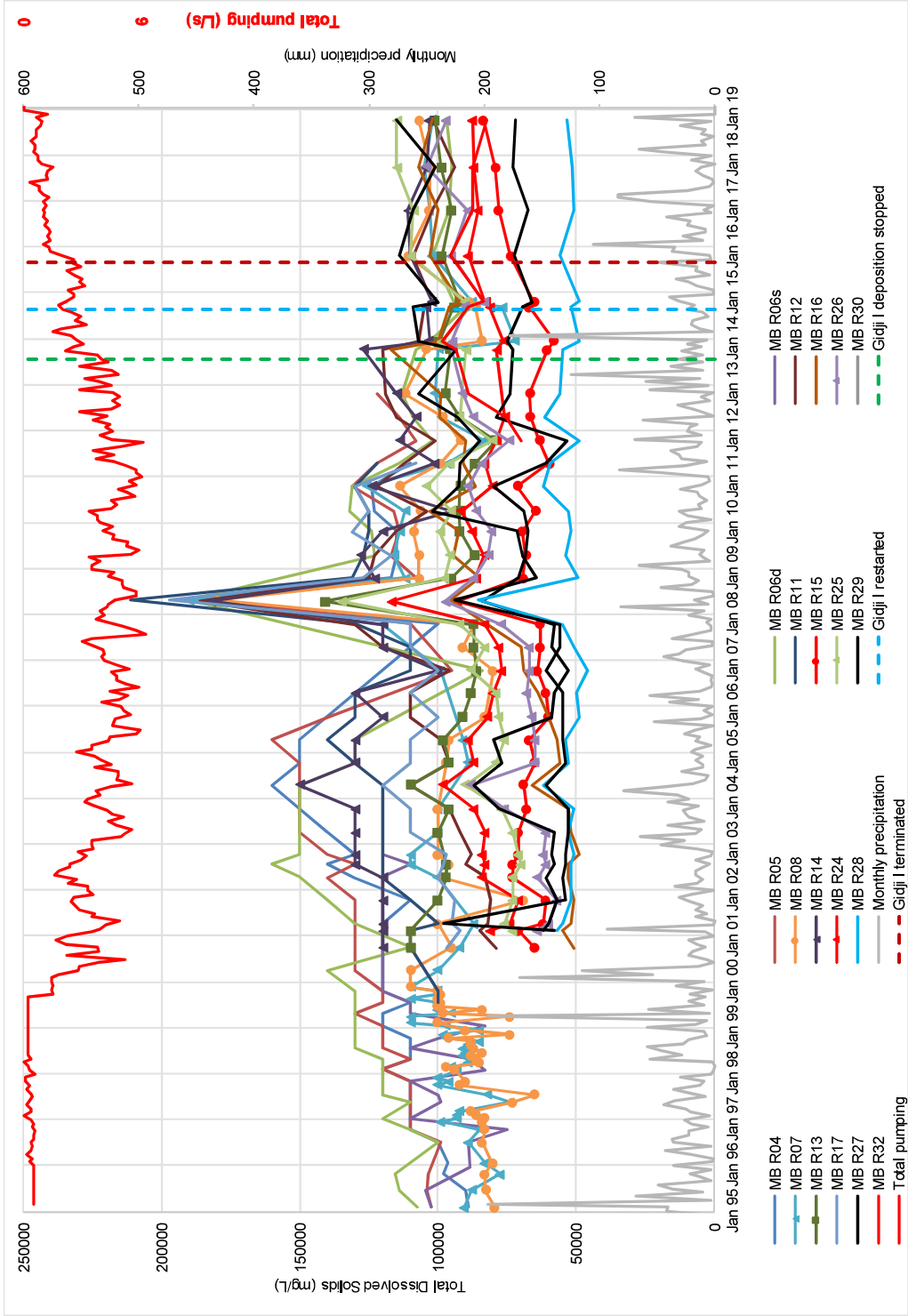
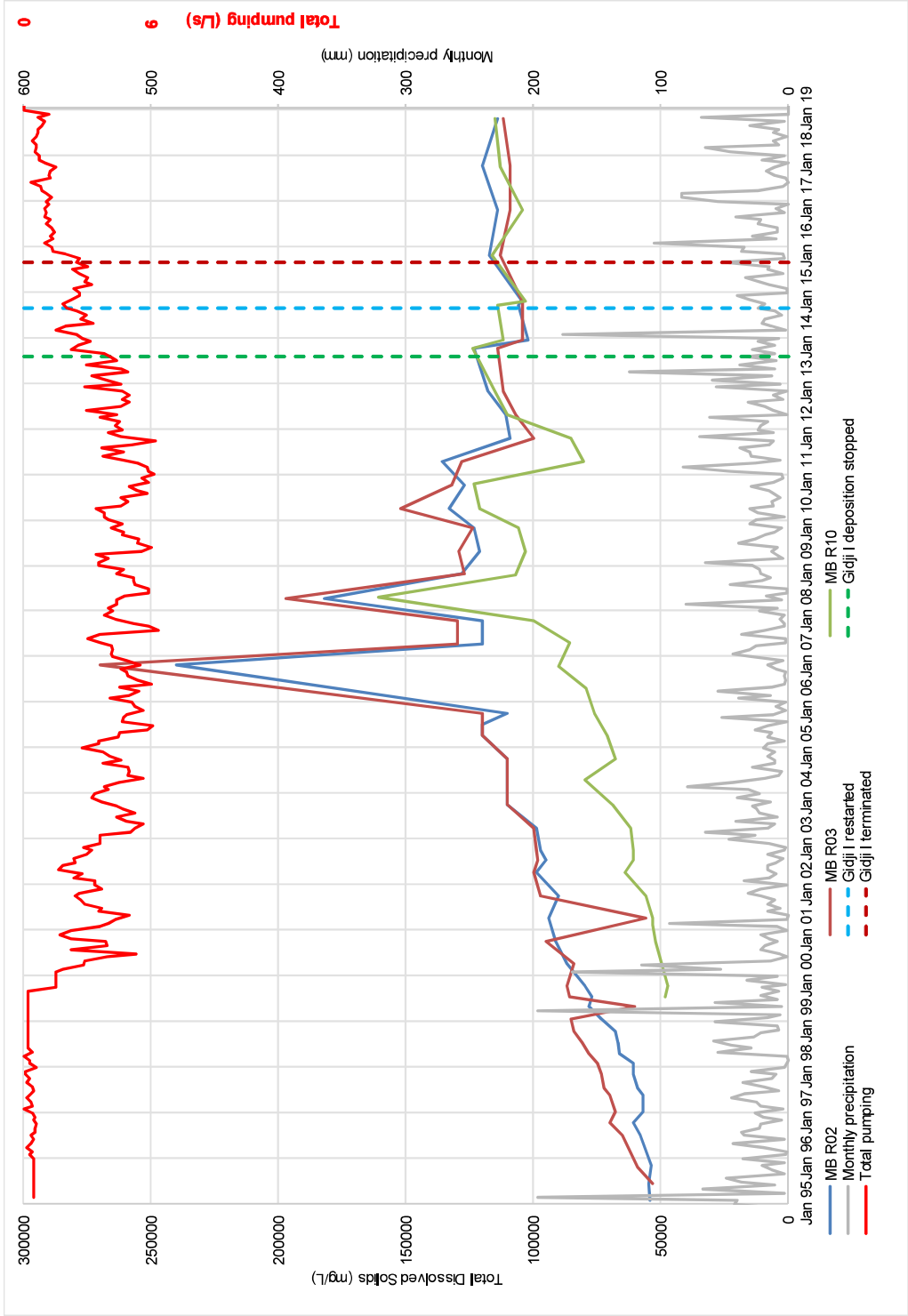


Figure C12

Date:	January 2019
Report:	KCGM Gidji TSF Hydrogeological Review

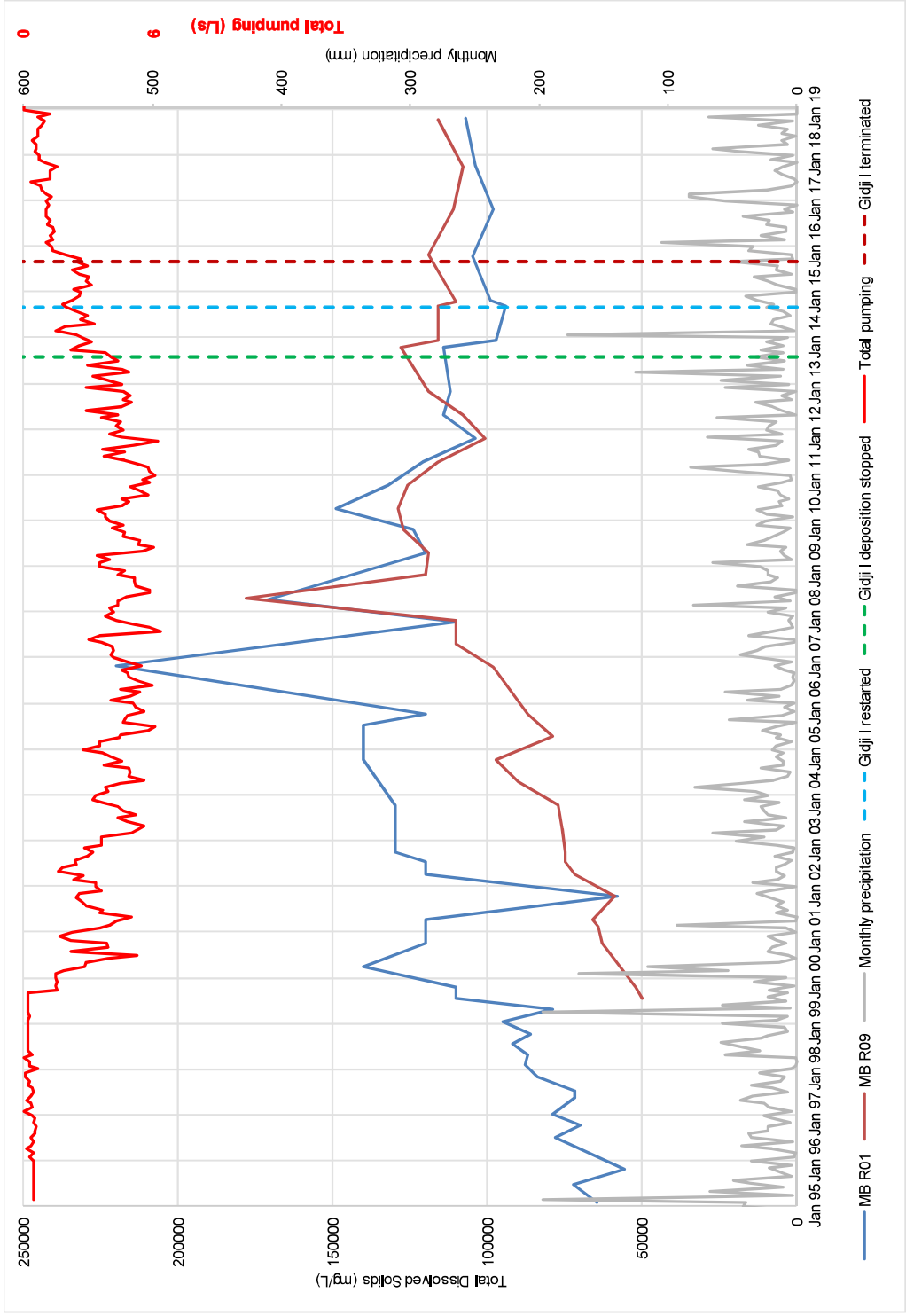
Groundwater TDS - western bores





Groundwater TDS - trench bores



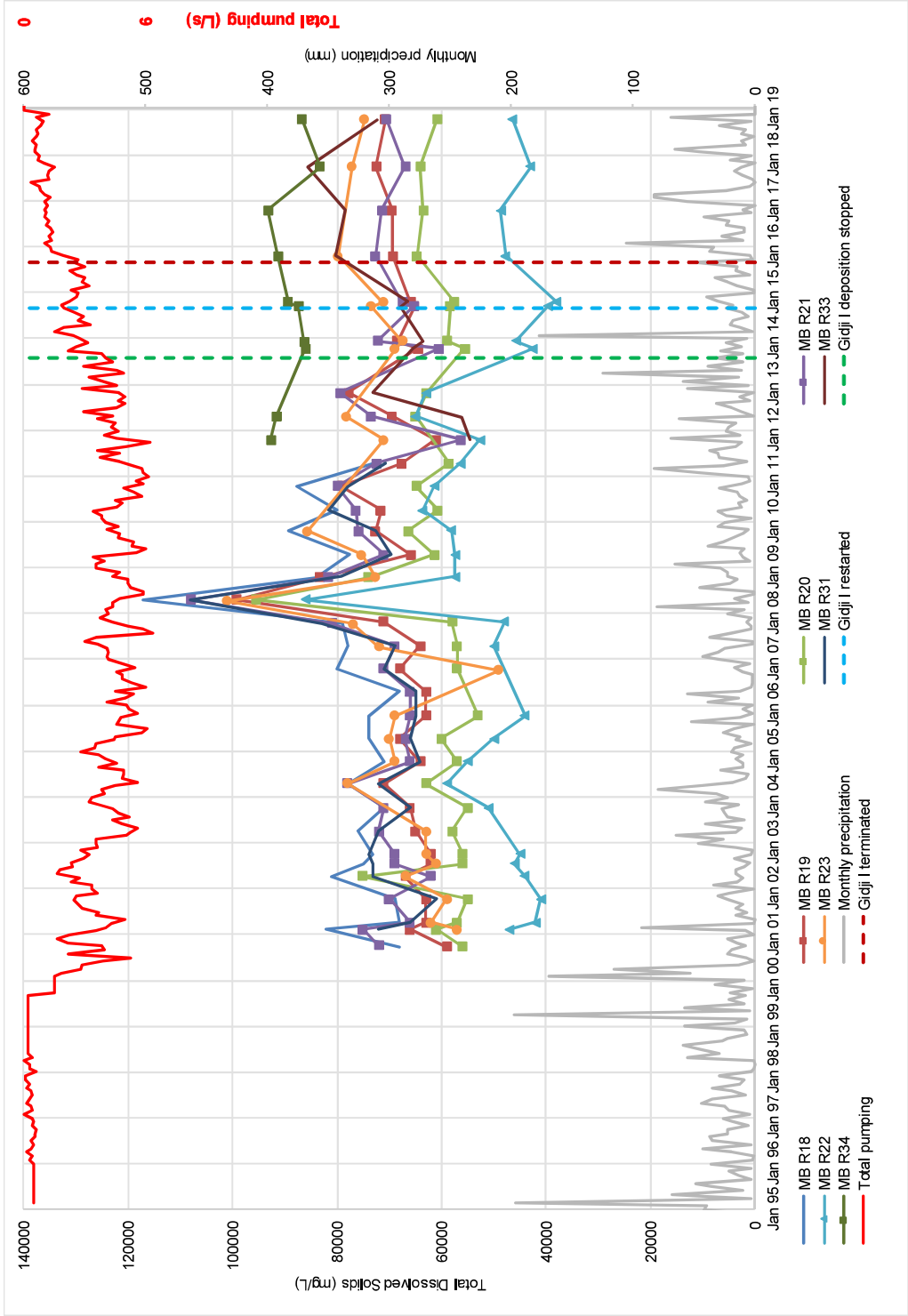


Groundwater TDS - decant bores

Figure C14

Date:	January 2019
Report:	KCGM Gidji TSF Hydrogeological Review

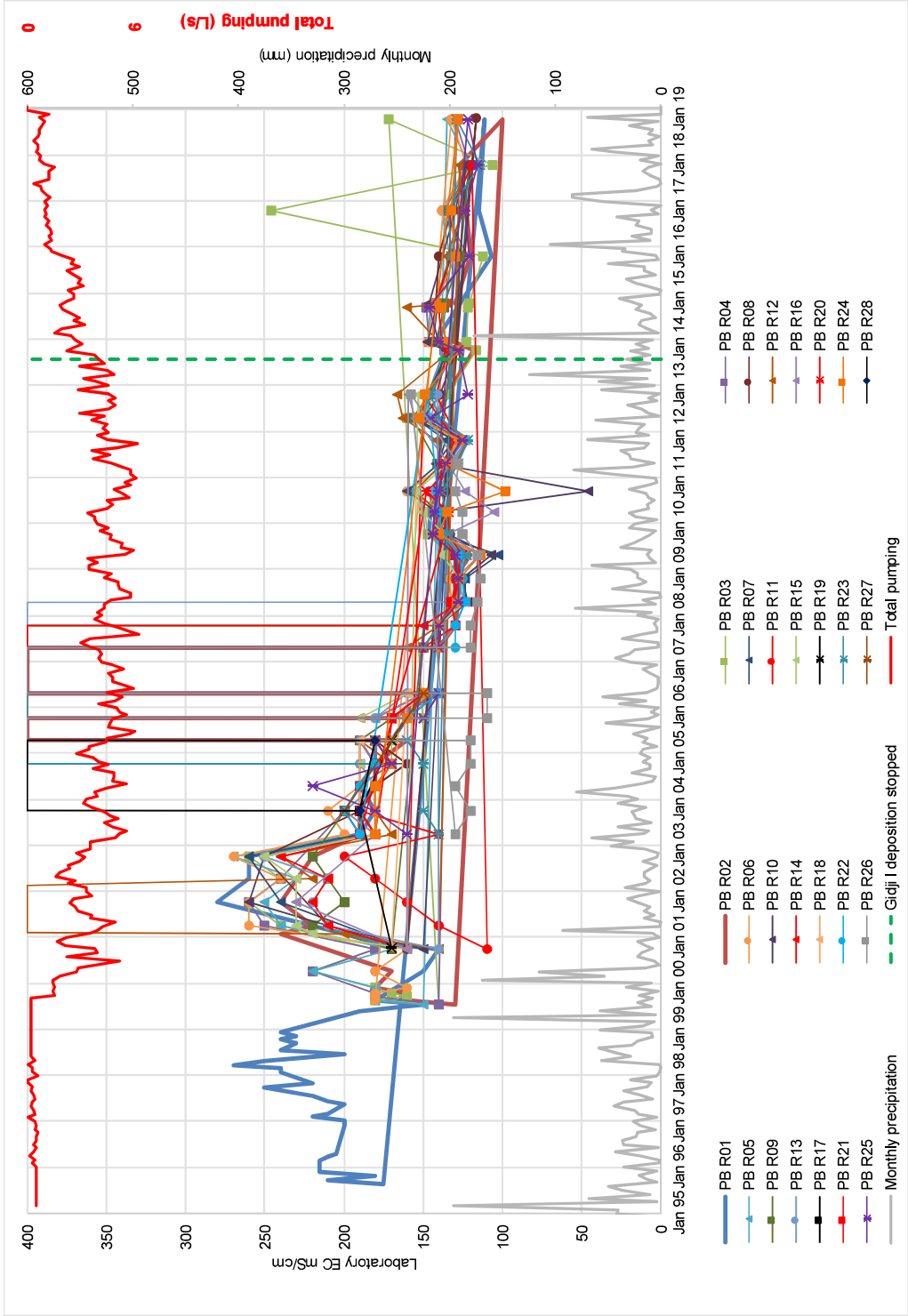




Groundwater TDS - eastern bores

Figure C15

Date:	January 2019
Report:	KCGM Girji TSF Hydrogeological Review



Groundwater Laboratory EC - production bores



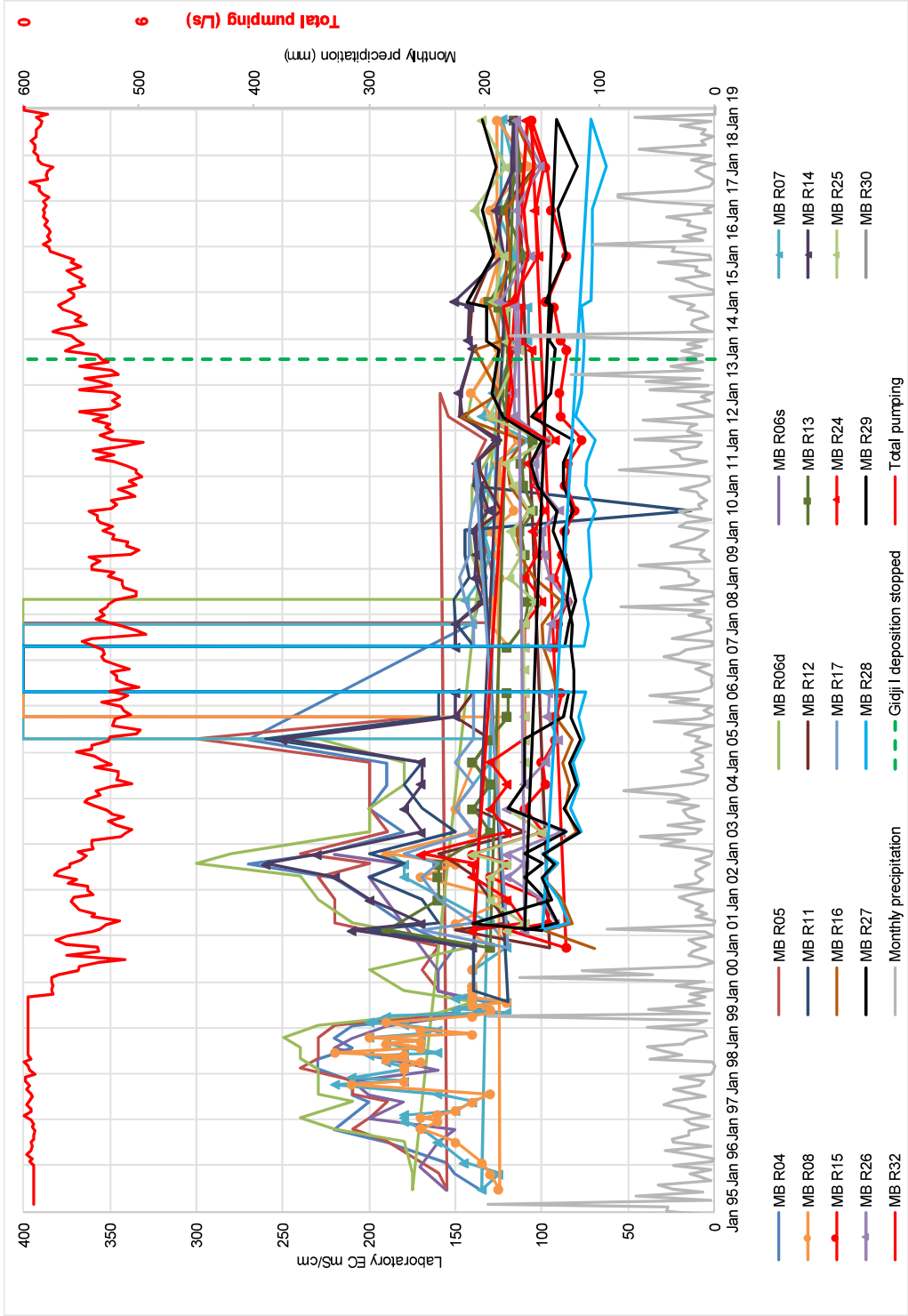
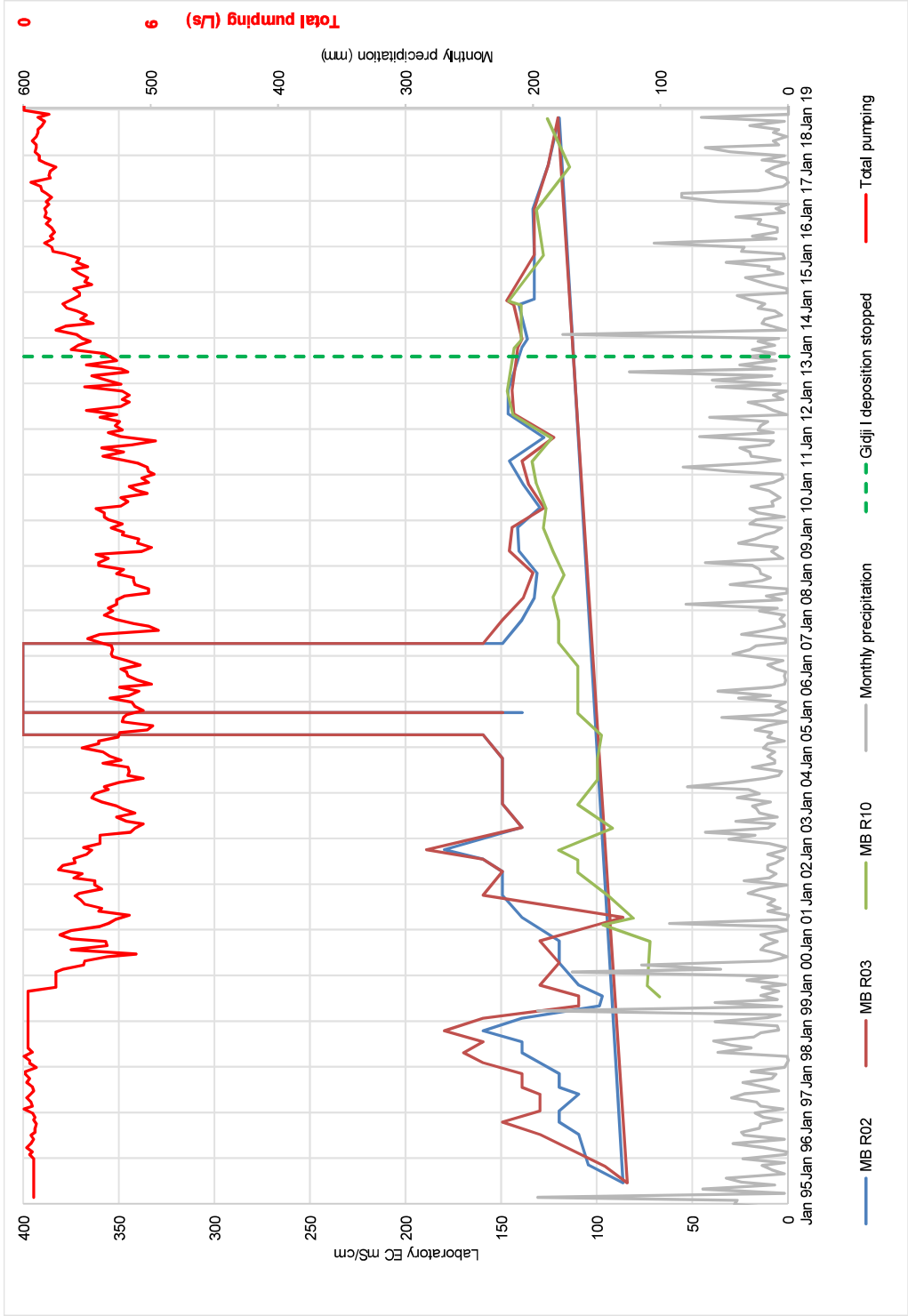


Figure C17

Date:	January 2019
Report:	KCGM Gidji TSF Hydrogeological Review

Groundwater Laboratory EC - western bores



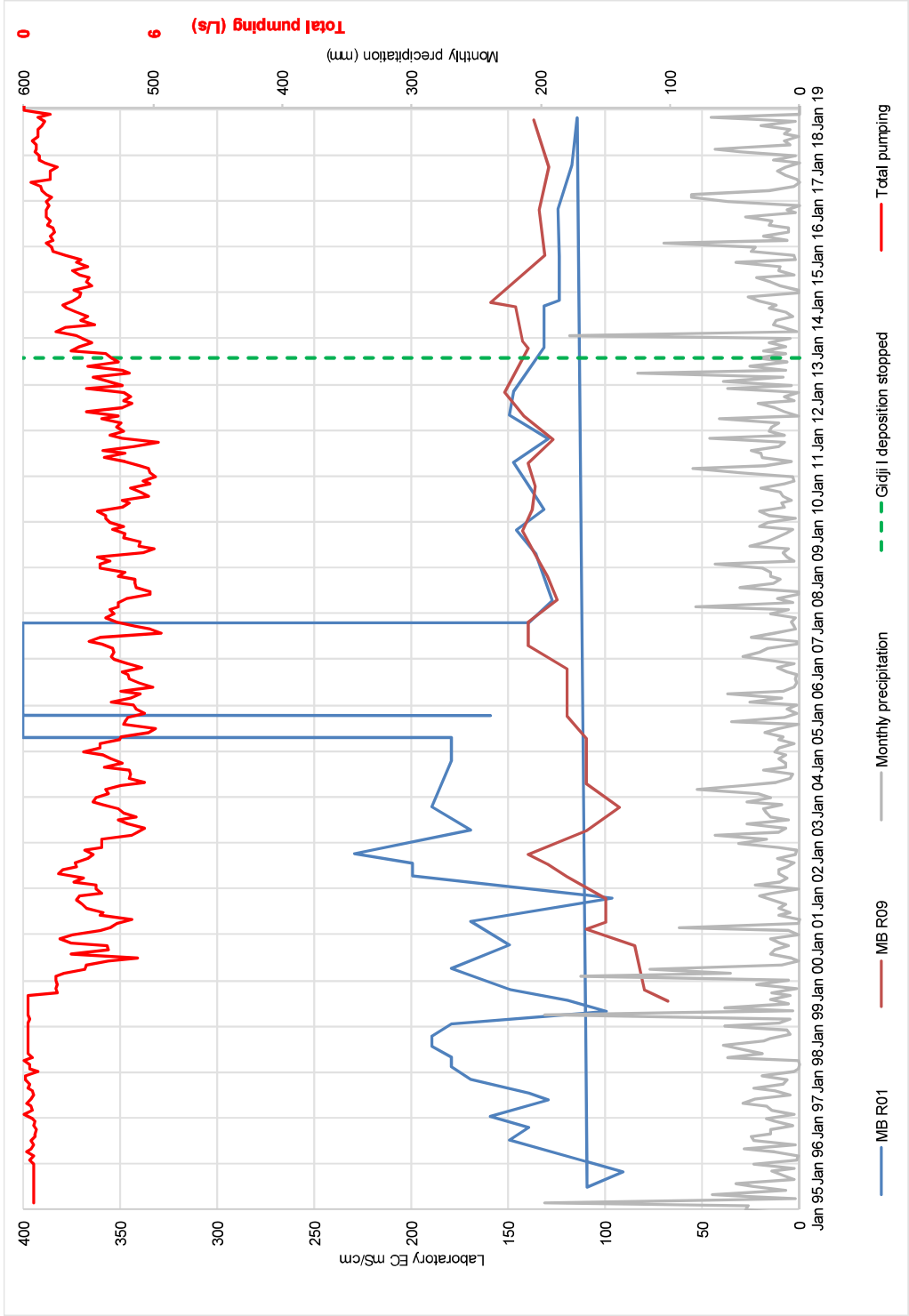


Groundwater Laboratory EC - trench bores

Figure C18

Date:	January 2019
Report:	KCGM Gidji TSF Hydrogeological Review

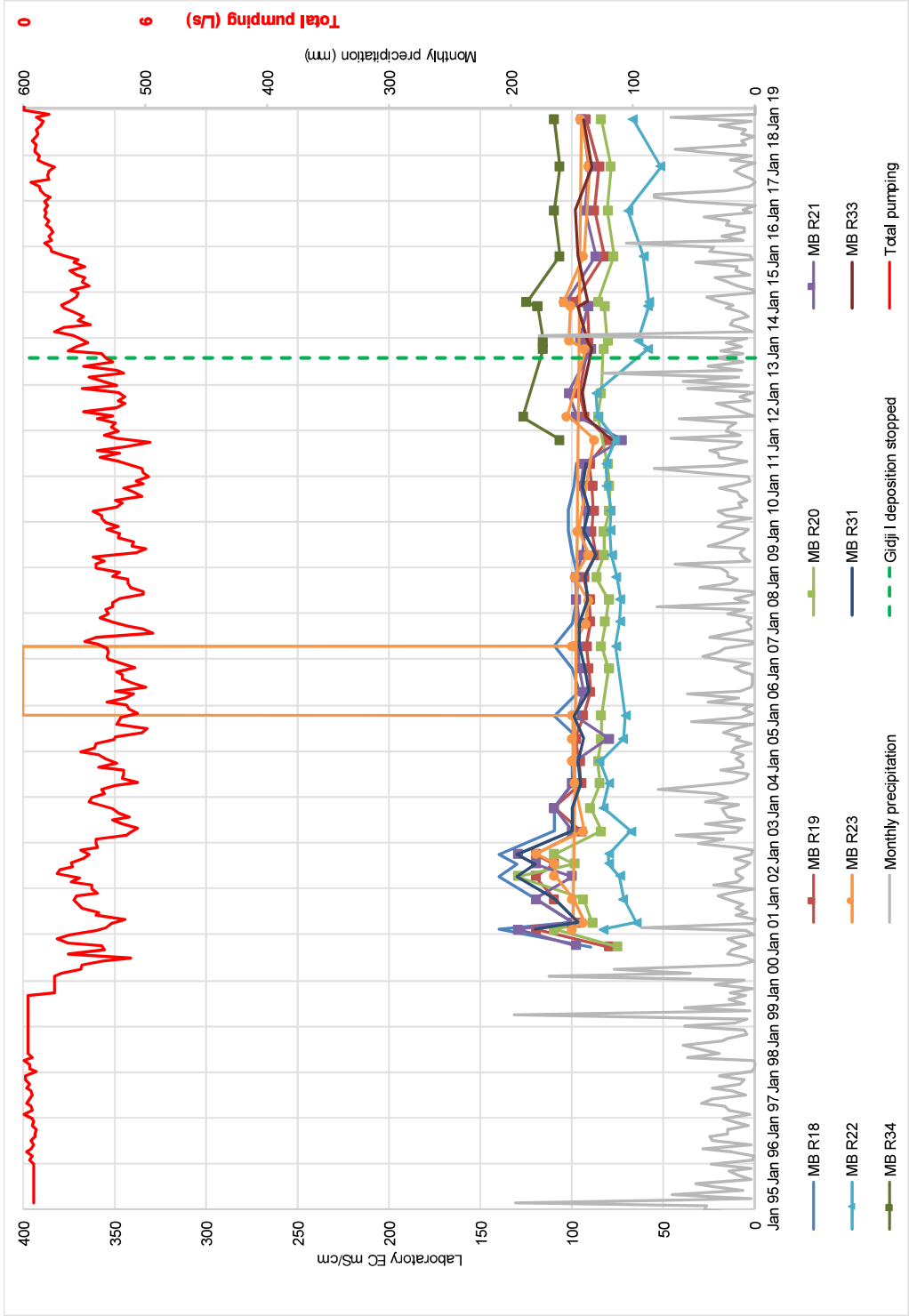




Groundwater Laboratory EC - decant bores

Figure C19

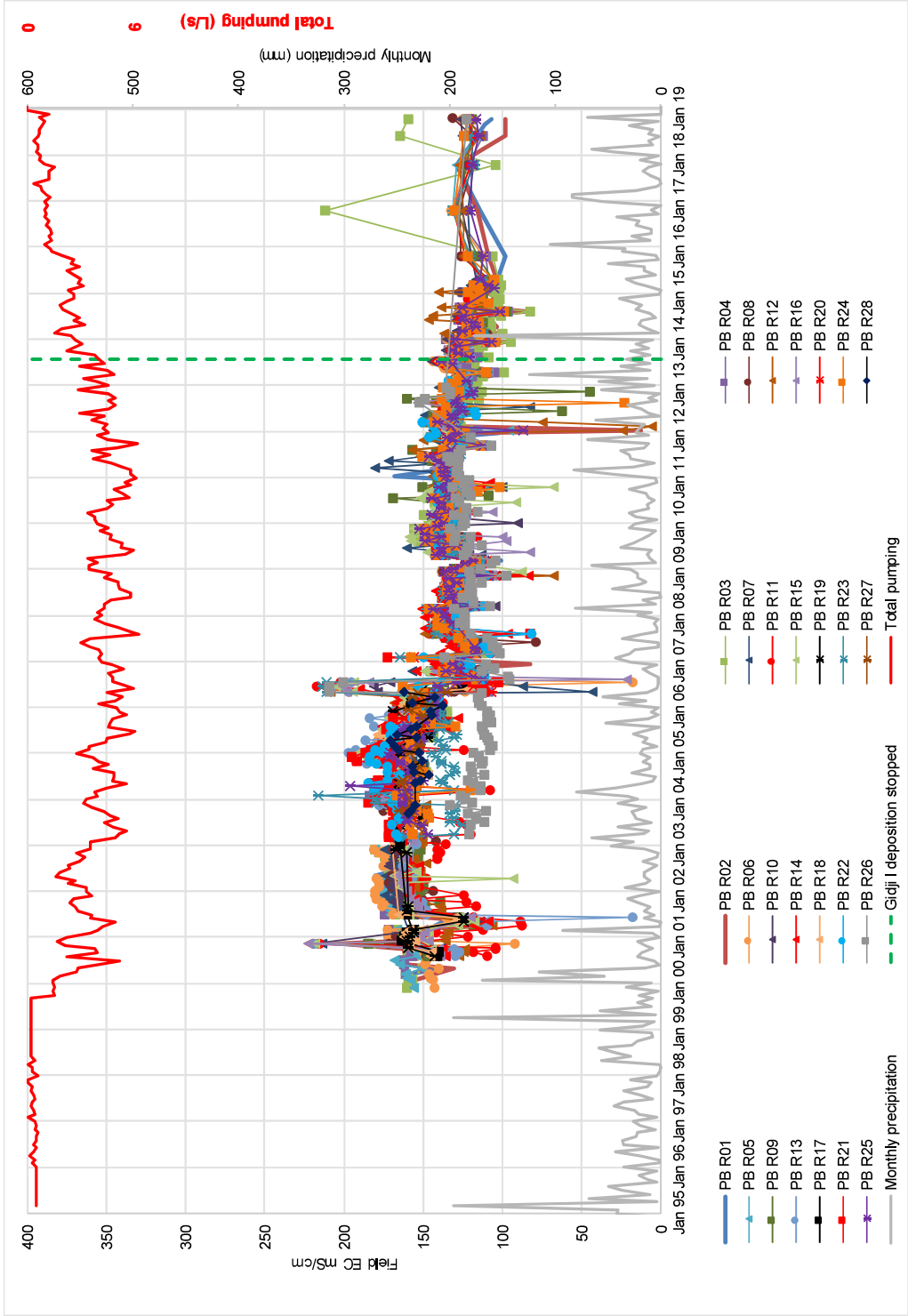
Date:	January 2019
Report:	KCGM Gidji TSF Hydrogeological Review



Groundwater Laboratory EC - eastern bores

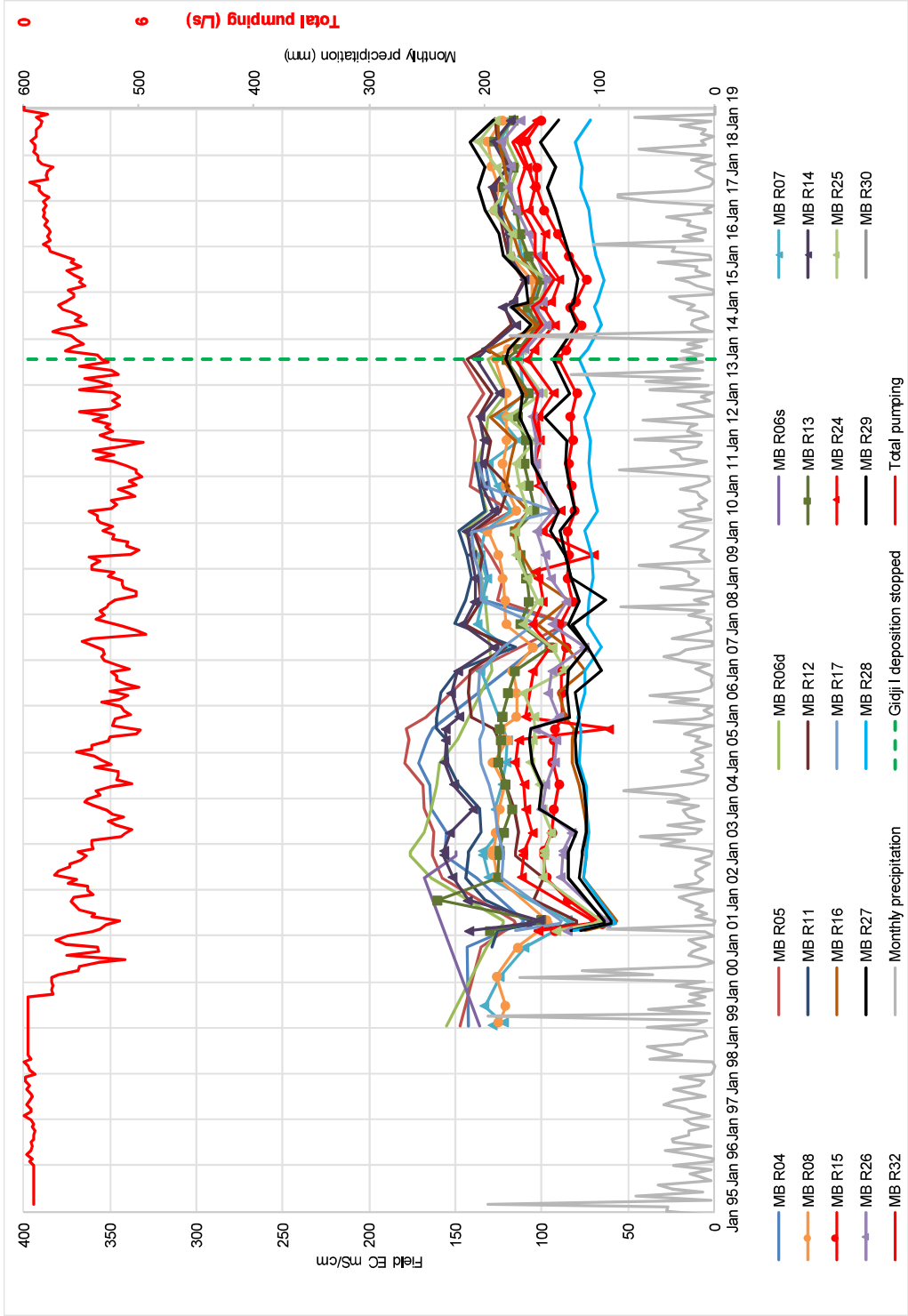
Figure C20

Date:	January 2019
Report:	KCGM Gidji TSF Hydrogeological Review



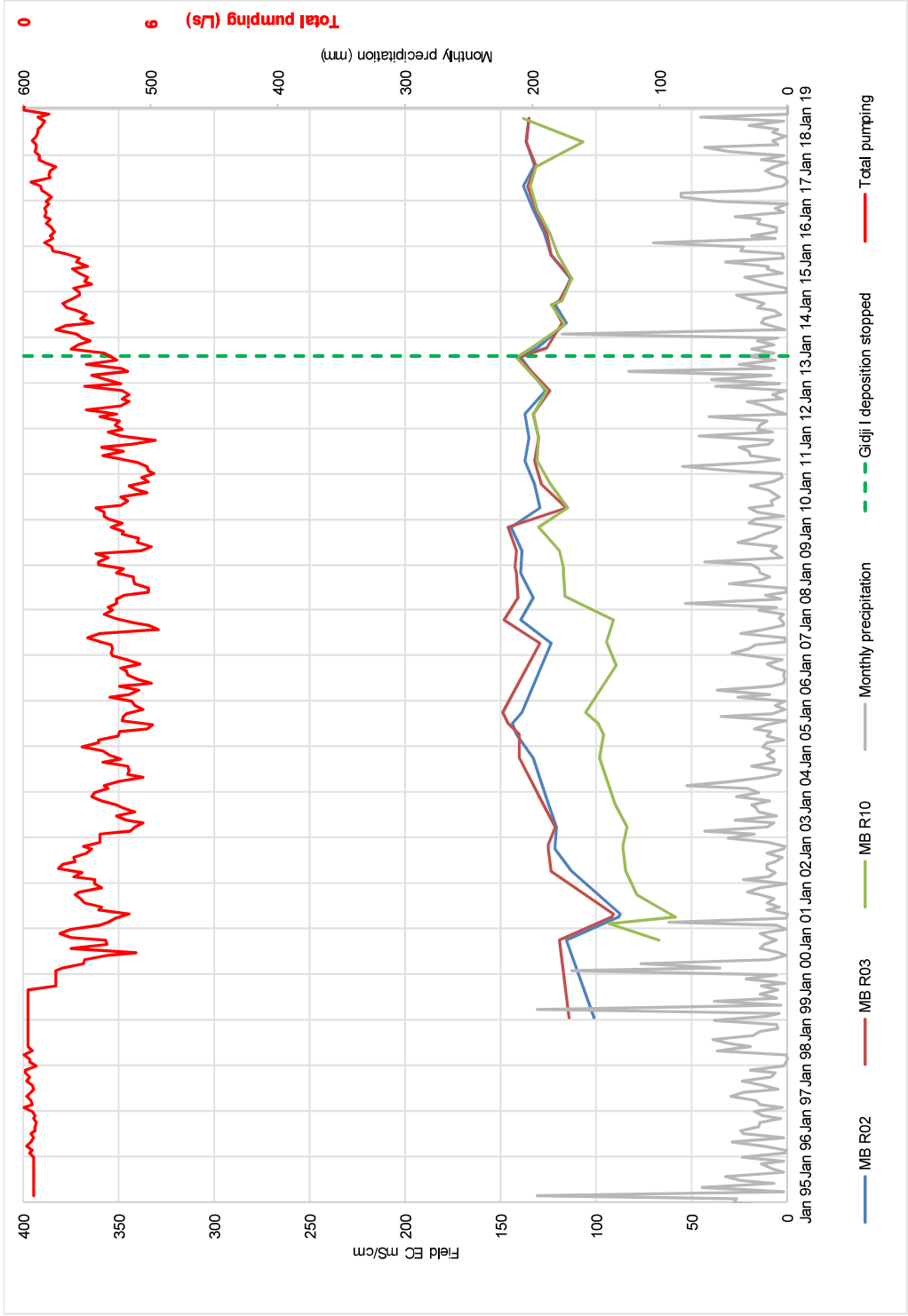
Groundwater Field EC - production bores

Figure C21	
Date:	January 2019
Report:	KCGM Gidji TSF Hydrogeological Review



Groundwater Field EC - western bores



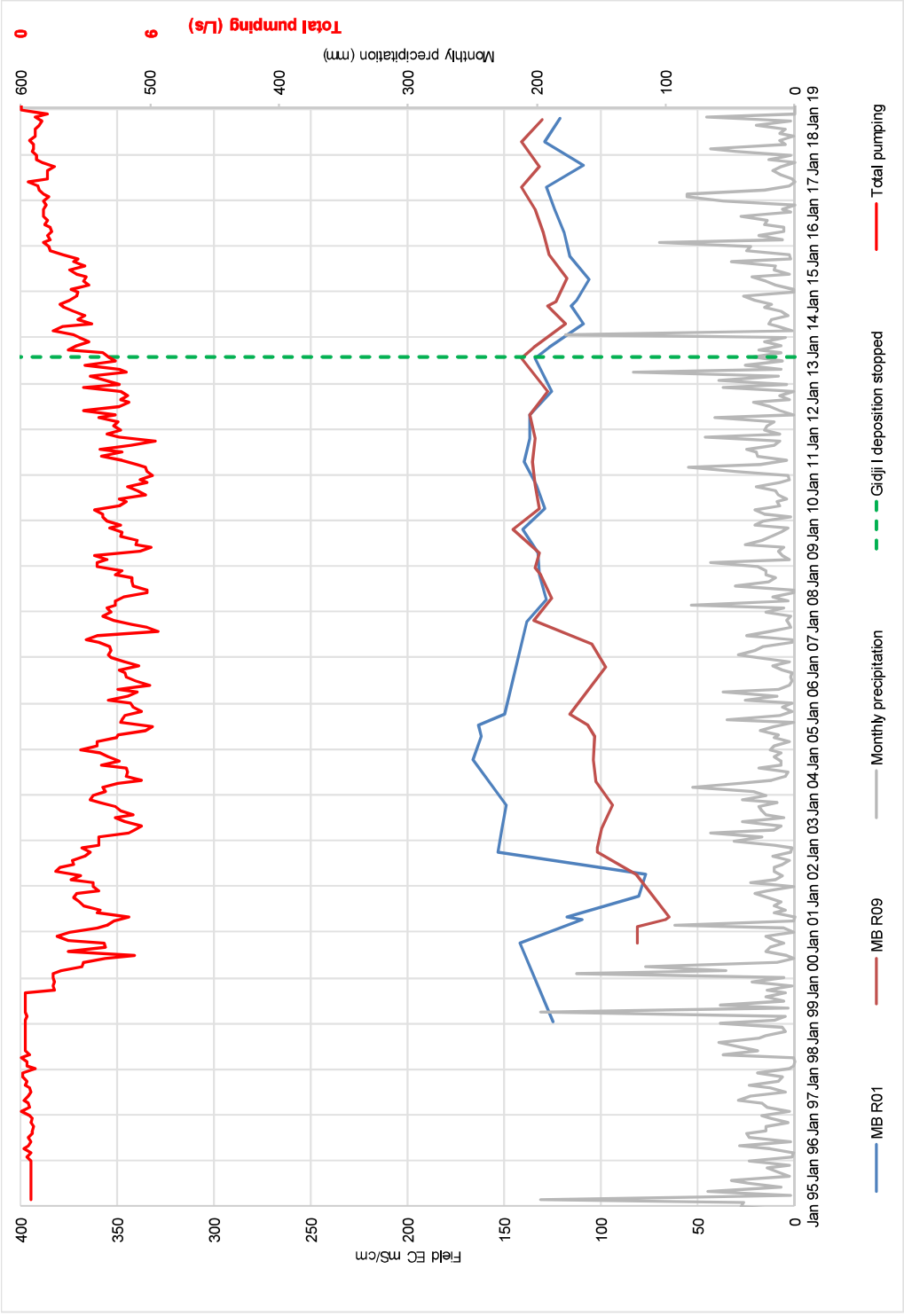


Groundwater Field EC - trench bores

Figure C23

Date:	January 2019
Report:	KCGM Gidji TSF Hydrogeological Review

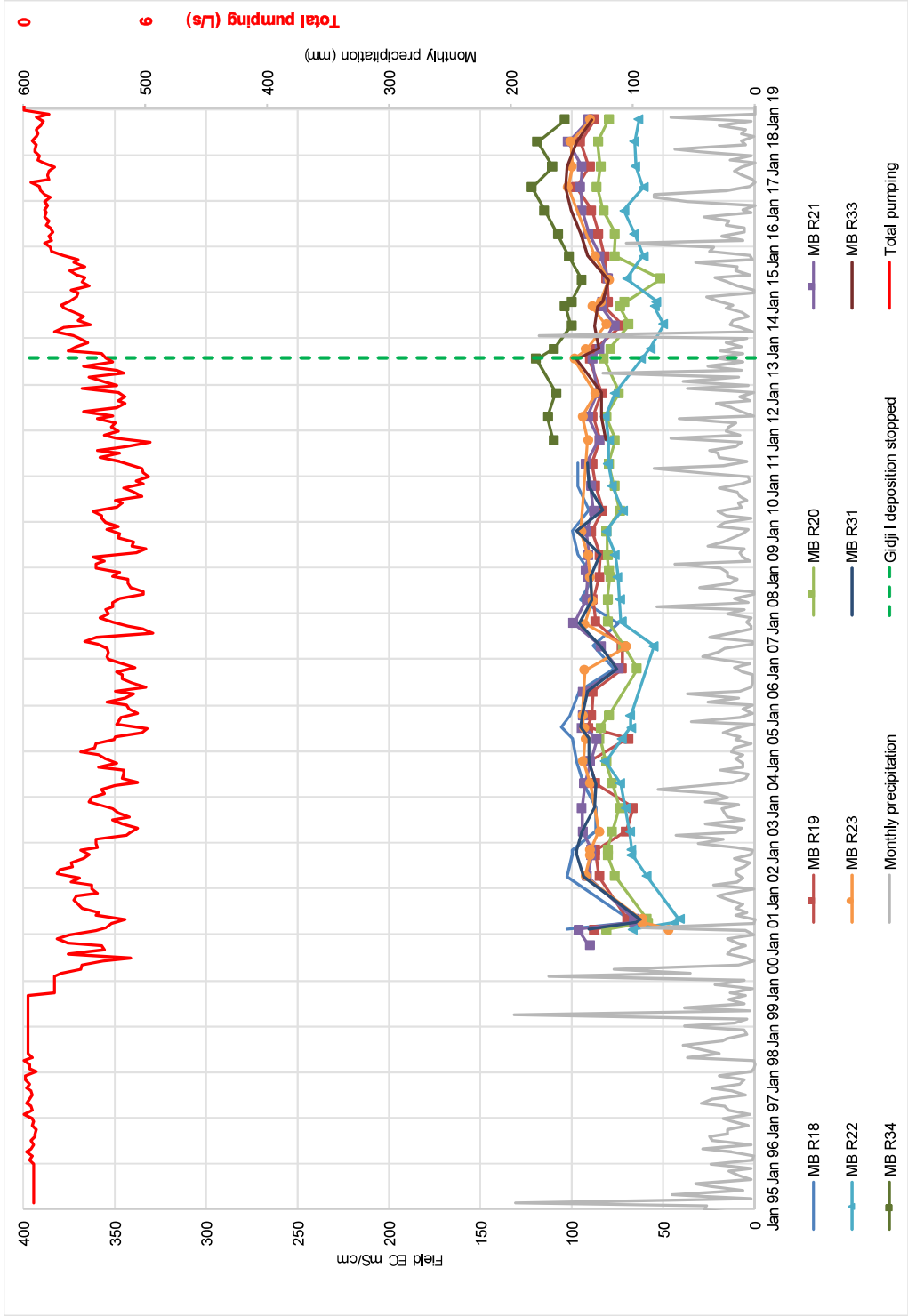




Groundwater Field EC - decant bores

Figure C24

Date:	January 2019
Report:	KCGM Gidji TSF Hydrogeological Review



Groundwater Field EC - eastern bores

Figure C25

Date:	January 2019
Report:	KCGM Gidji TSF Hydrogeological Review



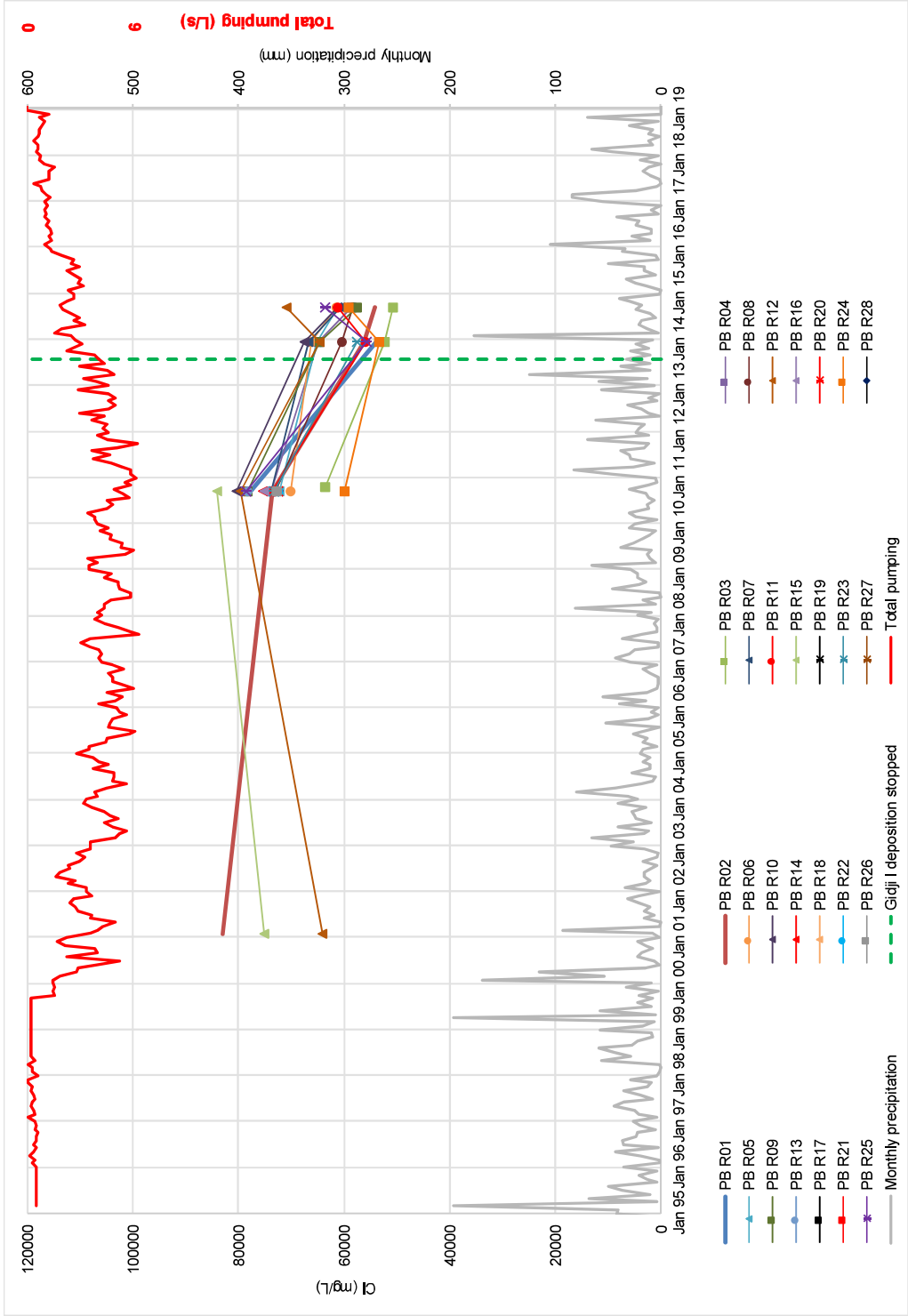


Figure C26

Date:	January 2019
Report:	KCGM Gidji TSF Hydrogeological Review

Groundwater Cl - production bores



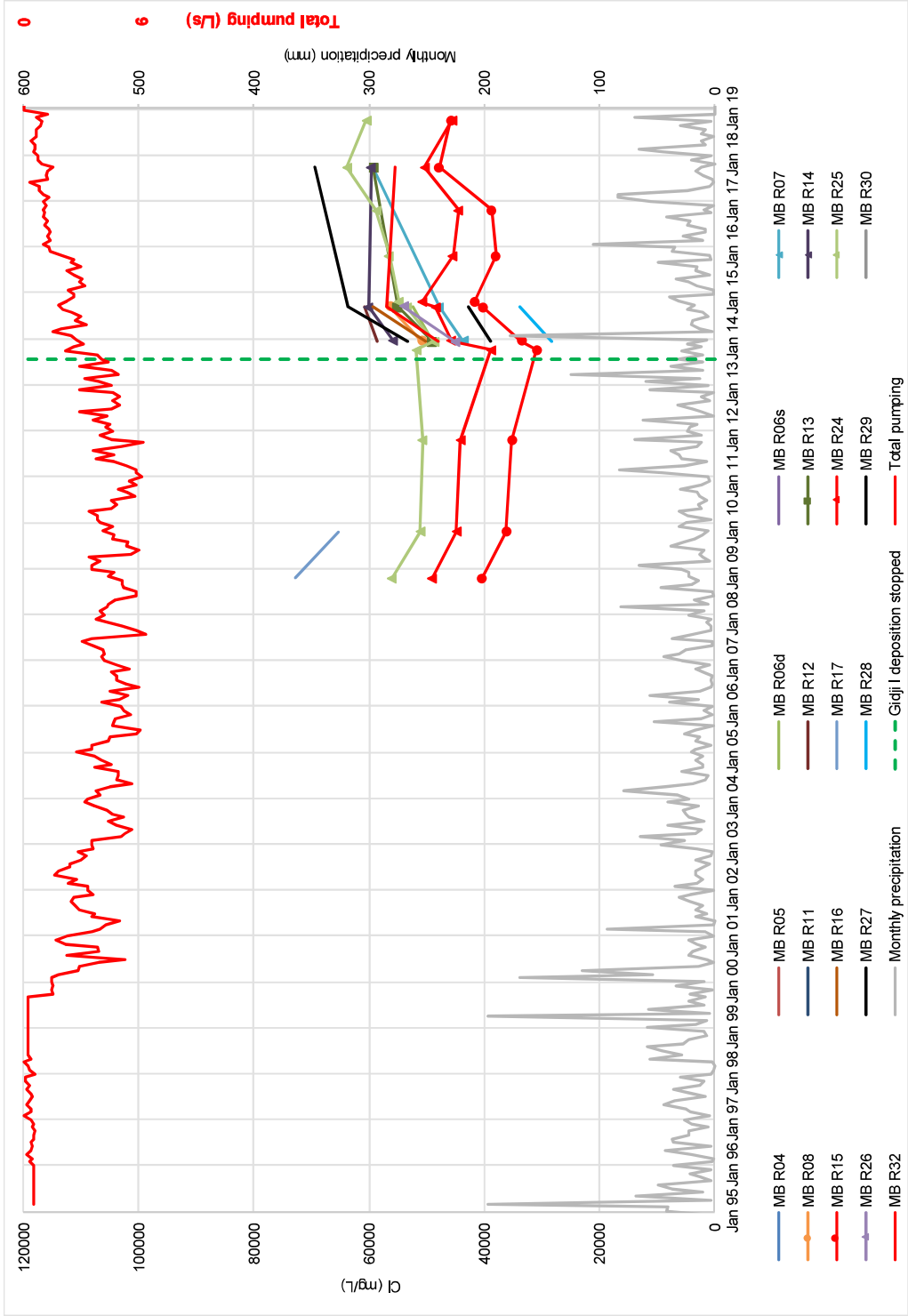
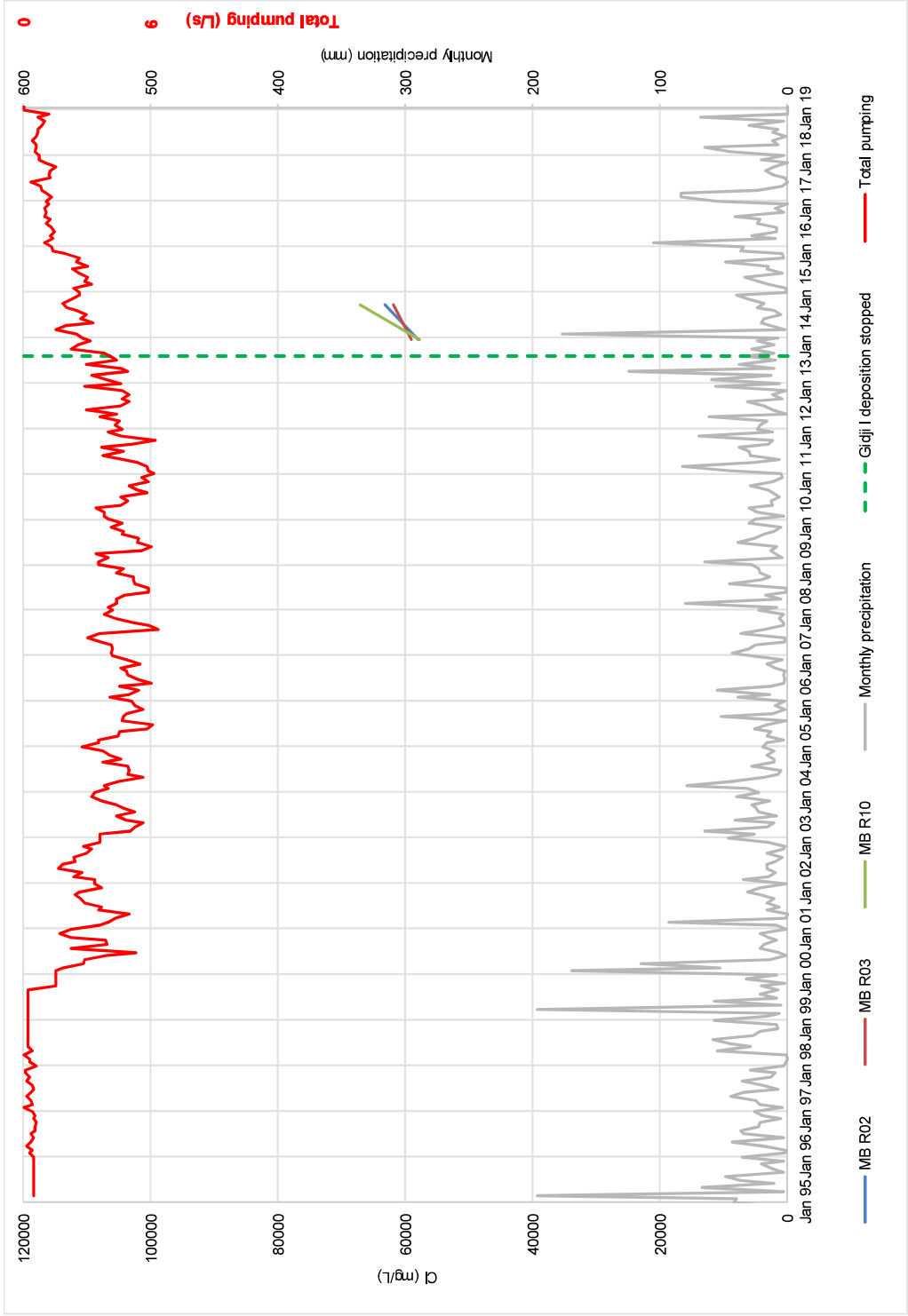


Figure C27

Date:	January 2019
Report:	KCGM Gidji TSF Hydrogeological Review

Groundwater Cl - western bores

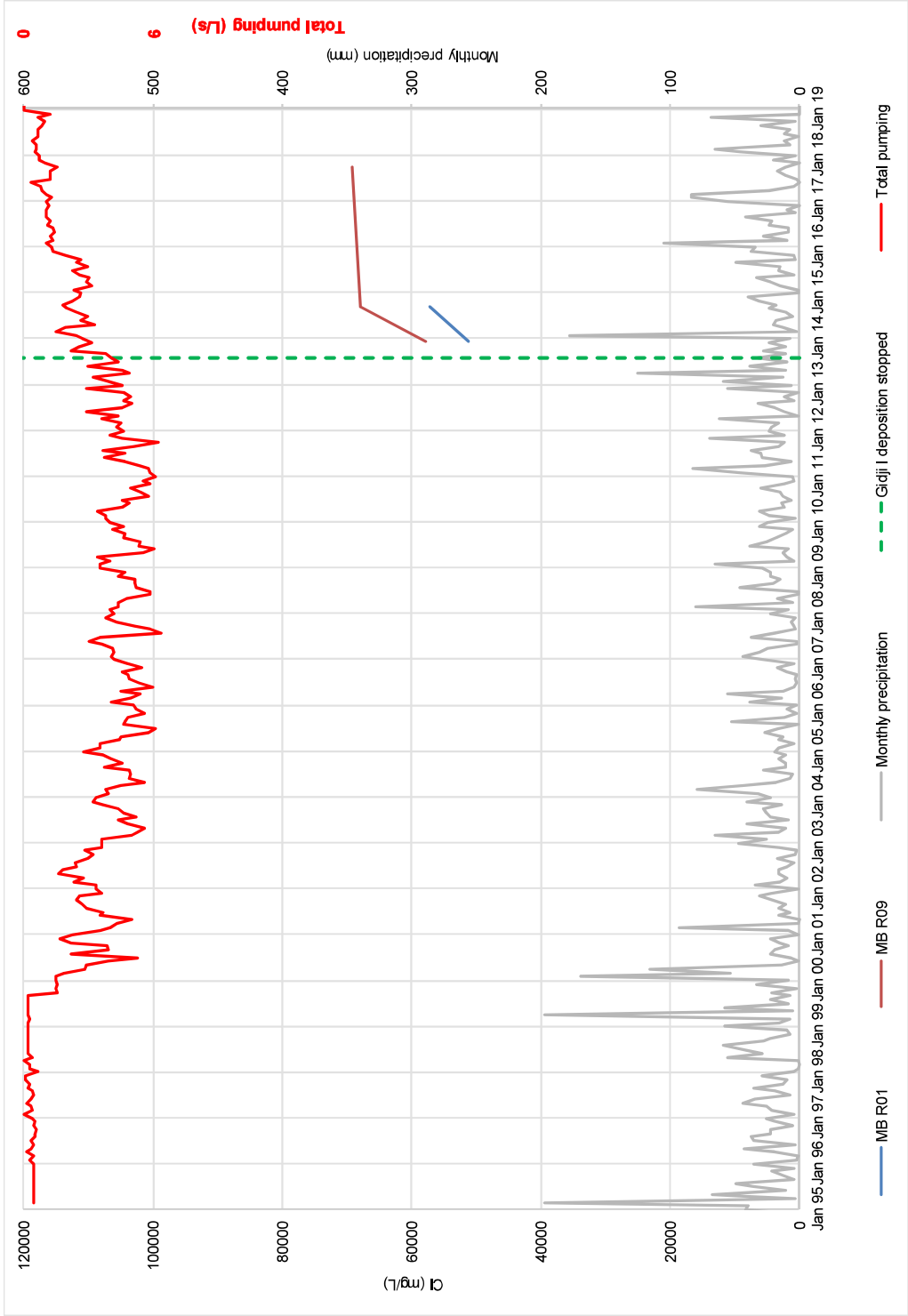




Groundwater Cl - trench bores

Figure C28

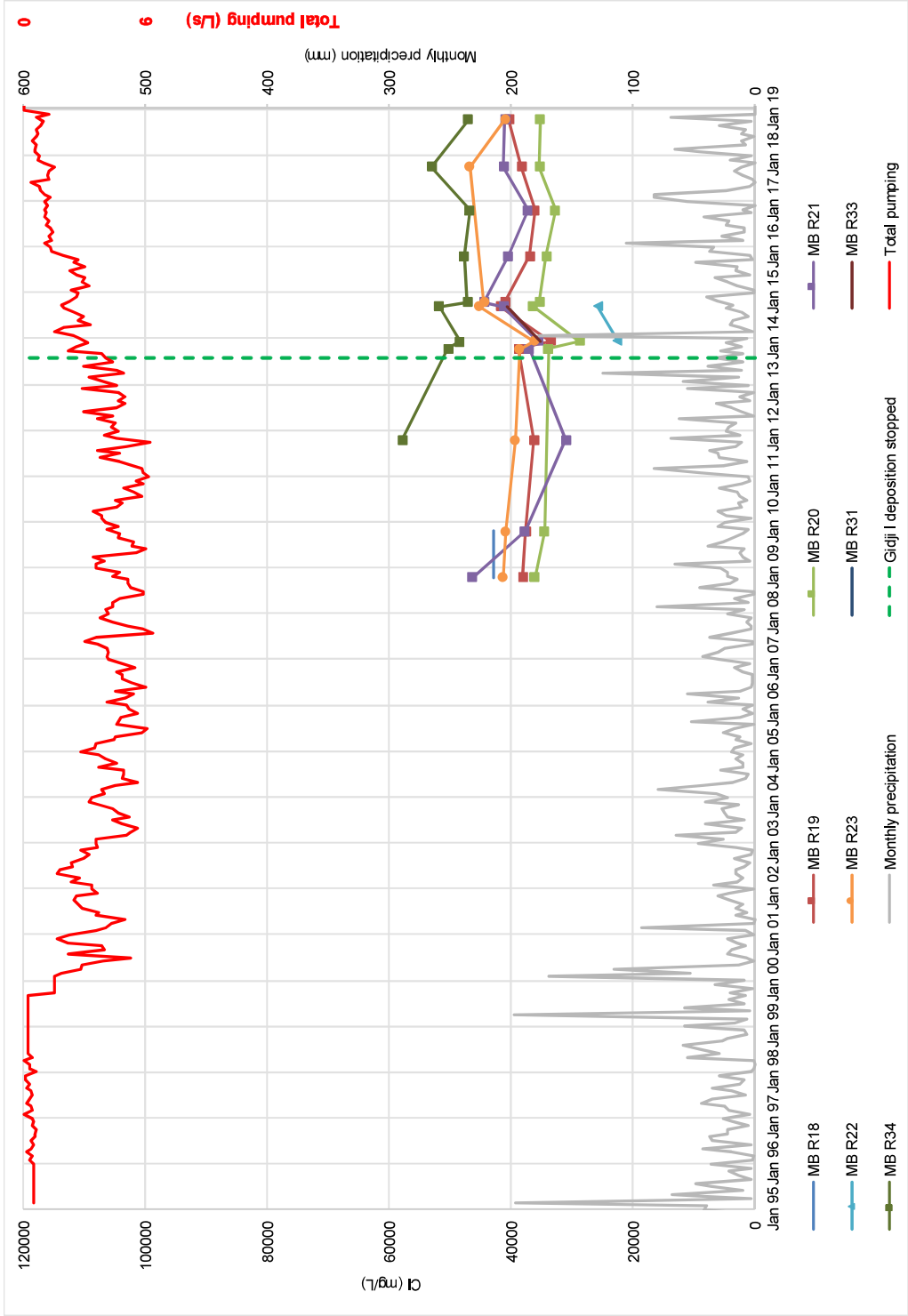
Date:	January 2019
Report:	KCGM Gidji TSF Hydrogeological Review



Groundwater Cl - decant bores

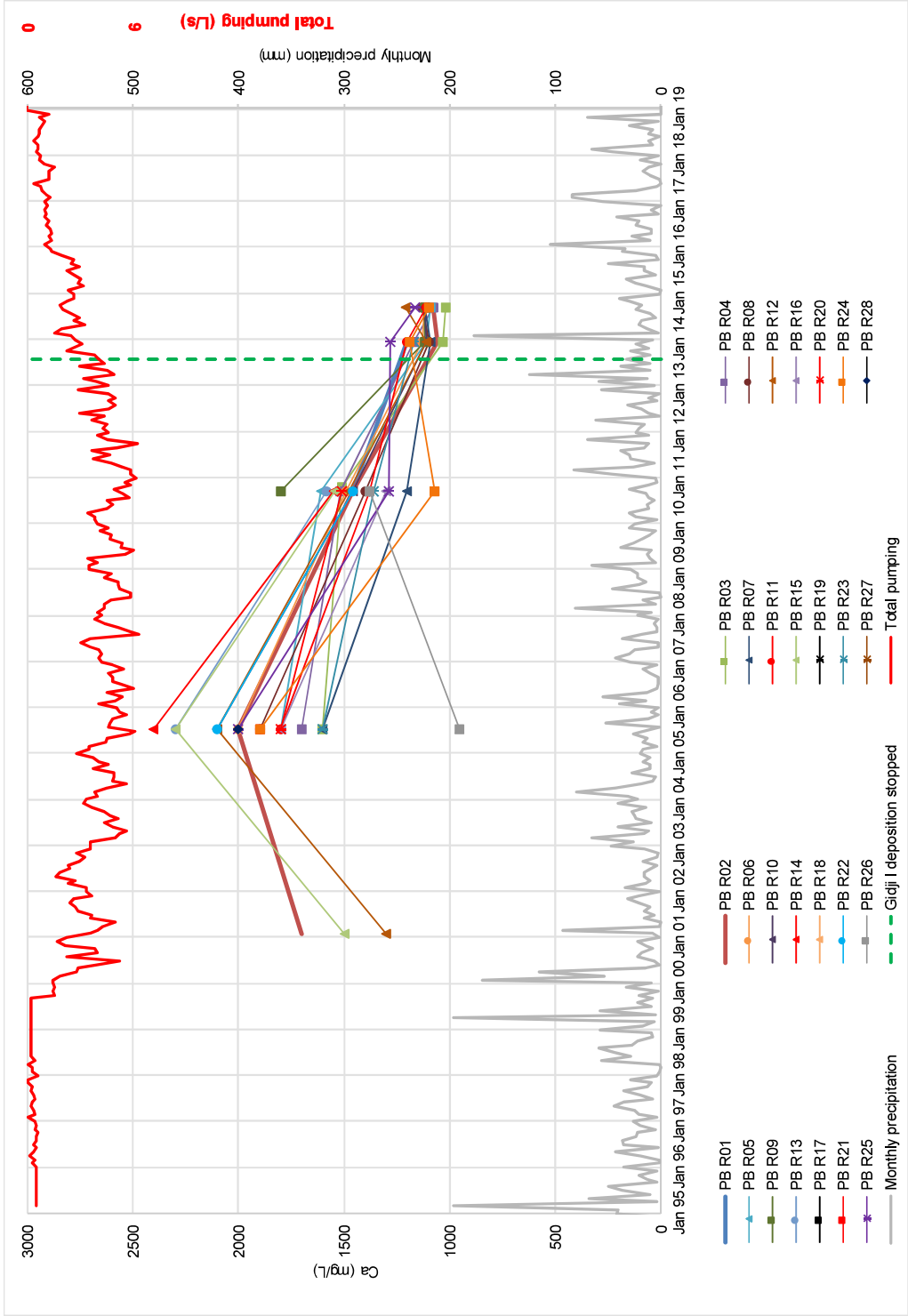
Figure C29

Date:	January 2019
Report:	KCGM Gidji TSF Hydrogeological Review



Groundwater Cl - eastern bores





Groundwater Ca - production bores

Figure C31

Date:	January 2019
Report:	KCGM Gidji TSF Hydrogeological Review

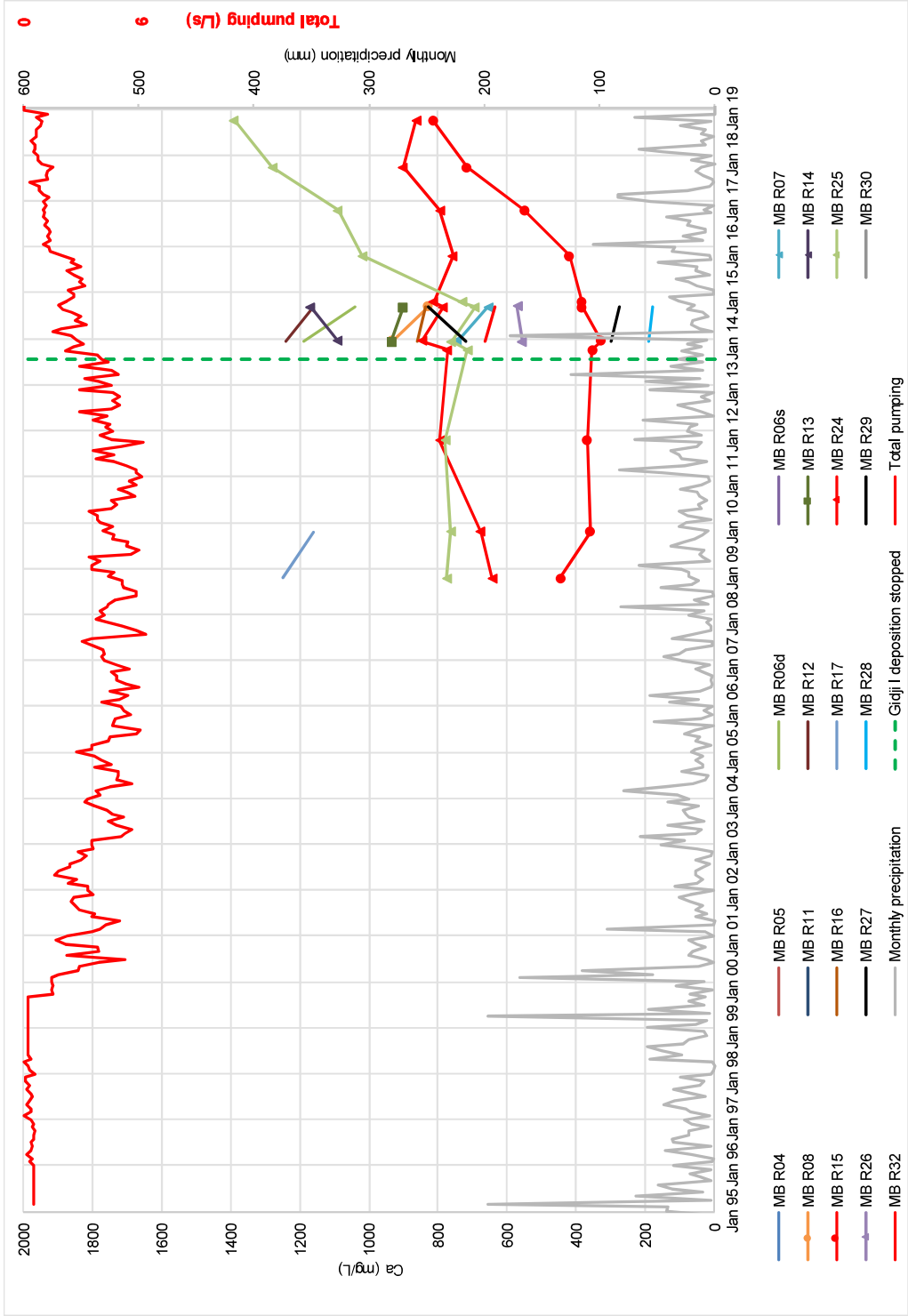


Figure C32

Date:	January 2019
Report:	KCGM Gidji TSF Hydrogeological Review

Groundwater Ca - western bores



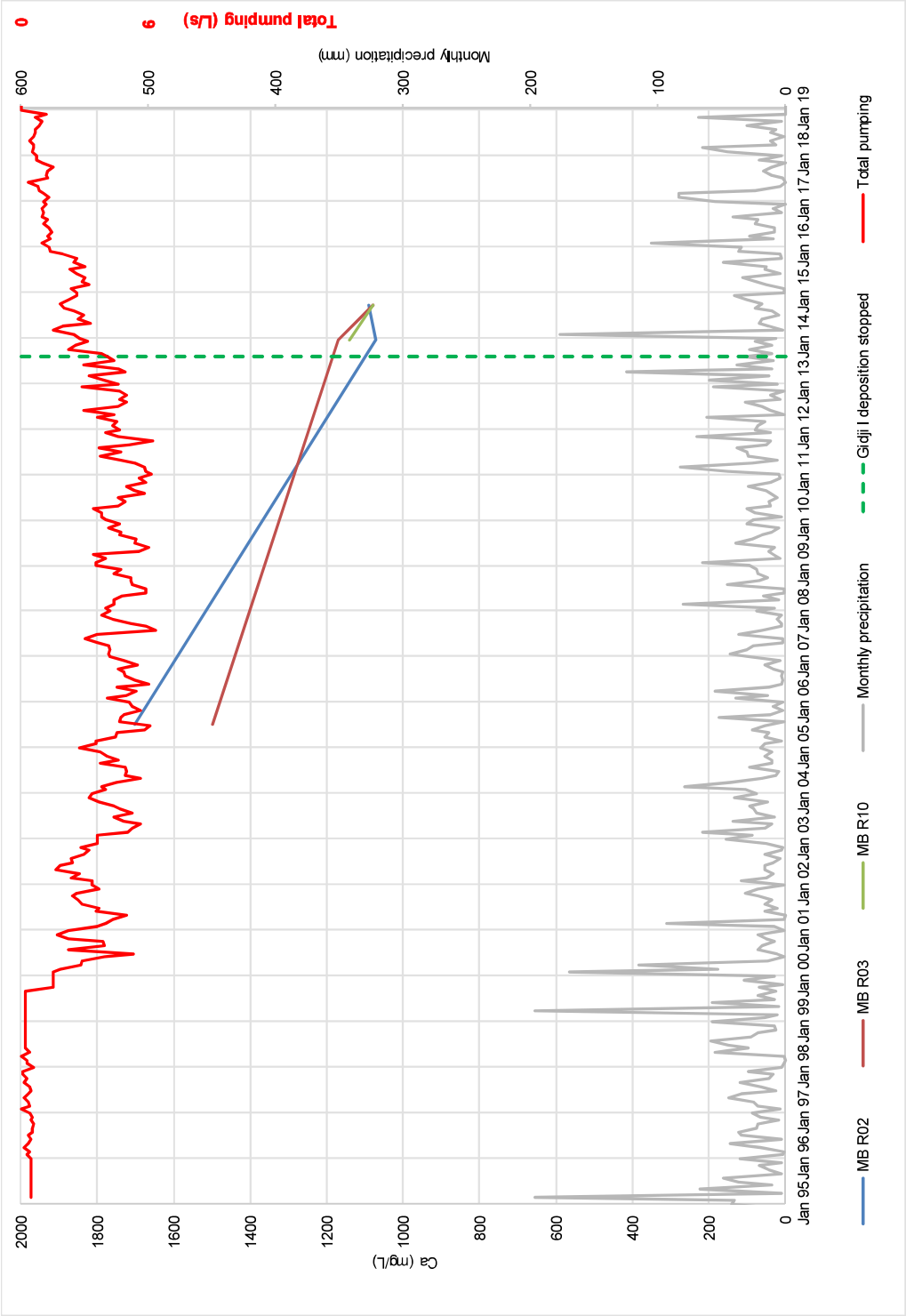
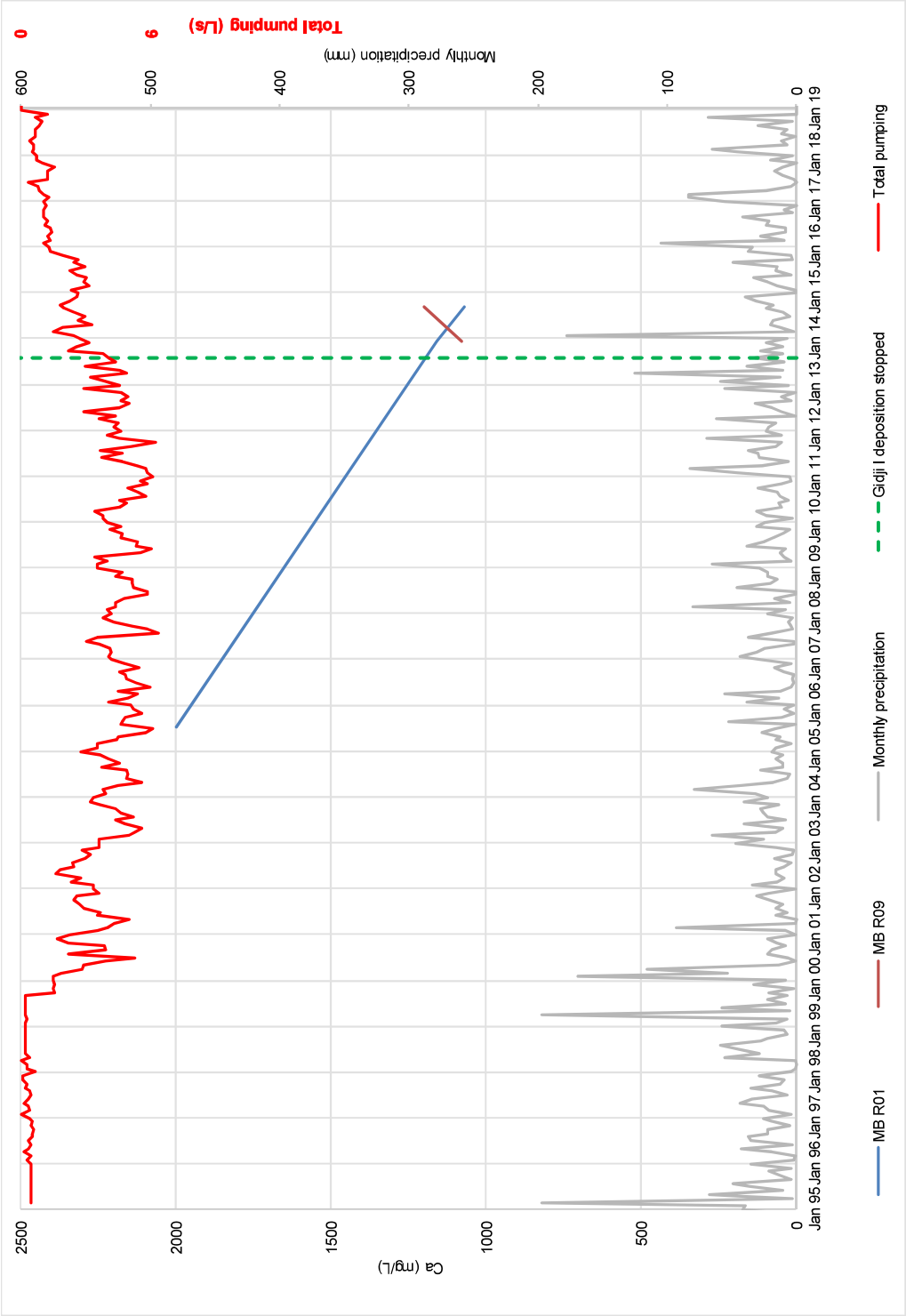


