
SOILWATER CONSULTANTS

Standard Operating Procedure for Groundwater Monitoring

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Revision Code*

- A - Report issued for internal review
- B - Draft report issued for client review
- C - Final report issued to client

LIMITATIONS

The sole purpose of this report and the associated services performed by Soil Water Consultants (SWC) was to prepare a Groundwater Monitoring Standard Operating Procedure (SOP) for the Twin Bonanza Gold Project. This work was conducted in accordance with the Scope of Work presented to ABM Resources ('the Client'). SWC performed the services in a manner consistent with the normal level of care and expertise exercised by members of the earth sciences profession. Subject to the Scope of Work, the Groundwater Monitoring SOP was confined to Twin Bonanza Gold Project Area. No extrapolation of the results and recommendations reported in this study should be made to areas external to this project area. In preparing this study, SWC has relied on relevant published reports and guidelines, and information provided by the Client. All information is presumed accurate and SWC has not attempted to verify the accuracy or completeness of such information. While normal assessments of data reliability have been made, SWC assumes no responsibility or liability for errors in this information. All conclusions and recommendations are the professional opinions of SWC personnel. SWC is not engaged in reporting for the purpose of advertising, sales, promoting or endorsement of any client interests. No warranties, expressed or implied, are made with respect to the data reported or to the findings, observations and conclusions expressed in this report. All data, findings, observations and conclusions are based solely upon site conditions at the time of the investigation and information provided by the Client. This report has been prepared on behalf of and for the exclusive use of the Client, its representatives and advisors. SWC accepts no liability or responsibility for the use of this report by any third party.

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1 INTRODUCTION

1.1 PURPOSE OF THIS DOCUMENT

This document aims to provide standard procedures for trained staff at the Twin Bonanza Gold Project engaged in groundwater sampling. This document is designed to work in conjunction with the Water Management Plan (WMP) to ensure a high standard of monitoring data collection, analysis, and reporting. This document was prepared in accordance with the Northern Territory (NT) Department of Mines and Energy (DME) Advisory Note on the '*Methodology for the Sampling of Ground Waters*', and with reference to the requirements of the *Minerals Titles Act 2010*, the *Mining Management Act 2001*, the appropriate Australian Standards (e.g. AS 5667.1:1998; 5667.4:1998; 5667.6:1998; and 5667.11:1998) and the *Mine Site Water Management Handbook* (Mineral Council of Australia, 1997).

1.2 SCOPE OF THIS DOCUMENT

This document details groundwater monitoring procedures for field staff at the Twin Bonanza Gold Project, from initial preparation for sampling through to field collection and measurement and final data analysis and Quality Assurance / Quality Control (QA/QC). Details of the overall monitoring programme, including the selection of sampling sites and the selection of particular analytes are covered in the Water Management Plan.

1.3 UPDATES TO THIS DOCUMENT

This is designed to be a "living document", and is expected to change as accepted sampling methodology and the site sampling program evolves. More site-specific information may also be incorporated to replace generic descriptions as the operation develops (e.g. a field sampling sheet should be attached in place of the generic information in Section 2.3), and the locations of monitoring points should be updated as they are added or removed.

1.4 OVERVIEW OF THE GROUNDWATER MONITORING PROGRAMME

1.4.1 SAMPLING LOCATIONS

Groundwater monitoring sites have been selected according to the Australian Guidelines for Water Quality Monitoring and Reporting (ARMCANZ, 2000) so that representative samples of the un-impacted (native or control) and potentially impacted groundwater may be collected both in the pre-mine period and throughout the life of mine. The monitoring program has been designed as a "Before-After, Control-Impact" (BACI) program, with priority applied to early detection, and assessment of biodiversity or ecosystem level response.

Because the majority of the proposed disturbance has not occurred, true pre-mine or "background" data may still be collected from the proposed monitoring bores in the period prior to full-scale mining activity. In addition, several continuous control sites (or "analogues") will be established in areas outside of the potential influence of site activities to monitor background levels throughout the life of mine. Therefore, the monitoring program is considered a BACI-style program according to ARMCANZ (2000), (Figure 1). This type of program design allows for the same parameters to be monitored at the control sites and the potentially impacted sites to determine whether or not any observed patterns of behaviour are likely to be due to natural variations or the impacts of site activities.

The proposed groundwater monitoring locations are specified in Table 1 and shown on Figure 2

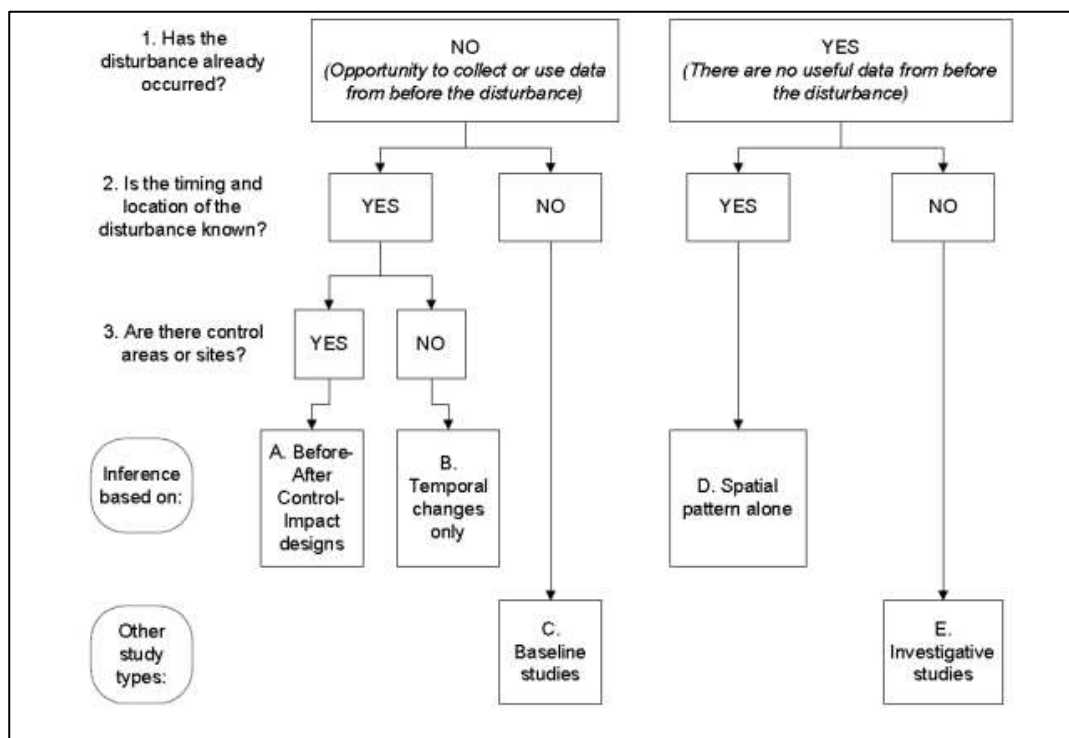


Figure 1: Monitoring program selection (ARMCANZ, 2000)

