# Notice: Request For Information

# Great Australia Mine

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# 1 Background

The Great Australia Mine (GAM), now operated by CopperChem, is located approximately 2-km south of the town of Cloncurry in North West Queensland. Since its discovery in the 1850s there has been a long history of mining at GAM, and as a result, CopperChem have inherited many environmental legacy issues. Nevertheless, since acquiring GAM in 2009, CopperChem have been improving these issues. With reference to the 2015 Annual Groundwater Report, provided to DEHP as a supporting document with the current Annual Return, there is evidence to support the improvements to water quality CopperChem have made with regards to current management operations.

The GAM site comprises inactive mining pits (i.e. GAM, Orphan Shear, Paddock Lode & Taipan), active and inactive waste rock dumps, a Run-Of-Mine (ROM) pad, a copper oxide and copper sulphide ore processing plant, a Tailings Storage Facility (TSF) and historical and active heap leach cells. The GAM operations are located on Mining Leases (ML) 90065 and 90108.

The heap leach operation is located towards the south of the mining lease and comprises a Solvent Extraction (SX) plant and copper crystallisation circuit for producing copper sulphate pentahydrate. At present six Stormwater Ponds (SP) are connected in series to contain contaminated stormwater runoff from the heap leach pads, spent heap leach landform and processing areas.

A TSF has been constructed to contain tailings from the flotation circuit of the sulphide ore processing facility. The TSF is located to the north-west of the processing area and east of the GAM WRD. However, as of July 2014, the operation of CopperChem’s sulphide ore processing plant has been temporarily suspended and, as a result, there has been no input into the TSF since this time.

# 2 Introduction

On 27 October 2014 the Department of Environment and Heritage Protection (DEHP) issued CopperChem a Notice Requiring Further Information (RFI) (DEHP Ref: 101/0088742, STAT877) relating to the CopperChem Environmental Evaluation report submitted on 13 October 2014. This RFI has been prepared to provide further comment with regards to the requirements as specified in Section B of the DEHP Notice.

Section 2 of this RFI reiterates each “Requirement Citation” from the DEHP RFI Notice, followed by the associated supplemental information as provided by CopperChem. There is some degree of repetition in this document, largely as a result of the carry-over queries made by DEHP in their RFI letter; therefore, each “Requirement Citation” should be evaluated independently.

This RFI should be read in conjunction with the CopperChem Environmental Evaluation (13 October 2014) (EE), DEHP RFI Notice (27 October 2014), the CopperChem Environmental Authority (EPML00876013) (EA), Environmental Management Plan (EMP – Amended 2012) and Annual Groundwater Report (2015).

# 3 Purpose

The purpose of this RFI and the associated EE is to determine whether CopperChem’s activities are causing unauthorised environmental harm, and where identified to recommend actions that can be undertaken to prevent environmental harm.

### 3.1.1 Recent Continuous Improvement Actions by Copperchem

Based on the data provided to DEHP and extended groundwater monitoring, Copperchem has no indication there are downstream impacts to EV’s at this time. Regardless of this during the last 12 months Copperchem personnel have implemented a number of improvements at the site as a planned approach.

This program has the objective of continuous improvement to the site environmental conditions and has included:

- Maintaining pump-back management strategy down-gradient to Heap Leach area;
- Monitoring and maintenance of launders in the Heap Leach Area;
- Suspension to the use of the TSF;
- Establishment of new reference bores;
- Continuous monitoring of 50 bores across the site; and
- Leak detection and shallow interception bores immediately down gradient to Heap Leach Area.

In April 2015, CopperChem representatives attended a meeting with DEHP personnel in Cairns and highlighted an approach towards revisiting the site risk review. This process is underway with the intention of defining further actions at the GAM site.

Some actions have commenced regardless of completing this work, including the decommissioning and rehabilitation of certain site infrastructure areas. Other remediation options are in the planning phase include the items discussed below:

- The removal or final capping to Spent Heap Leach material located to the south-east of the site (Figure 1);
- Changes to the ongoing management of Heap Leach Cells 1,2 and 3 (option to be entirely covered with poly-lining prior to ongoing use and hence introduce secondary protection measures) (Figure 1);
- The removal of waste rock in the Taipan/Paddock Lode WRD (to be disposed in the Taipan pit (complies with Schedule E19 of the GAM EA);
- Engineering assessment to optimal approaches for diverting off-lease surface water flows from entering the GAM site (south-east); and
- Although there is no evidence of contaminants in groundwater down-gradient to the GAM site, CopperChem propose to augment the existing groundwater pump-back strategy via periodic monitoring of third party bores.

Once CopperChem complete a full assessment (i.e. costs, due process, regulatory compliance etc.) of the abovementioned approaches, an update will be provided to DEHP.


**Figure 1.** Remediation options for the protection of the receiving environment proposed for GAM

# 4 DEHP Notice Requirements

## 4.1 Requirement 1a Citation

*The department recognises that CopperChem Ltd identified the Flinders River Catchment as an environmental value, however not all values relevant to the location were identified or described (sic).*

*CopperChem Ltd is required to identify and define the relevant environmental values in accordance with the ANZECC 2000 guidelines. Guidance material is available specifically in section 2.1.3 of ANZECC 2000, to fully address this requirement. Another document which may assist in meeting this requirement is the department's REMP guideline (sic)*.

### 4.1.1 CopperChem Response/ Supplemental Information

Section 2.1.3 of the ANZECC Guidelines (2000) define the Environmental Values (EVs) associated with a water resource; these are summarised in Table 1. The "regulatory approved" GAM Environmental Management Plan (EMP) (2012) also identified all EVs associated with the project. As specified in the ANZECC Guidelines, all water resources should be subject to at least one (1) of these EVs, and in most cases, more than one (1) could be expected to apply.

Table 1 lists the identified/ associated EVs at GAM that relate to those specified in the ANZECC Guidelines (2000) and the GAM EMP that specifically are linked to groundwater contamination concerns.

Water quality of EVs identified down-gradient of the GAM, are described in more detail under Section 4.2.1.

**Table 1 : Environmental Values as specified in ANZECC Guidelines (2000) and relevant examples as identified at GAM**

| ANZECC Environmental Values | Identified Environmental Value at GAM |
|---|---|
| Aquatic ecosystems | River Red Gum fringing riparian woodland communities.<br>Since there is no groundwater-surface water connectivity, EVs pertaining to macroinvertebrates communities in surface water systems are not relevant. |
| Primary industries (irrigation and general water uses, stock drinking water, aquaculture and human consumption of aquatic foods) | Neighbouring properties and downstream properties use groundwater to water livestock and irrigation. Water quality of these groundwater bores is described in detail under Section 4.2 of this RFI.<br>Surface water run-off has the potential to cause contamination to groundwater systems; however, control measures are in place to prevent this from occurring. |
| Recreation/Aesthetics | The Cloncurry River (including Coppermine Creek) flows into the Flinders River (and then into Gulf of Carpentaria – total distance of approx. 340 kilometres). As a result of their inability to hold/ retain water for long durations, the Cloncurry River and Coppermine Creek are not generally used for recreation purposes. However, as these surface water systems are located down–gradient to the GAM lease, there may be implications to aesthetics. |
| Drinking Water | Some downstream landholders use groundwater for livestock and human consumption. Water quality of these groundwater bores is described in more detail under Section 4.2 of this RFI. |
| Industrial Water (no water quality guidelines are provided for this environmental value) | None Identified |
| Cultural and spiritual (no water quality guidelines are provided for this environmental value) | None Identified. There are no Cultural or Spiritual assets associated with groundwater on, or adjoining, the GAM lease. |

## 4.2 Requirement 1b Citation

*As not all environmental values were identified in the initial environmental report, the assessment did not cover all potential impacts on those values (sic).*

*CopperChem Ltd is required to assess the impacts on the additional environmental values under requirement 1a (sic).*

### 4.2.1 CopperChem Response/ Supplemental Information

Table 2 lists all EVs as per the ANZECC Guidelines (2000) and the GAM EMP (2012) and lists the possible impacts (if relevant) caused to groundwater as a result of mining activities.