Figure C33	
Date:	January 2019
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Groundwater Ca - trench bores

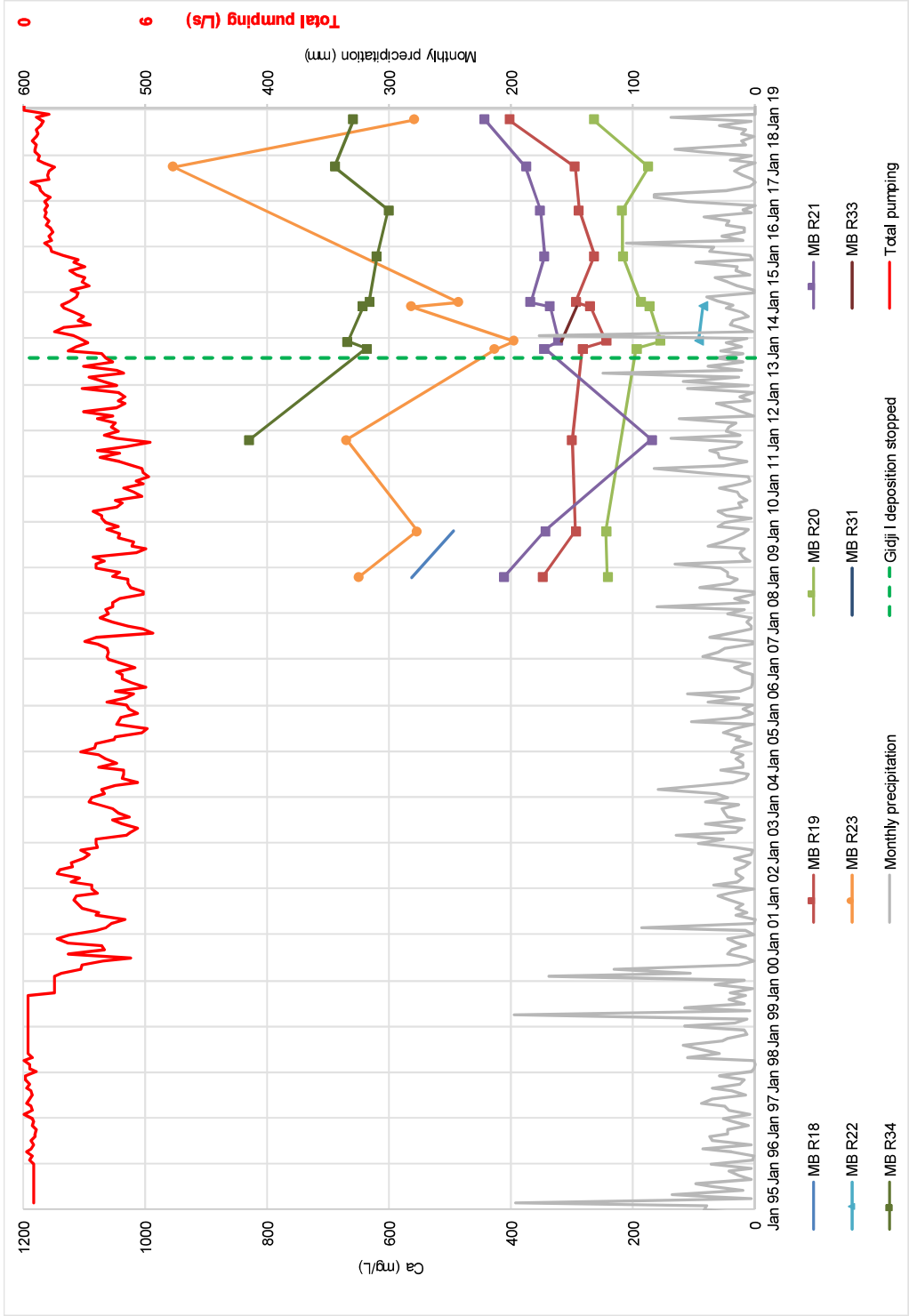




Groundwater Ca - decant bores

Figure C34

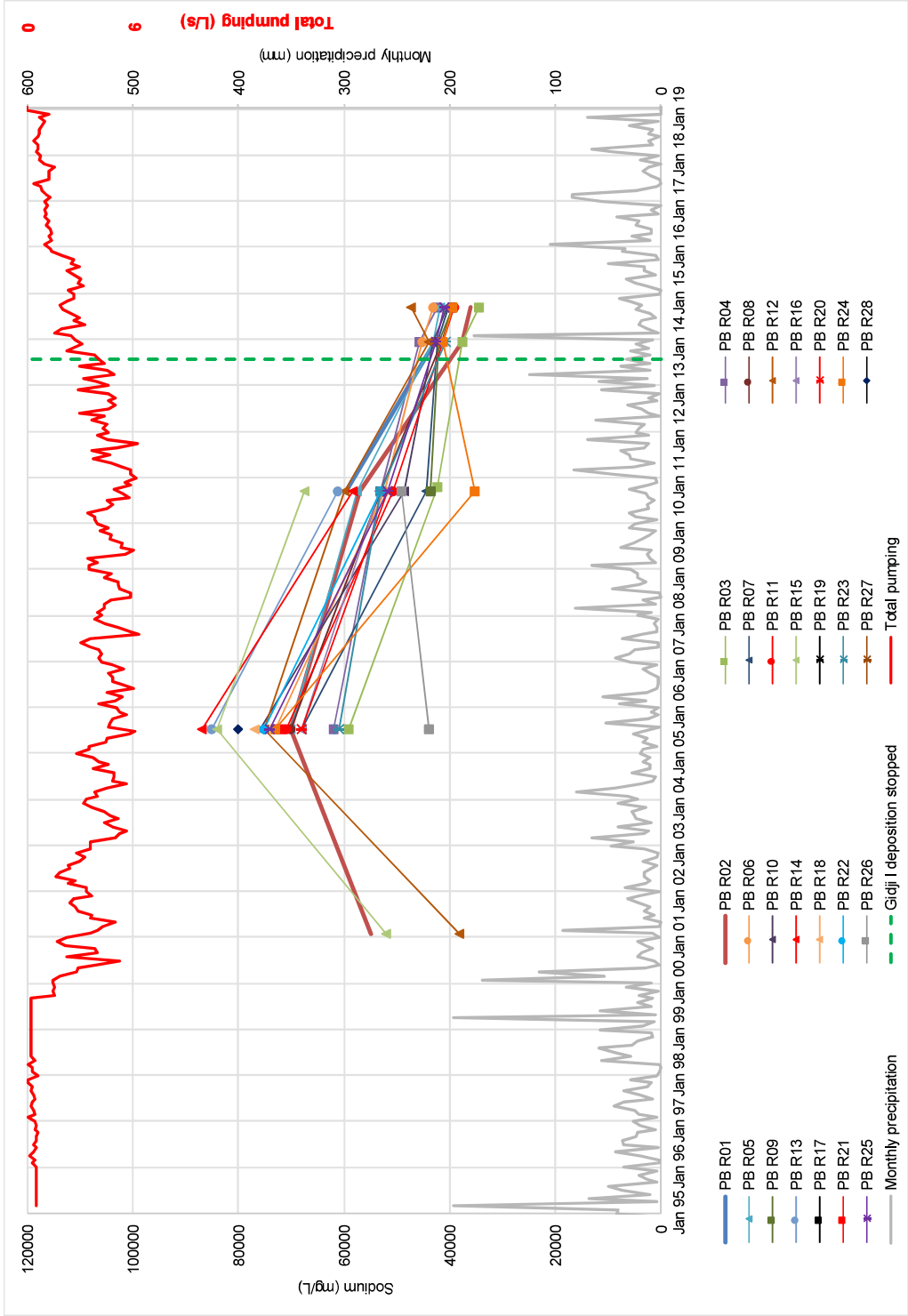
Date:	January 2019
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Groundwater Ca - eastern bores

Figure C35

Date:	January 2019
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Groundwater Na - production bores

Date: January 2019	
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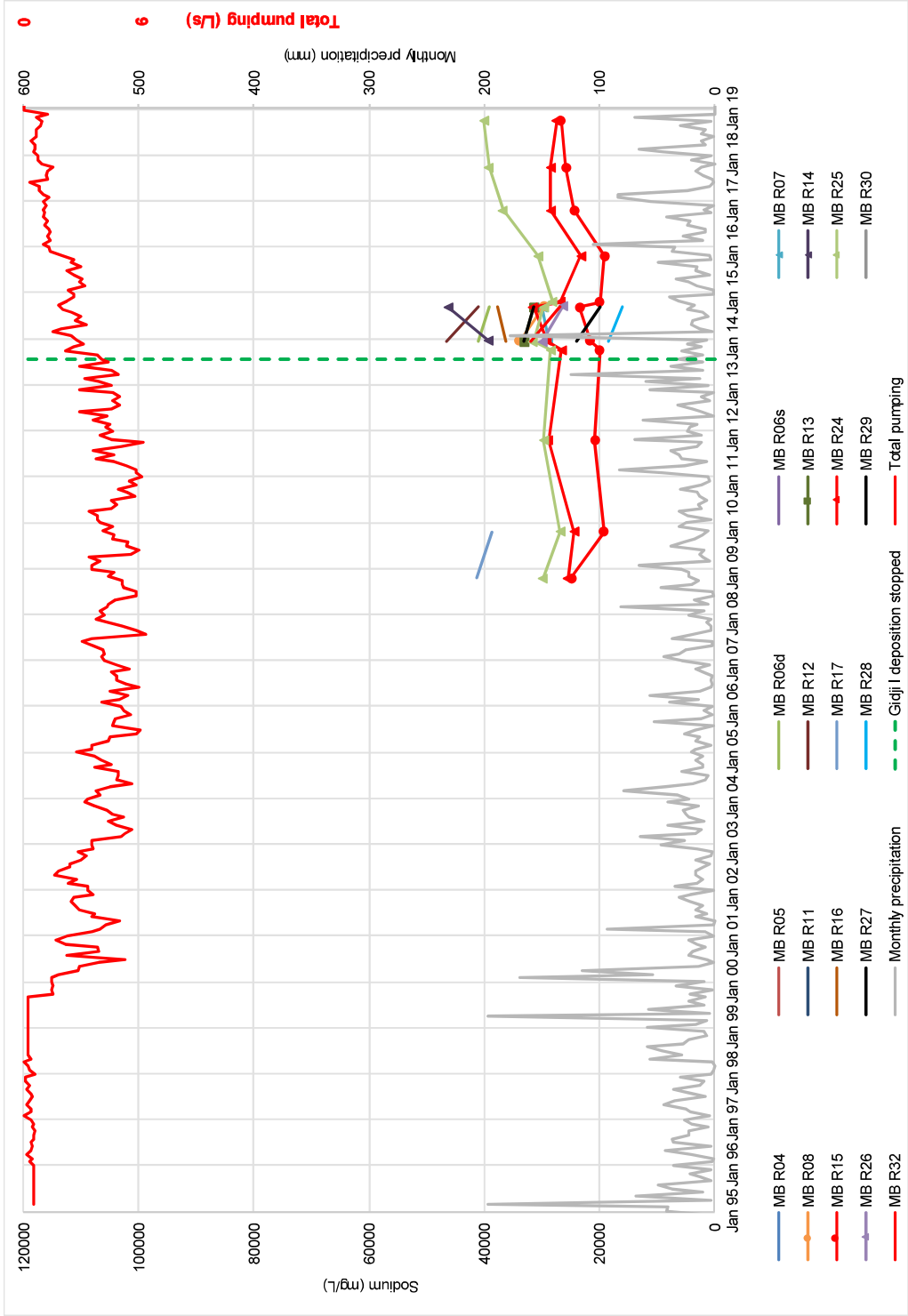
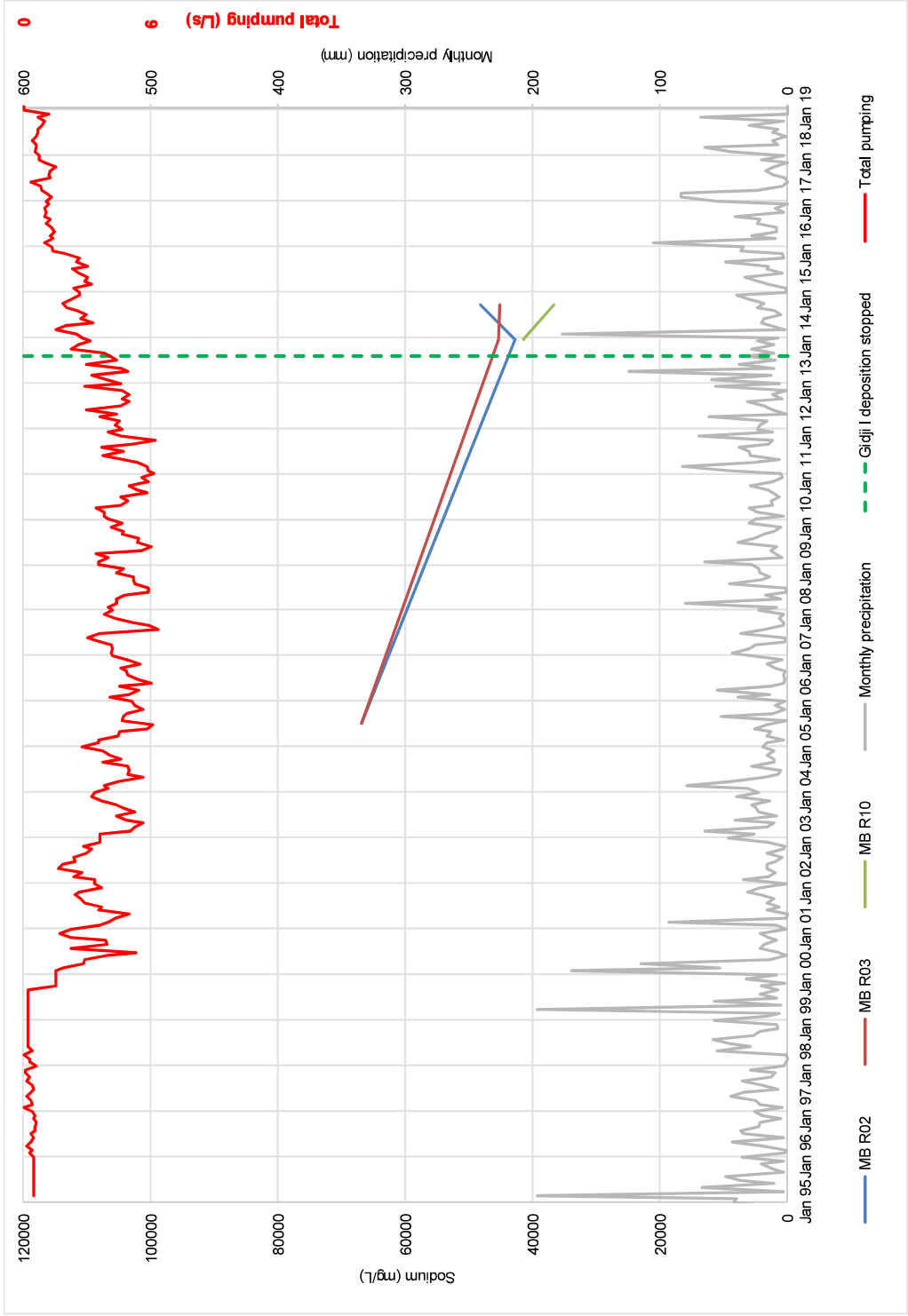


Figure C37

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Groundwater Na - western bores

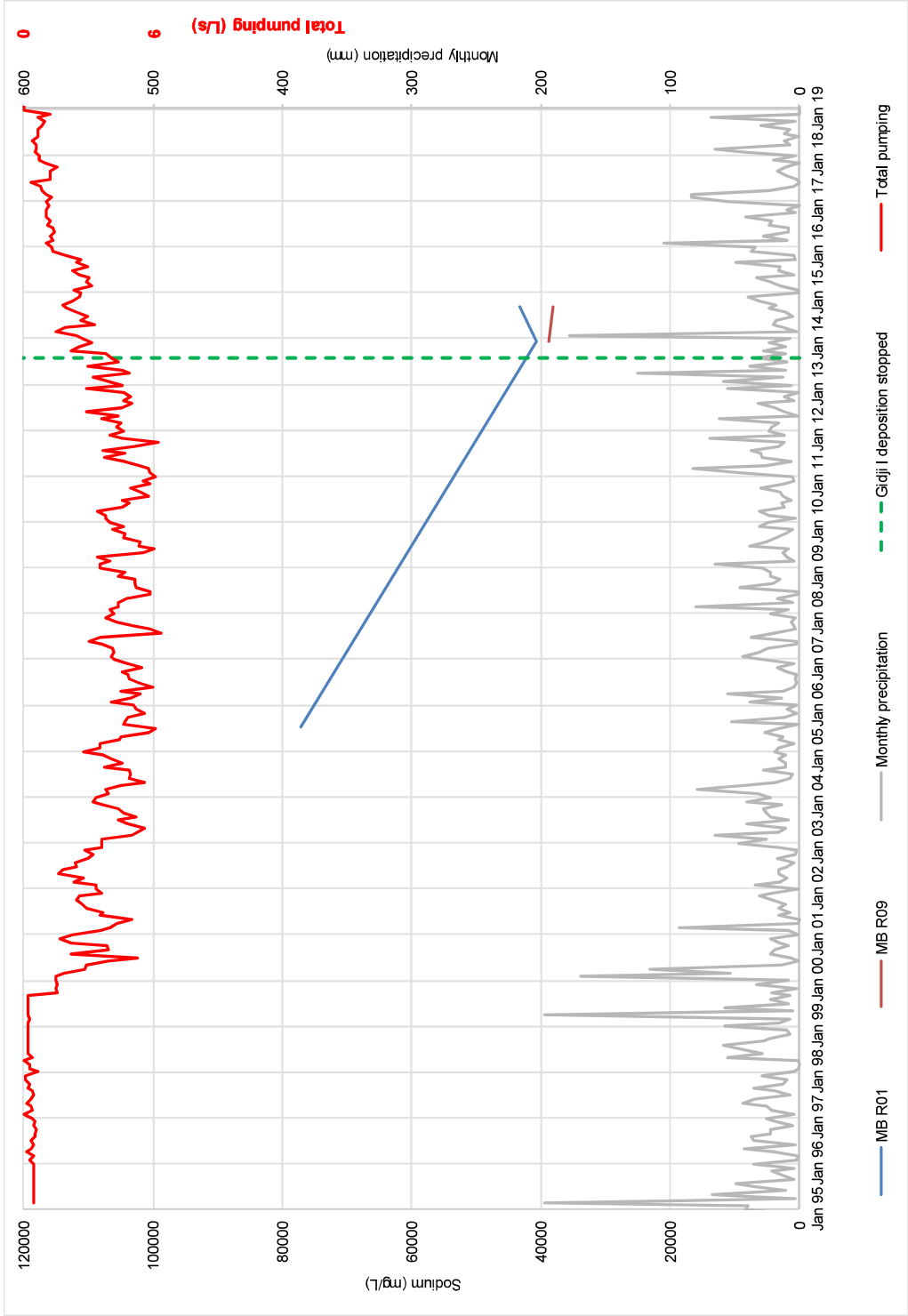




Groundwater Na - trench bores

Figure C38

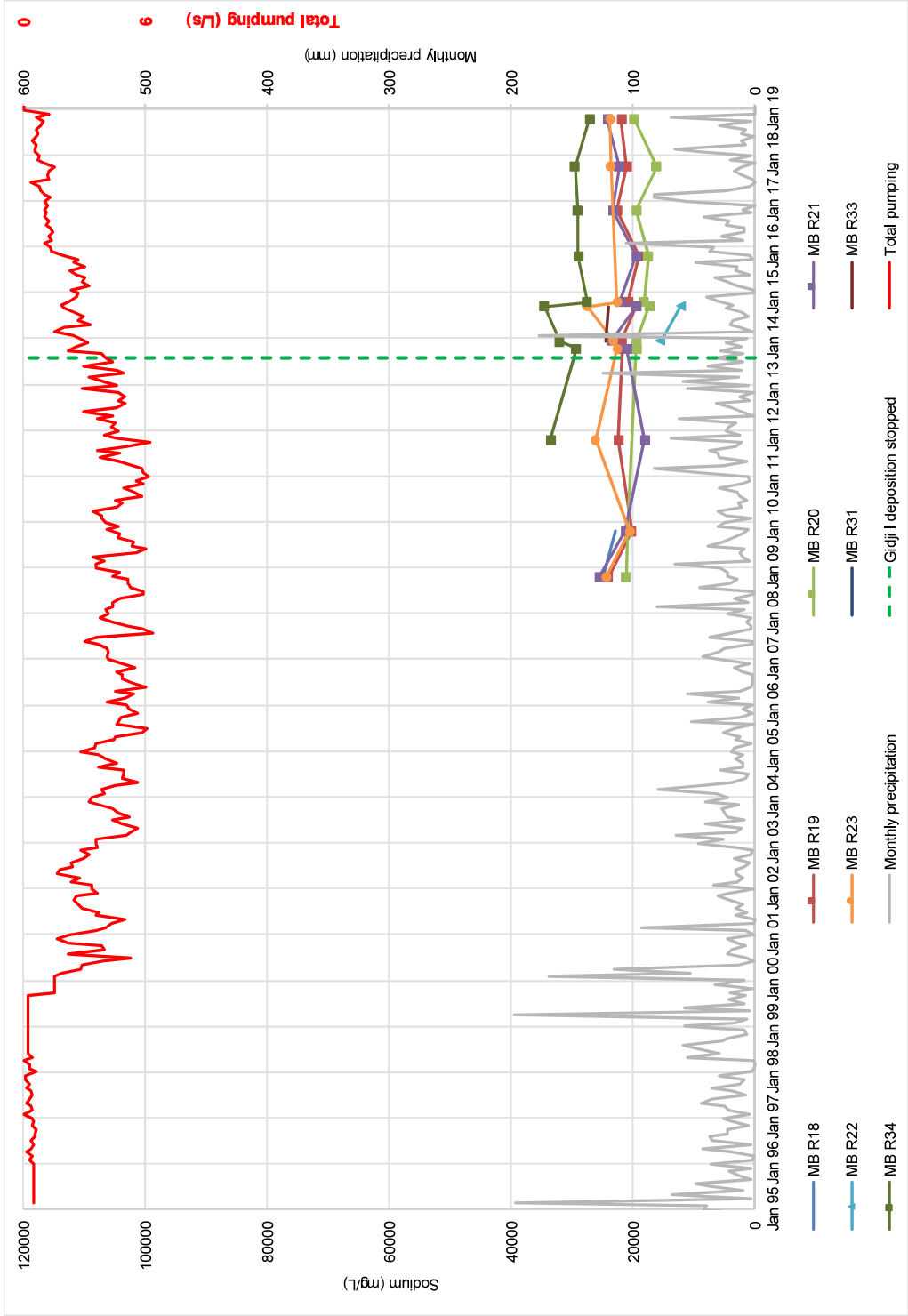
Date:	January 2019
Report:	KCGM Gidji TSF Hydrogeological Review



Groundwater Na - decant bores

Figure C39

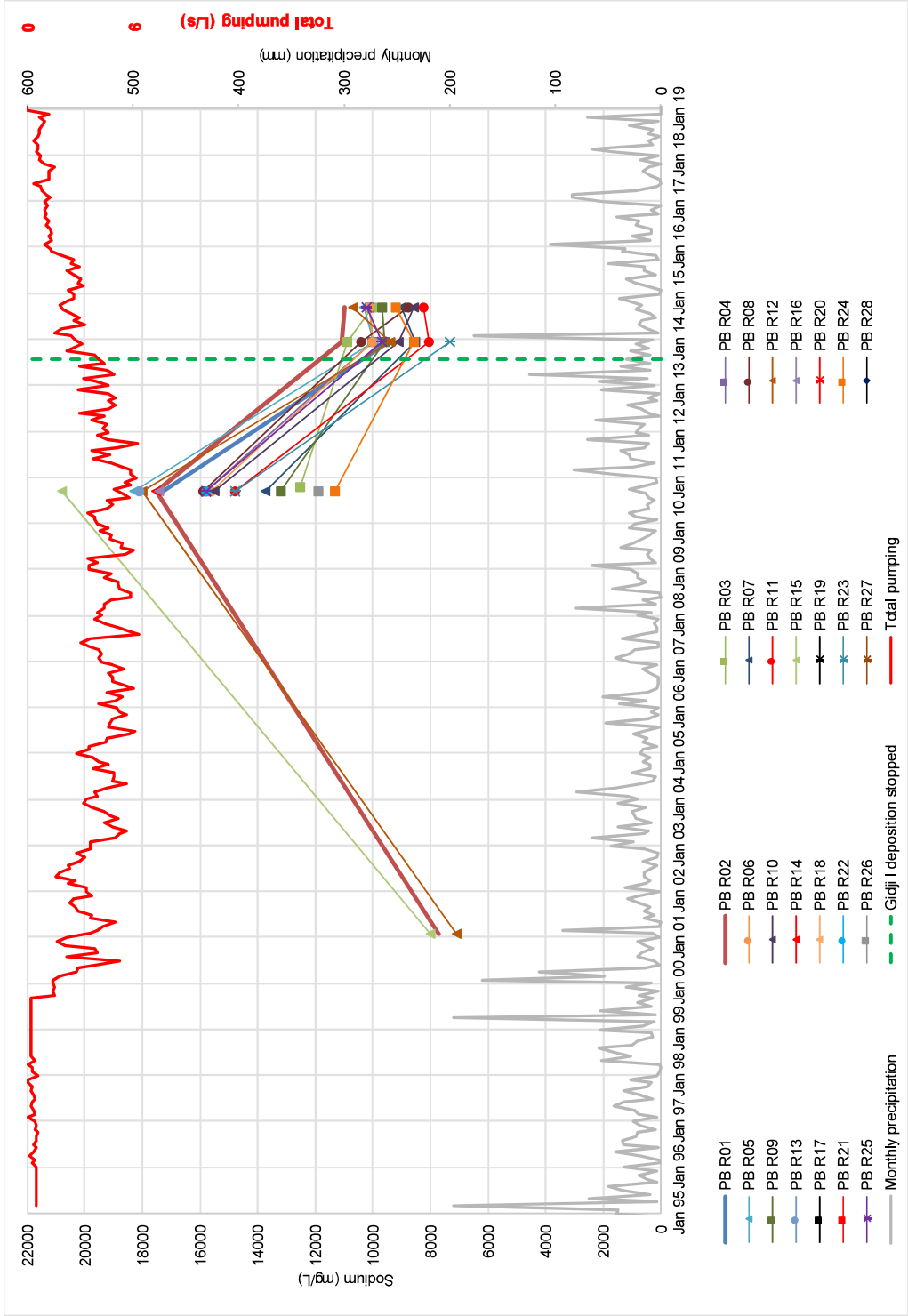
Date:	January 2019
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Groundwater Na - eastern bores

Figure C40

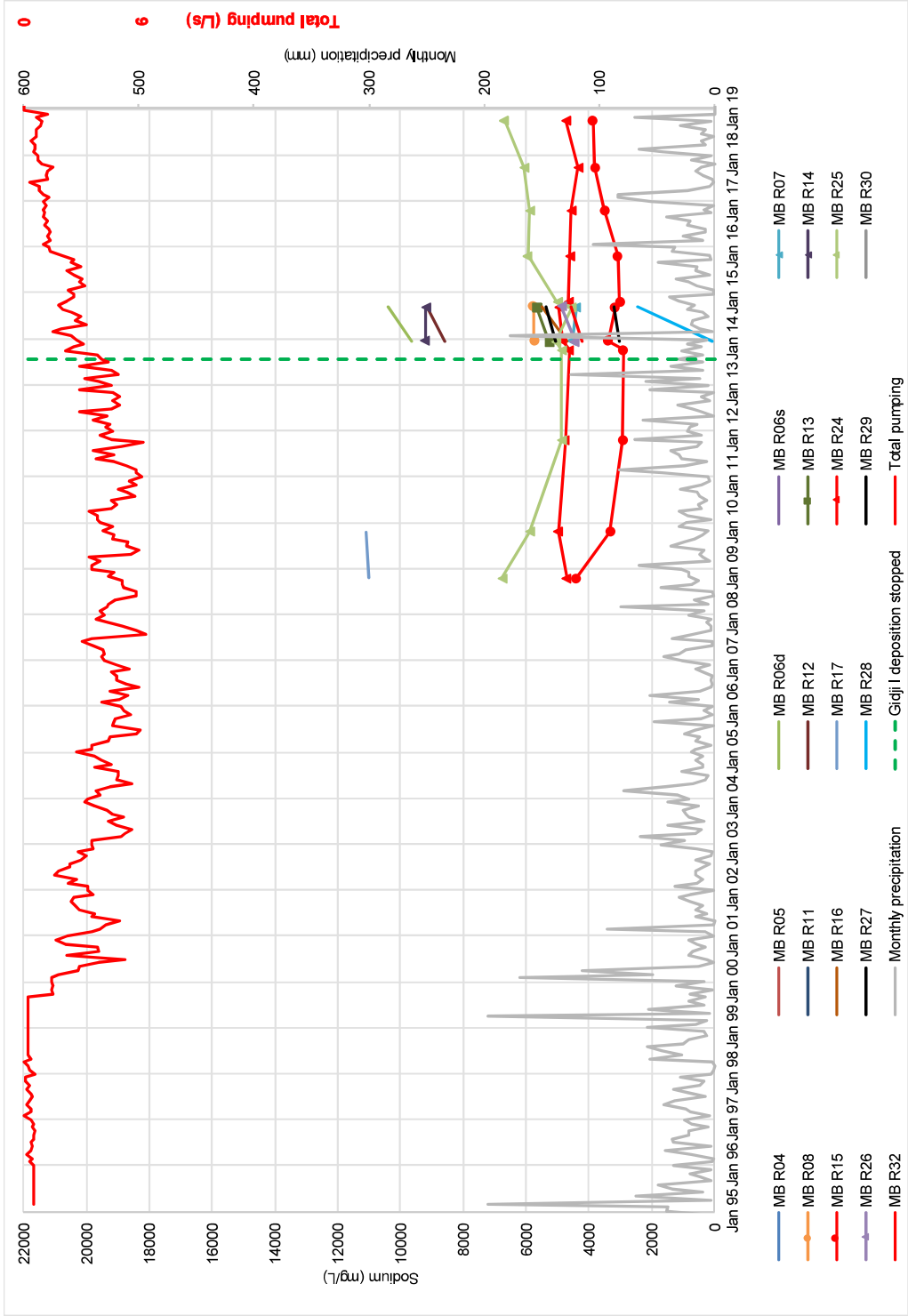
Date:	January 2019
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Groundwater sulphate - production bores

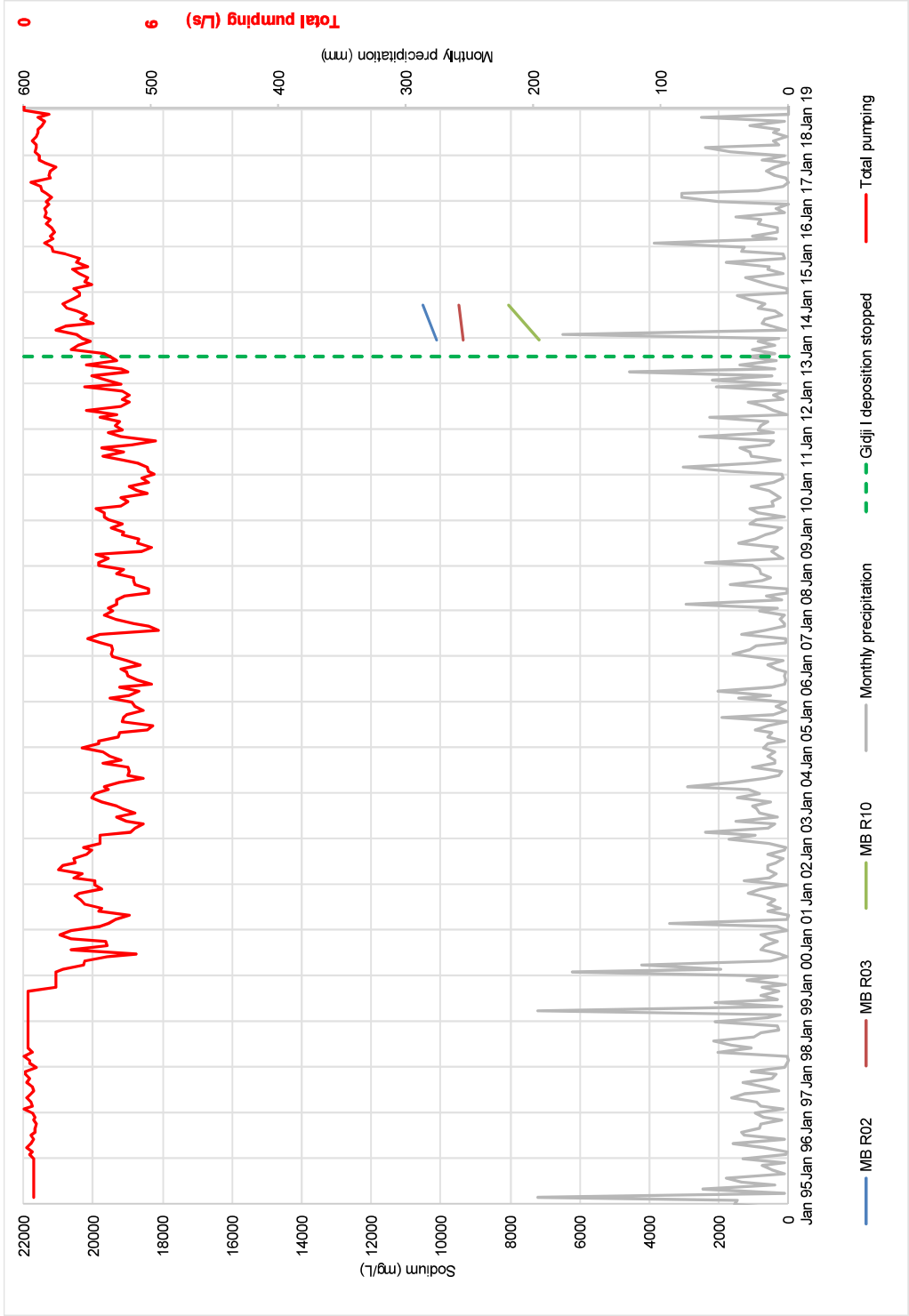
Figure C41

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Groundwater sulphate - western bores



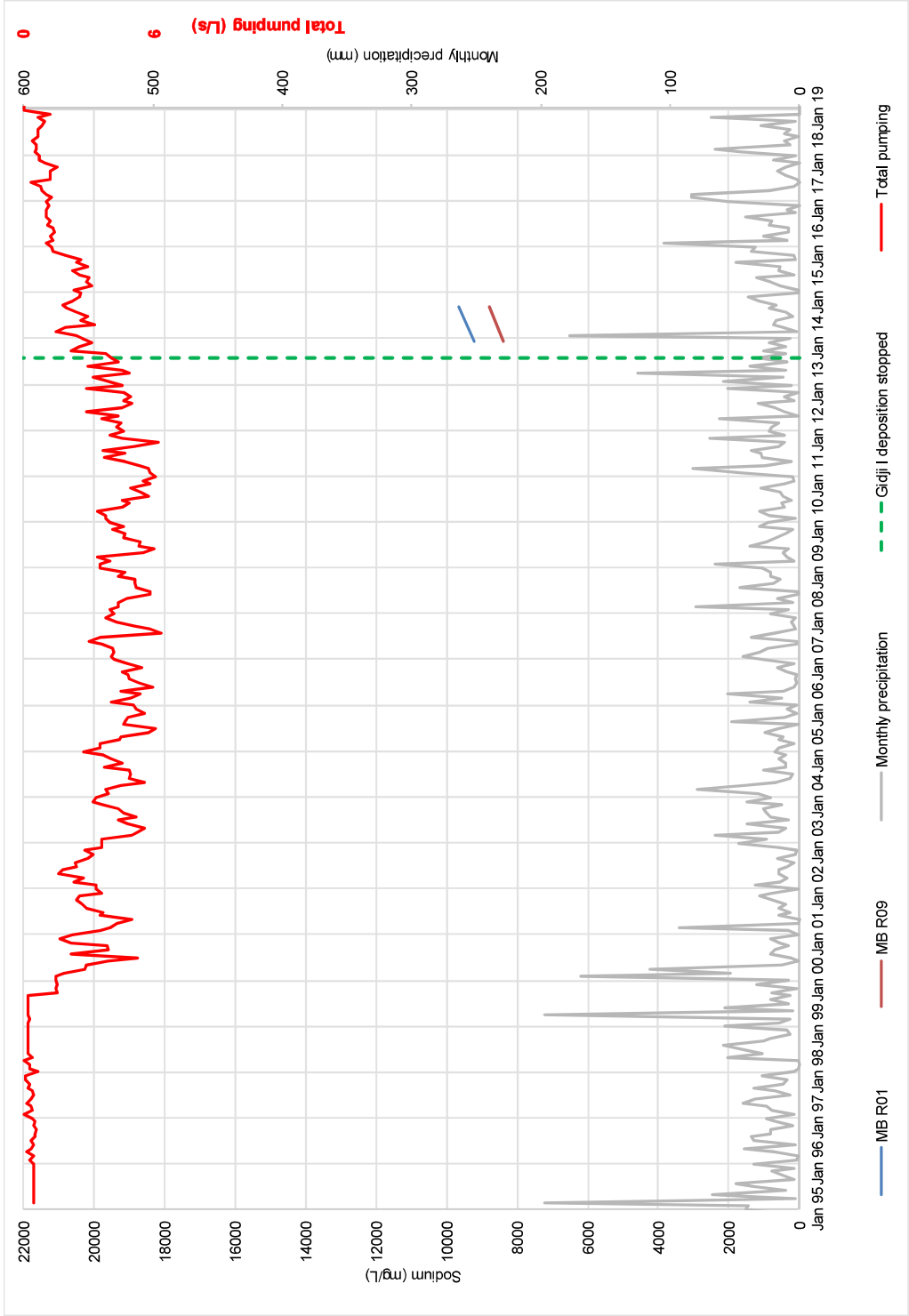


Groundwater sulphate - trench bores

Figure C43

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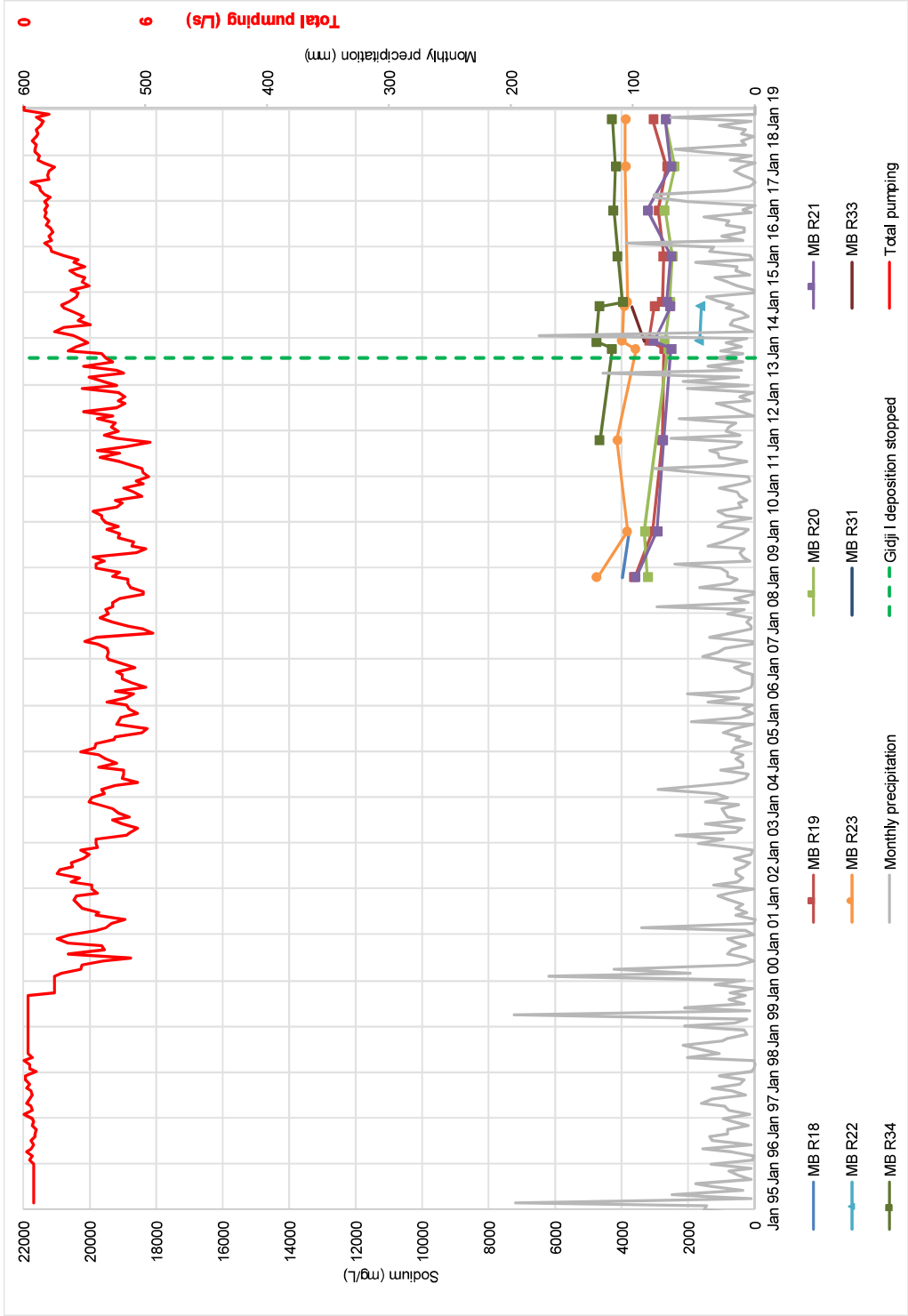


Groundwater sulphate - decant bores

Figure C44

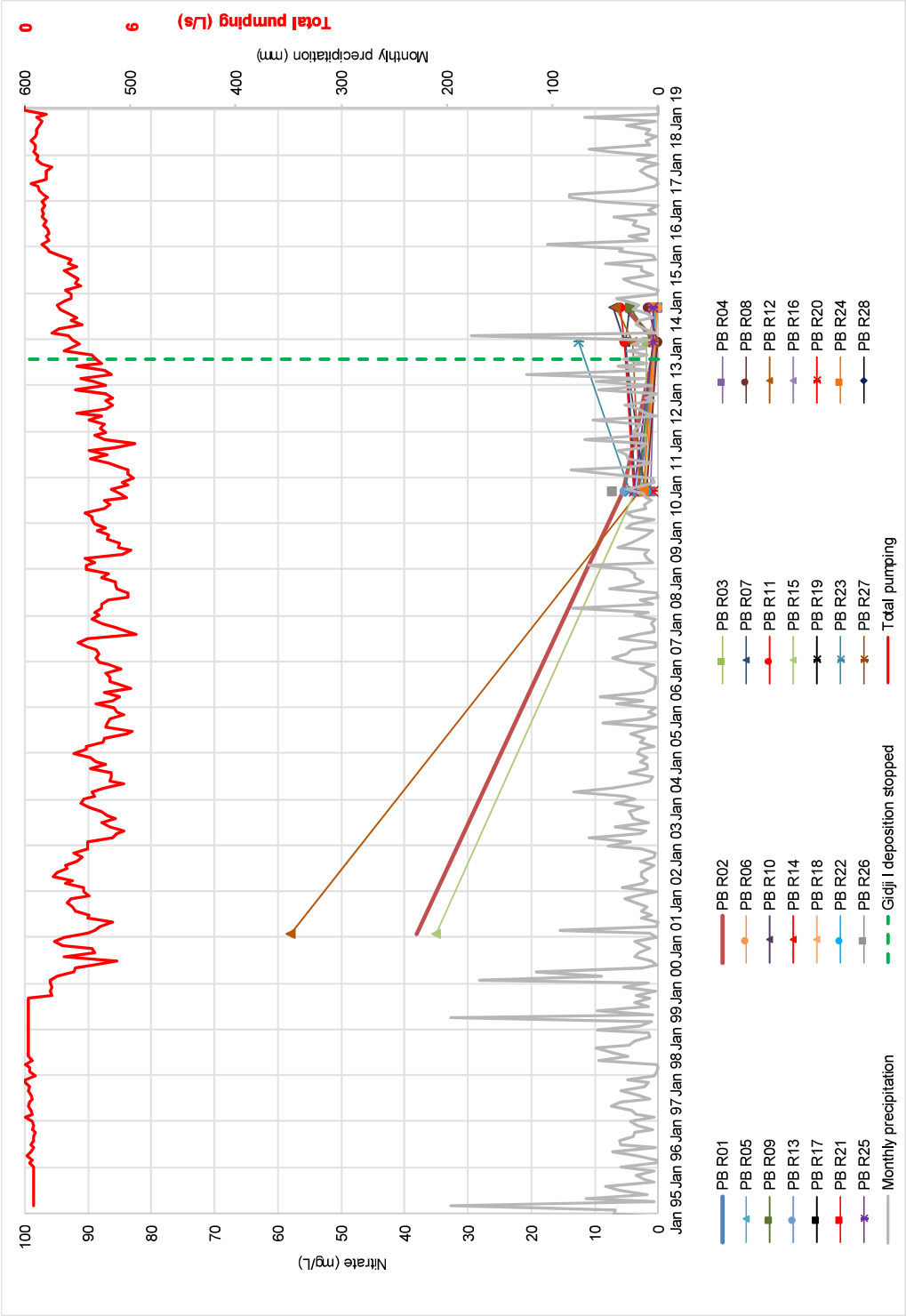
Date:	January 2019
Report:	KCGM Gidji TSF Hydrogeological Review





Groundwater sulphate - eastern bores

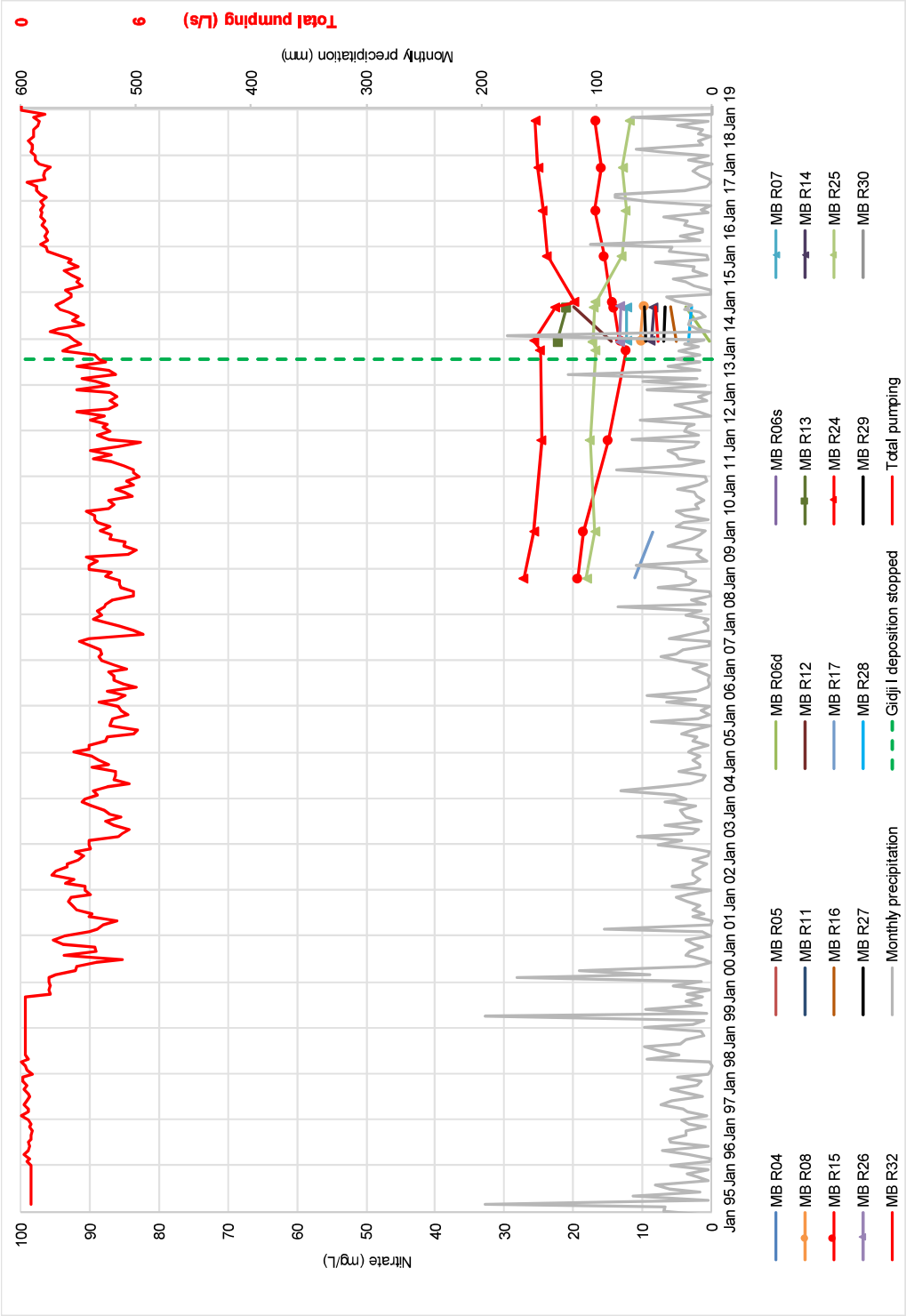




Groundwater nitrate - production bores

Figure C46

Date:	January 2019
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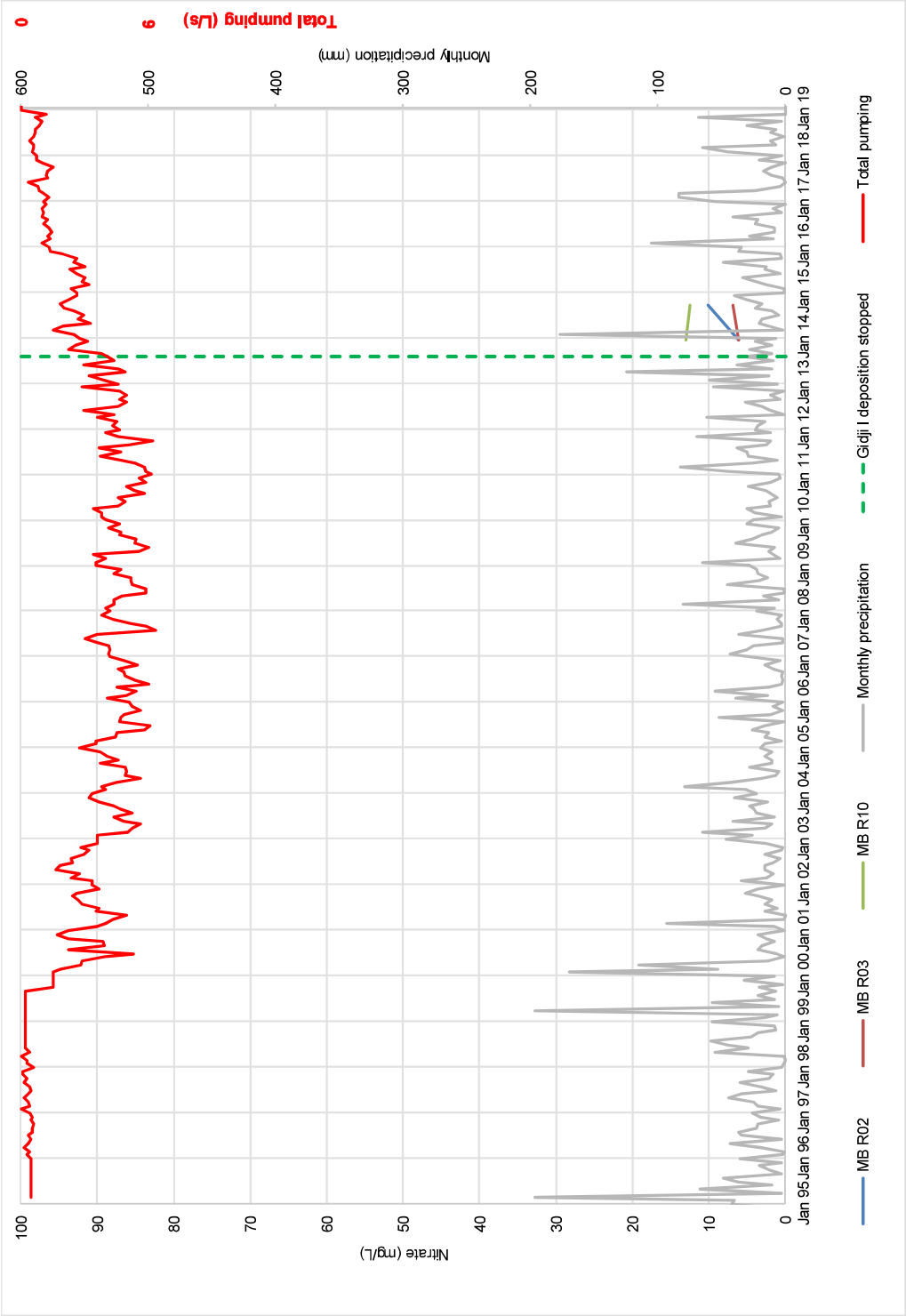
Groundwater nitrate - western bores

Figure C47

Date: January 2019

Report: KCGM Gidji TSF
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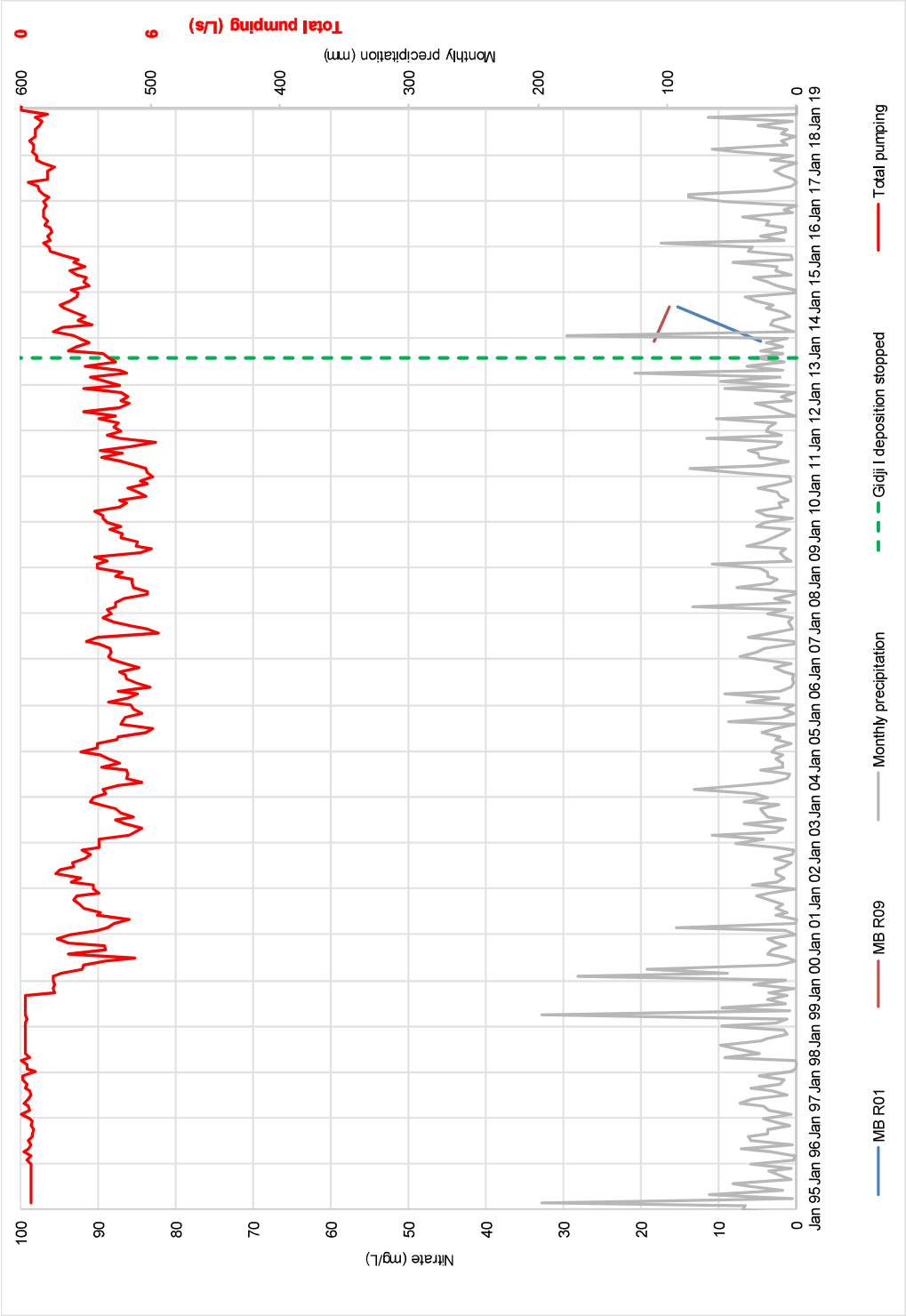




Groundwater nitrate - trench bores

Figure C48

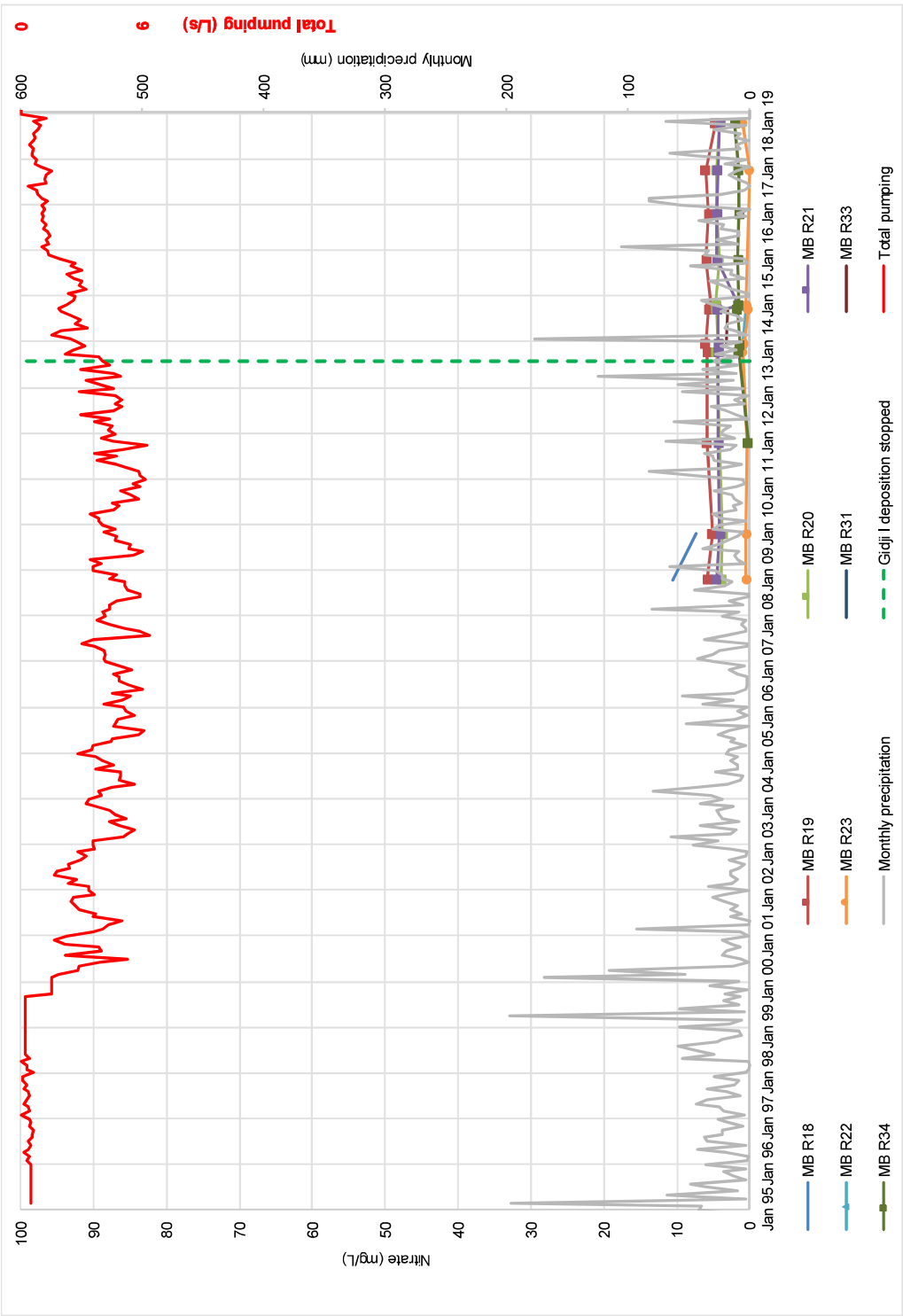
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Groundwater nitrate - decant bores

Figure C49

Date:	January 2019
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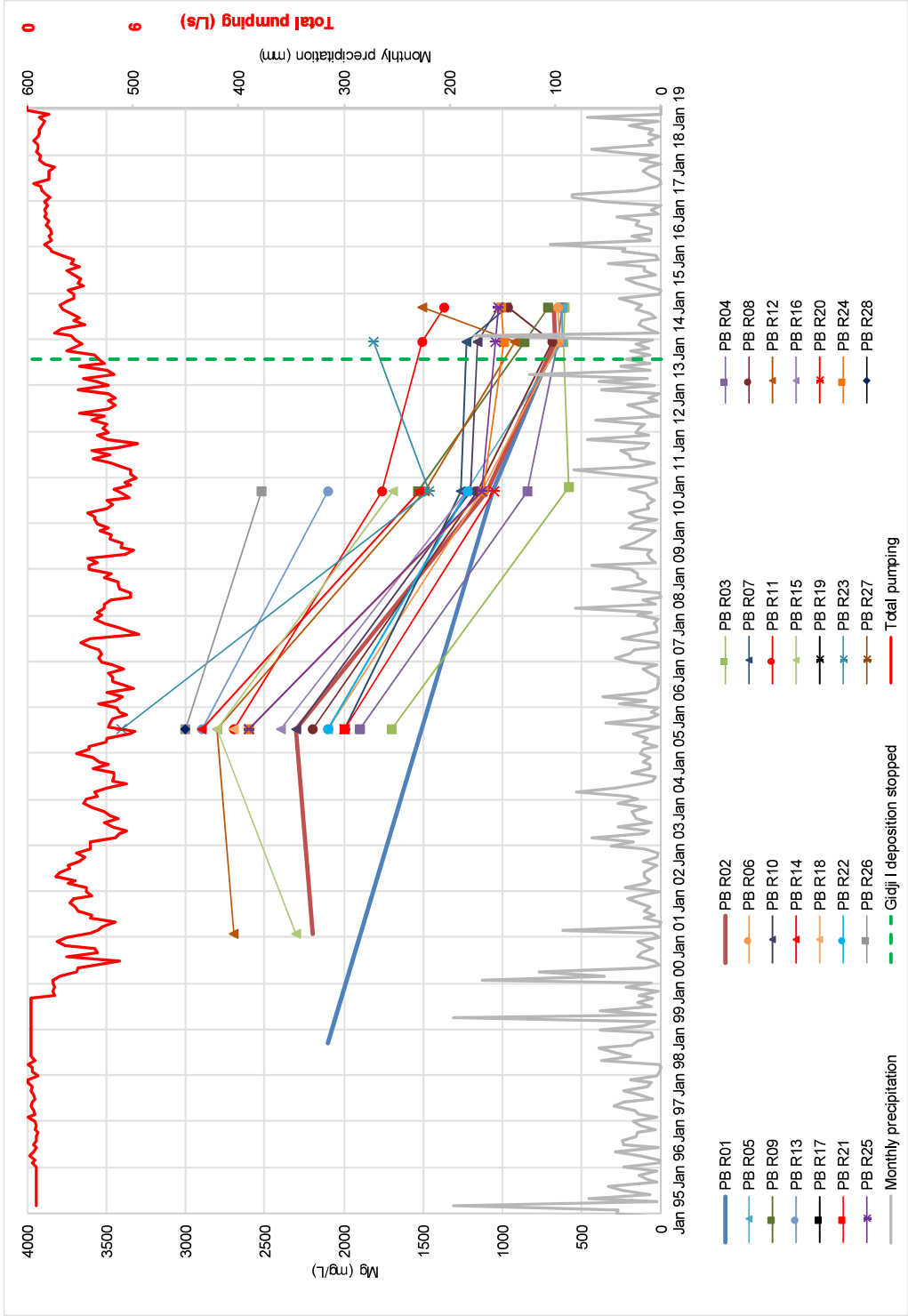
Groundwater nitrate - eastern bores

Figure C50

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Groundwater Mg - production bores



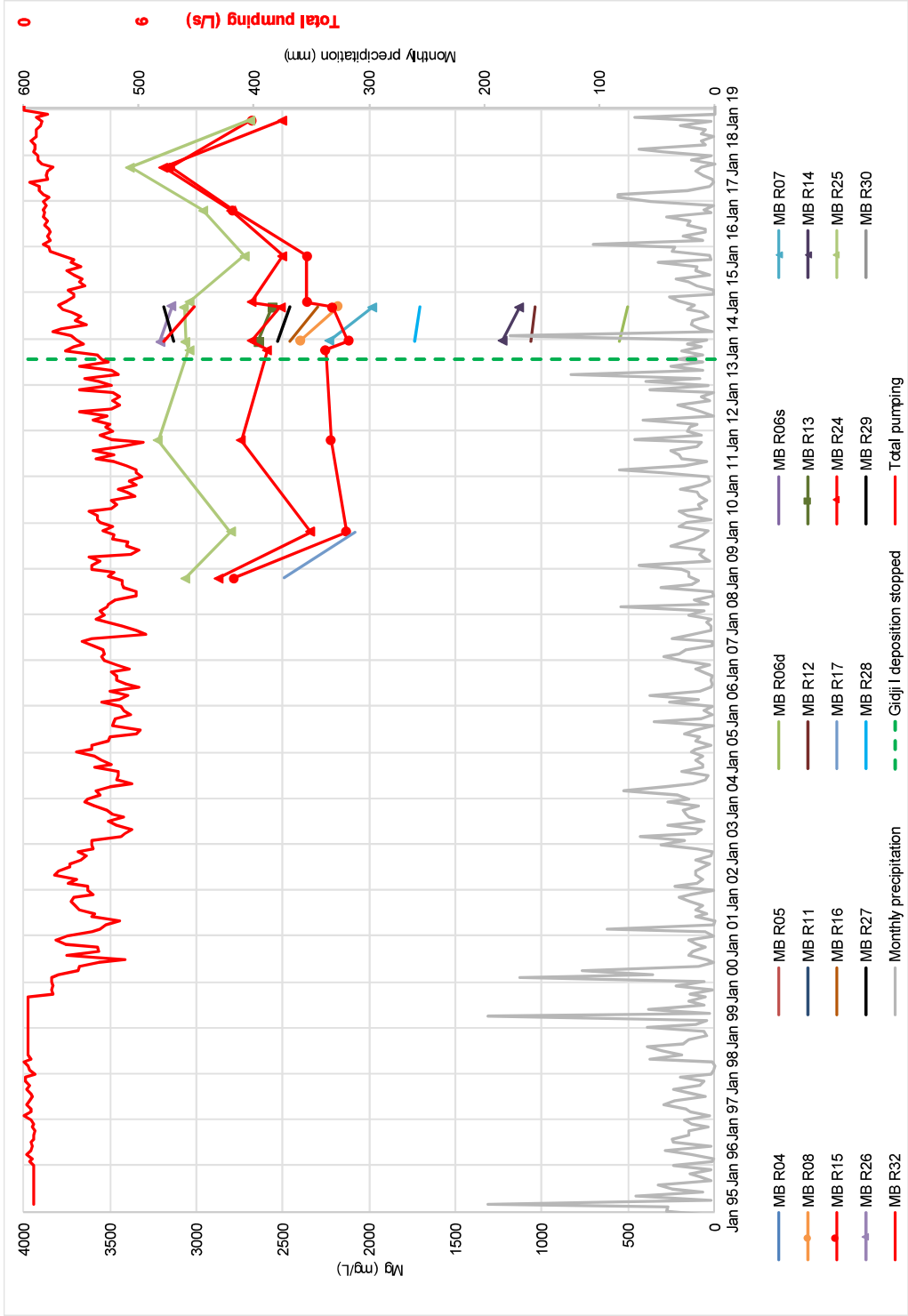
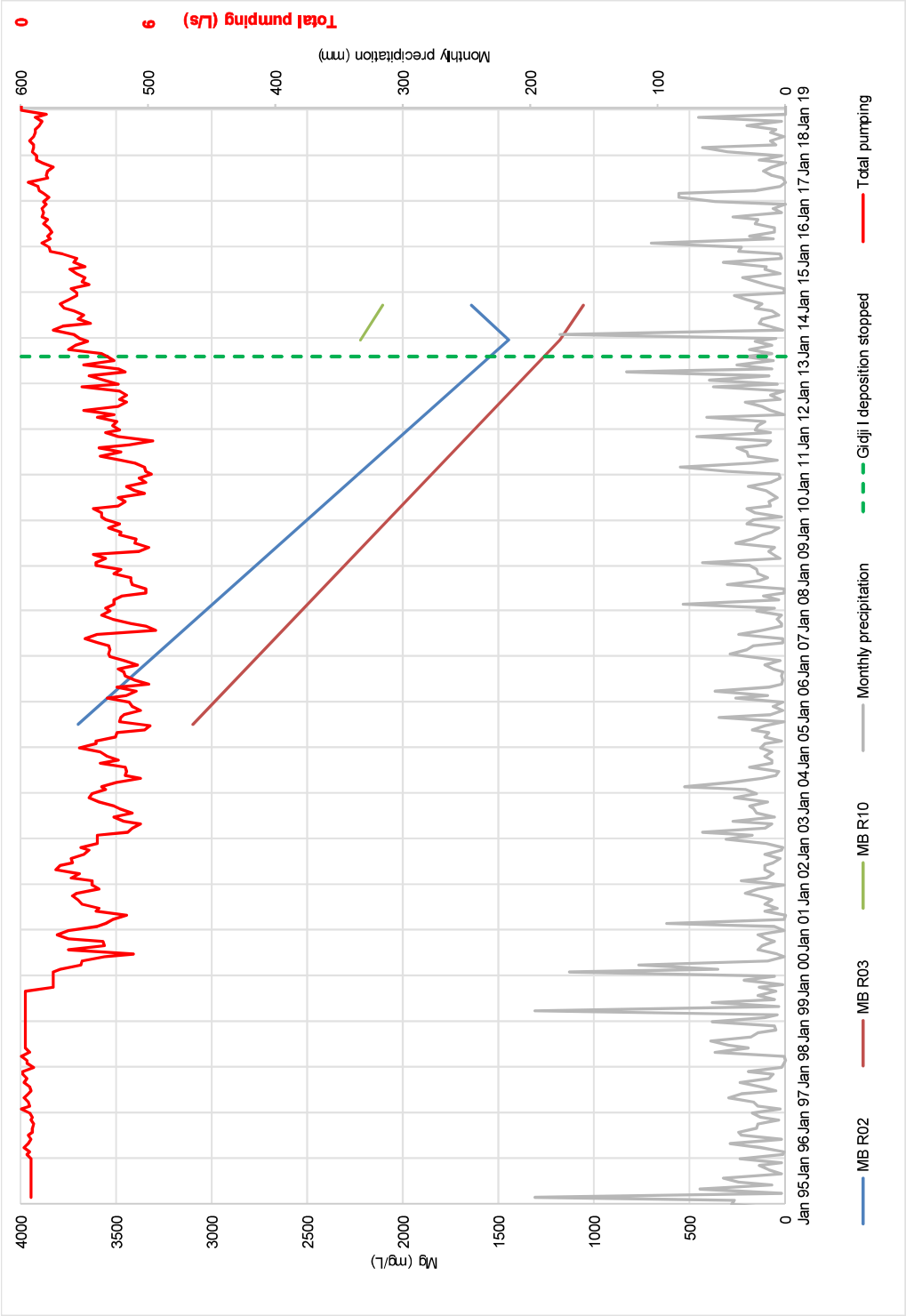


Figure C52

Date:	January 2019
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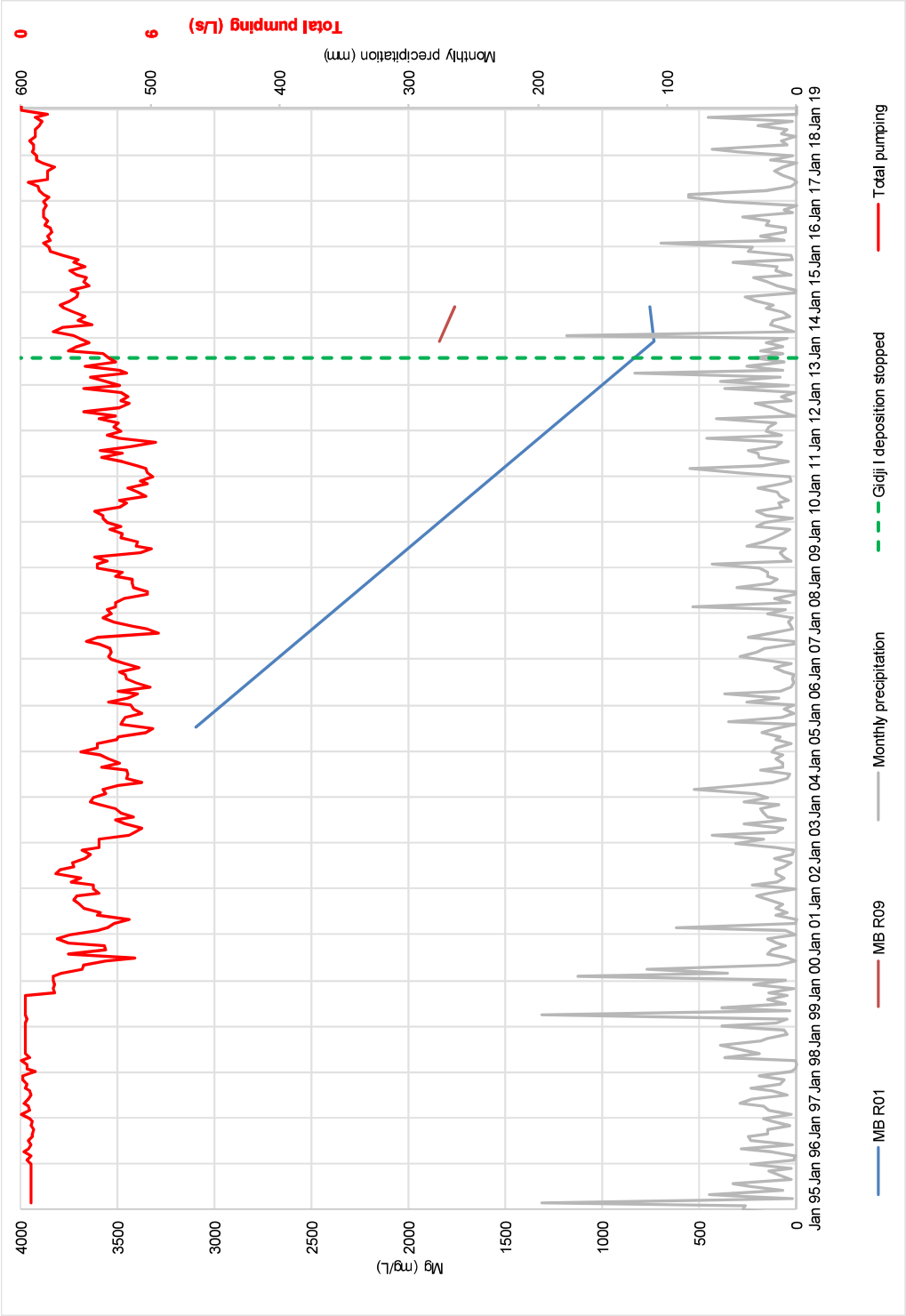
Groundwater Mg - western bores





Groundwater Mg - trench bores





Groundwater Mg - decant bores

Figure C54

Date:	January 2019
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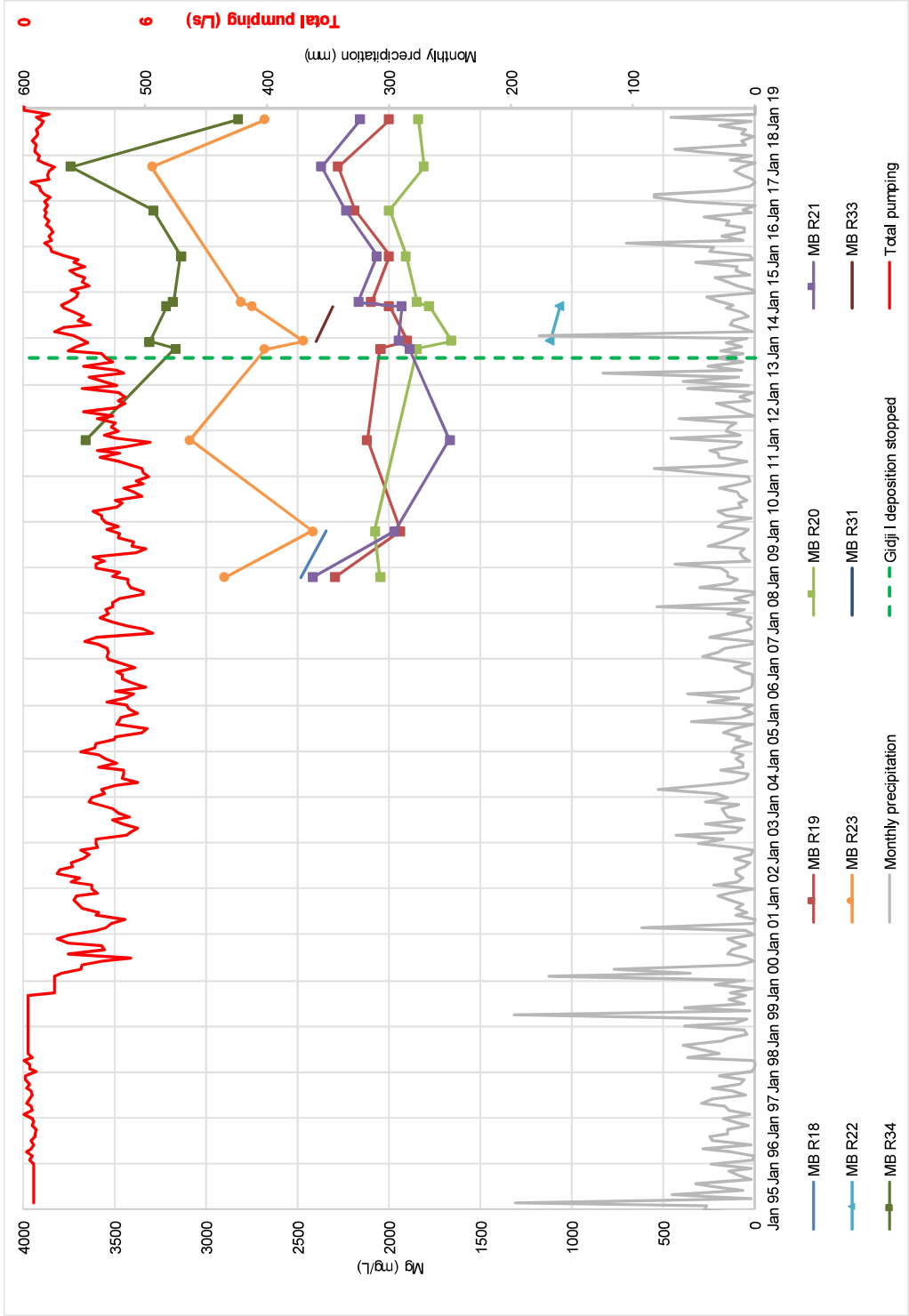
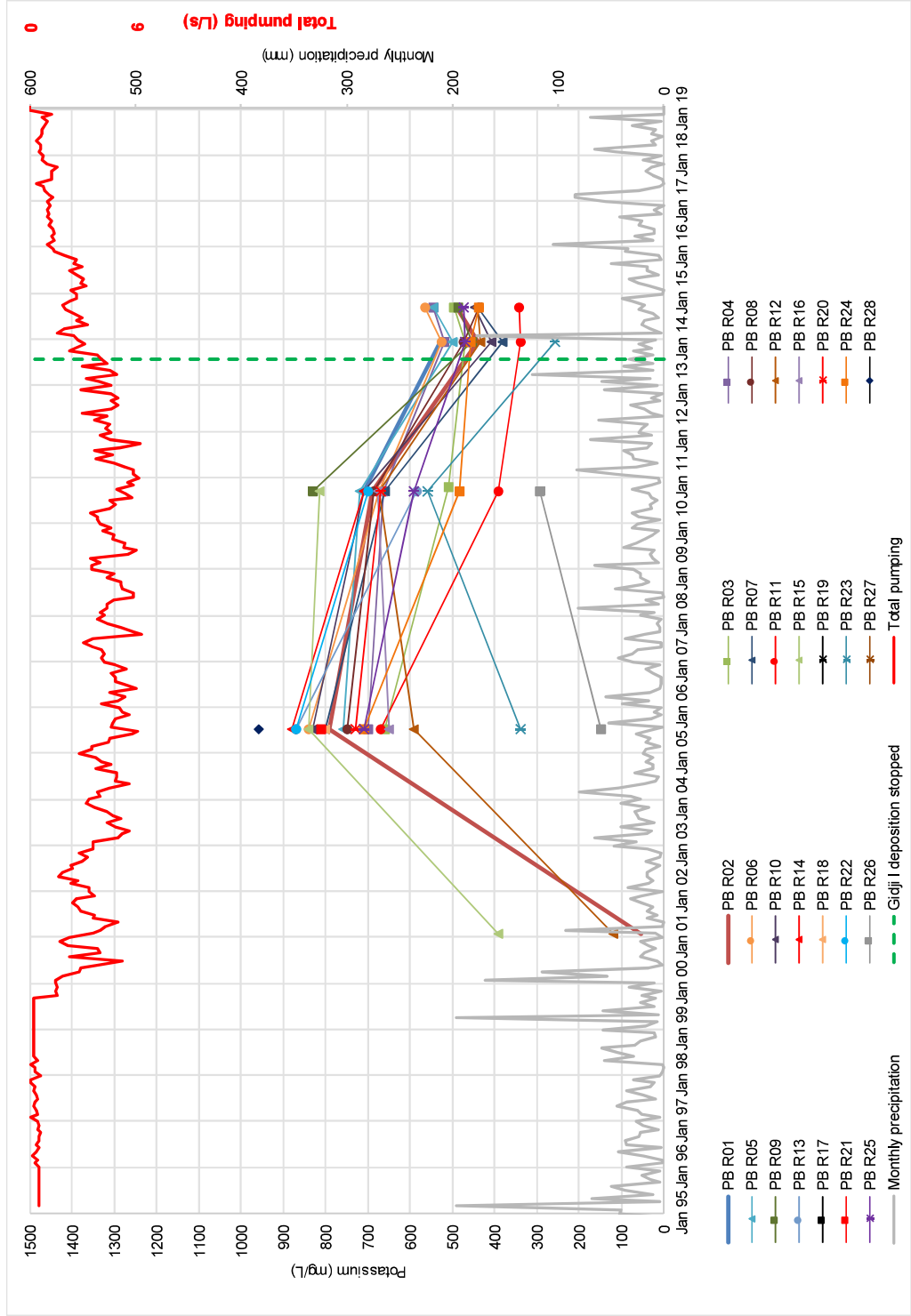