Table 1: Proposed groundwater monitoring locations

ID	General Location	Easting	Northing	Type	Aquifer
CB	Corsair's Bore	516550	7770180	Production bore	Bedrock
WB	Wilson's Bore	513529	7767170	Production bore	Palaeochannel
TB	Timmy's Bore	509507	7764901	New production bore	Palaeochannel
A01	4.1 km north of site	517374	7772534	Analogue	Bedrock
A02	3.7 km north of site	516995	7772128	Analogue	Palaeochannel
A03	3.7 km northwest of site	514335	7772882	Analogue	Palaeochannel
BF01	1 km up-gradient of TB	509830	7765915	Monitoring bore	Palaeochannel
BF02	200 m up-gradient of TB	509559	7765126	Monitoring bore	Palaeochannel
BF03	200 m adjacent to TB	509726	7764848	Monitoring bore	Palaeochannel
BF04	200 m down-gradient of TB	509444	7764705	Monitoring bore	Palaeochannel
M01	Down-gradient of WRD1	515432	7768610	Monitoring bore	Palaeochannel
M02	Down-gradient of WRD1	515115	7767679	Monitoring bore	Palaeochannel
M03	Down-gradient of TD / WRD2	515115	7766395	Monitoring bore	Palaeochannel
M04	Down-gradient of TD / WRD2	515525	7765687	Monitoring bore	Palaeochannel
M05	Northwest of WRD 1	515417	7768518	Monitoring bore	Bedrock
M06	Southwest of TD	515794	7765681	Monitoring bore	Bedrock
M07	Central to the site	516269	7767033	Monitoring bore	Bedrock
M08	Northeast of pits	516738	7768477	Monitoring bore	Bedrock
M09	Southeast of WRD 2	516951	7766088	Monitoring bore	Bedrock
M10	200 m down-gradient of WB	513277	7767141	Monitoring bore	Palaeochannel

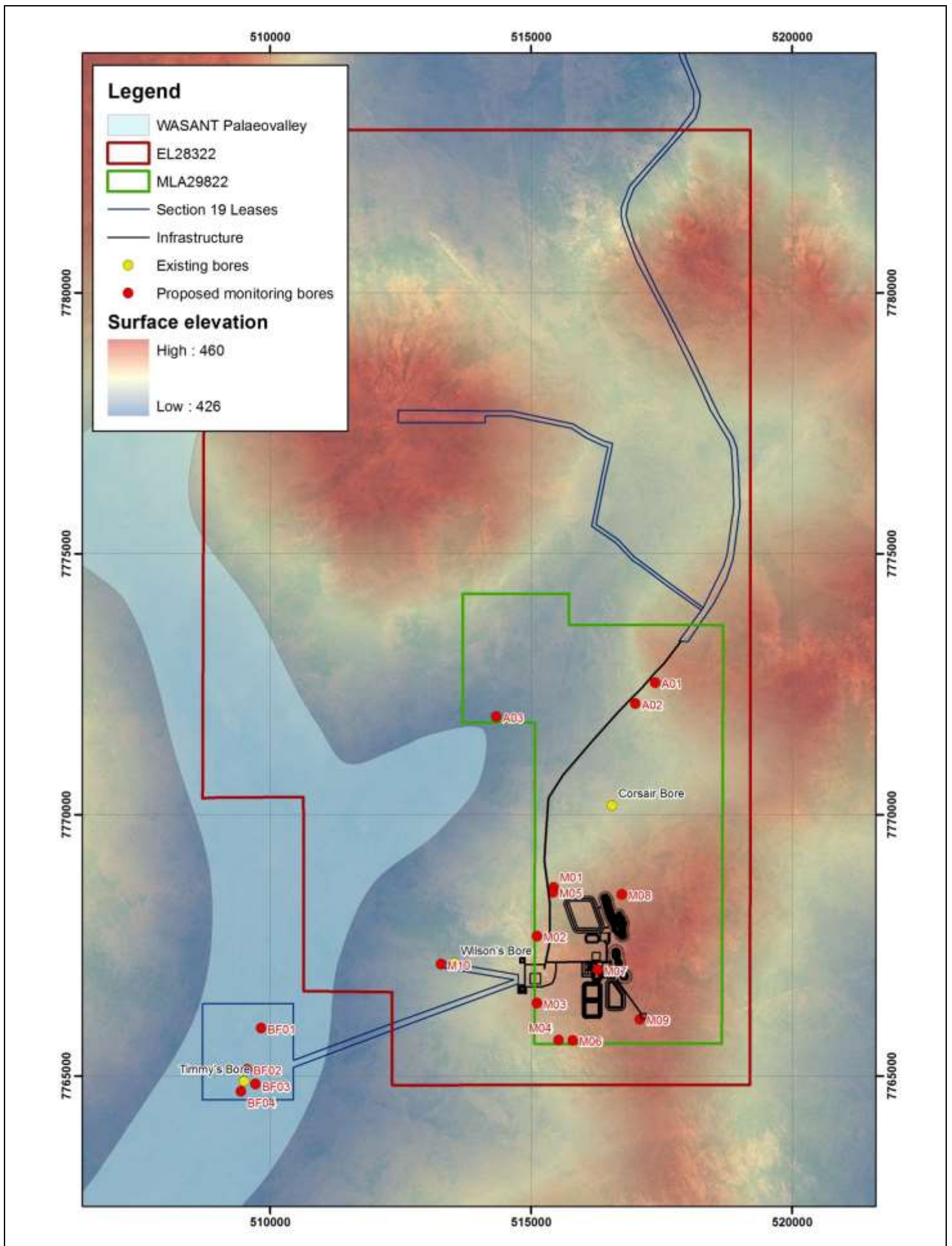


Figure 2: Groundwater monitoring locations

1.4.2 SAMPLING FREQUENCY

In general, groundwater monitoring activities will take place monthly. Groundwater extraction rates and volumes will be recorded automatically and on an ongoing basis by the flow meters; however, this information will be summarised monthly along with the rest of the monitoring data.

1.4.3 PARAMETERS TO BE MEASURED

A standard set of monitoring parameters will be implemented for all monitoring locations (see Table 2). The list of analytes applies to all “production”, “analogue”, and “monitoring” bores described in Table 1, with the exception of BF01 BF04, which will be used primarily for monitoring water levels in the palaeochannel aquifer.

In addition to the chemical analysis, groundwater elevations and extraction rates will also be monitored. Depth to groundwater will be recorded at all “analogue”, and “monitoring” bores described in Table 1, with water depth also being recorded in the “production” bores where practicable. All “production” bores will be fitted with a flow metering device capable of continuous recording of the extracted flow rate and volume.

