Fact Sheet 3

Identification and Characterisation of Materials

This fact sheet provides information to explorers about data and test work which can assist with determining if PAF is present in the host geology. The presence of PAF in the local geology can significantly affect overall profitability of an operation once the resource is proven. Initial efforts should be focused on identifying if PAF is present in the local geological setting and how much risk the PAF and AMD will pose to the profitability of the future operation.

Explorers should consider:

- Local geological setting;
- Waste domain mapping;
- Test work required to indicate AMD presence;
- Baseline water quality;
- Planning test work as development progresses; and
- AMD risk assessment.

Explorers should ensure that enough sampling is conducted and that samples are spatially distributed so that a reasonable understanding of the AMD risk is understood before the project progresses into the feasibility and construction phases.

Data Mining

Data mining can provide useful background information on a prospective area without committing a significant amount of funding to a project. Mineral Resources Tasmania (MRT) provides the public with many resources, available free of charge, on the MRT website. This data is intended to be a resource to complement data captured on site. Data is accompanied by metadata, which identifies the accuracy of the data. This accuracy information should be considered when using the data for resource estimation.

Past Exploration Reports

Past exploration reports become 'open file' once exploration is complete and the licence has expired, or after a period of 5 years after a report is published, whichever is soonest. Reports are available from the 'publications' area of the MRT website under 'document search'. Searches can be undertaken by keyword or map area.

State Geological Mapping

MRT has a program in place to review and update the 1:25,000 series geological mapping. The electronic data is freely available for download from the MRT website. Hardcopy maps are available from MRT or for download as a PDF file.

Other data available

MRT also houses airborne survey, drill hole data, gravity data, samples and geochemistry data, which is all open source and of variable quality. Using the 'Database search' part of the MRT website (shown in Figure 11) will allow interrogation of the data. MRT is happy to assist explorers with data accuracy concerns and with accessing the data.

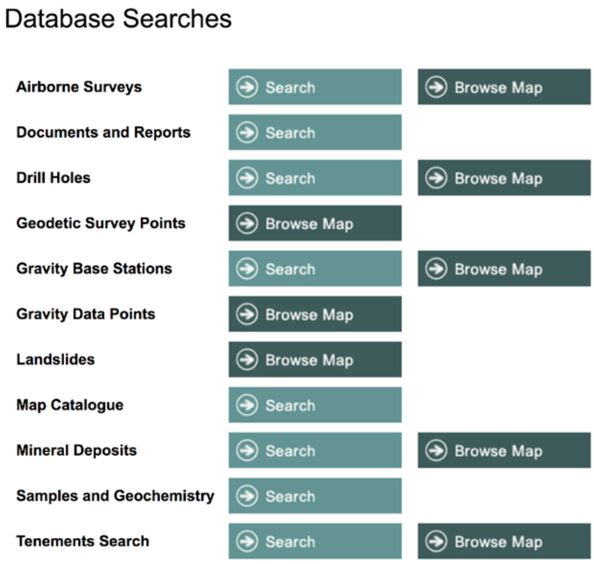


Figure 11 – Shows the database search area of the MRT website.

Geological Mapping

Geological mapping forms the initial understanding of the local and regional geology, including whether the area is predisposed to AMD. The importance of geological mapping is often overlooked. An understanding of the site geology is considered critical in (Price, 2009):

- Interpreting the drainage chemistry sampling;
- Calculating the amount of different materials present in the landscape; and
- Designing an appropriate sampling plan.

An understanding of the geology allows calculation of a representative number of samples to be collected from each lithology.

Geological mapping should initially be from surface or subsurface (excavated trenches). Once an exploration program progresses to drilling, waste domain mapping should be conducted alongside ore reserve mapping, particularly where sulfides are known to be present. During the later stages of exploration, drilling outside the ore zone should be considered to ensure that there is an adequate understanding of the different waste lithologies.

Ideally waste lithologies are entered into a waste model. Modelling gives a more detailed understanding of the 3-dimensional geology, which can assist when deciding how many samples are taken from areas of suspected PAF, and lower the risk that the calculation of AMD potential is incorrect. Figure 12 depicts development of a waste model through the various stages of mine development.

Sampling

Chemical sampling forms the basis of AMD prediction and waste characterisation. The implications of conducting inappropriate tests, or failing to undertake adequate test work, can be significant (USEPA, 1994). A sampling program must contain, as a minimum the below steps to achieve and appropriate estimation of AMD likely to be present:

- adequate sampling with appropriate spatial variability;
- a suitable choice of test work; and
- application of the AMD prediction theory correctly to achieve an appropriate result.