Figure C55

Date: January 2019
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Groundwater Mg - eastern bores

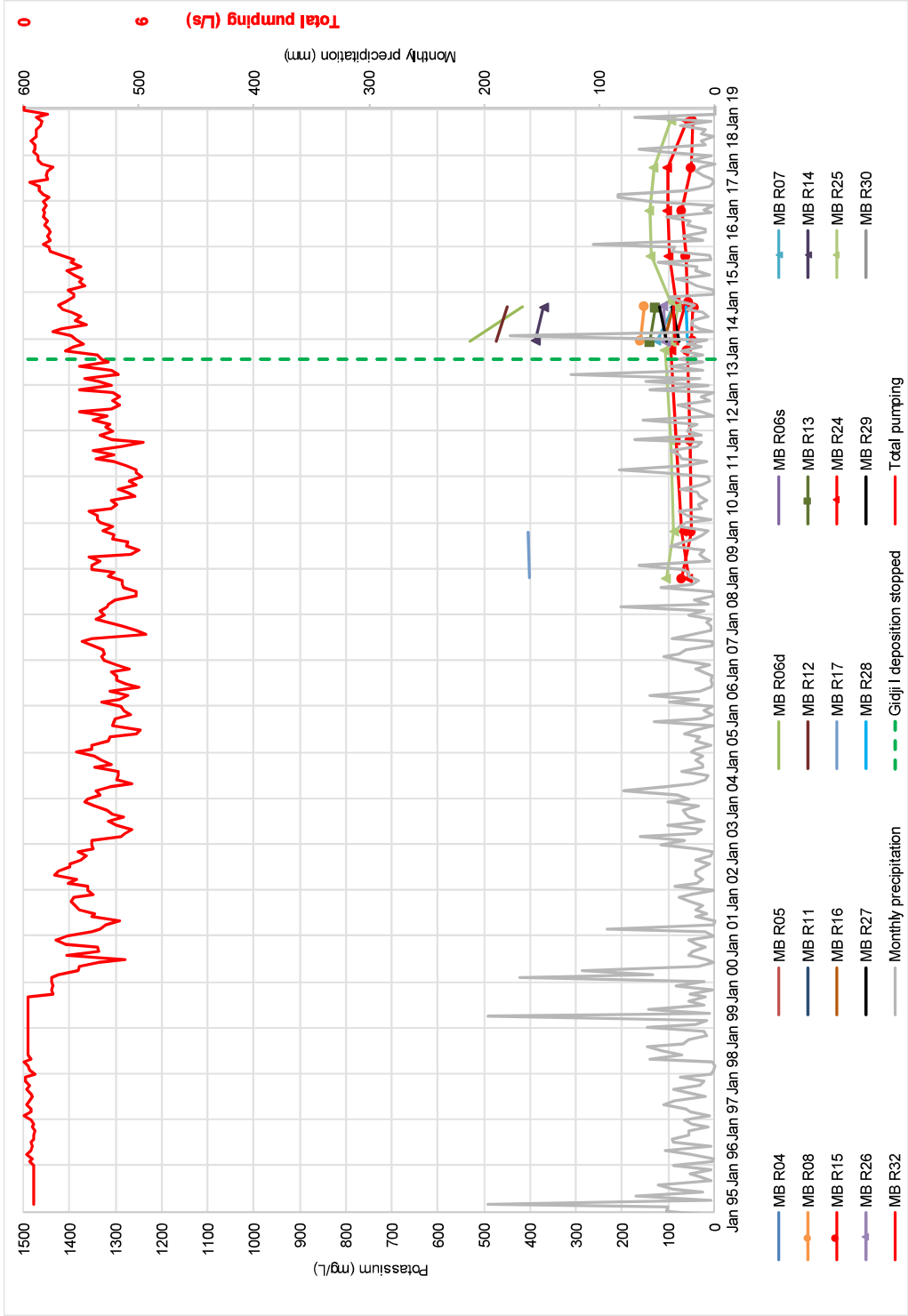




Groundwater K - production bores

Figure C56

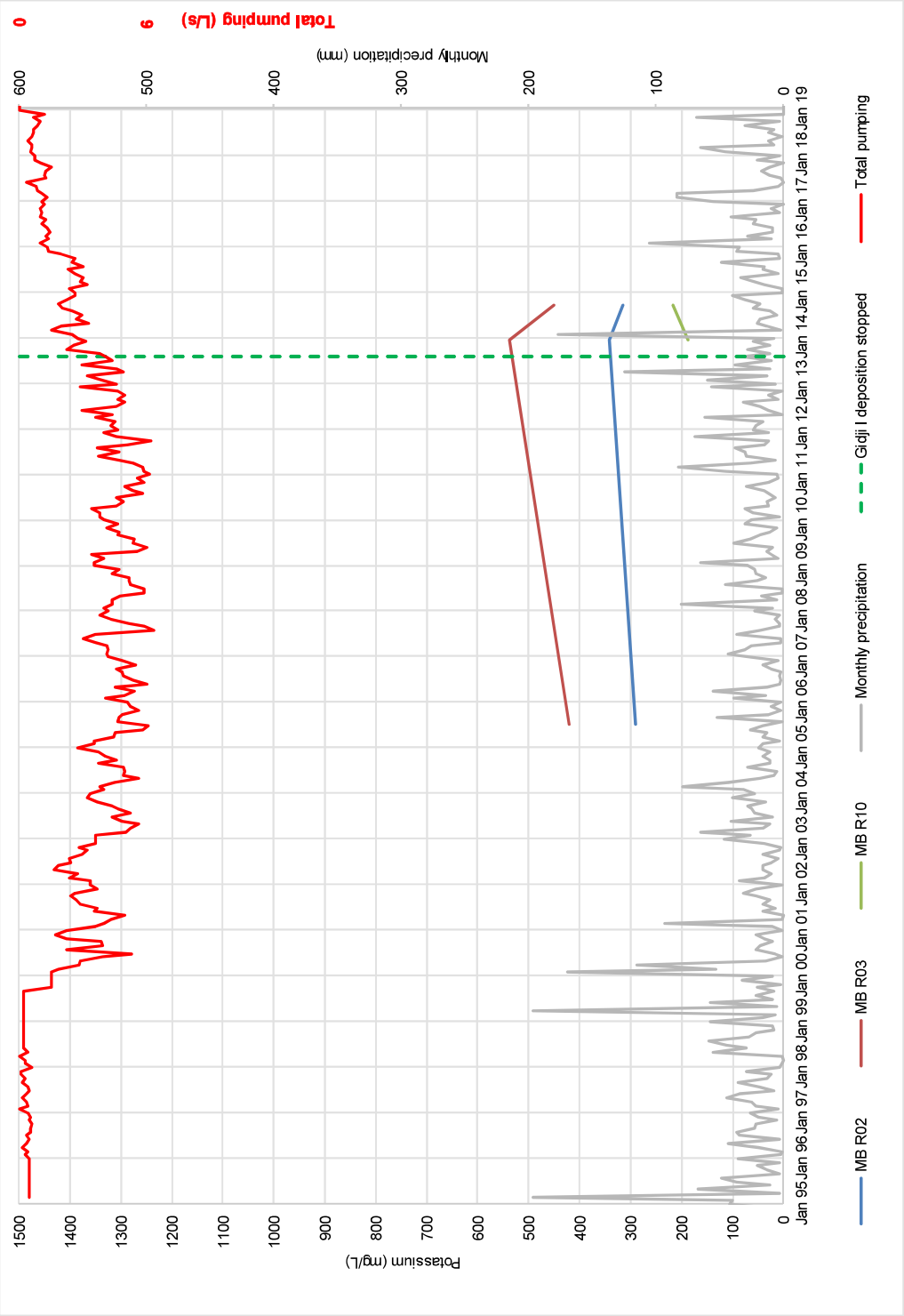
Date:	January 2019
Report:	KCGM Gidji TSF Hydrogeological Review



Groundwater K - western bores

Figure C57

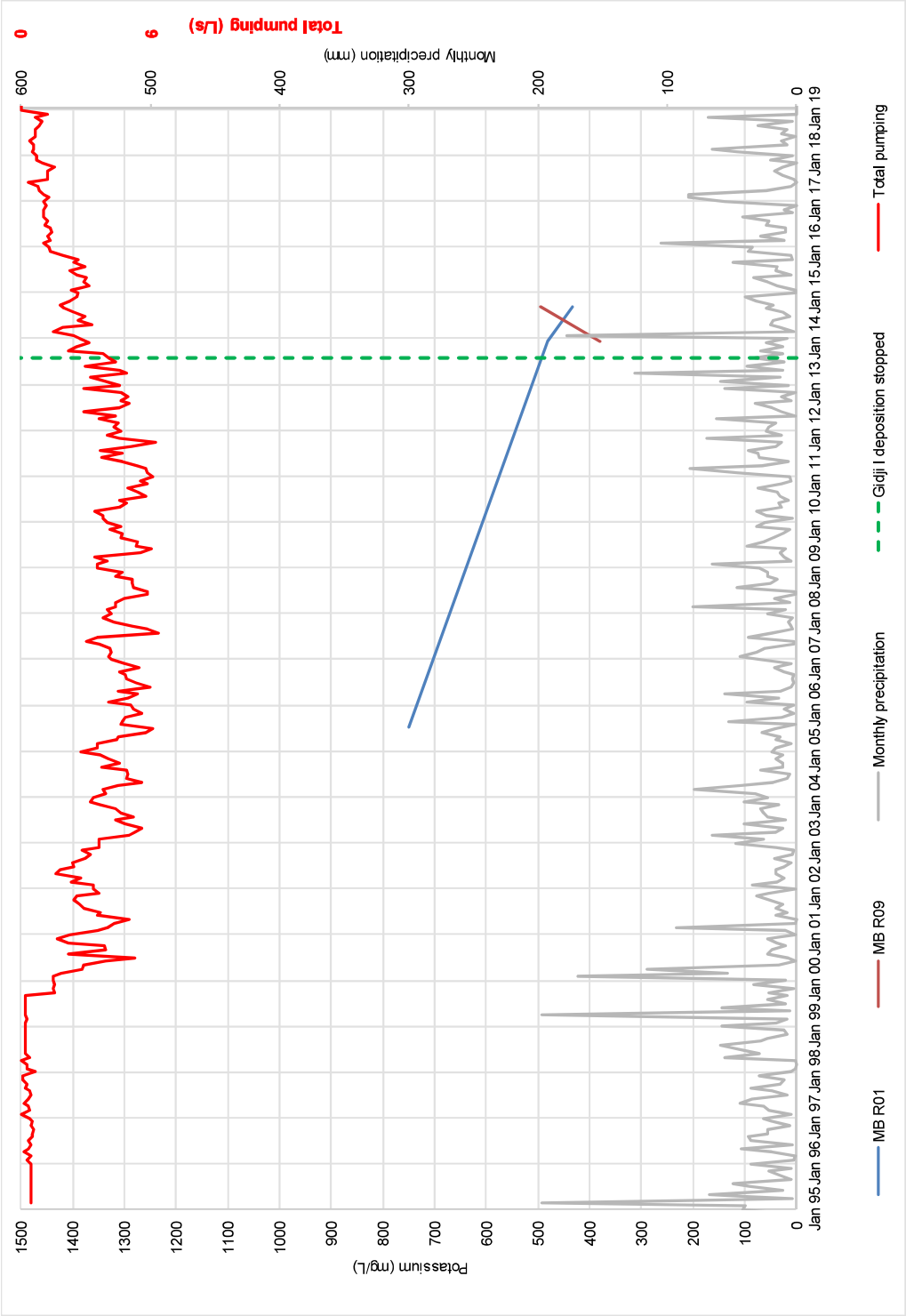
Date:	January 2019
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Groundwater K - trench bores

Figure C58

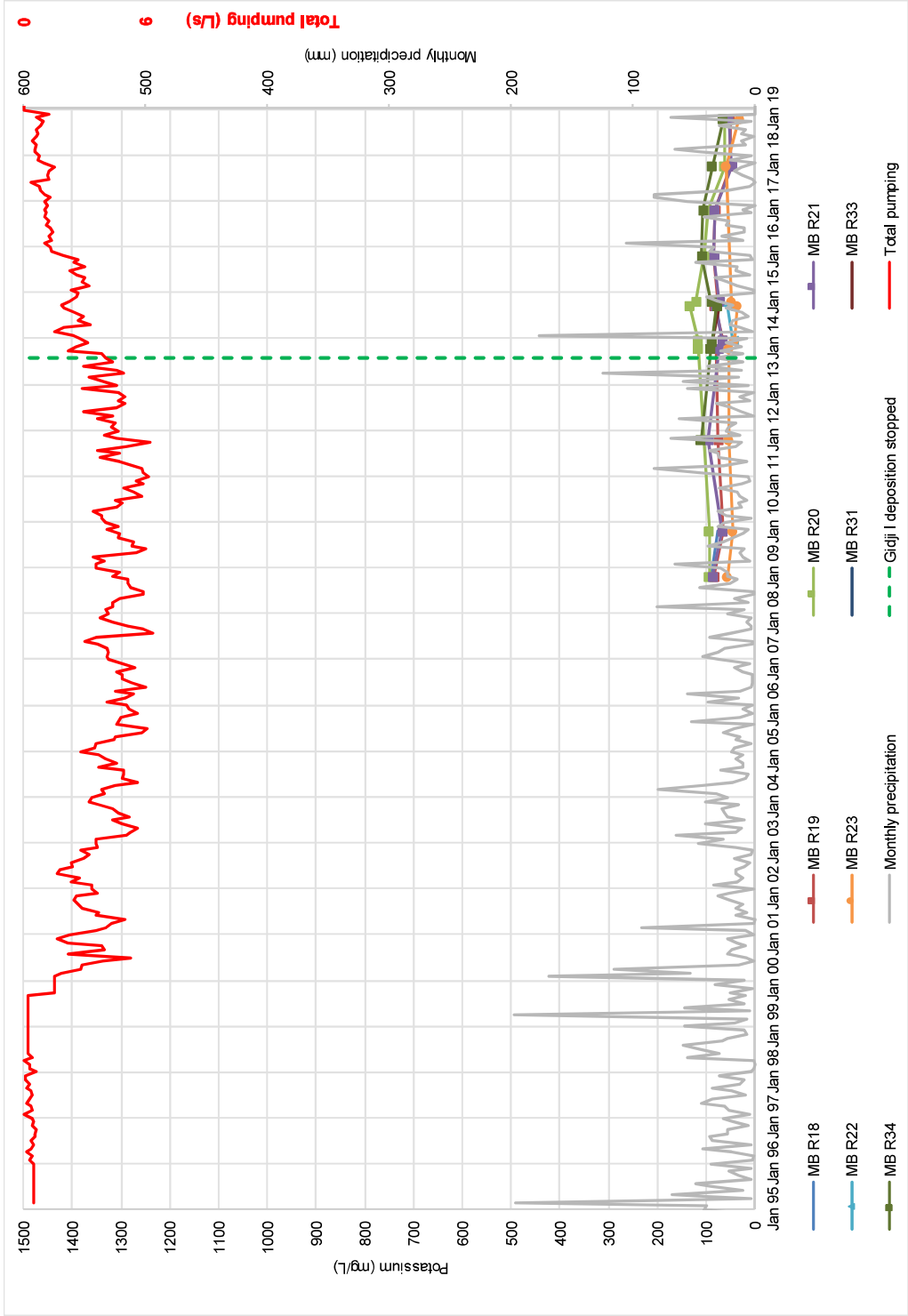
Date:	January 2019
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Groundwater K - decant bores

Figure C59

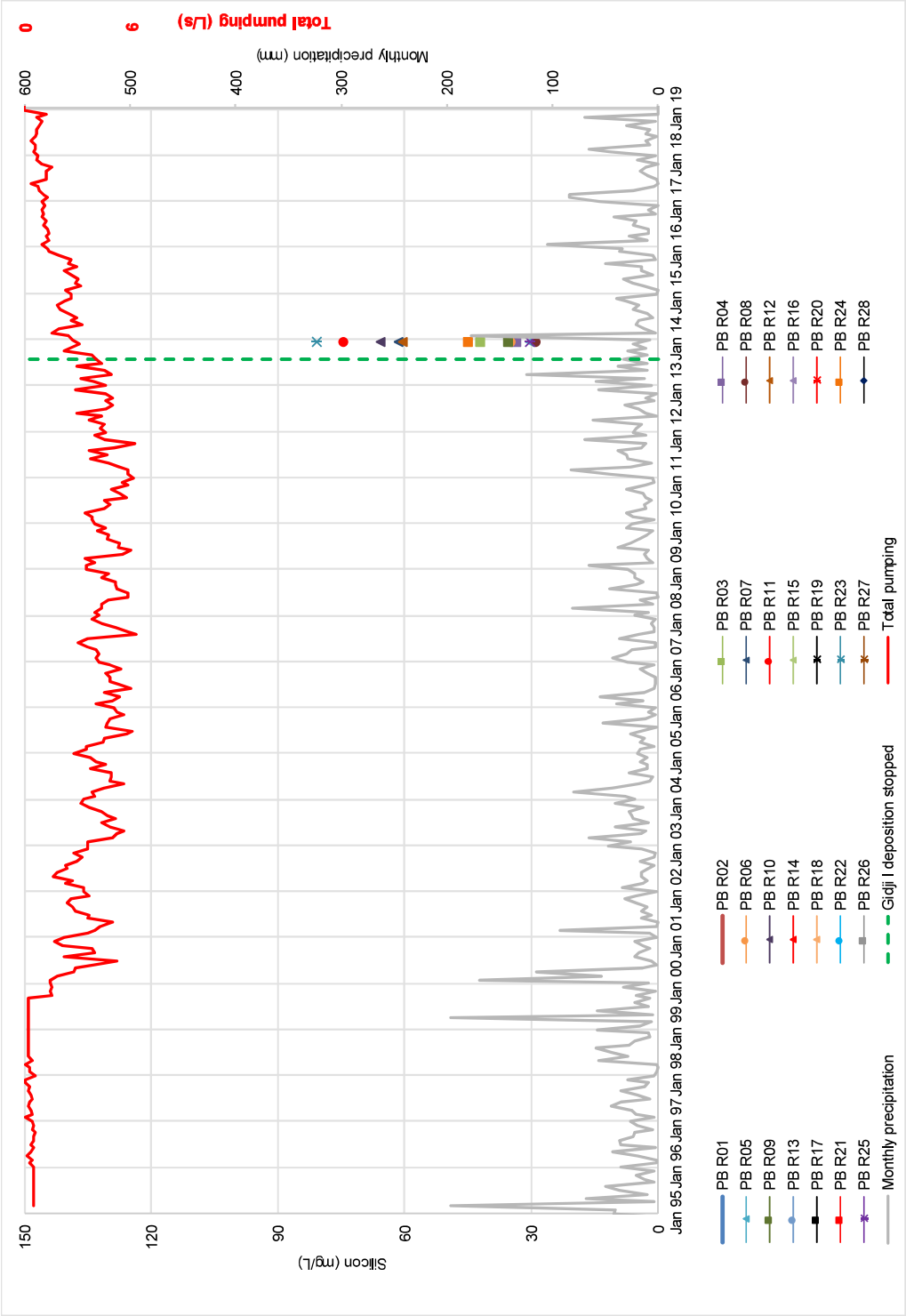
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Groundwater K - eastern bores

Figure C60

Date:	January 2019
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Groundwater silicon - production bores

Figure C61

Date:	January 2019
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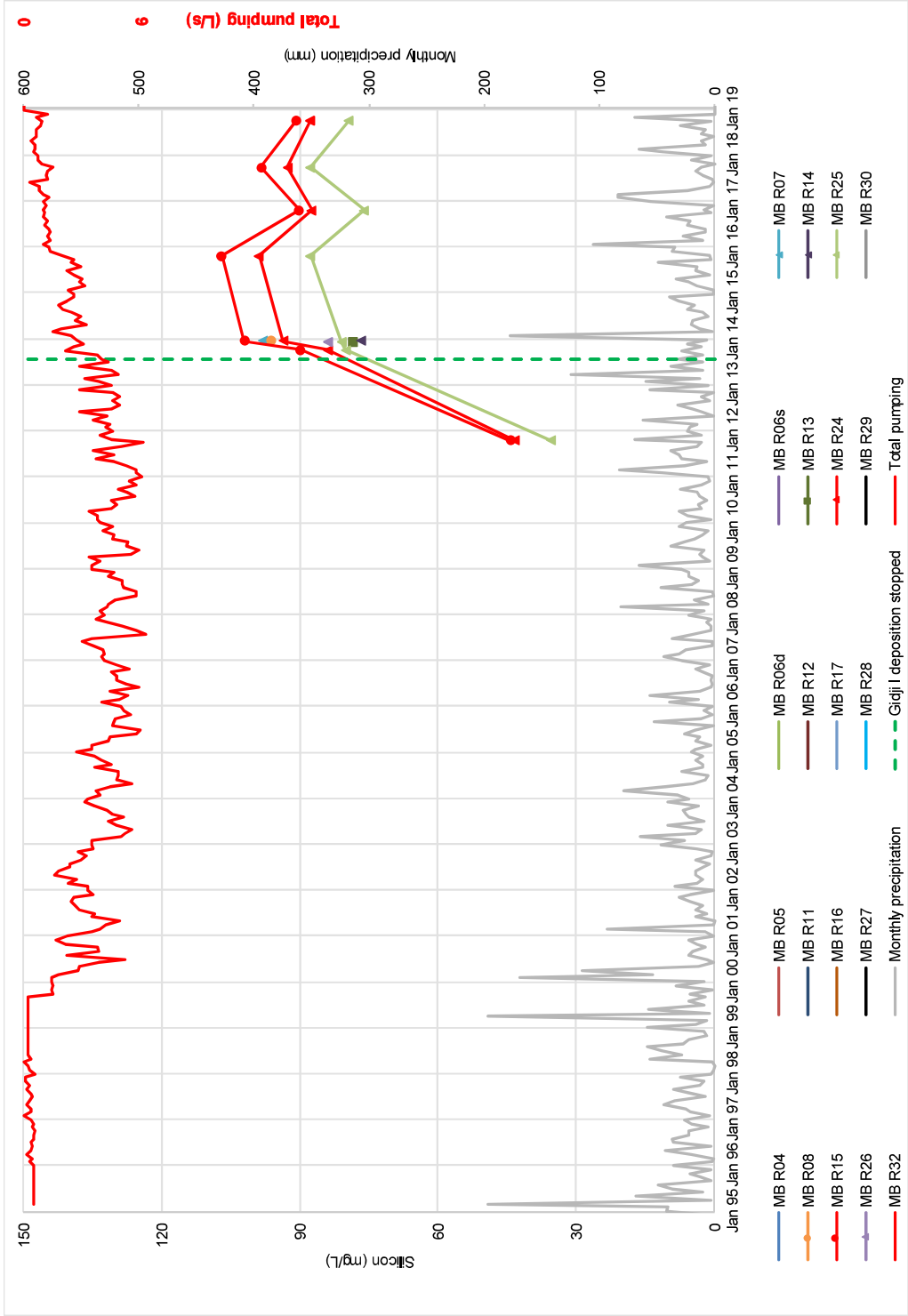


Figure C62

Date:	January 2019
Report:	KCGM Gidji TSF Hydrogeological Review

Groundwater silicon - western bores



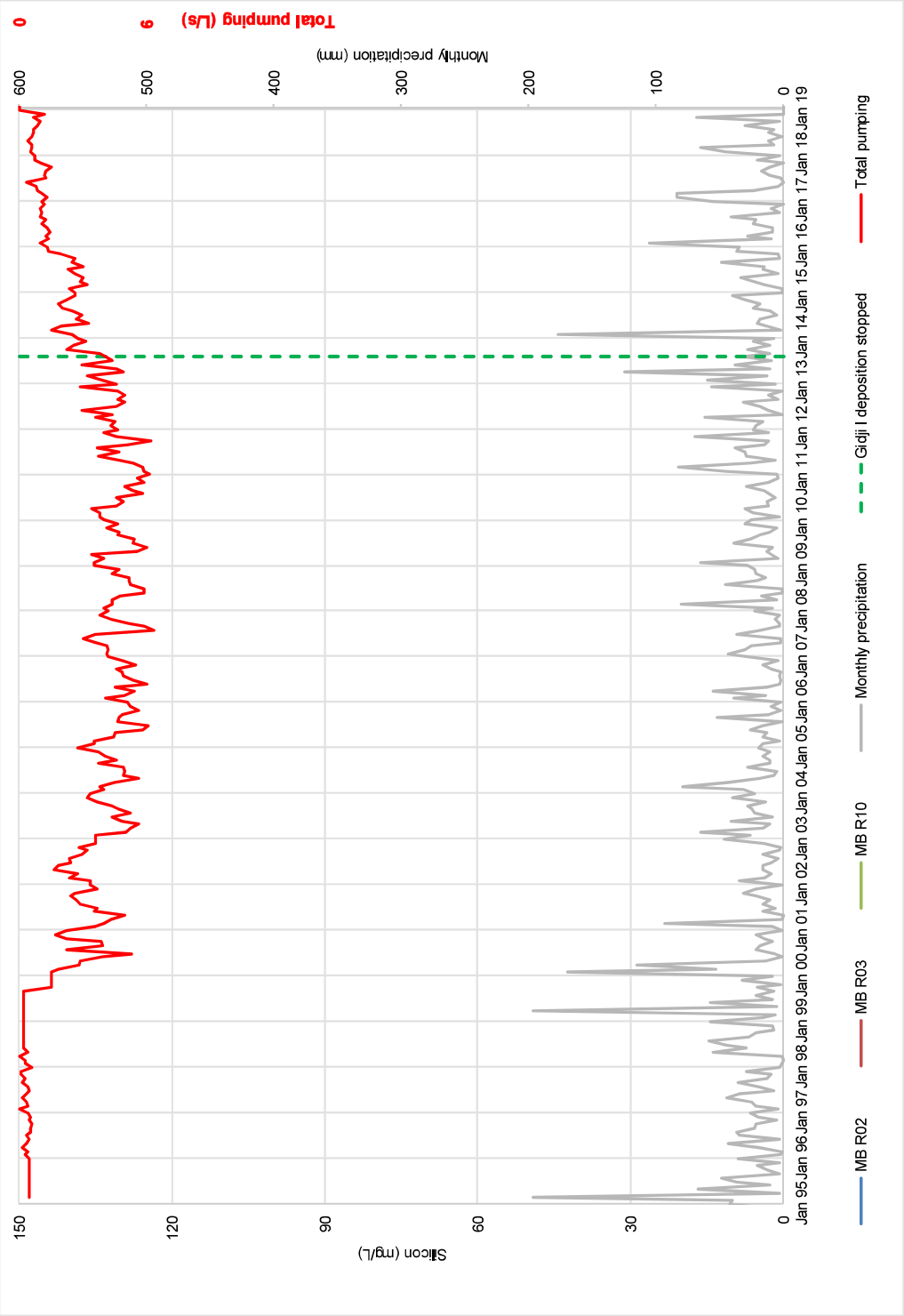
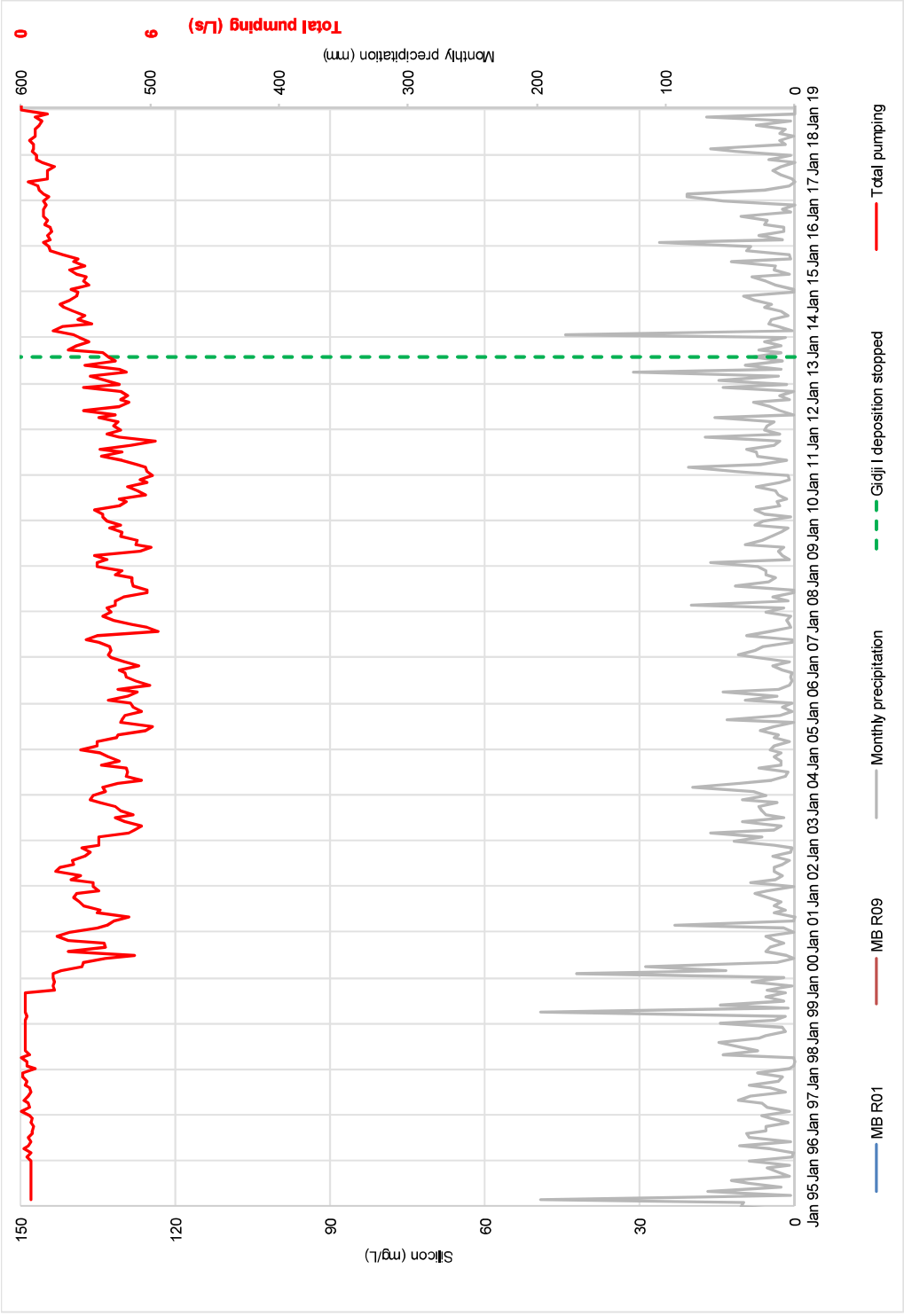


Figure C63

Date:	January 2019
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Groundwater silicon - trench bores





Groundwater silicon - decant bores

Figure C64

Date:	January 2019
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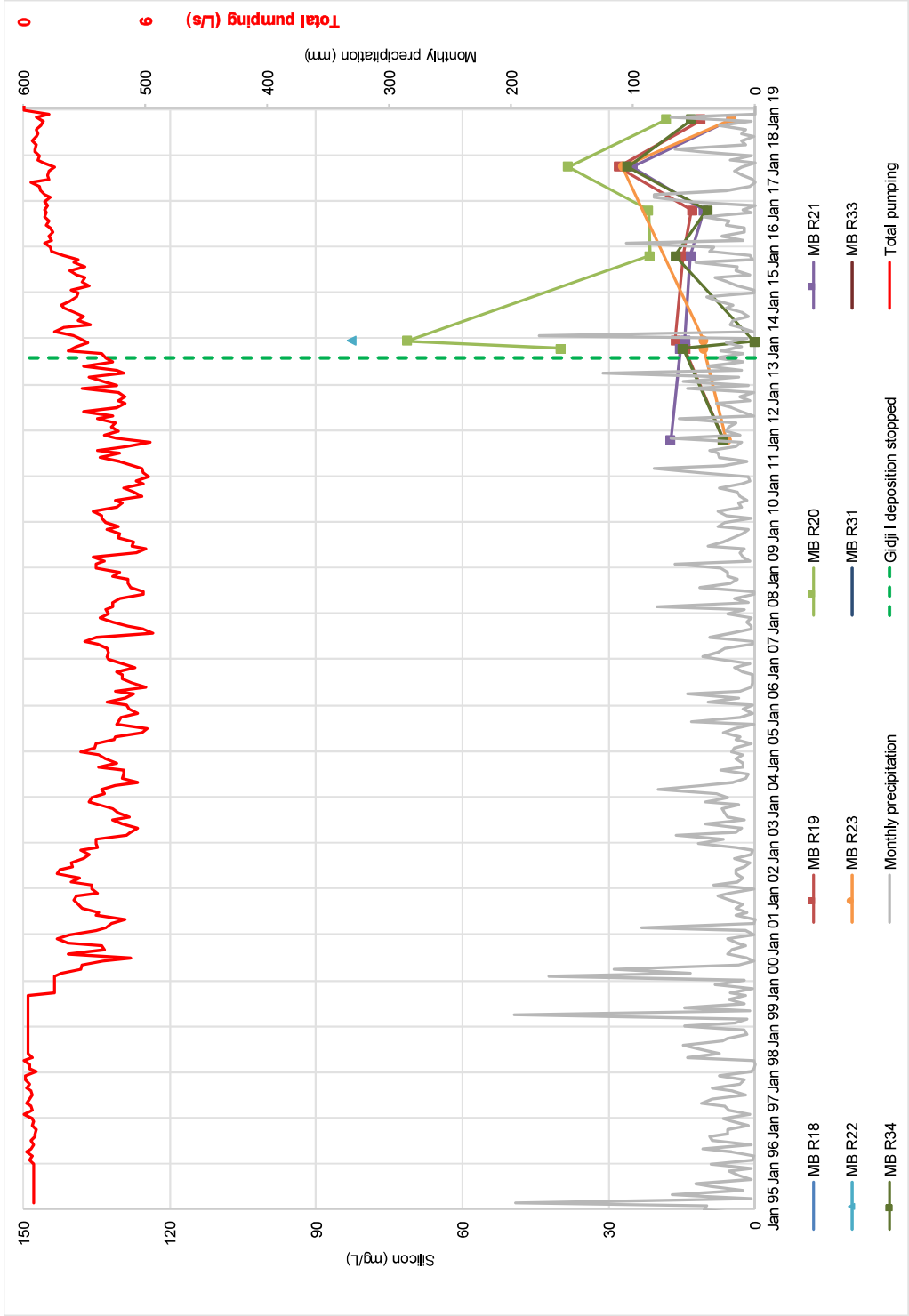
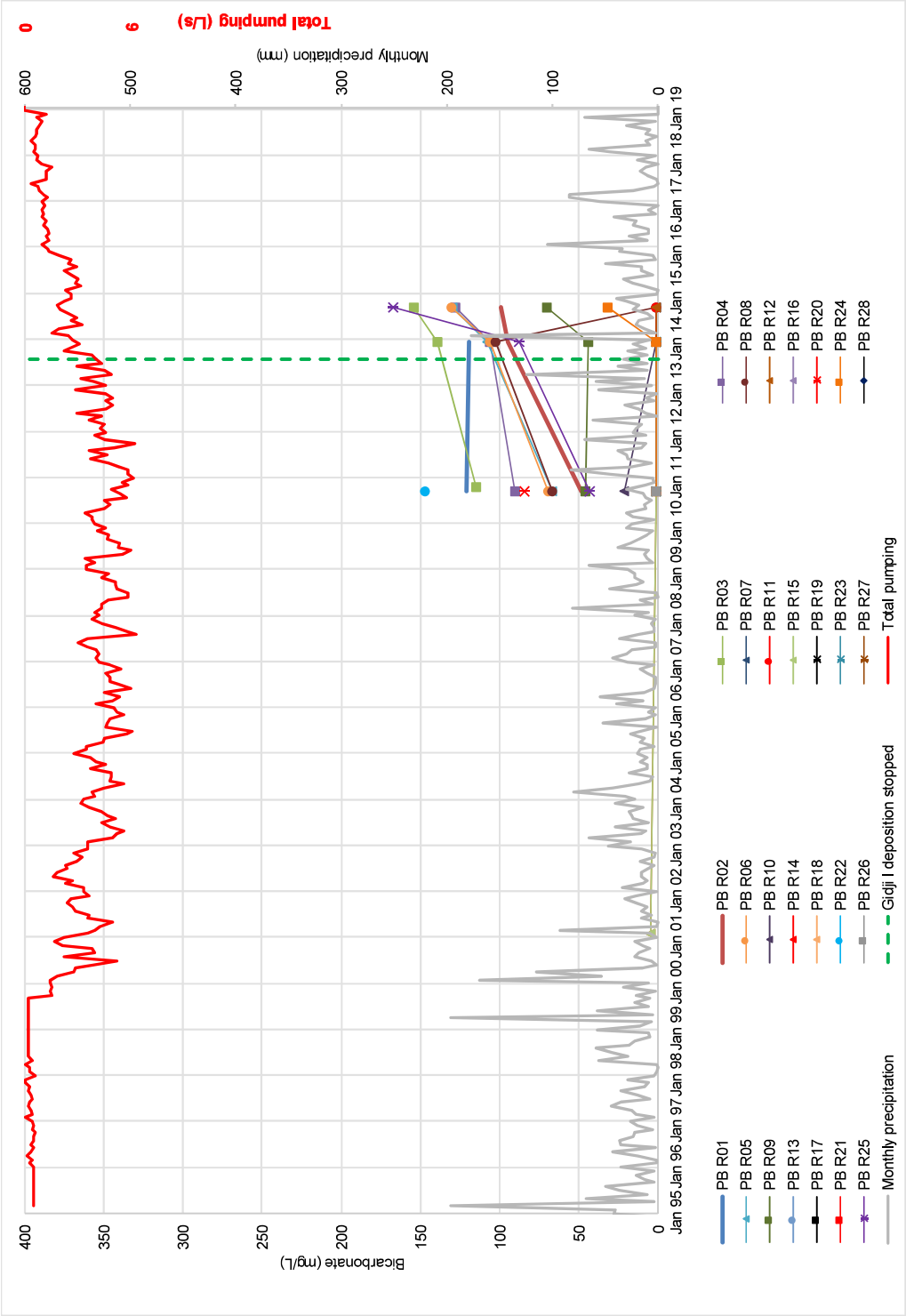


Figure C65

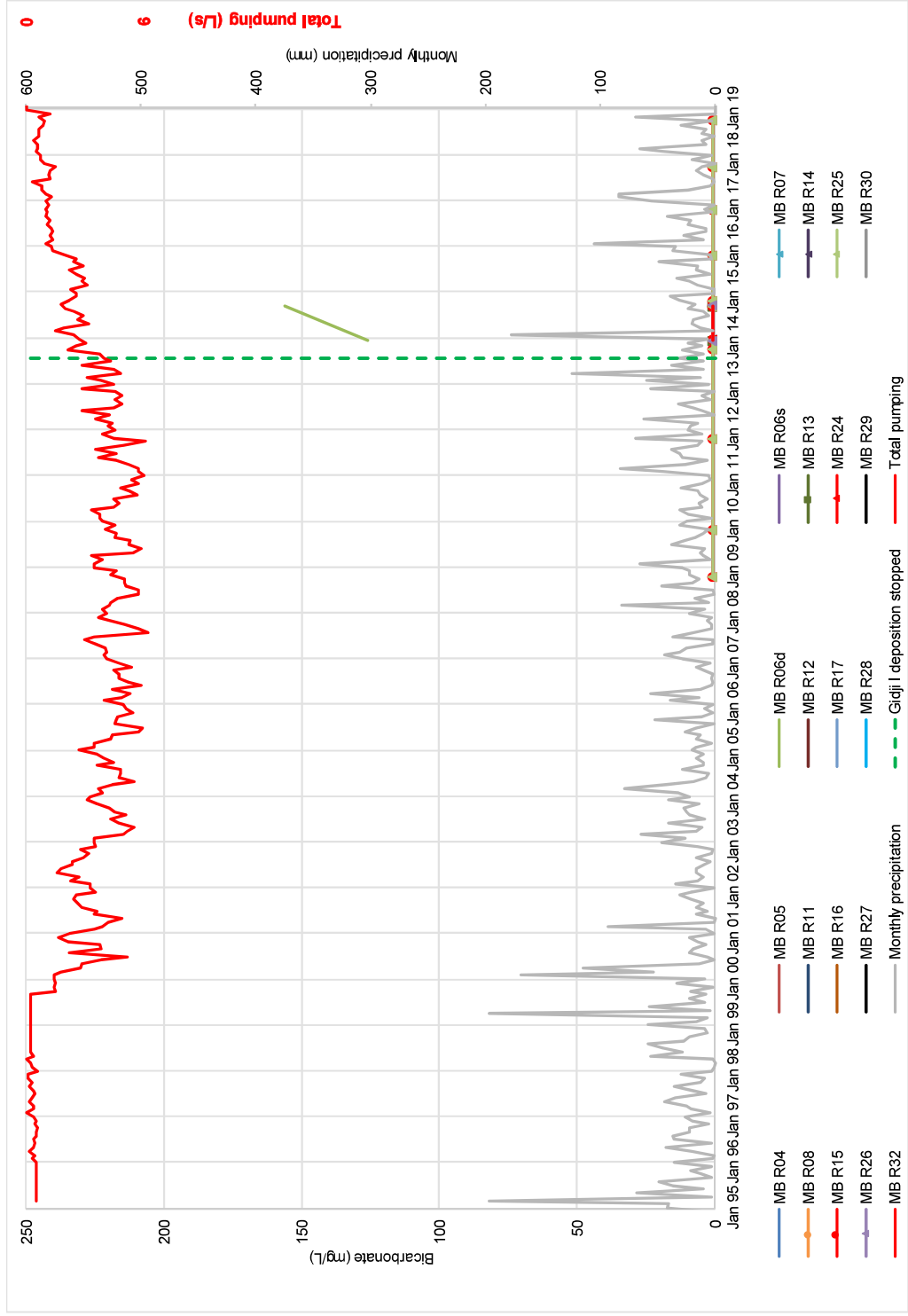
Date:	January 2019
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Groundwater silicon - eastern bores





Groundwater bicarbonate - production bores

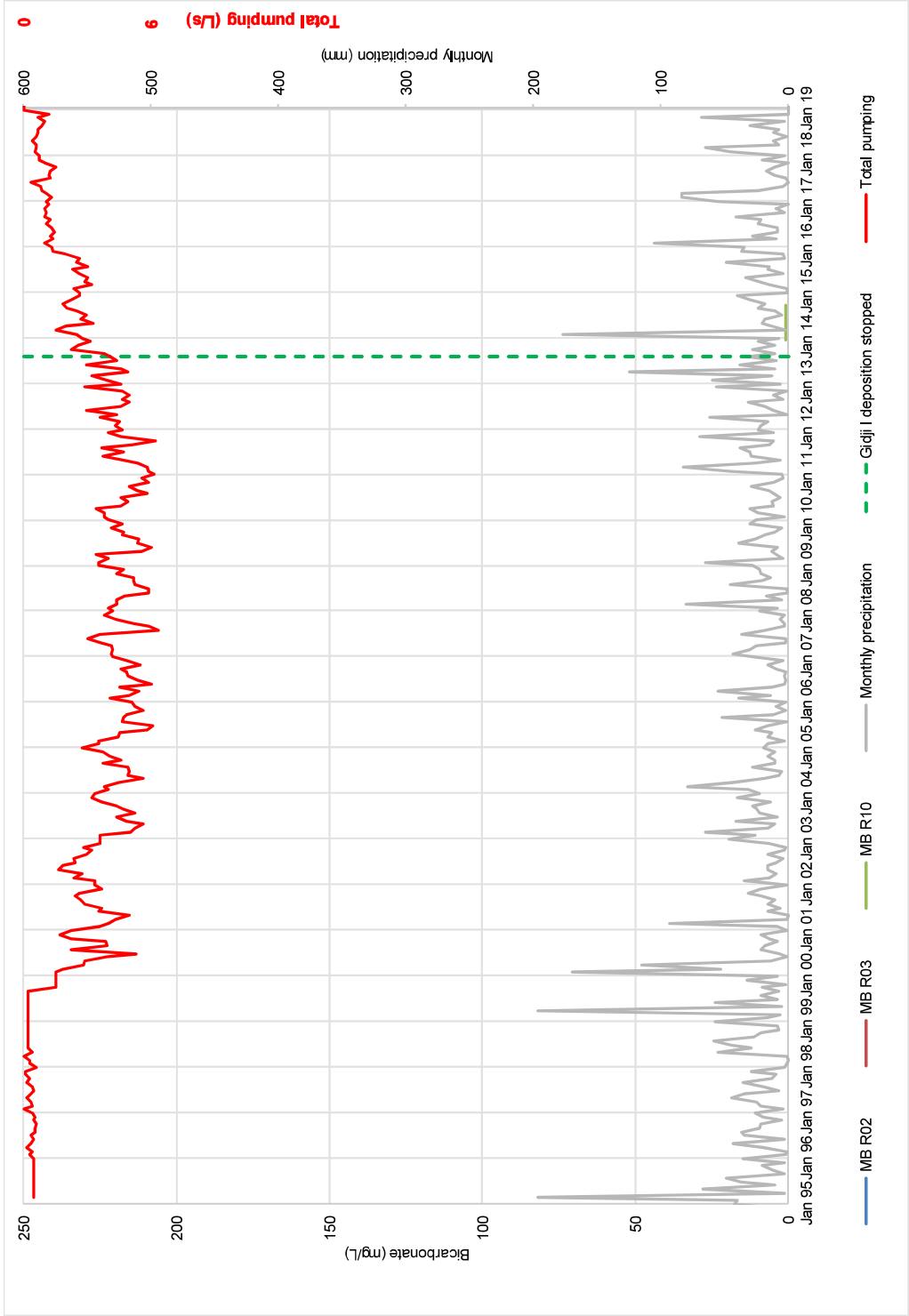


Groundwater bicarbonate - western bores

Figure C67

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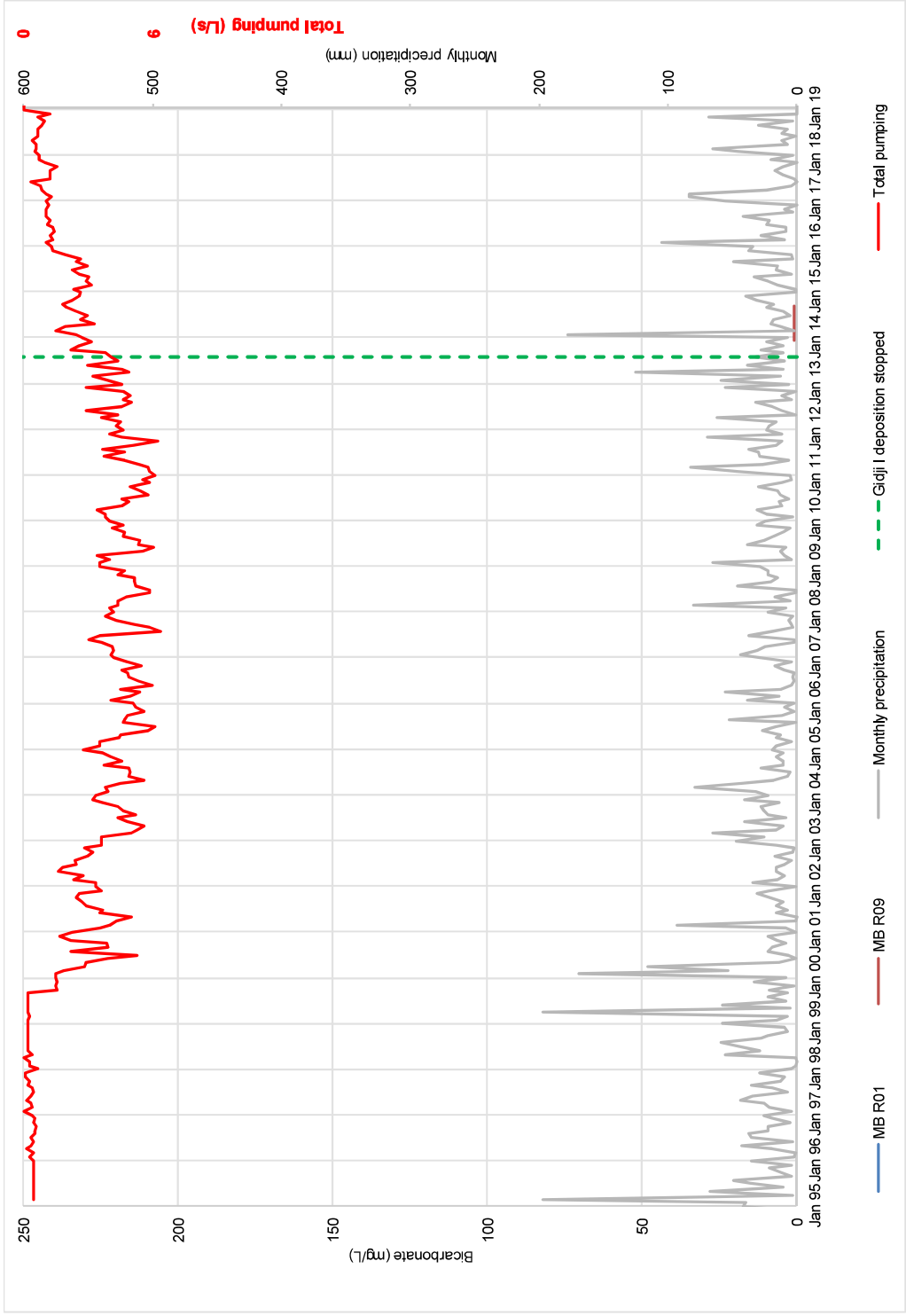


Groundwater bicarbonate - trench bores

Figure C68

Date:	January 2019
Report:	KCGM Gidji TSF Hydrogeological Review

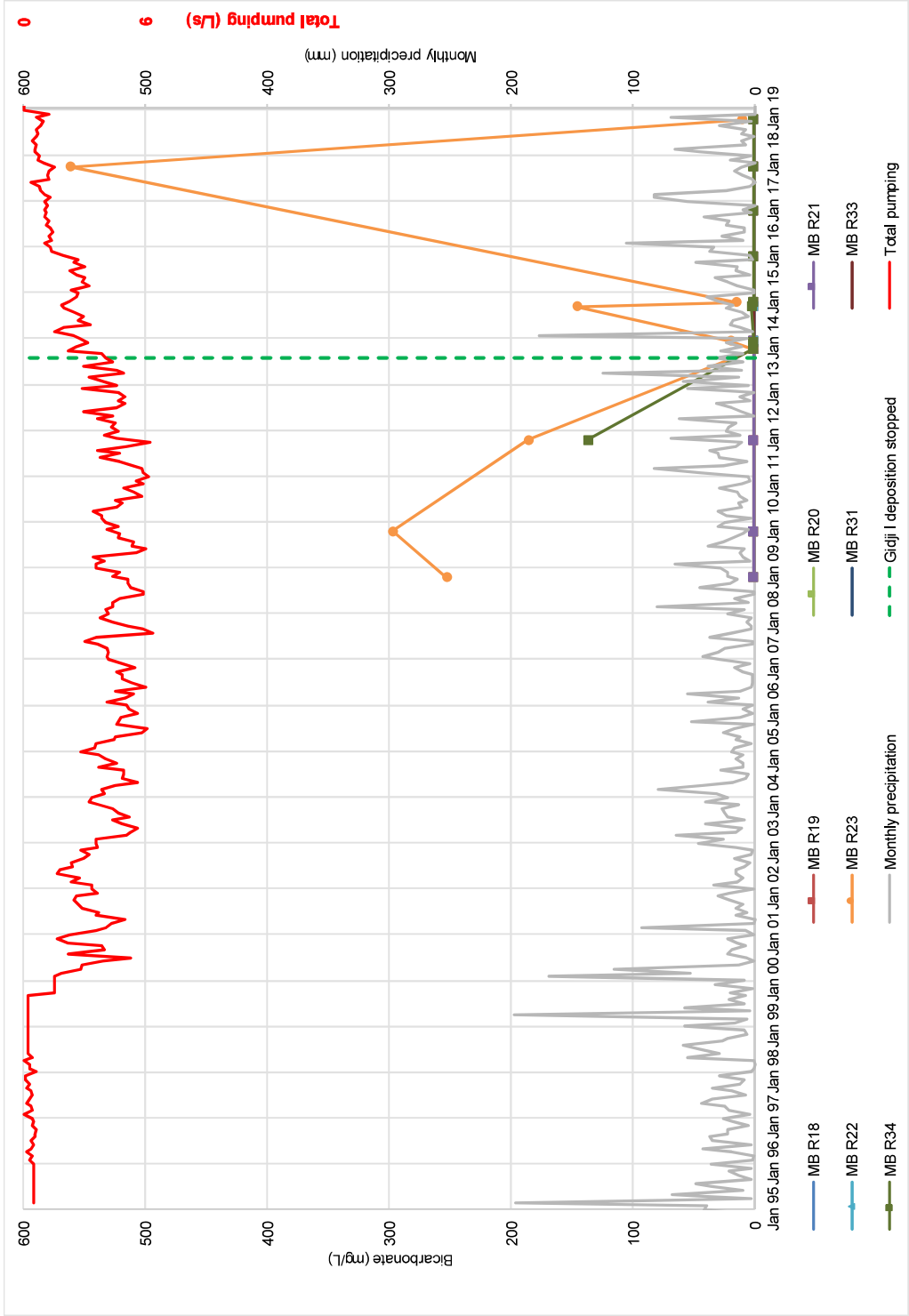




Groundwater bicarbonate - decant bores

Figure C69

Date:	January 2019
Report:	KCGM Gidji TSF Hydrogeological Review

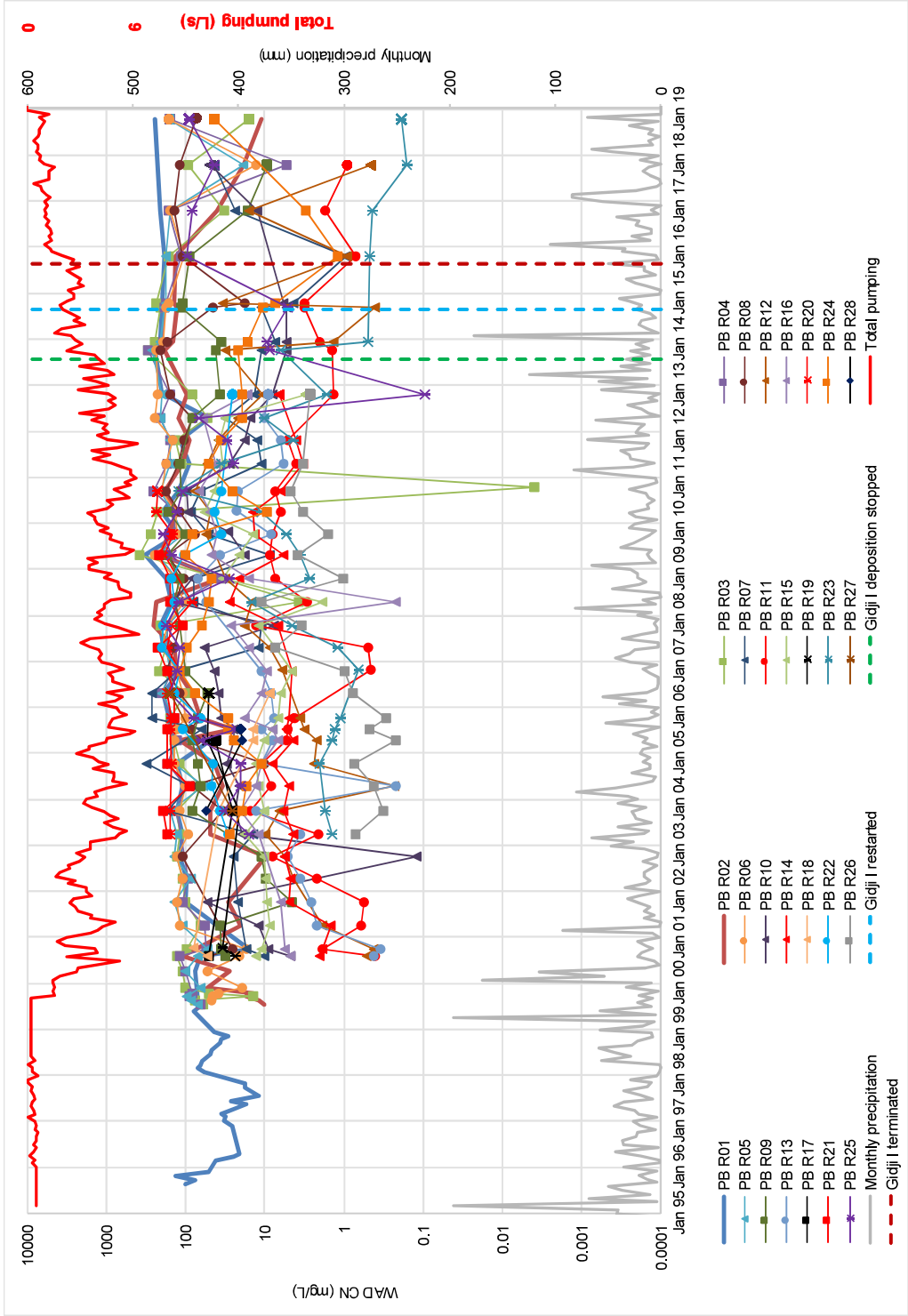


Groundwater bicarbonate - eastern bores

Figure C70

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Groundwater WAD CN - production bores



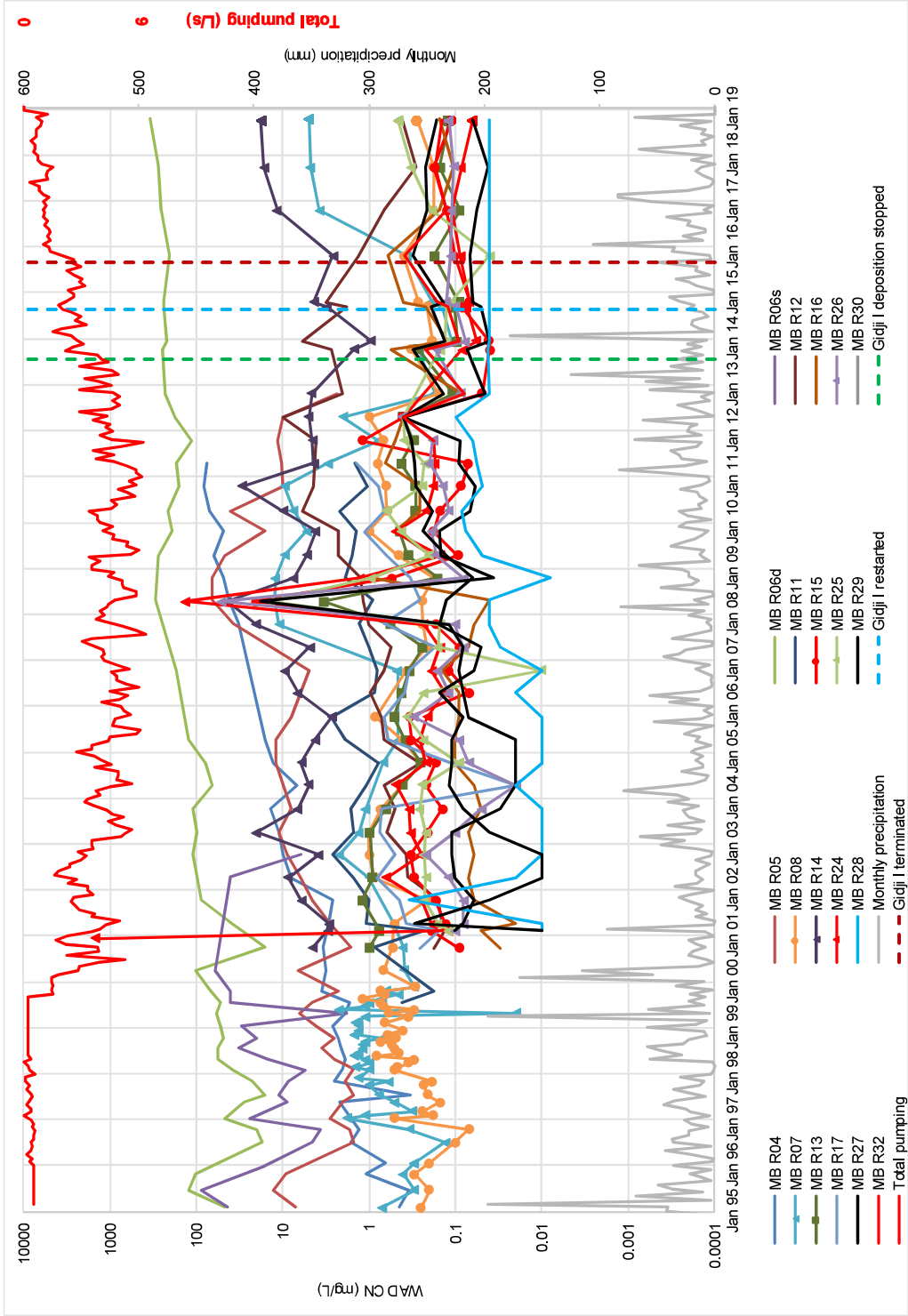
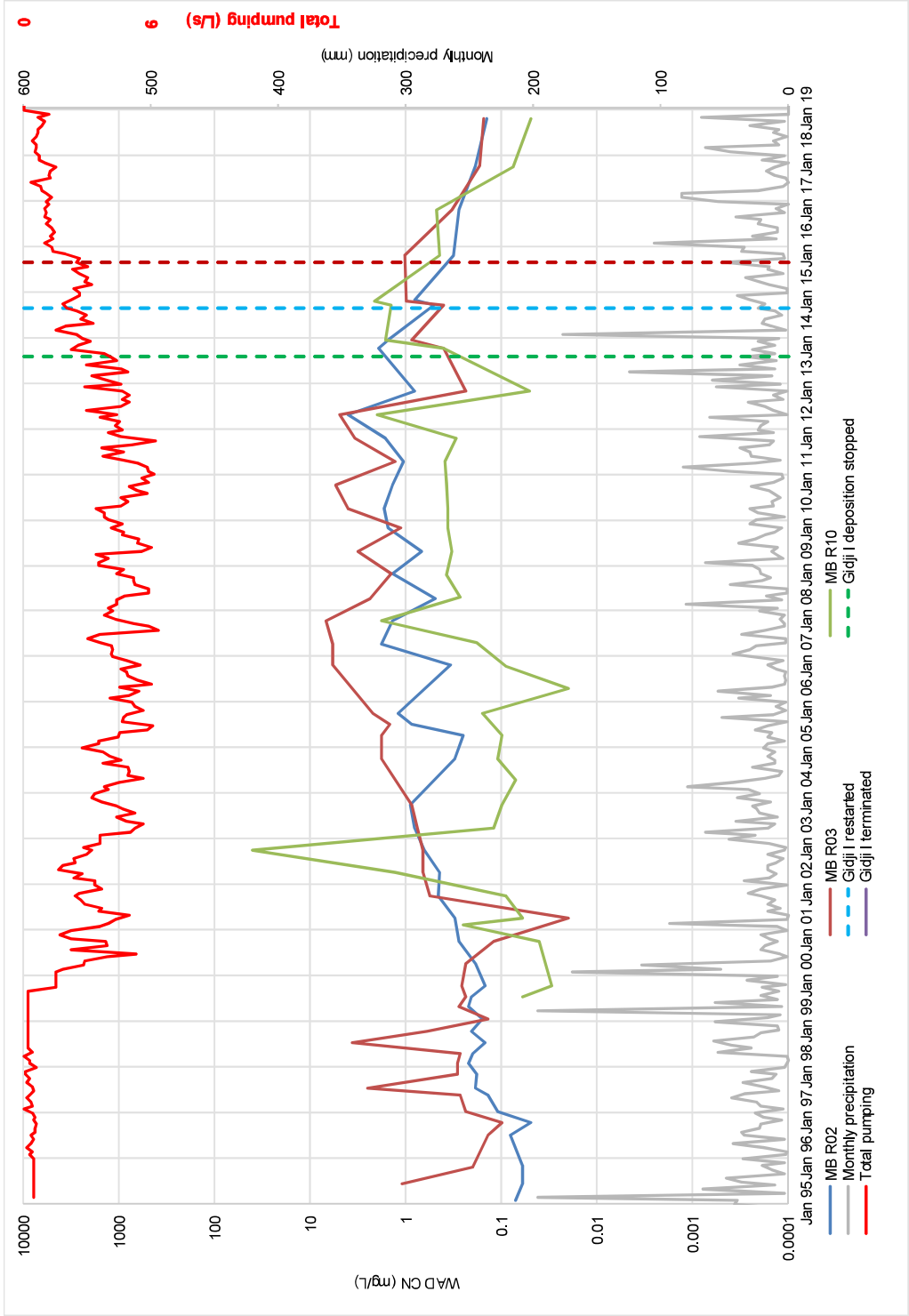


Figure C72

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Groundwater WAD CN - western bores



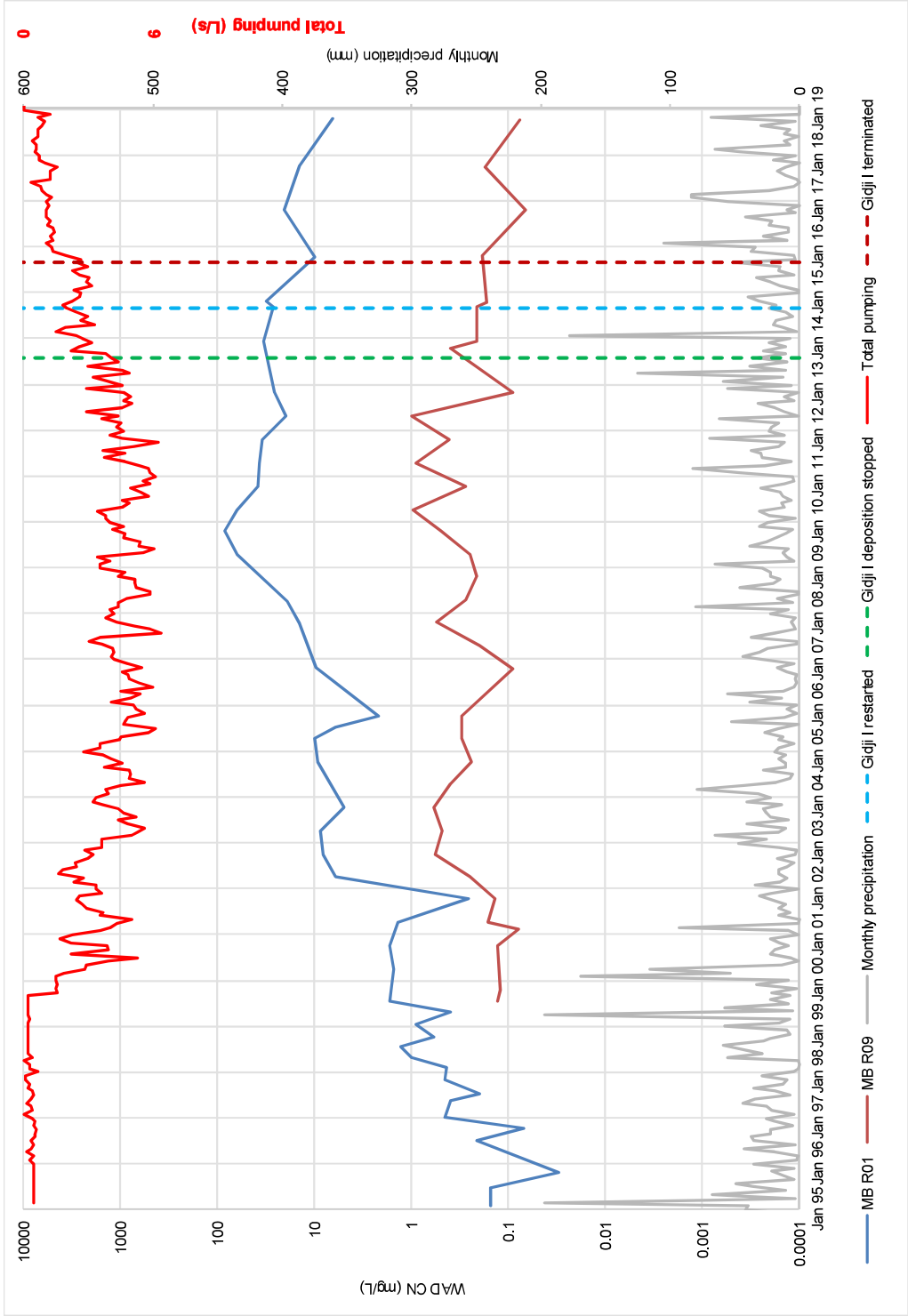


Groundwater WAD CN - trench bores

Figure C73

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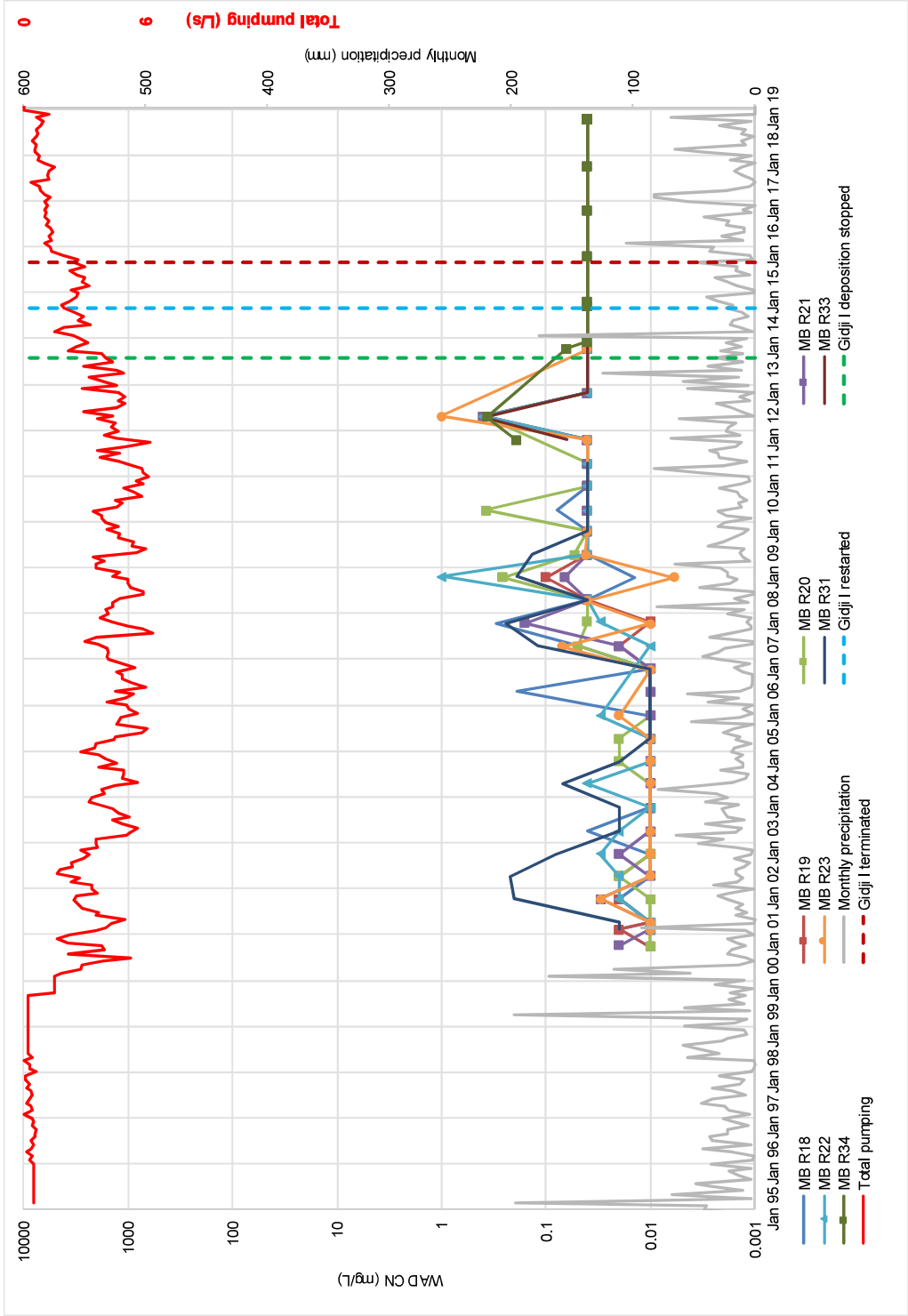


Groundwater WAD CN - decant bores

Figure C74

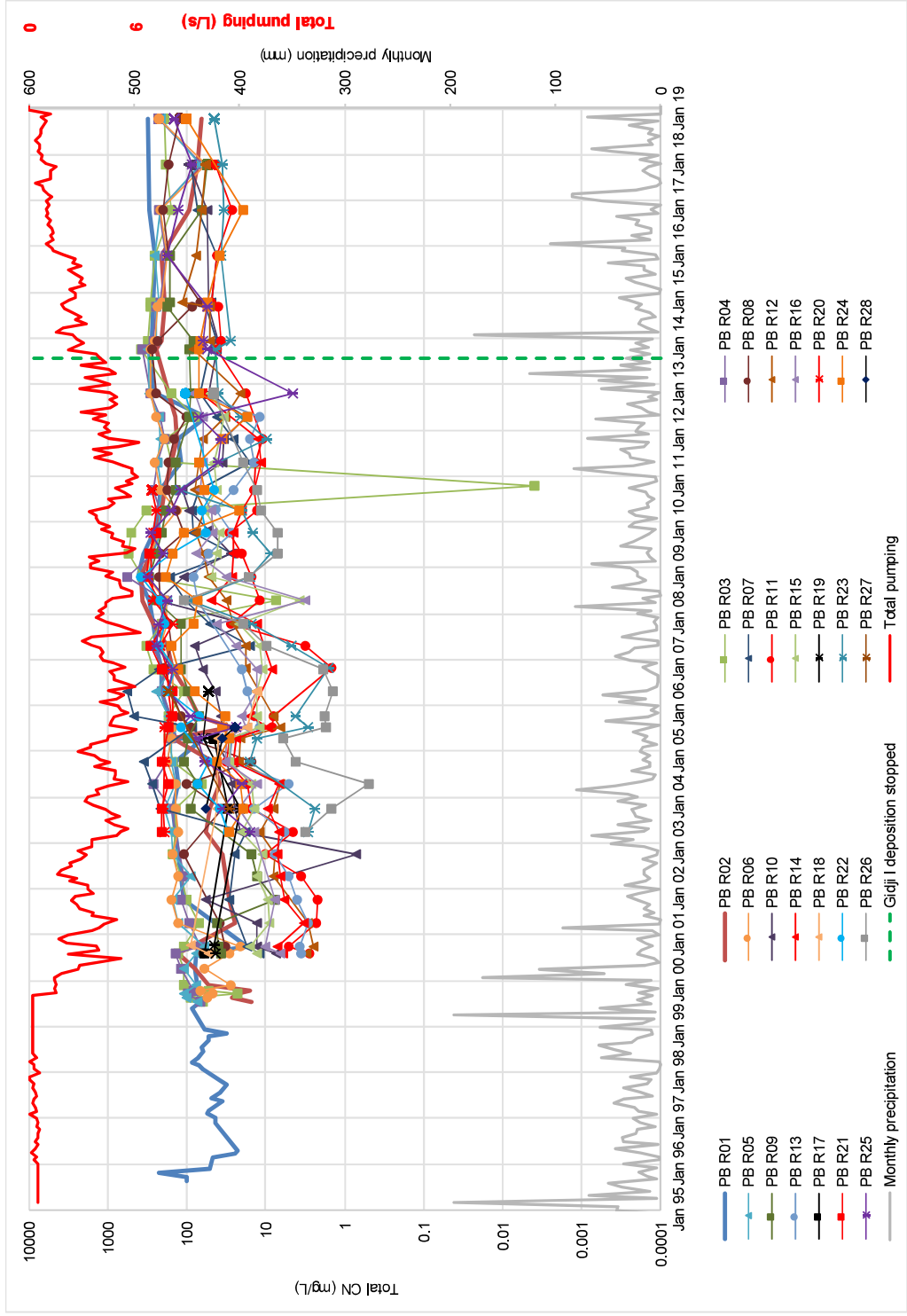
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Groundwater WAD CN - eastern bores

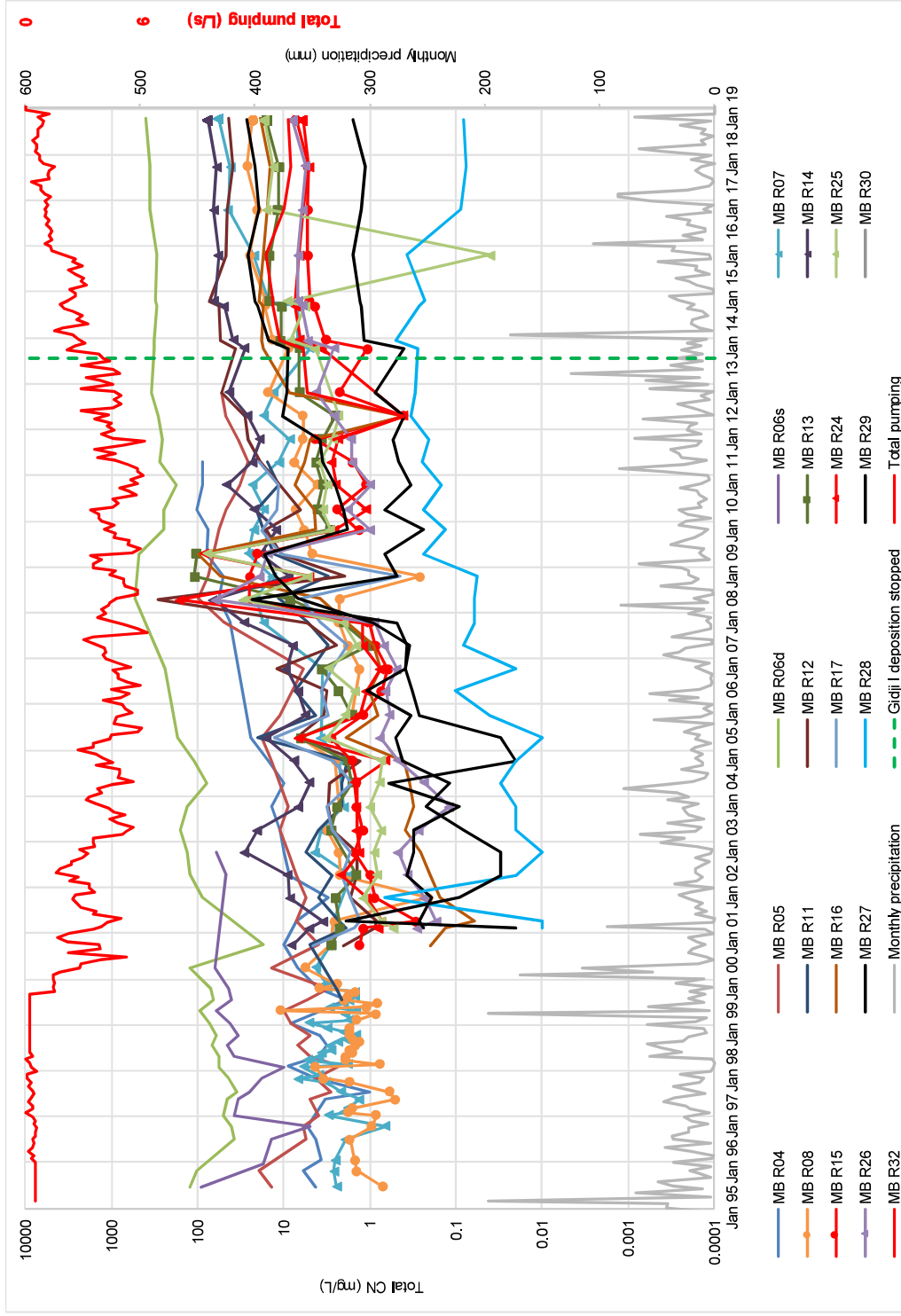




Groundwater Total CN - production bores

Figure C76

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Groundwater Total CN - western bores

Figure C77

Date:	January 2019
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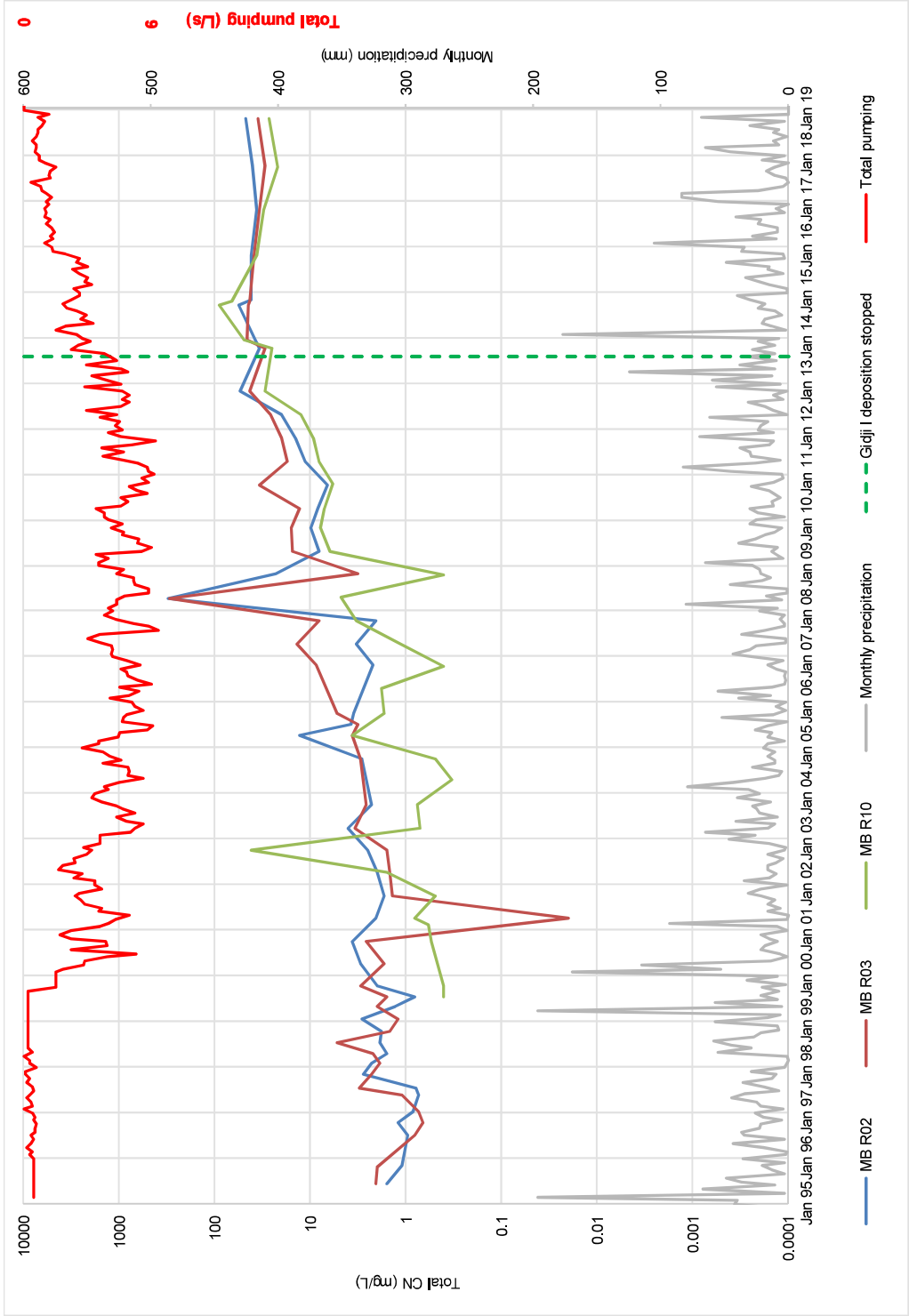
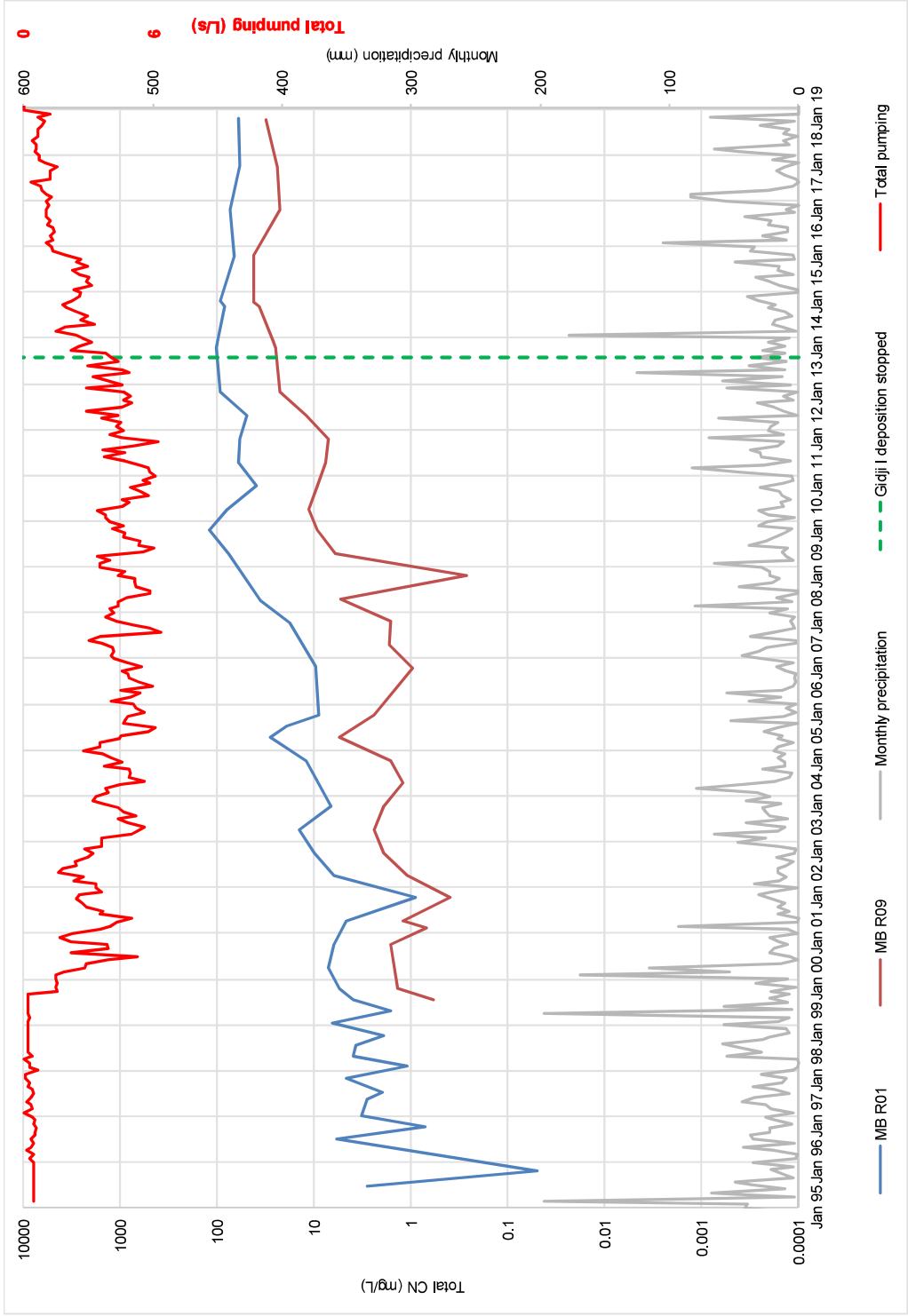


