MINE WATER MANAGEMENT STUDY FOR THE LAKE COWAL GOLD PROJECT, NSW AUSTRALIA

Bruce A. Dudgeon
Associate

Coffey Partners International Pty Ltd
142 Wicks Road
North Ryde NSW 2113
AUSTRALIA

ABSTRACT

A water management study has been undertaken in support of an application consent to develop a large, low grade gold deposit on the margins of Lake Cowal, New South Wales, Australia. A mine water management plan has been designed to control and contain surface and groundwater for mine process usage. Mine dewatering and wastewater control detention facilities are expected to be suitable for both normal and extreme surface runoff and mine groundwater inflow events. The combined usage of waters derived from aquifer dewatering, surface runoff containment, tailings decant water and off-site wellfield will control mine wastewater and supply mine water demands. It is envisaged that there will be no direct discharge of mine wastewater to the environment during mine construction, operation, shutdown and rehabilitation.

INTRODUCTION

This paper outlines water management studies undertaken as part of the requirements in support of an application for development consent for the Lake Cowal Gold Prospect, New South Wales, Australia. The Project proposes to develop a large, low grade gold deposit on the margins of Lake Cowal, an environmentally sensitive ephemeral lake and wetlands area in the Central West Region of New South Wales, Australia (Figure 1). Included in this paper is an outline of mine water management issues as related to the existing environment, ecologically sustainable development and operation, project impacts, rehabilitation and monitoring.

Main areas of concern for mine water management include:

- Regional effects of mine dewatering and off-site wellfield development.
- Lake water / groundwater interaction.
- Interaction between surface hydrology and mine.
- Water management within the mine perimeter bund area.
- Security of reliable mine process water supply.
- Long-term effects on hydrological regime.
- Public perception of mine water usage and discharge.