Table 2: Analytes for groundwater quality monitoring

Parameter	Units	Limit of Detection	Method Reference	Method
Field Parameters				
pH	-	0.01	APHA 4500-H ⁺ B	Electrometry
Electrical Conductivity (EC)	µS/cm	1	APHA 2510 B	Electrode
Temperature	°C	0.1		Electrode
Oxidation-reduction potential (ORP)	mV	1		Photometry
General Parameters				
pH	-	0.01	APHA 4500-H ⁺ B	Electrometry
Electrical Conductivity (EC)	µS/cm	1	APHA 2510 B	Electrode
Total Dissolved Solids (TDS)	mg/L	10	APHA 2540 C	Gravimetry
Alkalinity – Total (as CaCO ₂)	mg/L	1	APHA 2320 B	Titration
Ionic balance	Ratio (mg/L:mg/L)	1 mg/L		ICP-AES
Major Ions & Ligands				
Calcium (Ca ²⁺)	mg/L	1	APHA 3210	ICP-AES
Potassium (K ⁺)	mg/L	1	APHA 3210	ICP-AES
Magnesium (Mg ²⁺)	mg/L	1	APHA 3210	ICP-AES
Sodium (Na ⁺)	mg/L	1	APHA 3210	ICP-AES
Chloride (Cl ⁻)	mg/L	1	APHA 4500-Cl ⁻ B	Titration
Fluoride (F ⁻)	mg/L	0.1	APHA 4500-F ⁻ C	Ion-selective electrode
Sulfur Species				
Sulfate (SO ₄ ⁻²)	mg/L	1	APHA 4500-SO ₄ ⁻² E	Turbidimetry
Nutrients				
Nitrate (NO ₃ ⁻ as N)	mg/L	0.01	APHA 4500-NO ₃ ⁻ I	FIA-Photometry
Ammonia (as N)	mg/L	0.01	APHA 4500-NH ₃ ⁻ H	FIA-Photometry
Reactive Phosphorus as P	mg/L	0.01	APHA 4500 P-G	FIA-Photometry
Phosphorus – Total	mg/L	0.01	APHA 4500 P-H	FIA-Photometry
Total Kjeldahl nitrogen (TKN as N)	mg/L	0.1	APHA 4500-N _{org} D	FIA-Photometry
Chemical Oxygen Demand (COD)	mg/L	5	APHA 5220 B	Titration
Carbon				

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Parameter	Units	Limit of Detection	Method Reference	Method
Total Organic Carbon (TOC)	mg/L	1	APHA 5310 B	IR Spectrometry or titration
Dissolved Organic Carbon (DOC)	mg/L	1	APHA 5310 B	IR Spectrometry or titration
Cyanide				
Free Cyanide (CN ⁻)	mg/L	0.004	APHA 4500-CN- C&N	FIA-Photometry
Weak Acid Dissociable (WAD) Cyanide (CN ⁻)	mg/L	0.004	APHA 4500-CN- I&N	FIA-Photometry
Total Cyanide (CN ⁻)	mg/L	0.004	APHA 4500-CN- C&N	FIA-Photometry
Metals - Dissolved				
Aluminium (Al)	mg/L	0.01	USEPA 6020	ICP-MS
Antimony (Sb)	mg/L	0.001	USEPA 6020	ICP-MS
Arsenic (As)	mg/L	0.001	USEPA 6020	ICP-MS
Boron (B)	mg/L	0.05	USEPA 6020	ICP-MS
Cadmium (Cd)	mg/L	0.0001	USEPA 6020	ICP-MS
Chromium (Cr)	mg/L	0.001	USEPA 6020	ICP-MS
Copper (Cu)	mg/L	0.001	USEPA 6020	ICP-MS
Lead (Pb)	mg/L	0.001	USEPA 6020	ICP-MS
Nickel (Ni)	mg/L	0.001	USEPA 6020	ICP-MS
Manganese (Mn)	mg/L	0.001	USEPA 6020	ICP-MS
Selenium (Se)	mg/L	0.01	USEPA 6020	ICP-MS
Uranium (U)	mg/L	0.001	USEPA 6020	ICP-MS
Vanadium (V)	mg/L	0.01	USEPA 6020	ICP-MS
Zinc (Zn)	mg/L	0.005	USEPA 6020	ICP-MS
Mercury (Hg)	mg/L	0.0001	APHA 3112-Hg B	CV/FIMS
Hydrocarbons				
Total Petroleum Hydrocarbons (TPH) TPH (C6-C9) plus TPH (C10-C36)	µg/L	20	USEPA 5030	P&T/GC/MS
Biological indicators				
E. Coli	cfu/100 mL	1	-	-

2 PREPARATION FOR SAMPLING

Being prepared for a groundwater monitoring event means having the right equipment, sample bottles, safety gear, and a sampling plan in place before setting out. This section outlines standard procedures to ensure that field staff are well-prepared and able to collect high-quality monitoring data.

2.1 EQUIPMENT PREPARATION

Any equipment that will come into contact with water samples (e.g. pumps, bails, scoops) must be appropriately cleaned and decontaminated prior to each sampling round. Sampling equipment should be washed using detergent and tap water, and then rinsed thoroughly with deionised (DI) water. Sampling equipment should be rinsed with DI water again in between collection of each sample. Cleaning and preparation of sample bottles is discussed in Section 2.2.

Field meters (e.g. pH and conductivity meters) must be calibrated according to the manufacturer's instructions at the start of each day of monitoring. Calibration checks should also be performed periodically throughout the day. Calibration should be performed using standards of a known concentration appropriate to the anticipated range of values in the water to be sampled. Calibration standards should be stored appropriately (e.g. keep refrigerated and do not exceed 'use by' dates) to ensure their accuracy. The required volume of standard should always be decanted into a suitable receptacle for calibration purposes and then discarded.

After all equipment is cleaned and calibrated, a field kit with the following items should be prepared to take out on the sampling round

- Field data sheets
- Completed sample labels
- Chain of custody forms
- Sampling pump and tubing
- Flow-through container
- Sample bottles for dispatch to laboratory (as detailed in Section 2.2)
- Filtration equipment and syringe (if necessary)
- Field parameter meters or test kits (e.g. alkalinity/acidity test kit)
- Groundwater level probe
- Powder-less nitrile gloves
- Esky and ice packs for preserving samples
- If required, appropriate preservative (e.g. nitric acid)
- Personal Protective Equipment (PPE), first aid, and communication equipment

A list of all equipment to be taken into the field is provided in Attachment 1.

2.2 SAMPLE BOTTLE PREPARATION

The chemical elements of interest dictate the type of bottle to be used for sampling (e.g. glass or plastic), and the method of preservation required (e.g. filtered, acid preserved, frozen). It is best to contact the analysing laboratory to determine preservation requirements prior to undertaking sampling, and to have sufficient pre-prepared sample bottles despatched to site.

2.2.1 NUMBER OF BOTTLES REQUIRED

Colour coded bottles are provided to make it easier for people to differentiate them. The colour coding scheme is summarised in Table 3. The number of bottles required for a standard sampling event is summarised in Table 4

Table 3. Sample bottle colour coding scheme

Test Parameter	Label Colour	Container Type (Preservation)
Alkalinity, EC, pH, Cations, Chloride, Sulphate, Fluoride, TDS, Acidity	Green	1 x 500mL plastic (none)
Total Phosphorus	Purple	1 x 125mL plastic (Sulfuric acid)
DOC (Field Filtered)	Purple*	1 x 40mL Amber vials (Sulfuric acid)
TOC	Purple*	1 x 40mL Amber vials (Sulfuric acid)
Dissolved Heavy Metals (Field Filtered)	Red & Green Stripe	1 x 60mL plastic (none) AIRFREIGHT OPTION
TPH(C6-C9)	Purple*	2 x 40mL Amber vials (Sulfuric Acid)
TPH (C10-C36)	Orange*	1 x 100mL Amber glass (none) for primary analysis.