**Table 2 : Environmental Values as specified in ANZECC Guidelines (2000), relevant examples as identified at GAM and potential impacts caused as a result of mining activities**

| ANZECC Environmental Values | Identified Environmental Value at GAM | Potential Impacts from Mining Activities |
|---|---|---|
| Aquatic ecosystems | River Red Gum fringing riparian woodland communities | Receiving Environment Monitoring Programme (REMP) (AARC (2012, 2013) and CopperChem (2014) have shown that mining activities have not negatively impacted on these riparian woodlands. |
| Primary industries (Irrigation and general water uses, stock drinking water, aquaculture and human consumption of aquatic foods) | Neighbouring properties and downstream properties use water from Coppermine Creek | The Cloncurry River and Coppermine Creek only hold water for brief periods of time following rain events. These systems are regarded as "losing" systems where water reflects surface water flows and not groundwater.<br><br>There is no evidence of surface water-groundwater connectivity in the Coppermine Creek, therefore groundwater sourcing from GAM is unlikely to have any negative impacts to water quality in these (surface) systems. Moreover, as a result of there being no hydraulic connection between groundwater and surface water, it is unlikely that macroinvertebrates or vertebrates will be negatively affected.<br><br>Downstream landholders use groundwater as a source for watering cattle and irrigation. Groundwater quality at these locations is representative of the area, and water quality results (Section 4.2.1) are within the acceptable guidelines as stipulated in the GAM EA and ANZECC (2000). Therefore it can be established that mining operations has not caused adverse effects to groundwater quality and assets down-gradient to GAM. |
| Recreation/Aesthetics | Cloncurry River (including Coppermine Creek) flows into the Flinders River (and then into the ocean – total distance of approx. 340 kilometres). | **Does not apply** – groundwater does not supply water to the Cloncurry River or its tributaries, including Coppermine Creek, (within 100-km of GAM). Therefore, there is no possibility that groundwater can negatively affect visual amenity or impact on recreation activities. |
| Drinking Water | Groundwater in the Cloncurry area is generally not used for human consumption, but rather for livestock. Some downstream landholders use groundwater for watering livestock and for human consumption.<br><br>Some members of the Cloncurry community access groundwater from several hard rock and alluvial bores within and surrounding Cloncurry. | Where some landowners use their bore water for human consumption, water quality is representative of the area and acceptable under ANZECC Guidelines (2000).<br><br>With reference to the approved GAM EMP (2012), "*The Project has limited potential to impact on the quality of the water that the town utilises from the hard rock and alluvial aquifers given the surface water quality and groundwater controls proposed in this EM Plan*". |
| Industrial Water (no water quality guidelines are provided for this environmental value) | N/A | **Does not apply** |

| ANZECC Environmental Values | Identified Environmental Value at GAM | Potential Impacts from Mining Activities |
|---|---|---|
| Cultural and spiritual (no water quality guidelines are provided for this environmental value) | N/A | **Does not apply** – The Coppermine Creek and the Cloncurry River do not have any known Cultural and/or Spiritual Heritage sites near to, or downstream of, GAM. |

Due to the implementation of groundwater Control Strategies (implemented to protect groundwater quality, necessary to maintain each EV) identified in the GAM EMP (2012), CopperChem has reduced the risk of negatively impacting water quality. Some of the Control Strategies implemented on site, and listed in the GAM EMP (Section 5.3.5 - Amended 2012), include (taken from the EMP):

- HDPE liner systems are in place under all heap leach pads and within all process water ponds and these will continue to be maintained to prevent contamination of groundwater;
- Observation bores are in place, close to the heap leach area, to detect any infiltration of process liquors to groundwater and these will continue to be monitored/maintained;
- Groundwater observation bores are installed upstream and downstream of the TSF and monitored on a regular basis to detect any contamination;
- Pump-back bores were installed downstream of the spent heap leach pads; where groundwater is then pumped back into the process water dam. This water is then used in the plant when make-up water is required;
- The water in all mine voids is tested regularly to detect any degradation of water quality;
- All potentially acid producing waste rock is encapsulated within non-acid forming waste to prevent acid mine drainage;
- The relevant Plan of Operations will be updated with any new upstream or downstream monitoring points for Orphan Shear, Canteen, Bosca and Bosca West MLs prior to mining commencing;
- Water levels within the TSF water storages are monitored visually and recorded manually. Gauge boards were constructed showing the design storage allowance levels and mandatory reporting levels; and
- Water that is discharged from sediment traps or bund walls surrounding waste rock dumps is sampled for quality. Water quality discharged from these locations is compared to ANZECC, Livestock Drinking Water Guidelines.

To further investigate the impacts (if any) caused to down-gradient EV's (identified in Table 3), CopperChem undertook a groundwater sampling and analysis programme targeting "off-lease" EVs. These included:

- Adjoining property groundwater bores (i.e. for livestock watering and human consumption); and
- Surface water from the Cloncurry River (i.e. supporting River Red Gum communities).

The location of the groundwater bores sampled and the locations of the sampling points in the Cloncurry River are shown in 2. Table 3 details the groundwater bores sampled and their current use.

**Table 3: Details and current use of groundwater bores sampled to investigate impacts caused (if any) to Environmental Values down-gradient to GAM.**

| Location and Bore I.D | Groundwater Bore Details | Current use |
|---|---|---|
| **<u>Location A</u>**<br>**1 = Windmill Bore**<br>**2 = Garden Bore**<br>**3 = Potable Water Bore** | Approximately 10m deep and installed in metavolcanics<br>Approximately 10m deep and installed in metavolcanics<br>Sourced via pipeline from Location D (see Figure 2 and refer to Location "D") | Used to water livestock<br>Used for irrigation<br>Used for potable drinking water |
| **<u>Location B</u>** | Approximately 10m deep and installed in metavolcanics | Used for potable water |
| **<u>Location C</u>** | Approximately 10m deep and installed in small altered granite unit in the brecciated calc-silicate lithological unit | Used for potable water |
| **<u>Location D</u>** | Cloncurry Council owned and operated bore providing potable water to Locations A, D and E. Installed in alluvium associated with the Cloncurry River. | Used for potable water (sample acquired from Location A – Bore 3) |
| **<u>Location E</u>** | Cloncurry Council owned and operated bore providing potable water to Locations A, D and E. Installed in alluvium associated with the Cloncurry River. | Used for potable water (sample acquired from Location A – Bore 3) |
| **<u>Location F</u>** | Surface water sampling locations in the Cloncurry River. <u>At the time of sampling (early April) very little water was present upstream of location Fb.</u> | Supporting River Red Gum Communities |