Figure C78

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Groundwater Total CN - trench bores

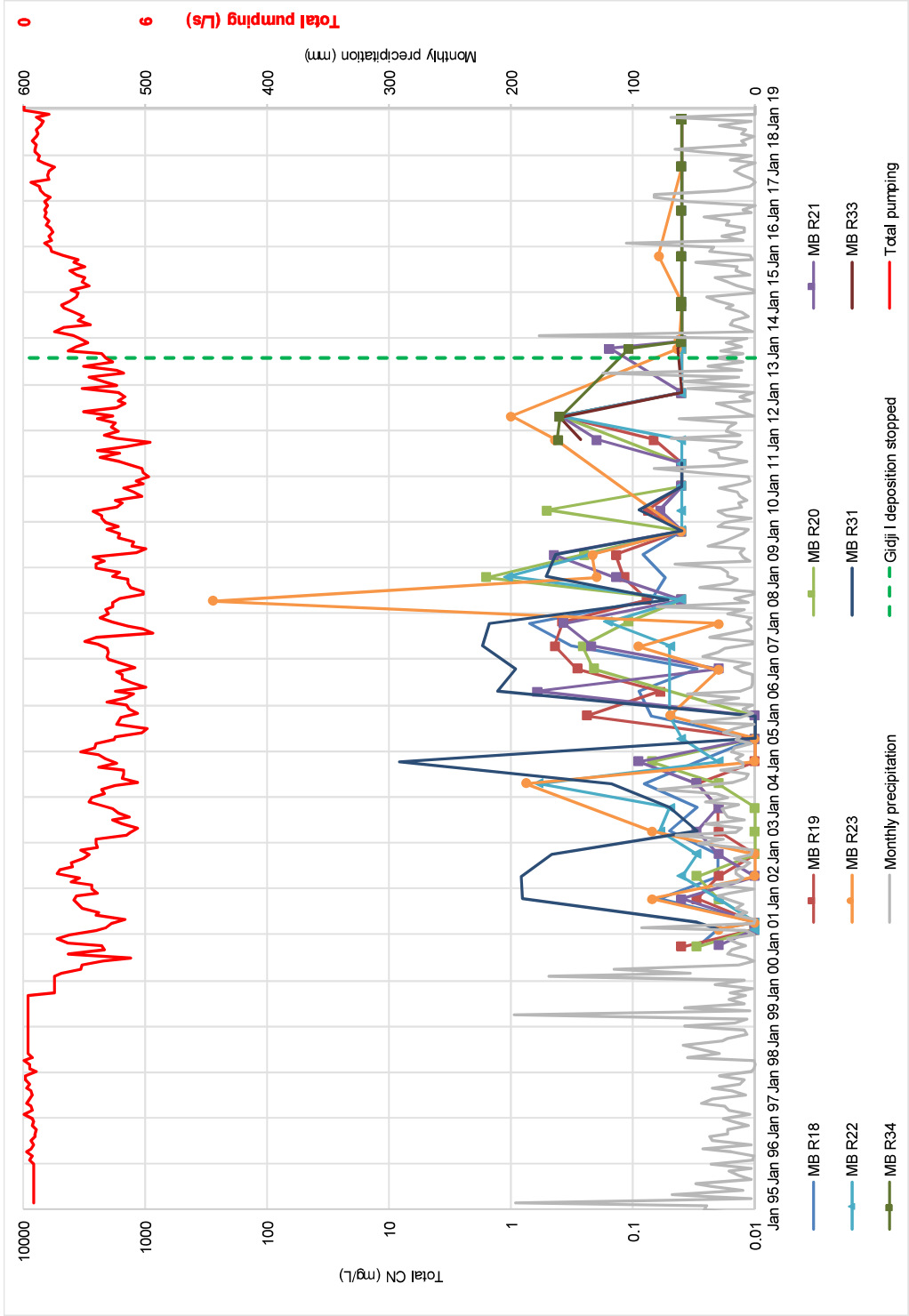




Groundwater Total CN - decant bores

Figure C79

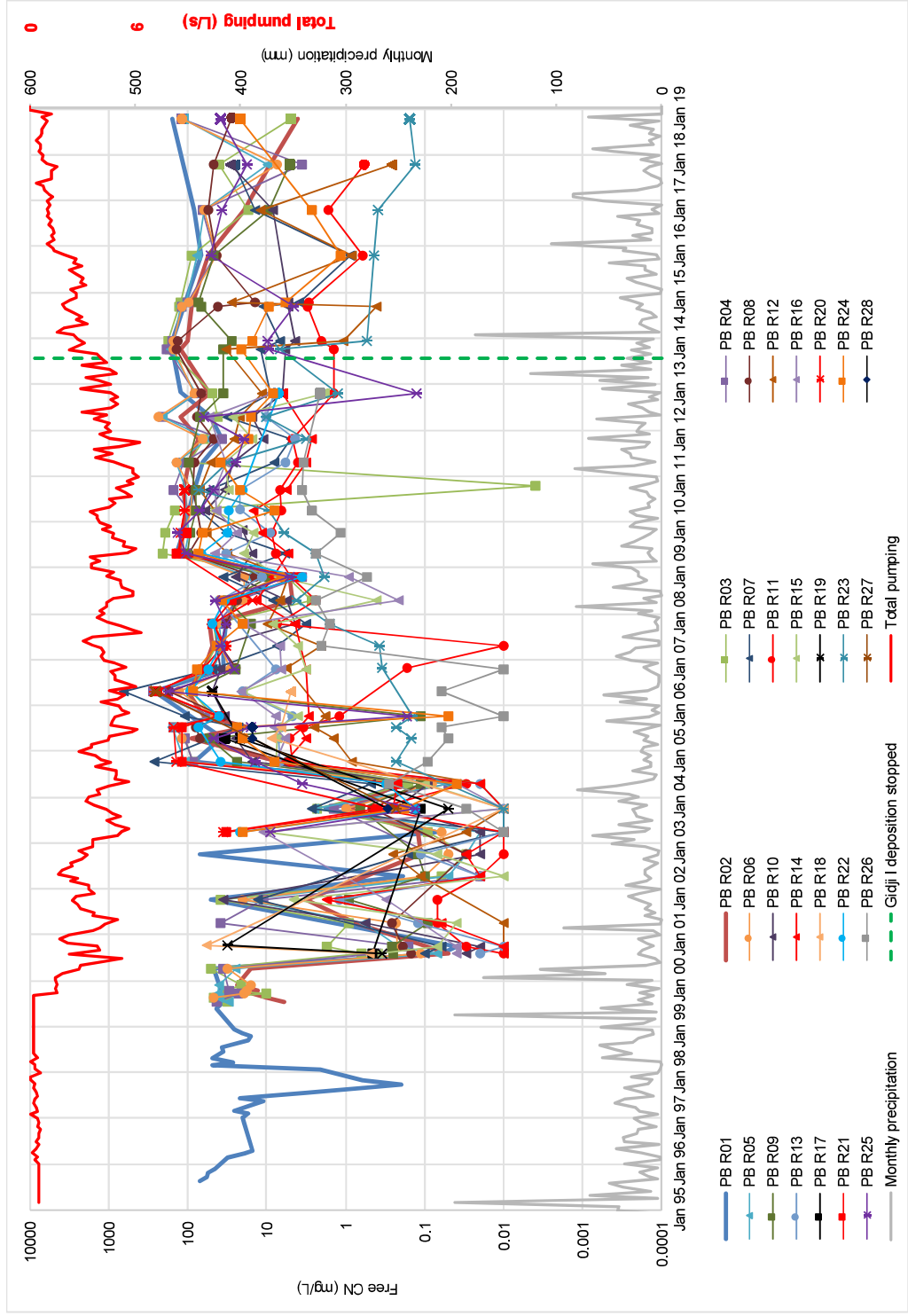
Date:	January 2019
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Groundwater Total CN - eastern bores

Figure C80

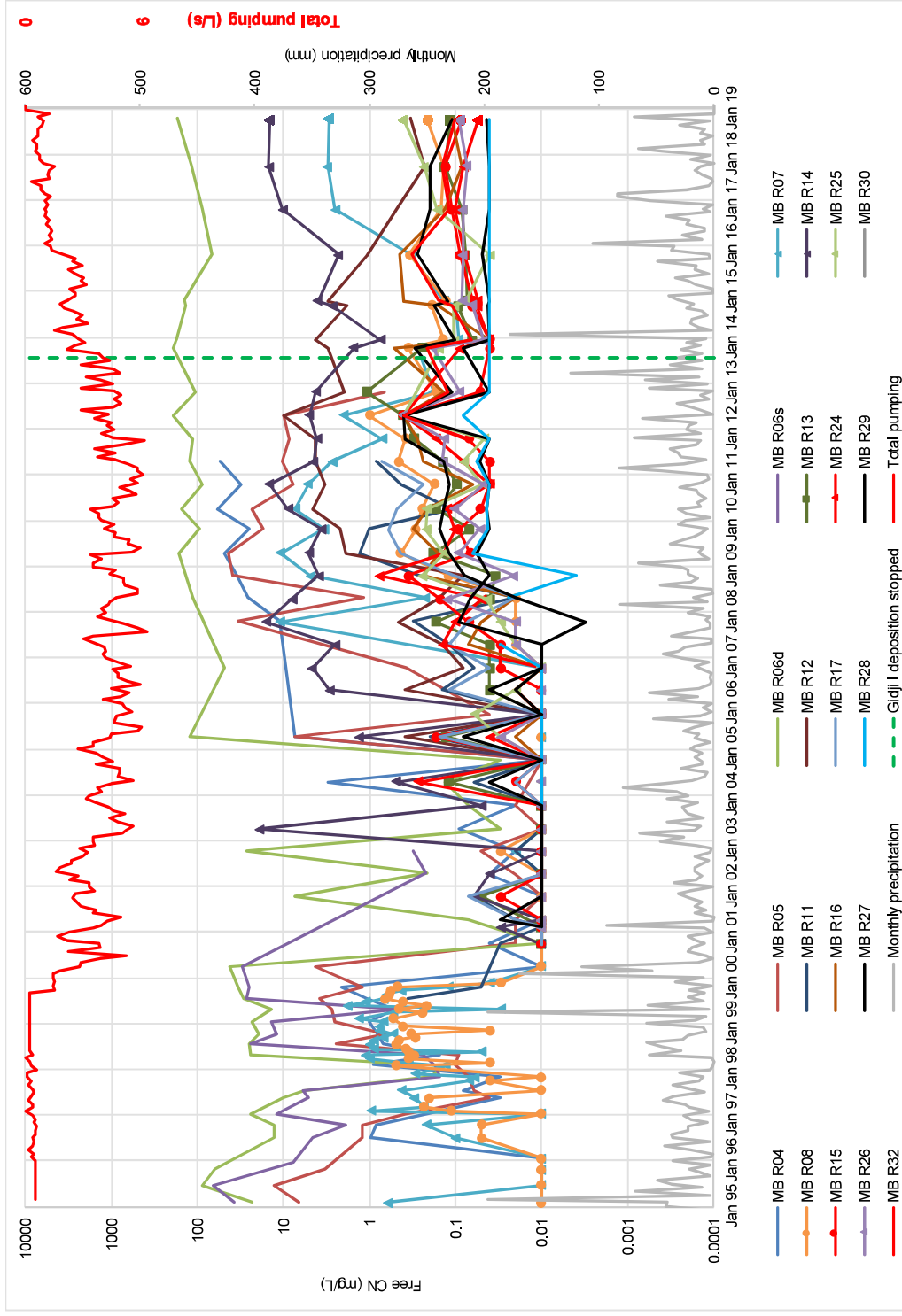
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Groundwater Free CN - production bores

Figure C81

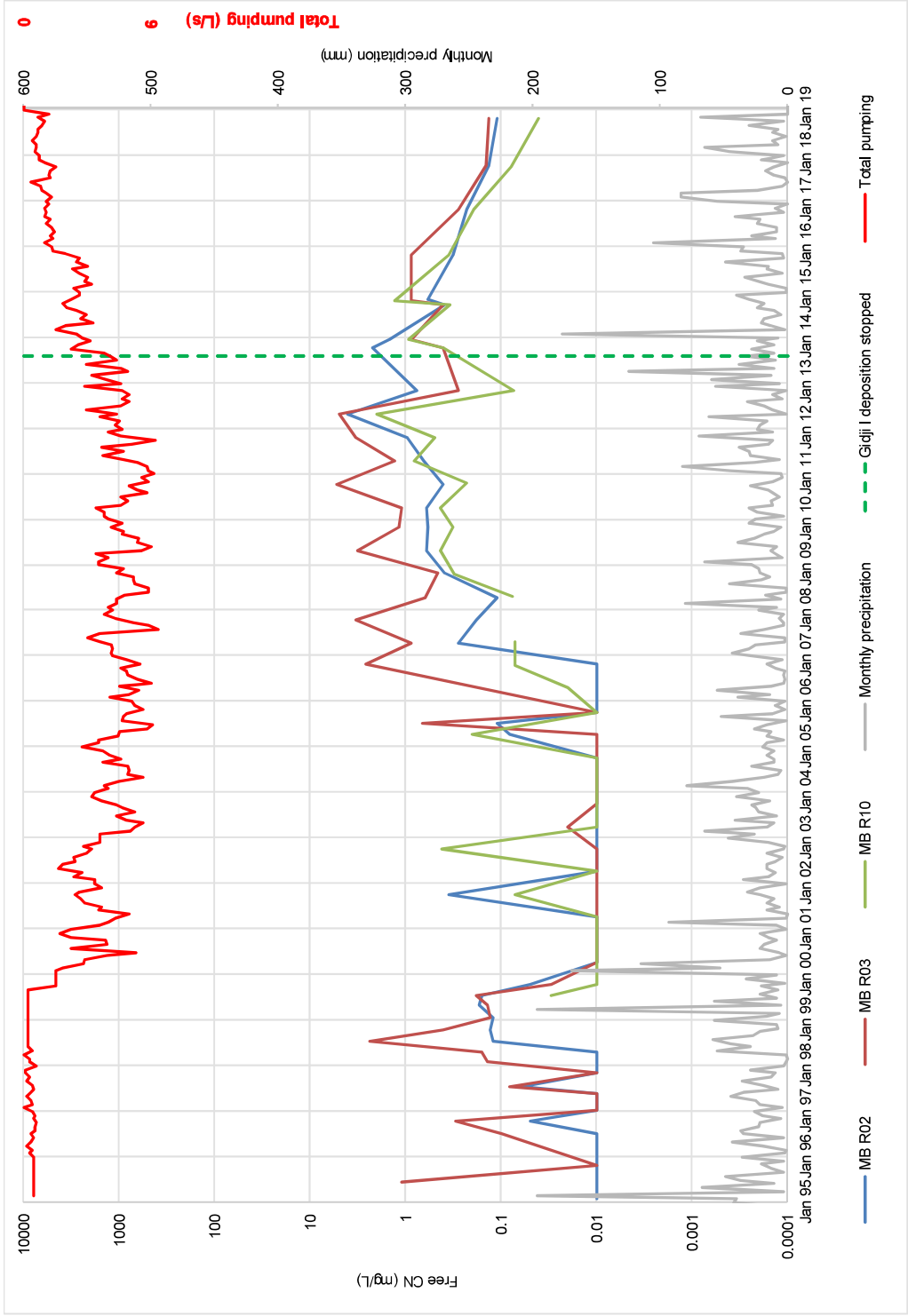
Date:	January 2019
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Groundwater Free CN - western bores

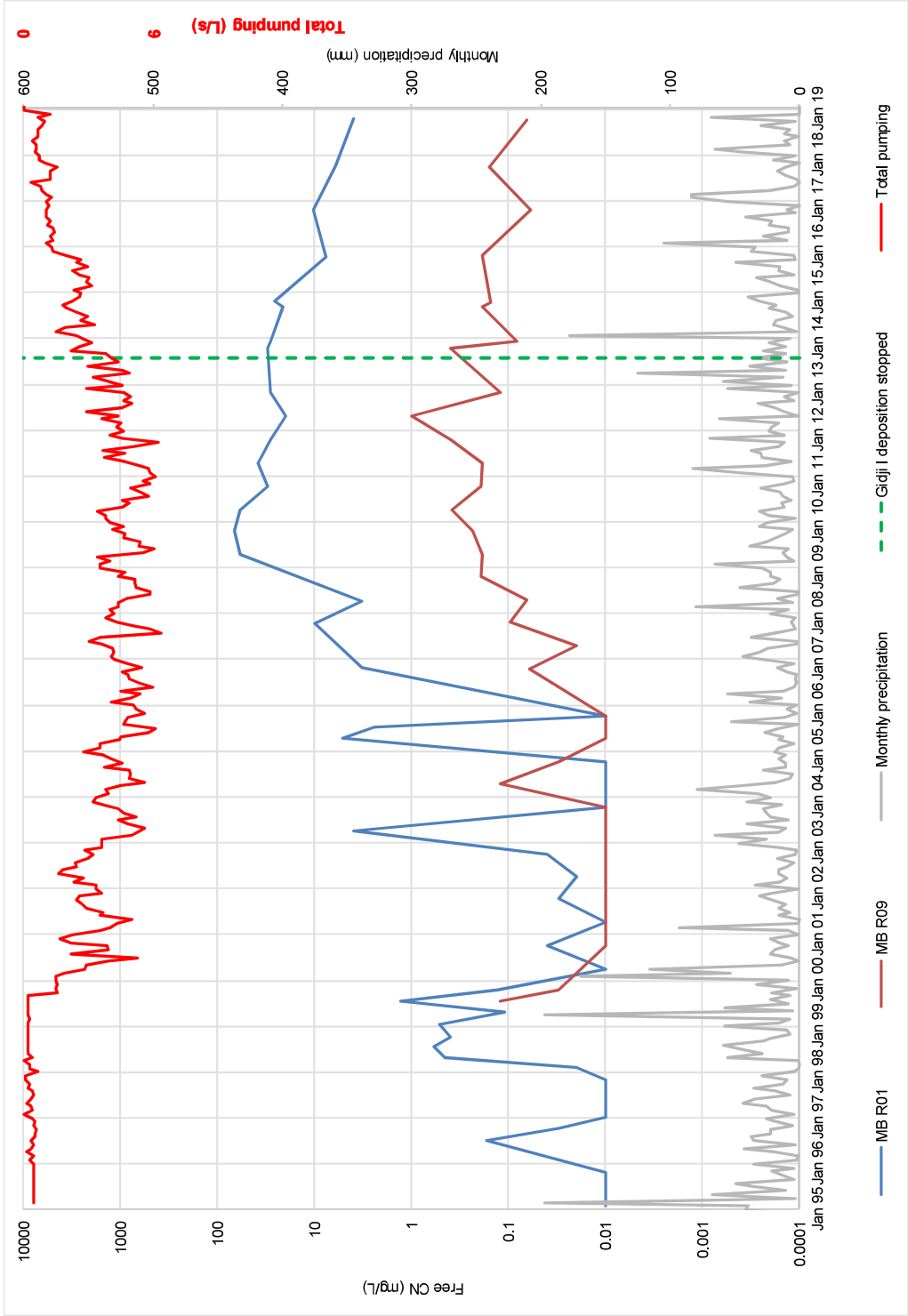
Figure C82

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Groundwater Free CN - trench bores

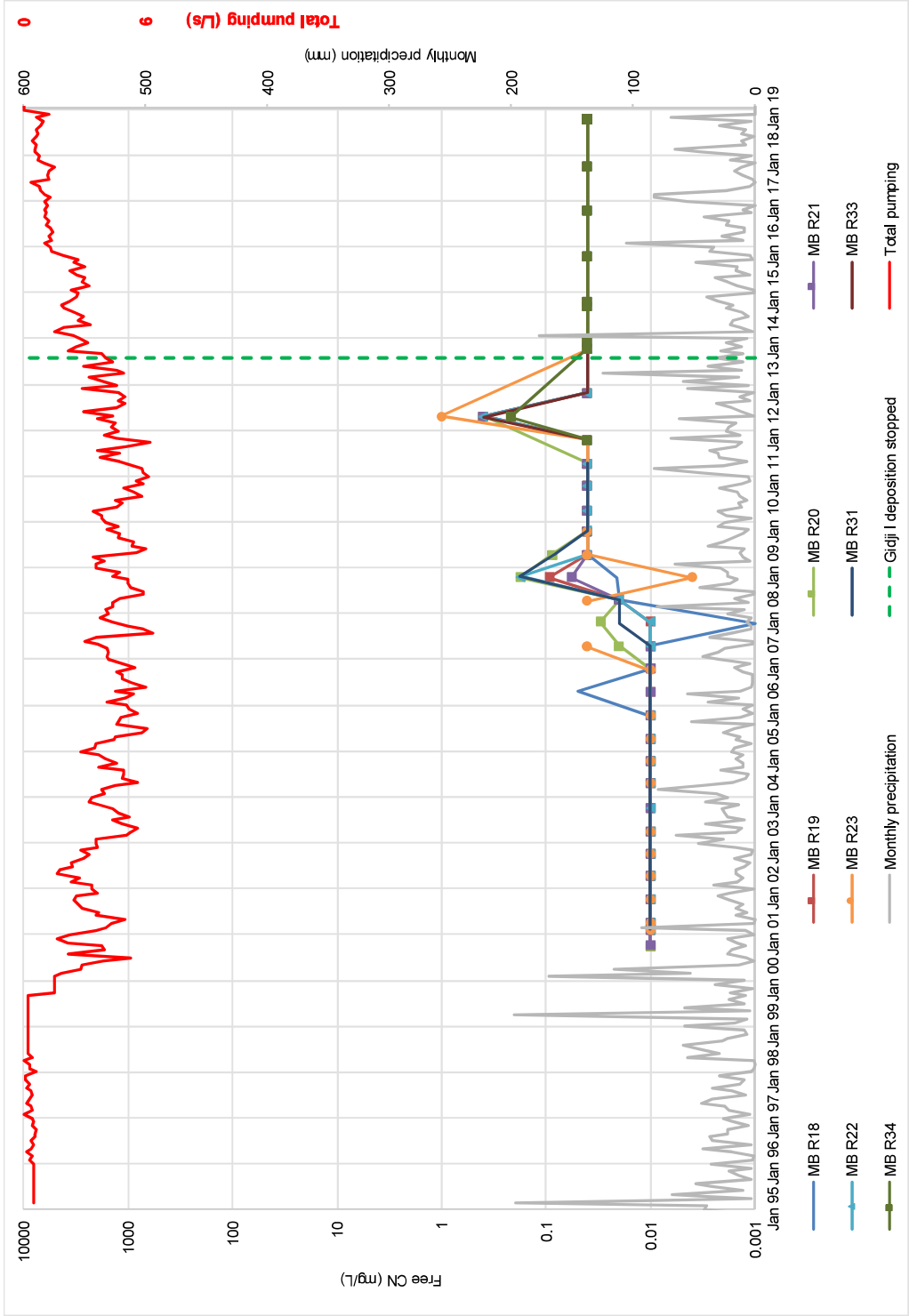




Groundwater Free CN - decant bores

Figure C84

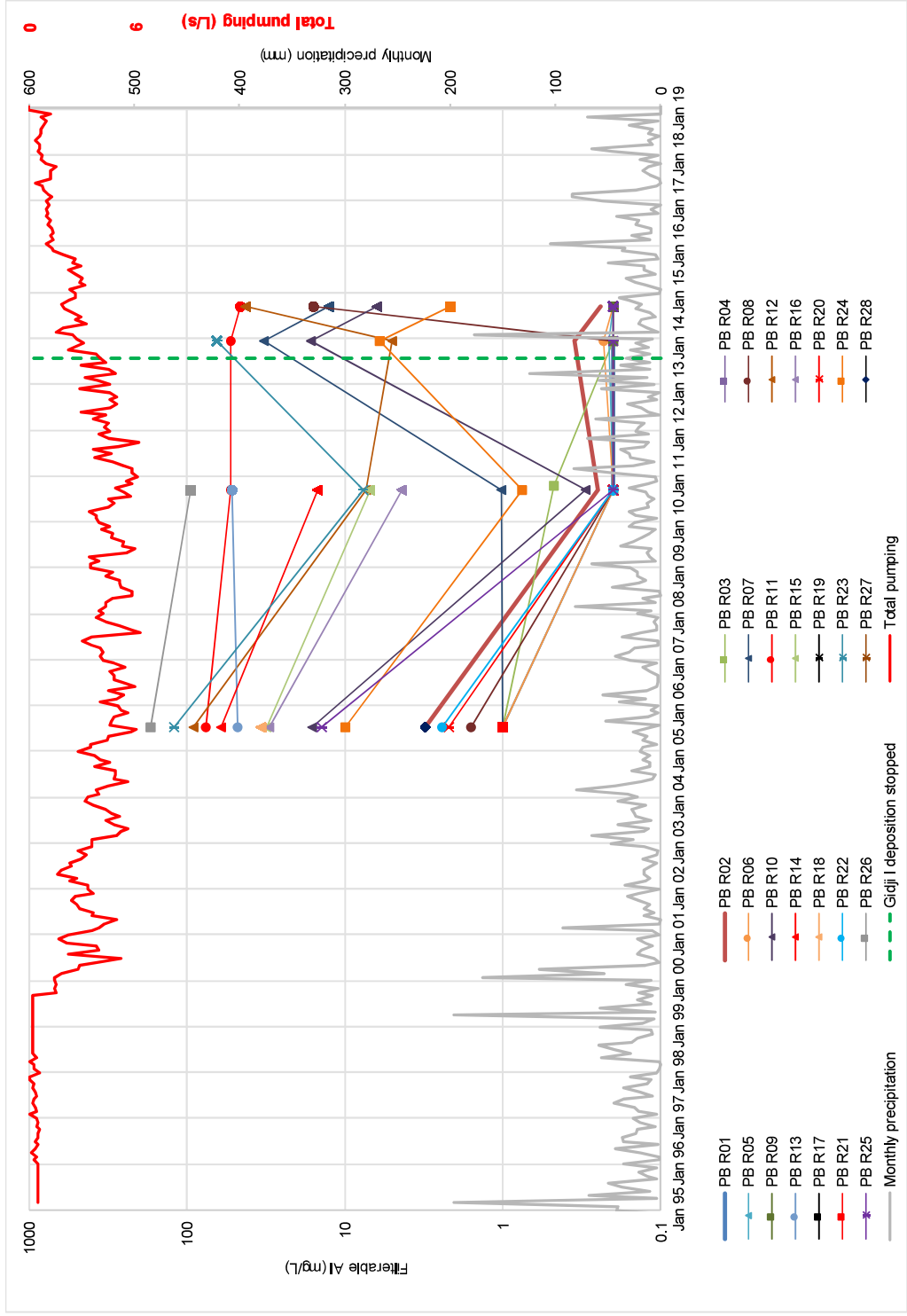
Date:	January 2019
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Groundwater Free CN - eastern bores

Figure C85

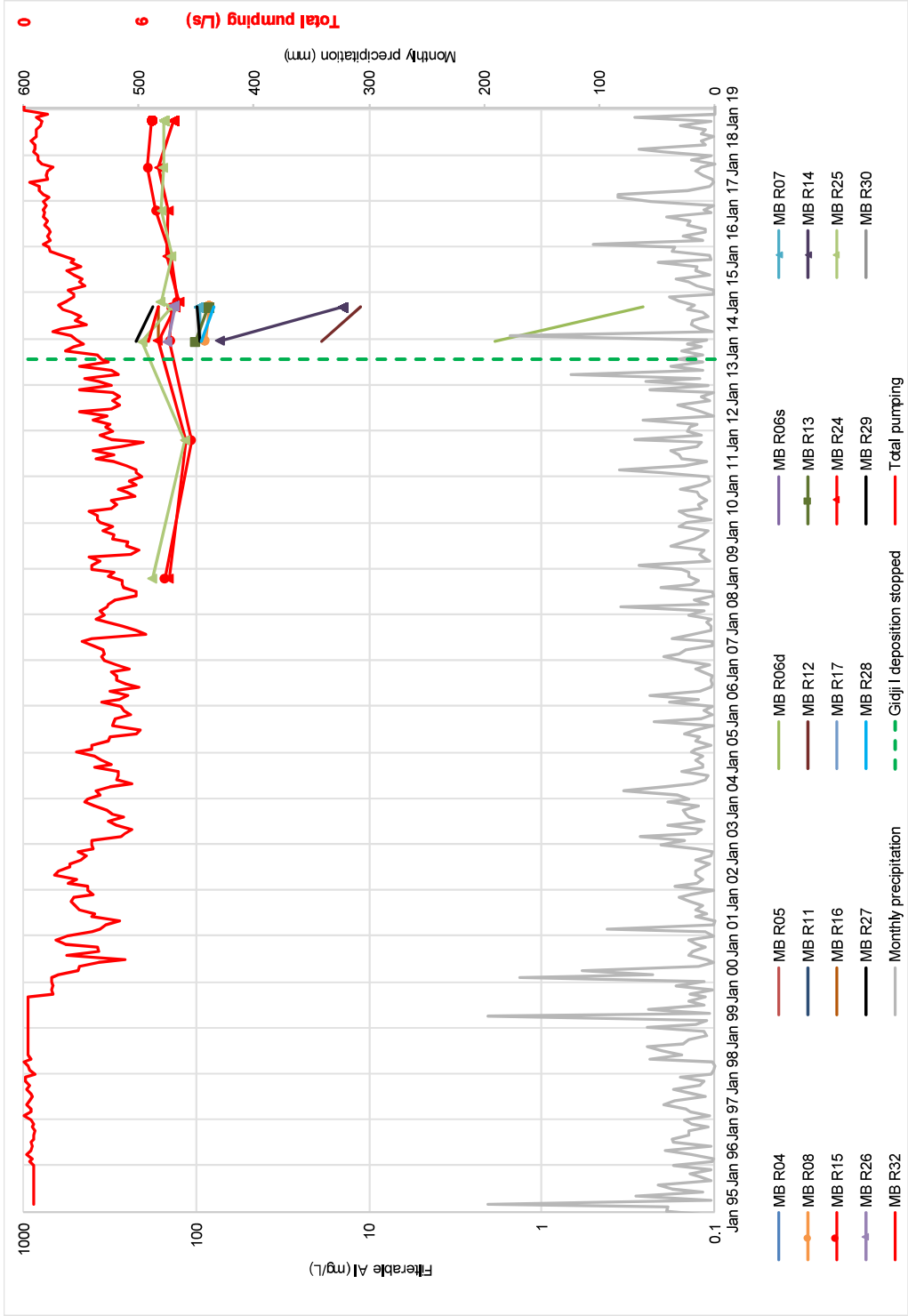
Date:	January 2019
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Groundwater Filterable Al - production bores

Figure C86

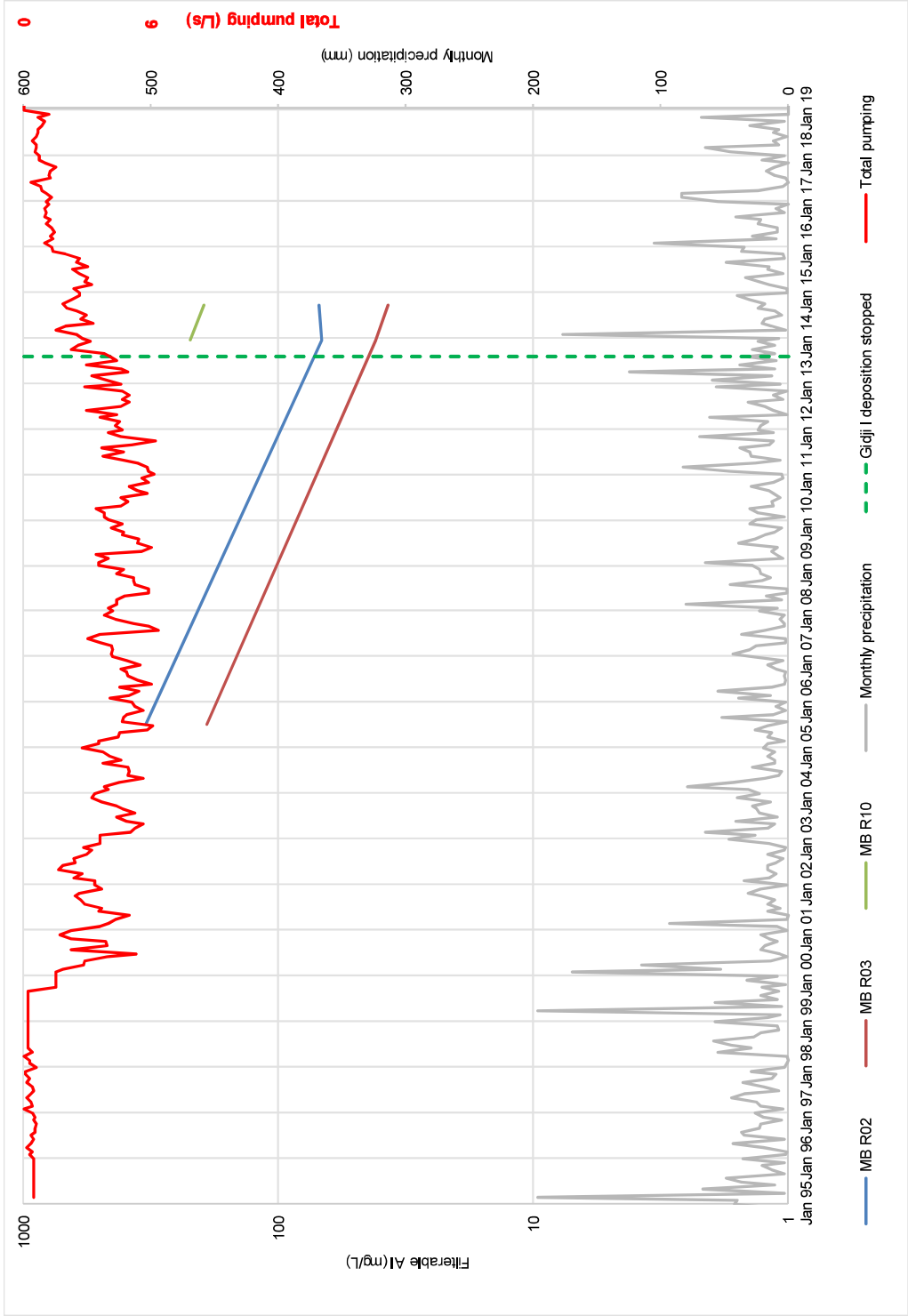
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Groundwater Filterable Al - western bores

Figure C87

Date:	January 2019
Report:	KCGM Gidji TSF Hydrogeological Review

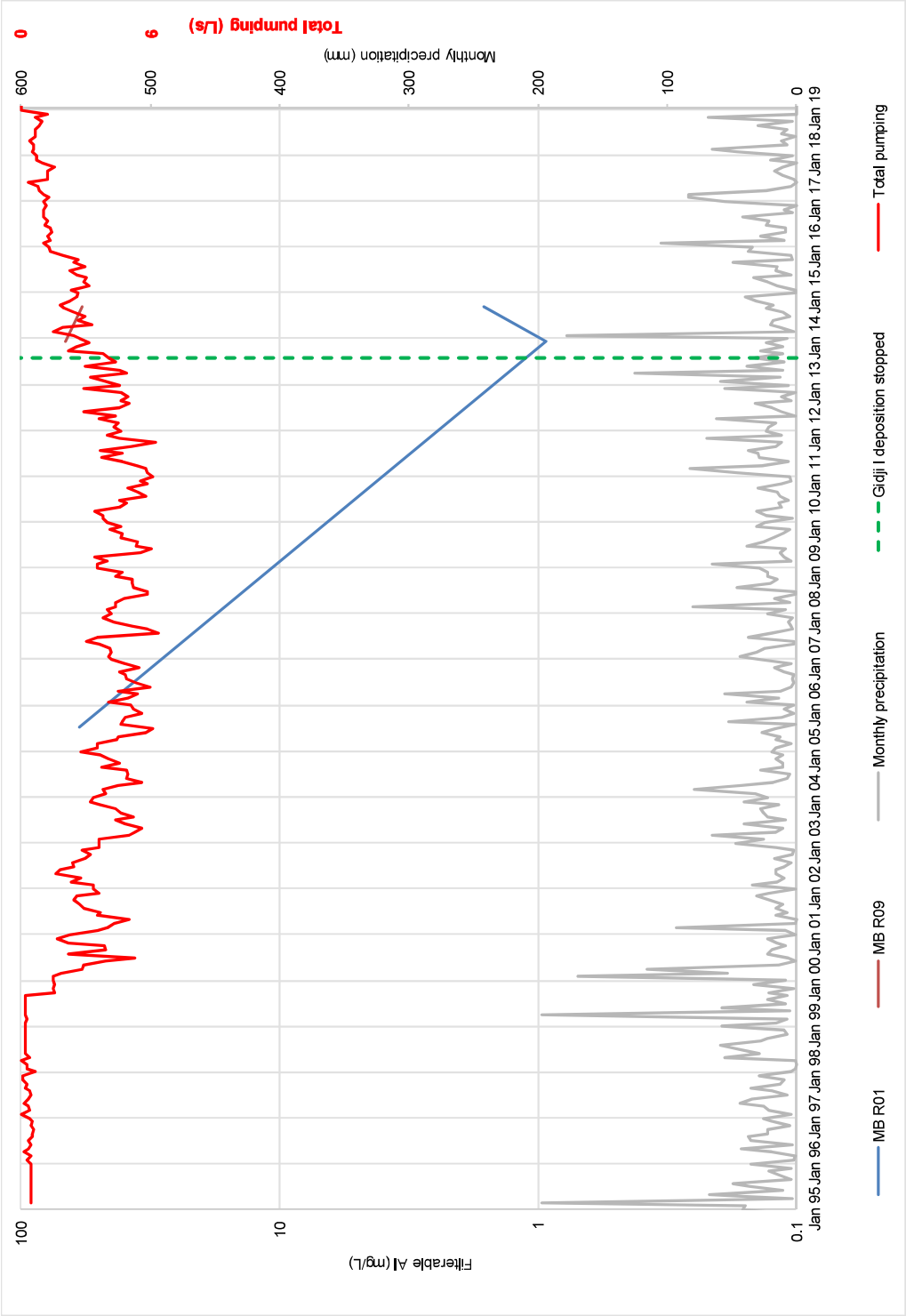


Groundwater Filterable Al - trench bores

Figure C88

Date:	January 2019
Report:	KCGM Gidji TSF Hydrogeological Review

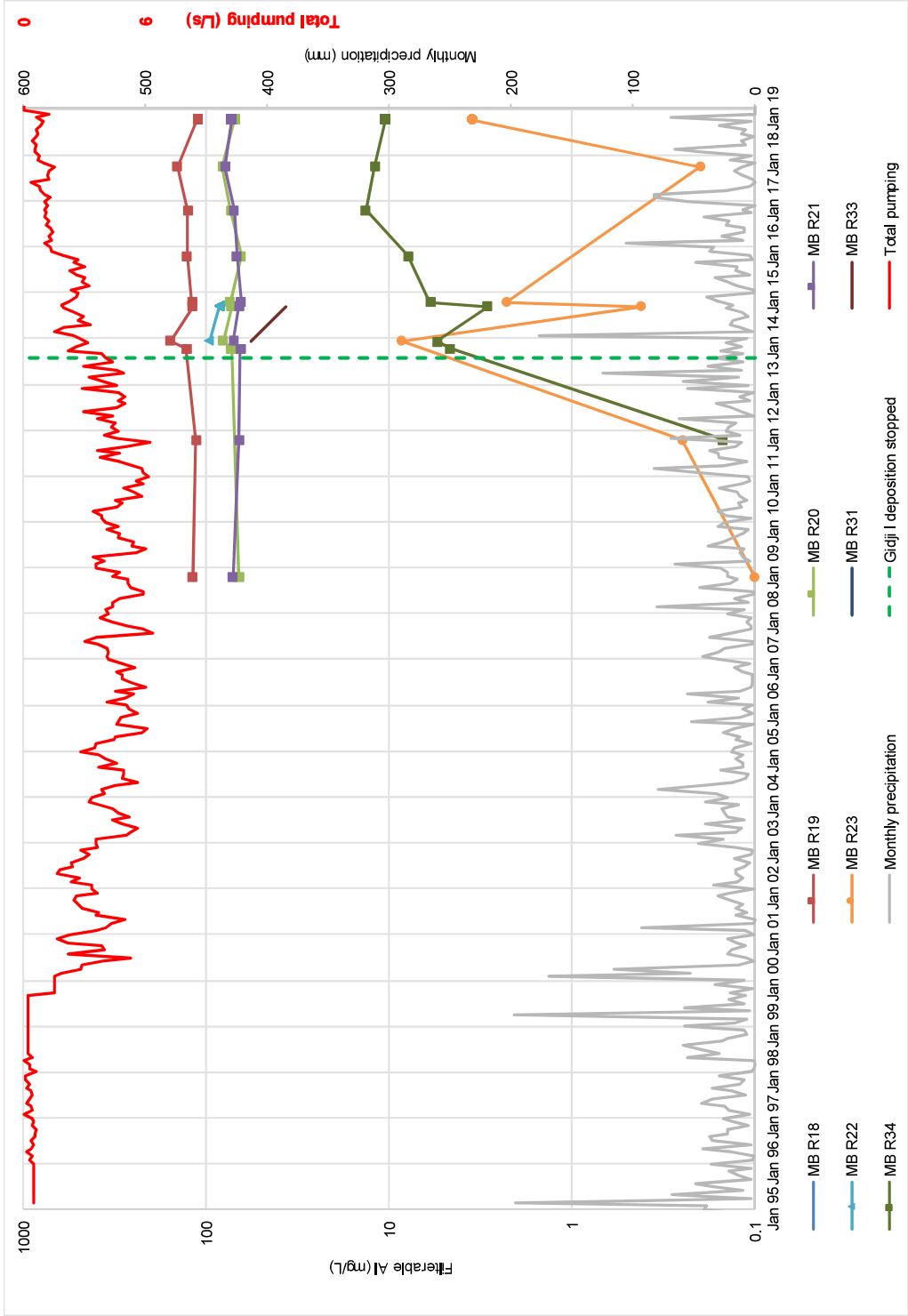




Groundwater Filterable Al - decant bores

Figure C89

Date:	January 2019
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Groundwater Filterable Al - eastern bores



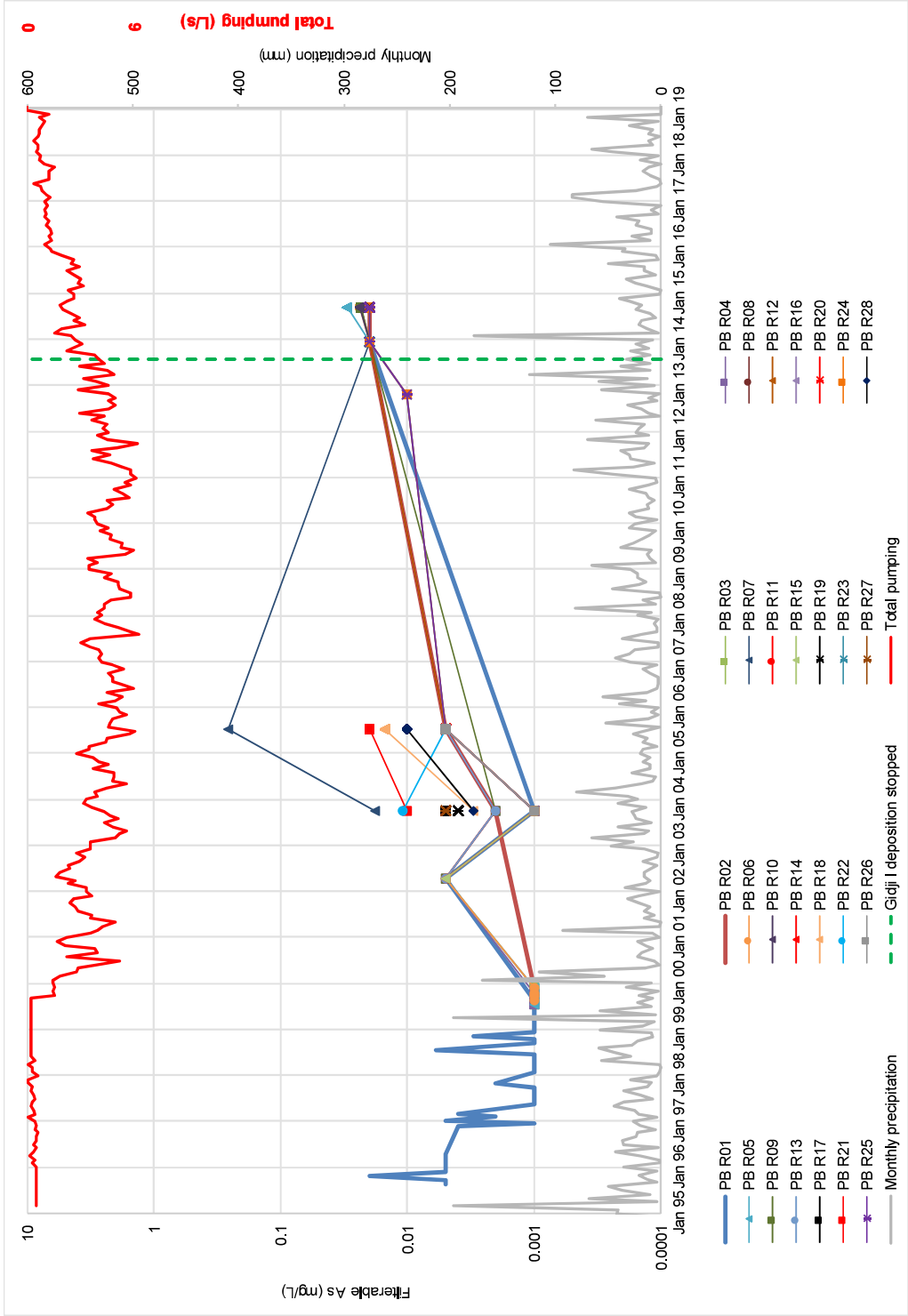
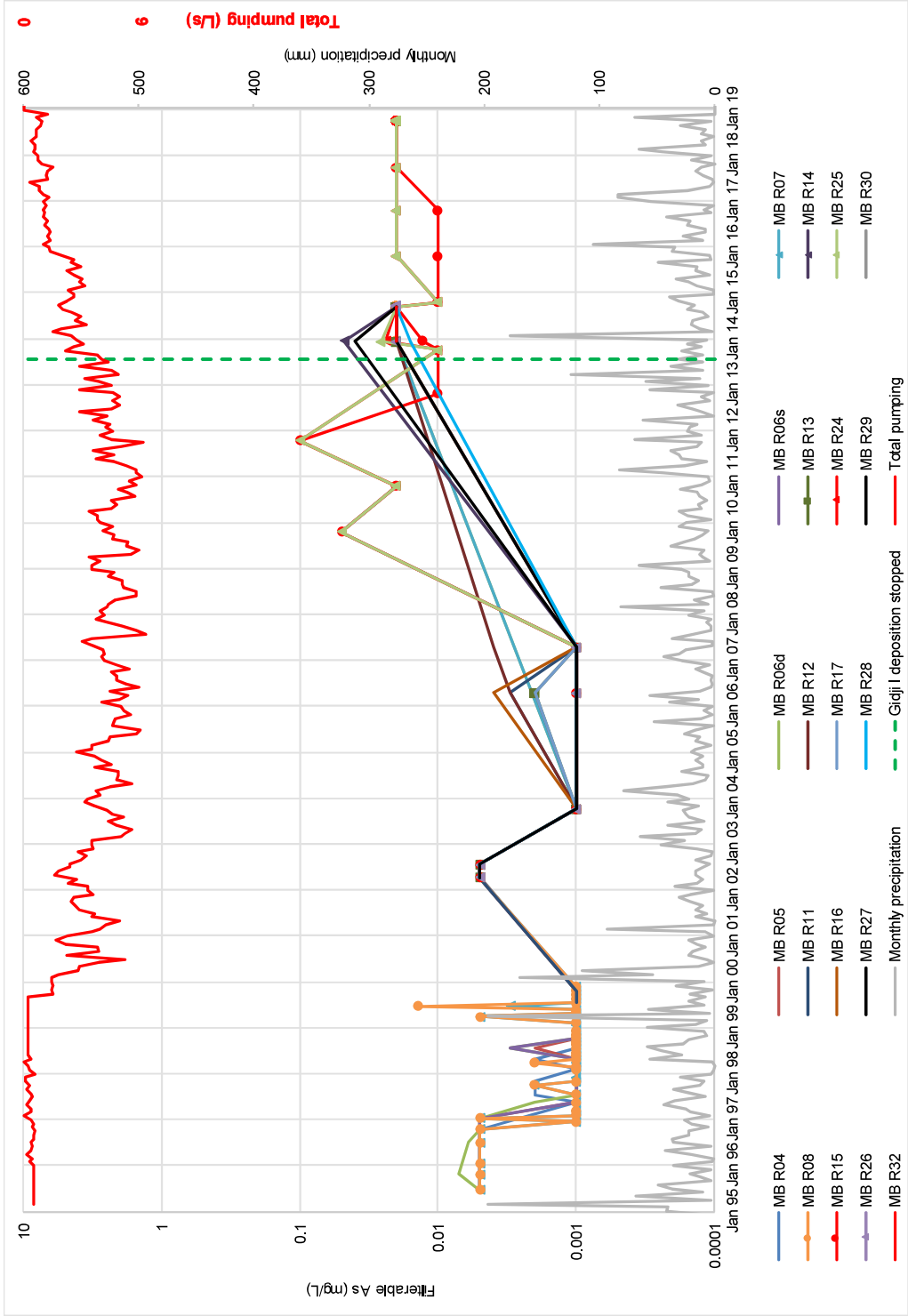


Figure C91

Date:	January 2019
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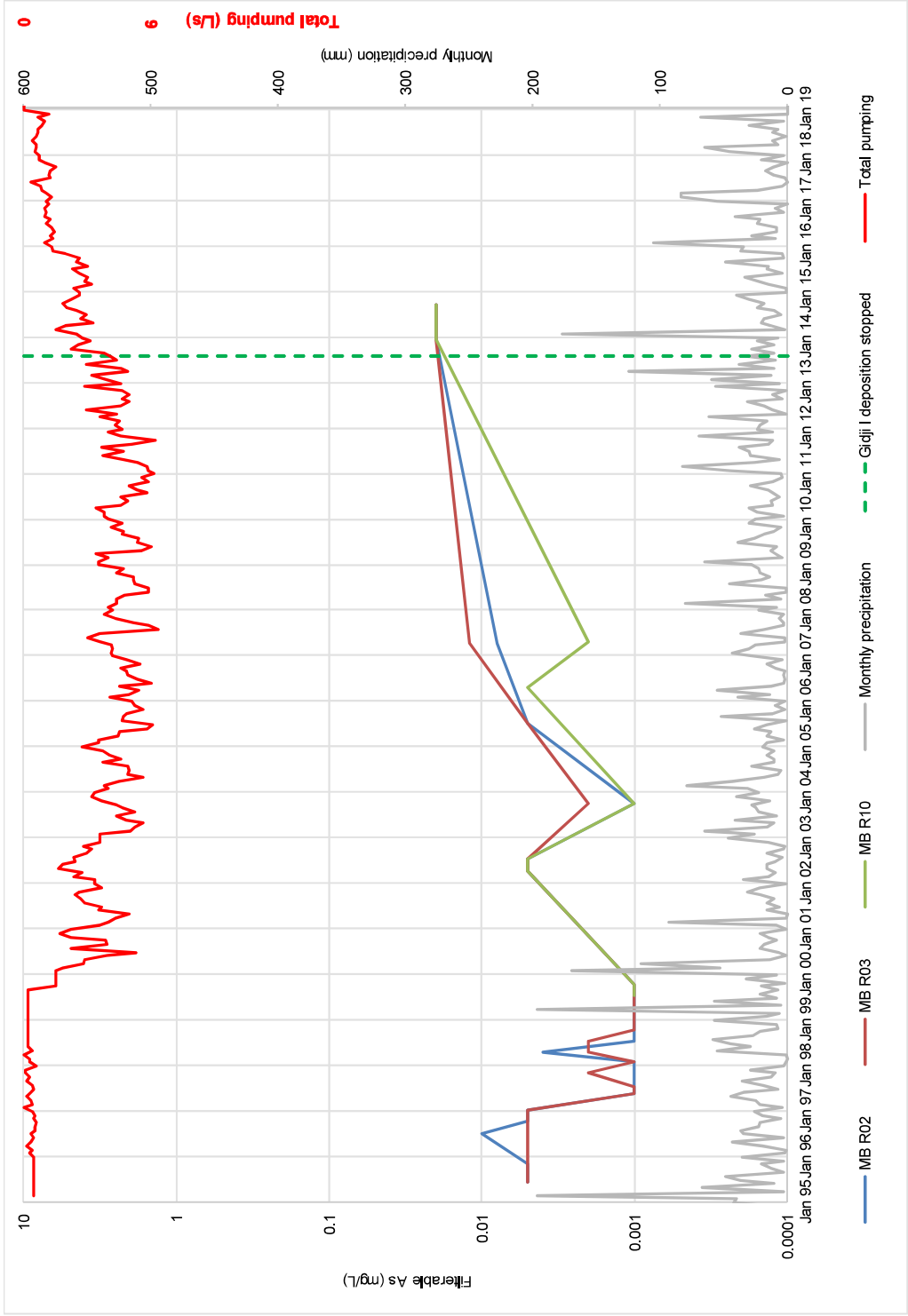
Groundwater Filterable As - production bores





Groundwater Filterable As - western bores



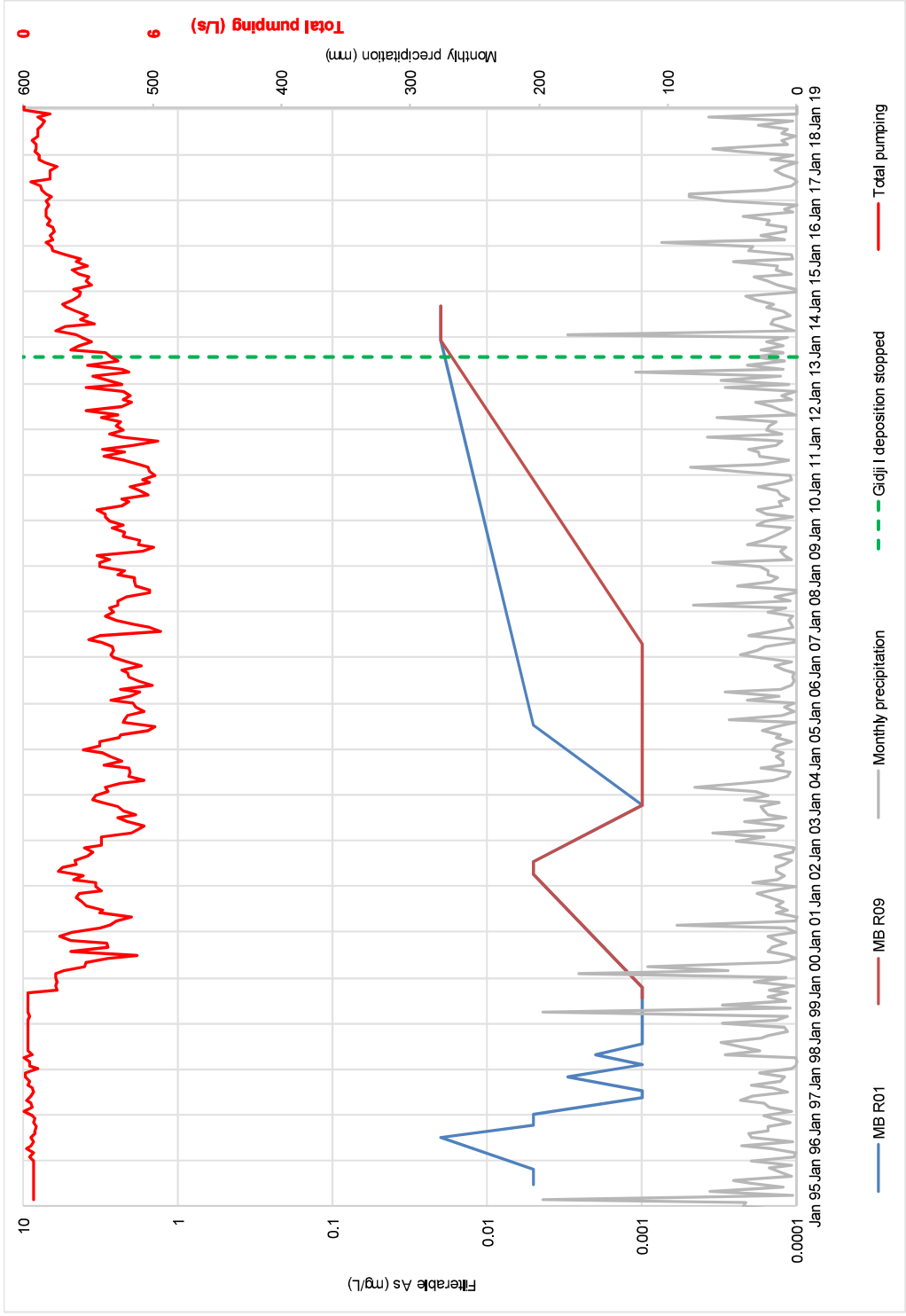


Groundwater Filterable As - trench bores

Figure C93

Date:	January 2019
Report:	KCGM Gidji TSF Hydrogeological Review



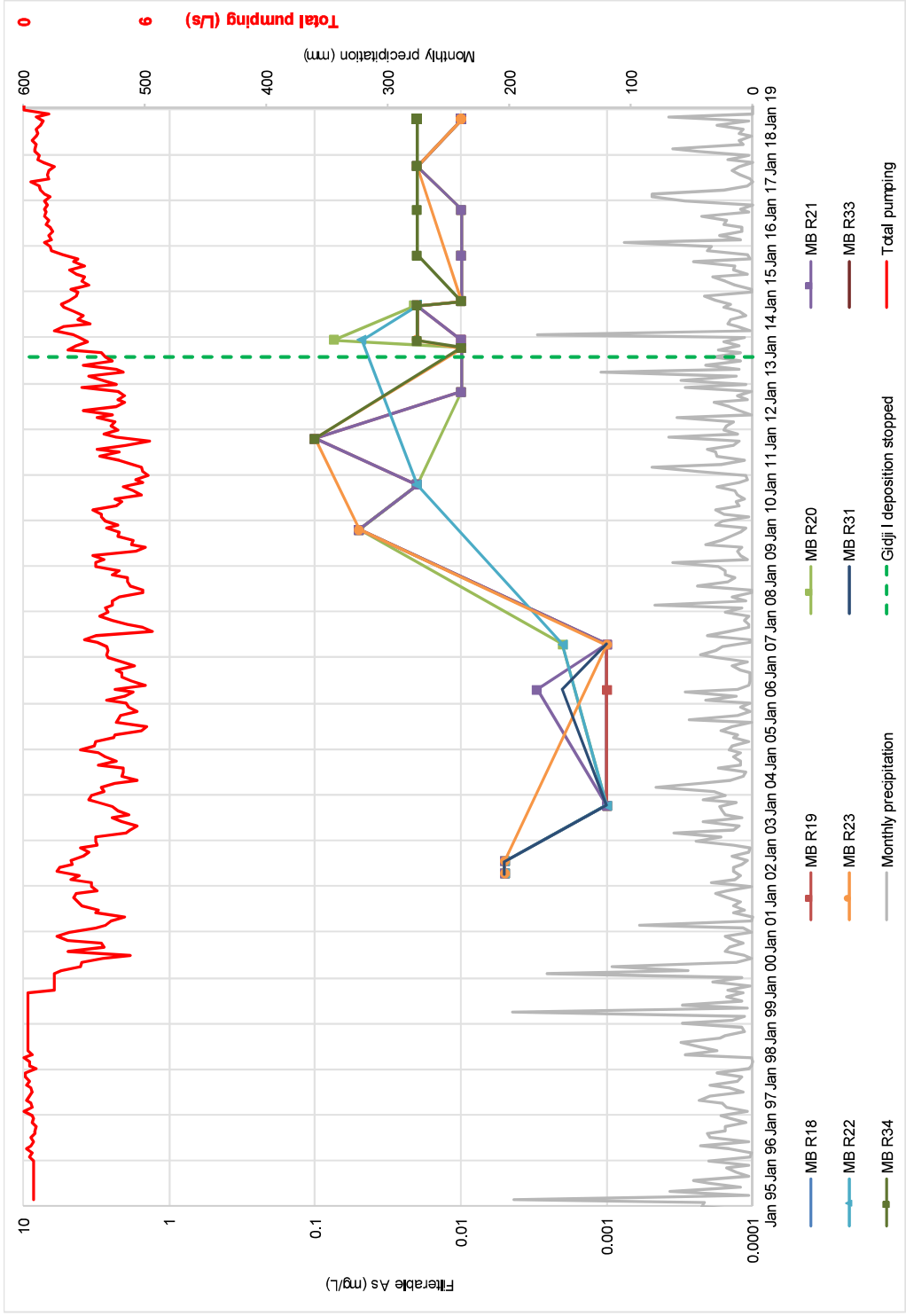


Groundwater Filterable As - decant bores

Figure C94

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Groundwater Filterable As - eastern bores

Figure C95

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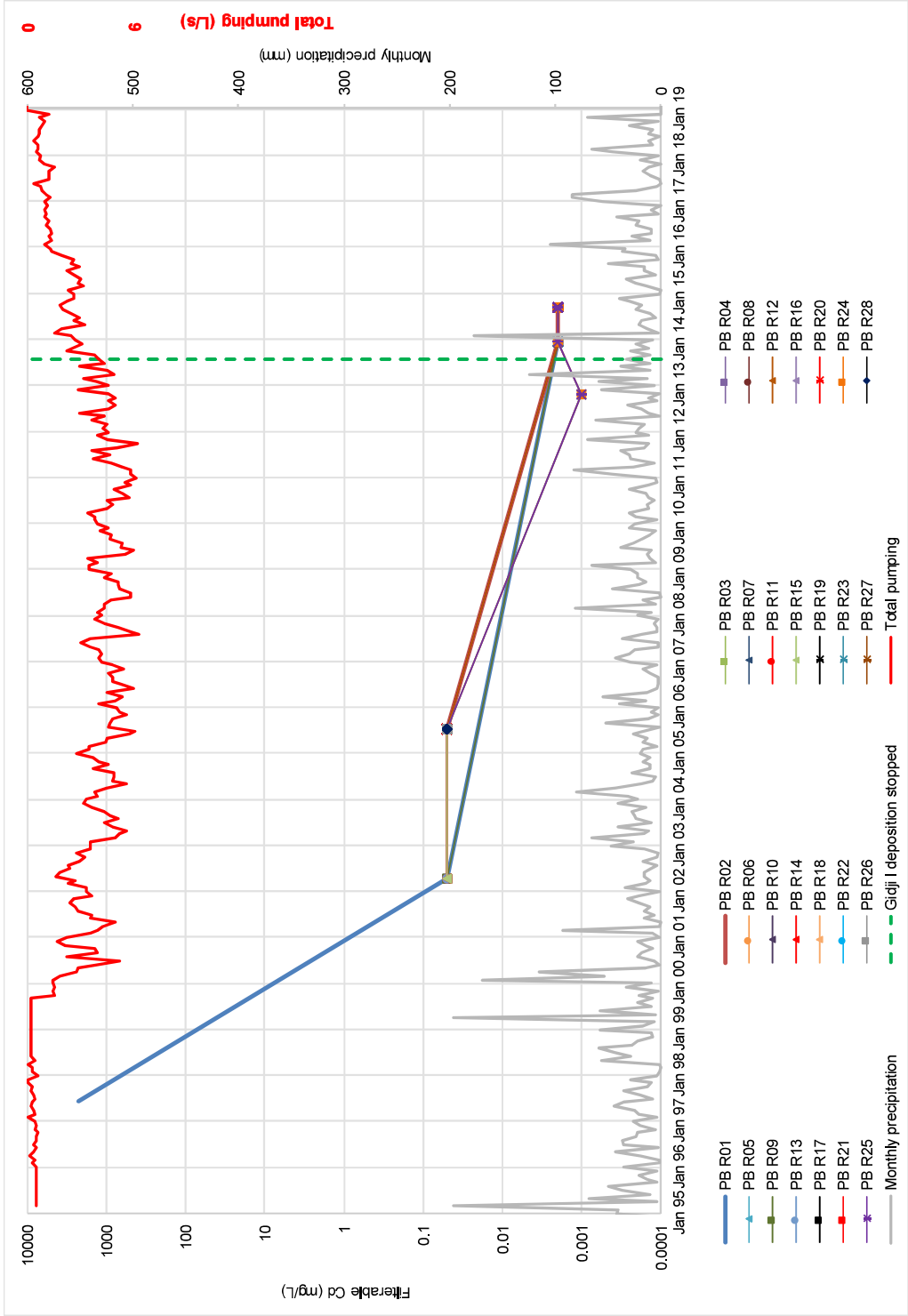
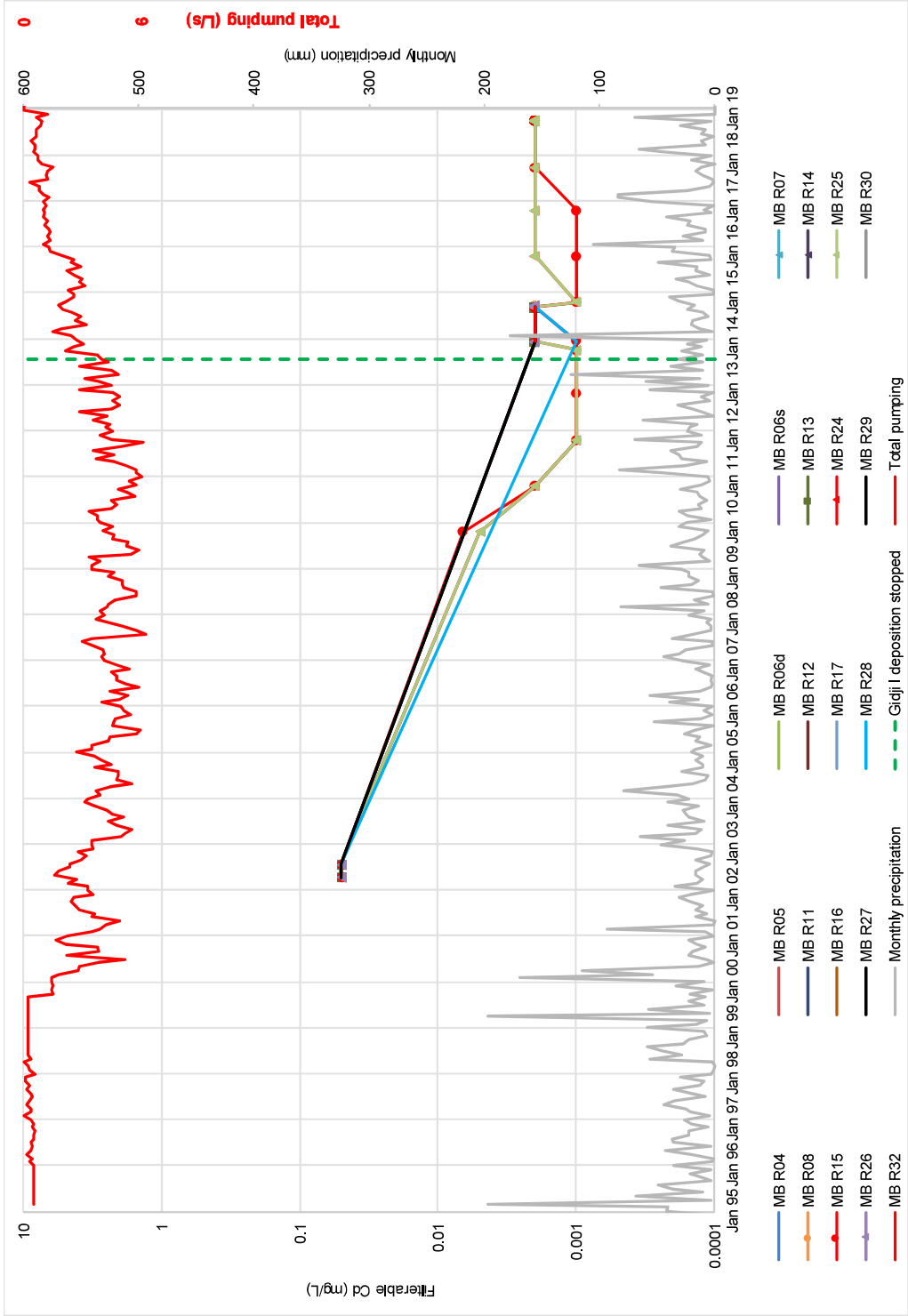


Figure C96

Date:	January 2019
Report:	KCGM Gidji TSF Hydrogeological Review

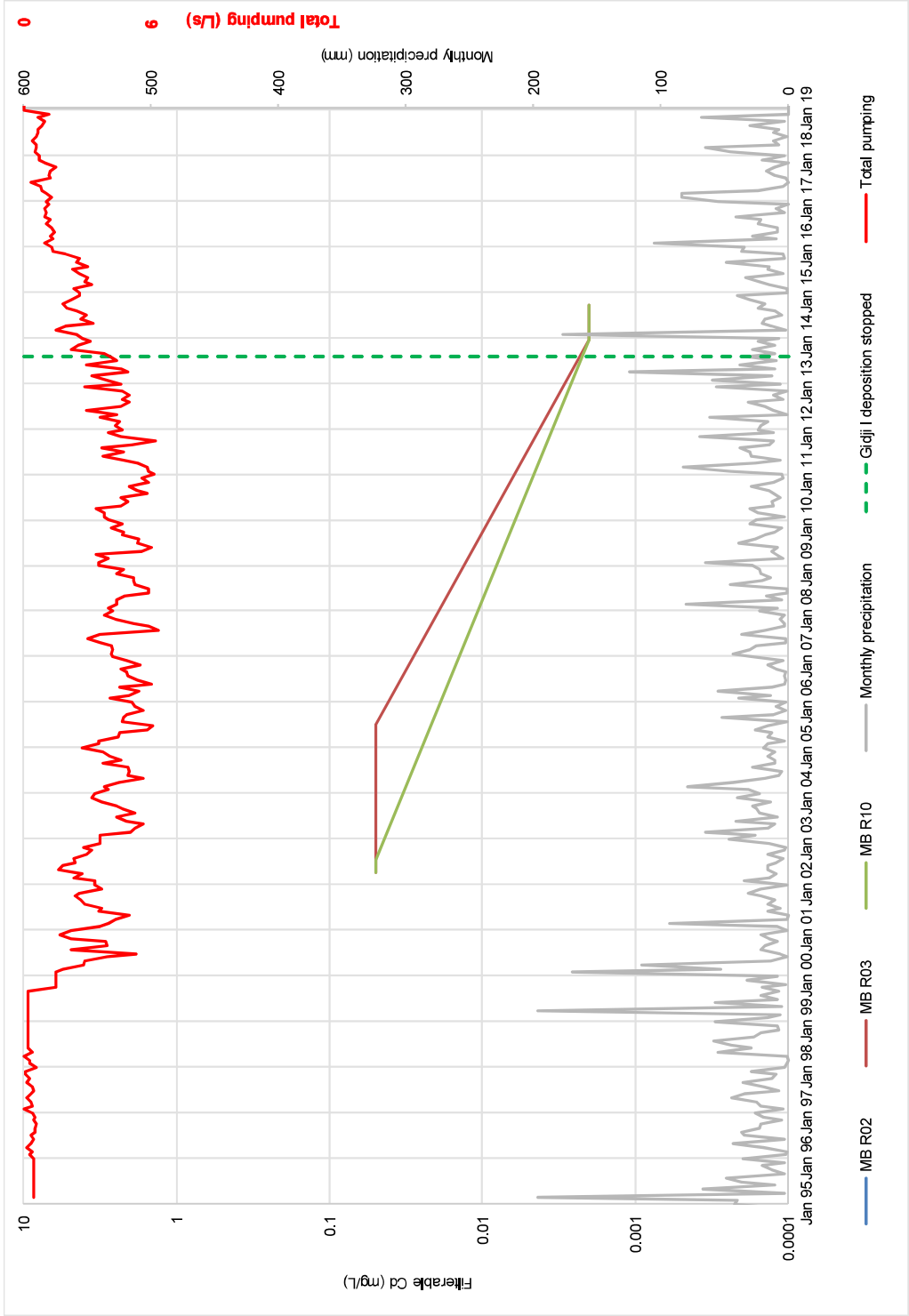
Groundwater Filterable Cd - production bores





Groundwater Filterable Cd - western bores



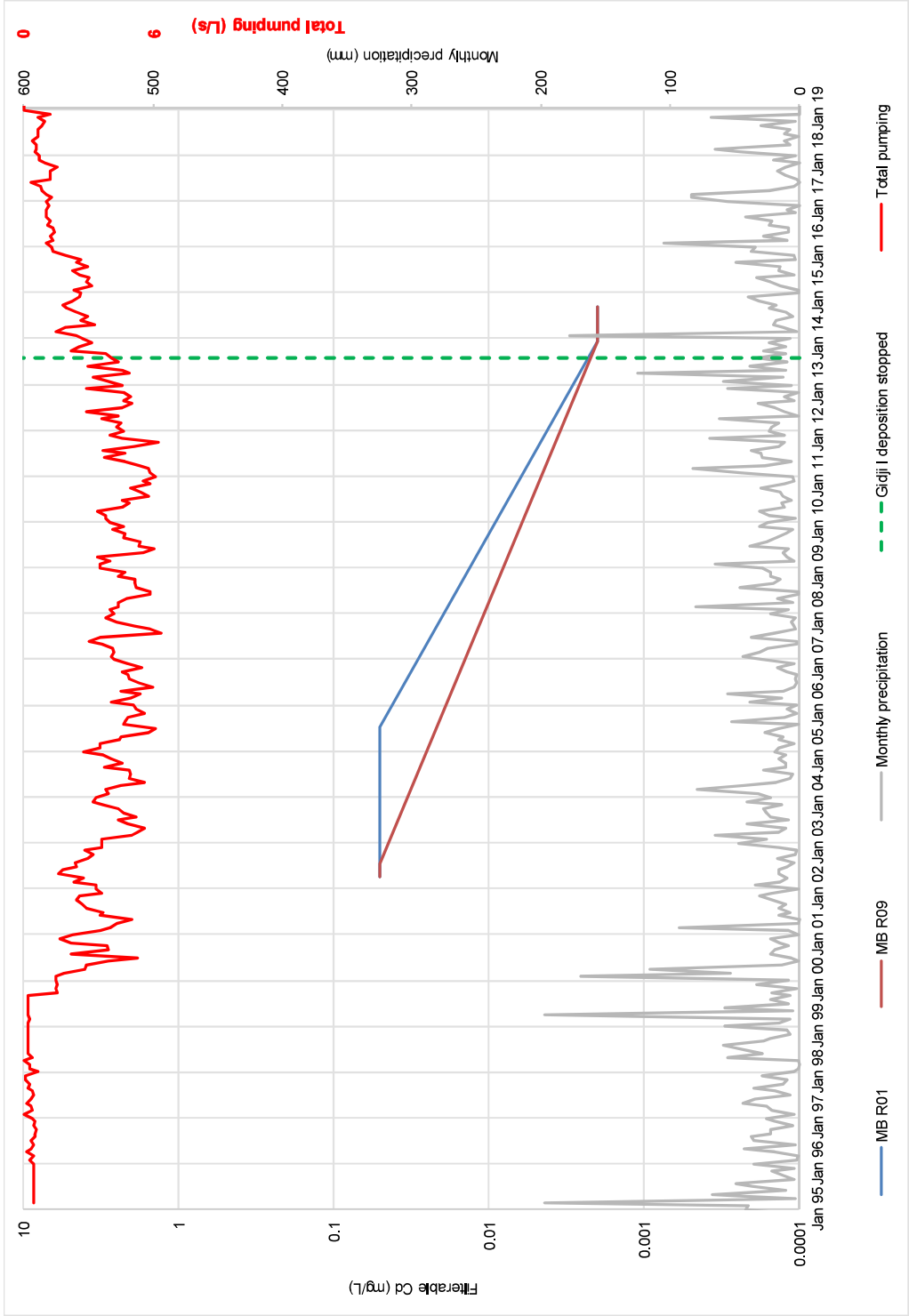


Groundwater Filterable Cd - trench bores

Figure C98

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Groundwater Filterable Cd - decant bores

Figure C99

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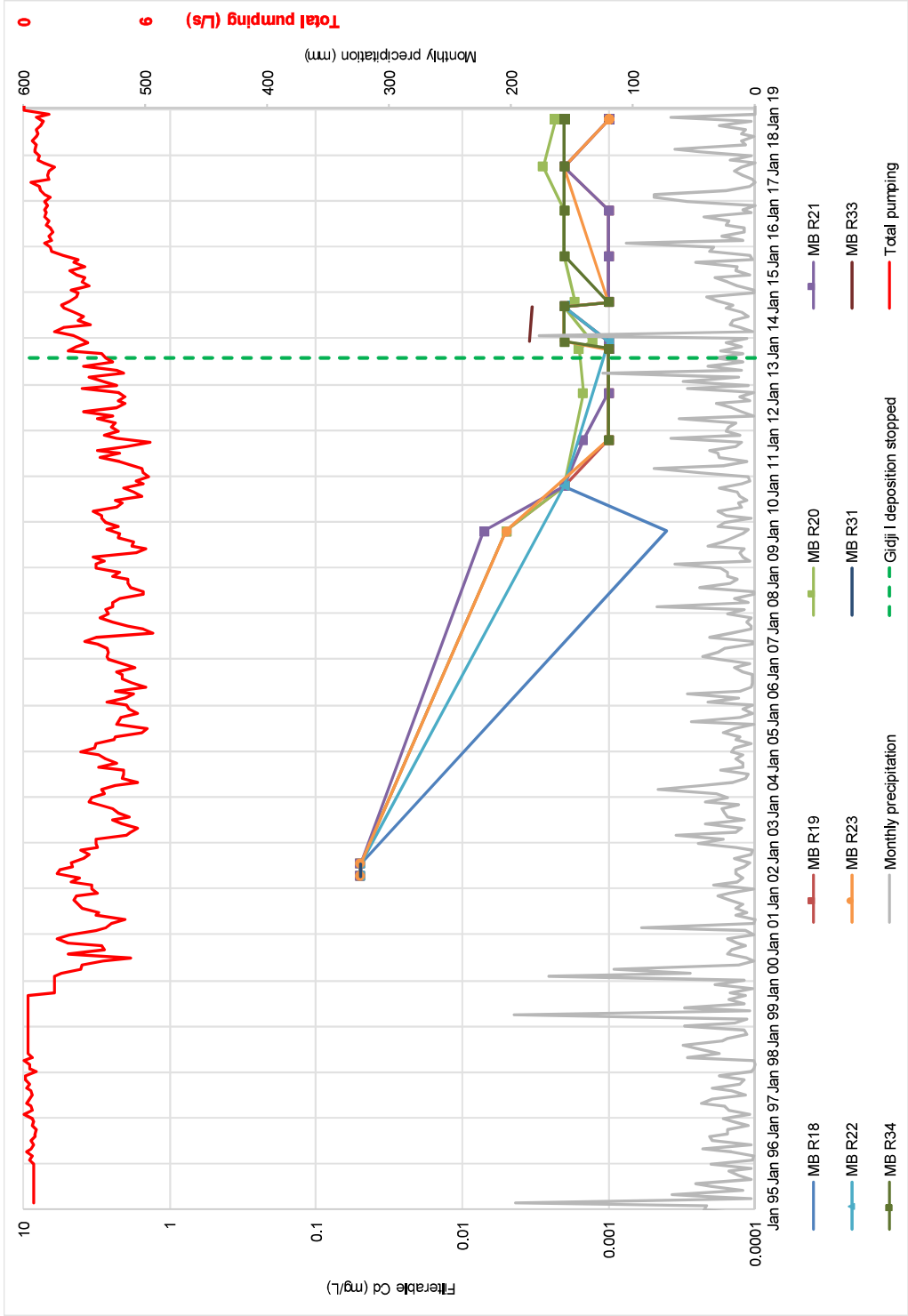


