11. Waste Dumps

11.1 *Waste Dump Construction for Water Management*

Attention to waste dump construction with a view to the final rehabilitation plan will minimise erosion potential and facilitate a drainage system that reflects the final drainage network. Accordingly, waste dump planning and construction should attend to the following critical matters.

11.2 *Surface Water*

The information provided in this section should be read in conjunction with Section 6.1 of AMIC (1990).

The type of material to be stored in the waste dump will determine its design and ongoing construction. The presence of acid or other undesirable leachate-producing waste may necessitate a capped waste dump which will generate high volumes of surface runoff. Alternatively, if the material is inert it may be desirable to encourage infiltration. The types of contaminants to be expected are discussed in Section 11.4. To ensure this contamination is minimised and contained there are many critical design issues for waste dumps. These are discussed below.

11.2.1 LOCATION OF WASTE DUMPS

The location of waste dumps should be planned well in advance to cater for the expected waste volumes, the final and intermediate design profiles, visual and noise screening of mine operations and the interaction with groundwater. The following surface water issues should also be considered in the plan:

- new waste dumps should be located within catchments serviced by dirty water interception and treatment facilities;
- where possible, natural drainage paths should be maintained, and room should be left around the base of the waste dump for interception drainage;
- waste dumps should not be constructed immediately adjacent to natural or uncontaminated watercourses. Provision must be made for intercepting runoff, leachate and seepage before it enters such watercourses;
- room should also be left for construction of retention ponds, or it must be possible to direct interception drains into existing ponds for the removal of suspended materials and the treatment of chemical contaminants; and
- avoid locating road culverts immediately downstream of waste dumps. The high sediment load in waste dump runoff can easily cause blockages. Where this is not possible, ensure that sediment retention dams are located upstream of the culverts. Culvert inlets should be carefully designed to maximise velocities into the culvert and outlets designed to ensure that sediment is removed from the outfall.

11.2.2 EROSION ON WASTE DUMPS

Severe rilling on waste dump batters and the problems associated with high sediment loads in waste dump runoff can be reduced by proper design and construction of the waste dump. This should include close attention to batter slopes, benching, armouring and drains. Apart from these 'geometric' design guidelines, the following points should be considered.

Capped Waste Dumps

Where acid drainage and other leachate formation is to be minimised by capping the waste dump with impervious clay or rock, there will be very high volumes of runoff. It is important to incorporate erosion control when constructing the capping layer. This will include properly designed drains, spillways, drop structures, armoured batters and immediate topsoil and grassing. It is also very important to ensure the impervious material selected is not excessively dispersive (clays) or soluble (weak limestone).

Encouraging Infiltration

If seepage of water into the waste dump will not cause structural instability or contaminated leachate and groundwater seepage, it can be very beneficial to encourage infiltration. This will greatly reduce runoff volumes and hence reduce erosion. Increased infiltration can be achieved by contour ripping of the surface, "moonscaping" (refer to AMIC, 1990), creation of small detention ponds or sink holes on top of the stockpile.

Erosion Control

Erosion control can be achieved through:

- effective and early revegetation of completed waste dumps or even of completed sections of active waste dumps. This will require thorough advance planning of final dump profiles, but in so doing may prevent double handling of waste;
- armouring or effective slope reduction which will reduce scour. Planning of open channels to achieve stable profiles and slopes (ie. 0.5% - 1.0%) is also important (refer to Fact Sheet No.4);
- reduction of slope lengths by construction of contour banks and/or drainage benches; and
- introducing storm water retention basins into the final profile to reduce the magnitude of peak flows.

11.2.3 INTERCEPTION DRAINAGE AROUND WASTE DUMPS

Contaminated runoff or leachate derived from waste dumps must be intercepted and directed towards 'dirty water' treatment ponds. The degree of treatment required to match the quality of natural watercourses in the area can vary from none at all, to removal of nearly all suspended solids and treatment for acid, salinity, and heavy metals. Typical techniques for runoff interception are discussed in Section 8.1.3 which, along with the following guidelines, will ensure that the interception system works effectively.

Separation of Water Streams

To avoid excessive volumes of water entering the dirty water treatment systems, runoff from undisturbed catchments around the waste dump should be kept separate from dump runoff and associated disturbed areas. If large quantities of dust from the waste dump settles on nearby areas, then these areas should be included in the dirty water system.

Vegetation Filters

The retention of natural vegetation between the waste dump and the interception drains can be highly effective for removing sediment from runoff and reducing contaminants in the leachate.

Drainage Design

If sediment cannot be retained on the waste dump then it must be kept in suspension until it reaches a designated location for sediment removal (ie. a sediment pond). Drainage velocities must be sufficient to keep sediment suspended but not too fast so as to cause scour.