Note: * These samples are for organics, and are supplied with Teflon lids

Table 4: Number of bottles required for normal sampling round

Bottle	Number required per sampling round
Green	TBD
Purple	TBD
Purple *	TBD
Orange *	TBD
Red & Green Stripe	TBD

Note: * These samples are for organics, and are supplied with Teflon lids

2.2.2 FIELD AND TRANSPORT BLANKS

In addition to the bottles required for sampling, one field blank and one transport blank are required for sampling every 6 months per analyte per day of sampling (i.e. one blank for metals, one for sulfate, etc.). Field and transport blanks are required as part of the QA/QC of the sampling programme (see Section 5). A field blank is used to estimate contamination of a sample during the collection procedure, and transport blank is used to estimate the contamination introduced during transport of the sample bottles to and from the field.

To obtain both a field and transport blank, the following procedure should be followed:

1. In the site laboratory, divide a water sample of appropriate quality into two parts.

2. Retain portion A at the site laboratory and transport portion B to the sampling site.
3. Divide portion B into two parts:
 - a. portion B1 is used as a field blank, and
 - b. portion B2 is used as a transport blank.
4. Process portion B1 using the same procedures used for sampling (e.g. pour it into the sample bottles using same sampling pump or scoops used for collection of the actual samples)
5. Return portions B1 and B2 to the laboratory using the same preservation and transport methods as the monitoring samples.
6. Portions A, B1 (field blank), and B2 (transport blank) can be analysed and results compared.

2.2.3 REPLICATE SAMPLES

Replication is the collection and analysis of more than one sample from the same location at the same time. This provides the experimental sampling error and thus a measure of the sampling precision. One replicate sample should be collected every 6 months per analyte, per sampling period.

2.2.4 BOTTLE WASHING

In the event that pre-preserved bottles cannot be obtained from the analysing laboratory the following guidelines may be followed.

All sample bottles must be washed prior to use. Unless otherwise prescribed, it is sufficient to wash both plastic and glass bottles using a standard detergent, according to the following procedure:

1. Wash container and cap with detergent and tap water.
2. Rinse thoroughly with tap water.
3. Rinse twice with DI water.
4. Drain thoroughly and replace cap.

For bottles requiring a solvent wash, use the following procedure:

1. Wash container and cap with detergent and tap water.
2. Rinse thoroughly with tap water.
3. Rinse twice with DI water and dry.
4. Rinse with acetone of an appropriate quality and drain
5. Rinse with a suitable solvent of an appropriate quality, dry and immediately replace cap.

NOTE: The solvent should be compatible with the analytes of interest and the analytical method to be used.

WARNING: Organic solvents may be hazardous. Provide suitable handling facilities and handle with care.

For bottles requiring acid-washing, use the following procedure:

1. Wash container and cap with detergent and tap water.
2. Rinse thoroughly with tap water.
3. Rinse with 10 % nitric acid.
4. Drain and fill with 10 % nitric acid.
5. Cap and store for at least a week.

6. Empty, rinse with DI water and immediately replace cap.

2.3 FIELD SHEETS

Field sheets should be used to record any details relevant to the subsequent analysis and interpretation of the results. This should include all the information necessary to assist in data interpretation and repeatability of sampling efforts, and should include:

- Location (and name) of monitoring bore or piezometer, with coordinates
- Details of bore, eg depth, screened interval, casing condition
- Date and time of sample collection
- Sampler name (or initials)
- Standing water levels
- Volume of water purged from bore or duration and rate of pumping prior to sampling
- Any relevant descriptive information (e.g. water level)
- Sample appearance at the time of collection (e.g. colour, clarity, odour)
- Field parameters measured, or results of any on site analysis (e.g. alkalinity).
- Sample treatment post collection (e.g. filtration, acidification)

An example of a field sheet is provided in Attachment 2.

2.4 HEALTH AND SAFETY CONSIDERATIONS

A risk assessment should be conducted prior to each sampling event to identify hazards and implement appropriate controls to reduce risks to safety and the environment. General guidance on safety matters is provided in the site Health and Safety Plan.

The following safety aspects should be considered when conducting any groundwater monitoring activities:

- The surface area around wells and boreholes should always be regarded with some caution since there may be a risk of surface collapse, especially around old wells.
- Suitable protective clothing must always be worn when undertaking sampling operations, and under no circumstances should any routine sampling activity continue if safety checks indicate that potentially unsafe conditions exist.
- When dealing with groundwater installations that are potentially contaminated, it is important to carefully consider and define the nature of the necessary safety checks.

A generic Job Safety Analysis (JSA) form is provided in Attachment 4.

3 FIELD MEASUREMENTS

In order for field measurements to be representative of the aquifer, samples withdrawn from the bore must reflect the spatial and temporal variation present in the aquifer. Standing water within a bore is often not representative of the water in the aquifer because it is exposed to atmospheric conditions and can undergo changes to its physical and chemical characteristics over time. Boreholes should therefore be purged before sampling by pumping 'to waste' a volume of water equivalent to at least 4 to 6 times the internal volume of the borehole (AS/NZS 5667.11-1998).

It is important that as many parameters as practicable are determined in the field, or as soon as possible after the sample has been collected. This is particularly important for physical parameters such as pH, electrical conductivity, dissolved oxygen and Eh (Redox). To accurately determine these parameters a continuous measurement technique, such as a flow through cell system, which minimises contact between the sample and the atmosphere, should be employed. The use of such a flow through cell system will also assist in the determination of stable chemistry prior to sample collection.

3.1 MEASURING STATIC WATER LEVEL

The depth to groundwater should be measured relative to an established reference point on the well casing and should be documented in the field records. This reference point is usually identified by the well installer using a permanent marker for PVC wells, or by notching the top of casing with a chisel for stainless steel wells. By convention, this marking is usually placed on the north side of the top of casing. If no mark is apparent, the person performing the measurements should take the water level reading from the north side of the top of casing and note this procedure on the recording sheet.

To properly measure the groundwater level in a monitoring bore:

- Decontaminate the measuring instrument (e.g. dipper tape) before lowering it into the well
- Remove the well cap and allow several minutes for the pressure in the well to equalise (this is a good time to set up the bore purging and sampling equipment)
- Lower the tape into the well until it indicates contact with the water surface.
- Move the tape up and down slowly several times in and out of the water to ensure the measurement is made at the precise top of the water surface
- Record the depth to water by reading the tape at the point where it meets the top of the bore casing (record to the nearest millimetre)

Static water level readings are possible in production bores only if the pumping equipment has been switched off for a sufficient length of time to allow full recovery of the groundwater table (this can take several days). An access tube is generally also required to allow clear passage of the water level probe past the pumping equipment.

3.2 BORE PURGING

If required, bore purging is completed by lowering a pump into the borehole to extract a volume of water sufficient to determine representative ground water chemistry. To properly purge a bore:

- Measure the depth to water in the well
- Calculate the total depth of water in the well (h) by:

$$h = [\text{total well depth}] - [\text{depth to water}]$$

- Calculate the well volume (in litres) by:

$$V = (D \div 2)^2 * h * 0.00314$$

Where V = well volume (L), D = well diameter (cm), and h = depth of the water column (m)

- Install pump in the well, ideally so that it abstracts water from near the top of the water column.
- Place pump outlet in a flow-through vessel.
- Purge 4 well volumes, using a low flow rate (ideally matched to the recharge rate so minimal drawdown occurs).
- Measure Temperature, pH, and electrical conductivity (EC) in the flow-through vessel as stabilisation indicators.
- If the values are stable for 3 consecutive readings (Temp $\pm 0.2^\circ\text{C}$, pH $\pm 10\%$, EC $\pm 10\%$), then measurements can be recorded, as per Section 3.3.
- If readings do not stabilise after 6 well volumes, then measurements can be recorded, as per Section 3.3.