Figure C100

Date:	January 2019
Report:	KCGM Gidji TSF Hydrogeological Review

Groundwater Filterable Cd - eastern bores



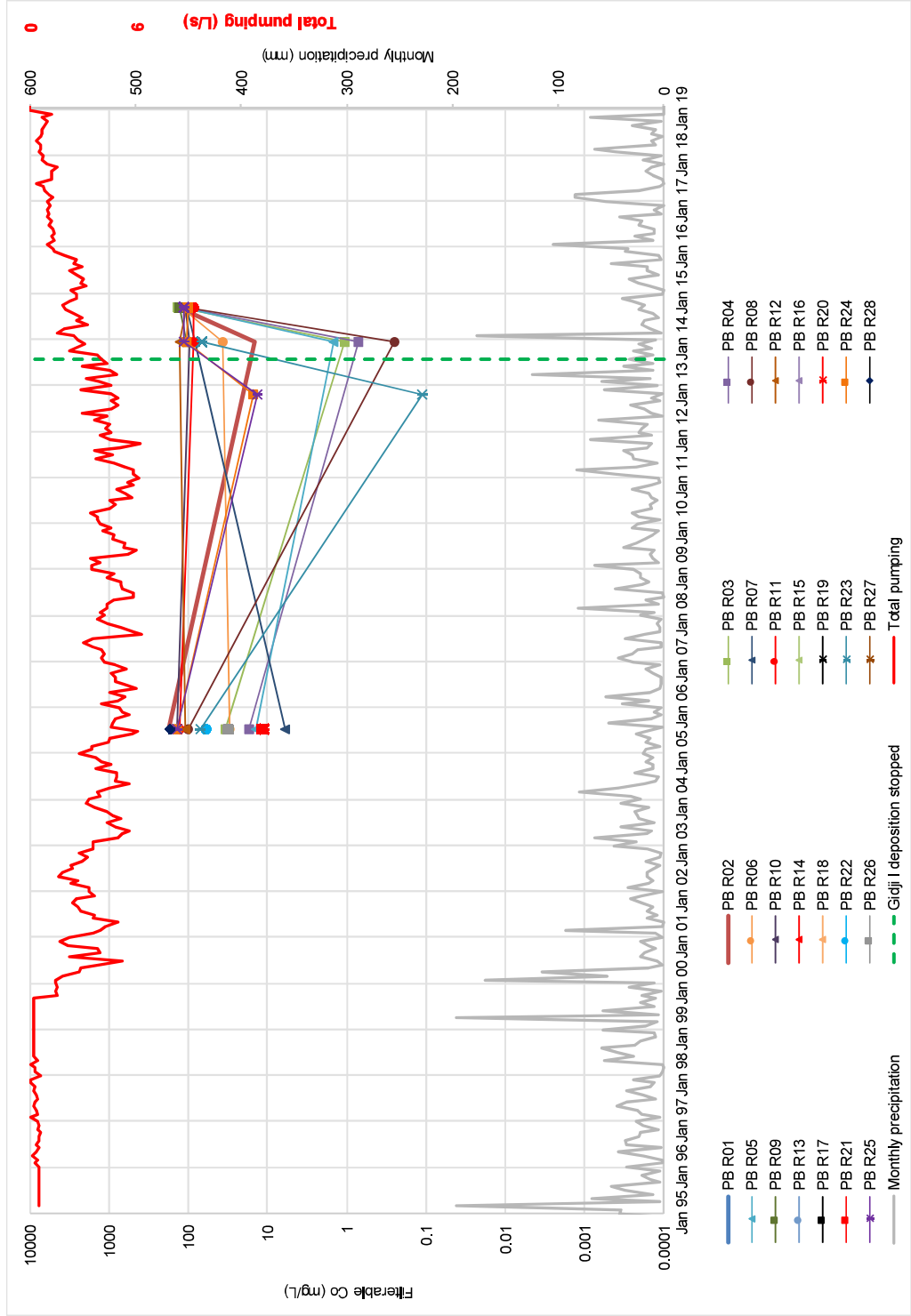


Figure C101

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Hydrogeological Review

Groundwater Filterable Co - production bores



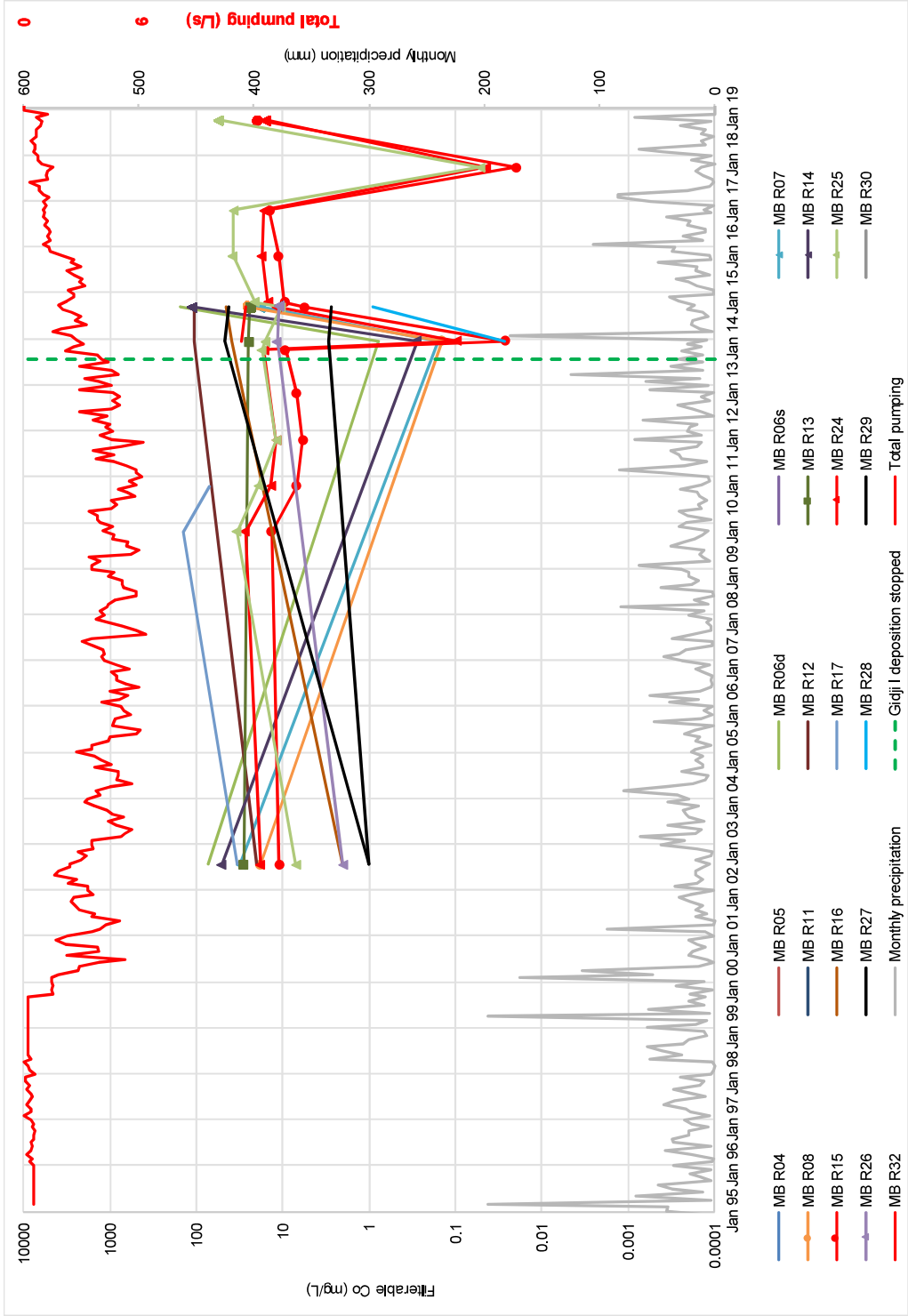
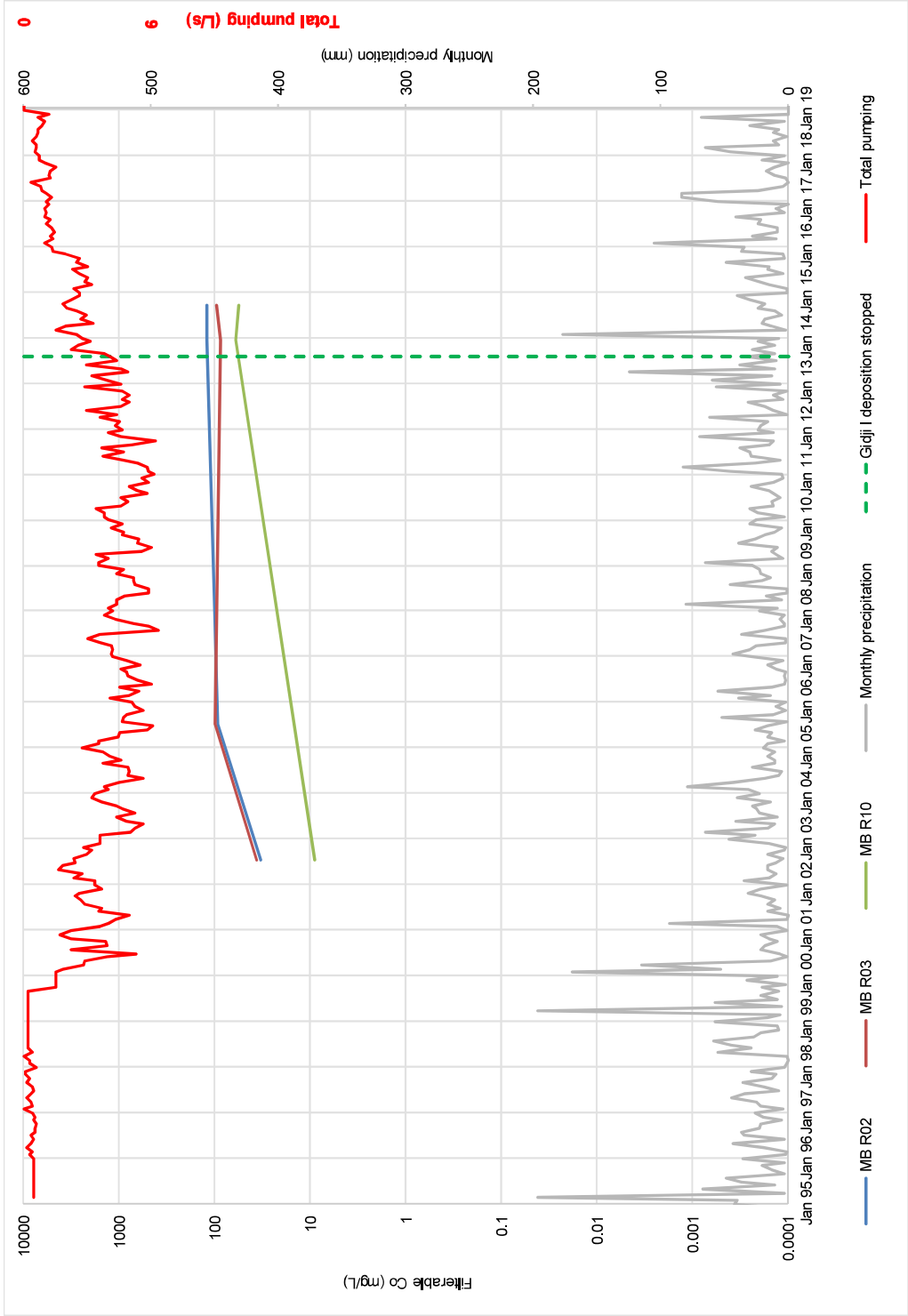


Figure C102

Date: January 2019
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Groundwater Filterable Co - western bores



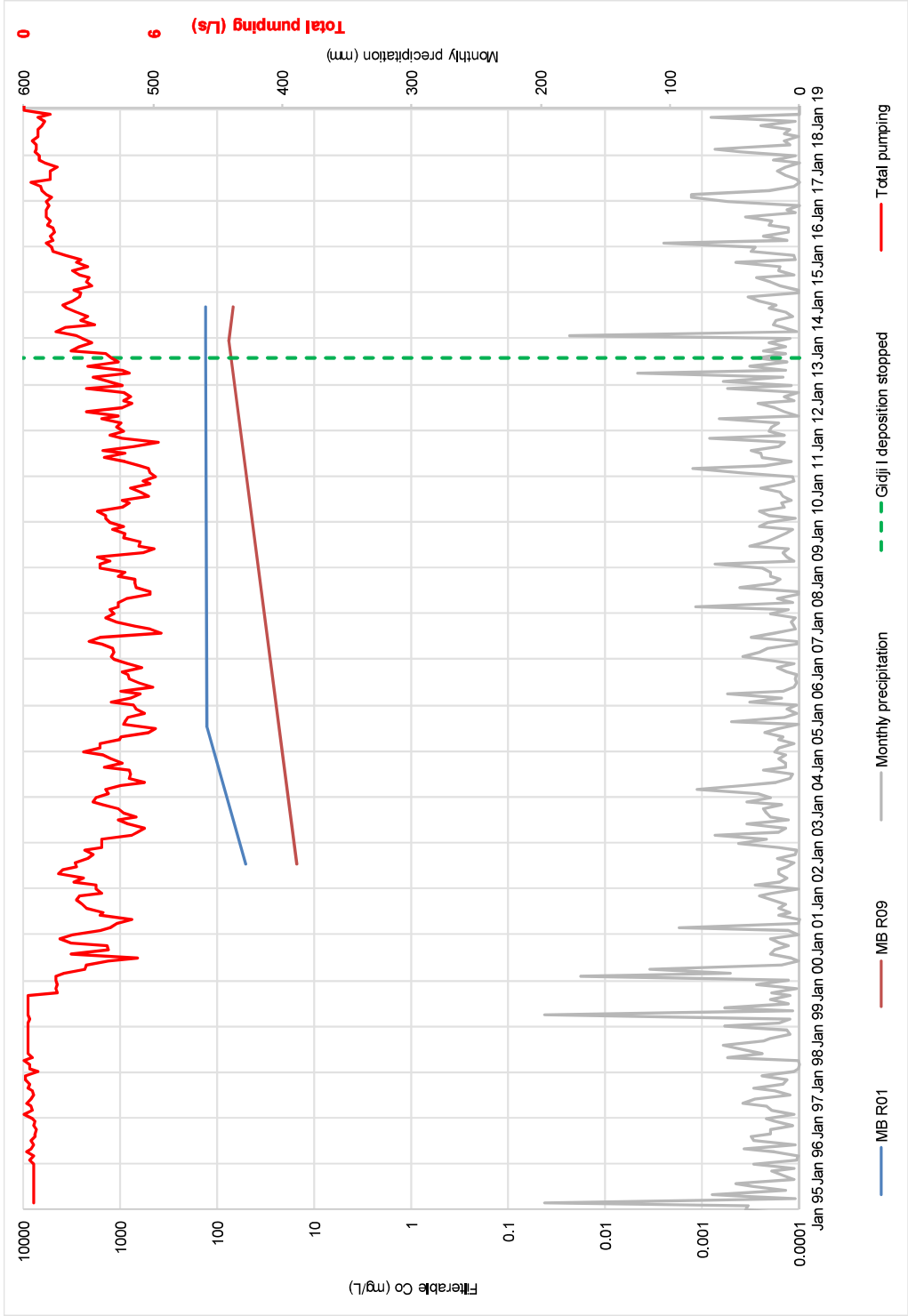


Groundwater Filterable Co - trench bores

Figure C103

Date:	January 2019
Report:	KCGM Gidji TSF Hydrogeological Review



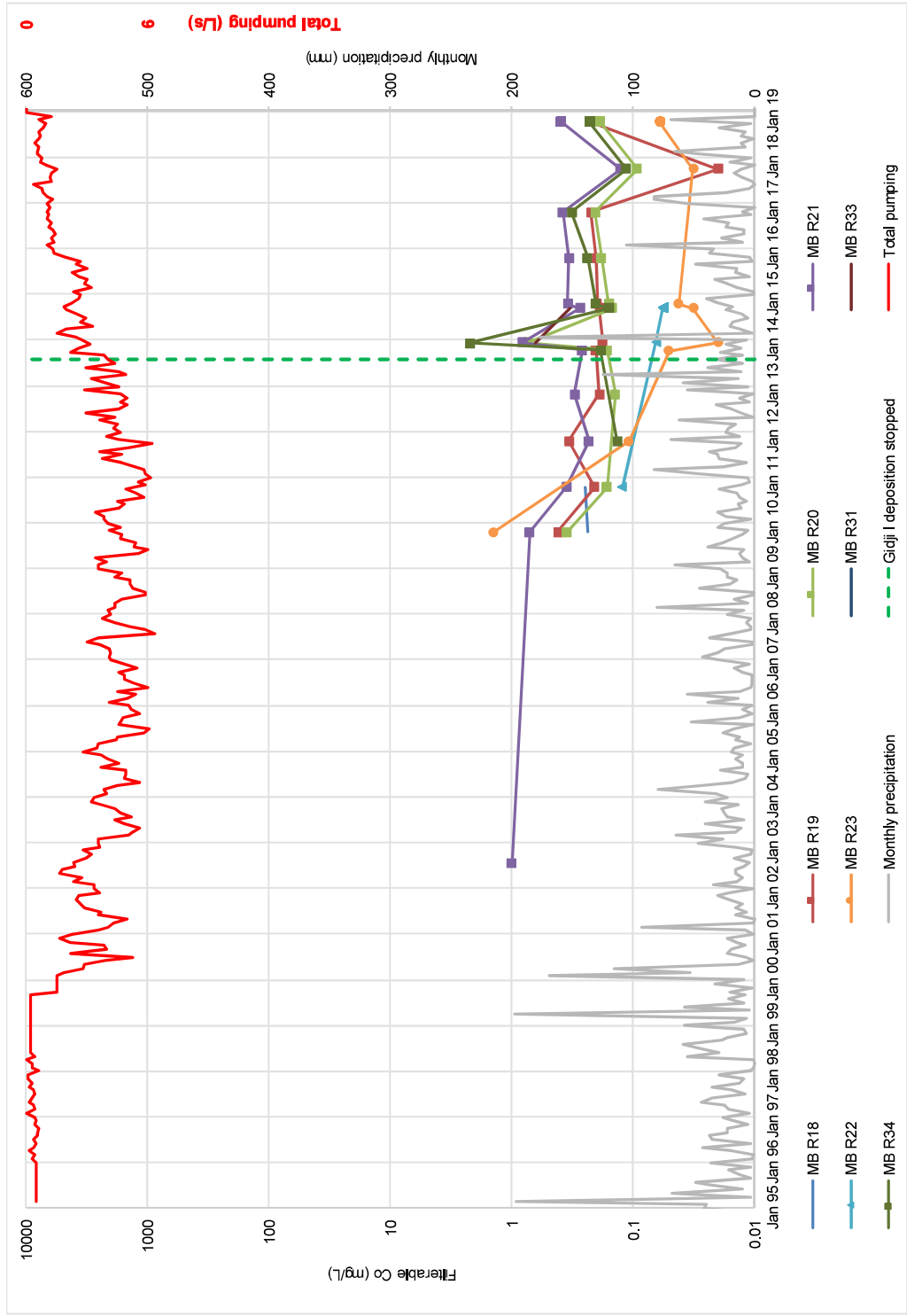


Groundwater Filterable Co - decant bores

Figure C104

Date:	January 2019
Report:	KCGM Gidji TSF Hydrogeological Review





Groundwater Filterable Co - eastern bores

Figure C105

Date: January 2019

Report: KCGM Gidji TSF
Hydrogeological Review

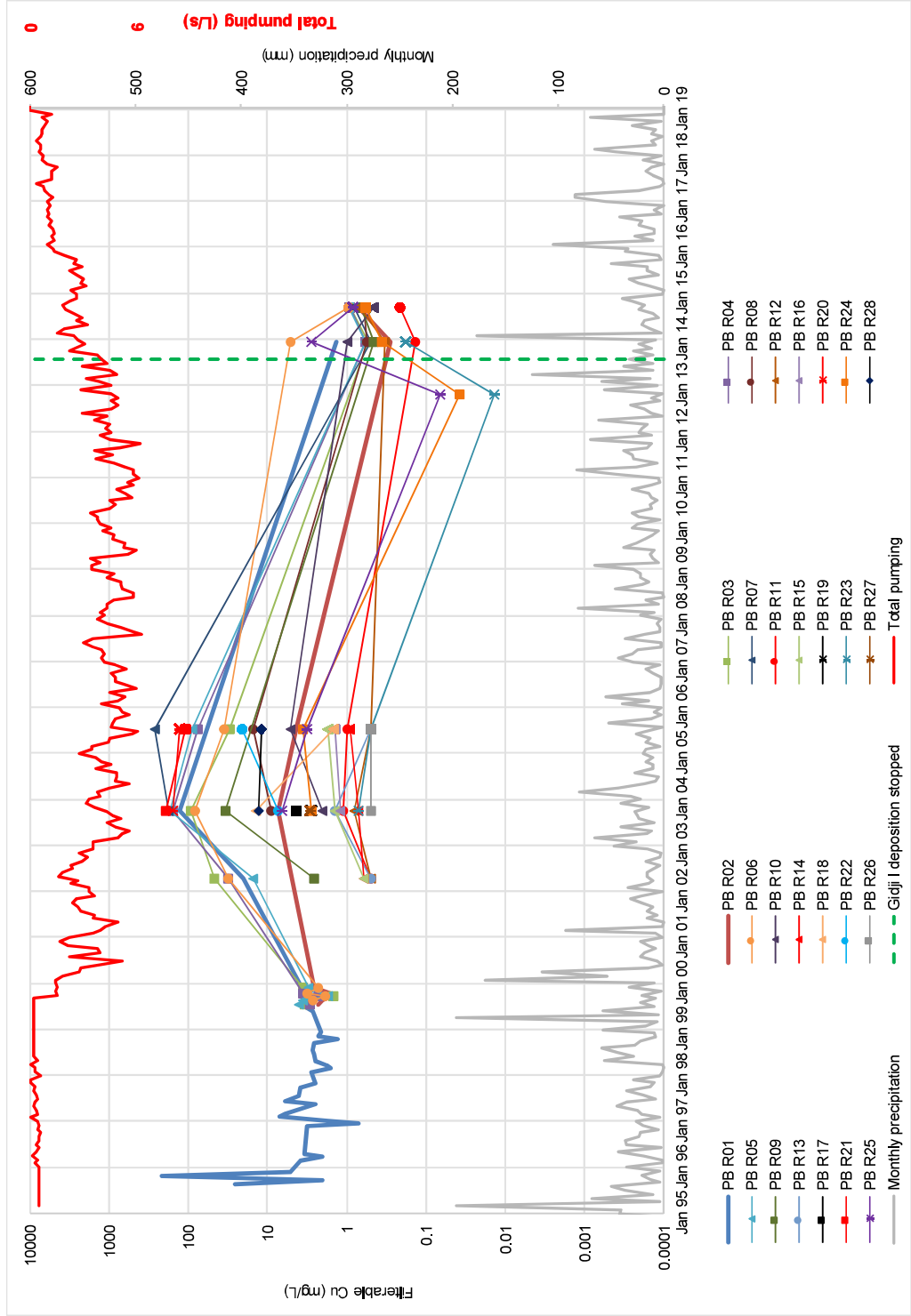
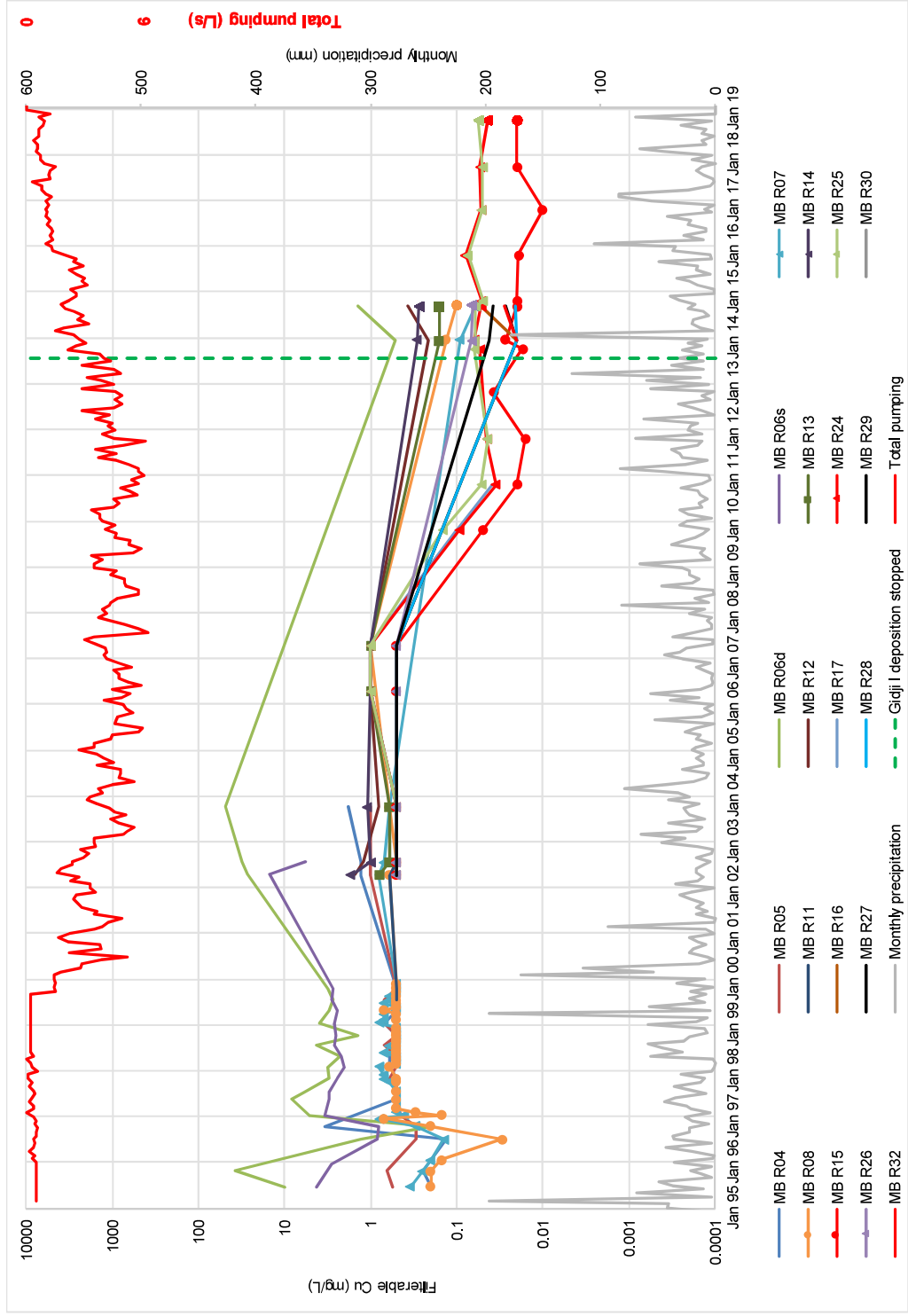


Figure C106

Date:	January 2019
Report:	KCGM Gidji TSF Hydrogeological Review

Groundwater Filterable Cu - production bores





Groundwater Filterable Cu - western bores

Figure C107

Date:	January 2019
Report:	KCGM Gidji TSF Hydrogeological Review



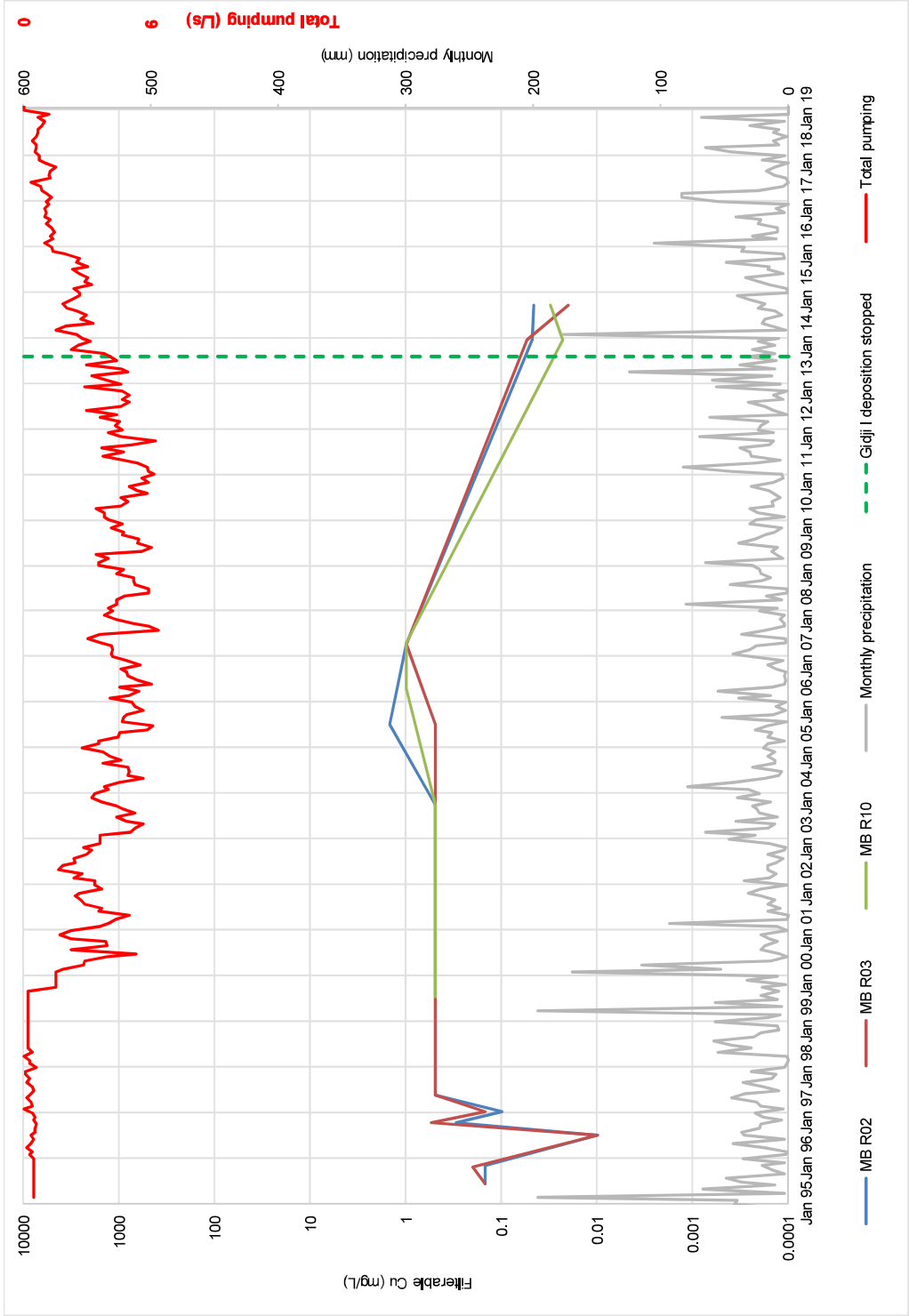


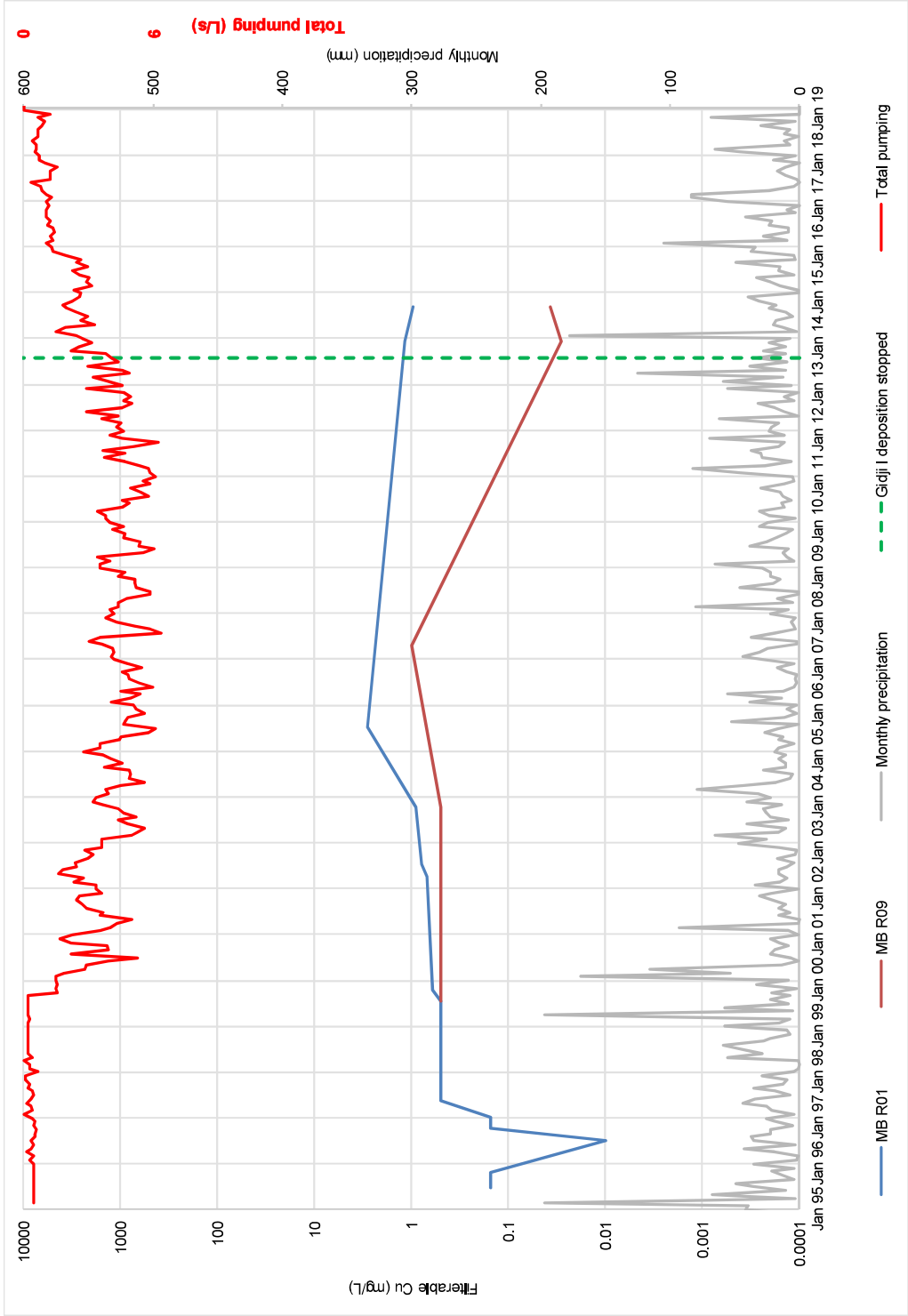
Figure C108

Date: January 2019

Report: KCGM Gidji TSF
Hydrogeological Review

Groundwater Filterable Cu - trench bores





Groundwater Filterable Cu - decant bores

Figure C109

Date:	January 2019
Report:	KCGM Gidji TSF Hydrogeological Review



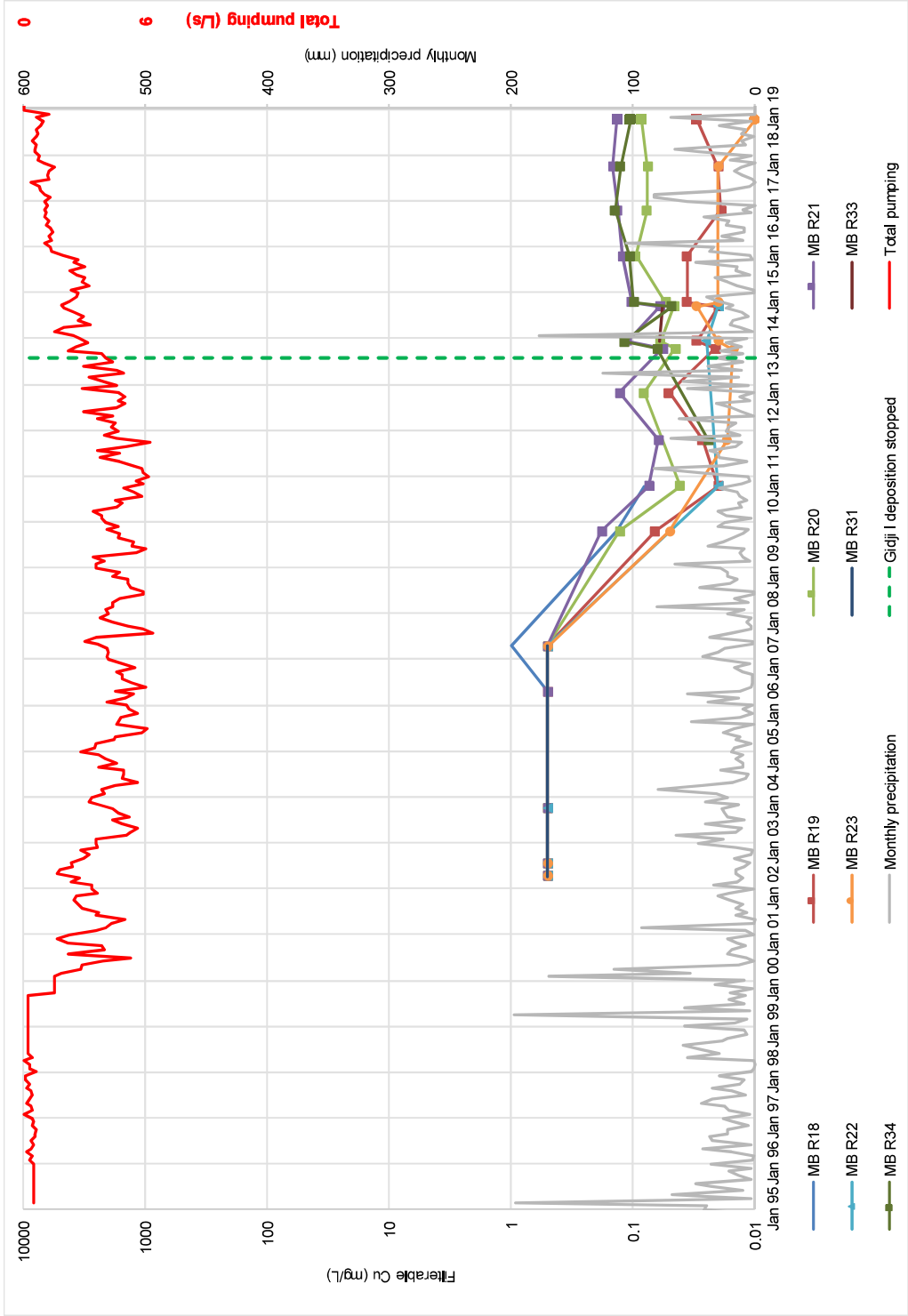
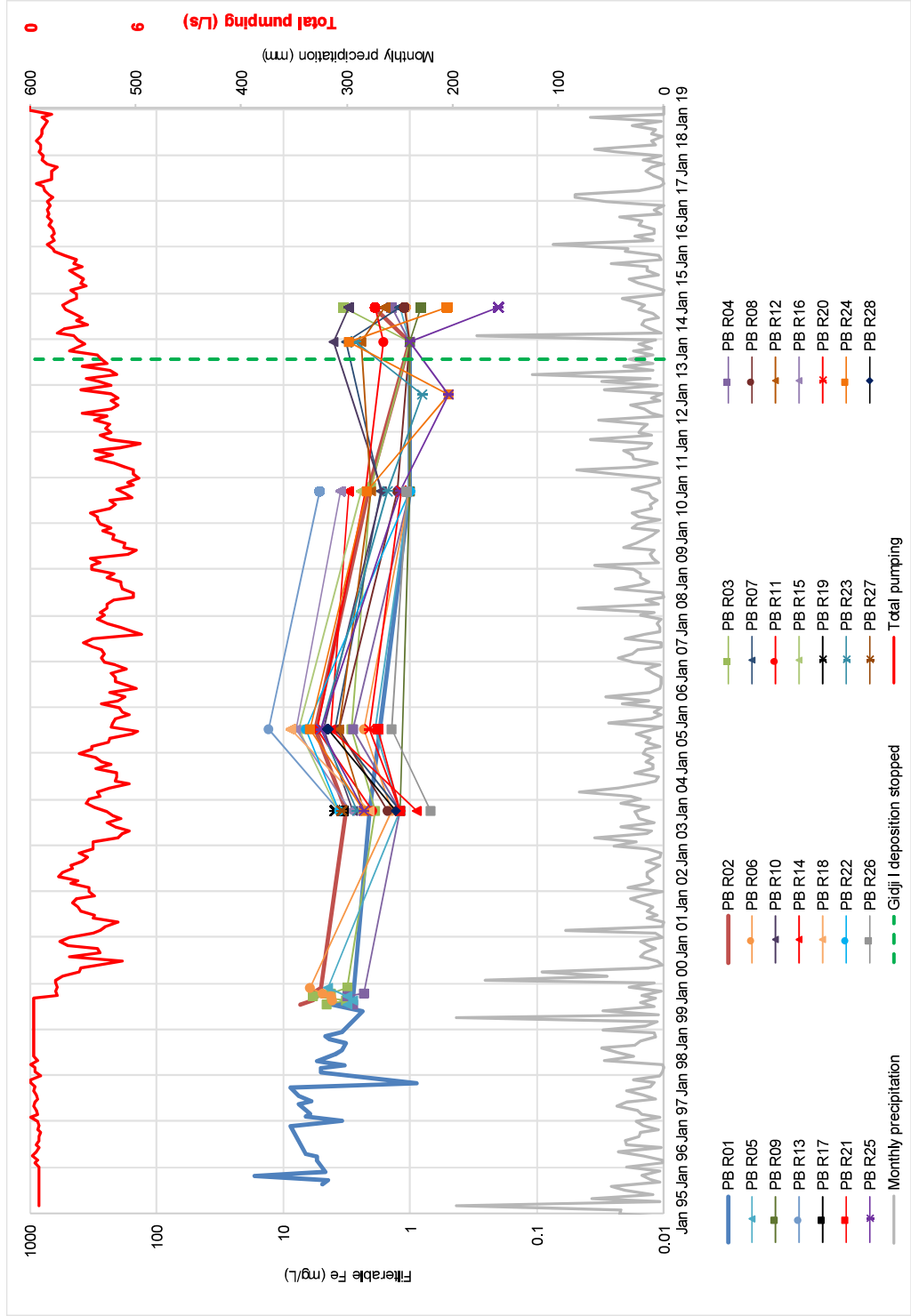


Figure C110

Date:	January 2019
Report:	KCGM Gidji TSF Hydrogeological Review

Groundwater Filterable Cu - eastern bores





Groundwater Filterable Fe - production bores

Figure C111

Date:	January 2019
Report:	KCGM Gidji TSF Hydrogeological Review

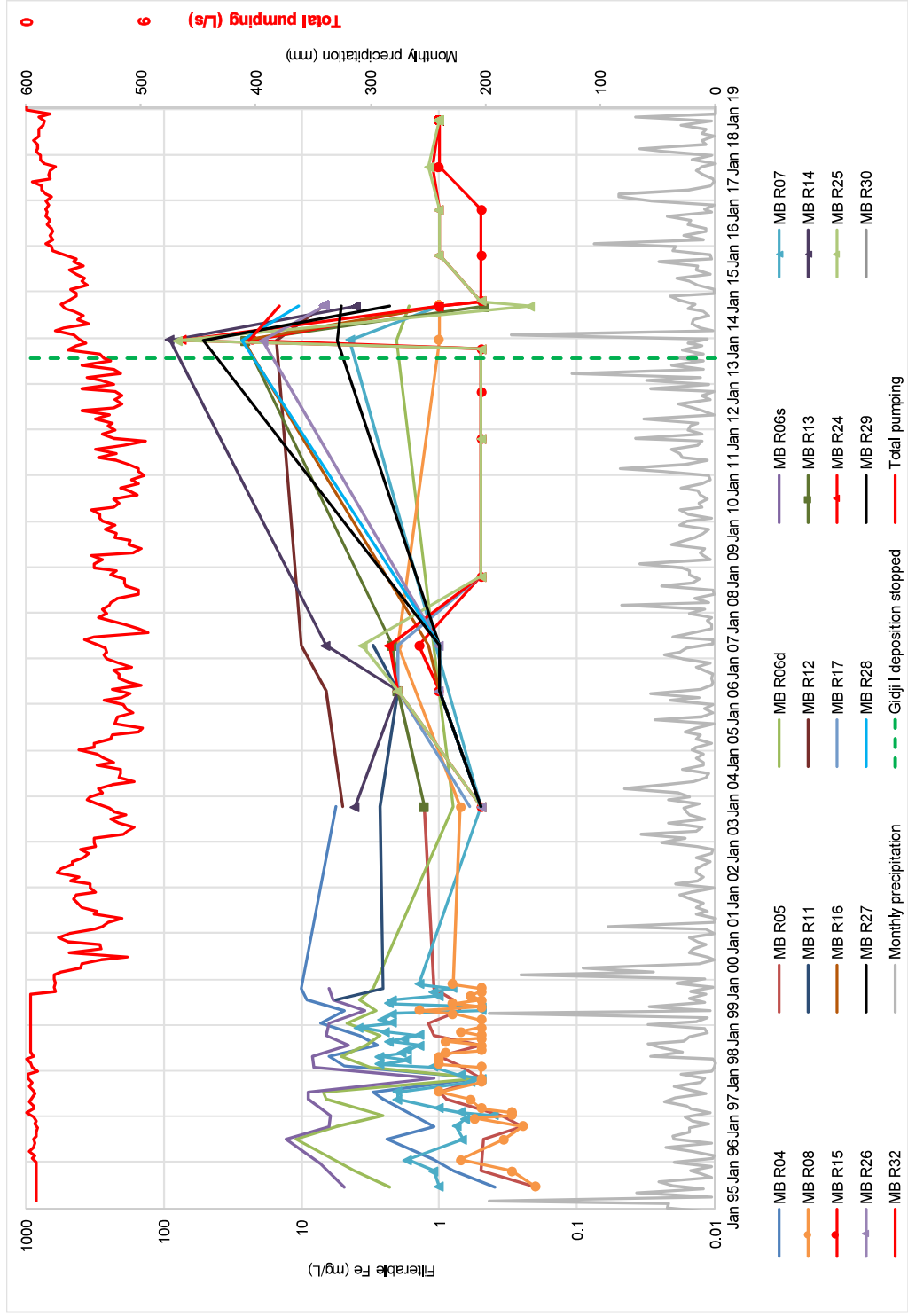


Figure C112

Date: January 2019
Report: KCGM Gidji TSF
Hydrogeological Review

Groundwater Filterable Fe - western bores



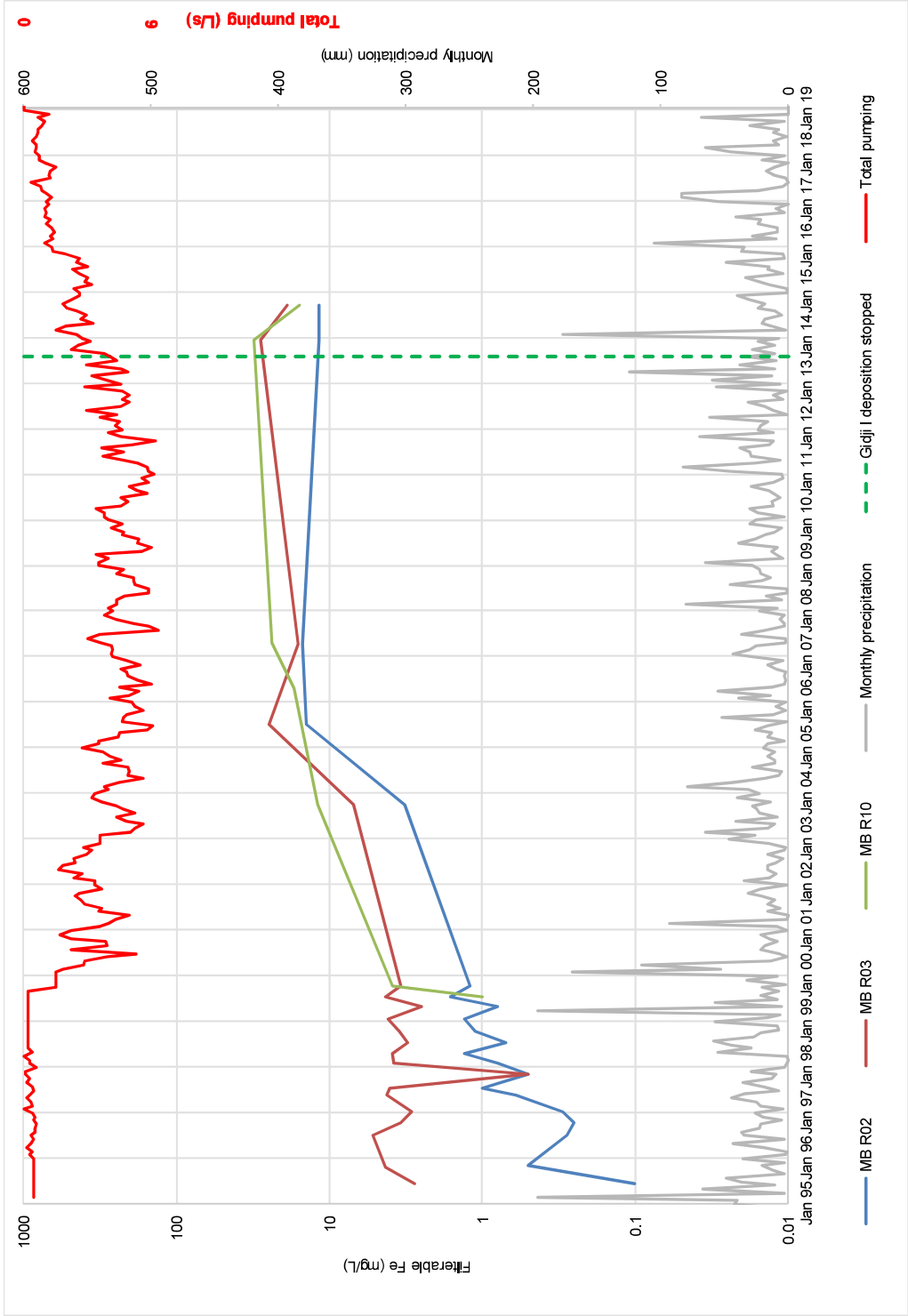
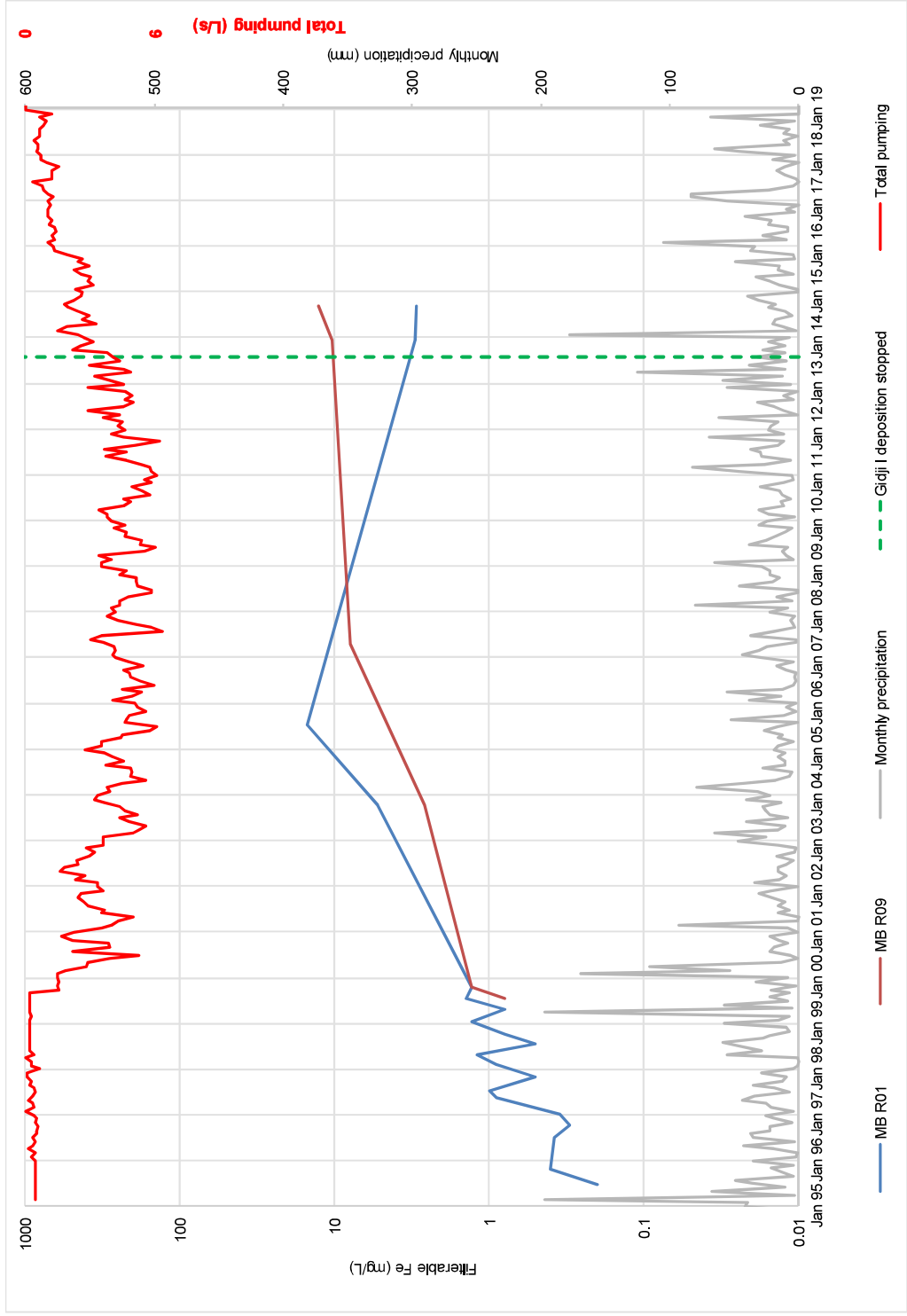


Figure C113

Date:	January 2019
Report:	KCGM Gidji TSF Hydrogeological Review

Groundwater Filterable Fe - trench bores



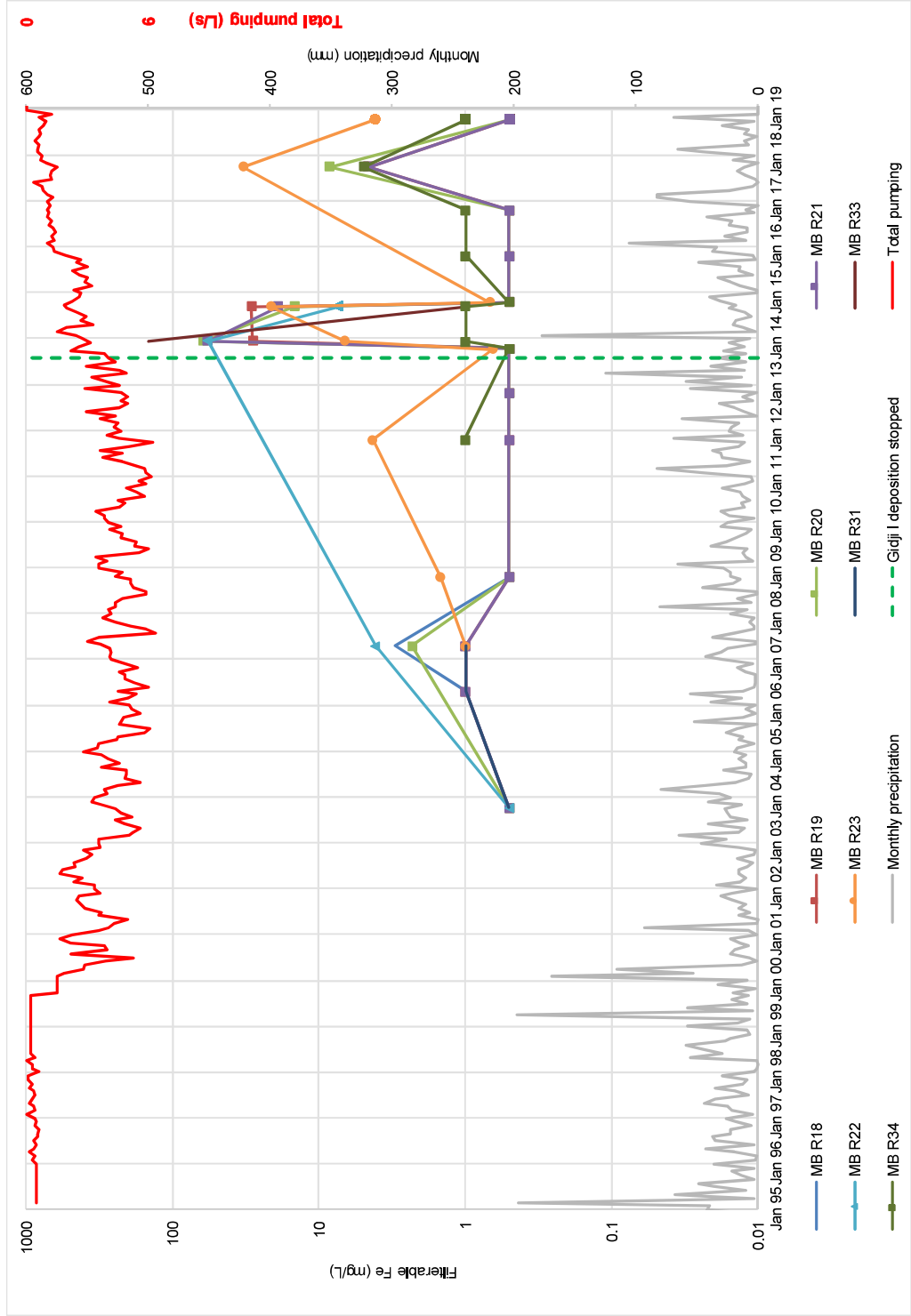


Groundwater Filterable Fe - decant bores

Figure C114

Date:	January 2019
Report:	KCGM Gidji TSF Hydrogeological Review





Groundwater Filterable Fe - eastern bores

Figure C115

Date:	January 2019
Report:	KCGM Gidji TSF Hydrogeological Review



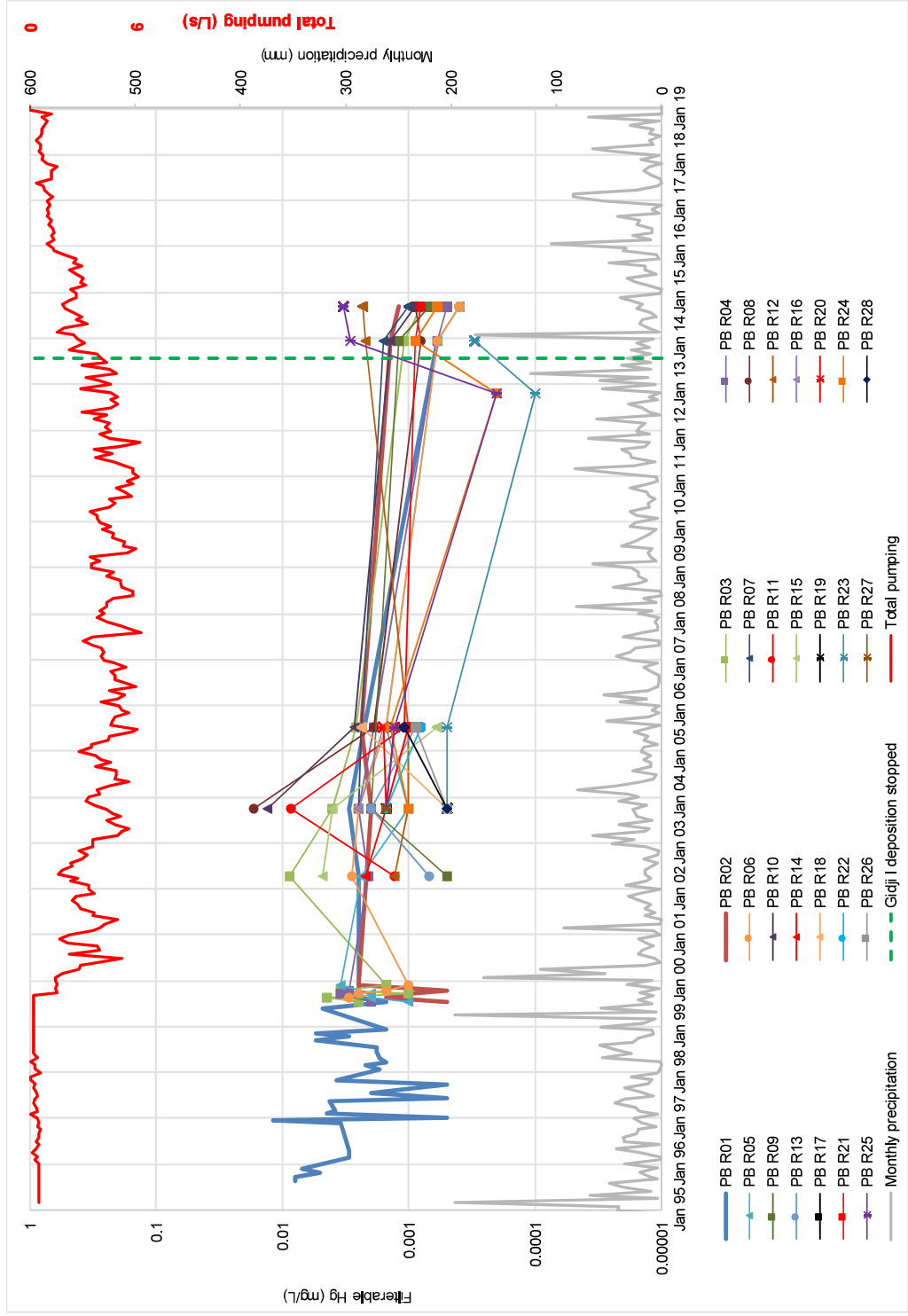
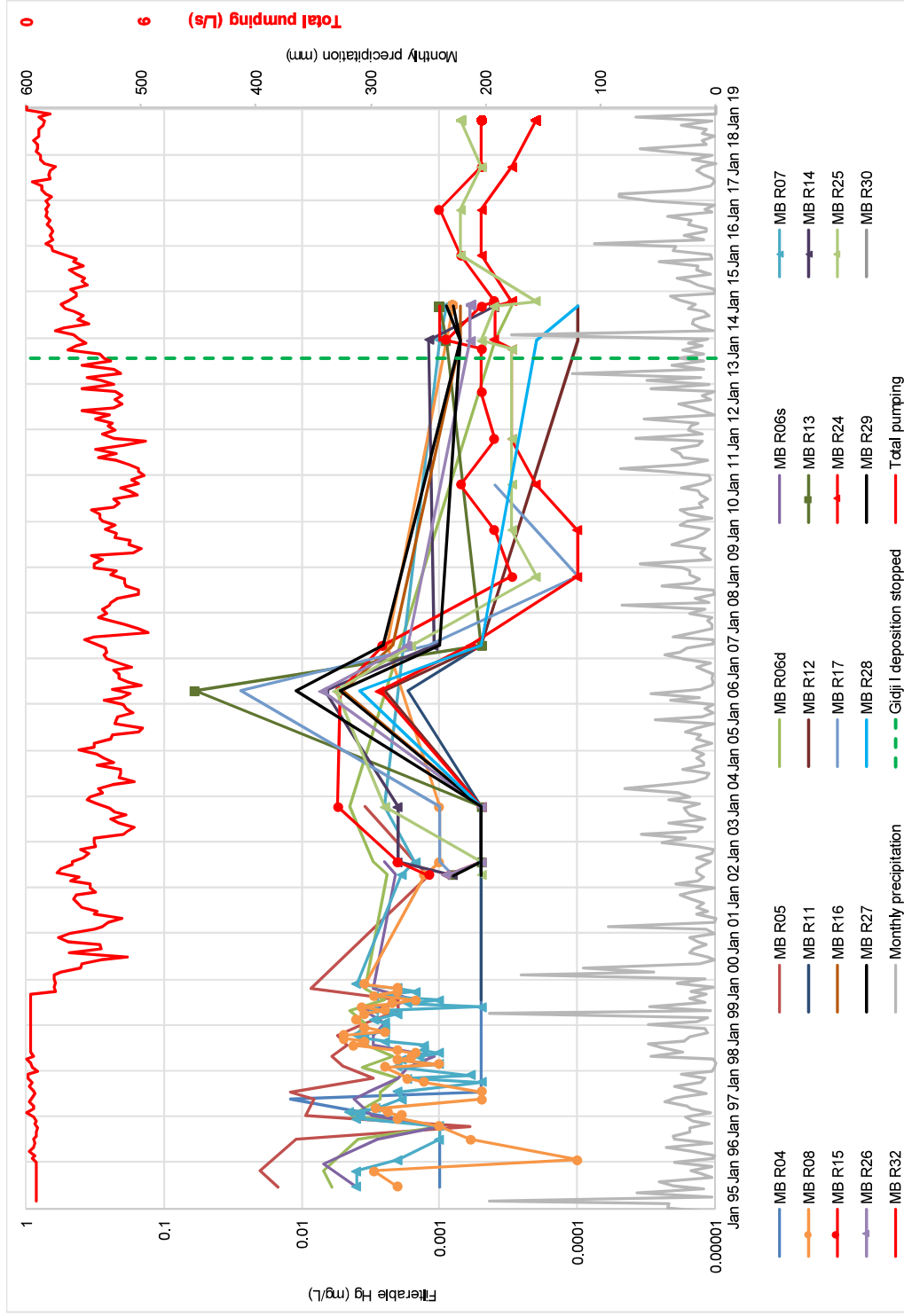


Figure C116

Date: January 2019
Report: KCGM Gidji TSF Hydrogeological Review

Groundwater Filterable Hg - production bores





Groundwater Filterable Hg - western bores

Figure C117

Date: January 2019
Report: KCGM Gidji TSF
Hydrogeological Review



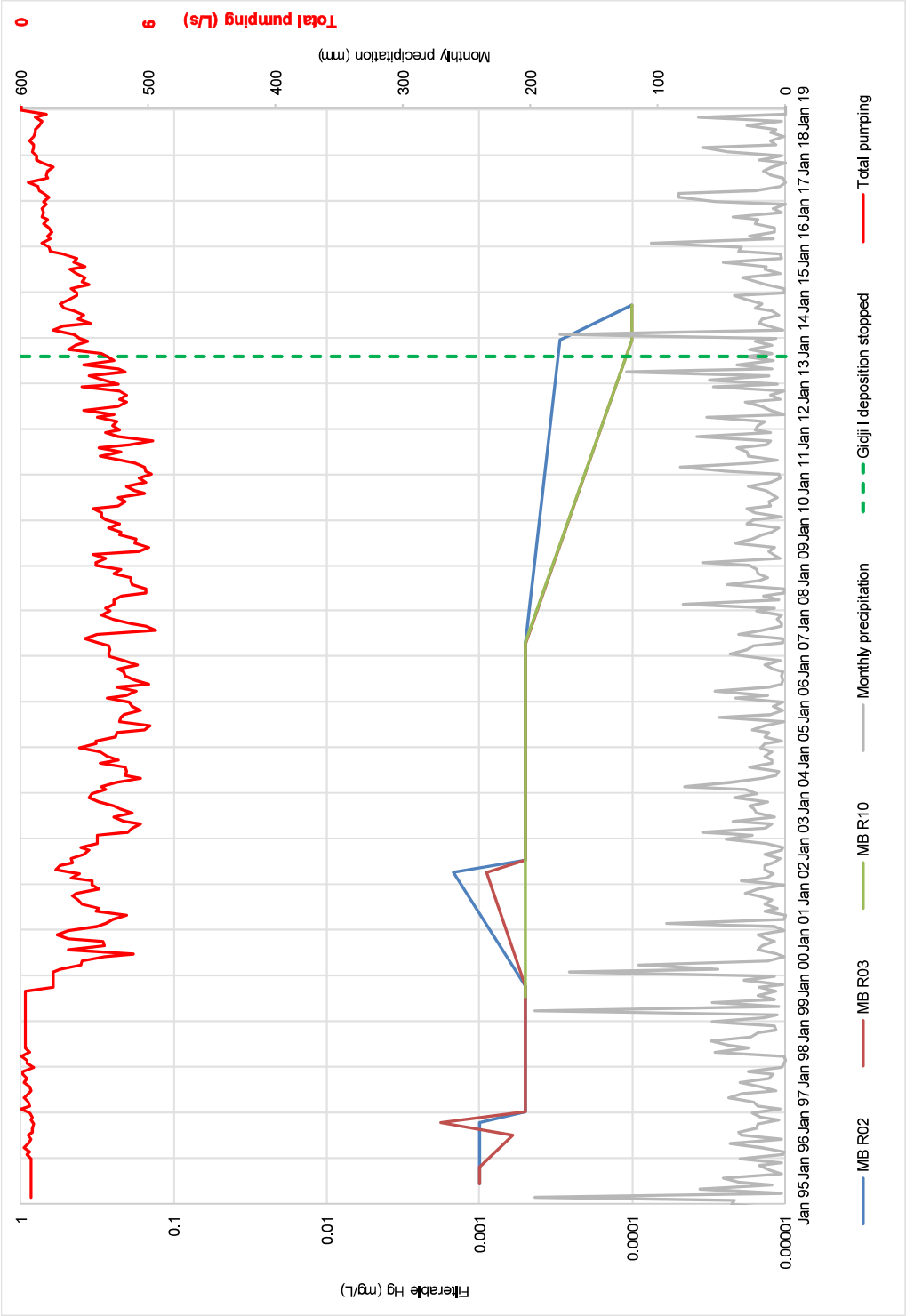


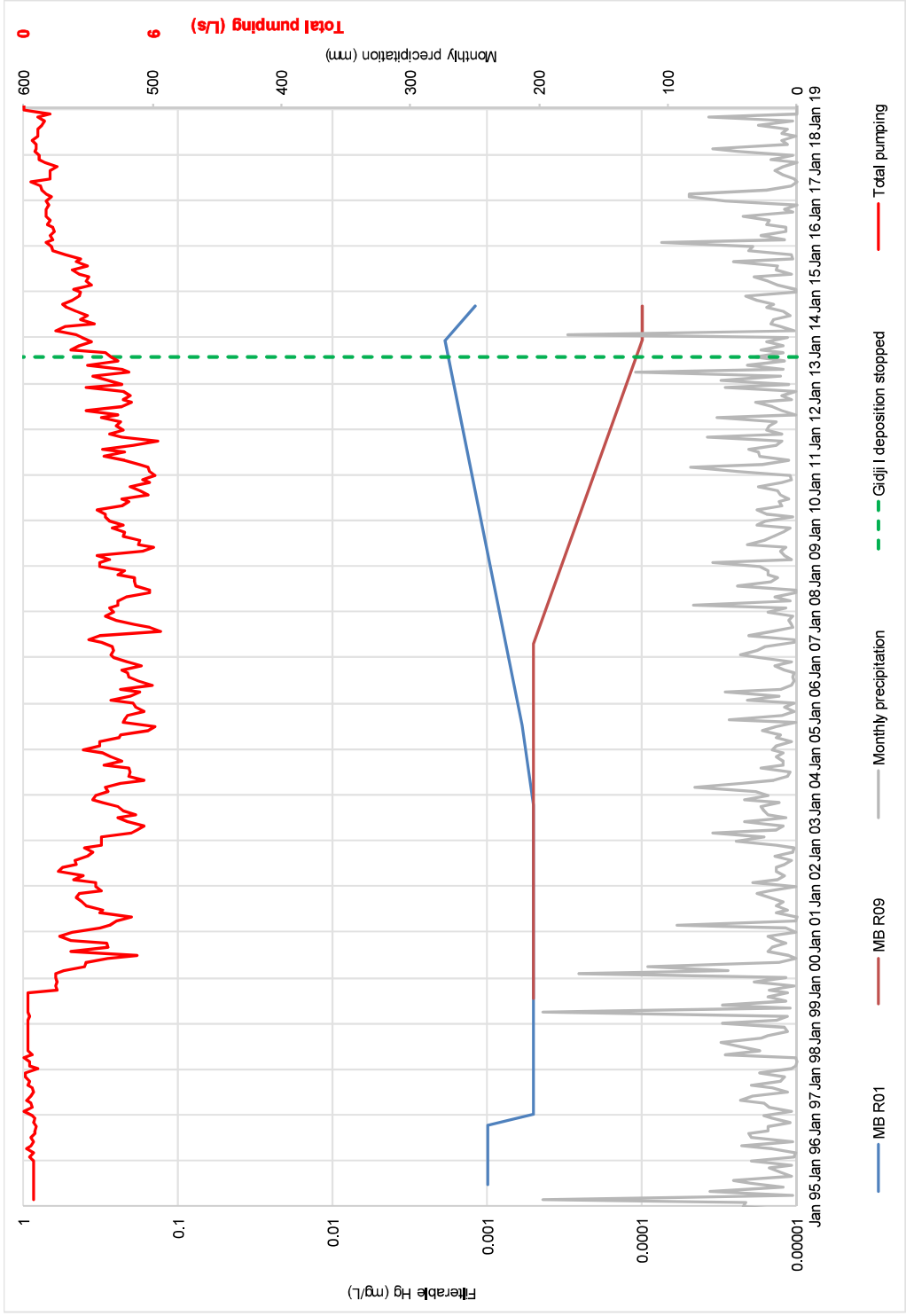
Figure C118

Date: January 2019

Report: KCGM Gidji TSF
Hydrogeological Review

Groundwater Filterable Hg - trench bores





Groundwater Filterable Hg - decant bores

Figure C119

Date:	January 2019
Report:	KCGM Gidji TSF Hydrogeological Review



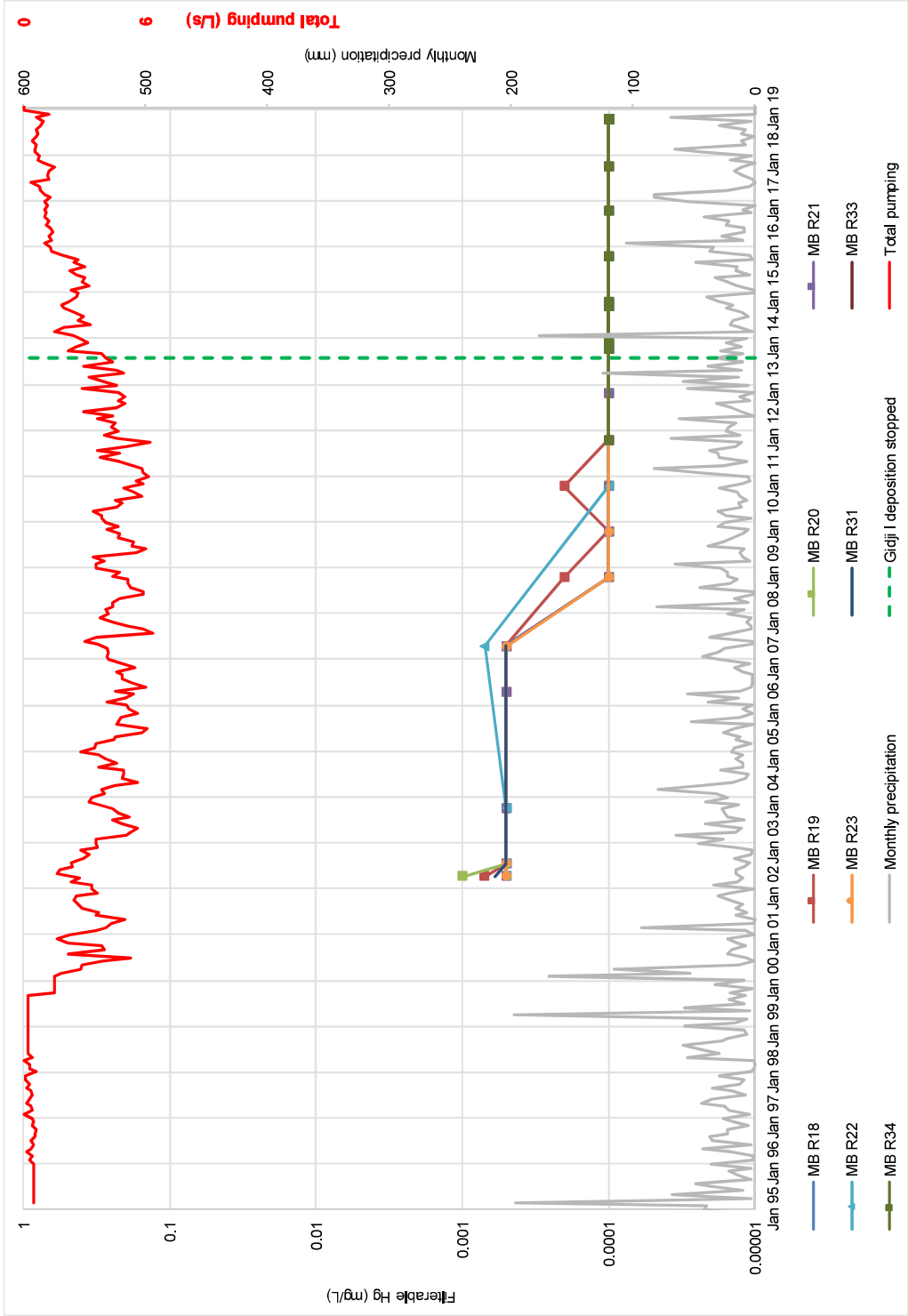


Figure C120

Date: January 2019
Report: KCGM Gidji TSF Hydrogeological Review

Groundwater Filterable Hg - eastern bores



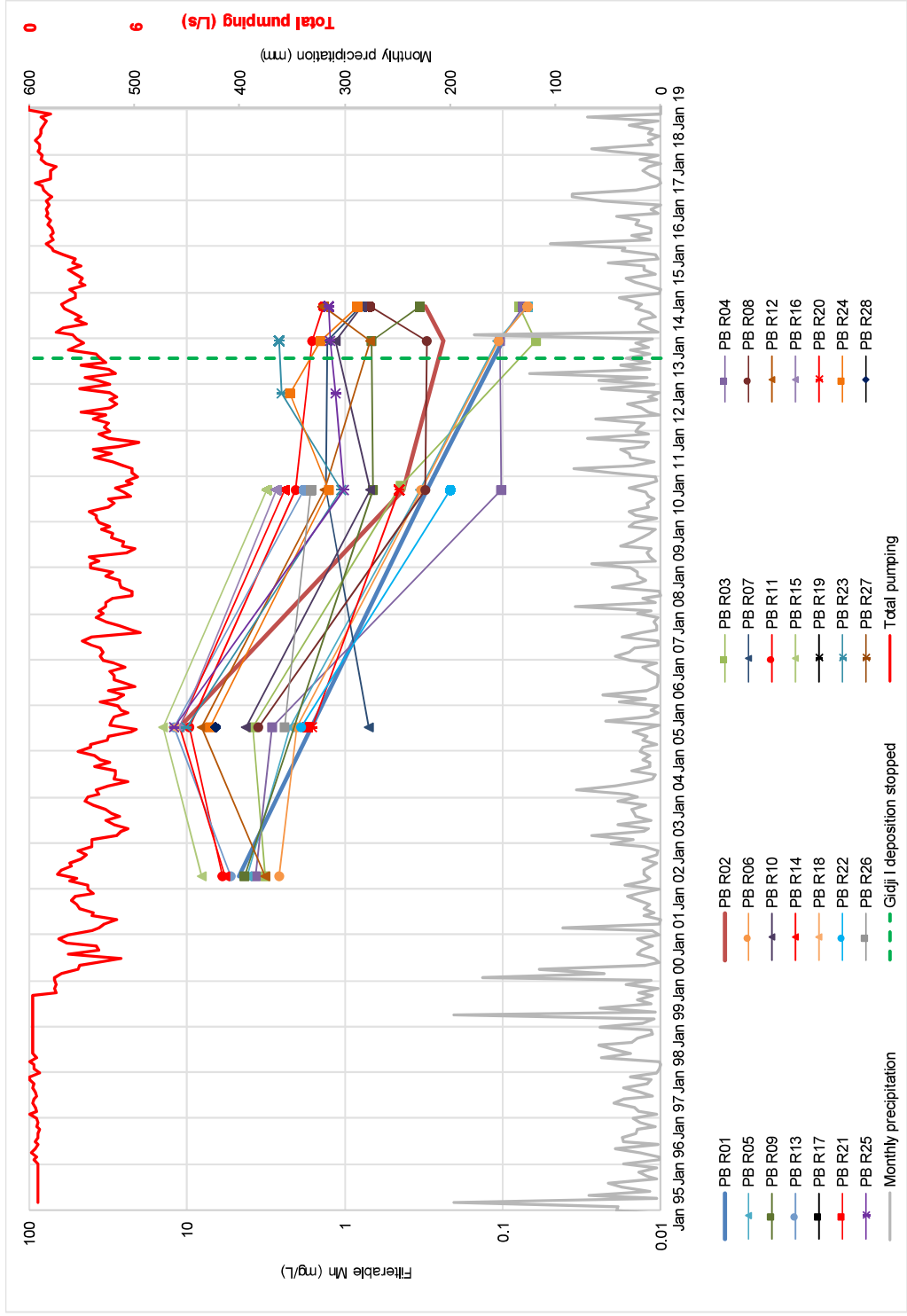


Figure C121

Date:	January 2019
Report:	KCGM Gidji TSF Hydrogeological Review

Groundwater Filterable Mn - production bores



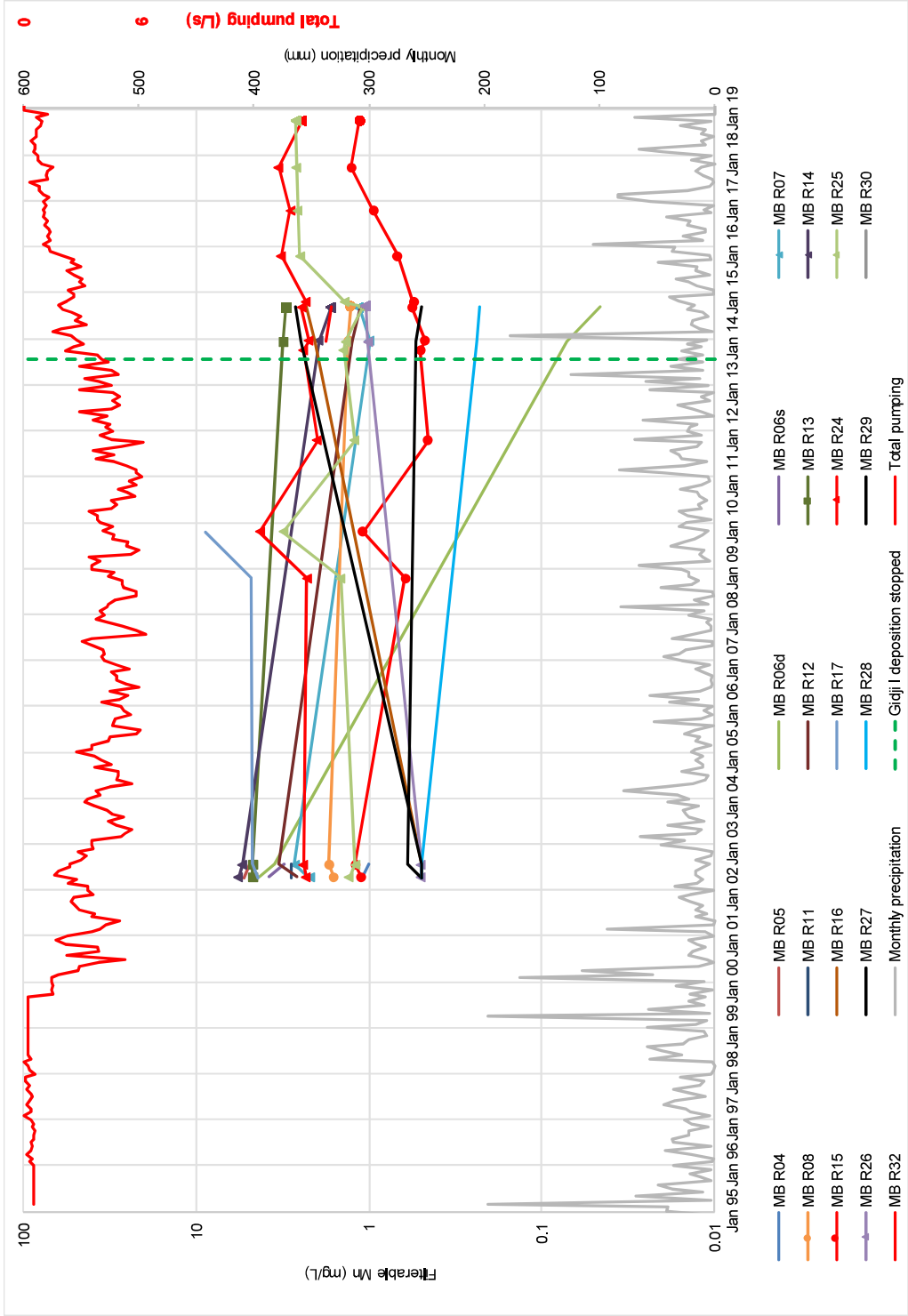
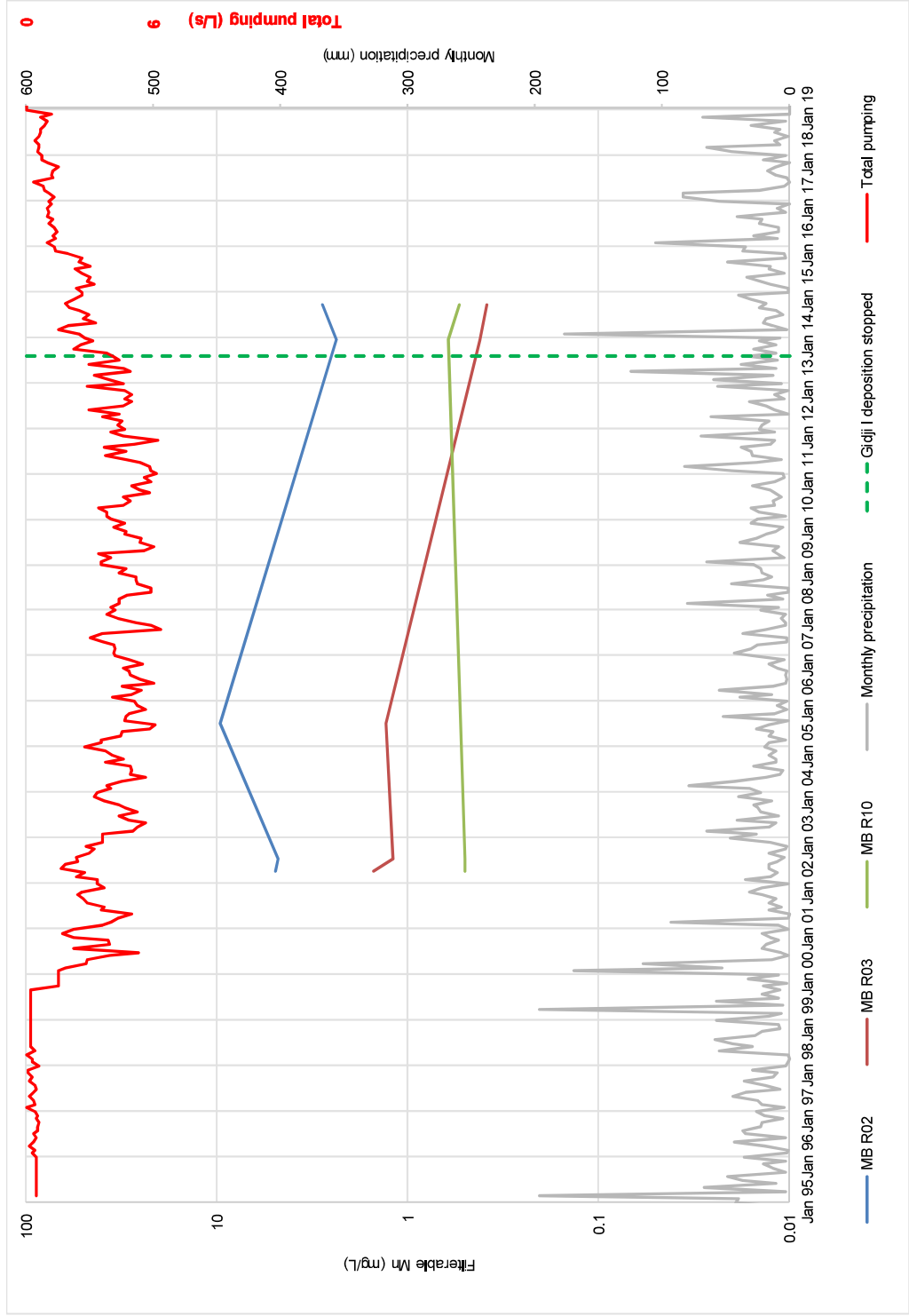