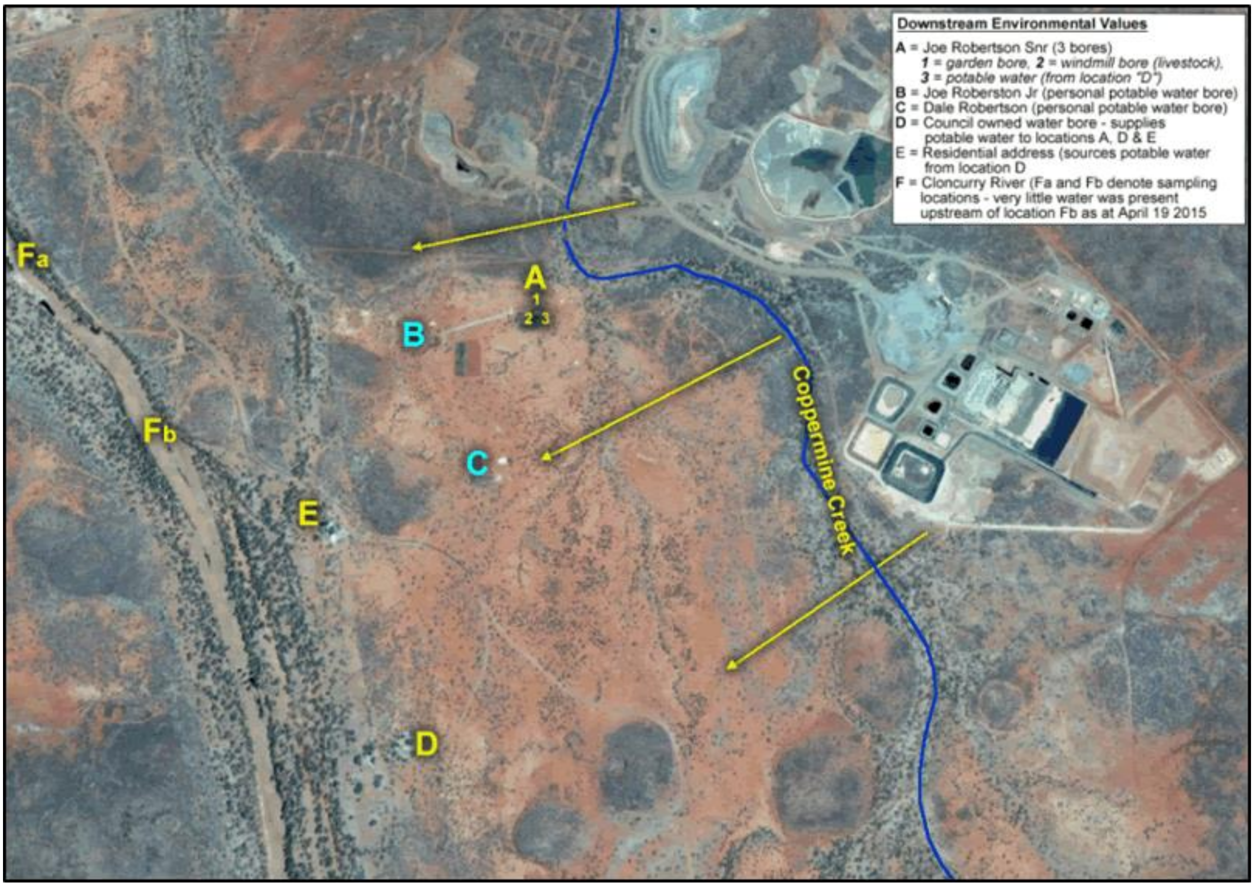


**Figure 2: Locations of down-gradient groundwater bores and the Cloncurry River targeted for a sampling and analysis programme to support investigations on impacts caused (if any) to Environmental Values**

The laboratory results from the Sampling and Analysis Programme aimed at the EVs down-gradient of the GAM site are shown in Table 4. For the purposes of this report, the main analytes chosen to report are sulfate ($SO_4^{2-}$), copper (Cu), cobalt (Co); while the physicochemical parameters include pH, Electrical Conductivity (EC), Eh (Redox) and Dissolved Oxygen (DO).

**Table 4: Groundwater quality results of down-gradient Environmental Values (EVs). Metals represent "Dissolved" species and physicochemical parameters represent "field measurements"**

| a | | Co mg.L$^{-1}$ | Cu mg.L$^{-1}$ | $SO_4^{2}$ mg.L$^{-1}$ | pH | EC mS.cm$^{-1}$ | Eh mV | DO ppm |
|---|---|---|---|---|---|---|---|---|
| **LOR** | | **0.001 mg.L$^{-1}$** | **0.001 mg.L$^{-1}$** | **1.0 mg.L$^{-1}$** | **NA** | **NA** | **NA** | **NA** |
| **A** | Windmill | <0.001 | 0.001 | 643 | 7.20 | 1.93 | 94.2 | 4.22 |
| | Garden | <0.001 | <0.001 | 912 | 6.86 | 2.63 | 151.9 | 3.92 |
| | Potable | <0.005 | 0.005 | 53 | 7.50 | 1.03 | 81.8 | 5.21 |
| **B** | | <0.001 | 0.005 | 452 | 7.43 | 1.85 | 94.5 | 5.83 |
| **C** | | <0.001 | 0.001 | 50 | 7.32 | 1.31 | 82.3 | 4.20 |
| **F** | Fa | 0.001 | <0.001 | 40 | 8.03 | 0.681 | 68.1 | 8.09 |
| | Fb | <0.001 | 0.002 | 20 | 8.22 | 0.614 | 72.4 | 7.10 |

**Note: Locations D & E are not included in the table above as results will be the same as Location "A-potable"**
**NA = Not Applicable, LOR = [Laboratory] Limits of Reporting.**

The results as shown in Table 4 indicate that, in all cases, $SO_4^{2-}$ is below the 1000 mg.L$^{-1}$ EA contaminant limit. Similarly, Cu results show that concentrations are below, or at, the Laboratory Limits of Reporting (LOR), except at bores "A-potable" and "B" where corresponding $SO_4^{2-}$ concentrations are 56 mg.L$^{-1}$ and 452 mg.L$^{-1}$ respectively. Concentrations of Co are below the EA contaminant limit at all locations, except at location Fb (i.e. the Cloncurry River) where the concentration is 0.001 mg.L$^{-1}$ above the LOR (where LOR is 0.001 mg.L$^{-1}$).

Results pertaining to the contaminants of concern, as raised by DEHP, at the down-gradient EVs, indicate that there is no imminent threat to groundwater. Moreover, water quality results from locations "A-Windmill", "A-Garden", "B" and "C", taken in September 2014, show that the concentrations of these parameters are alike to data presented herein, and to water quality throughout the region.