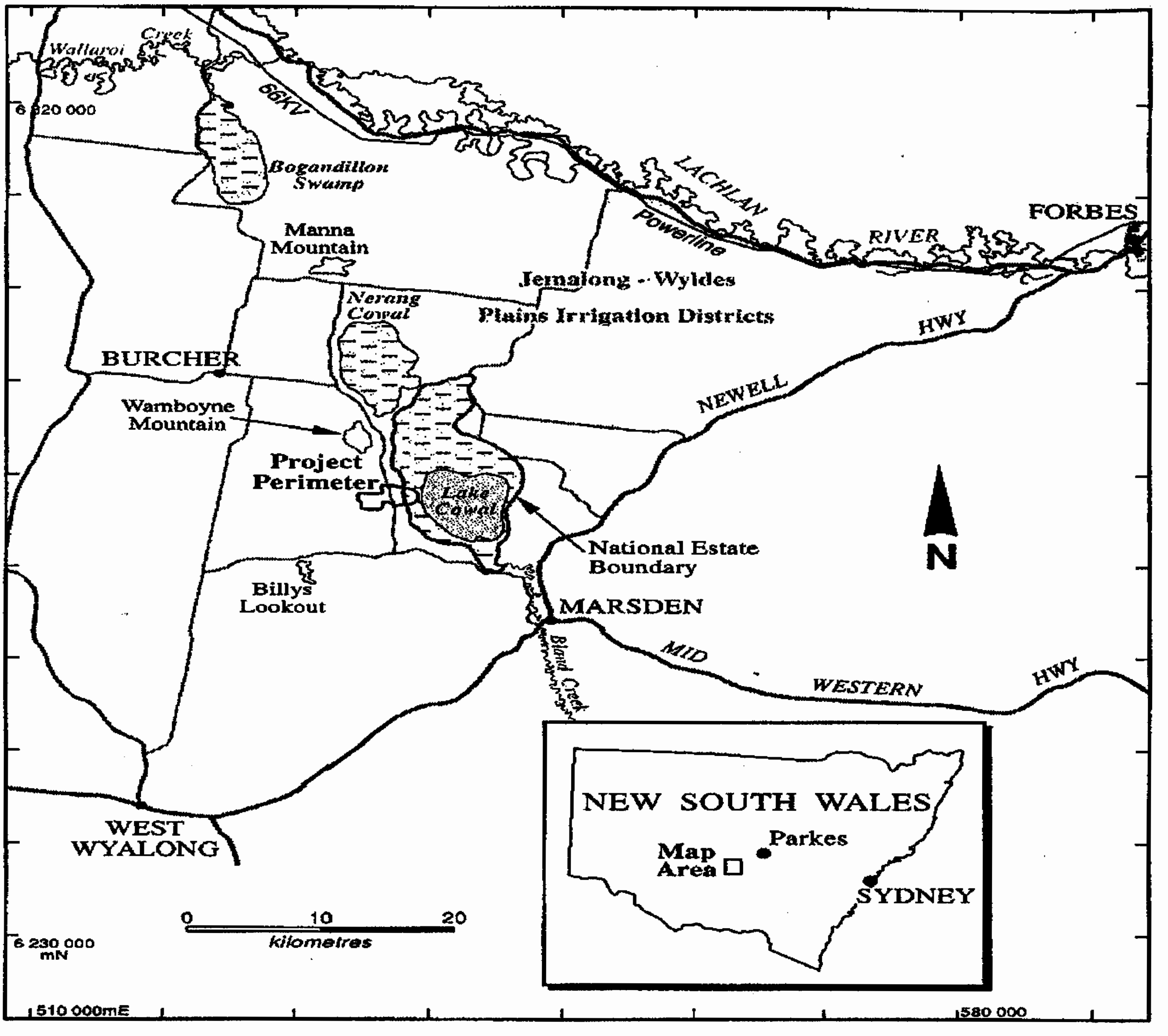

Figure 1: Location map (after NSR, 1996)

PROJECT DESCRIPTION

The Lake Cowal Gold Project will win gold from an open-pit mine which, when completed, will have dimensions of 800m diameter at ground surface and 320m deep. The pit will partially extend into Lake Cowal and will be isolated from the lake by a bund wall. Perimeter bunding surrounding the pit, waste emplacements, tailings storage area and process plant is designed to isolate the project from Lake Cowal and the regional environment and define a no-release zone for the mine water management system.

Principal features of the mine are the pit protection bund and temporary cofferdam, open pit perimeter bund, waste emplacements, pit dewatering borefield, ore stockpiles and process plant, tailings storage area, water storages, settling ponds, surface water deviation structures and services (Figure 2). An off-site wellfield will be developed remote from the mine on the opposite side of the lake approximately 10km from the mine site.