Figure C122

Date:	January 2019
Report:	KCGM Gidji TSF Hydrogeological Review

Groundwater Filterable Mn - western bores

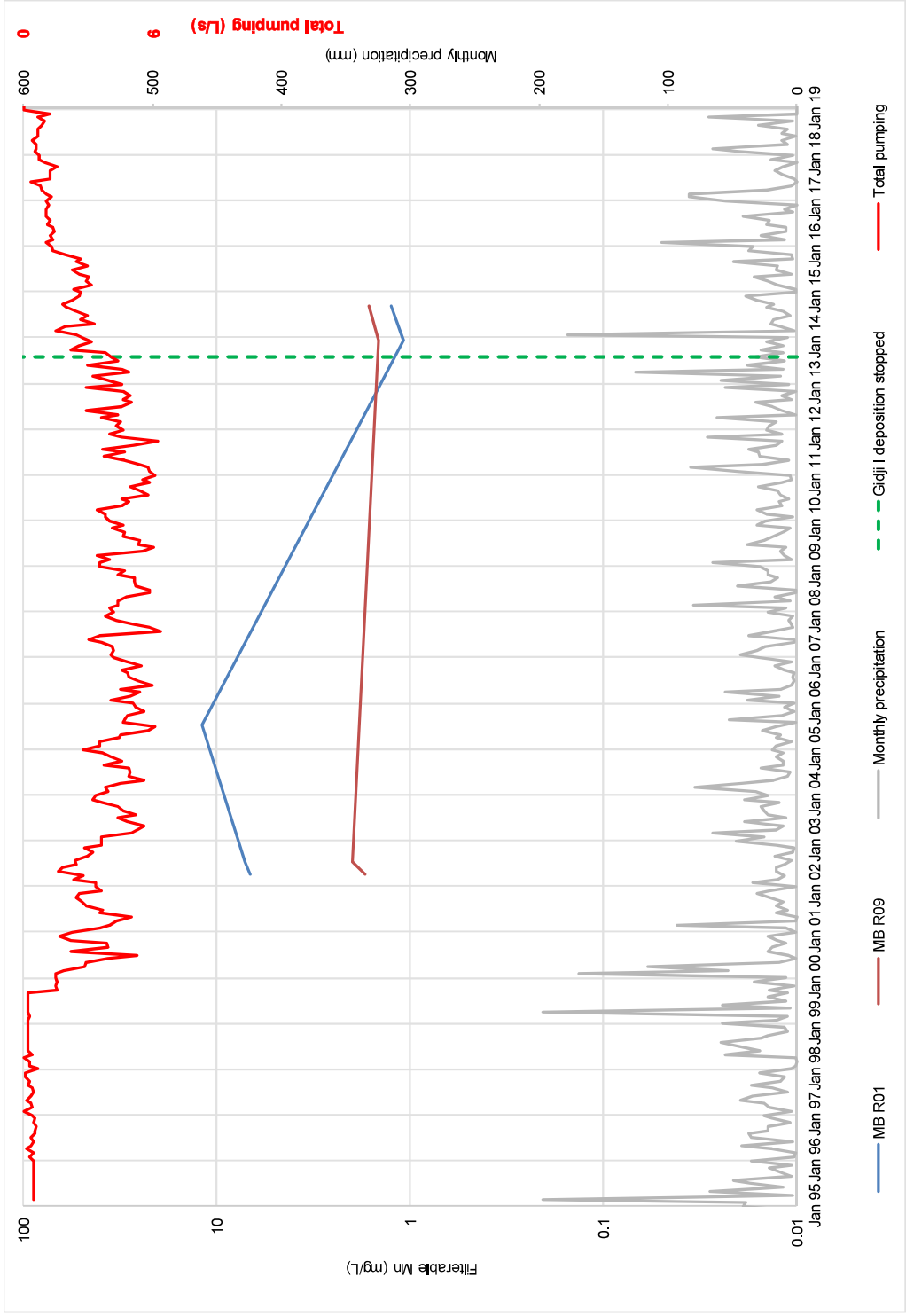




Groundwater Filterable Mn - trench bores

Figure C123

Date:	January 2019
Report:	KCGM Gidji TSF Hydrogeological Review



Groundwater Filterable Mn - decant bores

Figure C124

Date:	January 2019
Report:	KCGM Gidji TSF Hydrogeological Review



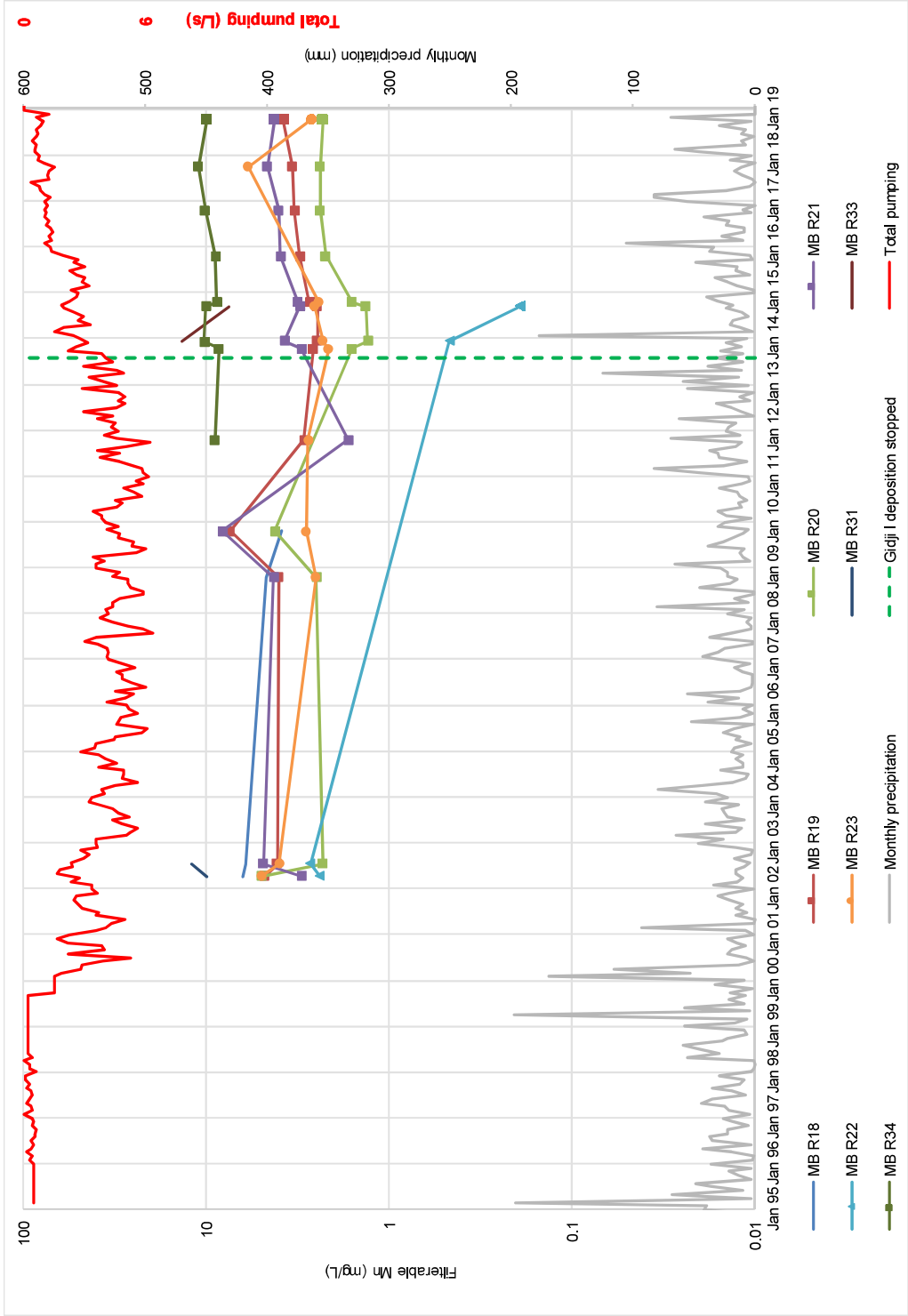


Figure C125

Date:	January 2019
Report:	KCGM Gidji TSF Hydrogeological Review

Groundwater Filterable Mn - eastern bores



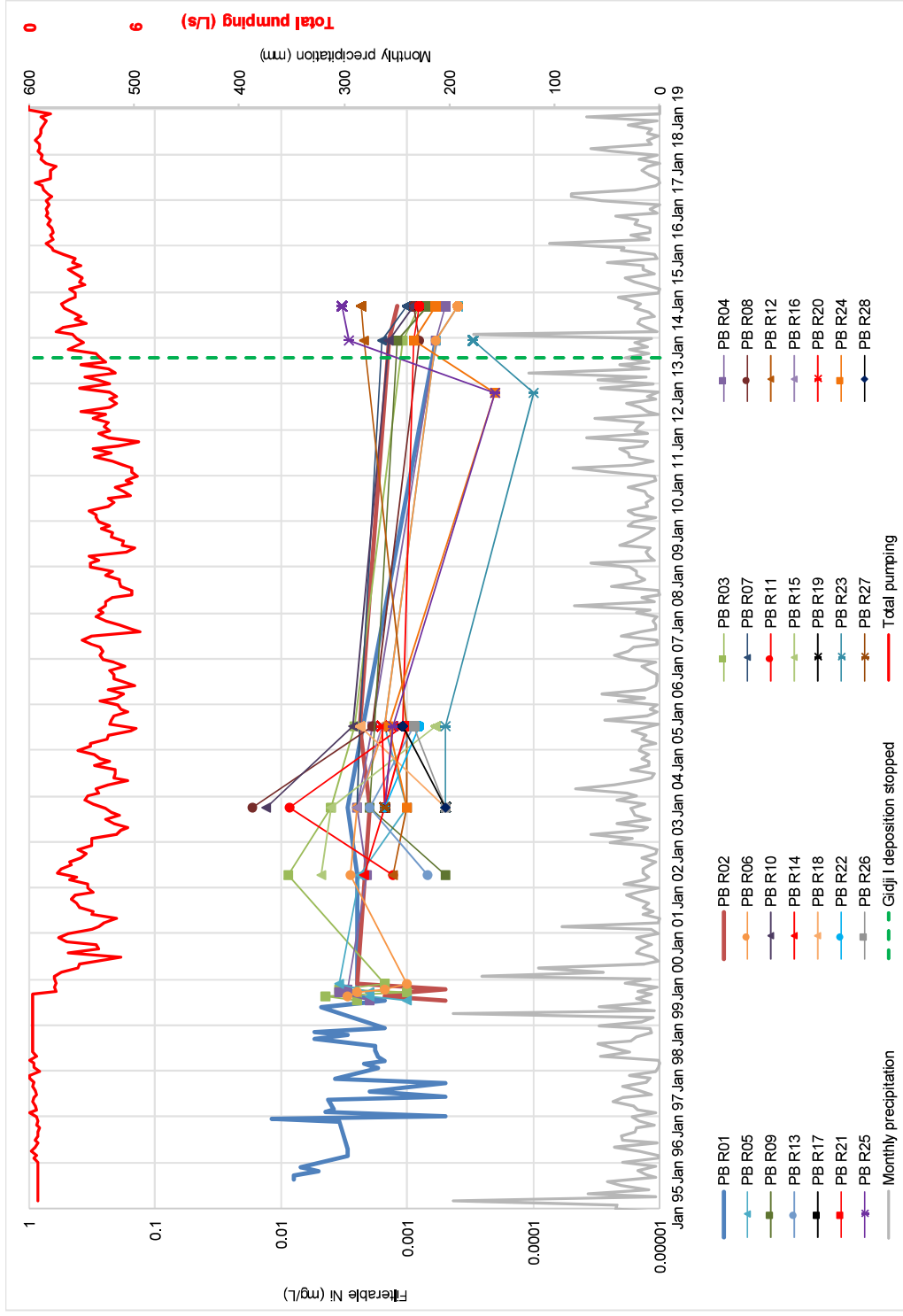


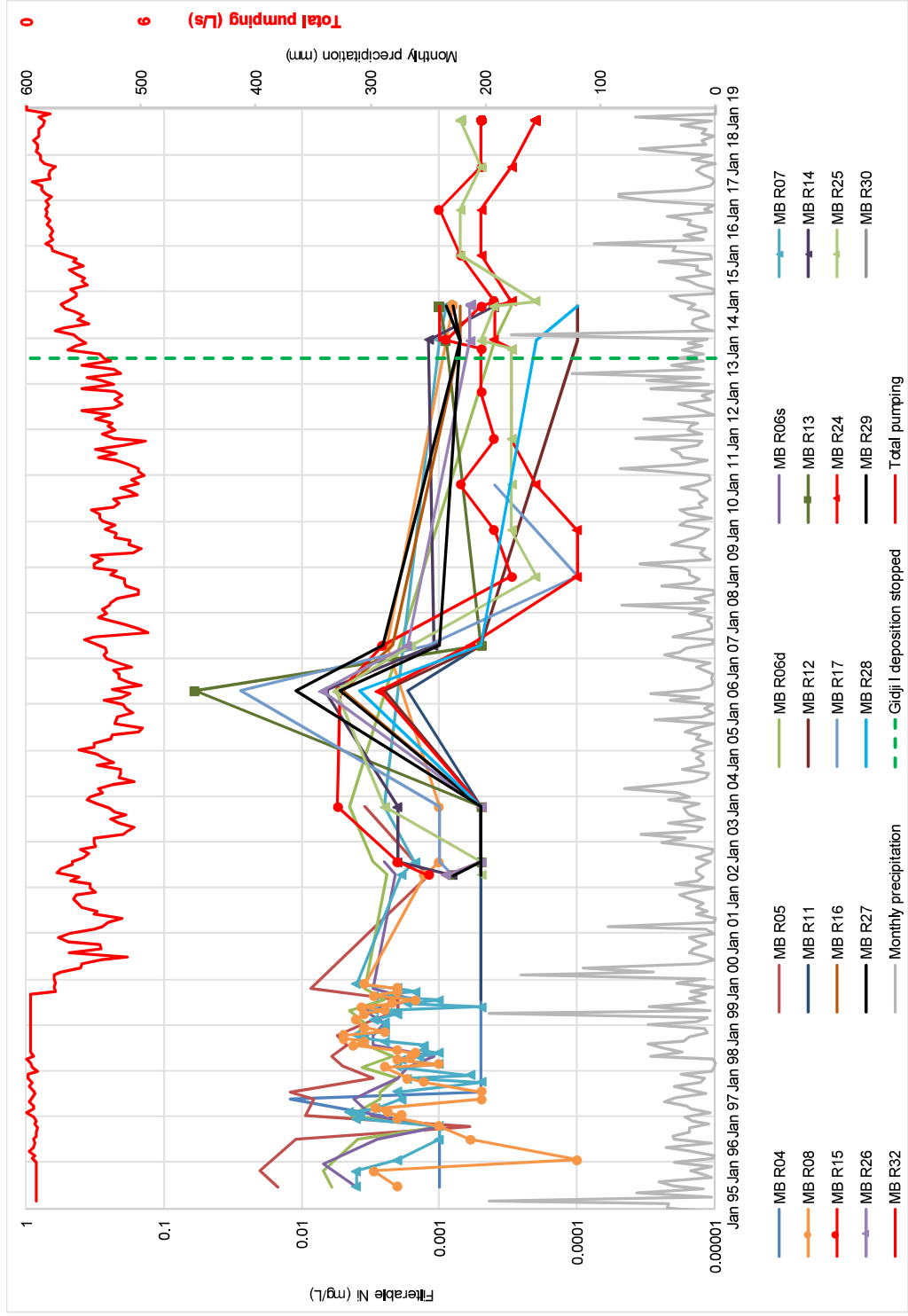
Figure C126

Date: January 2019

Report: KCGM Gidji TSF
Hydrogeological Review

Groundwater Filterable Ni - production bores



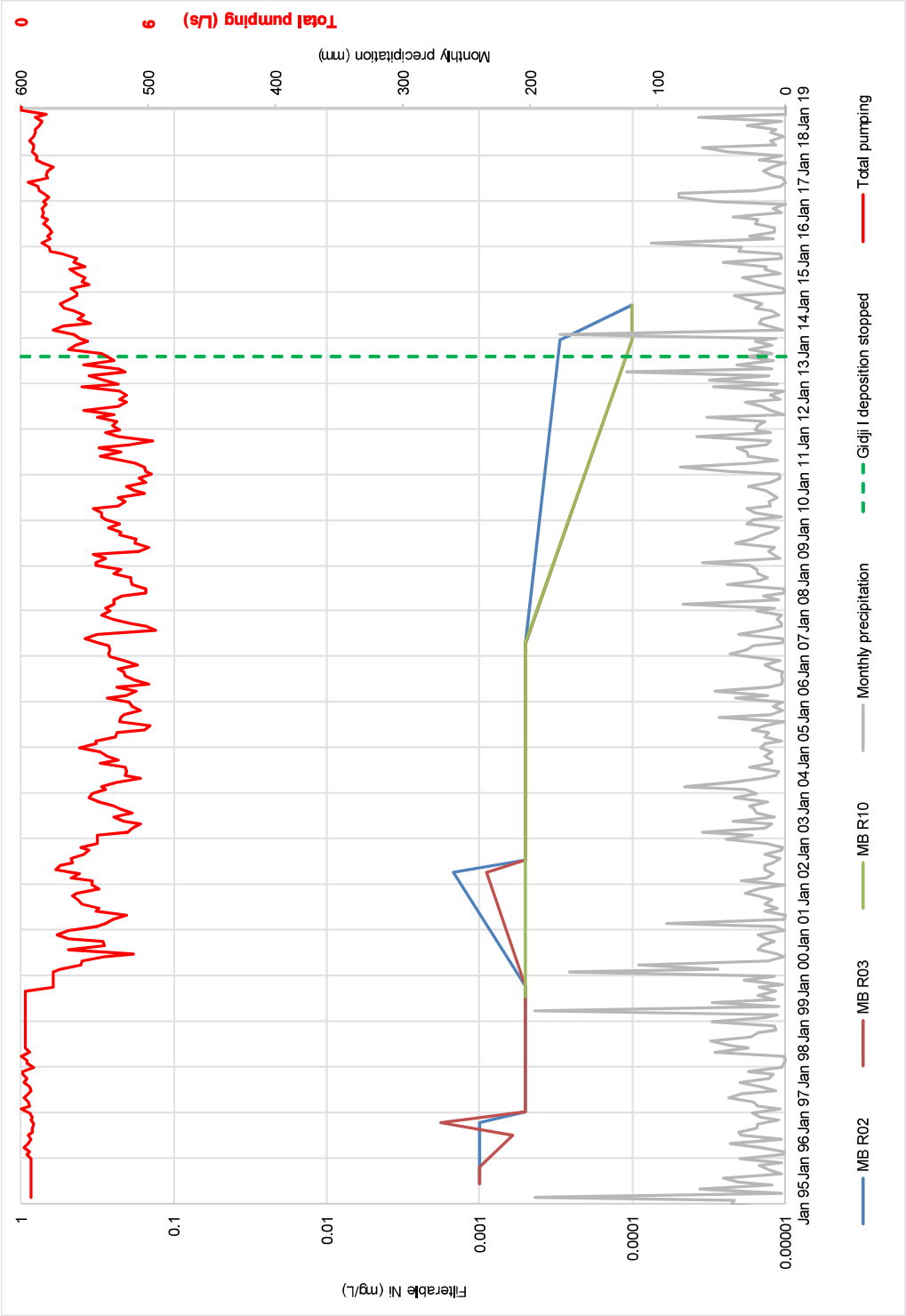


Groundwater Filterable Ni - western bores

Figure C127

Date: January 2019

Report: KCGM Gidji TSF
Hydrogeological Review

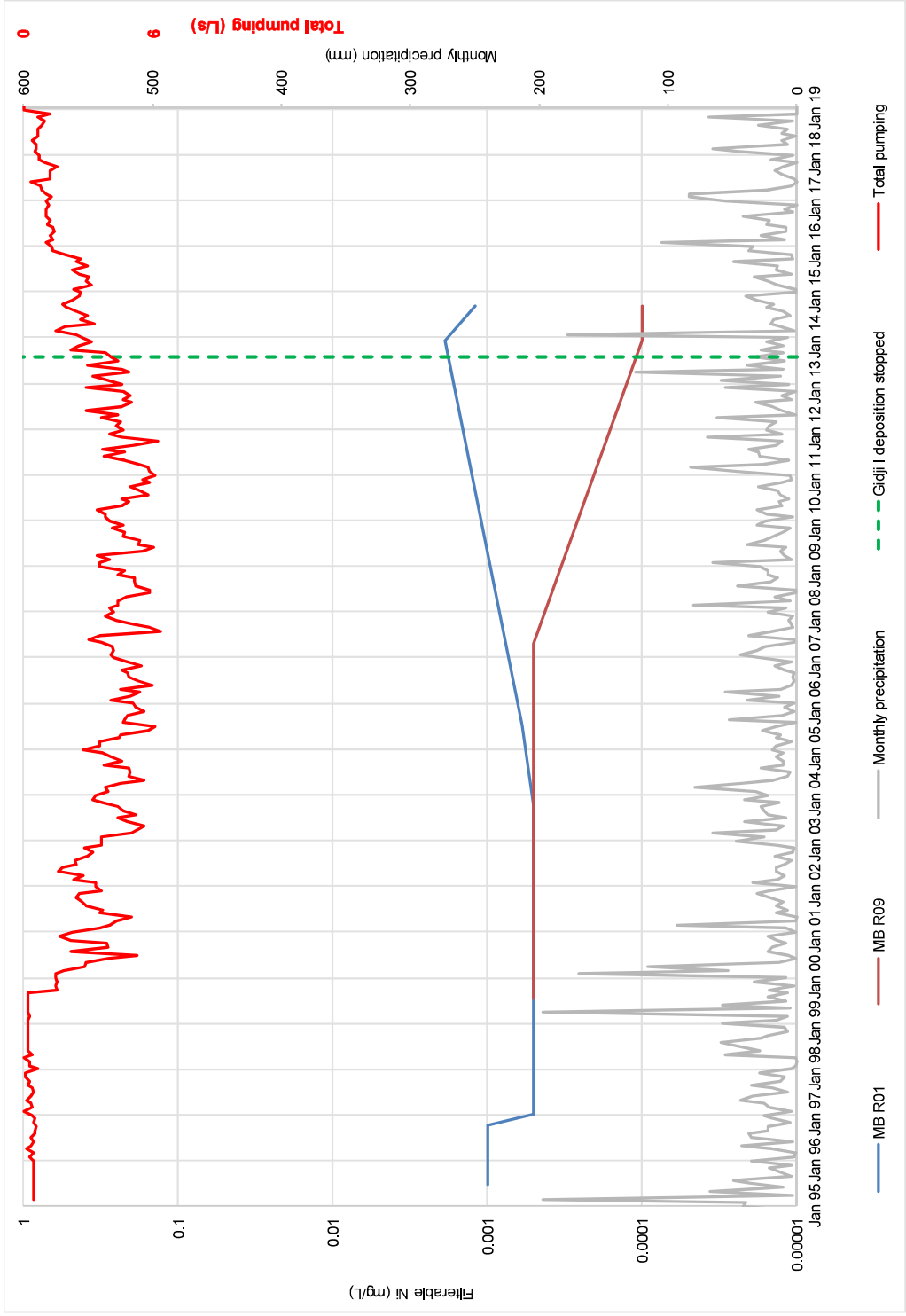


Groundwater Filterable Ni - trench bores

Figure C128

Date:	January 2019
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Groundwater Filterable Ni - decant bores

Figure C129

Date:	January 2019
Report:	KCGM Gidji TSF Hydrogeological Review



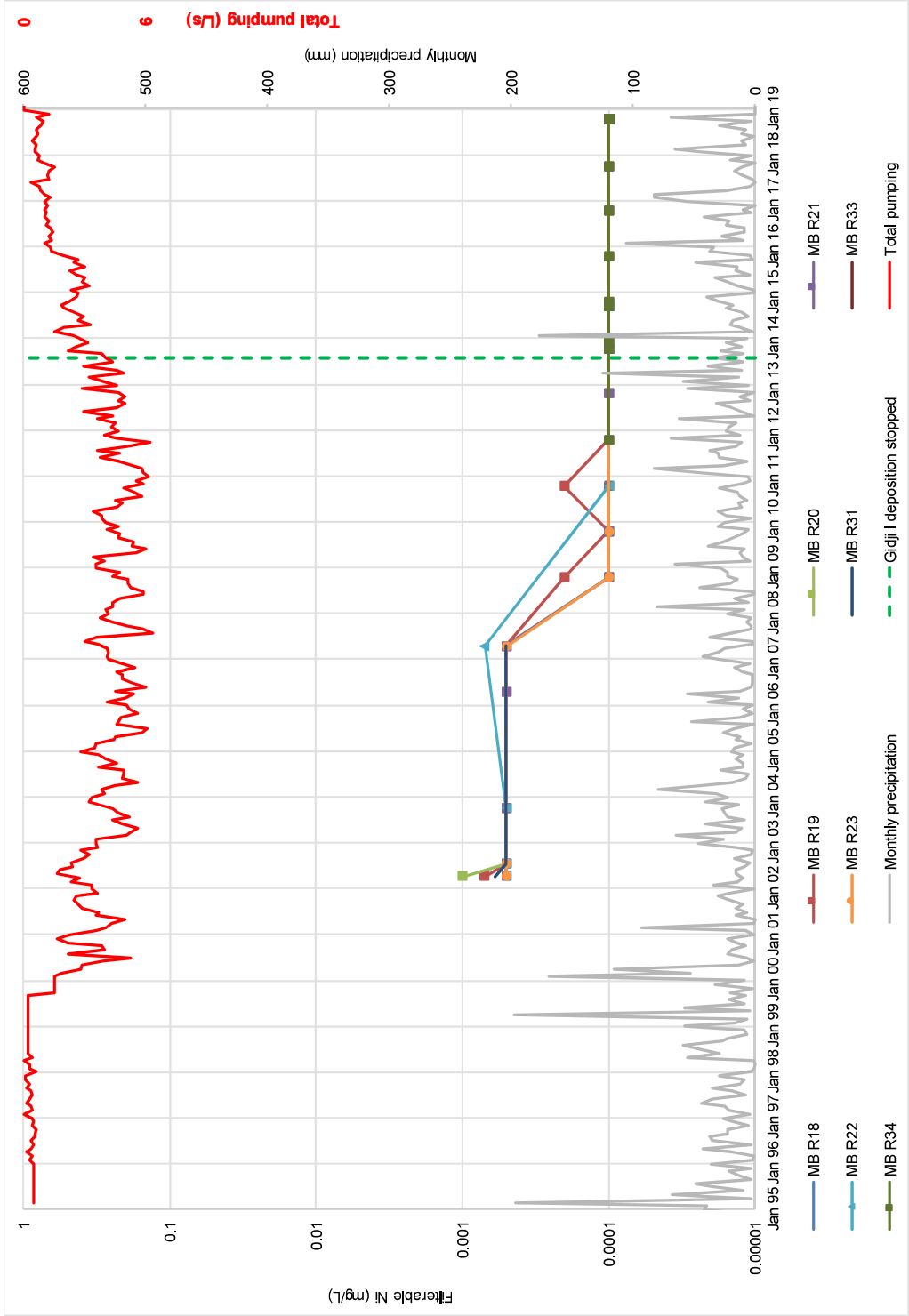


Figure C130

Date: January 2019
Report: KCGM Gidji TSF Hydrogeological Review

Groundwater Filterable Ni - eastern bores



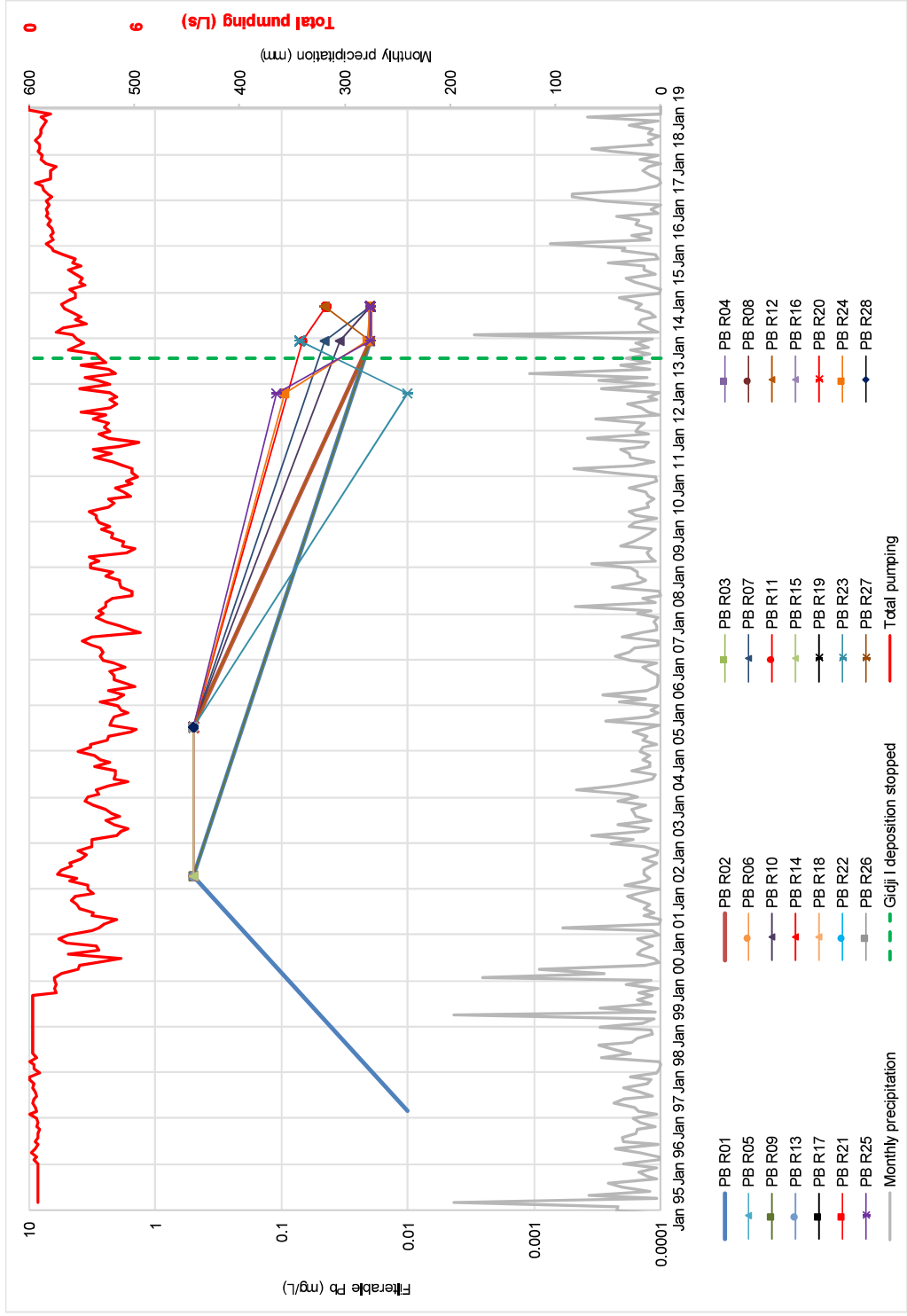
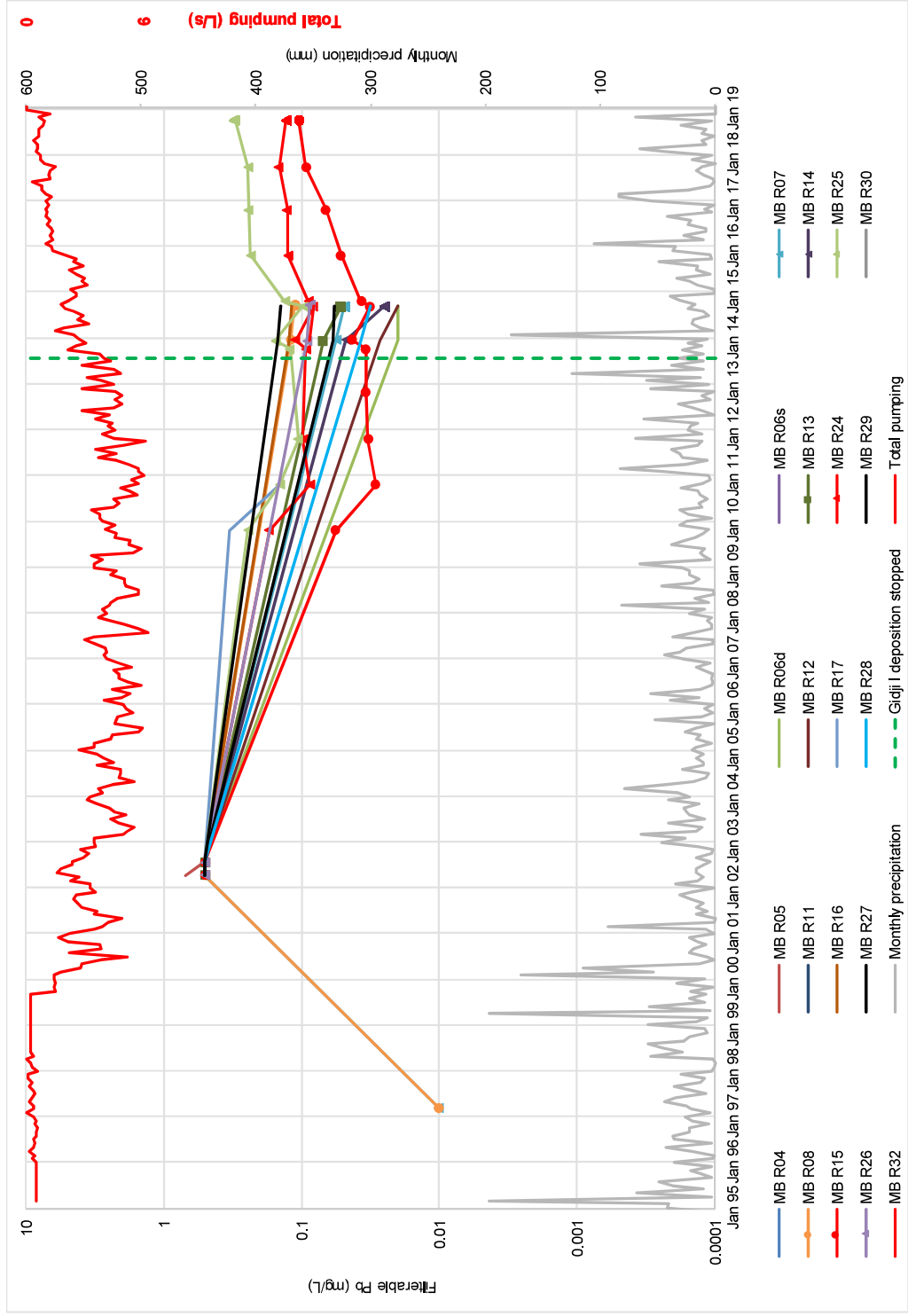


Figure C131

Date: January 2019

Report: KCGM Gidji TSF
Hydrogeological Review

Groundwater Filterable Pb - production bores



Groundwater Filterable Pb - western bores

Figure C132

Date:	January 2019
Report:	KCGM Gidji TSF Hydrogeological Review

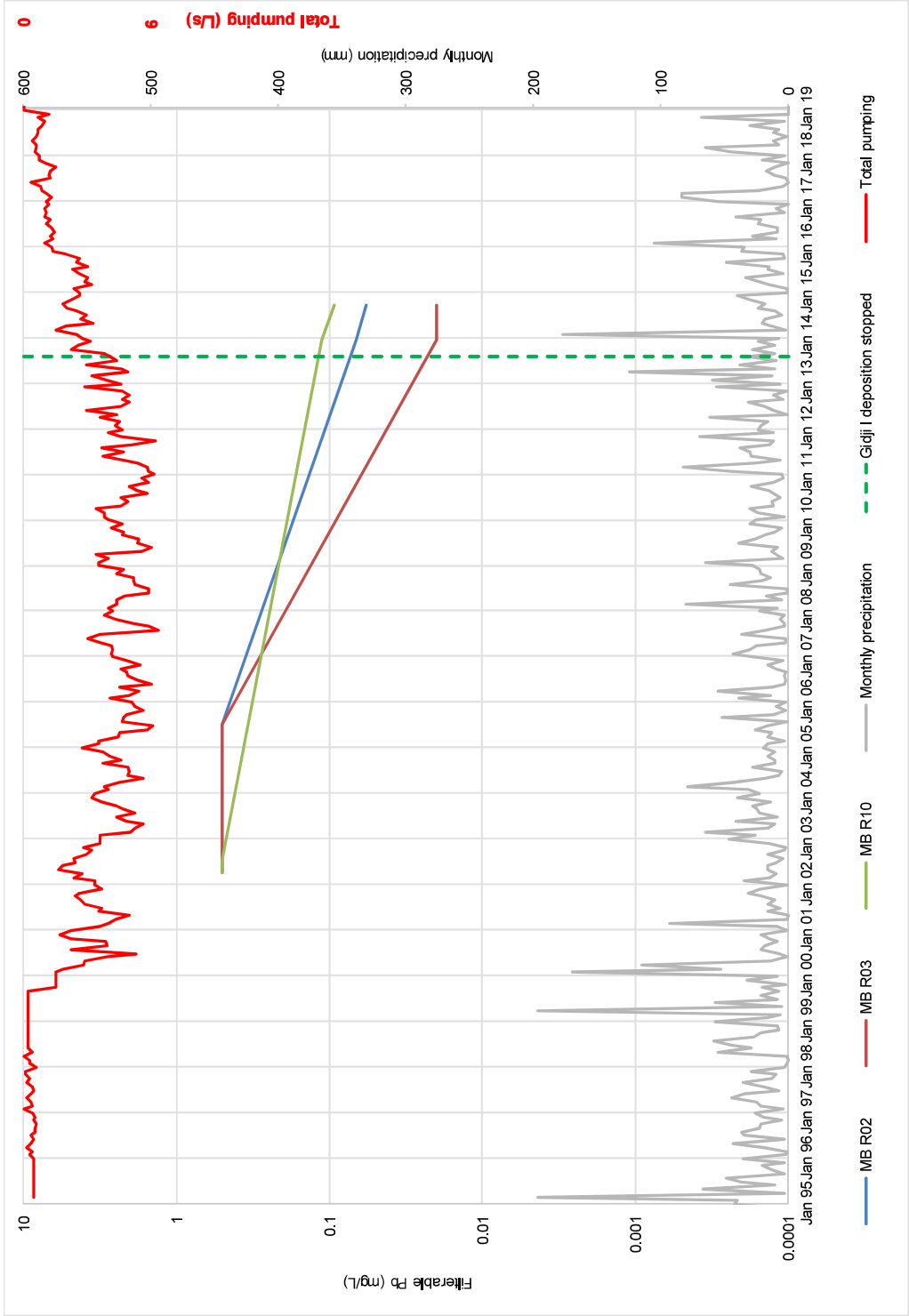
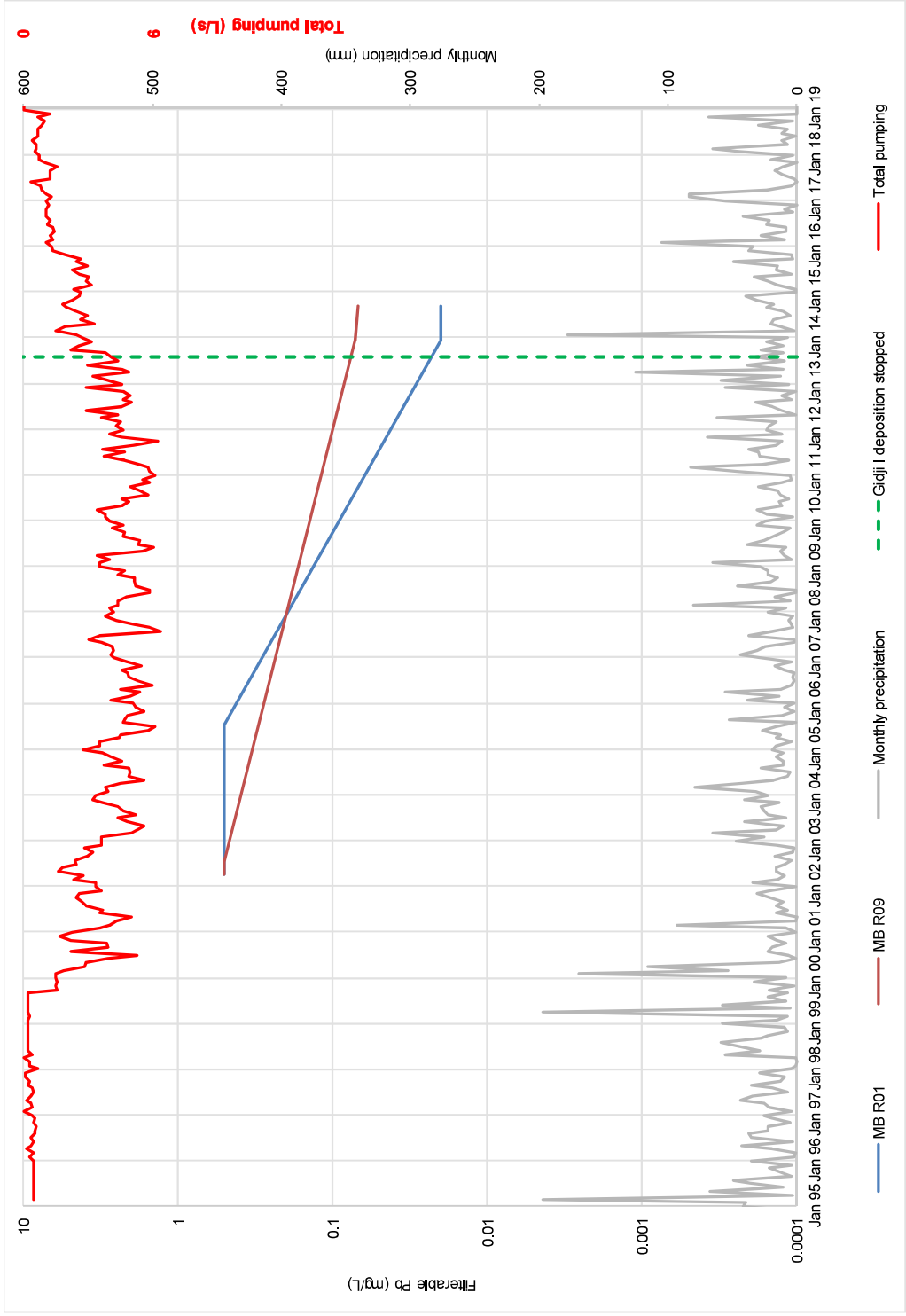


Figure C133

Date:	January 2019
Report:	KCGM Gidji TSF Hydrogeological Review

Groundwater Filterable Pb - trench bores





Groundwater Filterable Pb - decant bores

Figure C134

Date:	January 2019
Report:	KCGM Gidji TSF Hydrogeological Review



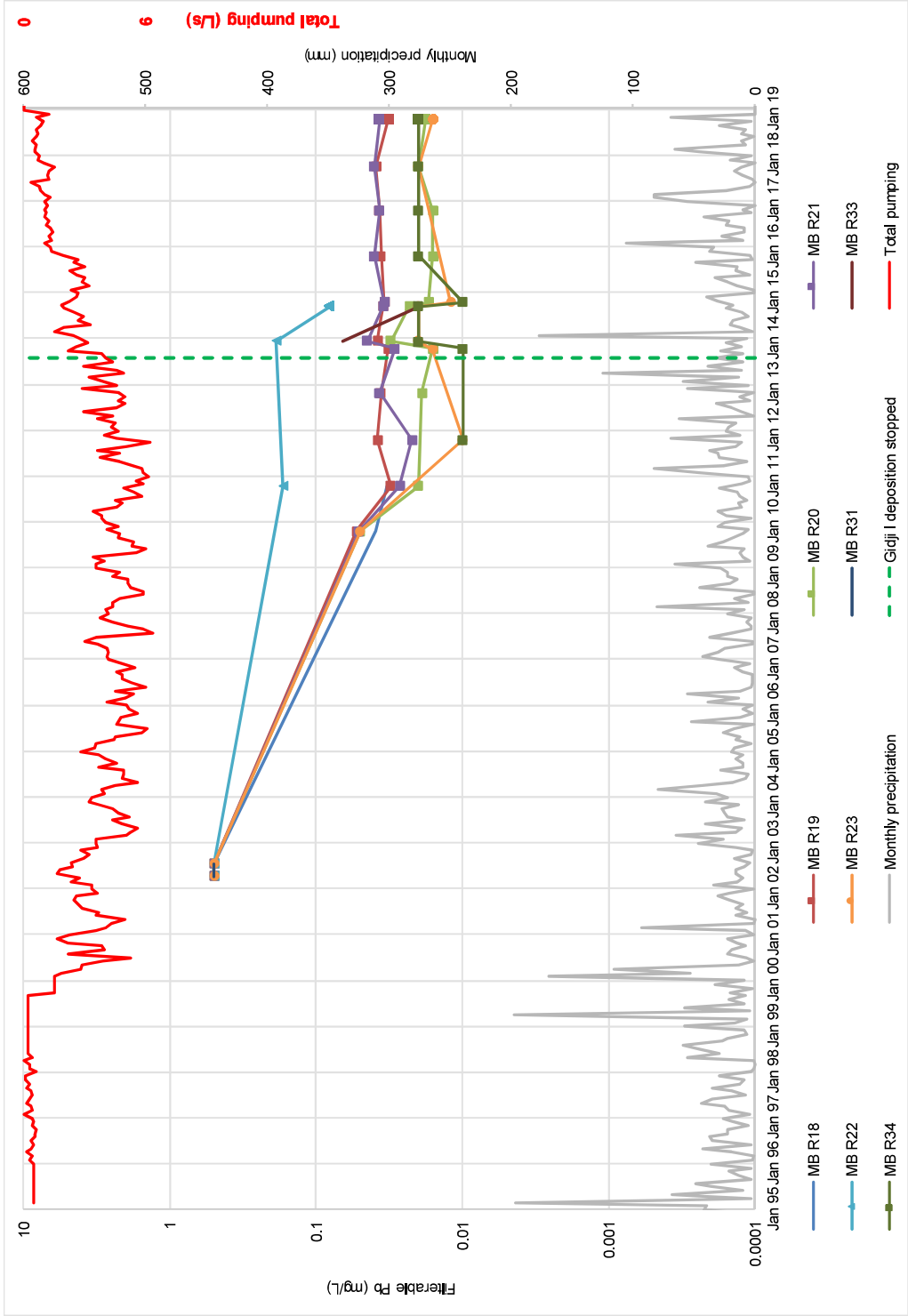


Figure C135

Date:	January 2019
Report:	KCGM Gidji TSF Hydrogeological Review

Groundwater Filterable Pb - eastern bores



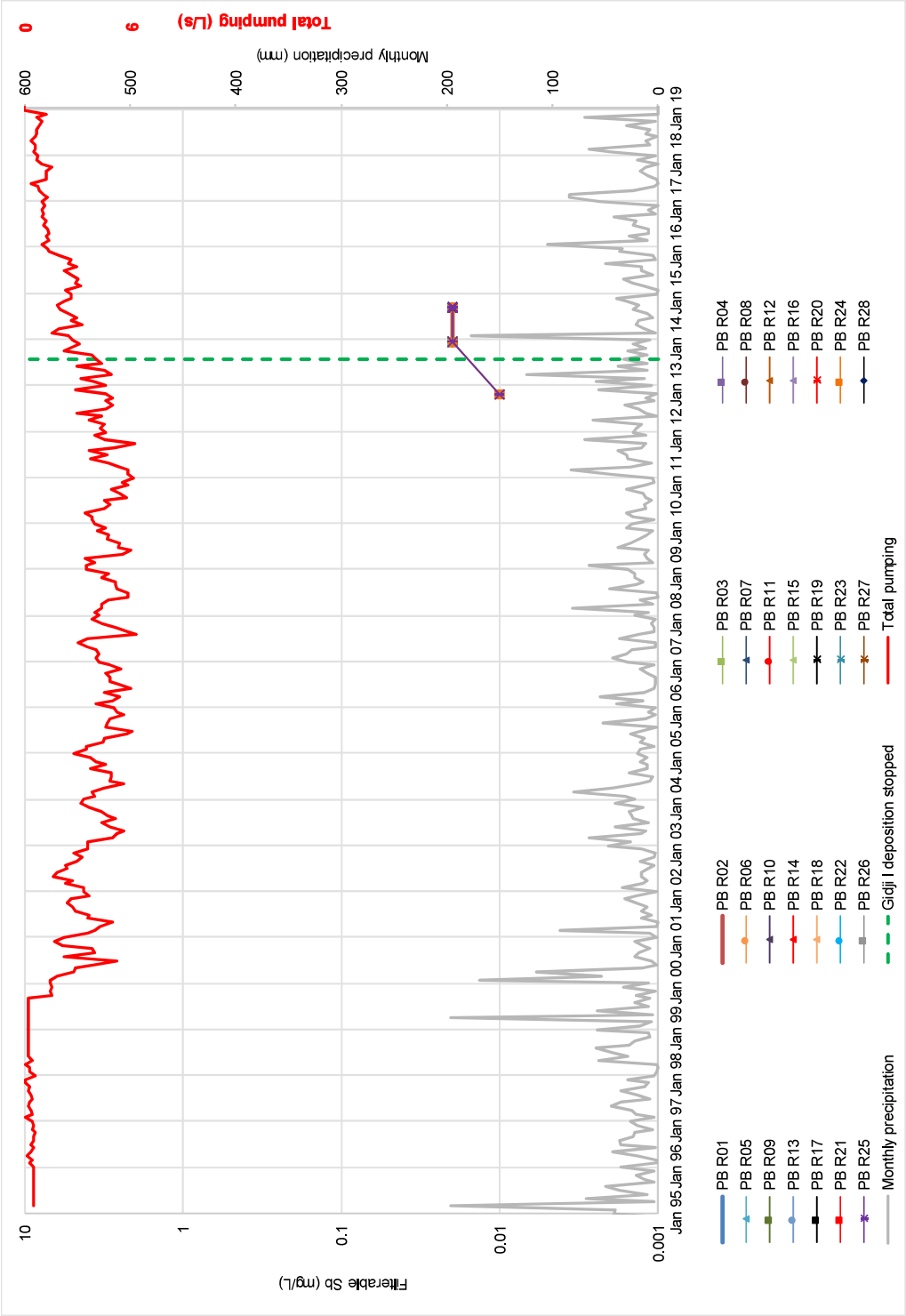


Figure C136

Date:	January 2019
Report:	KCGM Gidji TSF Hydrogeological Review

Groundwater Filterable Sb - production bores



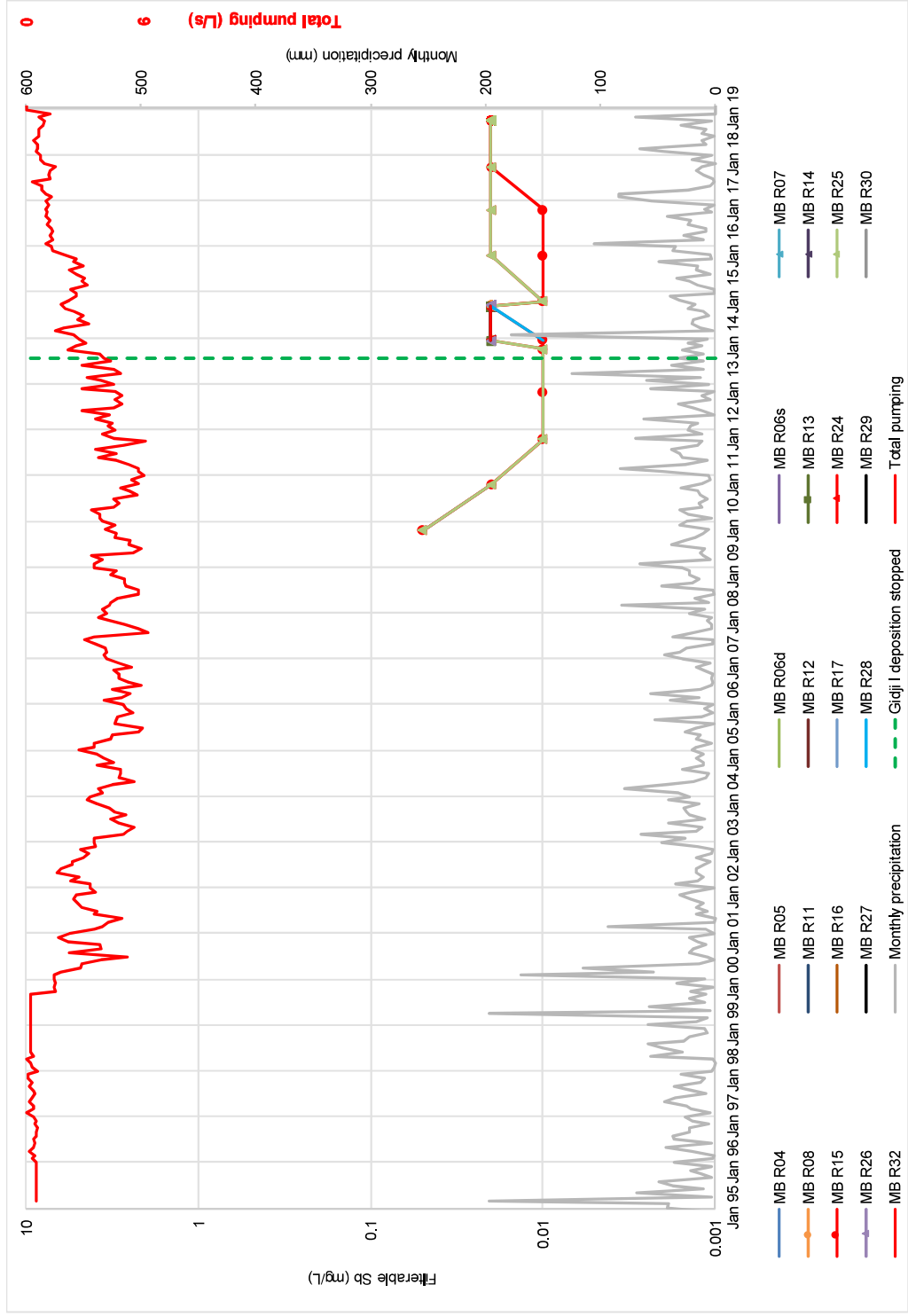


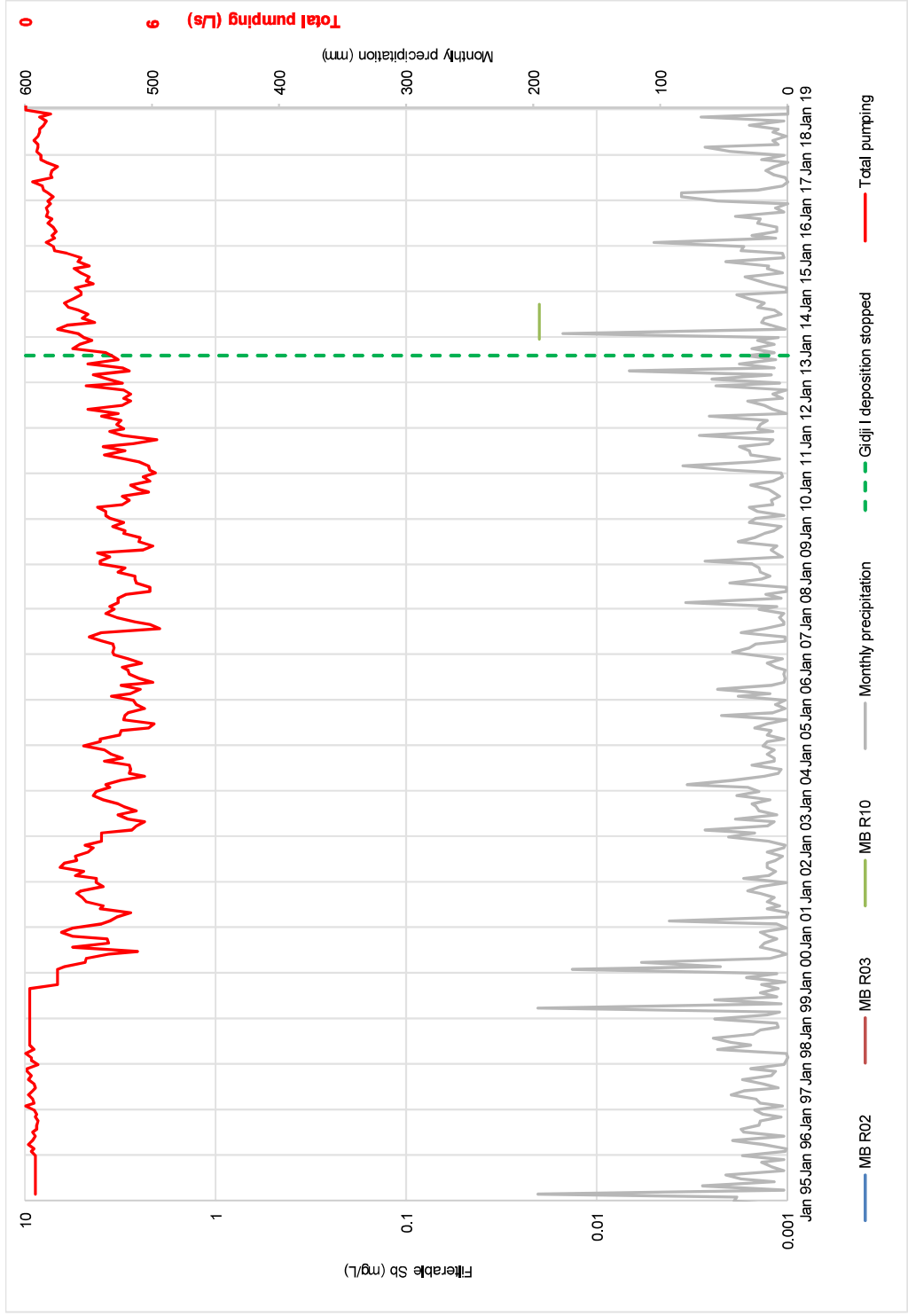
Figure C137

Date: January 2019

Report: KCGM Gidji TSF
Hydrogeological Review

Groundwater Filterable Sb - western bores



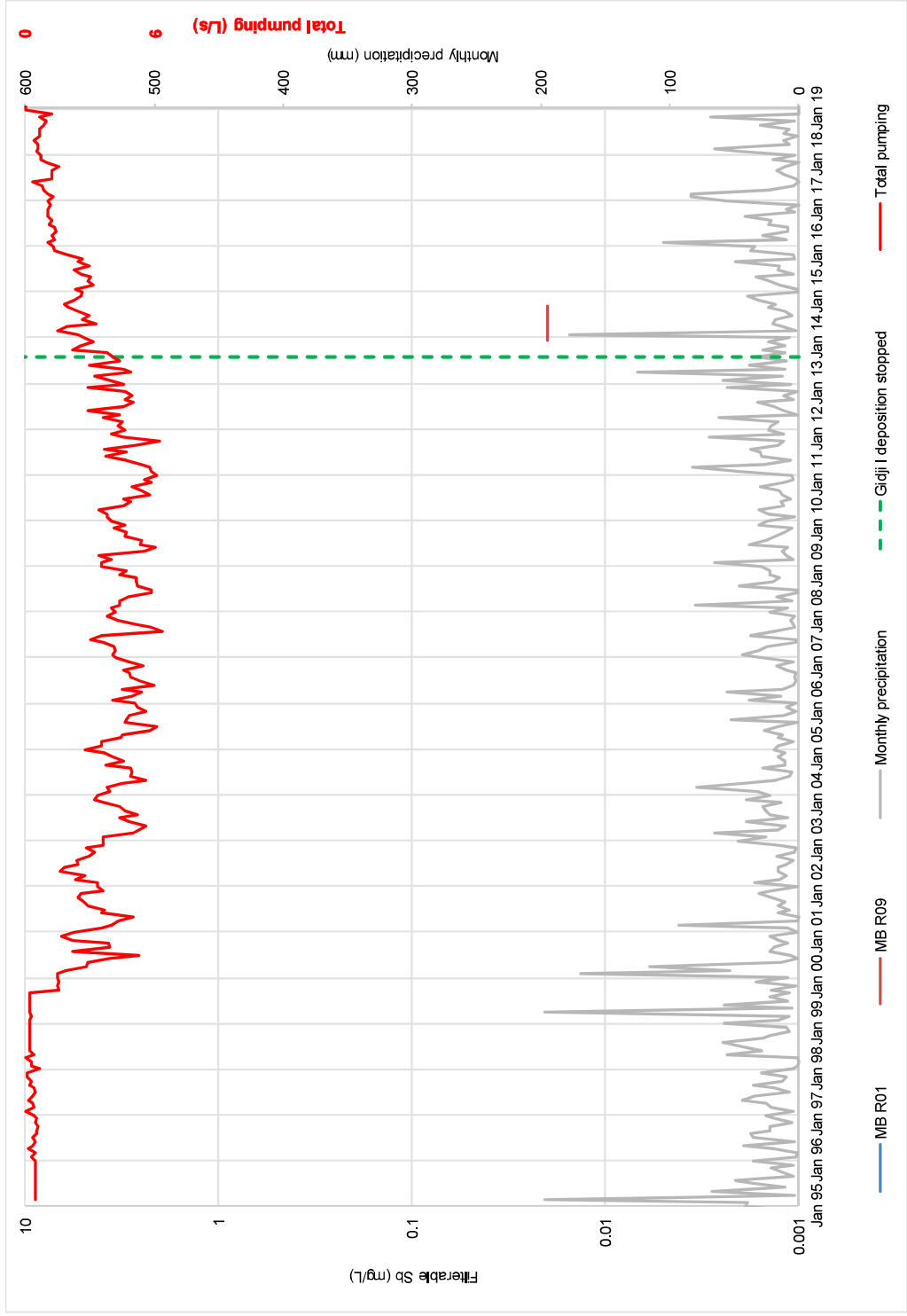


Groundwater Filterable Sb - trench bores

Figure C138

Date:	January 2019
Report:	KCGM Gidji TSF Hydrogeological Review



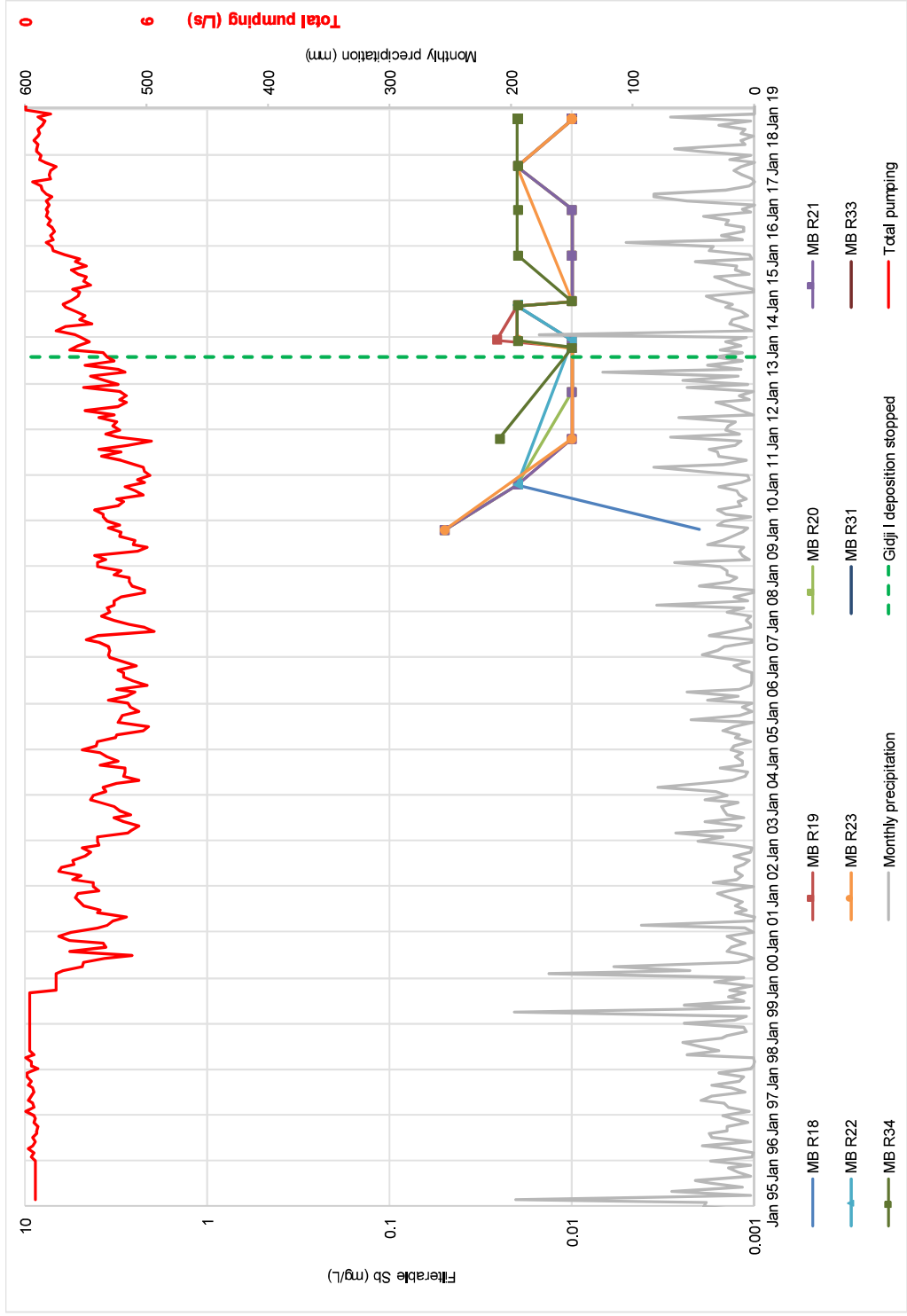


Groundwater Filterable Sb - decant bores

Figure C139

Date:	January 2019
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Groundwater Filterable Sb - eastern bores

Figure C140

Date: January 2019
Report: KCGM Gidji TSF
Hydrogeological Review

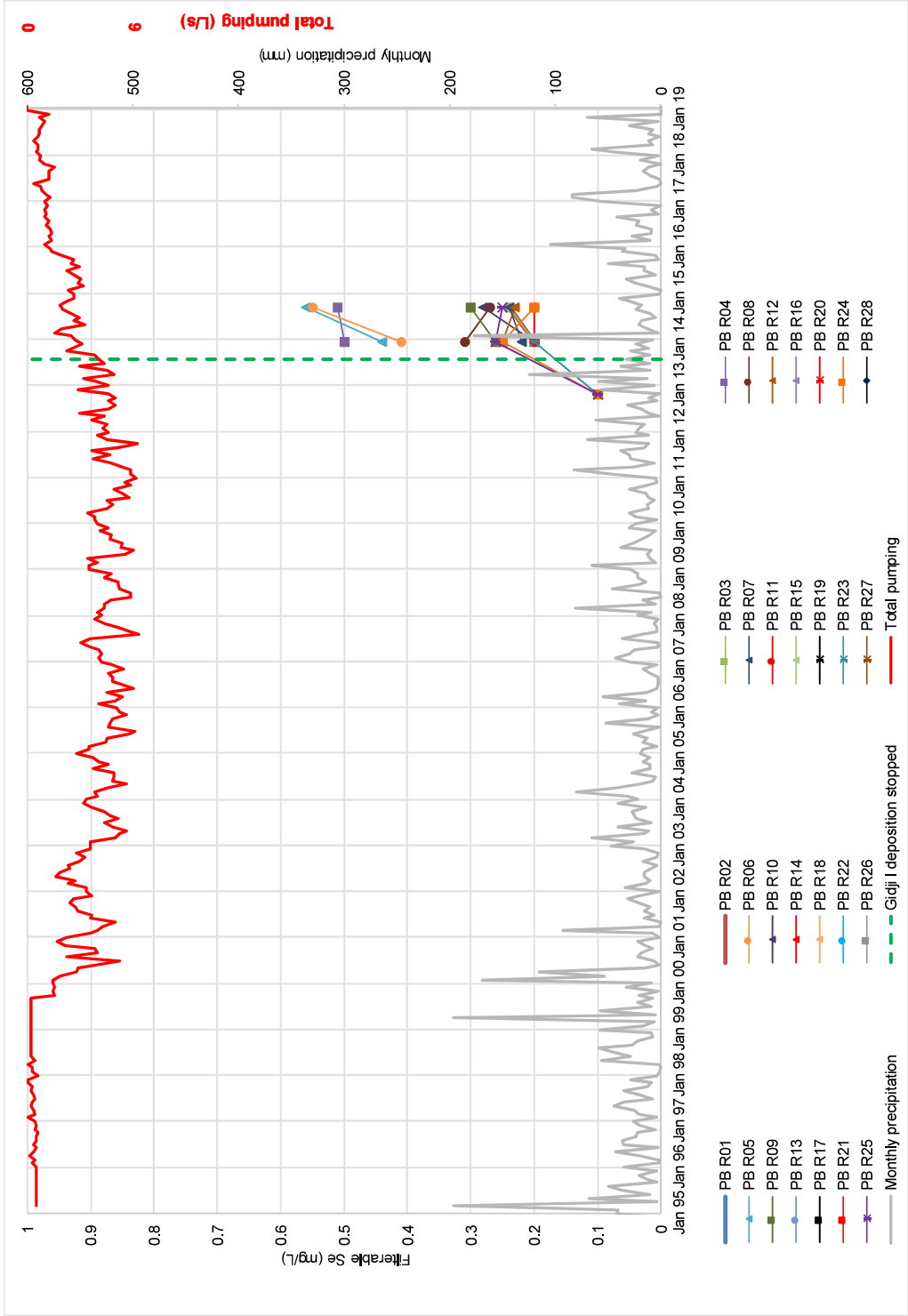


Figure C141

Date:	January 2019
Report:	KCGM Gidji TSF Hydrogeological Review

Groundwater Filterable Se - production bores



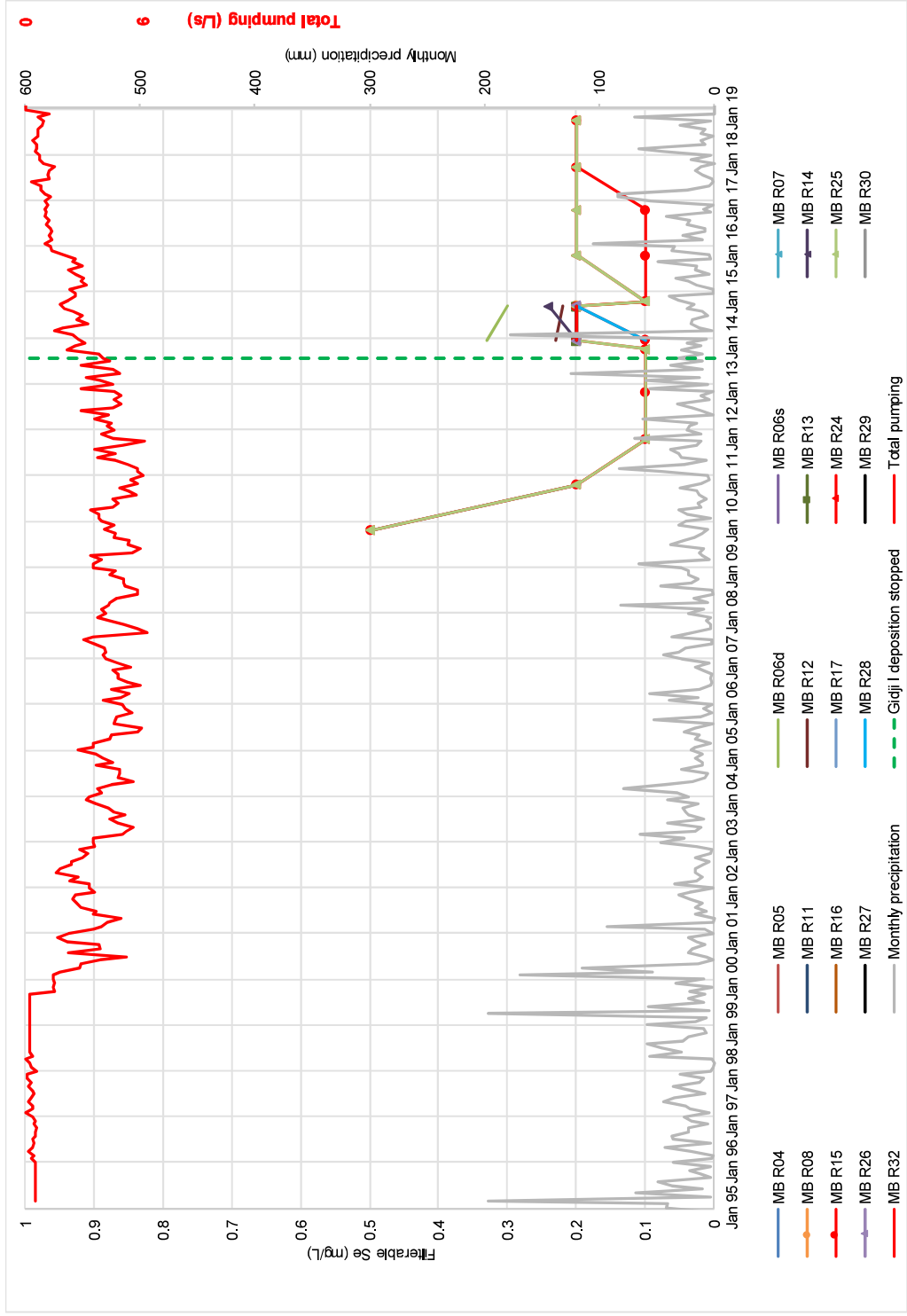
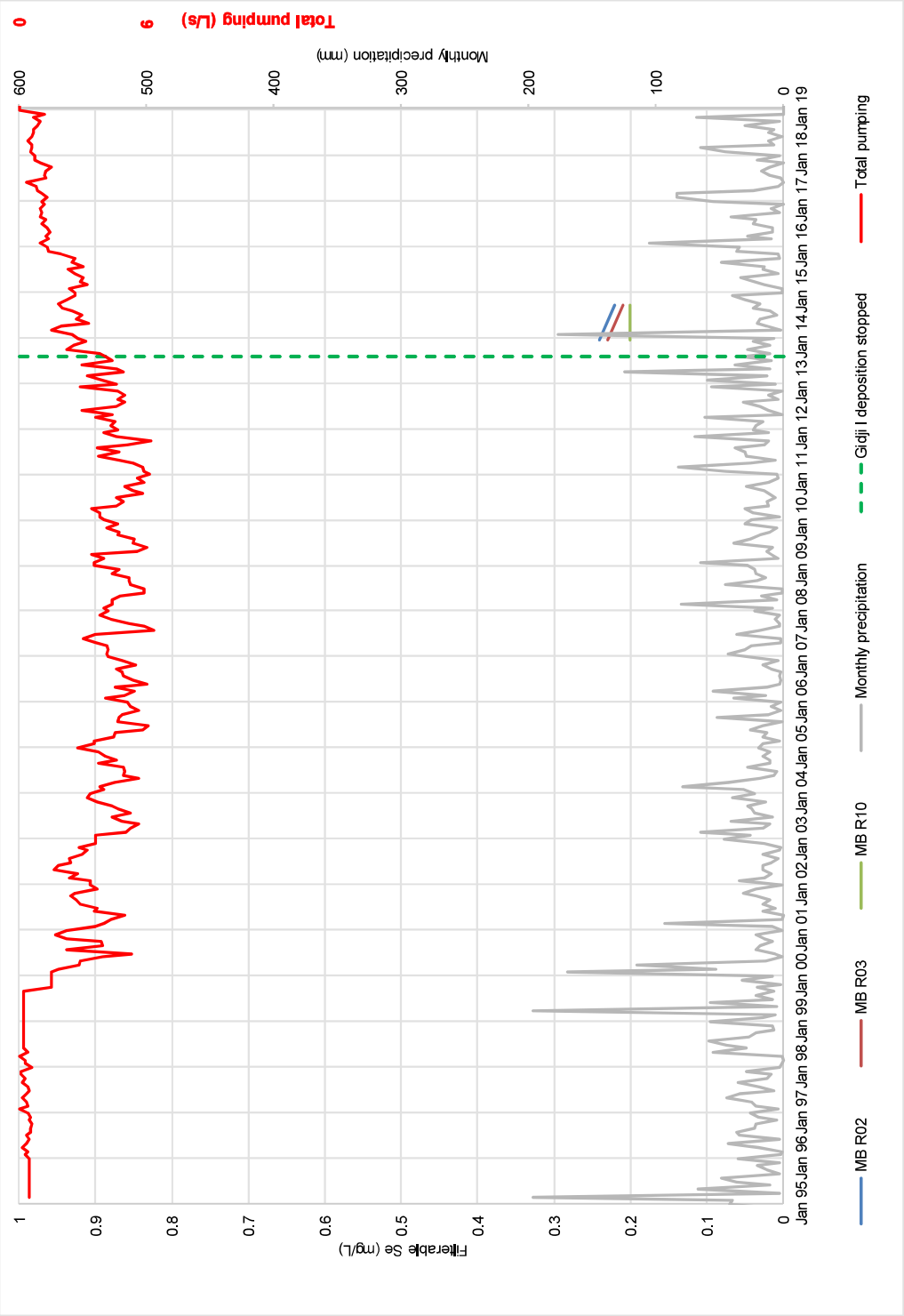