### 4.3 Requirement 1d Citation

*The department believe the reference bores identified may not be consistent with recognised standards for determining reference bores (sic).*

*CopperChem is required to provide supporting information to justify how the chosen 'proxy' reference bores meet the criteria of a reference bore location in accordance with recognised standards, ANZECC 2000. If the 'proxy' bores are determined to not meet the criteria in the recognised standards, further works, including installation of suitable reference bores, is required to be undertaken to address requirement 1d (sic).*

#### 4.3.1 CopperChem Response/ Supplemental Information

The groundwater bores, as stated in the CopperChem EE, that were used as "Proxy" reference bores were only used as proxies until CopperChem installed the new groundwater "reference" bores. This was stated in the EE. The reason these bores were used, or referred to as, "Proxies", for the purposes of the EE, was due to item 12 in the DEHP EE Notice (dated 12-June). This EE Notice inferred that, due to their low sulfate concentrations, water quality data from bores such as OB15 may be used as a means to distinguish what "reference" groundwater quality may be like (i.e. unaffected by mining operations).

CopperChem will not be using the "Proxy" groundwater reference bores (used in the EE) for future assessments; these were used in lieu of reference data. In late September (2014) two (2) appropriate EA Reference bores were installed at GAM. The following EA requirements and ANZECC Guidelines (2000) were considered when selecting locations for groundwater reference sites. These were:

- Be from the same bio-geographic and climatic region;
- Have a similar geology, soil types and topography;
- Contain a range of habitats similar to those at the test sites;
- Have a similar flow regime; and
- Not be so close to the test sites that any disturbance at the test site also results in a change at the reference site.9

The locations for the two (2) "reference" bores align with the requirements specified in the EA (listed above) and ANZECC Guidelines (2000) (refer to Section 3.1.4.1). The locations of the "reference" bores (i.e. OSOB1a and PLOB3) are shown on Figure 3. Additionally, there are two (2) remaining groundwater bores that could be used as "reference" bores; these are FPB_2014 & CB_2012 (Figure 3).

Although it may be regarded that some of these "reference" bores may not be suitable (i.e. they occur down-gradient to features such as the GAM WRD etc.), water quality results show that $SO_4^{2-}$ does not breach the EA contaminant trigger of 1000 mg.L$^{-1}$. Cu concentrations show similar trends to all bores across the GAM site (i.e. temporal and spatial variations where concentrations vary from being EA compliant to slight exceedances of EA contaminant limits). Furthermore, with reference to Figure 2, the installation of these groundwater bores ensure that groundwater quality can be sampled and analysed from all aquifers comprising all major geological units at GAM. In brief, CopperChem have "Reference" bores "upstream" and "down-stream" of the GAM site; of which undergo monthly monitoring.


**Figure 3: Location of groundwater reference bores at GAM. Note CB_2012 and FPB_2014 are existing bores that could also be used as an ancillary reference bore.**

### 4.4 Requirement 2 Citation

1. *The environmental report nominates potential sources of contaminants in the way of landform identification. There is also a reference to previous spills and discharge events that may have influenced the quality of groundwater. However, the report does not identify a specific source or relevant contribution of contamination input to groundwater. CopperChem Ltd is required to identify the likely sources and distribution of ongoing contamination discharge and inputs (sic).*

2. *The environmental report states that all open voids act as groundwater sinks and that the geology is laterally discontinuous. However, the environmental report also identified a fault line through the GAM Pit. CopperChem Ltd is required to provide further information as to the hydrological implications of this fault line (sic).*

3. *Further information is required regarding the shallow ephemeral groundwater system at the site. CopperChem Ltd is required to provide details of the flow paths, including hydraulic gradients, of the shallow groundwater system and an assessment of the site geology to determine the degree to which structural geology (faults zones/ joints etc.) act as conduits enabling contaminant migration (sic).*

#### 4.4.1 CopperChem Response/ Supplemental Information

1. As a result of the general lack of groundwater reference data at GAM, specifically “baseline” data where it is recorded that groundwater samples were collected and analysed as per best industry practice, CopperChem cannot accurately define if mine-site operations are causing elevated concentrations of analytes in groundwater.

   Prior to CopperChem’s acquisition of GAM, the project was being mined/managed by Tennant Ltd (Tennant). It is CopperChem’s understanding that baseline sampling of groundwater was not undertaken at GAM prior to Tennant’s tenure. Moreover, early records of compliance monitoring of groundwater quality by Tennant clearly shows that by the time the Administering Authority issued the EA, $SO_4^{2-}$ was already in excess of the Administering Authority “Default Trigger” (i.e. 750 $mg.L^{-1}$) (in some cases by a factor of 2). Additionally, early compliance monitoring of groundwater quality by Tennant also shows that since CopperChem have taken over as landowner/landholder, groundwater quality has greatly improved in some areas of GAM.

   CopperChem have placed a formal request to DEHP to provide early Environmental Authority licences (or equivalent) (pre 2005) to investigate further on whether [historical and] appropriate groundwater quality “environmental triggers” were generated, in an otherwise extremely disturbed site (i.e. 100-years of mining prior to Tennant’s operations).

2. As described above, and in the DEHP RFI letter, simple hydraulics demonstrate that groundwater (if it has an appropriate flow path) can report to any voids that intersect and extend below the static (ground) water level. Therefore, the fault that intersects the GAM Pit can <u>only</u> convey water away from the pit if pit water levels are above the height of groundwater outside of the pit (i.e.180 mAHD to 195 mAHD). So long as water levels in the GAM Pit are maintained below the height of groundwater immediately outside of the pit walls, groundwater can only flow towards the pit. This is also corroborated by industry professionals such as Australian Groundwater and Environment (AGE) consultants (2004).

   The response to the third point below discusses in more detail the implications of geological lineaments (e.g. faults etc.) in controlling/assisting groundwater flow.

3. With reference to DEHP comments concerning “ephemeral groundwater” at GAM, it should be stated that this is not a conventional term or phrase used in the field of hydrogeology. The term “ephemeral” is typically used for referencing seasonal flows of surface water systems (hydrological systems) and not groundwater (hydrogeological systems). Some people have used the term “ephemeral groundwater” in settings where groundwater may be seasonally perched (i.e. landfill settings);

however, this is considered erroneous. Nevertheless, in an email from Geraldine Davis (2-Feb 2015) it was specified that DEHP required more clarity regarding groundwater flow-paths and hydraulic gradients at GAM. Furthermore, DEHP wanted this information to extend to those areas beyond the mining lease (i.e. down-hydraulic gradient).

Figure shows the generalised direction of groundwater flow (denoted by yellow arrows) and calculated (horizontal) hydraulic gradient. As a result of the generally flat topography of the GAM lease, and neighbouring properties, extremely low hydraulic gradients occur. Hydraulic gradient is simply the slope of the watertable or potentiometric surface and is the change in hydraulic head over the change in distance between the two groundwater bores. Therefore, using two bores groundwater direction could be calculated as being towards the Coppermine Creek. However, as previously stated, although groundwater flow is in the direction of the Coppermine Creek, groundwater does not provide a source of water for the creek. In effect there are several metres of separation between the creek bed and groundwater.