An AMD Management Plan is required for new proponents in areas considered AMD-prone. It is therefore important to be able to adequately predict the future water quality (USEPA, 1994).

There are many opinions concerning the number of samples that should be collected to create a statistically meaningful dataset (USEPA, 1994). Sampling can be a significant operational cost, however adequate sampling lowers the risk for investment and future decision-making when calculating mine operational costs. The quantity of samples required is site-specific. Sites with simple lithology may require less sampling than complex ore bodies. Many of the currently available resources do not provide guidance on the number of samples which should be collected during any phase of the program, however the regulator does expect that the waste model used for AMD prediction is statistically valid. The GARD Guide suggests that five to 10 samples per material type are selected for static tests, and 1 to 2 samples per material type have kinetic tests conducted where the geology is AMD-prone (INAP, 2009). Individual sites need to decide if this is appropriate in highly altered Tasmanian geology.

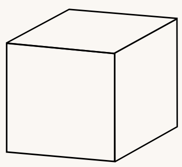
Kentwell et al., (2012) suggest that the number of samples required depends on two questions:

- What is the required level of confidence for the analysis?
- How significant is the spatial variability across the volume of each rock type?

The required level of confidence depends on many factors, including the stage of the project and the sensitivity of the receiving environment (Kentwell et al., 2012). The level of confidence required when estimating AMD generally increases as the project moves towards the operational phase. The confidence level is often commensurate with the engineering and cost level.

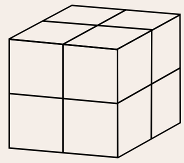
The second question relates to the spatial variability of the deposit. A good understanding of spatial variability can be important for developing management strategies such as a segregation plan. Figure 13 shows the sampling regime suggested in the GARD Guide.

Scoping & Exploration



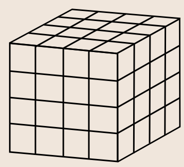
- Data mining
- Static testing
- Understanding of local geology
- Geological mapping with rock types characterised on each drill hole
- Adequate samples collected (Price)
- Baseline water testing

Feasibility



- Kinetic test work
- Waste model
- Ideal to identify mineralogy via XRD
- Continue static testing on new drill holes
- Data management and QA/QC
- Write AMD management plan
- Identify waste types
- Work out reaction rates

Operations



- Add to AMD management plan as new data becomes available
- Educate operations personnel on the need for correct waste management
- Check waste management is being conducted
- Manage and monitor site water
- Consider performance management by waste management rather than production
- Add data to waste model

Figure 12 – development of a waste model throughout the mining stages.

Baseline Water Chemistry, Hydrology and Hydrogeology

The surface and groundwaters of catchments around prospective zones often contain background contaminants in constituents above the ANZGFMWQ (2018) due to the sulfidic host geology in the region (Mccullough and Pearce, 2014). Without specific baseline data, the operator has no target to aim for when trying to achieve their closure outcomes and strategies. They may end up being bound by far more rigorous water quality requirements, such as the national guidelines (Plumlee GS and Nash JT, 1995; McCullough, 2016).

There is no argument that mining and quarrying can drastically alter the physical, chemical and biological processes in the environment. The more information collected before disturbance occurs, as 'baseline' conditions, the better the rehabilitation goals will be (Price W.A., 2009). Hydrologic and hydrogeological features on site play a major role in predicting the drainage chemistry leaving the site, designing the drainage lines and water impoundments. The process to start measuring the properties of these features on sites needs to commence as early as possible in the planning process (Price W.A., 2009).

One of the greatest challenges is estimating the subsurface impacts a mine site might have. It is useful to commence both surface and groundwater monitoring early in the exploration phase to establish how they are connected. Groundwater interpretations need to be closely considered for underground and deep open pit operations, as not only will the operation be impacting the water quality, but the volume of mine dewatering can also impact the operation's profit margins via pumping and dewatering costs (Price W.A., 2009).

Initial AMD Screening Tools

The AMIRA Handbook forms the primary basis for AMD prediction in Australia. The methods differ from the recommendations of MEND, however the outcomes tend to be similar. AMIRA separates their test work into two stages: Initial AMD Screening Tools, and Detailed AMD Screening Tools. In the exploration stage, it is critical to identify the lithology which has PAF material present.

AMIRA recommends the following tests are conducted:

- pH 1:2 and Electrical Conductivity (EC) 1:2 test;
- Total Sulfur (Leco) determination;
- Acid Neutralising Capacity (ANC) test;
- Net Acid Producing Potential (NAPP) calculation (based on S and ANC); and
- Single Addition Net Acid Generation (NAG) test.