Figure C142

Date: January 2019
Report: KCGM Gidji TSF
Hydrogeological Review

Groundwater Filterable Se - western bores

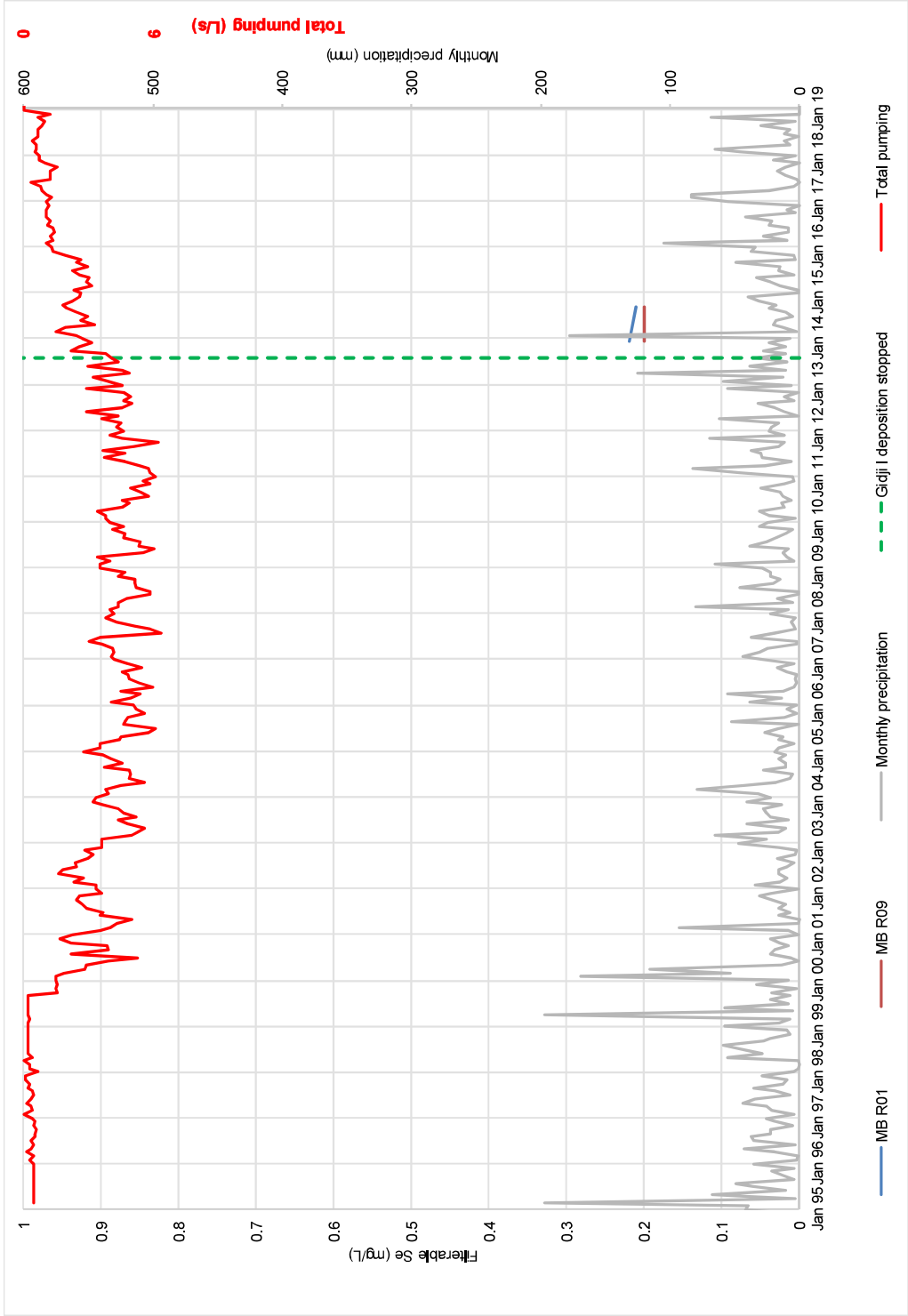




Groundwater Filterable Se - trench bores

Figure C143

Date:	January 2019
Report:	KCGM Gidji TSF Hydrogeological Review

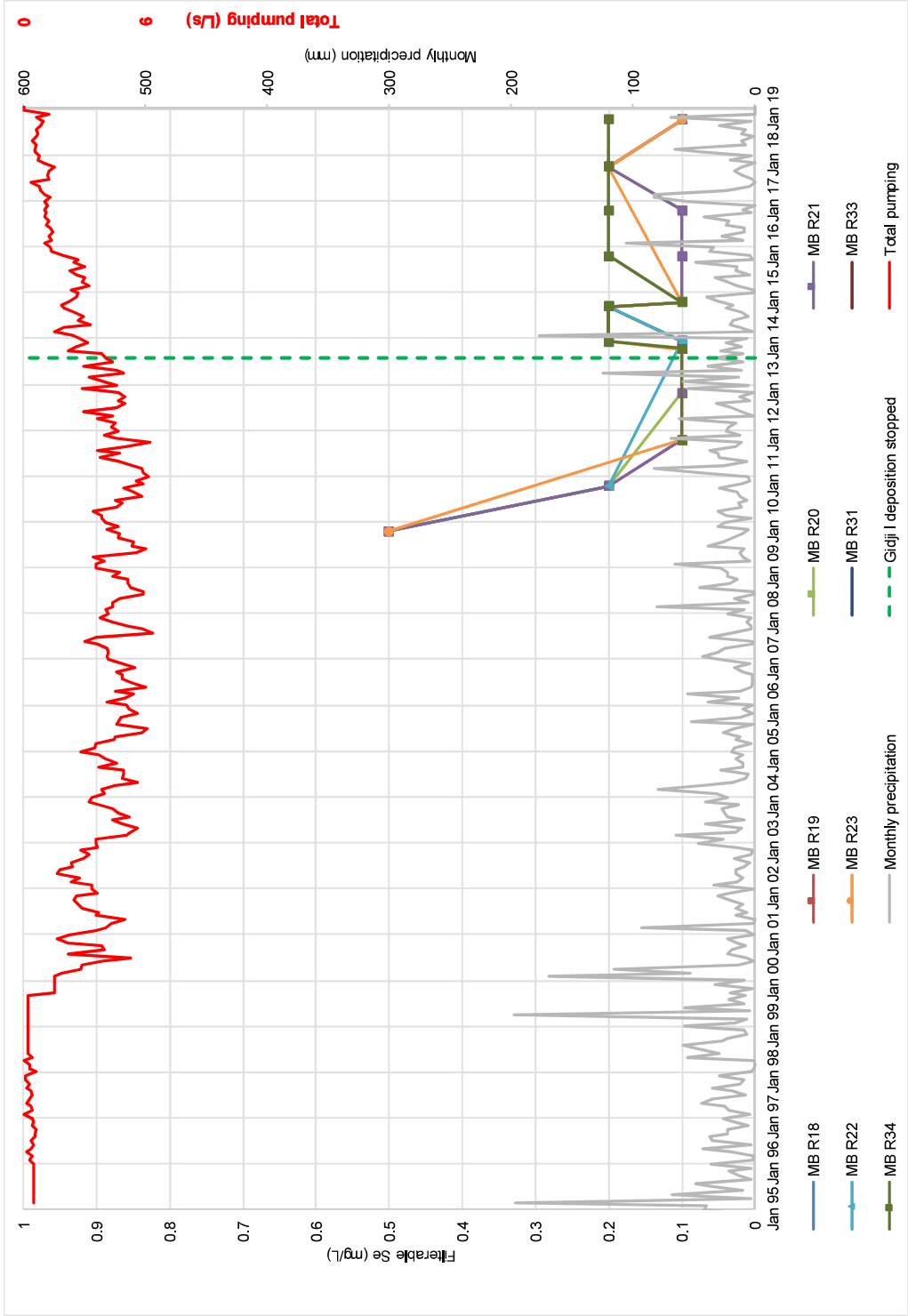


Groundwater Filterable Se - decant bores

Figure C144

Date:	January 2019
Report:	KCGM Gidji TSF Hydrogeological Review





Groundwater Filterable Se - eastern bores



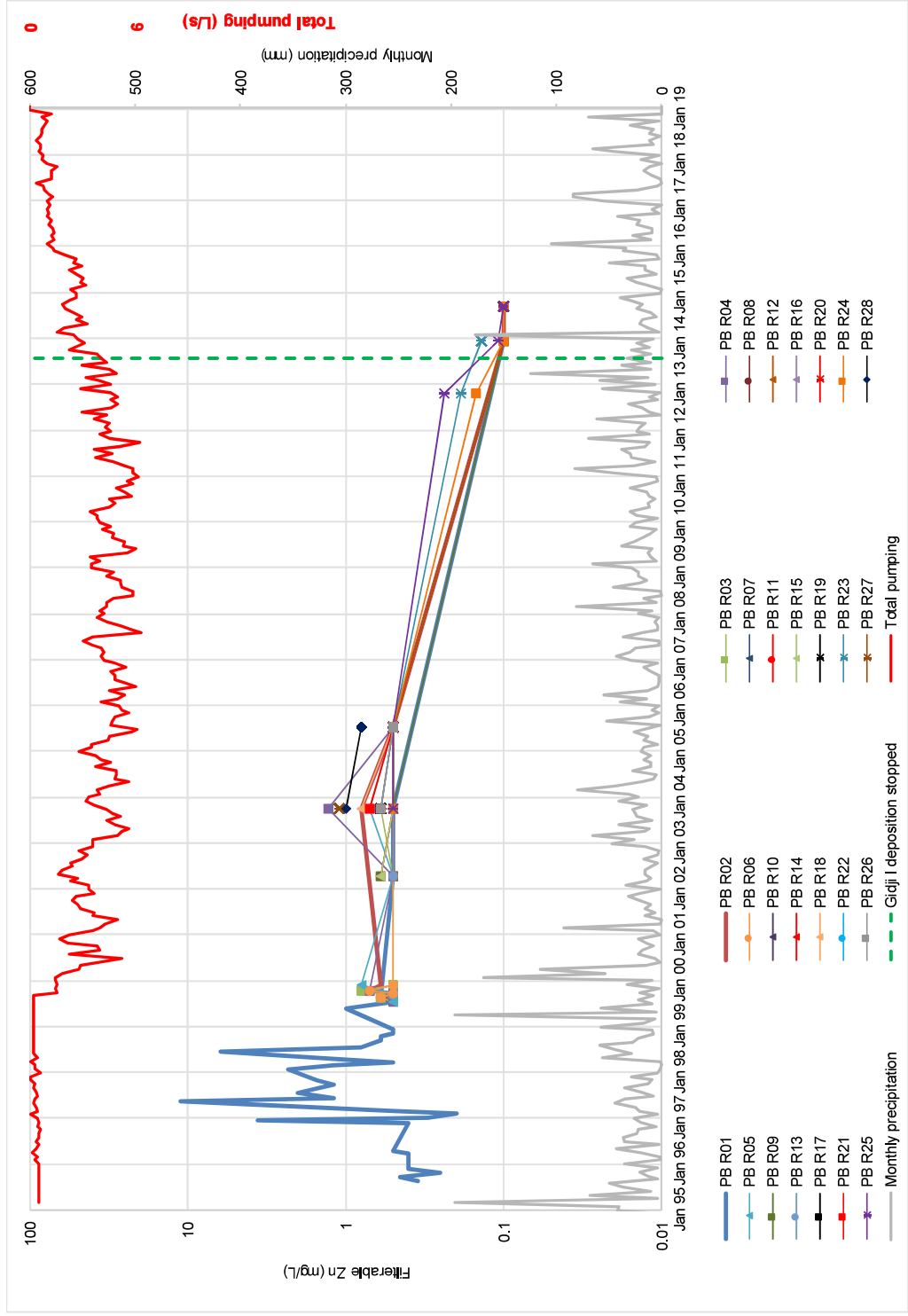


Figure C146

Date:	January 2019
Report:	KCGM Gidji TSF Hydrogeological Review

Groundwater Filterable Zn - production bores



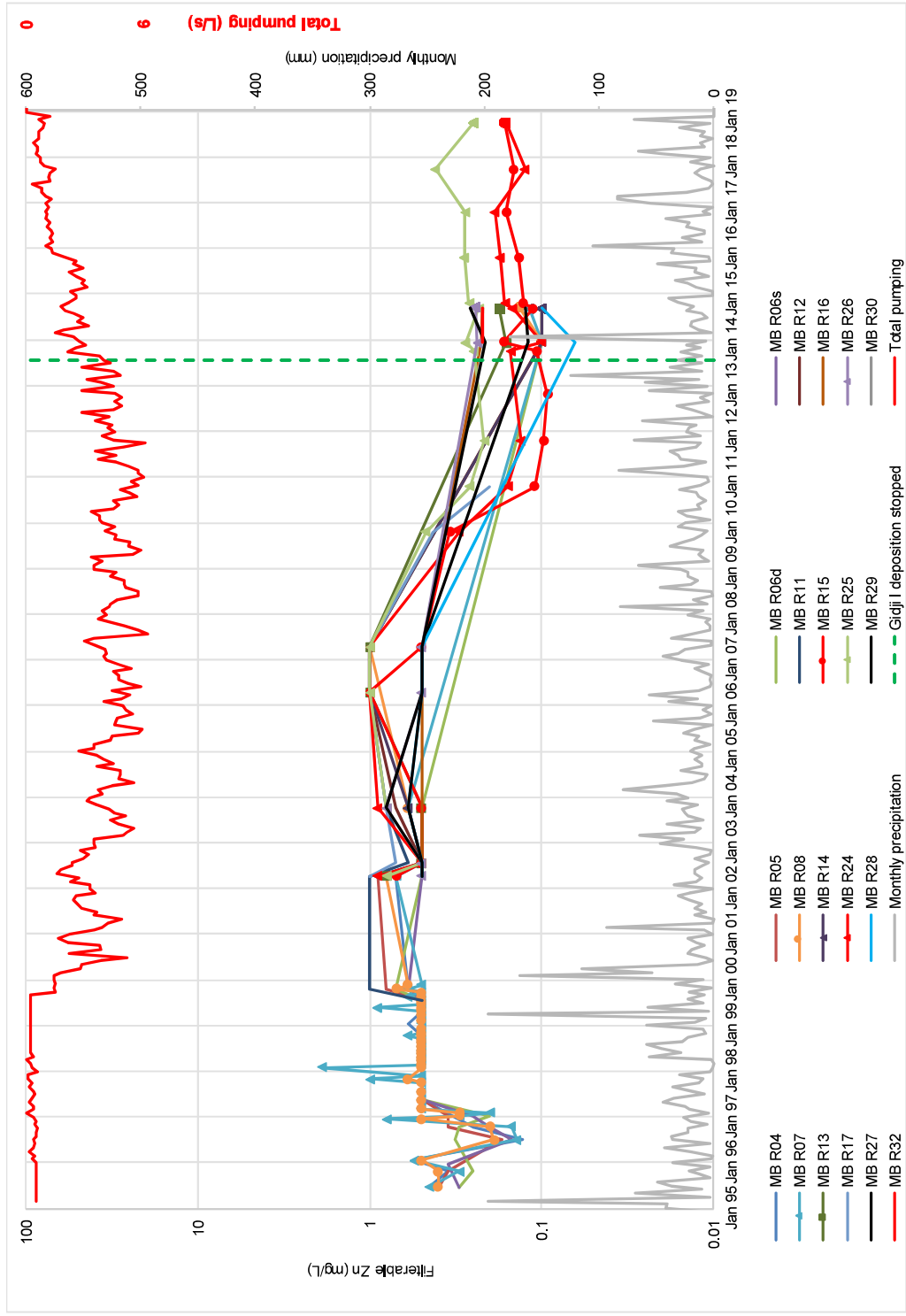


Figure C147

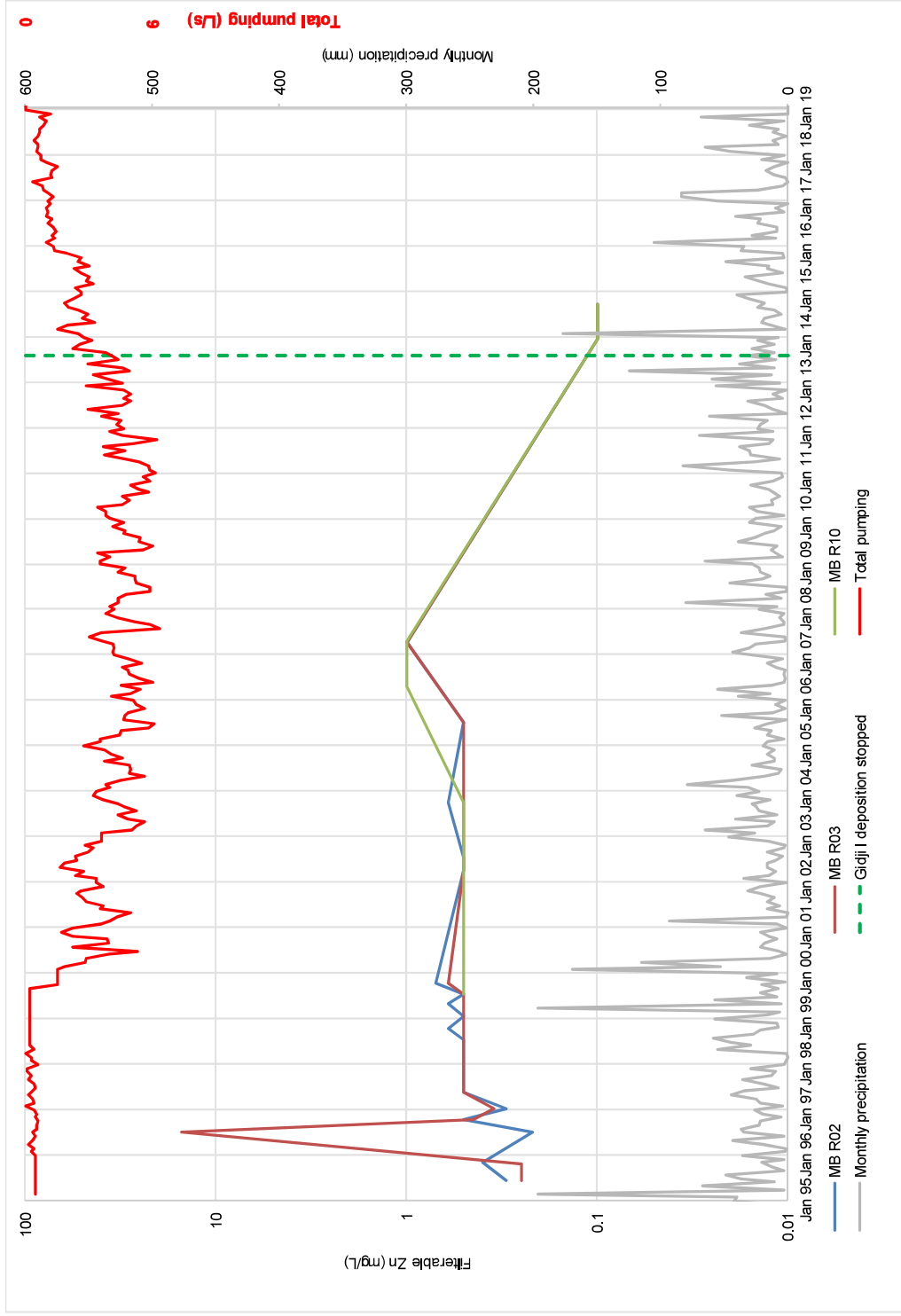
Date: January 2019

Report: KCGM Gidji TSF

Hydrogeological Review

Groundwater Filterable Zn - western bores



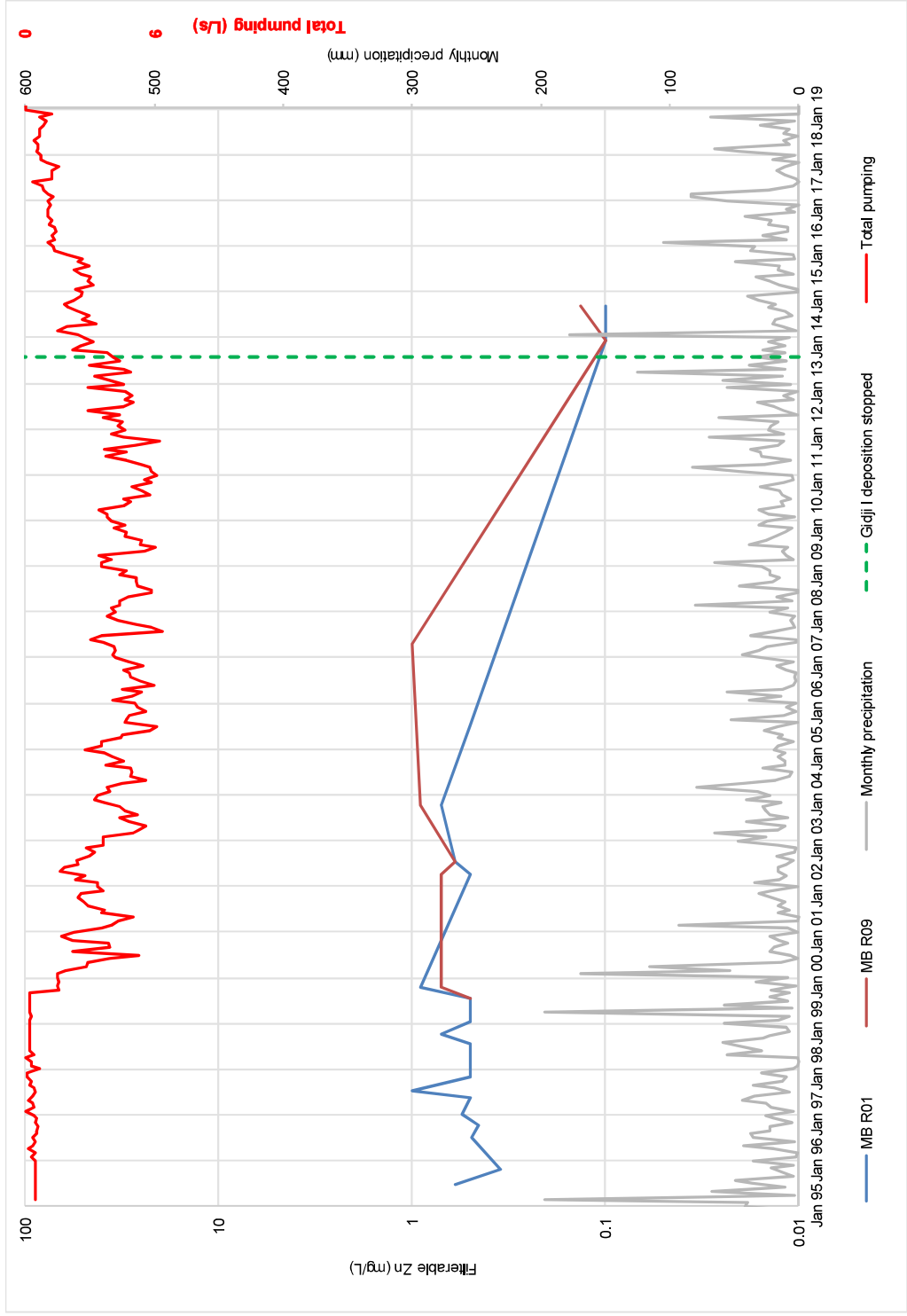


Groundwater Filterable Zn - trench bores

Figure C148

Date: January 2019

Report: KCGM Gidji TSF
Hydrogeological Review

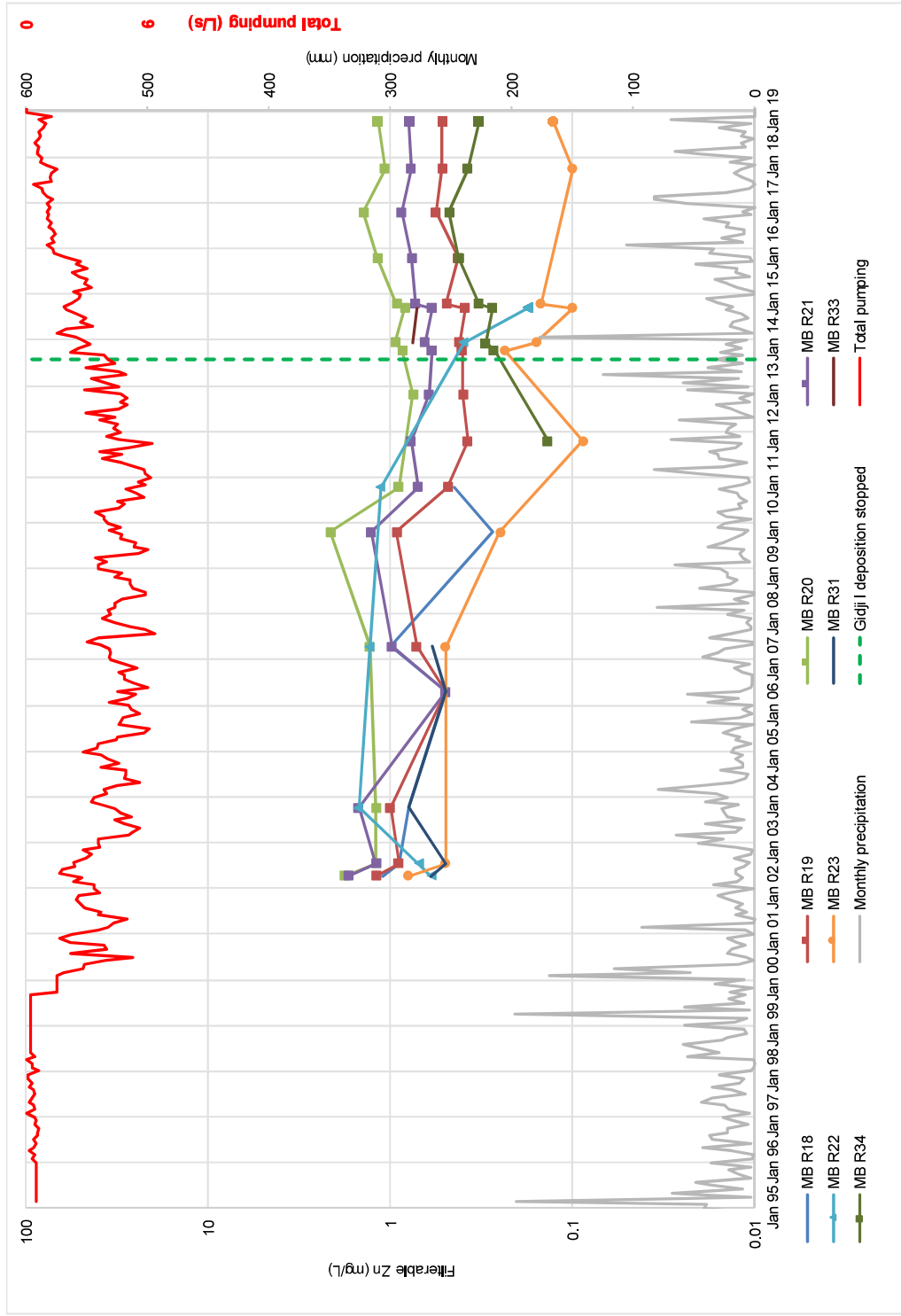


Groundwater Filterable Zn - decant bores

Figure C149

Date:	January 2019
Report:	KCGM Gidji TSF Hydrogeological Review





Groundwater Filterable Zn - eastern bores

Figure C150

Date:	January 2019
Report:	KCGM Gidji TSF Hydrogeological Review



6. APPENDIX 6: CONTAMINATED SITES SUMMARY



DEPARTMENT NAME / SITE / AREA

KCGM Contaminated Sites Summary

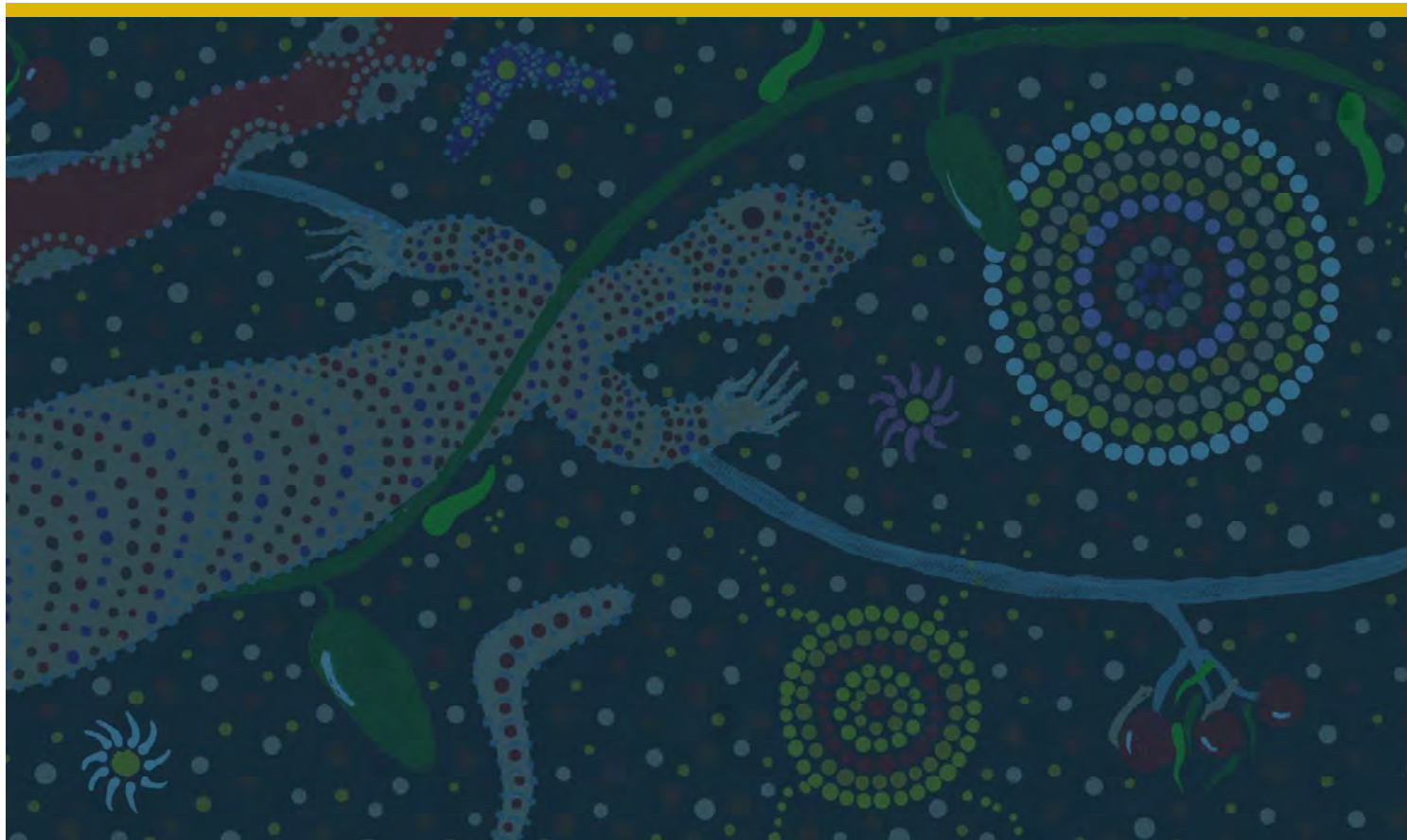


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APPENDICES

Appendix 1: AOC Historial Aerial Photographs

1. Purpose, Scope, and Background

This document provides a summary of the contaminated sites reported by KCGM since 2007.

One hundred and twenty five potentially contaminated sites have been identified within KCGM leases on the basis of activity currently or historically undertaken. Whilst normally a whole land parcel (either tenement, lot or other legally defined parcel) would normally be reported, in 2007, KCGM reported its contaminated sites by discreet 'Areas of concern' (AOC). Of these, 113 AOC had an individual Form 1 submitted to the DWER (formally DEC) as required under the Contaminated Sites Act 2003. The remaining AOCs were reported either by Normandy Kaltails (Newmont) in 2007 or subsequently by KCGM in later years. Tenements were used to locate each site and the boundaries of each area of concern were provided as coordinates.

When feedback was provided from 2010 onwards, DWER grouped these sites into two large 'Potentially Contaminated' zones. Some AOC were partially or completely excluded from these areas, leaving KCGM uncertain of their current classification (e.g., Gidji sites). Additionally, KCGM is yet to review correspondence from DWER in relation to the sites reported by Newmont in 2007. In order to resolve this uncertainty, KCGM intends to liaise with the DWER to confirm the status of all reported sites. Additionally, several legacy/historic sites were reported to the DWER for which KCGM may not be liable for investigation and remediation and KCGM intends to obtain legal advice in order to clarify liability surrounding these sites before any further works are completed.

During 2017, KCGM conducted a review of the reported contaminated sites as outlined above, applying a risk based methodology where sites were ranked (based on current knowledge) on their ability to potentially pose a risk to human health, the environment or environmental values, through application of current understanding of sources, pathways and receptors including acknowledgement of data gaps that may exist within the understanding of the conceptual site model. The intention is to prioritise higher risk sites for assessment, remediation and/or management. The risk methodology and rationale are presented in Section 2.1, along with the strategy that KCGM intends to implement moving forward around contaminated sites and resolving any outstanding governance issues.

Based on the risk assessment completed in 2017, from 2018 to 2021, Preliminary Site Investigations and data gathering was undertaken at several AOC/Zones of Influence (ZOI). The outcomes from these investigations have been incorporated into Section 3, which details the available information on each ZOI and its associated AOCs, including maps and photographs where relevant. Appendix 1 contains historical aerial photography of each ZOI and the AOC contained within each to illustrate potential activities and rehabilitation that has occurred over time.



Figure 1: Fimiston Mt Charlotte and Mt Percy Zones of Influence



Figure 2: Gidji (ZOI17) and Mt Charlotte (ZOI22) Zones of Influence

2. CONTAMINATED SITES FRAMEWORK

The *Contaminated Sites Act* 2003 (CS Act) was established to identify record, manage, and clean up contamination. It is important to note that whilst the *Mining Act* 1978 is generally the key legislative instrument for mine sites, whenever a provision of the CS Act is inconsistent with a provision of the *Mining Act* 1978 or a mining tenement, the provision of the CS Act prevails.

In line with the CS Act, contaminated sites (either known or suspected) are required to be reported to the Department of Water and Environmental Regulation (DWER) [formerly Department of Environment Regulation (DER)]. DWER administers and enforces the CS Act which includes classifying sites (in consultation with the Department of Health) and making information on contaminated sites available to the public. 'Contaminated' land, water or sites are defined by DWER guidelines as:

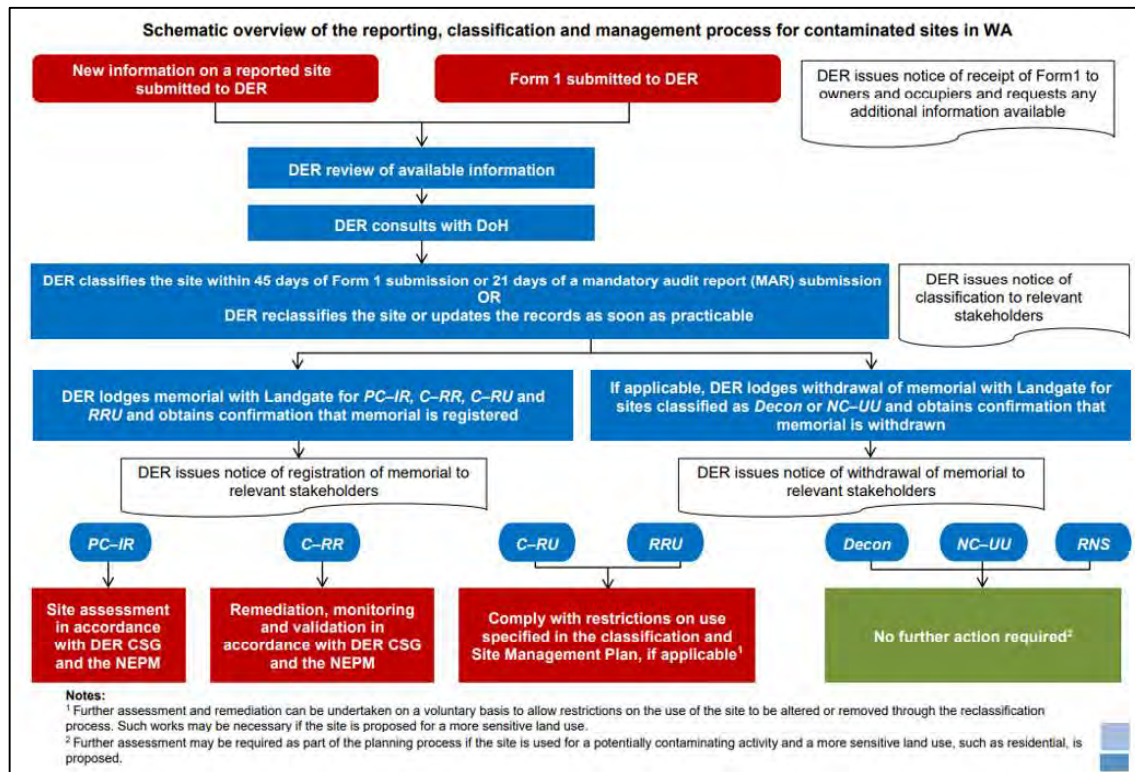
“...having a substance present in or on that land, water or site at above background concentrations that presents, or has the potential to present, a risk of harm to human health, the environment or any environmental value”.

Investigating and cleaning up contaminated sites is, in most cases, the responsibility of the polluter or current site owner. Part 3 of the CS Act deals with remediation of contaminated sites and includes the hierarchy of responsibility for remediation as follows:

- The person who has caused, or contributed to, the contamination of the site.
- The owner or occupier of the site who has changed, or proposes to change, the use of the site.
- The owner of the site.
- The State.

Note that a person who caused, or contributed to, the contamination of a site before the commencement of the CS Act is responsible for remediation of the site only to the extent that the person caused, or contributed to, that contamination by an act that was done without lawful authority. The person most likely to be

A schematic overview of the reporting, classification, and management process for contaminated sites in WA (DWER (2017) – *Identification, reporting and classification of contaminated sites in Western Australia*) is shown below in Figure 3. As per this process, once a site is reported, it is classified by DWER and a memorial on title (or the tenement) is lodged. In cases where the classification is potentially contaminated – investigation required (PC-IR), contaminated – remediation required (C-RR), contaminated – restricted use (C-RU) or remediated restricted use (RRU), then assessment, remediation and/or management is required.



KEY: PC-IR Potentially Contaminated – Investigation required; C-RR Contaminated – Remediation required; C-RU Contaminated – Restricted use; RRU Remediated – restricted use

Figure 3: Process for Classifying Contaminated Sites (DER 2017)

The DWER guidance document *Assessment and Management of Contaminated Sites* (DER, 2014) provides further information in relation to the following:

- Assessing and managing contaminated sites.
- Assessing risks to human health, the environment, and environmental values.
- Generic (tier 1) assessment levels and their application.
- Applying NEPM assessment levels in Western Australia.
- Reporting requirements.
- Community engagement.

DWER encourages a five-tiered staged and iterative approach to contaminated sites investigations, as outlined below (and illustrated in Figure 4):

- Stage 1 – Preliminary Site Investigation (PSI)
- Stage 2 – Detailed Site Investigation (DSI)
- Stage 3 – Remedial Action Plan (RAP)

- Stage 4 – Site Remediation and Validation (SRV)
- Stage 5 – Site Management Plan (SMP)

The overall objective is to reach end point classifications for each site, confirming that sites do not pose a risk to human health, the environment or environmental values or alternatively these risks can be effectively managed through restrictions and further actions are not required.

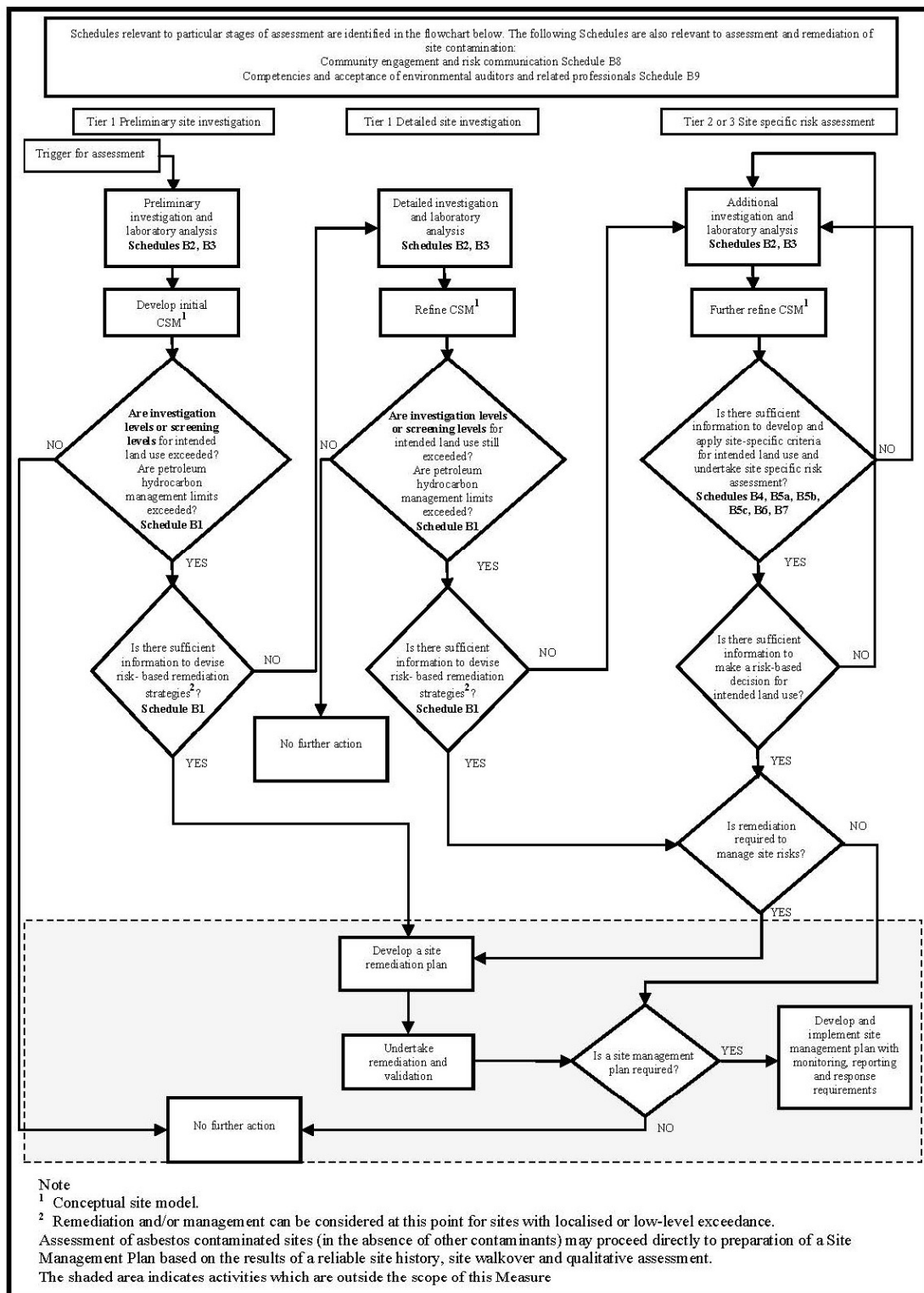


Figure 4: Five Tier Approach to Assessment of Contaminated Sites

2.1 KCGM Contaminated Sites Risk Assessment and Strategy

KCGM's Contaminated Sites Strategy aims to address its obligations under the CS Act (including protecting human health, the environment, and environmental values) while managing corporate risk and liability for rehabilitation. The objective is to achieve final end point classifications (ideally “decontaminated”, “not contaminated – unrestricted use” or “remediated restricted use”) under the Act which align with the potential and likely beneficial uses of sites and take into consideration expectations of key stakeholders through an open and transparent engagement process. Where areas are still operational, assessments and interim management measures will be undertaken to ensure that risks to human health are minimised with final remediation and validation undertaken as part of the approved Mine Closure Plan.

Mining and extractive industries are listed as potentially contaminating activities by the DWER. As noted in Section 1, initially 113 sites were reported to DER in 2007 by KCGM, mostly related to mining or ancillary processes (e.g., water transfer). DWER grouped these sites into two large ‘Potentially Contaminated’ zones when feedback was provided from 2010 onwards. Some AOC were partially or completely excluded from this area, leaving KCGM uncertain of their current classification (e.g., Gidji sites). KCGM intends to liaise with the DWER to confirm the status of all reported sites as investigations progress and more information becomes available. Additionally, several legacy/historic sites were reported to the DWER for which KCGM may not be liable for investigation and remediation. KCGM intends to obtain legal advice in order to clarify liability surrounding these sites before any further works are completed.

Notwithstanding, in 2017 KCGM undertook a review of all reported and classified contaminated sites and grouped them into zones of influence (ZOI). A risk-based methodology where those sites which are deemed (based on current knowledge) to potentially pose a risk to human health, the environment or environmental values are prioritised for assessment, remediation and/or management. This assessment examined sources, pathways and receptors including identification of data gaps that may exist within the understanding of the conceptual site model. Factors considered included (but are not limited) to:

- Current and future use of the area/sources (e.g., including beneficial use of groundwater)
- Contaminants of concern, including existing soil and groundwater data.
- Toxicology and fate and transport characteristics.
- Details of any existing engineering/management controls in place.
- Depth to groundwater and ambient groundwater conditions.
- Distance to sensitive receptors (including surface water discharge point, residential areas).
- Community expectations.

The intention is to prioritise higher risk sites for assessment, remediation and/or management.

3. DETAIL ON REPORTED CONTAMINATED SITES

3.1 ZOI1 – Fimiston I & II TSFs

This Zone of Influence contains the following AOCs:

- AOC16 Fimiston I TSF
- AOC107 Fimiston I TSF Groundwater Plume
- AOC14 Fimiston II TSF
- AOC15 Fimiston II TSF Groundwater Plume
- AOC38 Herliette TSF
- AOC75 Croesus TSF
- AOC62 Historic Shire Tip

These sites have been grouped due to the overriding influence of the Fimiston TSFs on adjacent sites, ensuring that source differentiation within this area would be difficult.

These sites are partially covered by the DWER Potentially Contaminated Zone.

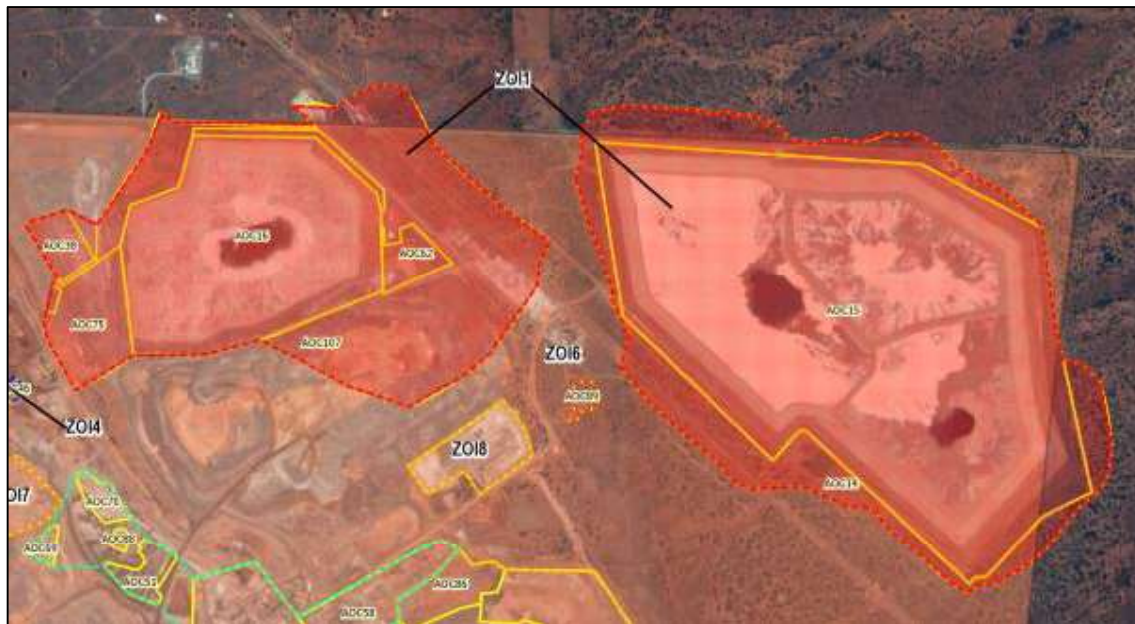


Figure 5: Zone of Influence 1 and associated Areas of Concern

3.1.1 AOC16 Fimiston I TSF & ACO 15 Fimiston II TSF

Tailings from the Fimiston Mill have been deposited into Fimiston I since the conception of KCGM and within Fimiston II since the mid-1990s. Tailings are managed during operations under the Fimiston Licence to Operate, issued under Part V of the *Environmental Protection Act* 1986 (EP Act) and also via tenement conditions issued under the *Mining Act* 1978 via Mining Proposals. Closure of the facilities will be in accordance with the approved Mine Closure Plan, which will outline the capping design required in order for the facility to be 'safe, stable and non-polluting'. Closure planning for the Fimiston TSFs included rock armouring the outer slopes and a rock or oxide cap on the upper surfaces to encapsulate the tails. In 2019-2021 implementation of capping and rehabilitation, i.e., encapsulation of a portion of the northern slope and SW slope was completed. This work will continue over the next few years.

Geochemical characterisation studies of Fimiston tailings have been conducted on five occasions. A summary of geochemical testing to date (MBS Environmental, 2018b) and further work by MBS on mercury characterisation (MBS Environmental, 2020) indicates that, post-closure, the tailings generated by the Fimiston Processing Plant (Fimiston tailings) will:

- remain NAF (non-acid forming) with alkaline pore water
- Remain hypersaline with the predicted formation of a surface gypsum crust, which is predicted to reduce infiltration rates into underlying tailings.
- During operation the solubility of trace metals and metalloids and any potential for infiltration to groundwater will reflect cyanide based chemistry of the Fimiston process water. Metals noted in low to moderate concentrations in Fimiston supernatant solution include copper, mercury, antimony, lead, nickel, and cobalt.
- Post closure the potential for leaching of trace metals and metalloids is considered very low as gradual cyanide degradation, surface adsorption (including arsenic as insoluble iron bound species) and the alkaline nature of the tailings will reduce the mobility of most metals and metalloids to very low levels. Simulation of oxidised tailings conditions by analysis of tailings solutions after accelerated laboratory oxidation with peroxide indicate extremely low levels of all environmentally significant metals and metalloids.
 - Mercury concentrations in Fimiston and Kaltails tailings solids and leachates are low.
 - Very low concentrations of tellurium in water and acetic acid leachates indicate that most of the tellurium is present as stable, insoluble minerals (namely coloradoite). Given the only beneficial use of groundwater is for industrial uses (including mining), and there are no ecological users of groundwater, the very low concentrations found in tailings leachate are unlikely to have an adverse impact.
 - KCGM tailings are not enriched with chromium. Seepage from the Fimiston TSFs is predicted to be circum-neutral to alkaline after mine closure, under which conditions trivalent chromium (III) concentrations are predicted to be very low and of limited environmental significance. Chromium (VI) is unstable in all but highly oxidising conditions and is not expected to be persistent in tailings seepage.

- Fimiston and Kaltails tailings are not enriched with nickel. Water leachates and tailings fluids of Fimiston and Kaltails tailings contain very low concentrations of dissolved nickel and predicted concentrations are unlikely to increase after mine closure.
- The risk of leachate from the stored Fimiston tailings once rehabilitated adversely impacting groundwater is considered low, especially considering the hypersaline groundwater receiving environment.

Surface runoff is intermittent and the adjacent Eastern floodway is ephemeral in nature. During active deposition and wetting of the facility, dust generation is minimised. Further, no receptor for any COPCs currently exists as groundwater within the area is suitable only for mineral processing due to naturally hypersaline conditions.

No pathway exists to enable any COPC to be made available to potential receptors.

SOURCE	RECEPTOR	PATHWAY	IMMEDIATE RISK
Tailings	• Local environment • Human (workers)	• Nil	Nil

3.1.2 AOC107 Fimiston I TSF Seepage Plume & AOC14 Fimiston II TSF Seepage Plume

Seepage from the Fimiston TSFs is regulated under the *EP Act* including Ministerial Statements, and a Part V Licence to Operate, with licence conditions imposed relating to maintenance of groundwater levels below the root zone of natural vegetation, the key environmental value. Closure of the facilities will be in accordance with an approved Mine Closure Plan, which will outline the closure design required in order for the facility to be 'safe, stable and non-polluting', including management of the seepage plume post closure to ensure no adverse impacts on native vegetation.

COPC within seepage from the Fimiston TSFs are considered to be low, as demonstrated by frequent monitoring in accordance with the current Licence to Operate. Leachate not considered to present a risk to the environment – see geochemical characterisation for Fimiston tailings in Section 3.1.1. Further, no receptor for any COPCs currently exists as groundwater within the area is suitable only for mineral processing due to naturally hypersaline conditions.

Further, no receptor for any COPCs currently exists as groundwater within the area is suitable only for mineral processing due to naturally hypersaline conditions.

No pathway exists to enable any COPC to be made available to potential receptors.

Source	Receptor	Pathway	Immediate Risk
Seepage	• Nil	• Seepage	Low

3.1.3 AOC38 – Herliette TSF

The Herliette TSF is an inactive, which operated from 1983/84 to 1990s, depositing tails from nearby mining operations. It is less than 15 m high, not lined and the base is constructed of insitu clays/silty

clays. It is likely that some nickel tails may be present. Following decommissioning of the facility, the site was rehabilitated in the late 1990s by placing approximately 1 m rock capping (to act as a capillary break) and approximately 0.2 m of local topsoil. In 2012, this topsoil was harvested for further use in rehabilitation prior to the facility being covered by construction of the Northern Waste Rock Dump (WRD). The TSF is now fully encapsulated by a minimum of 100m of fresh competent waste rock dumped to construct the Northern WRD.

Material characterisation sampling and analysis was conducted of the tailings prior to encapsulation, with results indicating that leaching of COPC would be unlikely (and will be further reduced by encapsulation), therefore there is a limited pathway for groundwater contamination (SoilWater, 2012). The waste rock cover has eliminated the pathway for dust generation.

KCGM consider that this site to be remediated and no further risk, as it has been completed encapsulated.

Source	Receptor	Pathway	Immediate Risk
Seepage	• Nil	• Unlikely	Nil

3.1.4 AOC75 – Old Croesus TSF

Old Croesus TSF abuts the Fimiston I TSF to the east. It was operational from the 1960s to 1988, initially as a fresh water tailings but then later changed to hypersaline tailings. The western external face was rehabilitated in 1999/2000 as a dust control measure by covering the batters with 1 m of competent waste rock and 0.5 m of oxide. Poor water control has caused tunnel erosion in this area. From 2012 onwards, the majority of the remaining exposed tailings were encapsulated during construction of the Northern WRD, although a very small area on the upper surface remains exposed.

In 2020 the western side of the TSF was rehabilitated, with the wall reshaped, water control measures put in place on the upper surface and capping of the slope with at least 0.5 m of waste rock, with a store and release cover of growth media. The TSF is now completely encapsulated.

A desktop review in 2007 (KCGM, 2007) of two studies conducted in 1997 (Normandy Kaltails, 1998) and 2006 (KCGM, 2006) on the potential re-treatment of the tailings determined that it was not economical to reprocess the TSF. In both instances, three tailings layers were assayed; the top was devoid of gold, the middle contained nickel residue and the bottom contained the highest gold grade. Historic sampling has provided indications that there are levels of nickel and copper above ecological levels within the middle layers of the TSF.

Material characterisation sampling in 2016 (MBS Environmental, 2016) indicates that:

- Tailings are classified as NAF with low to moderate theoretical acid production potential and correspondingly moderate to high levels of ANC; a significant portion of sulfur in most samples being in the already oxidised form (sulfate). Old Croesus was further classified as acid consuming.
- Leachate and hence any potential for seepage (depending on closure design) from these tailings is predicted to be brackish to moderately saline in perpetuity.

- The tailings are geochemically enriched in gold, silver, antimony and tellurium as a result of the nature of the particular gold mineralisation, but none of these elements were found to be soluble in water extracts or dilute acetic acid extracts to any extent considered to be of environmental concern post-closure when covered.
- The tailings are geochemically benign, with only moderate levels of salinity in leachates and/or potential seepage, which will remain alkaline.

The above geochemical assessment indicates that a suitably designed waste rock cover to prevent wind and water erosion will be sufficient post-closure to prevent negative impacts on the surrounding environment.

KCGM consider that rehabilitation of this TSF is now complete and no further risk, as it has been completely encapsulated by waste rock.

Source	Receptor	Pathway	Immediate Risk
Seepage	• Nil	• Unlikely	Nil

3.1.5 AOC62 – Historic shire tip

This small facility was operated as a municipal shire landfill until the mid 1980s. It has since been encapsulated by the North Eastern WRD during early 2000s and rehabilitated during works on Fimiston I. It is unknown what materials were deposited.

A pool of surface water occurs intermittent at the south eastern toe of the dump after rainfall events, although surface water flow is thought to be constrained by the adjacent topsoil stockpile and WRD.

KCGM considers that this site is of low risk due to source – receptor – pathways being limited by waste rock encapsulation, and the hypersaline nature of groundwaters. The area is limited in access by mining activities, however, care should be undertaken during any works which will disturb the toe of the existing WRD rehabilitation during movement of the topsoil stockpile.

Source	Receptor	Pathway	Immediate Risk
Seepage from landfill	• Local Environment	• GW unlikely • Surface water flows unlikely	Low

3.2 ZO12 – Kaltails TSF

This Zone of Influence contains the following Areas of Concern:

- AOC115 Kaltails Seepage Plume
- AOC116 Kaltails TSF
- AOC117 Former Kaltails Processing Plant

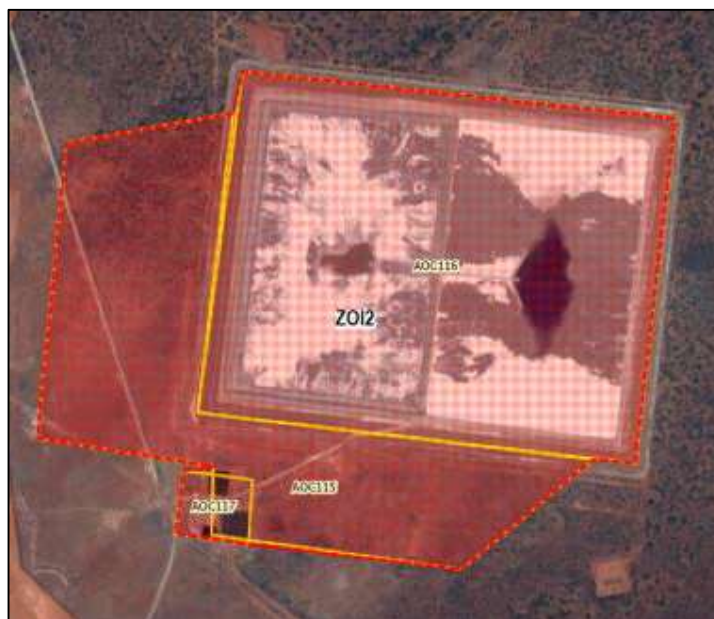


Figure 6: Zone of Influence 2 and associated Areas of Concern

3.2.1 ACO 117 Former Kaltails Processing Plant

This area contained the processing plant for the retreatment of hydraulically mined tailings during the Kaltails Project, which was decommissioned and rehabilitated when the Kaltails project ceased in the early 2000s. KCGM constructed water ponds and pipelines over some of this area as part of recommissioning of the TSF in 2011.

Residual COPCs within soils from the Kaltails Retreatment Project may be present, however limited soils testing has been completed as per Contaminated Sites Requirements. Given that much of the area is covered with operating infrastructure, and managed as per the EP Act and Regulations, KCGM considers that the immediate risk from this area to the environment and human health is low. Groundwater in this area is shallow, but is hypersaline and there is no other beneficial use other than industrial use (including mining).

Source	Receptor	Pathway	Immediate Risk
Contaminated soil	Local Environment (mining area)	- Dust - Vegetation uptake	Low

3.2.2 AOC 116 Kaltails TSF

The Kaltails TSF covers an area of approximately 216 ha and is located to the south east of the Fimiston WRDs. The Kaltails TSF was first operated between 1988 and 1999 as part of a major regional tailings retreatment project of tailings dams deposited in the footprint of the southern Fimiston WRDs. The facility was recommissioned by KCGM in 2011 for storage of tailings from the Fimiston Mill and is currently operated in accordance with the Part V Licence to Operate for the Fimiston Operations.

Closure planning for TSFs includes rock armouring the outer slopes and a rock or oxide cap on the upper surfaces to encapsulate the TSFs. In 2020 implementation of capping and rehabilitation, i.e., encapsulation of the northern slope of Kaltails East cell. This work will continue over the next few years.

Geochemical characterisation of Fimiston tailings as described in Section 3.1.1 is applicable to Kaltails TSF from 2011 onwards. Characterisation of Kaltails tailings deposited during initial operation from 1988 to 1999 indicated that the tailings were NAF (Golder Associates, 2008).

Dust generation from the TSF is adequately suppressed by the wet upper surface during operations, such that dust generation does not appear to be a significant issue. Surface water is managed from the TSF during operations within toe drains and dams surrounding the facility. As such, KCGM considers that the risk from the Kaltails TSF is low considering the benign nature of the tailings and current operational management programs. In 2020/2021 capping of the northern flank of the east cell was completed, with more than 0.5m of waste rock capping placed over the outer slope surface.

Closure of the facilities will be in accordance with an approved Mine Closure Plan, which will outline the closure design required in order for the facility to be 'safe, stable and non-polluting'. Current closure design is for a rock cap to be applied which will adequately mitigate the risk of wind erosion and dusting.

Source	Receptor	Pathway	Immediate Risk
Tailings	• Local Environment	• Nil	Nil

3.2.3 AOC 115 Kaltails TSF Seepage Plume

Due to the Kaltails TSF being unlined, seepage from active deposition on the dam occurs. KCGM currently undergoes seepage management during operations through a network of recovery bores in accordance with a Seepage and Groundwater Management Plan required by the Fimiston Operations Part V EP Act licence. As such, vegetation monitoring conducted since 2011 has not indicated that seepage from the Kaltails TSF has had any adverse effects on the surrounding vegetation.

Closure of the facilities will be in accordance with an approved Mine Closure Plan, which will outline the closure design required in order for the facility to be 'safe, stable and non-polluting', including management of the seepage plume post closure to ensure no adverse impacts on native vegetation.

KCGM does not consider the Kaltails Seepage Plume to be an immediate risk in terms of contaminated sites as levels are adequately managed in accordance with licence conditions. COPC within seepage from the Fimiston TSFs are considered to be low. Further, no receptor for any COPCs currently exists as the only beneficial use for groundwater within the area is mining and mineral processing due to naturally hypersaline conditions.

Source	Receptor	Pathway	Immediate Risk
Seepage	• Local Environment	• Seepage	Low

3.3 ZO13 – Mining Operations

This Zone of Influence contains the following AOCs:

- AOC51 Open Pits Fuel Farm
- AOC57 Fimiston Mill
- AOC58 Contractor Workshops
- AOC69 Sam Pearce Underground Support Facilities
- AOC70 Crushing Facilities
- AOC79 Chaffers Workshop Area
- AOC88 Saline Water Transfer Pond



Figure 7: Zone of Influence 3 and associated Areas of Concern

These areas are all currently part of active mining operations and are managed in accordance with the *EP Act* and *Mining Act*. KCGM considers that immediate risk from these sites is adequately managed through operational management procedures. Long term risk from these sites will be managed through investigation and remediation (if required) during closure.

Some sites have had opportunistic sampling undertaken during operations.

Source	Receptor	Pathway	Immediate Risk
Leaks, spills of chemicals; Seepage from ponds	Local Environment	- GW unlikely - Surface water flows	Low

3.3.1 AOC57 Fimiston Mill

The Fimiston Mill was constructed as the Processing Plant for ore from the Fimiston Open Pit in 1989. It covers approximately 20 ha and is located to the east of the Fimiston Pit. Two parallel circuits process refractory sulphide ore from the Fimiston Open Pit and Mt Charlotte Underground Mine. The key components of the processing circuit are:

- primary crushing plant;
- a semi-autogenous grinding mill with pebble crushing circuit;
- two ball mills; and
- flotation and two CIL circuits.

The Fimiston Mill and associated tailings deposition is managed in accordance with a Part V Licence and the International Cyanide Management Code, which has strict requirements on the protection of human health and the environment from releases of cyanide.

The infrastructure at the Fimiston Mill is underlain by a bitumen or concrete hardstand and all process water ponds are lined with concrete or poly liner (Figure 8). Surface water flows from drains surrounding the facility are monitored for exceedances of water quality parameters in accordance with *Environmental Protection (Unauthorised Discharge) Regulations*.

Preliminary drill composite sampling of the Fimiston Mill during 2013 (samples taken during geotechnical drilling for footings) indicated elevated concentrations of COPC confined to surface soils, below current concrete hardstands.



Figure 8: Fimiston Mill 2017 (facing west)

3.3.2 AOC58 Contractors Workshops

The Open Pits Contractor Workshops are operational areas used for the maintenance of the open pit mining fleet, washdown and laydown (Figure 9). Surface water flows from the drains surrounding the facility are monitored for exceedances of water quality parameters in accordance with *EP (Unauthorised Discharge) Regulations*. It is unlikely that there is a pathway to groundwater due to significant depth to groundwater. Due to dewatering of the adjacent Fimiston Open Pit, groundwater contours are towards the pit. At closure the pit will be a groundwater sink. There is no receptor due to the hypersaline nature of the groundwater (no other beneficial uses).



Figure 9: Contractor Workshops 2017 (facing east)

3.3.3 AOC69 Sam Pearce Underground Support Facilities

The Sam Pearce facilities are used for similar activities as the Open Pits workshops, but they are smaller in scale and are located on the edge of the Fimiston Open Pit. Surface water flow from this area reports to the Open Pit. It is unlikely that there is a pathway to groundwater due to significant depth to groundwater. Due to dewatering of the adjacent Fimiston Open Pit, groundwater contours are towards the pit.

3.3.4 AOC70 Crushing Facilities

These facilities are used for crushing of ore mined from the Fimiston Pit. Most likely COPC would be associated with hydrocarbon use. Surface water from this area reports to drainage adjacent to Fimiston Mill, which is monitored for exceedances of water quality parameters in accordance with *EP (Unauthorised Discharge) Regulations*. It is unlikely that there is a pathway to groundwater due to significant depth to groundwater. Due to dewatering of the adjacent Fimiston Open Pit, groundwater contours are towards the pit.

3.3.5 AOC79 Chaffers Workshop Area

This area was used as a mineral processing and workshop area until decommissioning in late 1990s and equipment removal in the early 2000s. This area has been mined through as part of the Morrison Cutback and no longer exists.

3.3.6 AOC88 Saline Water Transfer Pond

This area has been used for transfer of saline water for dust suppression. Further investigation will be conducted as part of closure planning for this feature. The COC are salts.

3.4 ZO14 – AOC46 Mines Rescue Fire Training Ground

This site has been used for firefighting training of the KCGM Emergency Responses Team, where active burning and extinguishing of materials has been conducted since the early 1990s. The current firefighting foams are unlikely to contain per- and polyfluoroalkyl substances (PFAS) although other PFAS-containing foams may have been used in the past. This area is currently part of active mining operations and is managed in accordance with the *EP Act* and *Mining Act*. KCGM considers that immediate risk from this site is adequately managed through operational management procedures.

In 2019/2020 further investigation was conducted at this AOC. The draft PSI has been completed, with some further actions required to complete the study. Early findings are as follows:

No soil samples exceeded the human health criteria for a commercial/industrial setting, indicating that the site does not pose a risk to site workers/visitors in the site's current setting. However, bonded asbestos containing materials (ACM) was identified during the site inspection in the bushland area north of the fire training ground, likely sourced from dumped waste material.

Elevated concentrations of hydrocarbons (TRH) were noted, consistent with the use of fire ignition (e.g., kerosene) and remnant burnt materials. Perfluorooctanesulfonic acid (PFOS) impacts exceeded

indirect ecological investigation levels at several locations including at a sample location in cleared bushland approximately 10 m north of the fire training ground.

Groundwater pathways for transfer of COPCs are not considered highly likely due to depth to groundwater and the only beneficial use being mining/mineral processing. The AOC is within the drawdown cone of the Fimiston Pit / Mt Charlotte underground mine. In the extremely unlikely event that any groundwater exists, it would report to mine pumping systems that are creating the drawdown and the water would become part of the mine water system. At closure water at the bottom of Mt Charlotte underground mine is expected to decant to the Fimiston Open Pit after approximately 100 years. Fimiston Open Pit is a groundwater sink at closure, and will eventually have a pit lake. Modelling has proved that the pit lake will fill to approximately halfway up the pit wall, and will never overtop. The pit lake water will be hypersaline, and unfavourable for development of any form of eco system.



Figure 10: Zone of Influence 4 and associated Area of Concern

Monitoring of long-term risk will continue. Additional containment controls are currently being considered for viability, as an outcome of the PSI. If remediation is required, expected to be actioned closer to closure, when the facility is no longer used.

Source	Receptor	Pathway	Immediate Risk
Leaks, spills of chemicals; Use of Fire Suppressants	Local Environment	- Surface water flows - Soils	Low

3.5 ZO15 – Mt Charlotte

This Zone of Influence contains the following:

- AOC29 Cassidy Headframe Workshops and Hydrocarbon Area

- AOC30 Mt Charlotte Vent Rise North
- AOC36 Mt Charlotte Southern Vent Rise
- AOC37 Mt Charlotte Compressor House
- AOC72 Historical TSF (Mt Charlotte)
- AOC87 Mt Charlotte Hydrocarbon Storage Area

These areas have been grouped together as they are located in the same geographical area, or are associated with the Mt Charlotte Underground. KCGM considers that the operational sites (29, 30, 36, 37, 72, and 87) are of a low immediate risk from a contaminated sites perspective as they are managed in accordance with the Mining and EP Acts.

These areas will be actioned for contaminated sites investigation closer to closure.

Source	Receptor	Pathway	Immediate Risk
Contaminated Soil	• Local Environment	• Soil • Air	Low



Figure 11: Zone of Influence 5 and associated Areas of Concern

3.5.1 AOC29, 37 & 87 Cassidy Workshops and Hydrocarbon Areas

Cassidy headframe and winder are still operational to service the Mt Charlotte mine. The remainder of the area is used as a core yard and has either been covered with road base, concrete hardstand or sheeted with gravels. Likely COPCs in this area would be associated with hydrocarbon use.

3.5.2 AOC30 & 36 Mt Charlotte Northern and Southern Vent Rises

These areas are operational ventilation shafts that have the potential for COPCs associated with hydrocarbons.

3.5.3 AOC72 Historical TSF

This area appears to have been used as a mineral processing facility, with small tailings and heap leach/ponds present in historical photos. Tailings material looks to have been partially removed in the early 1990s (final disposal destination unclear). The area was then ripped and seeded with a range of native plants. There is limited vegetation regrowth.

Testing of the soil in 2012 prior to earthworks around the Southern Ore body vent fan indicate that where present, the tailings material occurs at a depth of 60 cm, is extremely saline and had elevated levels of arsenic and mercury (Outback Ecology, 2012). Further sampling is required to suitably classify the soils throughout the entire area, concentrating on likely areas of contamination in association with remnant tailings. However, sampling and remediation of northern part of area is unlikely due to geotechnical safe working condition limitations around the Mt Charlotte Glory Hole. Due to constraints imposed by the Mining Act, this area is not easily accessible at present.

Given the current general success of revegetation in the area, the pathway for COPC transfer via dust is considered to be reduced. Groundwater is hypersaline, and the area is within the Mt Charlotte dewatering zone, and therefore not considered a viable pathway. The area is not accessible by the public due to security fencing.

3.6 ZO16 – Saline Water Transfer Station

This Zone of Influence includes:

- AOC 89 Saline Water Storage
- AOC 114 Saline Water Storage

These sites have been grouped as they are the same type of infrastructure, although geographically separated. KCGM considers the immediate risk from these sites to be low due to operational mitigation measures reducing the likelihood and consequence of any spills/leaks from infrastructure. The COC are salts.

Source	Receptor	Pathway	Immediate Risk
Bore/Process Water	• Local Environment	• Soil	Low



Figure 12: Zone of Influence 6 and associated Areas of Concern

3.6.1 AOC 89 & 114 Saline Water Transfer Tanks

This AOC contains a decommissioned saline water transfer tank and saline water catchpit. The catchpit has been partially backfilled and rehabilitated. Remaining area is operational and will not be treated or rehabilitated until end of mine life. The COC are salts.

3.6.2 AOC 114 Kaltails Borefield Transfer Tank

This AOC has been incorrectly reported to the DWER and an amendment will need to be submitted to correct its positioning. It was reported on the basis that spills of saline water abstracted from the borefields have occurred in this area, but potential COPCs within this water are limited. Secondary containment (earthen bunds) is present to prevent spills from reaching the wider environment. The COC are salts.

3.7 ZO17 – Pit Adjacent Legacy TSFs

This Zone of Influence contains the following Areas of Concern:

- AOC110 Croesus TSF
- AOC66 Morrisons TSF (also known as Calcine & Historic TSF)

These AOCs have been grouped as they share similar geochemistry and are within the immediate proximity of the Fimiston Pit.



Figure 13: Zone of Influence 7 and associated Areas of Concern

3.7.1 AOC110 Croesus TSF

The inactive Croesus TSF, located at the northern end of the Fimiston Pit, is currently rehabilitated or capped with waste rock. A very small section of the eastern wall is exposed, and has allowed for geochemical sampling. Approximately half of the TSF was reclaimed by Normandy Kaltails between 1998 and 1999 with recovery of further economic grade not considered viable. After mining of the northern portion of the tailings, the remaining area was ripped and seeded in conjunction with the Croesus Mill site in 2001.

Geochemical sampling conducted in 2016 (MBS Environmental, 2016) indicates:

- Tailings are NAF with low to moderate theoretical acid production potential and correspondingly moderate to high levels of ANC, with a significant portion of sulfur in most samples being in the already oxidised form (sulfate).
- Leachate and hence any potential for seepage (depending on closure design) is predicted to be alkaline and moderately saline in perpetuity.
- Tailings is geochemically enriched in gold, silver, antimony, and tellurium as a result of the nature of the particular gold mineralisation, but none of these elements were found to be soluble in water extracts or dilute acetic acid extracts to any extent considered to be of environmental concern when covered post-closure.
- Tailings are geochemically enriched in arsenic, cobalt, copper, molybdenum, selenium, and lead. Selenium, lead and copper were not found to be soluble under the alkaline conditions expected to prevail post-closure and these elements, despite enrichment, are not considered to pose a risk to the environment.
- Concentrations of cobalt (2.25 mg/L on a 1:20 basis) and molybdenum (0.202 mg/L on a 1:20 basis) in water leachate were found to marginally exceed the livestock drinking water guidelines of 1 mg/L and 0.15 mg/L, respectively.

The TSF is located within the cone of depression for dewatering of the Fimiston Open Pit and Mt Charlotte underground mine. Any operational seepage will report to mine pumping systems that are creating the drawdown and the water would become part of the mine water system. At closure water at

the bottom of Mt Charlotte underground mine is expected to decant to the Fimiston Open Pit after approximately 100 years. Fimiston Open Pit is a groundwater sink at closure, and will eventually have a pit lake. Modelling has proved that the pit lake will fill to approximately halfway up the pit wall, and will never overtop. The pit lake water will be hypersaline, and unfavourable for development of any form of eco system.

KCGM does not consider this TSF to be of immediate or future risk to the environment or human health as the pathways for transport of COPC are limited due to existing rehabilitation or capping, suppressing dust generation, depth to hypersaline groundwater and surface water drainage from this landform reporting to operational mining areas. Long term closure of this facility will consider the geochemical characterisation of materials in order to adequately minimise any potential seepage of COPC.

Source	Receptor	Pathway	Immediate Risk
Tailings	• Nil	• Nil	Nil

3.7.2 AOC66 – Historic TSF (Morrisons TSF)

This facility is a legacy of prior mining operations and has been partially reclaimed by Pericles Resources around 2005.

The has been relocated and is now dumped within the Trafalgar WRD. The calcine tailings have been capped with a domed (water shedding), traffic compacted oxide layer, with waste rock on top of the capping layer. Once the waste rock dump reaches final high, the upper surface will be rehabilitated with a store and release growth medium layer.

Geochemical characterisation of the material in 2016 (MBS Environmental, 2016) indicates that:

- Tailings are geochemically enriched in arsenic, cobalt, copper, molybdenum, and selenium.
- Selenium and copper were not found to be soluble under the alkaline conditions expected to prevail post-closure and these elements, despite enrichment, are not considered to pose a risk to the environment.
- Concentrations of arsenic (0.63 mg/L on a 1:20 basis) and molybdenum (0.175 mg/L on a 1:20 basis) in water leachate marginally exceeded the livestock drinking water guidelines of 0.5 mg/L and 0.15 mg/L, respectively.

The TSF is located within the cone of depression for dewatering of the Fimiston Open Pit. Any operational seepage will report to mine pumping systems that are creating the drawdown and the water would become part of the mine water system. The Fimiston Open Pit is a groundwater sink at closure, and will eventually have a pit lake. Modelling has proved that the pit lake will fill to approximately halfway up the pit wall, and will never overtop. The pit lake water will be hypersaline, and unfavourable for development of any form of ecosystem.

KCGM does not consider this TSF to be of immediate or future risk to the environment or human health as the pathways for transport of COPC are limited due to existing encapsulation, suppressing dust

generation, depth to hypersaline groundwater and surface water drainage from this landform reporting to operational mining areas.

Source	Receptor	Pathway	Immediate Risk
Tailings	• Nil	• Nil	Nil

3.8 ZO18 – AOC20 Paringa TSF

This Zone of Influence contains a single Area of Concern; AOC 20 – Paringa TSF (Figure 14). This TSF has been kept separate to other AOCs due to its use for operational activities other than tailings deposition after it was decommissioned.



Figure 14: Zone of Influence 8

The TSF ceased active deposition in 1987 after four years of operations. The TSF is not lined, the base is constructed of insitu clays/silty clays and it is less than 15 m high. The since the 2000s the TSF upper surface has been used for disposal/irrigation of Treated Waste Water and as a bioremediation facility. The western cell has also been used to dispose of carbon pulp (historical underground timbers pulped in the mill). For these activities, the TSF is managed in accordance with a licence issued under Part V of the *EP Act*.

Geochemical characterisation was conducted on a surface sample of Paringa tailings in 2016 (MBS Environmental, 2016). The results indicated that the tailings has low to moderate theoretical acid production potential and correspondingly moderate to high levels of ANC, with a significant portion of sulfur in most samples being in the already oxidised form (sulfate). As a result, all samples were classified as NAF, with Paringa TSF classified as acid consuming. Leachate and hence any potential for seepage from this tailings is predicted to be alkaline and moderately saline in perpetuity. The tailings were found to be geochemically enriched in gold, silver, antimony, and tellurium due to particular gold mineralisation, but none of these elements were found to be soluble in water extracts or dilute acetic acid extracts to any extent considered to be of environmental concern post-closure when covered. The Paringa TSF is therefore considered to contain geochemically benign tailings, with only moderate levels of salinity in leachates and/or potential seepage, which will remain alkaline.

Drilling and sampling of this TSF was undertaken in 2019, with assessment of results still underway. The drilling depth penetrated through the tailings pile, into the underlying ground surface. Piezometers were installed in some of the drill holes. The piezometers have been sampled, and have been dry, i.e., there is no water table in the TSF.

The TSF has not been observed to actively dust to any major degree. The current final closure design is encapsulation through expansion of the adjacent waste dump, which will eliminate the possibility of dust generation and greatly reduce the potential for seepage through reduction in water infiltration.

Therefore, the source of COPC is considered negligible in the long term. KCGM considers that this site is of low immediate risk due to source – receptor pathways being limited by active management of offsite environmental impacts, the benign nature of tailings, the hypersaline nature of the groundwater.

Drilling through the tailings dam was undertaken in 2019, with samples taken for analysis. Interpretation has not commenced. Piezometers were installed in some of the drill holes, but no phreatic surface was identified.

Source	Receptor	Pathway	Immediate Risk
Leaks, spills of chemicals Tailings	Local Environment	- GW unlikely - Dust	Low

3.9 ZO19 – Legacy TSF Footprints (Encapsulated)

This Zone of Influence contains the following:

- AOC64 Historic TSF
- AOC65 Historic TSF
- AOC 85 Historic Tailings Wash Area

These Areas have been grouped together as they are located adjacent to one another and have all been covered to some degree by the Fimiston WRDs.



Figure 15: Zone of Influence 9 and associated Areas of Concern

These areas contain the remnant footprints of tailings facilities that were reprocessed during the Kaltails project in the 1990s. They were covered under at least 40 m of waste rock within the Trafalgar Waste Dump during 2000s, eliminating the pathway for exposure via dust. Water infiltration through the WRD does occur, but is reduced by the waste rock capping, minimising the potential for transfer of COPC into surface and groundwaters.

Given testing conducted on similar tails within the area (MBS Environmental, 2016), it is likely that the remnant tailings contains elevated levels of COPCs, however if present, they are likely to be in insoluble forms. Further investigation of area not possible due to waste dump placement.

KCGM considers this AOC to be low risk considering the placement of waste rock limiting the pathways for COPC transfer to the wider environment.

Source	Receptor	Pathway	Immediate Risk
Tailings and Soil	Local Environment	Surface water movement (low)	Low

3.10 ZOI10 – Oroya, Balgold, and Galconda TSFs

This Zone of Influence includes:

- AOC52 Oroya TSF
- AOC53 Balgold Heap leach Footprints
- AOC74 Galconda TSF Footprint

- AOC86 Balgoid-Galconda Tails Wash Area
- AOC105 Former Balgoid Heap Leach Pads

These sites have been grouped together as they are located adjacent to one another and source differentiation between distinct sites within this area would be difficult, especially considering that they are almost completely covered by waste rock and/or subgrade stockpiles. All sites, other than ACO105 will be discussed together in the below sections.



Figure 16: Zone of Influence 10 and associated Areas of Concern

3.10.1 Oroya, Balgoid, and Galconda TSFs

The Oroya TSF received tailings from the Oroya Processing Plant until it was decommissioned in the late 1990s. After a period of consolidation and drying, the TSF was progressively encapsulated by waste rock from 1998 to 2002. Rehabilitation of the overlying waste rock dump was completed from 1998 to 2003. A geotechnical study of the TSF confirmed that it was stable under waste rock loading (Golder Associates, 2011). No sampling of the TSF was conducted to Contaminated Sites standards when the tailings was exposed and it is now no longer possible due to waste rock placement.

The Balgoid and Galconda TSFs were operational between 1984 and 1992 and were progressively encapsulated by waste rock from the mid-1990s to 2002. The majority of the tailings is covered by waste rock, with only small area of the Balgoid TSF wall remaining exposed. Geochemical sampling was conducted on this exposed tailings in 2016 (MBS Environmental, 2016):

- Tailings are NAF with low to moderate theoretical acid production potential and correspondingly moderate to high levels of ANC, with a significant portion of sulfur in most samples being in the already oxidised form (sulfate).

- Leachate and hence any potential for seepage (depending on closure design) is predicted to be alkaline and brackish in perpetuity.
- Geochemically enriched in gold, silver, antimony, and tellurium as a result of the nature of the particular gold mineralisation, but none of these elements were found to be soluble in water extracts or dilute acetic acid extracts to any extent considered to be of environmental concern post-closure when covered.
- Marginally enriched in mercury (1.1 mg/kg) along with a higher concentration of tellurium (13.9 mg/kg), but were not found to be soluble in water extracts and are not considered to pose a risk to the environment when covered with waste rock to prevent water and wind erosion.
- Tailings is geochemically benign but other materials within the Balgoid, Oroya, and Galconda operations area are expected to be variable in nature.

It was concluded that a suitably designed waste rock cover to prevent wind and water erosion will be sufficient post-closure to prevent negative impacts on the surrounding environment. Given that the majority of these tailings are already covered, KCGM considers that there is low immediate risk from this facility on any potential receptors.

The Balgoid-Galconda Tailings Wash Area (AOC 86) was reported as a tailings wash area, but recent review of historic photographs of the area suggest that it was more likely used as an infrastructure/laydown area. It is currently used as an operational laydown and storage area. Monitoring of surface water runoff has occurred during operations for unauthorised discharge, which could be used for preliminary investigations for effects on surface water. This site is unlikely to have groundwater impacts due to depth of the groundwater to surface and also the hypersaline nature of the groundwater (no other beneficial uses).

KCGM considers that risk from a Contaminated Sites perspective is adequately managed through encapsulation and the groundwater production borefields.

Source	Receptor	Pathway	Immediate Risk
Tailings Seepage	Local Environment (soil)	- Surface water movement (low) - Seepage expression	Low

3.10.2 AOC105 Former Balgoid Heap Leach Pads

Little information is known about this small area to the south of the large TSFs. Limited documentation states that they were heap leach pads/ponds and they appear to have been used up until the mid-1990s, when they were capped and rehabilitated. The area has been capped and rehabilitated. Rehabilitation has performed well, with less success on the upper surfaces of the ponds, suggesting high soil salinity.

KCGM considers that the risk from this AOC is low considering effective rehabilitation has limited pathways for COPC transfer via dust and surface water movement. There is no ecological or human

receptor for groundwater as the only beneficial use for groundwater is mining. Further sampling of this area may be undertaken to better understand any potential sources of COPCs.

Source	Receptor	Pathway	Immediate Risk
Mineral Processing Residues	Local Environment (soil)	- Surface water movement (low) - Seepage expression - Vegetation uptake	Low

3.11 ZOI11 – Croesus Mill

This Zone of Influence includes:

- AOC42 Former Croesus Mill
- AOC111 Historic Concentrate Storage Area
- AOC112 Historic Tailings Wash Area

These sites have been grouped together as they are located adjacent to one another and source differentiation between distinct sites within this area would be difficult, especially considering these sites have been partially buried under the Environmental Noise Bund and/or mined through.



Figure 17: Zone of Influence 11 and associated Areas of Concern

3.11.1 AOC111 – Historic Concentrate Storage Area

No information is available on this AOC, therefore it is unclear why it was originally reported. Review of aerial photographs from the 1980s and 1990s shows that the area has been heavily impacted by mining and mineral processing activities, including being mined through during development of the Croesus Pit and then backfilled during development of the Fimiston Pit. KCGM does not consider this area to be a source of COPC and will apply for this area to have a revised classification of 'Report unsubstantiated'.

3.11.2 AOC112 Northern Croesus Mill and Tailings Wash (a.k.a. Historic Tailings wash area)

This site consists of the rehabilitated footprints of ponds, pipeline corridors, laydowns and residue/tails stockpiles that were used during operation of the Croesus Processing Plant (Mill) in the late 1980s and early 1990s. The site was decommissioned and rehabilitated during 'Greening the Golden Mile' in 1999. Success of vegetation growth in the area has been variable, likely due to residual salinity.

The majority of this area is either covered by a waste rock dump (Croesus Noise Bund) or has adequate vegetation coverage to mitigate dust generation. Depth to hypersaline groundwater in this area is considerable, and the area is within the cone of depression for Fimiston Open Pit and Mt Charlotte, and as such KCGM does not believe seepage to groundwater is a viable COPC pathway. Soil contamination and uptake by vegetation may be a credible pathway; however, adequate soil sampling has not been undertaken. Preliminary sampling has indicated that metals contamination above Ecological Investigation Limits is confined to first 5-40 cm of soil profile, but original results were not conducted to

Contaminated Sites data standards. Further soil sampling should be conducted to further define potential sources of COPCs and the risk to the local environment. The entire area is currently fenced off and not accessible by the general public – likely to remain so indefinitely. Access by mine workers is limited to periodic rehabilitation monitoring.

KCGM considers that this area has low immediate risk from a contaminated sites perspective.

Source	Receptor	Pathway	Immediate Risk
Soils	Local Environment	Uptake by vegetation	Low

3.11.3 AOC42 – Former Croesus Mill

This site contains the rehabilitated footprint of the Croesus processing plant, which contained a roaster and associated infrastructure including carparks, tailings, and process water dams. The plant was decommissioned and rehabilitated (including hand planting with local native seedlings) in 1997-1999 and partially encapsulated by Croesus Noise Bund in 2001-2003. There are areas of limited vegetation success at within the northern section – salinity suspected to be a limiting factor. The entire area is currently fenced off and not accessible by the general public – likely to remain so indefinitely. Access by mine workers is limited to periodic rehabilitation monitoring.

Further sampling of soils is required in this area to define any potential sources of COPC. However, pathways and receptors for transfer of COPC are considered limited due to depth to groundwater and the hypersaline nature of groundwaters. Dust generation is not considered an issue from these rehabilitated areas and surface water flows are generally confined to within rehabilitated areas.

KCGM considers that this area has low immediate risk from a contaminated sites perspective.

Source	Receptor	Pathway	Immediate Risk
Soils	Local Environment	Uptake by vegetation	Low

3.12 ZO12 – Boorara Rd Rehabilitated Areas

This Zone of Influence contains the following AOCs:

- AOC40 Former Gold Processing Plant
- AOC41 Former Force Workshop
- AOC42 Former Croesus Mill
- AOC43 Former Gold Processing Plant
- AOC44 Historic TSF
- AOC45 Former Gold Processing Plant

It should be noted that further clarity on the liability for remediation of these sites is required. KCGM is unsure if they liable for investigation and remediation of these sites, despite initially reporting them.

No soil sampling has been completed in these areas, although poor vegetation growth from rehabilitation in some areas tends to indicate salinity may be present. Should KCGM be determined to be liable for remediation of this site, further testing of soils in the area is recommended to define any sources of COPC and the immediate risk from this area.

Source	Receptor	Pathway	Immediate Risk
Contaminated soil	- Local Environment - Humans	- GW unlikely - Dust - Surface water	LOW



Figure 18: Zone of Influence 12 and associated Areas of Concern

3.12.1 AOC40 Former Gold Processing Plant

This area was operated prior to the 1980s as a Processing Plant, with tailings/residue appearing to have been deposited in legacy TSF on site (see Appendix 1, Figure A30). The site was rehabilitated in 1993/94 with the processing plant removed and area ripped, seeded and hand planted with local provenance species.

The site is bordered by Borarra Rd to the south and an active infrastructure corridor to the east. It is currently accessible by members of the public.

A draft PSI has been prepared as an outcome over work done over the period 2019 – 2021. The likely outcome is, after removal of asbestos fragments, end classification to Contaminated, Restricted Use.

3.12.2 AOC41 Former Force Workshop (reported as Former workshop)

This site was used as a mining fleet maintenance workshop. It is bordered by Borarra Rd to the south and Goldfields Hwy to the West. It is currently accessible by members of the public and is used as public open space. No permanent structures are present.

Cleanup and rehabilitation of the site (approx. 10,804 m²) occurred in 2003 and documentation states that it was planned to include the removal of all equipment, waste and infrastructure, and hydrocarbon and saline contaminated soil. Soil was to be removed to a nominal 0.5 m depth or less where contamination was not visually evident.

A draft PSI has been prepared as an outcome over work done over the period 2019-2021. Additional sampling is required to make a determination on end point classification.

3.12.3 AOC43 Former Gold Processing Plant

This site encompasses part of the former “WAMPRI” processing plant and waste dump. The plant was decommissioned and rehabilitated in 1997-1999. Growth media and rehabilitation materials were trucked to site in order to construct a 2-3 m bund on the eastern and southern edges of the area. The area was hand planted and seeded, with vegetation growth being very successful.

The tailings may have been produced using potable, rather than saline water. The tailings storage appears to have been removed, with only the footprint of the tailings remaining. Internal KCGM documentation suggests that the tails were stockpiled on Croesus TSF and rehabilitated.

A draft PSI has been prepared as an outcome over work done over the period 2019-2021. The likely outcome is end point classification to Contaminated – Restricted Use.