The hydrogeological regime at GAM may be regarded as an unconfined fractured rock aquifer. These aquifers have effectively no primary porosity; groundwater may be held in secondary porosity features such as fractures and voids (i.e. GAM Pit). Aquifer transmissivity can be extremely variable and is dependent upon localised conditions such as the degree of fracturing and interconnection of the fractures. For example, it is very common for one bore to intersect groundwater, while an adjacent bore, only a few metres away, does not. In 2004, AGE suggested that as a result of the variability between bores, it is best to consider the GAM site as a whole, rather than focussing on individual data points or drill holes.
Since 2004 a series of additional groundwater bores have been installed at GAM allowing for the collection of more groundwater data. As a result of the supplemental data acquired from these bores, it is apparent that groundwater flow is towards the Coppermine Creek, and flow is likely disrupted as a result of the variability of fracturing (if present) of the aquifer.

In 2004, to further investigate matters concerning groundwater flow via secondary porosity features (i.e. geological features such as fractures, joints etc.), AGE were commissioned to submit a report based on their findings. The results of the AGE assessment stated that geological structures <u>may</u> function as secondary porosity for groundwater storage. The AGE report (2004) also concluded that the direction of groundwater flow at GAM is towards Coppermine Creek and existing groundwater sinks (i.e. Great Australia Pit and the Paddock Lode Pit), however the exact flow-paths cannot be fully defined.

In general terms, the direction of groundwater flow will conform to the local hydraulic gradient (i.e. towards the Coppermine Creek) and the speed of groundwater flow will be controlled by the local geology and recharge characteristics. For example, if geological lineaments exist within the rock units at GAM, and they have the capacity to store groundwater, flow through these features may be limited as such structures may not be connected with other structures. Moreover, within a weathered and fractured rock aquifer such as GAM, the speed of groundwater will depend on the presence, and geometry of, the fracture networks.

As a result of the semi-arid conditions in the region, where precipitation is below evapotranspiration, groundwater is not subjected to high recharge rates. Therefore, as a result of the low hydraulic gradient, low hydraulic conductivity (i.e. due to fractured rock networks) and variable recharge rates, the speed of groundwater flow is extremely slow (e.g. $1x10^{-9}$ m/sec to $1x10^{-7}$ m/sec).

To better illustrate the variability in groundwater response in relation to recharge events (i.e. rainfall), Figure shows daily rainfall (measured in mm) received at GAM versus groundwater levels measured at bore OB1, OB10, OB18, TSFOB7 (from March 2014 to February 2015). These bore were selected, as it is believed, they are spatially representative of the area immediately down-gradient of the TSF and Heap Leach facility.


**Figure 4: Generalised direction of groundwater flow and calculated hydraulic gradients (i.e. 0.008). Note: The yellow arrows denote the generalised direction of groundwater flow (calculated using groundwater levels from two distinct bores) and not actual groundwater flow-lines.**

It can be seen from Figure  that once the unsaturated zone becomes saturated during/following the wet season, in some instances there is a marked response (sometimes lag) in groundwater levels (i.e. OB18) to rainfall received; however, in other cases the response is much smaller (i.e. OB1 & TSFOB7) or inconsequential (i.e. OB10). The response of groundwater levels, following a rainfall event, is directly related to the aquifer material and conductivity.

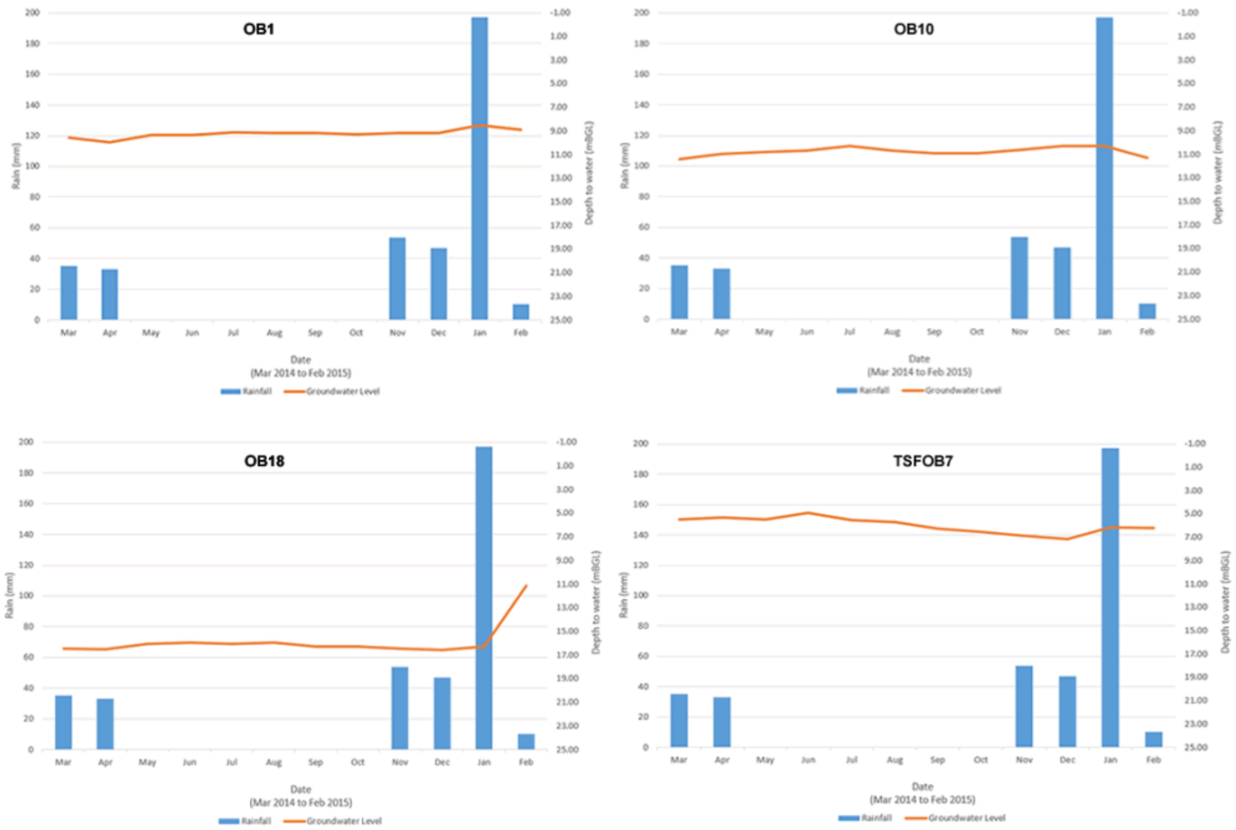


**Figure 5: Groundwater levels in OB1, OB10, OB18 and TSFOB7 following recharge events – groundwater level measurement (in meters below ground level (mBGL)) (right axis) and rainfall data (mm) (left axis)**

It is evident from drill logs that all groundwater bores, located down-gradient of the TSF, ROM and Heap Leach facility, were installed in the same geological unit (see Figure ) to a depth where fresh (i.e. unfractured) rock was intersected. The depth to fresh rock varies across site from a few metres, down to tens of metres. The completion of groundwater bores in fresh rock generally indicates that groundwater flow (if any) will be restricted to the fractured rock/weathered profile above.

With reference to Figure 6, AGE (2004) identified that the geological lineament oriented north-east, in the area of the TSF, is considered to be in an area of localised high transmissivity and groundwater flow. Therefore, it was suggested that this lineament had the potential to convey waters from the TSF towards Coppermine Creek. However in July 2014, CopperChem ceased operational inputs to the TSF, thus decreasing the possibility of any release from the TSF to down-gradient receptors.