Notes:

A variable pump rate can be employed to match extraction rates with borehole recharge rates and expedite the collection process. It is not recommended to use an air lift pump as the introduction of dissolved oxygen to the ground water will alter the sample.

Some bores will have a very slow recovery rate and may purge dry during sampling. If this occurs, make a note on the field sheet, and then allow it to recover overnight and come back and sample it directly the next day. Samples obtained in this manner are often highly turbid due to disturbance of sediment in the bore column, and the results from these samples should be interpreted with this in mind.

3.3 MEASURING FIELD PARAMETERS

Once the bore has been purged and the indicator readings have stabilised, field measurements can be recorded by placing the instruments directly in the flow-through vessel. The following should be recorded for each monitoring bore:

- pH
- Electrical conductivity (EC)
- Temperature
- Oxidation-reduction potential (ORP)

There is no need to stir the water with the instruments, as the water is already moving across the sensors as it flows through the vessel. However, instruments should be hand held, or otherwise installed in the vessel so that the sensing instruments are not in contact with the sides or bottom of the container. All readings should be stable ($\pm 10\%$) prior to recording.

If the meter is not compatible with the flow-through vessel, the outlet hose can be removed from the flow-through vessel to fill an appropriate container for immediate analysis.

3.4 MEASUREMENTS FROM PRODUCTION WELLS

There is no need to purge an operational production well prior to sampling because it is essentially being continuously purged under normal operating conditions. Field measurements may be made in a similar manner described in Section 3.3 by attaching a hose to the closest water spigot to the bore, and by setting up a flow-through vessel from this hose.

All readings should be stable ($\pm 10\%$) prior to recording.

4 COLLECTING SAMPLES FOR LABORATORY ANALYSIS

4.1 BORE PURGING

Bore purging should have already been completed according to the method described in Section 3.2. Collection of samples for laboratory analysis can proceed after the field parameters have been deemed stable.

4.2 SAMPLE COLLECTION

4.2.1 MONITORING BORES AND PIEZOMETERS

To collect a sample, use the overflow from the flow-through vessel, or the pump outlet hose, to fill the required sample bottles. If the bottles were not prepared with preservative in the laboratory, use the following method:

- Ensure that labelling on the bottle to be filled is correct and that the sample number matches the number on the paperwork.
- Perform any necessary filtration and/or preservation procedures, and fill the sample bottles. Note: ALS sample bottles contain preservatives and therefore should not be rinsed.
- Fill sample bottle with bore water.

If the sample bottles already contain preservatives (i.e. acid solutions), then the bottles should not be rinsed in the field, and can be filled directly from the overflow of the flow-through vessel or the pump outlet. All containers should be filled completely, to exclude air from the sample.

4.2.2 OPERATIONAL PRODUCTION BORES

To collect a sample, use the spigot or flow-through vessel described in Section 3.4 to fill the required sample bottles as per the method described in Section 4.2.1. The spigot and any attached tubing should be purged for a minimum of 60 seconds (but probably much longer, given the parameter stabilisation steps described in Section 3.4) prior to sampling.

4.3 FIELD FILTRATION

There are two main methods employed in the field filtration of water samples: pressure systems employing syringe, or gravitational pressure and vacuum filtration systems.

The standard procedure for syringe filtration is as follows:

- Draw an aliquot of the sample into the syringe from the flow-through vessel taking care to maintain an air gap between the base of the plunger and the sample to minimise contact and potential contamination.
- Dispense aliquot to waste to rinse syringe. Repeat.
- Draw an aliquot of the sample into the syringe taking care to maintain an air gap between the base of the plunger and the sample to minimise contact and potential contamination.
- Affix appropriate filter unit to syringe (between 0.4 and 0.5 μm) and dispense into laboratory sample container.
- Add any preservative to be used, re-seal laboratory sample container, and invert to mix thoroughly.

When using vacuum filtration, the pressure difference across the filter material is supplied via the application of a vacuum between the collected sample and the laboratory sample container. The standard procedure for vacuum filtration is as follows:

- Thoroughly clean filtration unit employing a method appropriate for the analyte of interest. For example, a filtration unit that is to be used for the collection of samples for metals analysis should be rinsed using a solution of 10% Hydrochloric acid followed by water of appropriate quality.
- Agitate sample bottle to thoroughly mix sample.
- Rinse the filter unit with the water to be sampled.
- Assemble filter unit taking care to not touch filter unit components that will be in contact with the sample or introduce small tears to the filter membrane.
- Apply vacuum
- Collect sample and distribute to laboratory sample bottles.
- Add any preservative to be used, re-seal laboratory sample container, and invert to mix thoroughly.

4.4 STORAGE AND TRANSPORT

Samples should be stored according to the preservation procedures summarised from AS/NZS 5667.1:1998 (or **Error! eference source not found.**). Generally, samples are stored on ice (or ice-bricks) in an esky for transport to the laboratory. However, depending on holding times and how long it will take you to get your samples to the lab, you may need to freeze some of them (note that some samples should never be frozen). The appropriate method and period of storage is dependent on the analyte of interest and must be adhered to so that representative results from analysis are obtained.

While sample preservation will limit degradation, dispatch to the laboratory should occur as soon as practicable.

The specific procedure for transporting samples is outlined as follows:

- Take the esky and wrap it in the bubble wrap provided, ensuring that all the sample details are complete. Double check to ensure you have ticked the right boxes on the Red / Green and two of the Purple bottles.
- Take the sample back to the camp, and place the esky in the fridge or in the cold room. Hopefully you will have found some form of ice brick for transport.
- Fill in the Chain of Custody Form (see Attachment 3). As well as being the Sample Submission Form, this is a way of tracking who has been responsible for the sample. The person travelling with the sample should typically sign on in the initial position.
- If you are using the small foam esky use some tape to hold the lid on strongly, and make sure the Fragile sticker is in an obvious position.
- Remember to remove the sample from the fridge and take it with you to the sample drop off point of flight, along with the Chain of Custody form.

5 DATA INTERPRETATION AND REPORTING

5.1 OBLIGATIONS

The obligation of an operator of a mining site in the Northern Territory is stipulated in the Mining Management Act Part 3, Division 1 s 16 (2) as:

...ensuring that the environmental impact of mining activities is limited to what is necessary for the establishment, operation and closure of the site. Further, the operator must establish, implement and maintain an appropriate environment protection management system and ensure by regular assessment of that system that it operates effectively. This can be adequately demonstrated by the regular submission of a report detailing the analysis and interpretation of monitoring data, and comparison with background or pre operation data.

5.2 INTERPRETATION OF RESULTS

Water quality data should be analysed and interpreted on an ongoing basis to identify potential impacts and/or assess the status of existing known impacts. Groundwater quality data are to be reviewed monthly, as they are obtained from the field or laboratory. These should be compared with all previous data to assess trends.