Many commercial labs offer these tests as an AMD screening 'set'. This test work is known as static testing.

As the name implies, static test work is conducted on a discrete sample at a point in time. Whilst static test work has been common practice to estimate AMD potential for the life of a mine, it does not provide reaction rates, and if applied incorrectly, can grossly under or over estimate the amount of potentially acid forming (PAF) waste which needs management over the life of the project (DFAT, 2016b). However, static tests remain appropriate for the exploration phase because they are quick, reasonably affordable and still provide an accurate representation of the presence of sulfides.

There are a large number of static tests available that aim to predict the chemical, physical and mineralogical properties of a sample (Price W.A., 2009). The static tests are used predominantly to classify waste as NAF or PAF. Static test work can be used to identify samples which need future assessment in kinetic or mineralogical assessment.

The use of total sulfur for the calculation of NAPP is often debated by experts in the field as the analysis includes the non-acid-bearing sulfur species, which inflates the acid potential (Parbhakar-Fox and Lottermoser, 2015; Dold, 2017). The use of chromium reducible sulfur (CRS), analysing for sulfate has been researched and tried, but this method tends to underestimate the acid potential (Parbhakar-Fox and Lottermoser, 2015). It is advisable to seek the assistance of a geochemist well versed in AMD test work.

The AMIRA protocol uses the test work discussed above to calculate the MPA and NAPP. A negative NAPP suggests that a sample has enough ANC to prevent acid generation, while a positive NAPP suggests that a sample might be acid generating (AMIRA International, 2002). Plotting the NAPP data against sulfur gives an ABA plot, which indicates the acid generating potential of a group of samples.

Samples are classified by plotting the NAGpH against the NAPP values, with the graph split into four quadrants, representing PAF, NAF and UC categories. Figure 14 shows an example of a waste characterisation plot using the AMIRA method. The plot shows a distribution of samples, with most falling into either a PAF or NAF classification, the site will need to further investigate the UC samples to determine if they are NAF or PAF. Samples can fall into the uncertain category for a myriad of reasons. Further mineralogical analysis maybe required to ascertain if these samples are in fact PAF or NAF. The level of detail in the static test work shows which samples are NAF or PAF with a fair degree of certainty if applied by an experienced practitioner.