In terms of the remaining geological lineaments promoting groundwater flow, this is largely unknown. Although such structures as faults can influence groundwater flow, this depends on the size of these features and the geology of which they intersect. Faults are not always preferential pathways for groundwater. For instance, and in many cases, fault networks can become filled with secondary precipitates originating from dissolved constituents in groundwater (i.e. carbonates, salts) or, as a result of the lithology, faults can be filled with fine-grained material. In a paper by Cannell and Davidson (1998) it was stated that many of the fractures and faults at GAM have been infilled by a calc-silicate assemblage. Fracture-filling of geological structure greatly impede groundwater storage, and flow, within in these features.

If, for instance, fault networks assist in controlling groundwater flow, the direction of flow will be in the direction of the regional hydraulic gradient. If groundwater flow was to occur across a fault system, then this may be considered to follow Darcian flow principles (i.e. being proportional to the hydraulic gradient existing between groundwater systems above and below a fault, if present). However, groundwater flow across a fault is almost impossible to model. This is due to the variability of lithological units, additional geological structures, aperture size of fractures and fracture density.

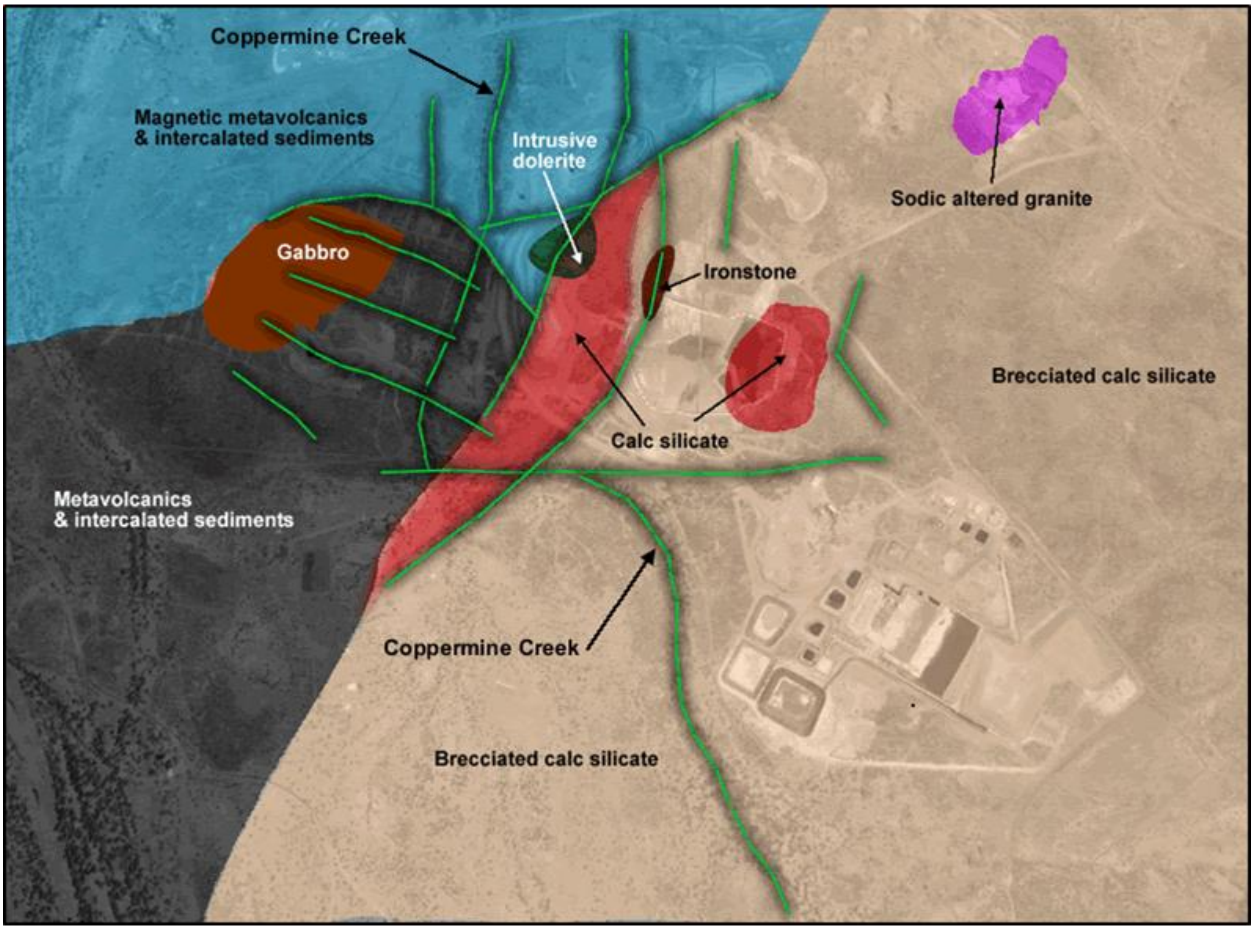


**Figure 6: Inferred geological structures (i.e. faults etc. denoted as green polylines) and main lithological units associated with the Great Australian Mine. Note: there have been no geological lineaments identified or inferred in the area of the GAM operational areas (i.e. heap leach or processing areas). Note: the Coppermine Creek has been identified as a fault system.**

In the case of GAM, if faults did convey groundwater flow, then the direction of flow would be south-westerly. In consideration of this account and the contaminant limits specified in the EA, the quality of groundwater as measured from the alluvial aquifer, making up the Coppermine Creek, is compliant. For example, although Cu and Co show temporal [yet minor] exceedances (not surprising since this aquifer bisects two ore bodies), $SO_4^{2-}$ concentrations are below 500 $mgL^{-1}$. Additionally, as DEHP have concerns regarding Co and Cu as potential contaminants in groundwater, groundwater quality from the alluvial aquifer indicate that the dissolved concentration of each of these transitional metals show temporal variability. For example, a particular sampling programme might show that the concentration for each is lower than the EA contaminant trigger limit; whereas a follow-up sampling programme might show that the concentration has exceeded the EA contaminant trigger limit. In most instances where these metals have exceeded the EA contaminant trigger limit, the concentrations are at or near to the laboratory Limits of Reporting (LoR)[1]. This does not necessarily indicate that these are harmful to groundwater receptors or users; but the inconsistency in results does indicate the [expected] natural variability of water soluble Co and Cu in the region.

[1] For example, the EA trigger limit for Cu is 0.0014 $mg.L^{-1}$ and LOR is 0.001 $mg.L^{-1}$.

### 4.5 Requirement 3.a Citation

1. *While the environmental report outlines the components of the current water management system, it does not assess the extent to which the system protects groundwater quality. Further information is required to evaluate the extent to which the current water management system is effective in protecting groundwater quality from impacts of mining activities (sic).*

2. *The Groundwater Sampling and Analysis Programme (SAP): CopperChem Operations document provides guidance on the filtration of water samples, however, there is no evidence in the environmental report as to whether the data for metals represent filtered (0.45 µm) or unfiltered concentrations. CopperChem Ltd is required to clarify whether the metal values referred to are filtered or unfiltered samples (sic).*

#### 4.5.1 CopperChem Response/ Supplemental Information

1. The GAM Mine Water Management System (MWMS) (URS, 2014), improved and current as at 1-November 2014, comprises a series of regulated dams; these include:

   - Poly-lined stormwater ponds;
   - Heap Leach circuit launders and ponds (i.e. Pregnant Leachate Solution (PLS) and raffinate ponds);
   - Surface water diversions drains; and
   - Poly-lined process water ponds.