11.2.4 SEDIMENT CONTAINMENT AROUND WASTE DUMPS

Containment of sediment on the stockpile is the ideal solution and can be maximised using silt fences, hay bales, silt traps, filter dams, retention basins and any other method which will temporarily reduce runoff water velocities to allow suspended solids to settle. A description of these techniques is given in Fact Sheet No.8.

When de-silting ponds, sediment should be dumped in a location where it will be exposed to minimal surface runoff. Methods of containing the sediment either on the waste dump or in a dirty water system are dealt with in detail in Fact Sheet No.8. If wetlands are used, they should only be used to remove very fine sediment particles and a pre-settling pond should be constructed upstream.

11.3 *Groundwater*

11.3.1 INFILTRATION TO GROUNDWATER

Between ground level and the top of the aquifer, the level of saturation in the soil may vary from zero (dry) to fully saturated (Figure 11.1). This zone, referred to as the capillary zone, contains water which is held under negative (suction) pressures within the soil matrix.

Flow in the capillary zone is strongly vertical and only weakly horizontal. Therefore water infiltrates or percolates through this zone. Similarly, the migration of contaminants is strongly vertical.

Flow in the capillary zone is complicated by the strong and variable presence of air in the soil matrix. This results in a variable hydraulic conductivity of the soil, which, in turn, results in variable groundwater infiltration characteristics between ground level and the top of the aquifer.

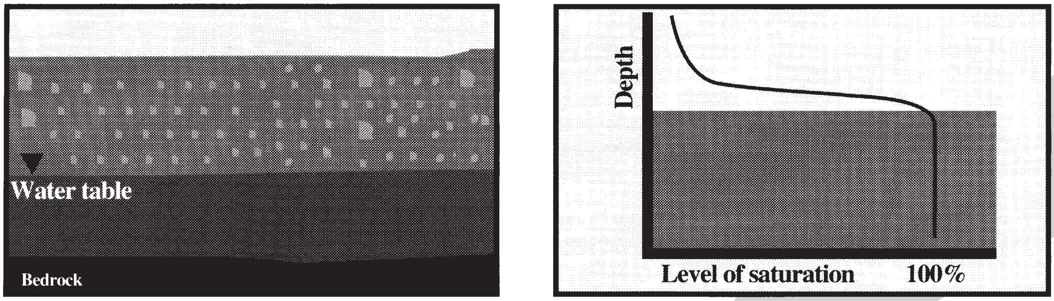
The main factors influencing groundwater contamination are:

- travel time of contaminated water from the ground surface to the water table;
- the fraction of contaminant that reaches the water table; and
- the rate at which the contaminant enters the aquifer from the capillary zone.

Characteristic behaviour of contaminants include:

- soluble contaminants collect near the water table in a floating lens and are then transported across the water table where horizontal dispersion occurs;
- solvents which are denser than water migrate downwards to the bottom of the aquifer and are then transported by a process of advection and diffusion; and
- residual (free phase) chemical contamination in the soil matrix above the water table has the potential to generate long-term problems.

FIGURE 11.1: **The Soil Capillary Zone**



Control of infiltration may be achieved through:

- liners or impervious layers placed between the waste dump and the soil matrix (eg. polyethylene, PVC, non-reactive clays or soil-bentonite mixtures);
- surface capping to insulate against the infiltration, percolation and contaminant migration via rainfall through the waste dump. Surface capping materials may be impermeable materials such as clay, concrete or liners; and
- adequate waste dump drainage to confine runoff to the surface, where it may be more easily contained and treated if required.

Attenuation of groundwater contamination may be achieved by isolating the groundwater near waste dumps using:

- slurry walls (Section 8.2.2);
- grout curtains (Section 8.2.2); and
- sheet piling (Section 8.2.2).

In addition, groundwater control methods such as dewatering bores and capture trenches (Section 8.2.2) may be used to collect water for pumping to treatment facilities. However, these methods should only be employed after source control methods have failed.

11.3.2 MONITORING

Groundwater should be monitored as close as practical to the perimeter of the waste dump and the piezometers should extend into the subsurface groundwater regime. Monitoring and sampling should be carried out both upstream and downstream of the prevailing groundwater flow direction near the waste dump (Figure 11.2).

Monitoring and sampling should include:

- groundwater levels or piezometric heads;
- pH and salinity; and
- chemical and/or biological analyses as appropriate.

When sampling for chemical or biological analysis, standard sampling procedures should be used (Section 5.4).