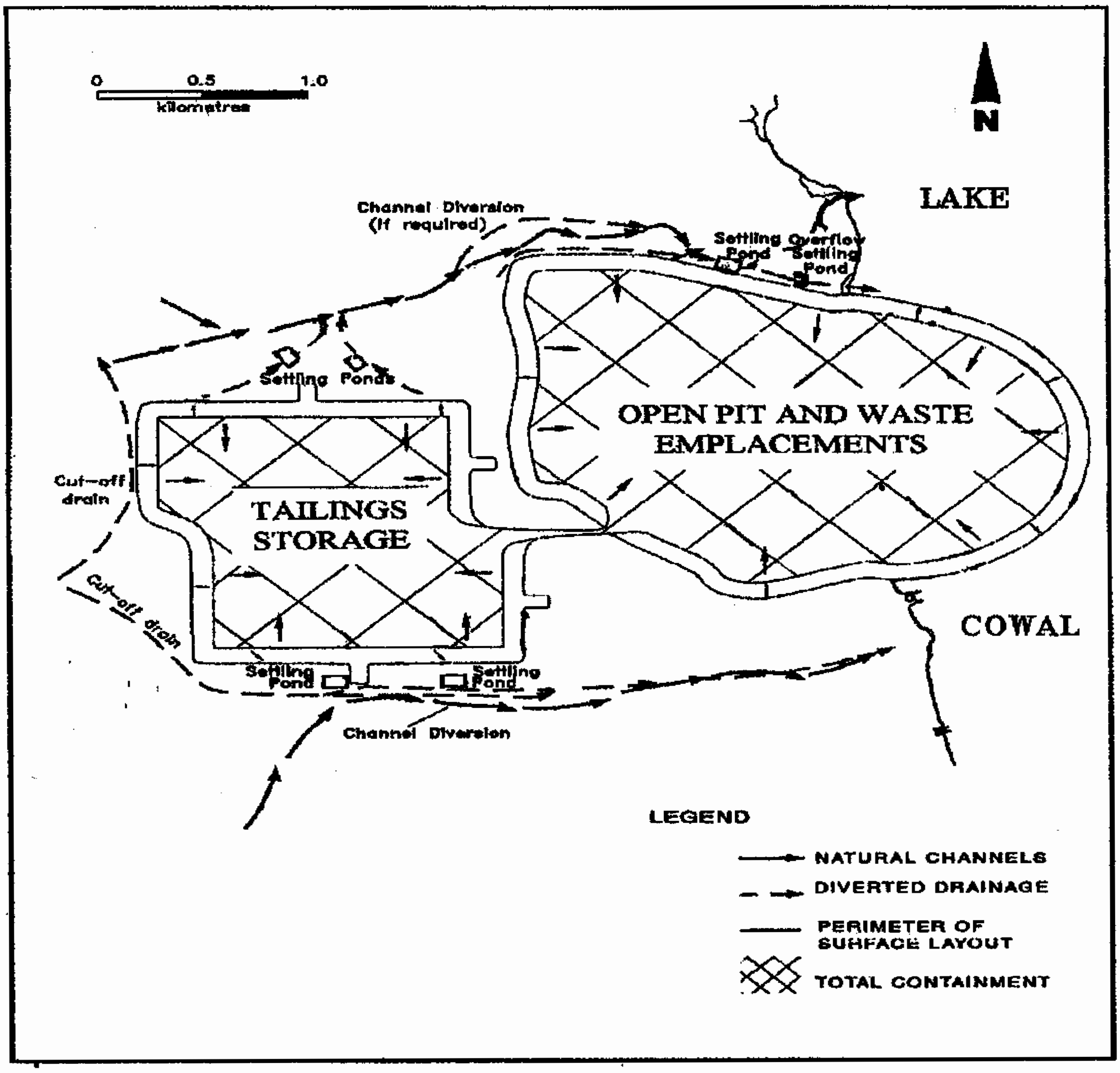

Figure 2: Mine site layout, drainage and water management plan (after NSR, 1996)

REGIONAL PHYSIOGRAPHY AND EXISTING ENVIRONMENT

General

The project is located on grazing land on the shores of Lake Cowal. This lake is the largest natural inland lake in New South Wales and is recognised as supporting one of the most significant water bird concentrations in the State.

Climate

The project area lies in a semi-arid to temperate region with a uniform but low monthly rainfall, with annual rainfall generally between 250mm and 500mm. Mean daily temperatures range between 33°C in summer months and 14°C in winter months. Annual evaporation is approximately 2 000mm, about four times the average annual rainfall.

Geology and Geomorphology

The project is located in the north-south trending Bland Creek Valley. Most of the land surface in the valley is flat (elevation approx. 200m above sea level (AHD)) and is comprised of alluvium. Hard underlying rocks crop out along ridges forming the western and eastern valley boundaries. The ridges are visible portions of mountain ranges that were eroded to their present state with resultant deep incised channels in basement rock, in which thick sequences of sediments were later deposited to form palaeochannels.

The geology of the Cowal Main deposit comprises a sequence of interbedded volcaniclastics and lavas. The sequence is underlain and intruded by diorite/gabbro emplacements. The upper horizons of the profile consist of unconsolidated alluvial and lacustrine sediments of Tertiary and Quaternary age underlain by a Tertiary lateritic profile and oxidised volcanics (saprolite) to a depth of up to 100m. Fault and shear zones appear as discrete structures typically less than 5m thick. Gold occurs primarily in hydrothermal quartz-carbonate-sulphide veins.

Groundwater Characteristics

Groundwater in the vicinity of Lake Cowal occurs in two distinct hydrogeological regimes, these being the Pleistocene to Recent alluvial deposits and the older fractured bedrock. Alluvial aquifers to the west of the lake (mine site) have private boreholes close to the mine site. These are relatively shallow, with high salinity and low yield. Alluvial aquifers to the east of the lake are higher yielding and are within the confines of the Bland Creek Palaeochannel. Here, groundwater yields are of sufficient quantity and quality for use as irrigation supply. Shallow groundwater beneath Lake Cowal usually exceeds 60 000 µS/cm. Throughout the region, groundwater in the fractured bedrock aquifers are generally highly saline and low yielding.

Surface Water Environments

Lake Cowal is an ephemeral lake fed by its major tributary, Bland Creek, and by large but infrequent southwesterly sheet-flood flows from the Lachlan River. Records since 1940 indicate that the lake is substantially full approximately 7 out of 10 years. The capacity of the lake when full is estimated at 200 gigalitres and covers an area of approximately 100km^2, with a maximum water depth of 5 metres. Once full, the lake takes approximately 2 to 3 years to deplete, depending on the size of the preceding flood, evaporation, rainfall and surface water input and extraction for irrigation. Shallow perennial drainage gullies transect the mine site, draining surface water runoff generated after storm events towards the lake.