The purpose of the GAM MWMS is to:

- Further develop systems to segregate waters based on source and quality;
- Minimise volumes of the mine affected water generated and stored onsite;
- Evaluate performance of mine-affected water storages;
- Ensure these regulated dams are adequately sized for containment and release requirements; and
- Ensure key water transfer systems are able to meet wet season requirements.

Upon completion of the GAM MWMS (prior to 1st Nov 2014), it was deemed from water balance modelling and Consequence Category assessment, the GAM site complied with the QLD Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (DEHP, 2013). However the site relies on a series of Operational Rules to achieve this.

In particular the MWMS is a series of connected stormwater ponds that operate by a common gravity outlet system (these have been assessed for Design Storage Allowance (DSA) and Extreme Storm Surge (ESS)), where each pond and launder/spillway has been poly-lined to protect groundwater assets. To achieve DSA, a shared approach has been implemented. For example, as the TSF has nearly reached its Mandatory Reporting Level (MRL), any water collected in this dam is to be transferred to the GAM pit (this approach has been approved by DEHP in October 2014). This DSA sharing approach also shows that, for a two month wet season, clean stormwater can be transferred to the GAM pit; maintaining the 167.3 mAHD[2] water cut-off level in the pit. CopperChem have ensured that appropriate pumps and infrastructure are in place to ensure that effective and timely water transfer can take place. Additionally,

[2] Reference to CopperChem EA Amendment application dated 7-November 2014 and DEHP Assessment Level Decision 567649, 101/0008742 (dated 20-November 2014)

each regulated dam, including the GAM pit, has been assigned an MRL; of which has been clearly been marked on the wall of each dam.

Where surface water enters the site from neighbouring properties, these ephemeral systems are diverted into a clean borrow pit for storage and then, if required, through a central mine drain. This central mine drain minimises any contact with mine-related contaminants. It is worth noting that during the most recent wet season, the regulated dams onsite did not reach 10% of their overall capacity; the TSF did not capture/store any water and the central mine drain did not flow.

Water balance modelling was undertaken with a five-year simulation period, based on 114 years of data, resulting in 109 realisation model runs. The results indicated that there were no external overflows to Coppermine Creek for the median Life of Mine.

For more detail with regards to the GAM MWMS, please review the Great Australia Mine – Water Management Strategy (URS, 2014) (as provided to DEHP in October 2014).

2. The results for metals/metalloids in the Environmental Evaluation Report are dissolved/ filtered. As specified in the Environmental Evaluation, the statistical results represent all available data; including (where applicable) water quality results from groundwater bores that precede CopperChem as owner/operator of GAM.

   With regards to the preceding water quality results, CopperChem are unaware if samples were collected, stored and analysed as per legislative requirements and using best industry practice.

### 4.6 Requirement 3.b Citation

1. *Location and types of aquifers:*

*The environmental report presents insufficient information to identify the locations and types of groundwater aquifers at the Great Australia Mine. CopperChem Ltd is required to address this requirement of the Notice (sic).*

2. *Groundwater contours and levels for contaminants which include but not limited to sulphate at the site and receiving environment:*
   a) *While the environmental report focussed on sulphate, the Notice required that investigations are not limited to this parameter. The department requires further justification regarding the basis for selection of contaminants for investigation reasons for discounting contaminants from the investigation (sic).*

   b) *The department recognised that CopperChem Ltd has included groundwater contours and level of contaminants for sulphate. However, the department requires further mapping be provided for other contaminants of concern and/or justification for discounting contaminants from the investigation (sic).*

#### 4.6.1 CopperChem Response/ Supplemental Information

1. Location and types of aquifers:

According to AGE (2004), there are three (3) distinct aquifers present at CopperChem's GAM. These include:

(i) A confined to semi-confined and fractured aquifer located in the metavolcanics and altered granites (see Figure 6). Although some authors have indicated that this aquifer typically shows poor airlift yields and is not sustainable for long-term water supplies, recent evidence at GAM contests this.

(ii) A semi-confined aquifer at the transition boundary between the near-surface (i.e. weathered and fractured zone) and the underlying fresh rock (located in the calc-silicates and brecciated calc silicates

– see Figure 6). This aquifer is largely present in the vicinity of the Tailings Storage Facility (TSF) and the area south and west of the Heap Leach facility and ROM, respectively; and

(iii) An unconfined aquifer making up the alluvium of the Coppermine Creek. This aquifer is laterally constrained; extending no more than approximately 30m from the creek bed. These aquifers undergo saturation for only a very short time after a surface flow event. Some authors have the view that this aquifer can be perched; however, there is no substantial evidence to support this. The aquifer materials that underlie the Coppermine Creek have groundwater associated with them all year around, and these aquifers undergo recharge following a surface flow event. However, surface water systems such as the Coppermine Creek (and Cloncurry River) are known as "losing systems" (Figure ) and dry up soon after a surface flow event.

These systems are not in direct hydraulic connection with groundwater. For instance, during the surface flow events of 2014 and 2015, although there was water in the Coppermine Creek, there was a ~7 metre separation between surface water and groundwater. Water in these creek systems lose their water slowly through infiltration, therefore the separation between the base of the creek and groundwater does not undergo saturation.

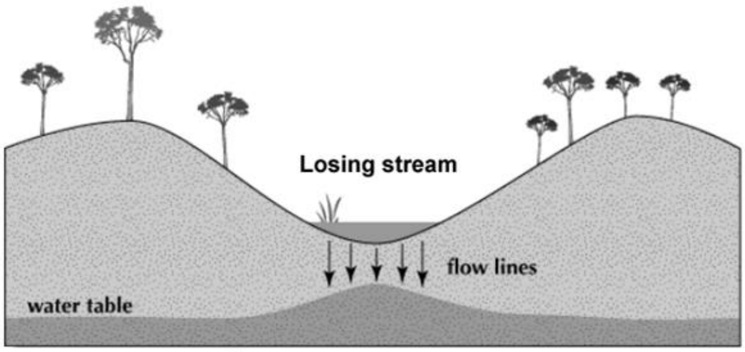


**Figure 7: Generalised schematic of a "losing" stream such as the Cloncurry River and Coppermine Creek. Note: the hydraulic disconnect between groundwater and surface water (EPA, 2015).**

2. <u>Groundwater contours and levels for contaminants which include but not limited to sulphate at the site and receiving environment:</u>

a) In an email to Geraldine Davis (DEHP) (dated 19th February 2015) it was discussed that $SO_4^{2-}$ was the primary focus because it is the one analyte that commonly occurs in groundwater as the main analyte exceeding EA criteria. There is temporal and spatial inconsistency (throughout the life of all groundwater bores, even pre-CopperChem ownership) where select "dissolved" metals/metalloids have exceeded the EA contaminant limits. However where these metals/metalloids have exceeded EA criteria, these are extremely irregular and likely a product of temporal variations. For example, as a result of their low $SO_4^{2-}$ concentrations, it was implied by DEHP (in their EE Notice) that groundwater bores OB15 and OB18, may not have been affected by mining activities; however, these same bores have shown temporal variations where dissolved Cu (and Co) concentrations are higher than identified in groundwater bores immediately down-gradient of the Heap Leach facility and TSF. As a result of the strong Cu (and associated Co) mineralisation in the region, it is no surprise that there is much variability in the concentration of some dissolved metals/metalloids identified in groundwater from the GAM site.