The monitoring program has been designed according to the *Australian Guidelines for Water Quality Monitoring and Reporting* (ARMCANZ, 2000) as a "Before-After, Control-Impact" (BACI) program (Figure 3 and Figure 4), with priority applied to early detection, and assessment of biodiversity or ecosystem level response. In order to determine if site activities are affecting the groundwater quality, the pre-disturbance, or "background", groundwater quality must first be known. It is anticipated that the first 6-12 months' worth of data collected from the "monitoring" and "analogue" bores will initially be used to set background levels, and this will be analysed and updated according to the *Australian Guidelines for Water Quality Monitoring and Reporting* (ARMCANZ, 2000) to develop a 24 month running average as further data is collected in subsequent sampling events. During site operation, the "analogue" bores will be used to track natural fluctuations in the background levels in both the bedrock and palaeochannel aquifer systems (i.e. a BACI analysis).

Once enough background data has been collected, trigger levels will be set according to appropriate statistical procedures, as outlined in ARMCANZ (2000). To allow for a high level of certainty that a trigger level has been exceeded, a value greater than the trigger level must be detected for three consecutive readings prior to initiating a response (e.g. arsenic detected at an elevated level in monitoring bore M05 for three consecutive months).

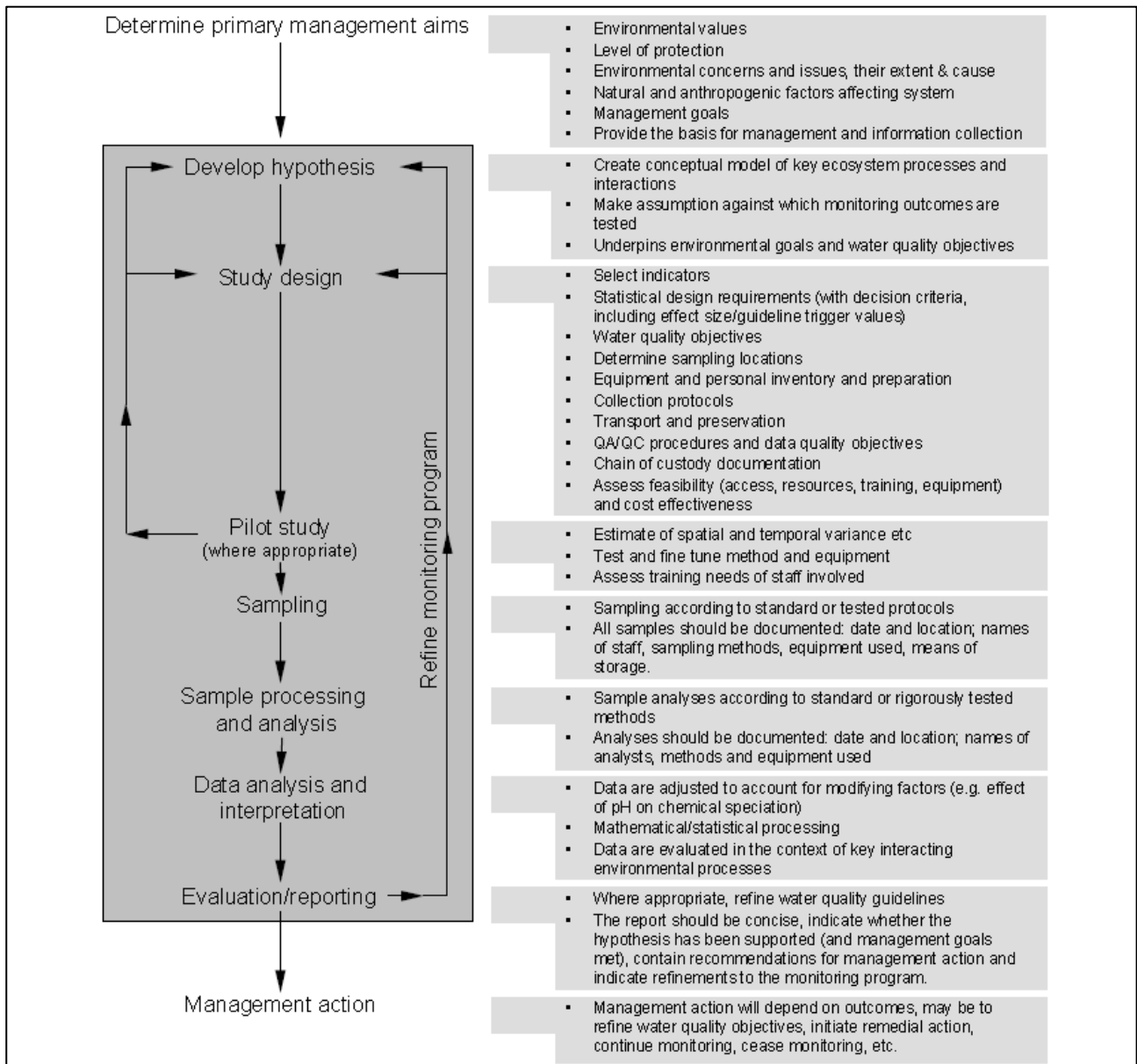


Figure 3. Procedural framework for the monitoring and assessment of water quality (ANZECC & ARMCANZ 2000)