IMPACT ASSESSMENT

Groundwater Effects

Pit dewatering will reduce pressures and draw down groundwater levels in the alluvial and fractured rock aquifers surrounding the mine. Numerical modelling of mine dewatering predicts this drawdown effect will be localised. Results of modelling indicate that after 8 years of continuous pumping at 4 ML/day, drawdowns at a distance of 10km east of the pit will be less than 1m in the alluvial aquifers and less than 3m in the fractured rock aquifers. This localised effect is due to the low permeability of both alluvium and bedrock at the mine site.

Groundwater drawdown in the confined aquifers below Lake Cowal will increase the differential hydrostatic head of lake water acting on the aquitard beneath the lake bed. Aquifer testing beneath the lake indicates the aquifers are hydraulically isolated from Lake Cowal, therefore it is foreseen that groundwater drawdown will have negligible impact on lake levels and lake water will not contribute to groundwater inflow to the pit. This assumption is reinforced by observations that:

- The lake bed comprises thick sequences of clay with very low permeability.
- Historically, the lake shows no evidence of water loss except by evaporation and the increases of salinity in lake water can be modelled on the basis of evapo-concentration with falling water levels.
- Satellite imagery shows no indications of saline seepage into the lake bed that may indicate a hydraulic link between the lake and underlying aquifers.
- The shallow alluvial aquifer beneath the lake has a piezometric head different from lake level.
- Lake water is substantially fresher (200 to 1 600 μS/cm) than groundwater beneath the lake (30 000 to 70 000 μS/cm).

Seepage from tailings storage facilities will be collected by an underdrainage system and returned to the process plant for reuse. In-situ low permeability clay profiles up to 20m in depth beneath the tailings dams will also serve to minimise seepage to groundwater.

The steady state level of water in the pit void after cessation of mining and pit dewatering will represent a dynamic equilibrium between inputs of rainfall and groundwater, and losses due to evaporation. This relationship has been modelled for a range of climatic and inflow conditions. Results indicate a potential range of pit water level of 40m, with the highest expected water level within the pit being some 25m below ground level (approximately 15m below full level of Lake Cowal). The pit lake is expected to be 95% recovered to equilibrium level within 50 years of cessation of mining.

The off-site wellfield will utilise the aquifers of the Bland Creek Palaeochannel. Water levels in irrigation bores located 20 km to the south of this wellfield will be drawn down but their present yields are predicted to remain unchanged. Minor localised subsidence may occur in the wellfield but is not expected to be significant.

Surface Water Effects

In an average rainfall and runoff year, the Project's water management scheme will retain approximately 245 ML of water that would otherwise run off into natural drainage lines and Lake Cowal. This volume represents 0.2% of average annual lake inflow.

The proportion of the lake surface area isolated by the mine perimeter bund varies from 0% to 1.4%, depending on lake level.

The lake will not be used as a source of mine water supply due to its transient nature and difficulties in obtaining licences for lake water usage.

Water quality impacts beyond the mine perimeter are expected to be negligible, with minor local turbidity expected during construction of the bund wall.

MINE WATER MANAGEMENT AND IMPACT MITIGATION

The principal underlying the mine water management strategy is that all water entering the active project area will be retained within the area. Runoff generated on the mining lease will be diverted away from the active project area and discharged to the natural stream system (Figure 2). Measures designed to mitigate effects of the Project on the environment are presented in Table 1.

Criteria

The mine water management system has been designed to;

- provide a reliable supply of process and potable water to the operations; and
- manage mining lease water in an economic and environmentally sound manner.

The water management system is designed to accommodate both average and extreme event shortages and surpluses of water over the estimated 11 year project life. With a climatic water deficit and low rates of pit dewatering, it will be possible to use all water entering the active project area for process or other purposes, with no discharge to the natural stream system.

Construction Phase

During the construction phase, waters generated on the site will be managed as follows:

- Saline groundwater from pit dewatering borefield will be produced before the ore processing plant is commissioned and hence there will be a water surplus during the initial years of mine development and operation. This water will be stored in tailings dam storage cells which will be constructed before pit dewatering commences.
- Sediments eroded from perimeter bund walls will be directed through settling ponds

Operations Phase

A schematic representation of the mine water management system during mine operation is presented in Figure 3.