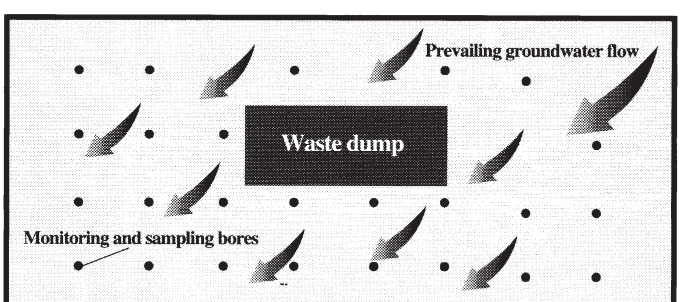
Contaminants may react within the soil matrix, so that groundwater monitored at the periphery of waste dumps may not directly reflect some characteristics of the primary contaminant infiltrating from waste dumps.

11.4 *Water Quality*

Waste rock dumps may be a source of contaminants to local streams and receiving waters. The range of problems that occur from these structures include:

- acid drainage;
- saline runoff;
- suspended solids runoff; and
- heavy metals in runoff and leachate.

FIGURE 11.2: **Monitoring Network Around a Waste Rock Dump**



11.4.1 ACID DRAINAGE

Acid drainage from waste rock dumps is normally a more significant problem than that from within open cut or underground mines. This is primarily a result of increased surface area of exposed reactive sulphides, higher porosity and infiltration within waste rock dumps and the difficulty in containing and/or treating leachate. The extent of the acid drainage and subsequent metal solubility problems within a waste rock pile will depend on the following physical, chemical and biological conditions:

- physical size and geological characteristics of the waste rock;
- the presence and type of sulphide bearing minerals;
- the extent of rainfall infiltration;
- the permeability of the waste rock dump to air and water;
- the presence of acid neutralising rocks within the waste rock dump; and
- the level of microbiological activity, including the presence of bacteria.

Monitoring techniques that can be used to identify acid generation within a waste dump include:

- the presence of “hot spots” on the waste surface that are warm to the touch;
- the appearance of steam from sections of the dump, particularly after rain events;
- red and brown coloured water around the base of the dump, red or brown colouring on stream bottoms and banks, or the presence of colloidal yellow precipitate in the water;
- the use of remote imaging techniques, such as thermal infra-red, to identify higher than ambient temperatures in the dump;
- in-situ temperature sensing;
- gas sampling within the partially saturated zone; and
- sampling and analysis of soluble acid drainage products in the waste rock and underlying geologic formation.

Specialised sampling techniques are required when monitoring for acid drainage and the reader is referred to Hutchinson and Ellison (1992) for further information.

A wide range of prevention and remedial strategies are available for acid drainage problems from waste rock dumps. These are shown in Table 11.1

11.4.2 SALINITY

Saline runoff from waste dumps can be a common problem at mines located within arid regions and regions with specific high salinity geological formations, for example, much of the Hunter and Bowen Basin coalfields. Overburden and waste rock that originated from within saline parent material can have high concentrations of dissolved and precipitated salts. Once this material is removed and placed on waste rock dumps, rainfall infiltration can result in highly saline runoff and leachate.

Runoff and leachate from saline waste rock dumps should be intercepted and directed to storage ponds for:

- evaporation;
- recycling if suitable;
- dilution with low saline water if available and subsequent use;
- treatment if feasible; or
- controlled discharge, for example under flood flows where natural dilution occurs.

The chosen option will depend largely on the water’s suitability for use on site and the characteristics of the receiving waterbody.

TABLE 11.1: **Prevention and Remedial Strategies for Acid Drainage**
Control of Acid Generation
• pre-treatment to remove or exclude sulphide minerals
• use of an impermeable cover to exclude rainfall infiltration and oxygen
• waste segregation and blending to control pH
• use of bactericides to control bacterial oxidation of sulphide minerals
• avoid exposing reactive minerals to atmospheric conditions by modifying the mine plan or avoid mining sections of the deposit
Control of Acid Migration
• use of covers and seals to exclude infiltration
• controlled placement of waste to minimise infiltration
• interception and diversion of surface and groundwater
Collection and Treatment of Acid Drainage
• use of a physical and/or chemical treatment system
• use of biological treatment systems such as wetlands
Modified from Hutchinson and Ellison (1992)

11.4.3 SUSPENDED SOLIDS

Common techniques used to control sediment runoff from waste dumps have been outlined in Sections 11.2.2 and 11.2.4. Further techniques applicable to erosion control and the rehabilitation of waste rock dumps are provided in Fact Sheet No.8 and AMIC (1990).

11.4.4 LEACHATE AND OTHER CONSTITUENTS

Additional contaminants that may emanate from waste rock dumps include:

- asbestos fibres from naturally occurring minerals;
- soluble cations and anions such as chlorides, sulphates and carbonates;
- heavy metals which may be dissolved by acid forming processes; and
- acid and alkaline waste streams from naturally forming inorganic acids and natural carbonates or alkaline silicates.

Specific treatment of these waste streams may be required, and special disposal techniques may be needed for sediment derived from these materials and deposited in sedimentation dams.