Likewise, and to better demonstrate this regional variability of dissolved Cu in groundwater, CopperChem also monitor baseline groundwater conditions spanning distances of 30 to 150-km from the GAM lease, that show elevated $SO_4^{2-}$ (i.e. ~1000 $mgL^{-1}$) in an area that has never been mined. Moreover, these same regional bores show markedly similar dissolved Cu concentrations to those at GAM (i.e. at, near to and exceeding the GAM EA Trigger limit of 0.0014 $mgL^{-1}$).

To further describe the solubility of Cu in water, during the wet season CopperChem sample surface waters that flow on, or near to GAM. During the most recent wet season, surface water samples were taken at the two locations (A & B) shown on Figure 8. At these locations, surface water enters “upstream” of the GAM site from the neighbouring property to the east. The results show that $SO_4^{2-}$ at location “A” had a concentration of <1 $mg.L^{-1}$ to 39 $mg.L^{-1}$, while location “B” had a $SO_4^{2-}$ concentration of <1 $mg.L^{-1}$. Similarly, dissolved Cu at these locations had concentrations of 0.001 $mg.L^{-1}$ to 0.048 $mg.L^{-1}$ to 0.034 $mg.L^{-1}$, respectively. Since Cu is in its most stable form, as an oxide, at a pH a ~7.0, it is evident that Dissolved Cu is present in both surface water and groundwater.


**Figure 8: Locations where “upstream” surface water samples were located. Note: Yellow arrows show the direction of surface water flow onto GAM**

<u>Evidence of Improvement to Groundwater Quality</u>:

Sulfate concentrations in groundwater have shown progressive increases over time in those bores closest to the Heap Leach processing ponds and TSF. However, since August 2014 the TSF has no longer been receiving any operational inputs, and as a result, some groundwater bores located down-hydraulic gradient have shown a steady decrease in $SO_4^{2-}$ concentration. The TSF bores that continue to show improvements in water quality are TSFOB5, TSFOB6, TSFOB7, TSFOB8, TSFOB10 and TSFOB11 (Figure 9). In some cases, $SO_4^{2-}$ concentrations are now below the 1000 $mgL^{-1}$ “Contaminant” limit as specified in the CopperChem EA.

Similar to the effects seen in down-gradient TSF bores, there are general observation bores located down-gradient of the processing ponds that are showing similar trends. For example, $SO_4^{2-}$ concentrations continue to show diminishing trends (since 2014) in groundwater bores OB3, OB4, OB12, OB13 and OB16 a (Figure 9).


**Figure 9: Location of groundwater bores that have shown an apparent decrease in SO42- since 2014**

b) As conveyed in an email to Geraldine Davis (dated 19th February 2015) and during a follow-up telephone discussion, in terms of consistent elevated concentrations of analytes/metals/metalloids exceeding the EA "Release" limit in most groundwater bores, $SO_4^{2-}$ is constant. This is the reason why CopperChem focussed primarily on $SO_4^{2-}$. Given the evidence for "dissolved" Cu, in concentrations exceeding the GAM EA criteria regionally and, in areas on the GAM lease that is considered to be unaffected by mining activities, CopperChem do not believe that the concentrations of dissolved Cu (or Co) represent a threat to biodiversity assets. If the concentration of dissolved Cu in groundwater (locally and regionally) is considered "natural", then, as described in ANZECC (2000), natural systems will undergo assimilative capacity.

As a result of the temporal and spatial variability (i.e. intermittent positive exceedance of EA Trigger criteria) of "Dissolved" metals/metalloids, identified in groundwater as sampled from the bores at GAM, it makes it very difficult to produce contour maps to illustrate this effectively.

## 4.7 Requirement 4 Citation

*Reference is made to requirement 4 of the Notice. CopperChem Ltd has stated that a Groundwater Management Plan will be provided, however, the department does not consider this to adequately address requirement 4.*

- *CopperChem Ltd is required to provide a report outlining remediation options to ensure protection of the environmental values of the receiving environment, including those that were not previously identified under requirement 1.a (sic).*

### 4.7.1 CopperChem Response/ Supplemental Information

Based on the information presented in the RFI report, and in accordance with the "Regulatory Approved" EMP (Amended 2012), CopperChem will continue to apply Control Strategies aimed at protecting groundwater resources and EVs. These Control Strategies are listed under Section 2.2.1 of this RFI and 5.3.5 of the GAM EMP.

For instance, to show that some of the Control Strategies are currently working, and to ensure that any sulfate-rich groundwater (if present) is to be contained onsite, a more rigorous groundwater pump-back strategy commenced in January 2015. For example, groundwater bore OB10 (see Figure ) shows declining groundwater levels (from background (from January 2015 onwards)) as a result of a continuous pump-back strategy in this area of the GAM.

At present there are three groundwater pump back bores currently in operation at GAM, where abstracted groundwater is subsequently stored in a HDPE-lined stormwater pond and re-used during processing operations. Therefore, if contaminated water was being generated onsite, and if it was leaking to groundwater, then it is anticipated that the groundwater pump-back strategy would contain this contaminated water onsite. With reference to the groundwater quality results from down-gradient bores (see Table 4), it is evident that the alleged contamination sourcing from GAM is not present.

With reference to ANZECC Guidelines (2000), specifically in consideration of natural variability[3] of metals/metalloids in the environment, it is stated under Section 2.1.4 (i.e. Water Quality Guidelines), that; "*there is such inherent variability within the environment that 'site-specific' environmental information needs to be used to develop appropriate guidelines and indices of environmental quality*". With regard to this statement, and with reference to the groundwater Trigger and Release Limits established in the GAM EA, it would seem that 'site-specific' water quality criteria were not used to develop these, and as a result "Default" Triggers were adopted.

## 5 References

Australian Groundwater and Environmental Consultants (AGE). 2004. Hydrogeological Regime Environmental Management Overview Strategy- Great Australian Mine. Report prepared on behalf of Tennant Ltd, September 2004.

Australia and New Zealand Guidelines for Fresh and Marine Water Quality, Volume 1. 2000. The Guidelines (Chapters 1-7) October 2000. Australian and New Zealand Environment and Conservation

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Rob Lait and Associates (RLA). 2012. Hydrogeological Assessment of Seepage Related To The Tailings Storage Dam. Report prepared on behalf of CopperChem, October 2012 -Project 220.

Rob Lait and Associates (RLA). 2013. Progress Report On Groundwater Aspects Of The Transitional Environmental Plan – Great Australia Mine. Report prepared on behalf of CopperChem, June 2013 -Project 220.

[3] Reference to CopperChem EA Amendment application dated 7-November 2014 and DEHP Assessment Level Decision 567649, 101/0008742 (dated 20-November 2014)