CUBE CONSULTING

Dilution and ore loss – A short practical guide

Following are a few helpful pointers when dealing with dilution and ore loss. Please refer to the 'suggested reading' list that is at the bottom of this paper for a more comprehensive coverage of this topic or alternatively, contact the author (andrewg@cubeconsulting.com) with specific questions.

Introduction

The word 'dilution' is enough to strike fear into the heart of any mine geologist, especially when the site GM comes into the office asking why the grade is not appearing at the mill!

Interestingly, in the authors' experience, the term 'ore loss' is used far less frequently or not mentioned at all. This is a little perplexing, as the potential economic impact of ore loss is far greater than dilution. This document discusses both of these factors, as the causes of both are virtually the same.

So what is dilution? The best definition I heard was given to me by a work colleague many years ago – he defined it as "water in your beer". For ore loss, using the beer analogy, think about buying a beer and then tipping some out before starting to drink it!

Most of the information in this whitepaper is relevant to open pit operations, however many of the concepts can be applied to underground situations.

The Basics

One of the first things a mine geologist should do is understand the potential financial losses due to ore loss and dilution. The creation of a simple 'ore loss and dilution' calculator in Excel is a good first step - see the example below. This simple calculator can also form the basis of a justification to the relevant manager for a capital expenditure request for equipment\systems or a change in procedure that will reduce ore loss and dilution.

Ore Loss\Dilution Calculator				
Inputs		**Loss of revenue per truck ($)**	**Annual loss of revenue due to ore loss ($)**	**Annual loss of revenue due to dilution[1]**
Gold Price ($/oz)	1600	**9,259**	**7,716,198**	**1,800,000**
Average grade (g/t)	1.5			
Tonnes per truck	120			

[1] *Assumes diluted material = 0.0 g/t*

Processing cost	18
Annual ore production	2,000,000
Current % ore loss	5
Current % dilution	5

Communication

Geologists do not have sole responsibility for dilution and ore loss - a whole list of personnel have responsibilities, from the drill and blast engineers to the ROM loader operator. The key is to inform and educate all stakeholders. The delivery of dilution awareness and operators presentations\inductions is one method that can give everyone a basic understanding of what they can do as an individual to reduce ore loss and dilution.

Data collection and processing

The process of reducing ore loss and dilution starts with the data collection phase. The assigning of material as either ore or waste, with an attributed grade, comes down to the interpretation of collected data, in particular sample data. The old adage of “garbage in, garbage out” is especially relevant here. As this whitepaper is a high level guide and not a comprehensive document, the advantages and disadvantages of various sampling techniques will not be discussed here, however ensuring the methodology of sample collection is fit for purpose for your orebody is fundamental. There have been some excellent and comprehensive papers written in the past that contain most of the information you require to make an appropriate selection for your orebody.

Data collection does not just include sampling. Get to know your orebody, understand the mineralisation, alteration and structural and grade interrelationships through mapping, character sampling and review of core. This data must be stored in an appropriate form so it is accessible to all and also in a form where it can be used to aid dig block design.

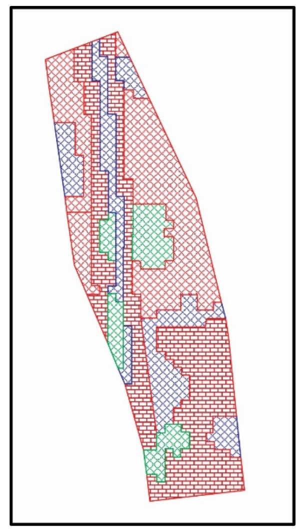
The assay laboratory is often the focus of intense scrutiny. It is important to put everything in perspective, as the errors that can occur in the analysis part of the laboratory are potentially small compared to what happens at the sample collection stage. Therefore, a background knowledge of sampling theory is essential for any mine geologist.

Often decisions on estimation methodologies are pre-determined and outside the realm of the mine geologist, however a basic understanding of the estimation process and how it works will help you identify potential issues. There is the danger in a high pressure production environment that mine geologists can sometimes just keep ‘pressing the buttons’ to keep production going.