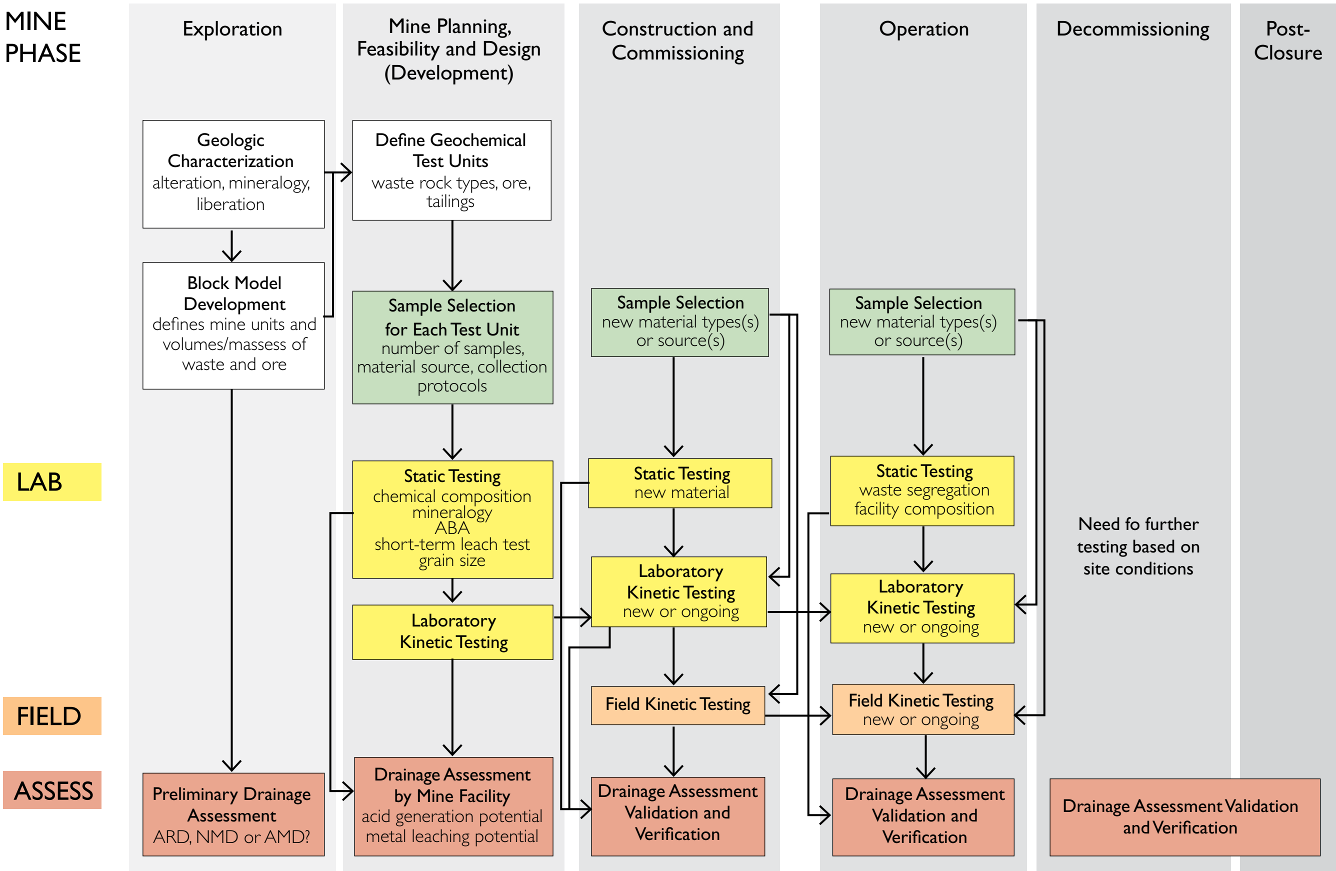


Figure 13 – Source Material Geochemical Testing Program Components.(source: GARD Guide, Chapter 4).

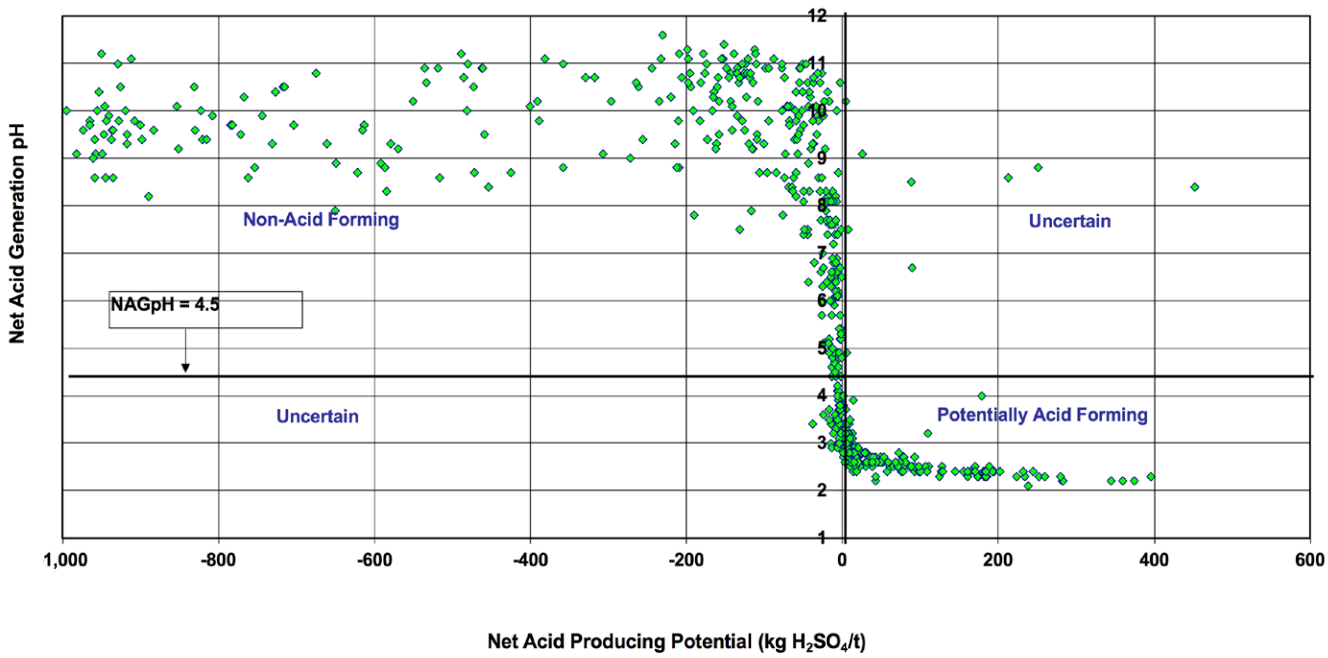


Figure 14 – Example of a waste characterisation plot using the AMIRA protocol.