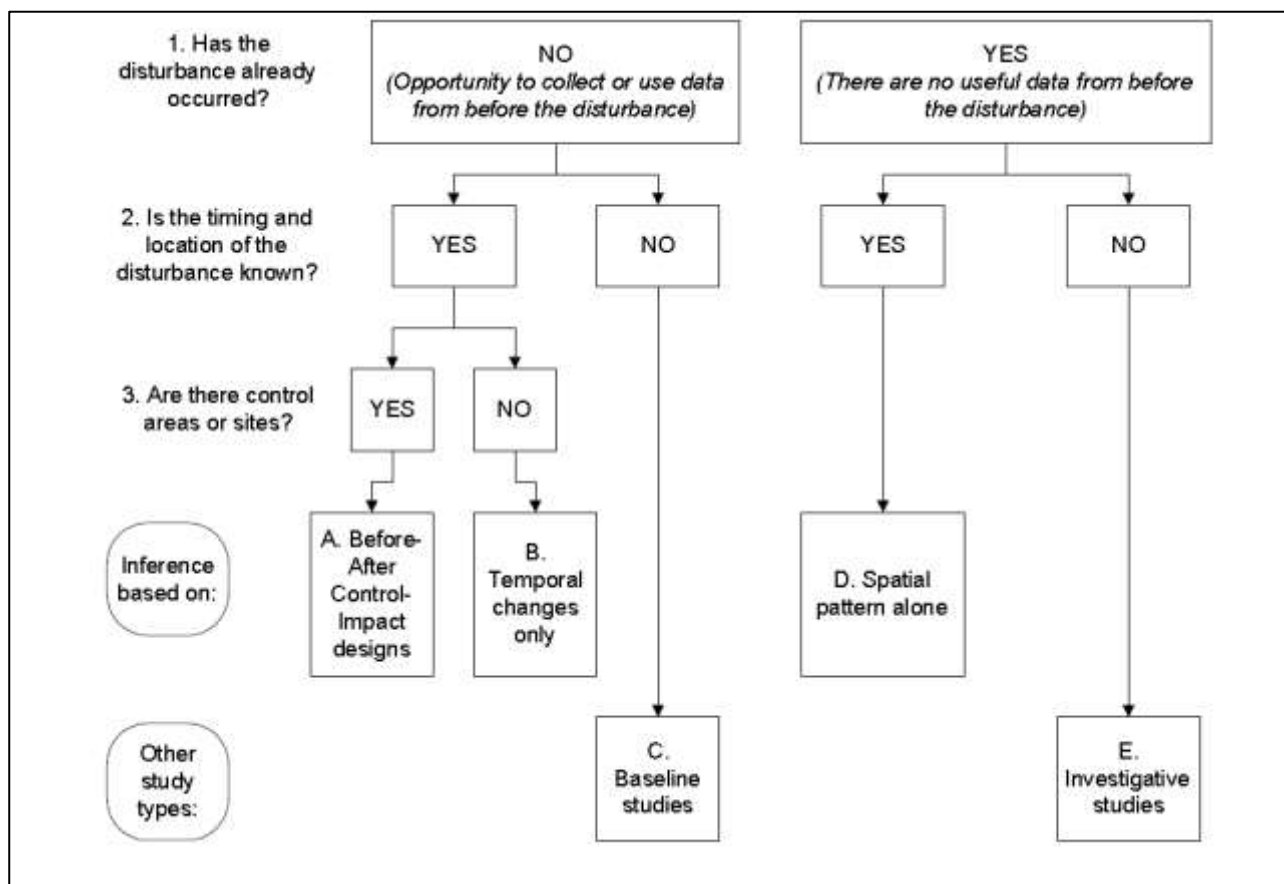


Figure 4. Monitoring program selection (ARMCANZ 2000).

5.3 QUALITY ASSURANCE / QUALITY CONTROL

The collection of field and transport blanks (see Section 2.2.1) enables the identification of any deficiencies in the methodology employed in sample collection or any further training required by the environmental officers collecting the sample. Sample blanks that return greater than anticipated values for analytes may indicate exposure to atmospheric contaminants or introduction of contaminants to the sample by the operator during collection and treatment of the sample.

Replicate samples should return results within a determined acceptable relative percentage difference. This acceptable difference between results can be determined using the detection limits of the analytical procedure employed by the testing laboratory. For example, Replicate samples that return a large relative percentage difference ($\geq 20\%$) for high concentrations of analytes when compared with the detection limits are potentially indicative of a problem with sampling methodology and warrant further investigation and/or training. The converse is true when samples return a large relative percentage difference for low concentrations of analytes that are close to the detection limits of the analytical procedures employed. In these situations the large relative percentage difference is less indicative of potential methodological problems but does warrant further scrutiny with future sampling efforts. To calculate relative percentage difference:

$$RPD = \left[(C_1 - C_2) \div \frac{(C_1 + C_2)}{2} \right] \times 100$$

Where C1 = Concentration of analyte in sample 1 and C2 = Concentration of analyte in sample 2.

5.4 REPORTING

Groundwater monitoring data should be recorded monthly, and reported annually in the *Mining Management Plan* (MMP) in accordance with the *Mining Management Act 2001*. Reporting to regulatory authorities (through the MMP) and stakeholders at the appropriate level of detail is important to demonstrate the effective implementation of an environmental management system on site. The MMP will incorporate an annual water quality report, summarising the water quality data for the previous period, and discussing the implications for the continued management of the site and the potential risks to the environment. This report will include:

- Graphs summarizing water quality data
- Where applicable graphs should indicate:
 - site specific trigger values
 - “total” and “filtered” sample analysis results
- An interpretation and discussion of this data including:
 - identification of any issues (e.g. degrading water quality in a specific site/area);
 - actual and / or potential causes of issues and
 - conclusions drawn from the results.
- Details of any incidents affecting water quality;
- Details of actions taken to address any water quality issues;
- Commitments to specific areas for improvement in the next reporting period
- A list of water quality reporting requirements for wastewater discharge licence purposes if applicable (e.g. bi-monthly reporting due dates, annual report due date etc.).

All the raw data for the previous reporting period is to be presented as appendices to Part B (confidential section) of the MMP.

6 REFERENCES

- ANZECC and ARMCANZ (2000) Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Environment Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand. Canberra, ACT.
- ARMCANZ, A. a. (2000) Australian Guidelines for Water Quality Monitoring and Reporting. In National Water Quality Management Strategy. October. Canberra, ACT. Minerals Council of Australia (1997). Minesite Water Management Handbook. Minerals Council of Australia. Earth Systems (2013): Preliminary groundwater resources assessment for the Old Pirate Gold Project, Tanami Desert, Northern Territory. Prepared for ABM Resources NL by Earth Systems.
- Minerals Council of Australia (1997). Minesite Water Management Handbook. Minerals Council of Australia.
- Northern Territory Department of Mines and Energy (2009): Methodology for the sampling of ground waters. Advisory Note #: AA7-024.
- Standards Australia 1998a, AS/NZS 5667.1:1998: Water quality – sampling. Part 1: Guidance on the design of sampling programs, sampling techniques and the preservation and handling of samples. Standards Australia, New South Wales.
- Standards Australia 1998b, AS/NZS 5667.11:1998: Water quality – Sampling. Part 11: Guidance on sampling of groundwaters. Standards Australia, New South Wales.

7 ATTACHMENTS

Attachment 1: Field sampling equipment list

ALS Sampling Pack


















- Foam Esky
- Security Labels
- 1 x 500mL plastic (*none*) (green)
- 1 x 125mL plastic (*Sulfuric acid*) (purple)
- 1 x **40mL Amber vials** (*Sulfuric acid*) (purple)
- 1 x **40mL** Amber vials (*Sulfuric acid*) (purple)
- 1 x **60mL** plastic (*none*) (red and green stripe)
- 2 x **40mL** Amber vials (*Sulfuric Acid*) (purple)
- 1 x **100mL** Amber glass (*none*) for primary analysis (orange)
- Syringes
- Filters

Field Gear

- Calibrated probe for measurement of *in situ* parameters (whatever you need or have available to you, e.g. Minisonde, Hydrolab, Quanta or WTW instruments), probe cover, protection cap, surveyor.
- Field filtering gear (e.g. hand pump, filter tower, filter papers and tweezers) if required.
- Laboratory deionised (DI) water for field blanks (and quality control samples) if required.
- Deionised water in a spray bottle for cleaning filter tower (and spare deionised water for refills).
- Sampling pump and tubing
- Flow-through container
- Groundwater level probe
- Tap water for filling the probe protection cap and drinking water – in separate bottles.
- Bucket for measurement probes/surveyor.
- A copy of the sampling and analysis plan (SAP).
- A copy of the safety plan (includes emergency numbers and routes to nearest hospitals).
- Chain of custody (COC) forms.
- Field observation forms (FOF).
- Plastic lunch bag for COC/FOF to go into in eskies.
- Courier (or laboratory) information (where do you drop the samples off? e.g. road or air freight couriers; the office address; information to attach to esky with samples to ensure that they are couriered correctly and arrive at the laboratory).
- Eskies with ice bricks – make sure you have enough!
- Extendable grab pole sampler.
- Masking tape (always useful).
- Nitrile gloves, gumboots, waders, coveralls, safety glasses, sunscreen, hat, and any other personal protective equipment (PPE)
- Map of sites.
- A GPS, if sampling at a new site.
- Permanent marker and pens.
- Extra labels.