Clean surface water runoff from catchments surrounding the project area will be intercepted by cutoff drains and discharged to natural water courses. Runoff from the external slopes of tailings storage, perimeter bund and local runoff will be directed through settling ponds and discharged to natural water courses.

Contained waters will comprise recycled process water, runoff from waste emplacements, internal perimeter bund slopes and water from in-pit dewatering operations.

Recycled water from tailings storage comprises decant water and underdrainage water. Mine drainage surface water and groundwater inflow will be collected in the base of the pit and pumped to storage ponds. Mine aquifer dewatering from the mine dewatering borefield will supply saline groundwater from alluvial and fractured bedrock aquifers. Project area stormwater will be directed into retention basins sized to receive a 100-year average recurrence interval (ARI), 72-hour storm event.

An outside borefield will be required to meet the predicted insufficient long-term water demands for the mine. The predicted long-term demand for make-up water from an outside borefield averages 4 ML/day. The actual demand will vary throughout the mine life, and will be dependent on ore type being processed, volume of water produced from on-site runoff and losses from surface water storage due to evaporation.

Water Supply Demands for Mine Development and Operation

Mine water requirements include ore processing water plus water for general mine operations (e.g. dust suppression, cleaning, septic systems and potable supplies).

Table 1: Measures to mitigate effects of the Project on the environment

Mitigation Measure	*Effect*
Water management system	Contains, for use, all waters generated within the bunded area. No discharge of process, groundwater or surface water to the surrounding environment.
Pit protection bund	Isolates lake water from the open-pit
Mine perimeter bund	Isolates mine operations from the regional environment
Pit dewatering borefield	Improves pit wall stability and safety
Tailings storage location and geology	Remote from the lake for increased safety and underlain by low permeability clay layer and underdrainage system to minimise seepage to groundwater
Channel runoff from external perimeter bund walls	Minimises sediment load to the lake and preserves lake water quality

OPERATIONS MONITORING

Monitoring points will be established for surface and groundwater data collection. These will include:

- Water quality monitoring in the lake surrounding the mine perimeter bund and natural surface runoff discharge points to the lake.
- Lake level and inflow monitoring points.
- Surface water detention pond quality.
- Tailings seepage monitoring trenches and bores around the perimeter of tailings storage.
- Tailings decant quality monitoring.
- Pit dewatering wellfield piezometers for groundwater level and quality.
- Pneumatic piezometers in aquifers beneath lake bed for piezometric head monitoring.
- Off-site wellfield piezometers for groundwater level and quality.
- Survey benchmarks for ground subsidence monitoring.