3.12.4 AOC44 & AOC45 Historic TSF and Former gold processing plant

This site, also known as Mt Ferrum, operated in the mid-1980s and consisted of an open pit, mineral processing plant, heap leach and tailings facilities. Operations were backfilled, mineral processing plant decommissioned, and tailings/heap leach rehabilitated in 1997. There is currently good vegetation growth present.

The area is accessible to the general public, although visitations are infrequent. A dust monitor is present on the upper surfaces of the facility, although it only measures size fractions, not speciation of COPC.

A draft PSI has been prepared for work completed over the period 2019 – 2021. The likely outcome is end point classification to Not Contaminated – Unrestricted Use for both AOC44 and AOC 45.

3.13 ZOI13 – Morrison’s Flats Tailings Wash Area

This site is known as AOC63.



Figure 19: Zone of Influence 13 and associated Area of Concern

Tailings have been deposited in this area since before the turn of the 20th century, processing ore from the Golden Mile. Due to mineral processing methods used at the time, much of these tailings were enriched in heavy metals, including gold. Some of the tailings were reclaimed as part of the Kaltails Retreatment Project from 1988 to 1999 and the resulting tailings were deposited within the Kaltails TSF. Some of the remaining footprints of the TSFs have been progressively covered by the expansion of the Finiston WRD to the south. Other historical TSFs in the area have been subjected to sheet wash flows which have spread tailings material over surrounding areas of soil. Further expansion of the WRD is planned which will gradually cover the remaining footprints.

Initial sampling and analysis of the tailings (including the Joshtails TSF) and tailings wash areas indicated that tailings material was fully oxidised (not PAF) but contained variably enriched levels of mercury, arsenic, silver, antimony, and tellurium. Concentrations were highest areas where tailings piles were evident. Analysis of underlying soils in wash areas indicated the species were not migrating through into the soil. Concentrations of tailings (but generally not the underlying soils) exceeded Ecological Investigation Limits but were below levels of concern for human health.

Further geochemical assessment and results indicated the species were largely insoluble – particularly for some samples where porewaters have gradually developed higher concentrations of soluble forms of mercury. Speciation indicated mercury was present as either coloradoite (insoluble) or mercury salts but not volatile elemental mercury. The properties of the tailings indicate no increased risk of mobilisation of metals if wash area tailings are relocated for remediation/closure purposes.

Further work is being completed to characterise the groundwater environment surrounding this ZOI to determine any potential impacts from tailings seepage.

Source	Receptor	Pathway	Immediate Risk
Tailings	Local Environment	Groundwater	Not Yet Determined

3.14 ZO114 – Mt Percy Open Pit Lakes

This Zone of Influence includes:

- AOC101 Union Club Pit
- AOC102 Sir John
- AOC103 Mystery Pit



Figure 20: Zone of Influence 14 and associated Areas of Concern

Mining occurred at the Mt Percy site between 1985 and 1992 when the Mystery and Union Club Open Pits were mined to a maximum depth of 90 m.

The groundwater phreatic surface coincides with the Mystery Pit floor. As a result, this wall section appears to be fully drained and the mine void contains no permanently ponded water. The Union Club Pit floor however extends deeper to 300 m AHD resulting in the lower part of the pit intersecting the groundwater table. The intersection of the phreatic surface within the moderately to slightly weathered zone implies the uppermost Union Club slope, i.e., the weathered zone, is fully drained. The current pit lakes have remained relatively stable for a number of years reflecting the balance between groundwater and rainfall inflow and evaporation from the lake.

Routine analysis of pit lake waters as part of ongoing operational water monitoring indicates that COPCs are below investigation levels. There is also no beneficial use of groundwater other than mining – therefore there is no receptor. KCGM does not consider these areas to be a source of COPC and will apply for to have a revised classification of ‘Report unsubstantiated’.

Source	Receptor	Pathway	Immediate Risk
Nil	• Nil	• Groundwater	Nil

3.15 ZOI15 – Mt Percy Rehab Features

This Zone of Influence includes the following Areas of Concern:

- AOC8 Mt Percy TSF
- AOC10 Former Mt Percy Plant
- AOC25 Mt Percy Workshop and Wash Area
- AOC31 Sir John Open Pit
- AOC90 Mt Percy Former ROM Pad

These sites have been grouped together due to geographical location and their closed and rehabilitated status. All Mt Percy sites are fenced and public access is excluded.



Figure 21: Zone of Influence 15 and associated Areas of Concern

3.15.1 AOC8 Mt Percy TSF

The Mt Percy TSF consists of two paddocks (TSF 1 and TSF 2) and is approximately 39 ha, with embankments (maximum height of 24m) constructed both of mine waste (oxide) and tailings. It received tailings from the Mt Percy processing plant (AOC10) from 1985 to 1997, and was rehabilitated in 2001. The final geotechnical stability assessment (conducted in 1997) indicated satisfactory stability.

Rehabilitation involved capping with a considerable amount of oxide (1-2 m in places) and slope angles were either constructed, or reshaped with oxide waste to 20°. At the time, the main purpose of rehabilitation was for prevention of dust and increased amenity to the City of Kalgoorlie Boulder.

Limited characterisation of tailings from the Mt Percy TSF was undertaken by Australian Groundwater Consultants as a part of the Mt Percy TSF extension works approval in 1988 (selected metals, cyanide, salinity, and pH). In addition, one tailings sample was assessed in 1991 by KCGM and was found to have a pH of 7.6, electrical conductivity 120 dS/m, labile N 21 ppm, phosphorus 6 ppm, potassium 90 ppm, sodium 27,000 ppm, and phosphorus retention index (PRI) 148.

Further geochemical characterisation in 2016 (MBS Environmental, 2016) indicates:

- Tailings are classified as NAF with low to moderate theoretical acid production potential and correspondingly moderate to high levels of ANC; a significant portion of sulfur in most samples being in the already oxidised form (sulfate). Mt Percy TSF was further classified as acid consuming.
- Leachate and hence any potential for seepage from these tailings is predicted to be brackish in perpetuity.
- Geochemically enriched in gold, silver, antimony and tellurium as a result of the nature of the particular gold mineralisation, but none of these elements were found to be soluble in water extracts or dilute acetic acid extracts to any extent considered to be of environmental concern post-closure when covered.
- That the tailings are considered to geochemically benign, with only moderate levels of salinity in leachates and/or potential seepage, which will remain alkaline.
- Geochemical assessment indicates that a suitably designed cover to prevent wind and water erosion will be sufficient post-closure to prevent negative impacts on the surrounding environment.

During operational monitoring of groundwater around the TSF, shallow groundwater was intersected in four boreholes on the south eastern side, where groundwater occurs as a result of a perched water table in shallow alluvium (the only location near the Mt Percy TSF where this unit occurs). As of 2000, only the four monitor bores on the south eastern side of the Mt Percy TSF contained groundwater (Peter Clifton & Associates, 2001). It was expected that as the TSF drained, groundwater levels would subside. The remaining five monitor bores on other sides of the TSF were dry, indicating that groundwater at these sites was below the bottom of the monitor bore casings.

Hydrochemical data from monitor bores south eastern side of the TSF indicate that seepage from this TSF influenced the chemistry of shallow groundwater, but this shallow alluvium aquifer is not significant aquifer and does not contain significant amounts of groundwater. The pH of groundwater appears to

decrease in a south easterly direction moving away from the TSF, an expected trend as the geochemical environment in the shallow alluvial and colluvial soils in this area would promote acidic conditions. The background groundwater quality in this alluvial unit is unknown, but data collected by KCGM in the same catchment and down-gradient of the Mt Percy TSF suggest any natural groundwater in this unit would be moderately saline and acidic (TDS ~40,000 mg/L and pH ~3-4). Some of this seepage was recovered by the Mt Percy Trench until mid-1999 when the trench became dry.

There are no records of cyanide concentrations in the slurry that was discharged to the Mt Percy TSF, however based on other TSFs operated by KCGM these concentrations were expected to be around 100 mg/L. The shallow groundwater on the south eastern side of the TSF is therefore expected to contain much less cyanide than the water that was discharged to the TSF. Cyanide is not expected to persist in the shallow groundwater around the Mt Percy TSF because the prevailing acidic environment would promote cyanide degradation.

KCGM considers that the risk to the environment and human health from the Mt Percy TSF to be low due to the geochemically benign nature of the tailings material and material used in rehabilitation, naturally saline and acidic groundwater and rehabilitation mitigating dust generation from the TSF.

Any further long term risk from the TSF will be adequately managed through implementation of KCGM's Mine Closure Plan.

Source	Receptor	Pathway	Immediate Risk
Tailings Seepage	Local Environment	Groundwater	Nil
Tailings	Local Environment	Nil	Nil

3.15.2 AOC10 Former Mt Percy Plant & AOC90 Mt Percy Former ROM Pad

The Mt Percy Plant was commissioned in 1986 and decommissioned in mid-1997. The mill had the capacity to process approximately 1 Mtpa of ore, and consisted of a two stage crushing circuit, grinding circuit, leach tanks, CIP adsorption tanks and carbon stripping circuit.

Rehabilitation of the plant area consisted of picking up surface material to a depth of 1 m and was likely deposited into the open pits. The ROM pad was battered down to less than 15° and ripped to 0.75 cm deep with 1.5 m spacing. No additional rehabilitation materials were applied. Visual inspections of the plant site in 2014 indicate that the site has good recruitment of understorey species, and scattered growth of overstorey species such as *Eucalyptus*. The ROM has variable re-vegetation, with some areas performing poorly.

Further sampling of soils is required in this area to define any remaining potential sources of COPC. However, pathways and receptors for transfer of COPC are considered limited due to depth to groundwater and the hypersaline nature of groundwaters. Dust generation is not considered an issue due to rehabilitation and surface water flows are generally confined to within rehabilitated areas.

KCGM considers that this area has low immediate risk from a contaminated sites perspective.

Source	Receptor	Pathway	Immediate Risk
Soil	Local Environment	Vegetation Uptake	Low

3.15.3 AOC25 Mt Percy Workshop and Wash Area

This area appears to have been used as a material stockpile, and also as a workshop area. It was rehabilitated in the late 1990s, with varying success, likely due latent salinity in the soil. Surface water tends to pool in the centre of this area due to operational pipeline bunding (Fimiston water transfer) blocking flow of water offsite.

Materials are generally sandy clay loam in texture, had very high soil strength and had varying levels of structural stability (Emerson Class 2 to 4) (Outback Ecology, 2010). The materials were moderately alkaline, generally had extreme salinities and had low organic matter and nutrient status. No additional soil analysis has been undertaken.

Further sampling of soils is required in this area to define any potential sources of COPC. However, pathways and receptors for transfer of COPC are considered limited due to depth to groundwater and the hypersaline nature of groundwaters. Dust generation is not considered an issue from these rehabilitated areas and surface water flows are generally confined to within rehabilitated areas.

Source	Receptor	Pathway	Immediate Risk
Soil	Local Environment	Vegetation Uptake	Low

3.15.4 AOC31 Sir John Open Pit

Mining occurred at the Mt Percy site between 1985 and 1992. In 1999, the Sir John Open Pit was used for the disposal of tailings material removed from the Hannans North Tourist Mine (formerly the Australian Prospectors and Miners Hall of Fame site (AOC26)). Potentially acid forming Black Flag Bed shale that was stockpiled on the Mt Percy ROM pad was also deposited into this open pit and encapsulated within the tailings material. The pit has not been completely backfilled, with general waste also dumped in the pit, such as conveyors, PVC piping, and tyres. Settlement cracks and subsidence exist within the already backfilled portion.

Surface sampling of the material used to backfill the pit was conducted in 2010 (Outback Ecology, 2010). The materials range from silty loam to sandy clay loam in texture, have very high soil strength values and are structurally unstable (Emerson Class 2) although non-sodic (Table ES1 and ES2). The materials were moderately alkaline, extremely saline and, as would be expected, had low organic matter and nutrient status. In addition, the in-fill material commonly reported concentrations of arsenic, chromium, copper, and nickel which were above their respective Ecological Investigation Levels (EILs), however higher EIL values may be acceptable for some metal concentrations in areas where soils naturally have high background concentrations of these elements.

Further sampling of soils is required in this area to define any potential sources of COPC. However, pathways and receptors for transfer of COPC are considered limited due to depth to groundwater and

the hypersaline nature of groundwaters. Dust generation is not considered an issue from this area and surface water flows are generally confined to within rehabilitated areas.

Source	Receptor	Pathway	Immediate Risk
Soil	• Local Environment	• Vegetation Uptake	Low

3.16 ZOI16 – Hannans North Tourist Mine

This Zone of Influence contains the following Areas of Concern:

- AOC12 Mullingar TSF
- AOC26 Former TSF at Hannans North Tourist Mine
- AOC27 Mullingar Tailings Wash Area



Figure 22: Zone of Influence 16 and associated Areas of Concern

3.16.1 AOC12 & 27 Mullingar TSF & TSF Wash Area at Hannans North Tourist Mine

This TSF is the last historical 'hand built' TSF on the Golden Mile and as such may be considered to have heritage value. There are currently some concerns over geotechnical stability of this TSF.

Geochemical testing of the tails in 2017 have indicated that the tailings are:

- NAF and Acid Consuming;
- Marginally enriched in lead and mercury;
- Substantially enriched in Molybdenum, Tellurium (insoluble forms), Antimony;
- Water leachates were brackish to saline and circum-neutral to moderately alkaline;
- Slightly elevated (>0.01 mg/L, above non-potable groundwater re-use guidelines) concentrations of mercury were recorded in three water leachate Mullingar samples (maximum 0.025 mg/L). No samples exceeded the non-potable groundwater use guideline of 0.01 mg/L if adjusted for a 1:20 ratio extraction. Three samples also reported molybdenum (maximum 0.40 mg/L) concentrations above the livestock drinking water guideline;
- All Mullingar samples contained detectable concentrations of soluble mercury, ranging from 0.002 mg/L to 0.007 mg/L, although the concentrations of soluble mercury are still relatively low and total mercury also low as evidenced by only marginal enrichment (maximum concentration 1.1 mg/kg; and
- Concentrations of soluble aluminium, boron, barium, bismuth, iron, chromium, manganese, nickel, uranium, vanadium, and zinc were very low and therefore considered to be of no environmental consequence.

The tailings is therefore considered to contain geochemically benign tailings, with only moderate levels of salinity in leachates and/or potential seepage, which will remain alkaline.

Drilling through the tailings dam was undertaken in 2019, with samples taken for analysis. Interpretation has not commenced. Piezometers were installed in some of the drill holes, but no phreatic surface was identified.

Source	Receptor	Pathway	Immediate Risk
Tailings	• Local Environment	• Dust • Sediment Transport	Low

3.16.2 AOC26 – Former TSF at Hannans North Tourist Mine

This facility was a legacy of prior mining and mineral processing in the area, with tailings appearing to have been deposited directly into the environment, i.e., no modern tailings management practises were used. In the late 1990s, tailings were removed and placed in Sir John Pit at Mt Percy and the area was rehabilitated. Part of the area was then used for the Mining Hall of Fame (MHoF) building and grounds

in the early 2000s. These buildings and the surrounding area are publicly accessible and now part of a tourist attraction. Approximately 40-50% of the site is sealed below buildings or roads/carparks.

Further sampling of soils is required in this area to define any potential sources of COPC. However, pathways and receptors for transfer of COPC are considered limited due to depth to groundwater and the hypersaline nature of groundwaters. Dust generation is not considered an issue from sealed and rehabilitated areas and surface water flows are generally confined.

Source	Receptor	Pathway	Immediate Risk
Soil	Local Environment	Vegetation	Low

3.17 ZO17 – Gidji Sites

This Zone of Influence contains the following Areas of Concern:

- AOC1 Gidji Processing Plant
- AOC2 Gidji TSF Plume
- AOC3 Gidji TSF
- AOC4 Chemix Pond
- AOC6 Chemix Plant
- AOC7 Former Gidji Landfill Site
- AOC9 Temporary Gidji Concentrate Storage Sites

These sites have been grouped as they are located in the same area, separated from the other KCGM sites by approximately 17 km.

It should be noted that these sites were reported in 2007 in accordance with requirements, but KCGM has not received formal classification from the DWER. Re-reporting of these sites to ensure they are included in the regulatory database may be required based on advice received. Opportunity to consolidate and redefine site boundaries may be possible at this time.

Management of these sites is completed in accordance with an *EP Act* Part V Licence and is also managed in accordance with approvals received under Part IV of the *EP Act* and Mining Proposals submitted in accordance with the *Mining Act*. Therefore, KCGM considers that the immediate risk to the environment and human health from a contaminated sites perspective is adequately mitigated by operational management.



Figure 23: Zone of Influence 17 and associated Areas of Concern

3.17.1 AOC1 Gidji Processing Plant

The Gidji Processing Plant was commissioned in 1989 to treat concentrate from the Fimiston Plant. This provided the opportunity for a phased reduction of in-town roasting through the decommissioning of the remaining three in-town roasters and the establishment of a central roasting facility, Gidji, located 18 km north of the City. In 2015, the roasters were decommissioned and Ultra Fine Grind (UFG) became the primary methods for treating concentrate at Gidji. The Processing Plant is predominantly covered by a concrete or bitumen hardstand, with drains surrounding the facility to re-direct runoff into catch dams for use within the plant.

Preliminary sampling during geotechnical testing for new infrastructure footings has indicated low levels COPCs confined to surface soils. Further investigation will be conducted opportunistically during operations and prior to decommissioning to aid management of any contaminated soil material.

The site investigation boundary should be expanded to consider the Cyanide Destruct Plant to the north, process water ponds and laydowns.

Source	Receptor	Pathway	Immediate Risk
Soil	• Local Environment	• Vegetation	Low

3.17.2 AOC2 &3 – Gidji Groundwater Plume and TSF

The Gidji I facility comprises two cells and was constructed in 1988/1989, with deposition commencing in 1989. The starter embankments were constructed from clay, silt and clayey sand sourced from within the storage footprint. Subsequent upstream raise construction has utilised deposited tailings sourced from within the impoundment. Both cells reached approved height in 2013 and all tailings produced from Gidji Plant are now deposited only within Gidji II. No rehabilitation has been undertaken at the Gidji I TSF as the tailings material is being used to construct the downstream lifts of Gidji II TSF. The TSF has been observed to dust during high winds.

Tailings deposited within the Gidji I TSF are a mix of a calcine tailings stream produced by the roaster and a minor stream of tailings produced from Ultrafine Grinding (UFG), reflecting a change in processing methods over time. A review of the available geochemical data was completed in 2021 (MBS Environmental 2021) which identified that the Gidji I tailings are:

- NAF with a greater ANC than acid production potential.
- Significantly enriched in several environmentally significant metals and metalloids based on screening by GAL; silver, arsenic, chloride, cobalt, copper, mercury, Molybdenum, lead, selenium and tellurium.
- Water leach extraction indicated that some but not all of the enriched chemical species (see above) are likely to be soluble to the extent where consideration of potential environmental risk is warranted.
 - Whilst the tailings are enriched in silver, lead, selenium and antimony, water leachable concentrations of these species were below the analytical limit of reporting (LOR). Water leachable molybdenum was below the livestock drinking water default guidance values (DGV). The solubility of these species in terms of rainfall runoff and percolation/seepage is unlikely to be environmentally significant.
 - Whilst arsenic was leached at around the non-potable use guidelines (NPUG) trigger level, the concentration was below the corresponding livestock DGV and, at this concentration, arsenic oxyanions (e.g. arsenate) are expected to be effectively adsorbed or co-precipitated with iron oxyhydroxides present in the soils and regolith of the surrounding environment. The overall risk from arsenic leachability is considered to be low. The extraction ratio (1:1, porewater) is also noted to be substantially higher than typical used for assessments against these trigger values - a more typical extraction ratio for such comparison (1:10 or 1:20 ratio extract) would be expected to produce concentrations in the order of 0.01 mg/L (1/10th) and hence below the NPUG value.
 - Cobalt, copper and mercury were leached from the tailings at concentrations exceeding broadly applicable water quality screening values. Cobalt and copper marginally exceeded the livestock drinking water DGVs of 1 mg/L, whilst mercury (0.02 mg/L) exceeded the corresponding DGV of 0.002 mg/L by one order of magnitude. These findings are consistent with the formation of soluble cyanide-metal complexes. These complexes will likely decrease in solubility over time with cyanide decomposition (aging), and again noting the high extraction ratio used for these tests.

- Water leach extraction also indicated that runoff or seepage from the Gidji 1 tailings is likely to be neutral to basic (pH 8.5), of brackish salinity (4,480 mg/L total dissolved solids, TDS) and to contain sulfate concentrations at around the livestock drinking water DGV (1,000 mg/L).
- Given the environmental context and low acid formation risk and low potential for further oxidation of the material, the tailings are unlikely to generate harmfully saline or acidic seepage.

A ferricrete and alluvial sediment groundwater system is present below the Gidji TSFs, and seepage has caused localised groundwater levels to rise which contains elevated concentrations of both TDS and WADCN. During operations, a seepage and groundwater recovery borefield (a seepage interception trench and low yielding production bores) has been operated to control groundwater levels, and prevent the naturally saline groundwater from rising into the root zone of vegetation. The borefield also acts to minimise the migration of the elevated TDS and WADCN concentrations in groundwater observed near the TSF.

A seepage model was developed in 2015 for the Gidji I TSF (PCA,2015). This work indicated that:

- Most seepage from Gidji I TSF will report to the shallow groundwater system and migrate westwards towards Gidji Lake or more likely become isolated pockets of perched groundwater, due to active abstraction bores.
- Seepage will not adversely affect the current beneficial users of the groundwater resource (mineral processing and mining).
- While a rapid decline in the phreatic surface within the Gidji I TSF is expected post-deposition, dissipation of the groundwater mound would be slow.
- Large rainfall events are unlikely to have a material effect on groundwater levels around the TSFs.

Groundwater levels at Gidji are declining, as the seepage source, Gidji I TSF, is no longer operational. However post-deposition, dissipation of the groundwater mound is expected to be slow, due to the nature of sediments that form the aquifer.

During operations, the health condition of the Eucalyptus woodland in the vicinity of the TSF has been classified as being in very good and good condition, with no impact from the TSFs.

KCGM considers that the immediate risk to the local environmental and human health from Gidji I TSF seepage is low, despite elevated COPC considering that there is no ecological or human receptor – groundwater's only beneficial use is for mining. As the Gidji II TSF is lined, KCGM does not believe that it poses a risk as a Contaminated Site.

Source	Receptor	Pathway	Immediate Risk
Tailings	• Local Environment	• Dust	LOW
Tailings Seepage	• Local Environment	• Soil • Groundwater	Low

3.17.3 AOC 4 & 6 – Chemix Pond & Plant

The Chemix plant was located on a Miscellaneous Licence overlying KCGM tenements near the Gidji roaster, used to convert manganese oxide to manganese sulphate using the sulphur dioxide emitted by the roasting process at Gidji. Production at the Chemix site ceased in April 1995 and the site remained on the KCGM managed lease without ongoing care and maintenance by the owners who went into administration.

The Chemix site was decommissioned and rehabilitated by KCGM in 2000. Sampling of materials from locations around the Chemix site was undertaken by KCGM in 1998 (original results unable to be located). Analysis identified all samples collected as either manganese oxide or manganese sulphate. No significant quantities of heavy metals were identified in any of the samples. Further sampling is required to adequately assess any sources of COPC from this site, however, receptors for any COPCs are limited due to the depth and saline nature of groundwater underlying the site.

Source	Receptor	Pathway	Immediate Risk
Soil	• Limited	• Vegetation uptake	Low

3.17.4 AOC7 – Former Gidji Landfill Site

Little is known about this site other than it was used as a landfill. The site appears to be relatively small and has been covered and rehabilitated.

Further sampling is required to adequately assess any sources of COPC from this site, but receptors for any COPCs are limited due to the depth and saline nature of groundwater underlying the site.

Source	Receptor	Pathway	Immediate Risk
Soil	• Limited	• Vegetation uptake	Low

3.17.5 AOC9 – Temporary Gidji concentrate storage site

Little known about operation of this area, other than it was used as a temporary concentrate storage area. The site has been rehabilitated and appears to have good vegetation growth.

Further sampling is required to adequately assess any sources of COPC from this site, however, receptors for any COPCs are limited due to the depth and saline nature of groundwater underlying the site.

Source	Receptor	Pathway	Immediate Risk
Soil	• Limited	• Vegetation uptake	Low

3.18 ZOI 18 – Johnson St East

This Zone of Investigation contains the following Areas of Concern:

- AOC104 19 Johnson St Boulder

- AOC98 24 Johnson St Boulder
- AOC99 28 Johnson St Boulder

These sites have been grouped together as they are located close to each other and have been used for light commercial premises.

19 Johnson St currently has permanent structures on it and is used for storage of infrastructure and core from the Fimiston Mining area. Activities of tenants of the property (whilst managed by KCGM) may have resulted in concentrations of COPC within the permanent structures. Since this site was reported as a contaminated site, no tenants have occupied it.

24 and 28 Johnson St are currently vacant land, with 28 Johnson St almost completely covered by the Environmental Noise Bund, limiting any pathways for COPC due to prevention of dust and reduction of water infiltration. 24 Johnson St has had a history of rubbish being dumped on the vacant land, and also has issues with safe access due to historical mining voids. Further investigation of this site is required to adequately assess the risk to the environment and human health, although KCGM considers that this site has a low risk from a contaminated sites perspective considering it is well vegetated (reduce dust), has no permanent structures and has deep connection with groundwater.

In 2020 a PSI was undertaken, with the report currently in draft format. The following outcomes are expected:

- 19E Johnston Street (AOC104) – end point classification as C-RU, suitable for commercial/industrial use no further actions required.
- 24E Johnston Street (AOC 98) – end point classification as NC-UU, no actions required
- 28E Johnston Street – end point classification as NC-UU, no further actions required.



Figure 24: Zone of Influence 18 and associated Areas of Concern

Source	Receptor	Pathway	Immediate Risk
Soils	- Local Environment - Humans	- Dust - Vapours	Low

3.19 ZOI 19 – Dwyer St – Light Commercial

This Zone of Influence includes the following Areas of Concern:

- AOC93 3 Dwyer St Boulder
- AOC92 6 Dwyer St Boulder

These sites are grouped together as they are in the same geographical area and have both been used for similar light commercial premises. Both properties are currently leased by KCGM.

3 Dwyer St was reported due to suspected hydrocarbon contamination due to leaks from above ground hydrocarbon storage tanks.

6 Dwyer St was reported due to past activities completed on the property (Hydrocarbon storage, metal treatment/finishing and sand blasting) potentially being the source of COPCs such as hydrocarbons and metals. Due to the managed light commercial nature of surrounding properties, they are not considered to be an immediate risk to human health or the environment.

In 2020 a PSI was undertaken, with the report currently in draft format. The following outcomes are expected:

- 3 Dwyer Street (AOC 93) – end point classification as PC-IR, suitable for commercial/industrial use, additional sampling required before being able to close out the assessment process.
- 6 Dwyer Street (AOC 92) – end point classification as PC-IR, suitable for commercial/industrial use, additional sampling required before being able to close out the assessment process.



Figure 25: Zone of Influence 19 and associated Areas of Concern

Source	Receptor	Pathway	Immediate Risk
Soils	- Local Environment - Humans	- Dust - Vapours	Low

3.20 ZOI 20 – Holmes St – Technical College

This Zone of Influence includes the following Areas of Concern:

- AOC108 31 Holmes St Boulder
- AOC109 29 Holmes St Boulder

These sites were grouped as they are adjacent to each other and buildings overlap each block. The valuation description for the blocks adjacent to and including these two AOC in 2004 was “35 year old brick office and 2 sheds on 5 freehold lots” and “Secondary office and industrial accommodation”.

31 Holmes St was reported as it was a former site of a metallurgical laboratory, which is no longer used for this purpose. Buildings used for laboratory work still remain and no further testing of the buildings or grounds has been completed.

29 Holmes St was reported as Light Commercial, but shares a building with 31 Holmes St, so most likely has the same usage history.

A PSI investigation has been undertaken on these blocks, with a draft report completed.

31 Holmes Street – end point classification as C-RU, suitable for commercial/industrial use, no further actions required.

29 Holmes Street – end point classification as NC-UU, suitable for multiple uses, no further actions required.



Figure 26: Zone of Influence 20 and associated Areas of Concern

Source	Receptor	Pathway	Immediate Risk
Soils	- Local Environment - Humans	- Dust - Vapours	Low

3.21 ZOI 21 – Oroya & Chaffers St – Vacant Land

This Zone of Influence includes the following Areas of Concern:

- AOC94 13 Chaffers St Boulder
- AOC95 11 Chaffers St Boulder
- AOC96 3 Chaffers St Boulder
- AOC97 15 Oroya St Boulder

These sites were grouped as they are in close proximity to each other and were all reported as asbestos contamination was suspected due to presence of asbestos housing. Since reporting of these sites, demolition of the permanent structures has been completed and all four lots are now vacant.

In 2016, KCGM was informed by the City of Kalgoorlie Boulder of 'extractive materials' (rock and soils) that had been illegally dumped on 3, 11 and 13 Chaffer St. The source of the materials could not be determined (unknown disposer) and KCGM removed the materials to its nearby waste dump.

In 2020 a PSI was undertaken, with the report currently in draft format. The outcomes likely to be an end point classification 'suitable for commercial/industrial use'. Further actions likely to be required are asbestos fragments remediation and final walk over before being able to close out the assessment process.



Figure 27: Zone of Influence 21 and associated Areas of Concern

Source	Receptor	Pathway	Immediate Risk
Asbestos materials	Local Environment	- Dust - Fragmentation	Low

3.22 ZOI 22 – Williamstown Suspected Asbestos

This ZOI contains the following properties:

- VCL PIN 687197 (2 Austral Street)
- VCL PIN 687234 (7 Kanowna Old)
- VCL PIN 692786 (5 Kanowna Old)
- VCL PIN 692786 (19 Austral St)
- 36 Austral St (Lot 3547 on Deposited Plan 175259)
- Lot 3548, 38 Austral St
- 77 Brownhill Rd
- Lot 3956 on Deposited Plan 215926

- 11 Brownhill Rd
- 12 Brownhill Rd

These properties were all reported due to the suspected presence of asbestos. In 2015, it was identified that remnant asbestos material remained within vacant blocks in the suburb of Williamstown, adjacent to the Mt Charlotte surface operations, after KCGM had demolished houses on these parcels.

Investigations and decontamination of several of these properties were undertaken in accordance with Contaminated Sites requirements, which resulted in three of these sites being classified as 'Decontaminated' by DWER. The other eight sites remain as 'Potentially Contaminated – Investigation Required'.



Figure 28: Zone of Influence 21 Areas of Concern

Source	Receptor	Pathway	Immediate Risk
Soils	• Local Environment • Humans	• Dust • Inhalation • Ingestion	Low

3.23 Returned Form 1s

3.23.1 AOC 5 & 11 – Borefields and Pipelines

The submitted Form 1s for these two AOCs were returned/rejected by the DWER after initial submission in 2007 as insufficient information to adequately assess them was provided. Correspondence states that:

“None of the reports provide any details of actual leaks or spills... or any other evidence to support a suspicion that contamination is present or likely to be present... DEC considers that the information currently contained in these Form 1 submissions does not provide reasonable grounds to believe or suspect that the sites are contaminated. The Form 1 submissions have therefore not been accepted as valid reports... and are returned to you for further consideration... Where KCGM is aware of additional evidence to support a suspicion that contamination may be present at a site (e.g., records of leaks or spills, observations or soil staining or groundwater monitoring results), the relevant Form 1 report should be resubmitted to DEC accompanied by this additional evidence. ”

KCGM is in agreement with DWER’s judgement that reporting of the borefields as a whole is not likely to represent actual potentially contaminated areas.

3.24 Not KCGM Liability

3.24.1 AOC50 – Former State Battery

Mineral processing operations have likely occurred on this reserve since the 1940s. Liability for this site lies with the State (Perth Mint), and it lies outside of the DWER Contaminated Zone for KCGM sites.

The State Battery reserve was reported by KCGM due to known elevated levels of mercury present during drilling prior to the construction of the re-alignment of the Kalgoorlie Bypass road (to allow expansion of the Fimiston Pit). During construction of the Bypass Rd, the area that was suspected of containing elevated levels of mercury was capped with 700 mm of clean fill. A second round of validation drilling was conducted following construction, and elevated levels of mercury were not detected.

The remaining areas of the site which were rehabilitated are currently accessible to the public and are utilised for a harness horse racing training track. Approximately 75% of the area is covered by the KCGM Environmental Noise Bund. Drilling at the time of road realignment did not intersect groundwater, indicating it is >50 m bgl.

KCGM considers that liability for this site lies with the State Mine and it is not required to perform any further work for this AOC.

4. REFERENCES

Golder Associates Pty Ltd. (2008). Geotechnical and Geochemical Characterisation of the Existing Kaltails Tailings. Memo prepared for KCGM Pty Ltd.

Golder Associates Pty Ltd. (2010). Gidji Tailings Storage Facility Seepage Assessment. Unpublished Report Prepared for KCGM Pty Ltd.

Golder Associates Pty Ltd. (2011). *Piezocene Penetration Testing and Interpretation for the Oroya Tailings Storage Facility*. Unpublished Report Prepared for KCGM Pty Ltd.

KCGM (2006). *2006 Croesus Tailings Dump Drilling Results*. Memorandum prepared by Geology Department.

KCGM (2007). *Out of Box Ounces – Croesus Tailings*. Internal memo prepared by CI Department.

MBS Environmental. (2016). *KCGM Geochemical Assessment of Historical Tailings DRAFT*. Unpublished Report Prepared for KCGM Pty Ltd.

MBS Environmental. (2017). Tailings Geochemistry Overview. Unpublished Report Prepared for KCGM Pty Ltd.

Normandy Kaltails (1998). *Old Croesus Testwork Summary*. Report No. KMS 98/05. Unpublished internal report.

Outback Ecology (2010). *Soil and Waste Characterisation Section 8 – Mt Percy*. Unpublished Report Prepared for KCGM Pty Ltd.

Outback Ecology (2012). Soil Assessment of the Golden Pike Noise Bund, Mt Charlotte Southern Ore Body Vent Fan Bund and the Orica Topsoil Stockpiles. Unpublished Report Prepared for KCGM Pty Ltd.

Peter Clifton & Associates (1999). Mt Percy Tailings Storage Facility Annual Review of Groundwater Monitoring Data 1998. Unpublished Report Prepared for KCGM Pty Ltd.

Peter Clifton & Associates (2001). Mt Percy Tailings Storage Facility Annual Review of Groundwater Monitoring Data 2000. Unpublished Report Prepared for KCGM Pty Ltd.

Schlumberger Water Services. (2015). *KCGM Site Wide Closure Water and Hydrochemical Model*. Unpublished Report Prepared for KCGM Pty Ltd.

SoilWater. (2012). *Herliette TSF soil analysis*. Unpublished Memo prepared for KCGM.

APPENDIX 1: AOC HISTORIAL AERIAL PHOTOGRAPHS

ZOI1 FIMISTON I & II TSF



Figure A1: Fimiston TSF Plume and TSF 1999 (left) and 2014 (right)



Figure A2: Fimiston I 1997 (left) Fimiston I 2014 (right)

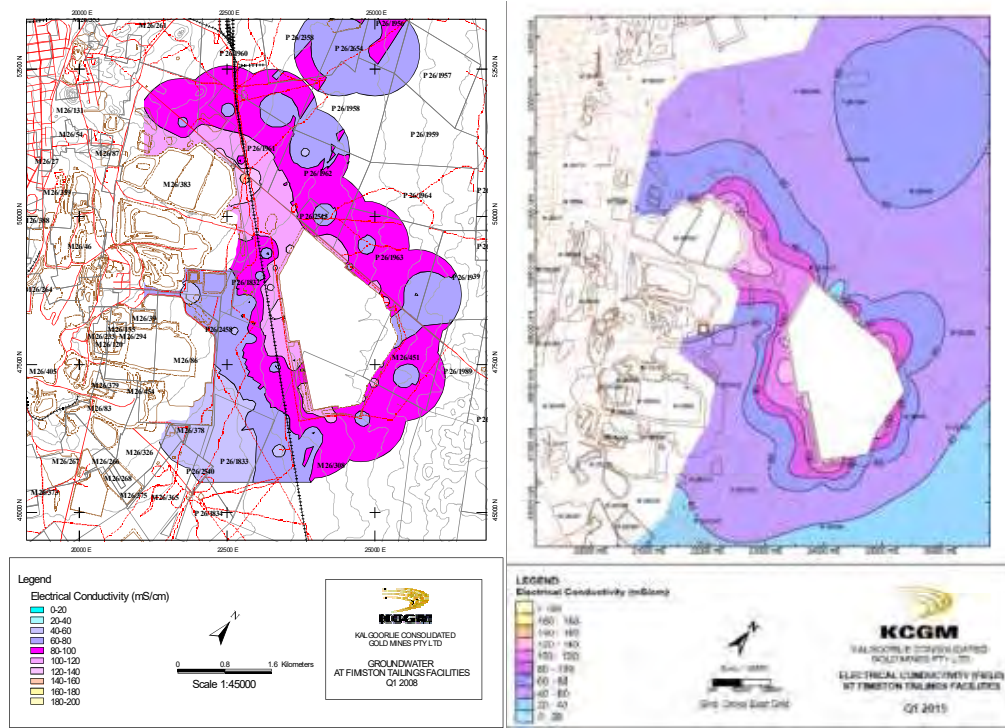


Figure A3: Herliette TSF 1989 (left) and 2014 (right)



Figure A4: Croesus TSF 1983 (left) and 2014 (right)

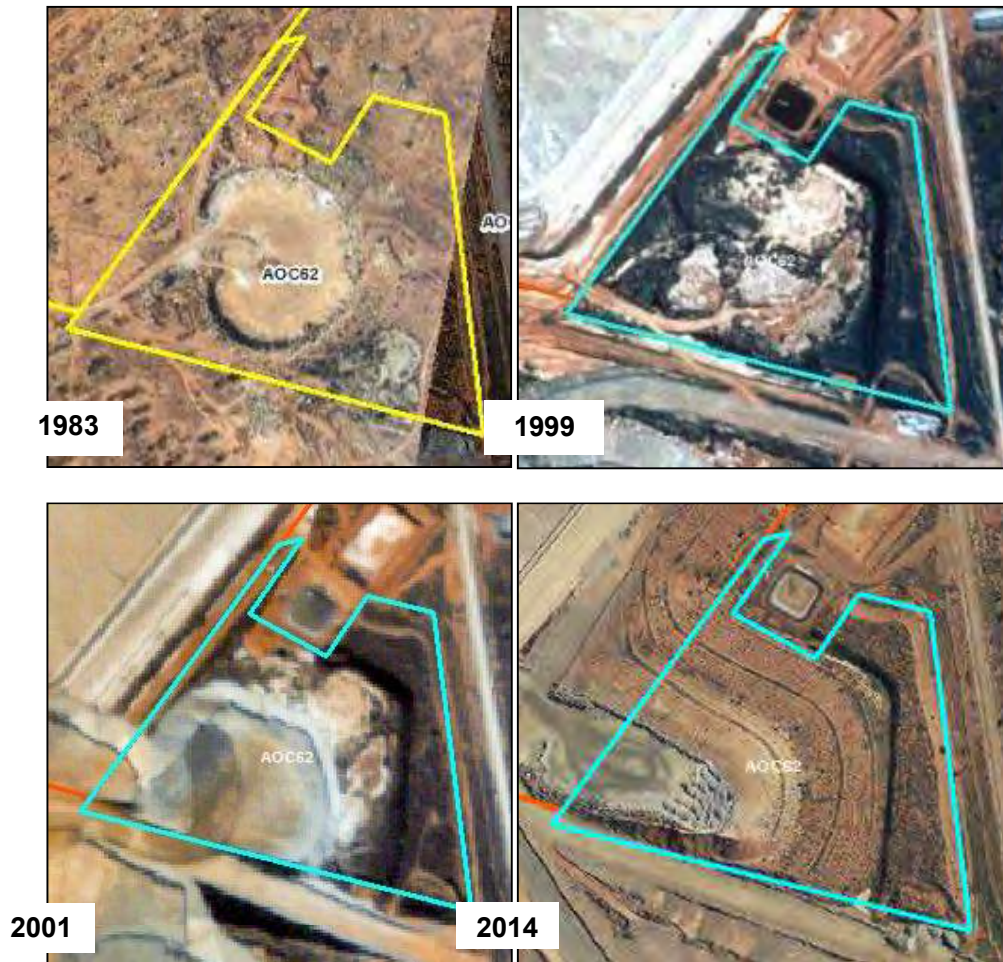


Figure A5: Historical Shire Tip 1983-2014

ZOI 2 KALTAILS TSF



Figure A6: Kaltails Reported Contaminated Sites 1999 (top) and 2013 (bottom)

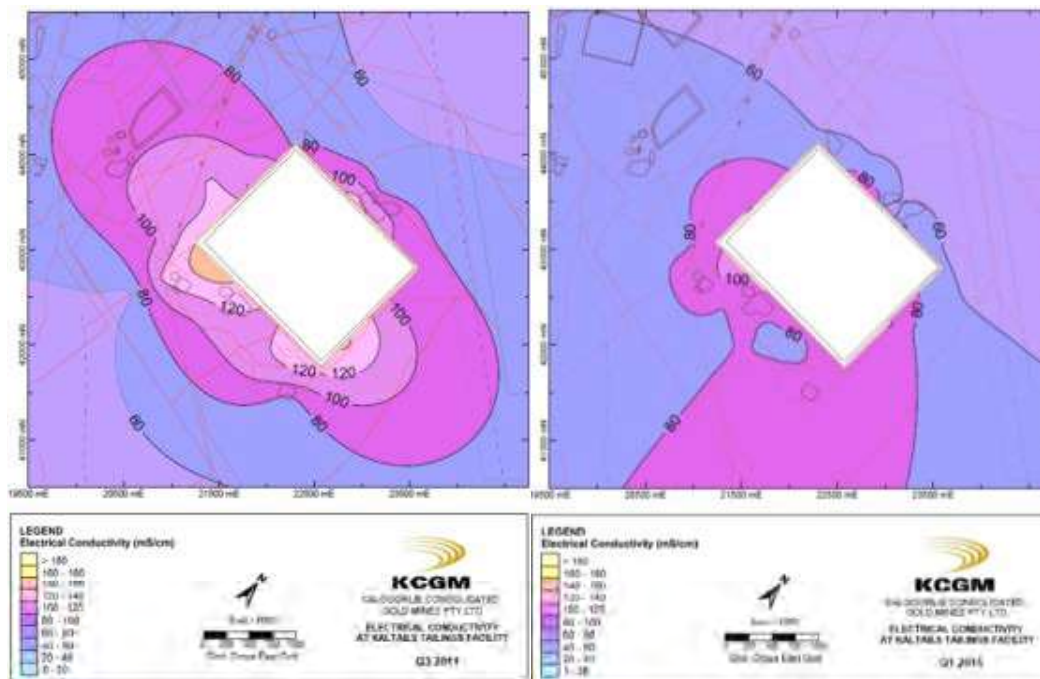


Figure A7: Kaltails TSF Seepage Plume EC Contour Graphs

ZO13 MINING OPERATIONS



Figure A8: Fimiston Mill 1989 during construction (left) and 2014 (right)



Figure A9: Crushing Facilities 1989 (left) and 2014 (right)



Figure A10: Chaffers Workshop Area 1987 (left) and 2014 (right)

ZOI 5 – MT CHARLOTTE



Figure A11: AOC 29 – Workshops and hydrocarbon storage area at the Cassidy headframe



Figure A12: Mt Charlotte Northern Vent Rise (left) and Southern Vent Rise (right)



Figure A13: Mt Charlotte compressor house 2014



Figure A14: Mt Charlotte Historical TSF



Figure A15: View from Cassidy Head Frame circa. early 1980s



Figure A16: AOC87 Mt Charlotte hydrocarbon storage area

ZOI 6 – SALINE WATER TRANSFER



Figure A17: Saline Transfer Tank AOC88 Area 1980s (left) and 2014 (right)



Figure A18: AOC89 Saline water transfer station

ZOI 7 – PIT ADJACENT TSFS

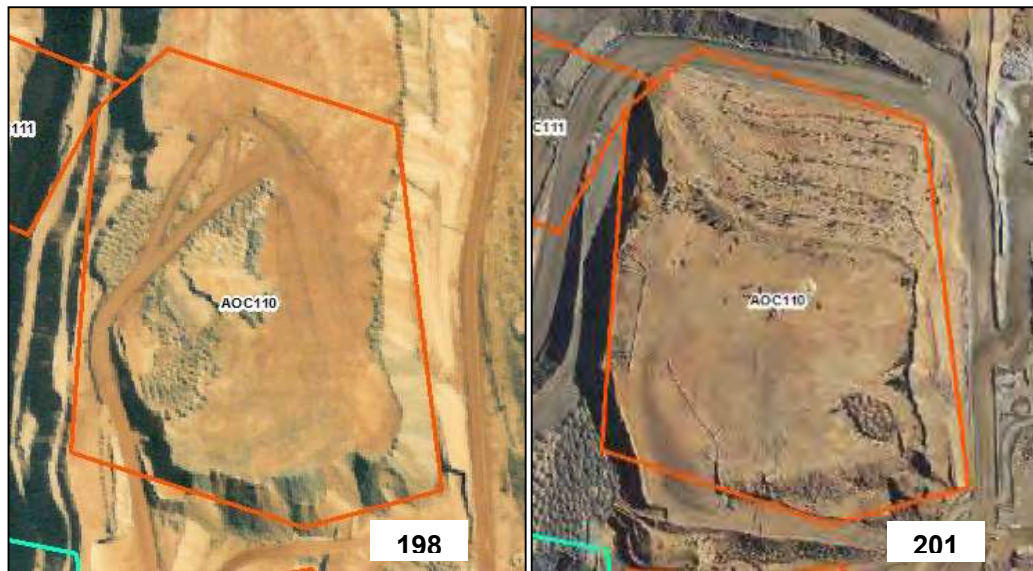


Figure A19: Croesus TSF 1988 (left) and 2014 (right)



Figure A20: Historic Calcine TSF

ZOI 8 – PARINGA TSF



Figure A21: Paringa TSF ZOI 9 – Legacy TSFs (Encapsulated)

ZOI 9 – LEGACY TSF FOOTPRINTS (ENCAPSULATED)



Figure A22: AOC64 – Historic TSF

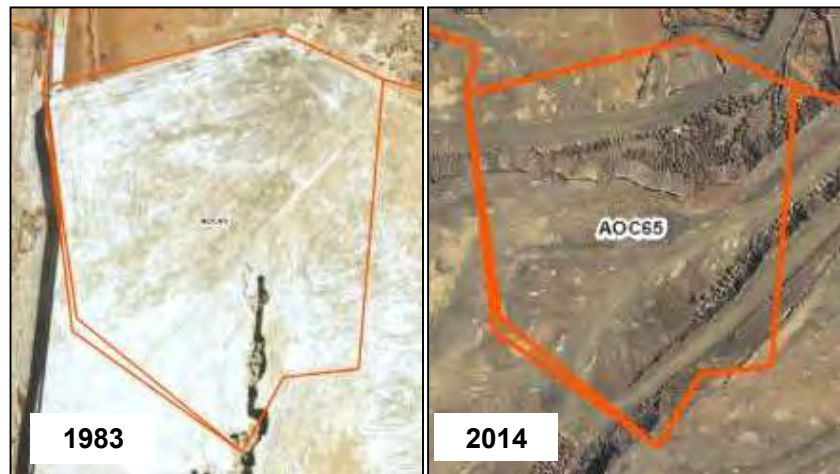


Figure A23: Historic TSF AOC 65



Figure A24: AOC85 Historic tailings wash area

ZOI10 – OROYA, GALCONDA, AND BALGOLD TSFS

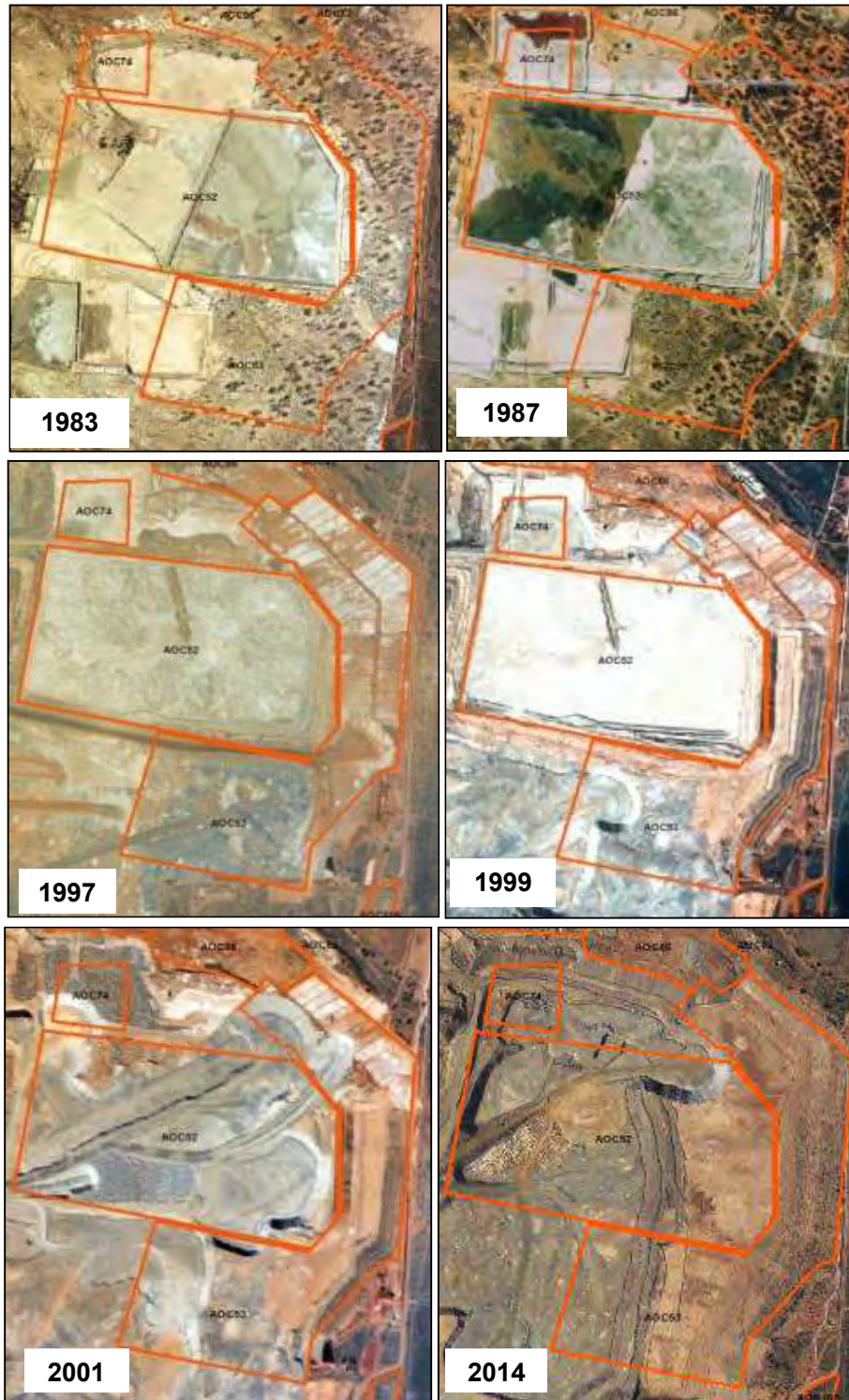


Figure A25: Oroya, Balgold and Galconda TSFs



Figure A26: Contractors Workshops and Balgold-Galconda tailings wash area 2014

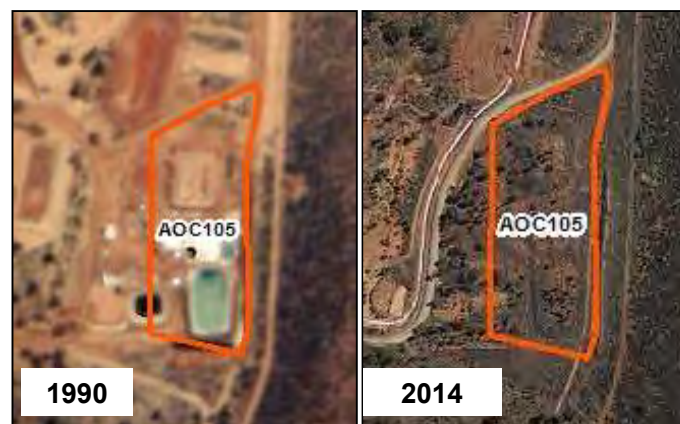


Figure A27: Former Balgold heap leach pads 1990 (left) and 2014 (right)

ZOI11 – CROESUS PLANT

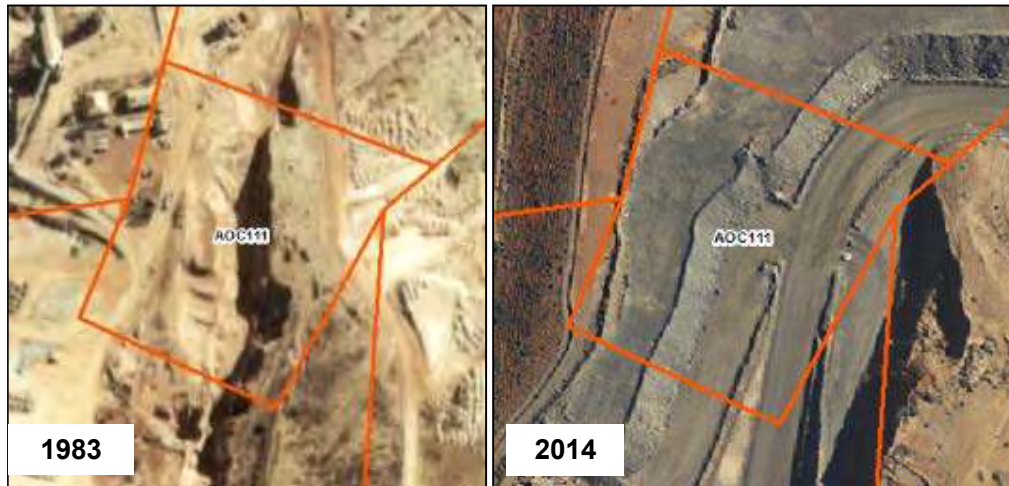


Figure A28: AOC111 Historic concentrate storage area





Figure A29: AOC112 Historic tailings Wash Area

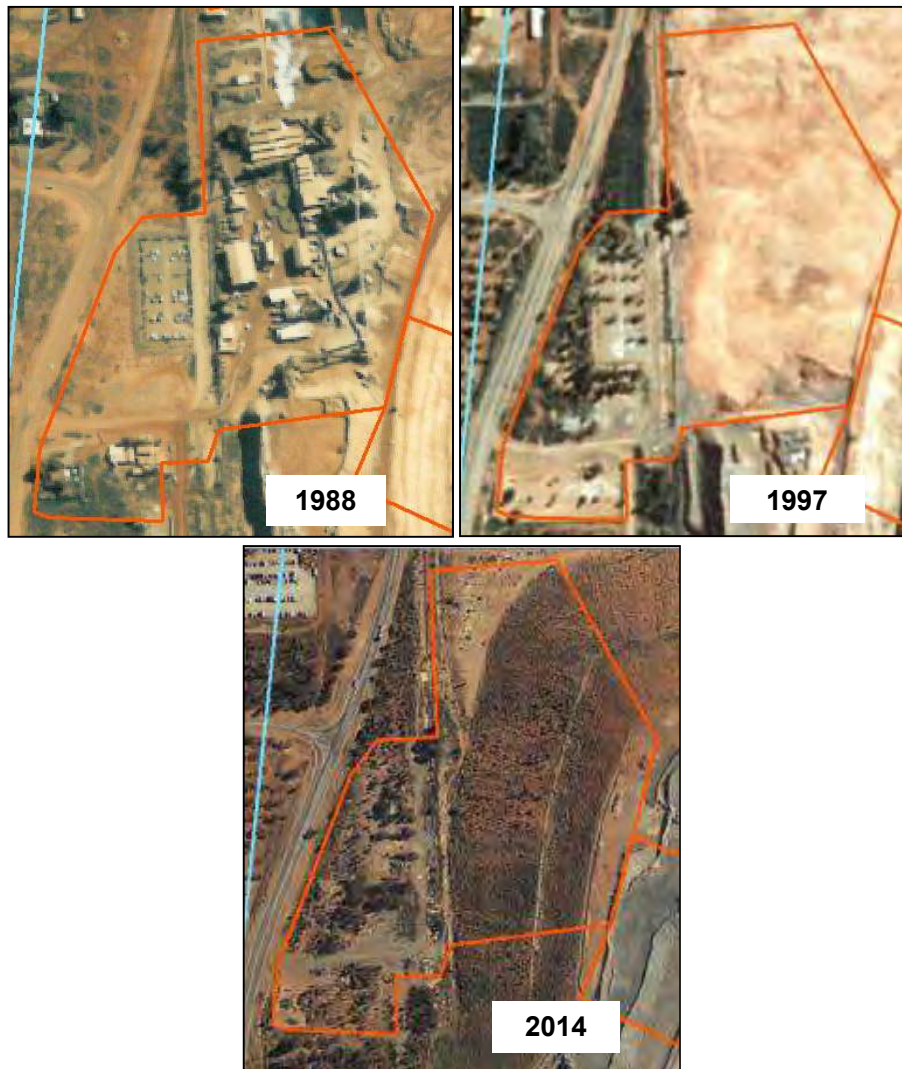


Figure A30: Croesus Mill 1988 (top left), 1997 (top right) and 2014 (bottom)

ZOI12 – BORRARA RD REHAB AREAS



Figure A31: Former Processing Plant

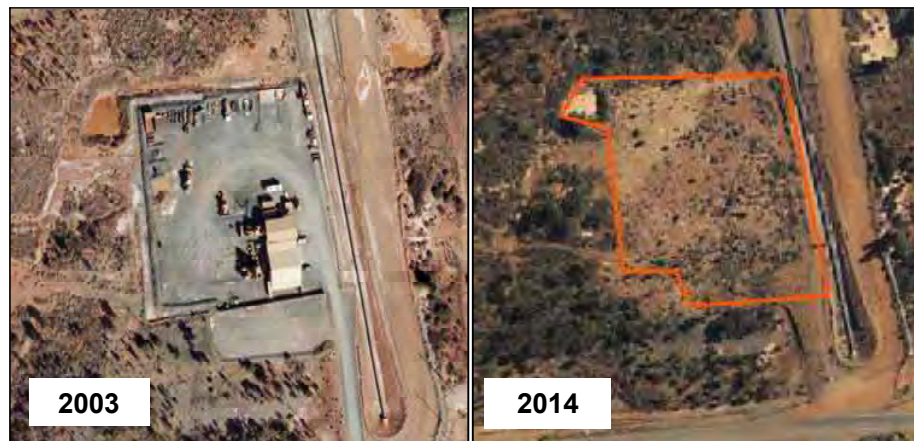


Figure A32: Force Workshop

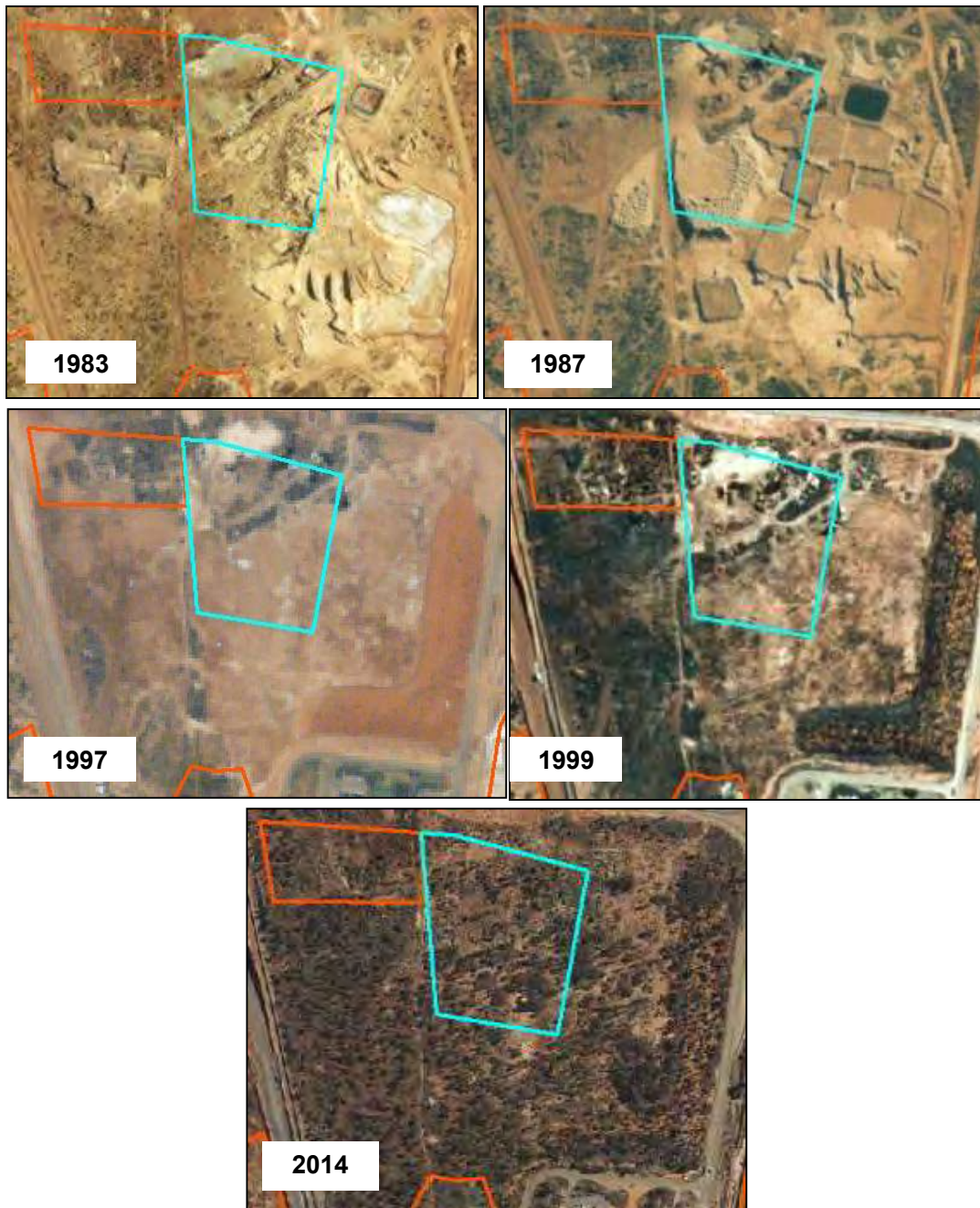


Figure A33: Former gold processing plant

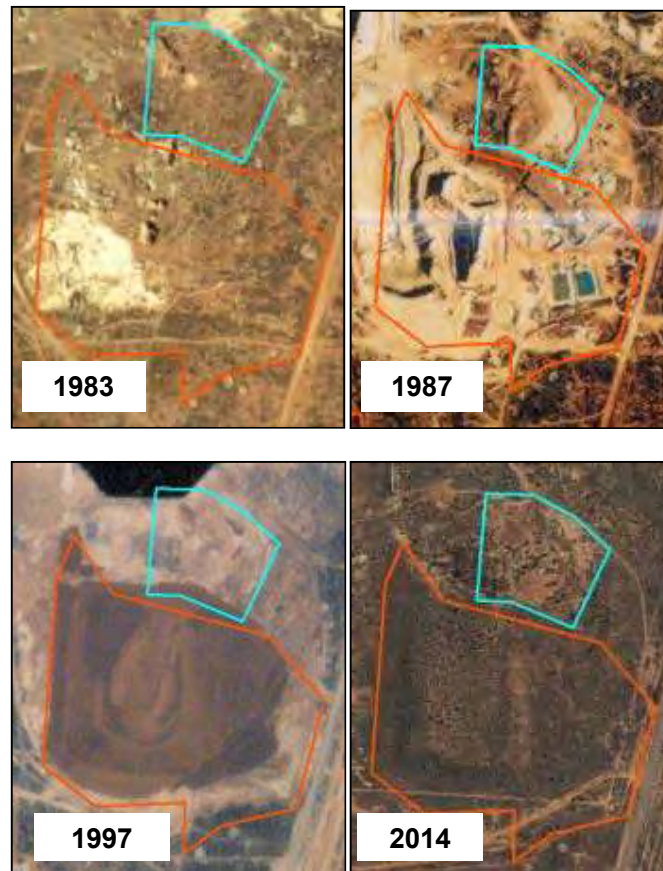


Figure A34: Mt Ferrum TSF (orange) and Mineral Processing Plant (blue)

ZOI 13 – MORRISONS FLATS

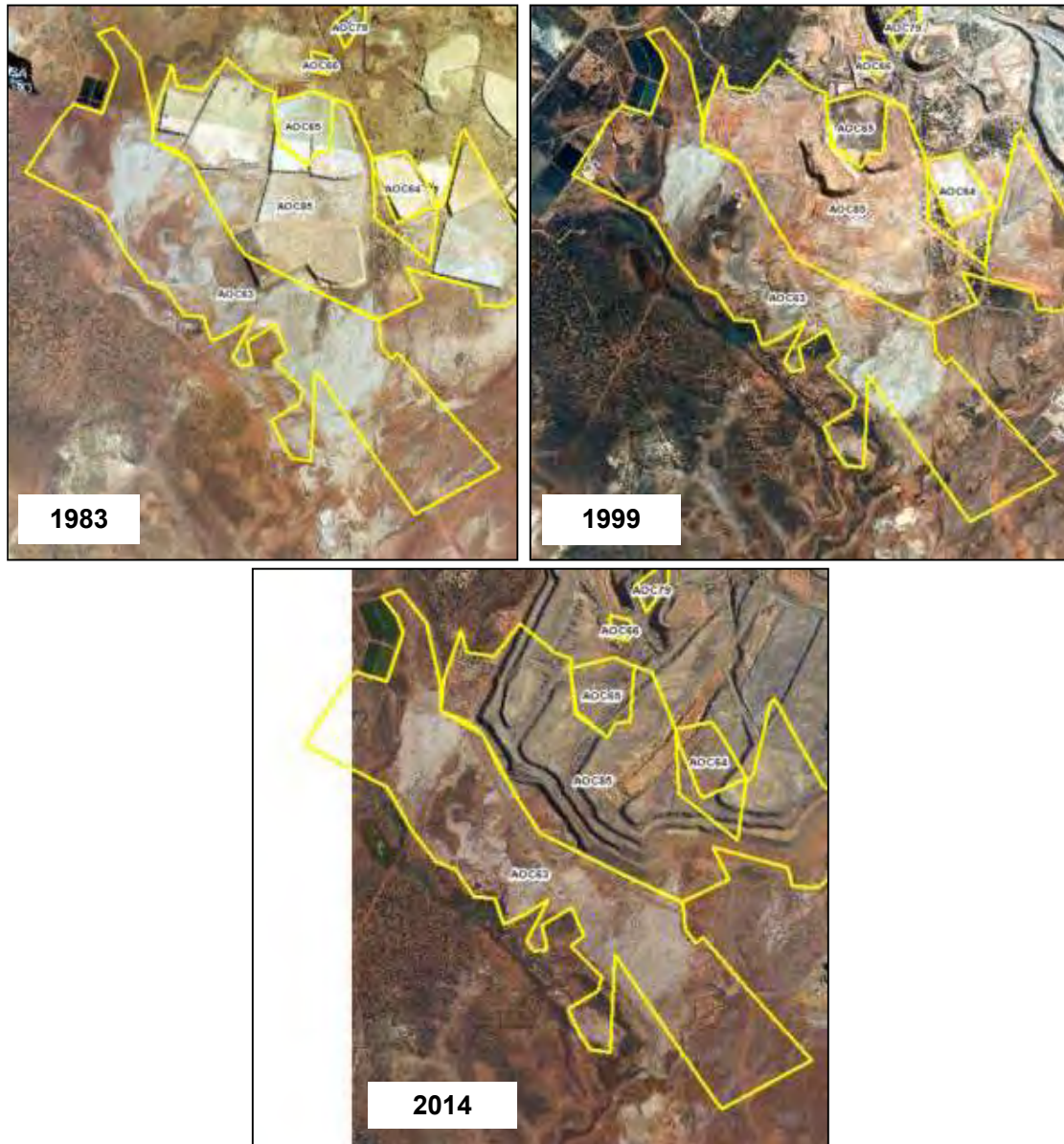


Figure A35: Morrisons Flats

ZOI 14 – MT PERCY PIT LAKES

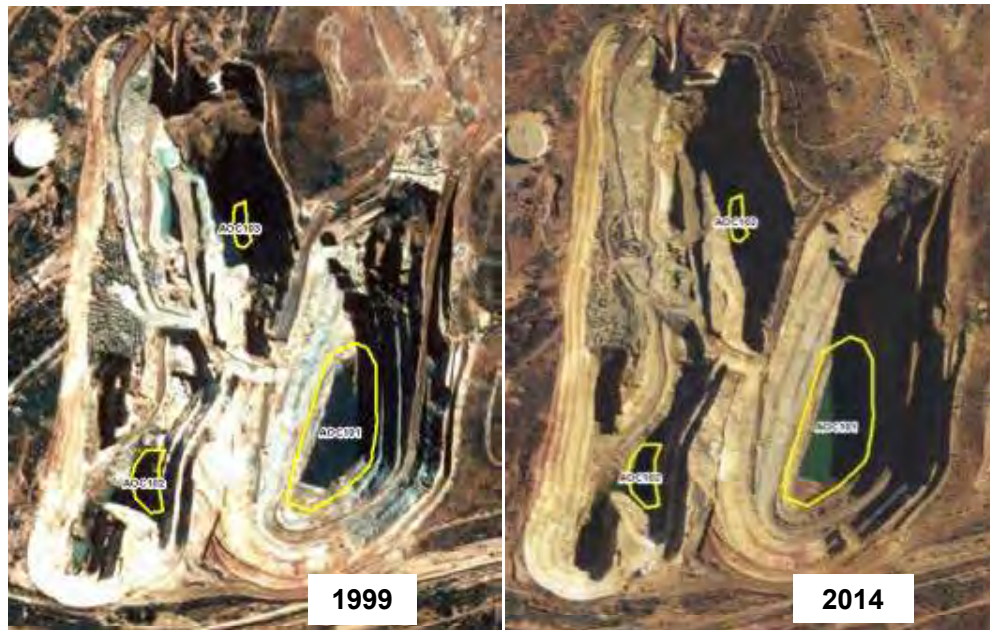


Figure A36: Mt Percy Pit Lakes

ZOI15 – MT PERCY REHABBED AREAS



Figure A37: Mt Percy TSF

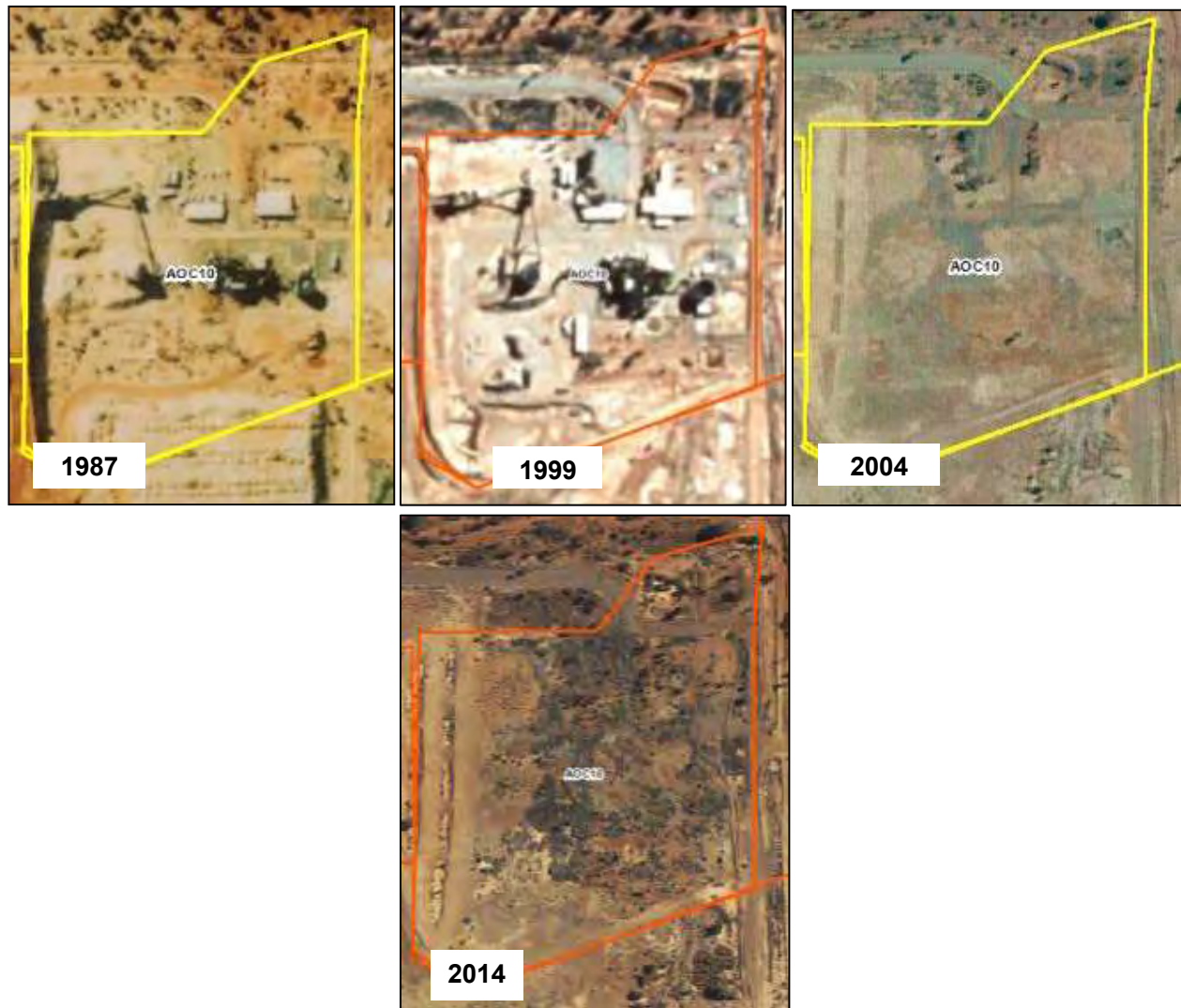


Figure A38: Mt Percy Former mill 1999 (left) and 2014 (right)

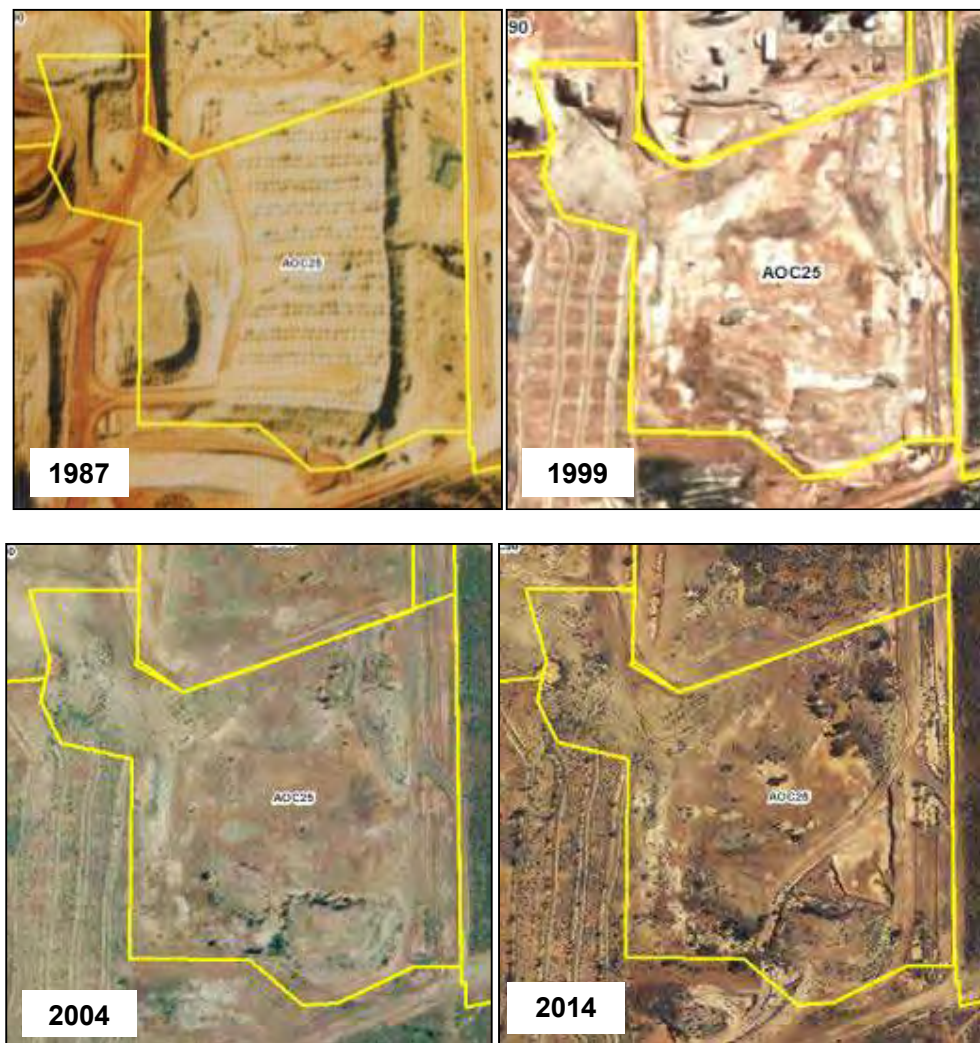


Figure A39: Mt Percy Workshop



Figure A40: Sir John Open Pit Feature (showing extent of backfill)



Figure A41: Mt Percy Sir John Pit 2009

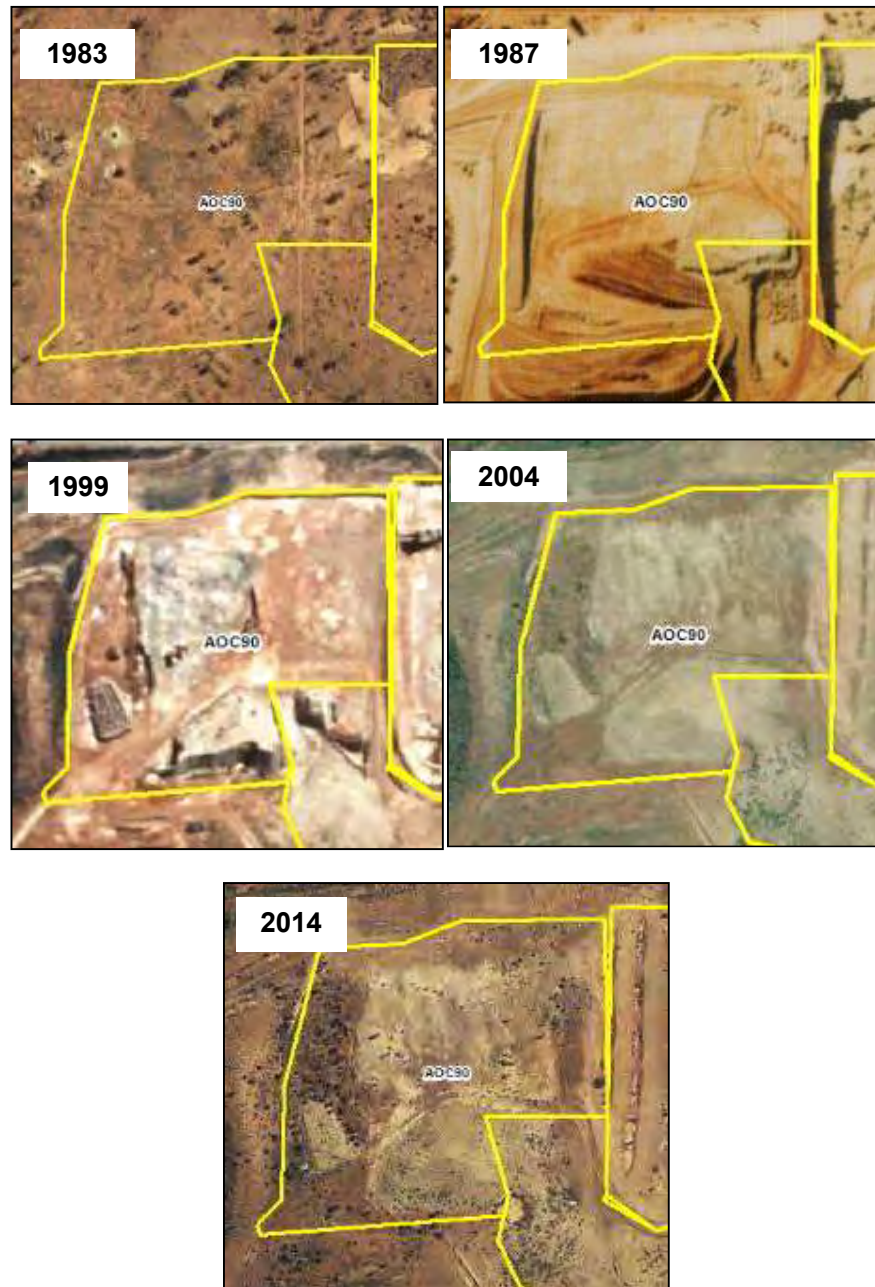


Figure A42: Mt Percy ROM Pad

ZOI 16 – HANNANS NORTH

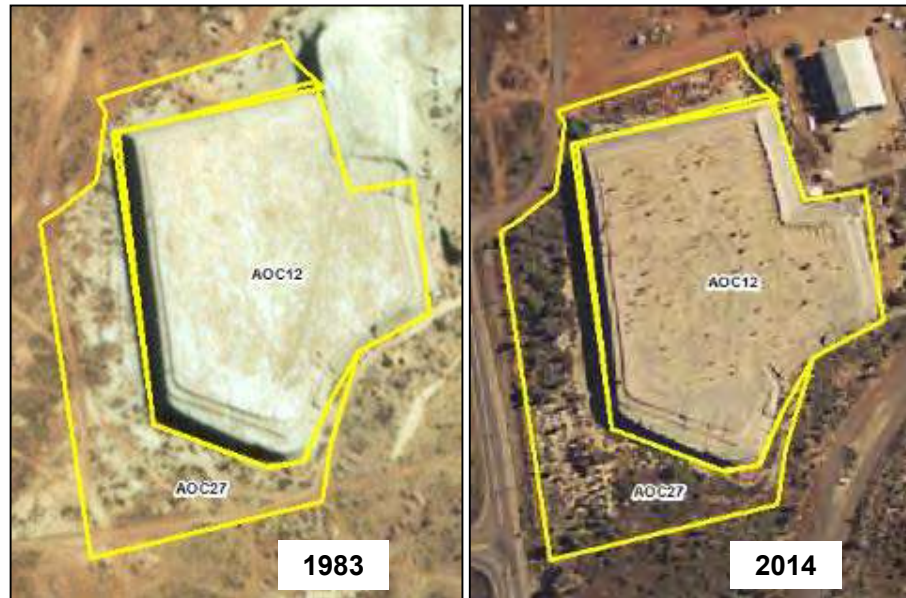


Figure A43: Mullingar TSF

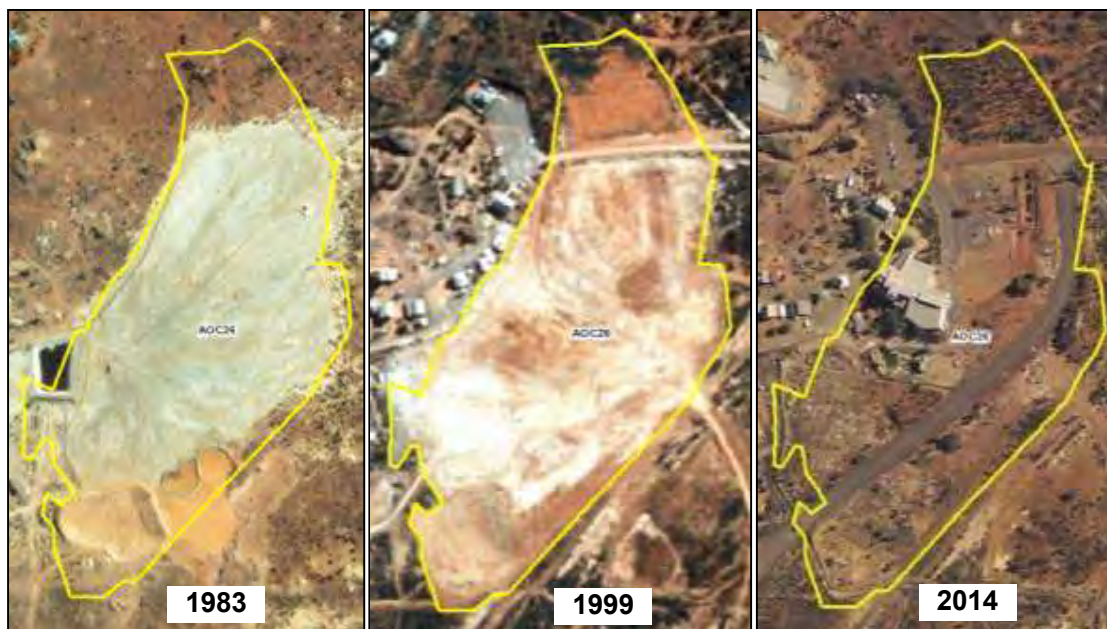


Figure A44: Hannans North Former TSF