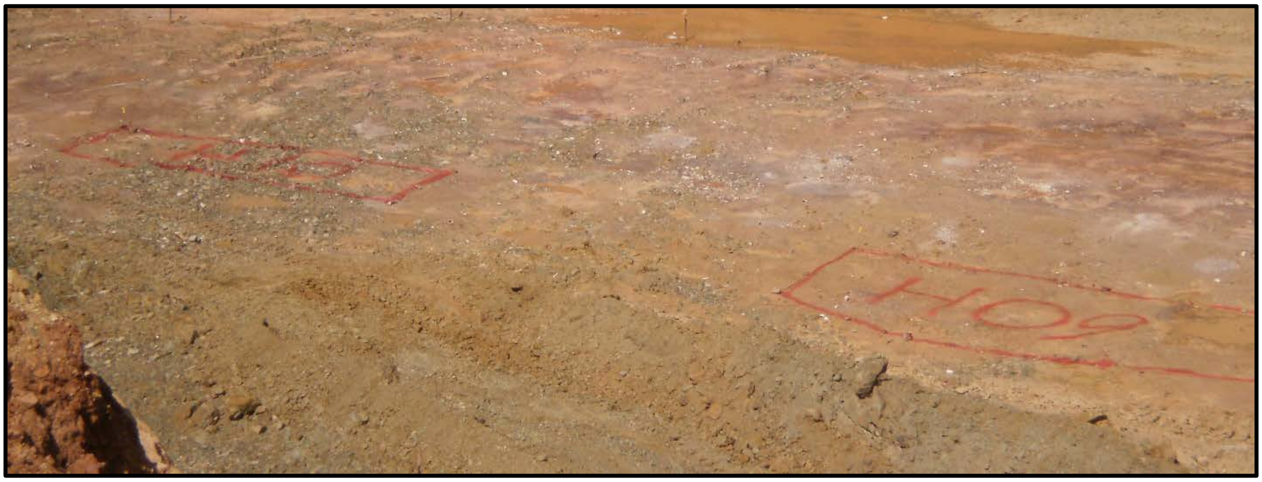
Interpretation

Mine geologists make huge economic decisions on a regular basis in terms of evaluating what is ore and what is waste, therefore as much care as possible should be taken during this important process .

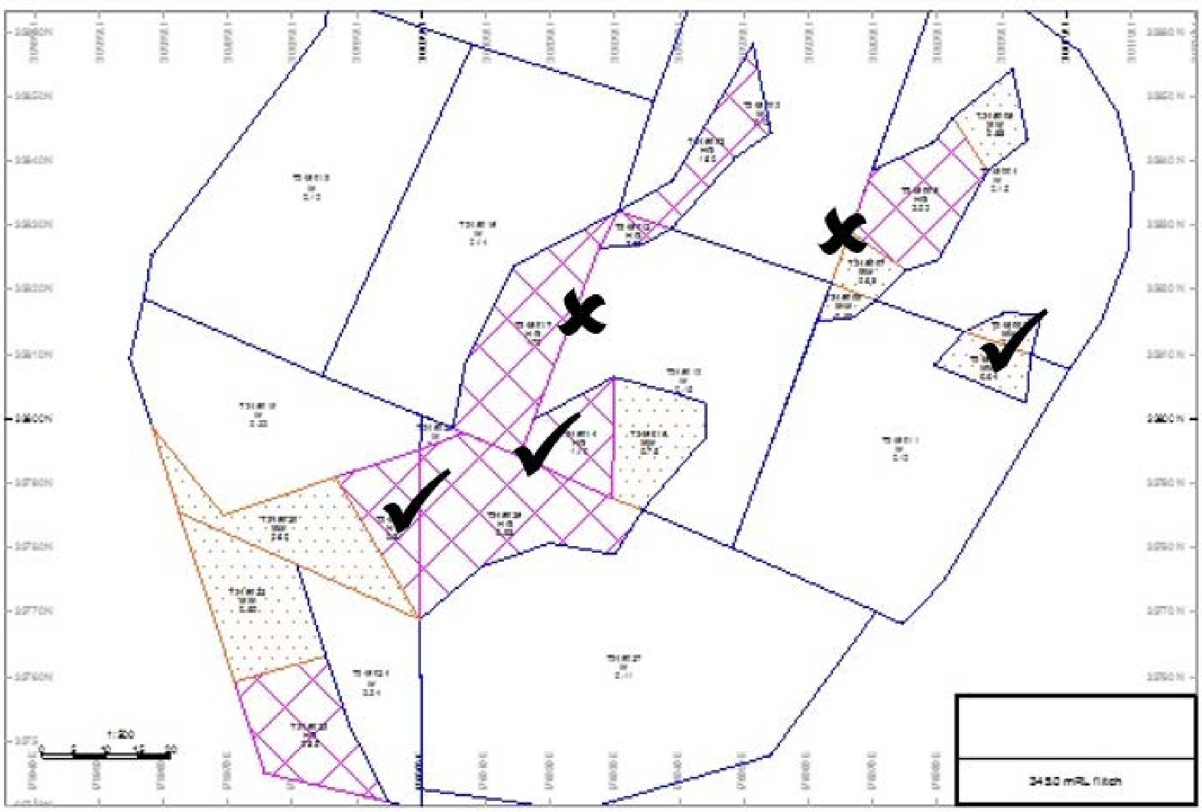
Fundamentally, dig blocks reflect a compromise between the geometry of the mineralisation and the size and type of mining equipment. The two examples shown below are perfect examples of what **<u>not</u>** to do - they are not geologically possible and next to impossible to excavate.



For lithological or structurally hosted mineralisation, the mine geologist needs to consider blocking out the structure and not just relying on the assay data. The picture below shows a break in the ore blocks along a narrow shear hosted Archean lode deposit. At first glance, this looks questionable. To confirm this, ground “truthing” and knowledge of the local geology confirms that there isn’t a cross-cutting barren dyke with a review of the data showing that the sampled blast holes actually straddled the zone. This is a good example of potential ore loss.