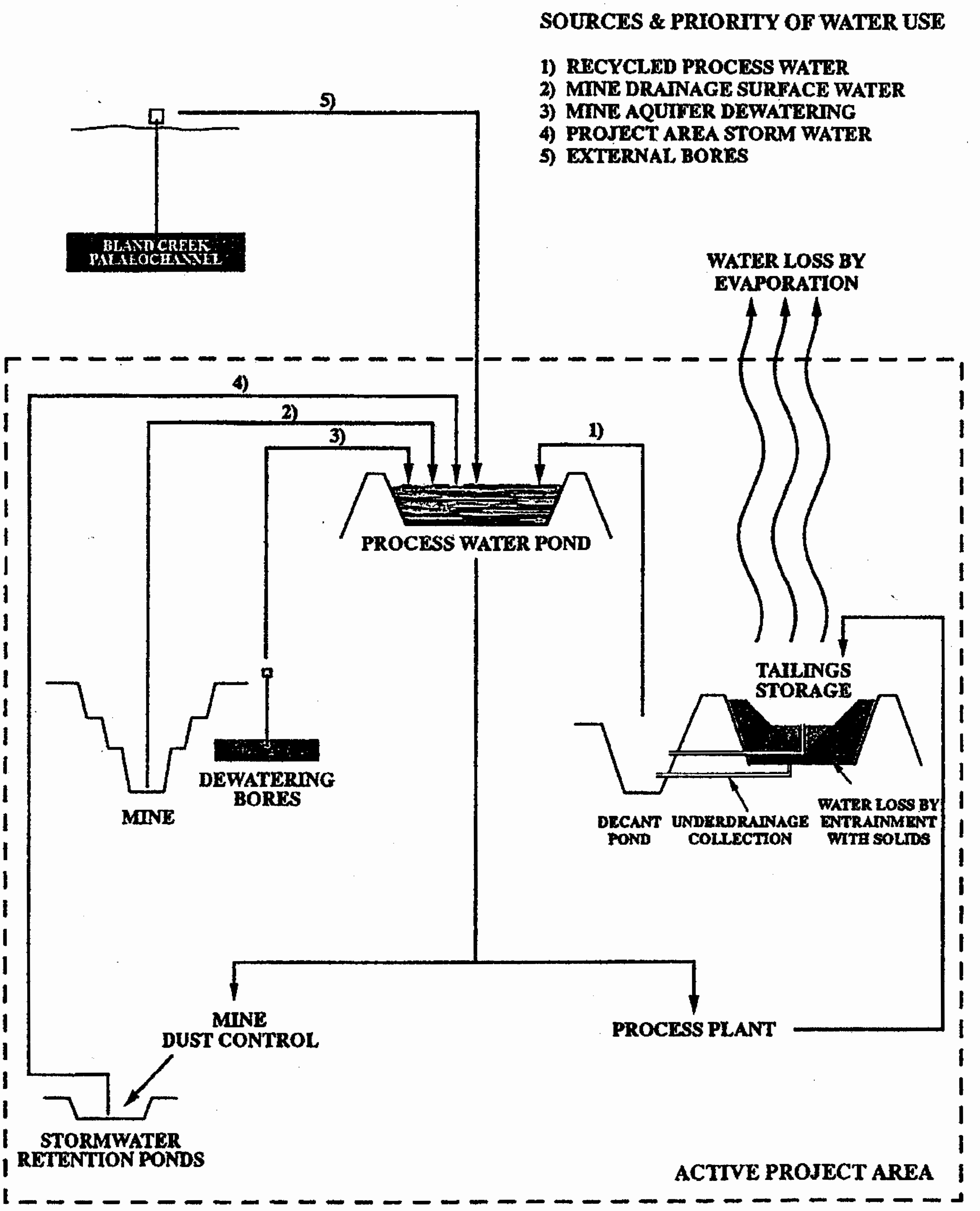

Figure 3: Mine water management flowsheet (after NSR, 1996)

ISSUES RAISED BY GOVERNMENT AUTHORITIES AND PUBLIC BODIES

In response to questions and concerns raised by Government Authorities and Public Bodies during the preparation of a water management plan for the Project, several key issues were seen as perceived impacts of mine development on the environment. These issues had to be addressed in such a way as to be readily understood by people not familiar with mine water management. A summary of these issues how they were addressed are given in Table 2.

Table 2: Water management issued raised by Government Authorities and Public Bodies

Issue	*Perceived impacts*	*Protection measure*
Tailings storage	• Seepage of leachate to lake via groundwater • Bird deaths from cyanide poisoning	• Tailings storage area underlain by low permeability clay horizons • Decant cyanide levels generally non-toxic • Tailings water removed by decant and underdrain systems • Pond size minimised to discourage use by birds • Tailings waters and runoff contained and used
Off-site wellfield	• Loss of groundwater supplies for irrigation	• Nearest irrigation bore located 20km away • Numerical modelling indicates minimal effect to existing irrigation bores
Effect on lake level	• Loss of lake water • Change to regional flooding regime	• Mine isolation with bund wall reduces lake surface area by less than 2% • Runoff containment reduces lake inflow by less than 1% • Lake flood levels not affected
Effect on lake quality	• Contaminated mine runoff entering lake	• Containment of all mine runoff will prevent mine water discharge to lake
Pit lake / Lake Cowal interaction	• Saline water in final pit void will flow into lake	• Predicted maximum pit void water level is 15m below full lake level • Sufficient runoff storage within pit void to accommodate severe rainfall events

REFERENCES

1. Coffey Partners International Pty Ltd., (1993). Water Management and Mine Geotechnical Studies. Report for Geopeko. Report No. G255/10-AE, December.

2. Coffey Partners International Pty Ltd., (1995). Endeavor 42 Gold Mine Surface Hydrology Study, Lake Cowal. Report for North Group. Report No. G255/28-AF, April.

3. Coffey Partners International Pty Ltd., (1995). Lake Cowal Project, Hydrogeological Modelling and Dewatering Study. Report for North Group. Report No. G255/28-AF, April.

4. NSR Environmental Consultants Pty Ltd., (1995). Lake Cowal Gold Project, Environmental Impact Statement. Prepared for North Mining Limited. Report No. CR521/11, August.