- Extra sample containers.
- Spare bucket to carry bottles to and from vehicle

Attachment 4: Field sampling health and safety forms

		<h2 style="margin: 0;">JOB SAFETY ANALYSIS</h2>													
JSA Number :		Supervisor:		Date of issue:		Time of issue:									
JSA Team		Scribe:													
		Facilitator:													
Description of Work/Task:				Work Location:											
Qualifications & Training Requirements:				Tools, Equipment & Substances Required:											
Isolation Requirements: <i>(Please List)</i>															
PERSONAL PROTECTIVE EQUIPMENT - Place a cross in the box of the PPE required to do the task															
 <input type="checkbox"/>	 <input type="checkbox"/>	 <input type="checkbox"/>	 <input type="checkbox"/>	 <input type="checkbox"/>	 <input type="checkbox"/>	 <input type="checkbox"/>	 <input type="checkbox"/>	 <input type="checkbox"/>	 <input type="checkbox"/>	 <input type="checkbox"/>	 <input type="checkbox"/>	 <input type="checkbox"/>	 <input type="checkbox"/>	 <input type="checkbox"/>	 <input type="checkbox"/>
WORK PERMITS REQUIRED - Place a cross in the box of the required permit															
Confined Space Entry		Work Box	HV Electrical Permit	Excavation / Penetration	Floor Roof Wall Opening	O/Side Vessel – Platform	Other								
Live Electrical Work		Non Standard Lift	ATWP Permit	Hot Work	Work at Height	Power Vicinity / Corridor Access	Other								
JOB SPECIFIC RESOURCES – Place a cross in the box of resources required															
Barricading		Sentry & Sentry Board	Fire Blankets	Phones	Other										
Drinking Water		Running Water	Voltage Reducer	Extinguishers	Other										
Warning Signs		Fire Watch	Radio	First Aid Kit											
Step No	Job Step <small>(Break the job into logical stages)</small>	Existing & Potential Hazards <small>(associated with this step)</small>	Initial Risk	Control Measures <small>(implemented to reduce the level of risk to acceptable levels)</small>	Residual Risk	Controls in place prior to commencement of task									



JOB SAFETY ANALYSIS

						Whom responsible	Initial



JOB SAFETY ANALYSIS

Step No	Job Step (Break the job into logical stages)	Existing & Potential Hazards (associated with this step)	Initial Risk	Control Measures (implemented to reduce the level of risk to acceptable levels)	Residual Risk	Controls in place prior to commencement of task	
						Whom responsible	Initial



JOB SAFETY ANALYSIS



Sign Off By Persons Conducting the Work:

Name	Signature	Position	Signature	Name	Position

Authorised By:

Name	Signature	Position	Signature	Name	Position

Situations to consider

Work Environment	Human Factors	Skills required	Can anyone be:
Illumination/ Lighting	Pace, stamina	Truck operator	Crushed, sheered or cut
Noise	Complexity	Machine operator	Injured by ejected objects or substances under pressure – compressed air or hydraulic fluid
Temperature / Humidity	Familiarity, Job knowledge, Repetition	Boiler maker / Mechanic	Electrocuted
Vibration	Concentration, Alertness	Dogman	Slip or trip or fall
Dust	Resources available to do the job	Crane driver	Fall from heights - unprotected edges, brittle surfaces, fall from ladder
Space available	Manual handling	Forklift operator	Strain from pulling, pushing, lifting
Tools, Equipment	Time	Engineer	Exposure to a substance - inhalation, ingestion, skin or eye exposure
Facilities to be used	Existing Work Instructions	Electrician	Exposed to excessive noise, heat or cold
	Supervision	Observer/Spotter	Risk of fire, explosion or major spill



JOB SAFETY ANALYSIS

Risk Calculator – use this methodology for both initial and residual risk

Step 1 – Consider the consequences

What are the consequences of this incident occurring? Consider what could reasonably have happened as well as what actually happened. Look at the descriptions and choose the most suitable Consequence

Step 2 – Consider the likelihood

What is the likelihood of the consequences identified in step 1 happening? Consider this without new or interim controls in place. Look at the description and choose the most suitable Likelihood.

Step 3 – Calculate the risk

1. Take Step 1 rating and select the correct column
2. Take Step 2 rating and select the correct line.
3. Circle the risk score where the two ratings cross on the matrix:

Hierarchy of control

Elimination	Eliminate the risk altogether. <i>eg. stop the activity altogether.</i>
Substitution	Substitute a hazardous item with a safer alternative. <i>eg. use water based chemicals rather than solvent based chemicals</i>
Isolation / Engineering	Isolate the hazard from workers and/or install equipment to counteract the hazard. <i>eg. Install machine guarding, mechanical lifting aids, exhaust ventilation.</i>
Administrative	Procedures and work practices to control the hazard. <i>eg. Training / Procedures / Job rotation for repetitive tasks.</i>
PPE	Specialised clothing to protect workers from the hazard. <i>eg. ear plugs / safety glasses / gloves / high-visibility clothing.</i>



JOB SAFETY ANALYSIS

Risk Matrix

CONSEQUENCE		Insignificant	Minor	Moderate	Major	Catastrophic
LIKELIHOOD	Almost Certain	11	16	20	23	25
	Likely	7	12	17	21	24
	Possible	4	9	13	18	22
	Unlikely	2	5	10	14	19
	Rare	1	3	6	8	15
SEVERITY RANKING		RESPONSE				
Extreme		Immediately stop the job				
High		Immediate risk controls required, including instruction and training to exposed persons				
Medium		Risk controls required as soon as possible				
Low		Maintain Risk Awareness – introduce additional controls if practicable				

CONSEQUENCE	PRIMARY INCIDENT TYPE			
	INJURY, ILLNESS, DISEASE	SYSTEM OR PROCESS FAILURE	ENVIRONMENTAL EFFECTS	PROPERTY DAMAGE
INSIGNIFICANT	Low-level short-term subjective inconvenience or symptoms. No measurable physical effects. No medical treatment.	Immediate corrective action. No loss of production. No damage to equipment	No lasting detrimental impacts. Little impact on environment. Minor repairable damage. Minor infringement of cultural values.	> \$1,000
MINOR	Any one-time treatment & any follow-up visit for observation	Minor damage to equipment and/or facility. No loss of production.	Short-term impact with no lasting detrimental effects. Minor permanent disturbance or damage to significant structures or sites.	> \$10,000
MODERATE	Any work injury/illness incurred which results in a modified or alternate work program being established. No lost time.	Serious service deficit. Moderate damage to equipment and/or facility. Loss of production < one day	Significant general impact or damage. Significant impact on environment. Moderate permanent damage to significant structures or sites.	> \$100,000
MAJOR	Any incident where the employee is affected to such an extent that they are required to take time off from work.	Potential loss of business. Major system failure. Loss of production < one week	Widespread impact. Destruction with long-term effects to environment, endangered species, flora and fauna. Significant damage to structures, sites or items of cultural significance.	> \$1,000,000
CATASTROPHIC	Fatality and/or severe irreversible disability or impairment(>90%)	Loss or major client due to service deficit. Urgent corrective or remedial action. Loss of production >one week.	Extensive long-term detrimental impacts on the environment, community, public health. Total destruction of highly valued structures, sites or items of cultural significance or sacred value.	>\$10,000,000

Rating/Level	Measure – What is the likelihood of the hazard resulting in an incident?
Almost Certain	The event will occur more than once per year
Likely	The event will occur once every 3 years
Possible	The event will occur once every 10 years
Unlikely	The event does occur somewhere from time to time.
Rare	Have heard of the event occurring elsewhere