When creating dig blocks, use all available information, including data from the bench above (previous GC drilling) and below (resource or deeper GC drilling) and data across individual blasts. The diagram below shows examples where adjacent blasts were considered (good) and not considered (bad), when creating dig blocks.



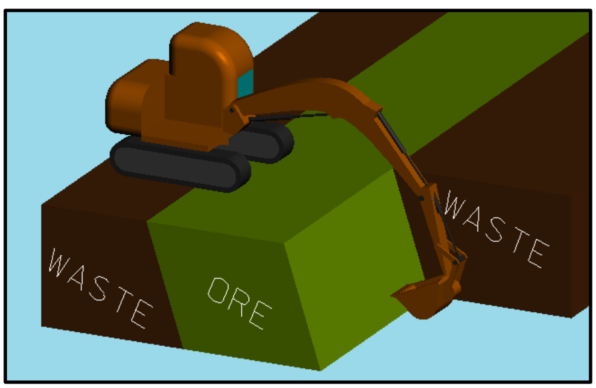
Ideally mineralisation wireframes should be built as mining progresses, and be based on the existing resource wireframes adjusted for the closer spaced GC data in order to create your dig blocks.

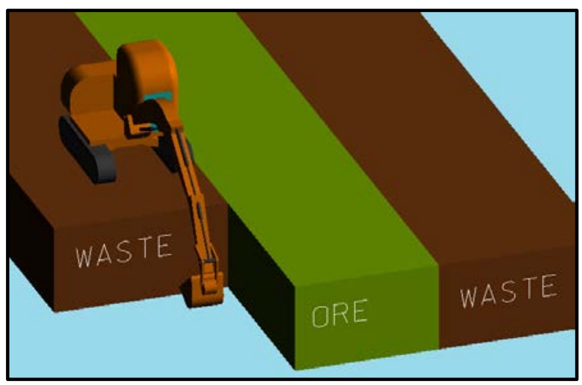
It's a very good idea to have your dig block design peer reviewed by another mine geologist.

Mining

Blast monitoring is an essential consideration for open pit operations, with blast movement undoubtedly the single biggest input factor to ore loss and dilution. Case studies have shown that electronic blast movement monitors (BMM) are far superior to poly pipe BVI's, with numerous published examples of the cost benefits of using these devices.

In addition to the use of blast movement monitoring, mine geologists need to liaise with the mining engineers and supervisors to determine the correct excavation methodology and sequence for each blast. The indication of digging directions and the dip of the ore blocks should be displayed on the dig plan that is given to the excavator operator. Operator education and good communication is the key. The decision to excavate along or across strike will depend upon the mineralisation geometry (see below). The actual excavation of the dig blocks can contribute significantly to ore loss and dilution.





Whether ore spotting can occur, or whether it's viewed as beneficial can be a contentious issue, as many factors have to be taken into account e.g. heavy equipment interaction, safety issues such as old underground workings, the visual nature of the mineralisation etc. This decision must be made on a case-by-case basis. However, given the right conditions, ore-spotting can be a valuable way to minimise the impact of ore loss and dilution.

Reporting and reconciliation

If you don't have good reporting and transparent reconciliation practices, you will not know if you have a problem in your grade control processes. In addition, poor systems can take up valuable time for the mine geologists and take them away from their core duties.

In the reporting process, some mines use a 'mine call' factor. This is a factor that is applied to the grade control defined block grade and is sometimes then reported as the actual defined grade. This practice can hide issues and problems whereas the key to success is to be transparent. If you want to report material with a mine call factor applied, then clearly state that this is the case. It is still crucial that the grade control defined dig block grade is reported i.e. no factors applied. There is always going to be ore loss and dilution during the normal mining process, therefore the reporting of mined grade and tonnes (and ultimately mill reconciled grade and tonnes) separate to grade control grade and tonnes, will indicate the performance of the grade control process and the resource and reserve models against what is actually recovered. This will provide valuable feedback to the resource geologists and mining engineers on the parameters used in their models.

The calculation of dilution by adding a 'skin' around the dig blocks is somewhat problematic and should be used with caution. A consistent skin is rarely mined and determining the grade of this skin is difficult.

Suggested reading

- International Mining Geology Conference Proceedings (available from AusIMM website – (www.ausimm.com.au)
- Mineral Resource and Ore Reserve Estimation. The AusIMM guide to Good Practice, Second Edition, Monograph 30

Cube's capabilities and experience

Cube's consultants are highly experienced and skilled in all forms of grade control. Cube can provide training\mentoring for mine geologists and undertake reviews and audits of grade control practices\procedures and practical advice – all of which add significant value to your operation.

Cube is also the provider of the Surpac-based GCX grade control system. GCX is an integrated grade estimation and reporting system that is in use in over 30 operations, in multiple commodities, all over the globe.