

Risk Assessments for End Use

1 HUMAN HEALTH RISK ASSESSMENT FOR END USES

For protection of human health there are standard preventive measures required at site of use for all schemes regardless of recycled water quality. These standard measures are:

- Cross-connection controls to ensure protection of drinking water supplies;
- Using signage, labelling and communication to minimise accidental exposure;
- Reducing occupational exposures to those who work with recycled water.

Details regarding these standard preventive measures are included in the HEMPs. Education of customers about these measures will occur according to the Stakeholder Engagement Strategy.

In addition, specific preventive measures are required at site of use for some schemes depending on recycled water quality.

Bendigo WRP Recycled Water

To determine the specific preventive measures required, a risk assessment was undertaken through consideration of log reductions, in line with the *National Guidelines for Water Recycling*. The log reductions required for the various types of end use take into account the quality of the source water, the likelihood of exposure, dose response and ratio of infection to illness.

Table A Human Health Risk Assessment for Bendigo WRP Recycled Water

Pathogen	Level to be delivered by Bendigo WRP including Class A Plant	Levels required to ensure no specific on-site preventive measures required			
		Dual reticulation - toilet flushing, washing machines, garden use	Municipal use - open spaces, sports grounds, golf courses, dust suppression	Commercial food crops consumed raw or unprocessed	Nonfood crops - trees, turf, woodlots, flowers
Virus	> 7 log reduction	6.5	5	6	5
Protozoa	> 6 log reduction	5	3.5	5	3.5
Bacteria	> 6 log reduction	5	4	5	4

Table A shows that for all proposed recycled water uses, no specific preventive measures are required at site of use for protection of human health.

BML Treated Groundwater

The expected quality of the treated groundwater from BML is shown in the Fit For Purpose Assessments earlier in this Appendix D of the REIP. There are no parameters requiring specific preventive measures at site of use for protection of human health.

2 ENVIRONMENTAL RISK ASSESSMENT FOR END USES

2.1 Preliminary Screening Risk Assessments

To determine which environmental risks required detailed risk assessment and potentially the development of preventive measures, the following preliminary screening risk assessment process was followed, in line with the *National Guidelines for Water Recycling*.

Table B Environmental Risk Assessment For Combined Recycled Water Streams

KEY ENVIRONMENTAL HAZARDS IN RECYCLED WATER	POTENTIAL ENVIRONMENTAL END POINT					
	Plants growing on Class III soils	Plants growing on Class V soils	Soil structure	Groundwater	Waterways	Aquatic biota in distribution system
Boron	Low	Low	Low	Low	Low	Low
Cadmium	Low	Low	Low	Low	Low	Low
Chlorine disinfection residuals	Low	Low	Low	Low	Low	Low or Moderate
Hydraulic loading	Low	Low	Low	Low	Low	Low
Nitrogen	Low	Low	Low	Low	Low	Low or Moderate
Phosphorus	Low	Low	Low	Low	Low	Low or Moderate
Salinity	Low	Low or Moderate	Low	Low	Low	Low
Chloride	Low or Moderate	Low or Moderate	Low	Low	Low	Low
Sodium	Low or Moderate	Low or Moderate	Low or Moderate	Low	Low	Low

As a result of this preliminary screening, detailed risk assessments were carried out for nutrients, salinity, chloride and sodium impacts. These are documented in the following section.

Issues not requiring further investigation are:

- Boron – concentration in the recycled water is less than target criteria for protection of plants and freshwater species.
- Cadmium – the cadmium concentration in the recycled water is very low, however application of saline water can potentially mobilise existing cadmium in the soil. This risk is included in the salinity risk assessment following.
- Hydraulic Loading – there will be no change to the current (non-drought) situation in terms of amount of water applied. Therefore use of recycled water does not increase the risk. In addition the cost of the recycled water will deter over-use.
- Chlorine disinfection residuals – impact has been assessed as part of development of the HEMP for Recreational Lakes. The recycled water is de-chlorinated at the treatment plant, and remaining chlorine will degrade along the pipeline. Risk to aquatic biota is low.

2.2 DETAILED RISK ASSESSMENTS

2.2.1 Salinity

Expected Salinity

In the initial phase of the project (Milestone 1), no salinity reduction has been undertaken for Bendigo WRP recycled water, so salinity will be similar to historical levels. Over the last 2 years, the salinity has typically ranged from approximately 500 to 800 mg/L TDS with a median of approximately 600 mg/L TDS. Following November 2007 (Milestone 2), the increased water treatment will reduce this salinity. However, the level of reduction has not yet been determined.

BML mine water has an upper limit of 350 mg/L TDS. In general, the Bendigo WRP and BML streams will be mixed at a ratio of approximately 2:1, and the resulting salinity will typically be below 500 mg/L TDS.

The salinity of the combined stream is likely to vary over time, and in a worst case when Bendigo WRP water only is supplied, the salinity may be elevated for a short time. However it should be noted that most salinity impacts are chronic rather than acute. Therefore it is appropriate to use the long term average salinity in an assessment of risk.

The rural channel users have historically received water with 100 – 450 mg/L TDS, while parks and gardens using the town potable supply have received 160 – 500 mg/L TDS. Supply of recycled water will result in a small increase in salinity for all customers. However, the salinity level of the recycled water is still relatively low.

Potential On-site Impacts

Increasing Soil Salinity (Osmotic Effect)

Salt in the soil increases the force a plant must exert to extract water – referred to as the osmotic effect. The risk of salt accumulating in the soil depends on the irrigation water quality and the adequacy of drainage through the soil profile. Impacts of any build up are then dependent on plant sensitivity to soil salinity.

A risk assessment method for increasing soil salinity is presented in EPA Publication 168a (Draft Version 4, Prepared by RMCG for EPA Victoria, March 2004), as follows:

Table C Risk of Increasing Soil Salinity

Application Salinity, mg/L TDS	Soil Class				
	I	II	III	IV	V
<175	VL	VL	VL	L	L
175-500	VL	VL	L	L	M
500-1000	VL	L	M	M	H
1000-1500	L	M	M	H	E
>1500	M	M	H	E	E

Soil class denotes the permeability of the soil, with Class I being the most permeable and Class V the least permeable. The assessment presented assumes annual rainfall < 700 mm, which is appropriate for Bendigo.

After mixing with BML mine water, the salinity of the recycled water to be delivered will typically be less than 500 mg/L TDS. Table C shows that the risk of salts accumulating in the soil is low, unless the soil is impermeable. In the Bendigo area there are two distinct land systems – alluvial flood plains and sedimentary hills. The majority of irrigated areas are on the alluvial flood plains as these have the better soils (approximately Class III). Where areas within the sedimentary hills are irrigated, some Class V soils may be encountered and these may be subject to a slight increase in soil salinity.

This risk assessment is relevant for both residential garden watering and irrigators, most of whom produce small amounts of crops on "hobby farms".

Customers irrigating Class V soils can improve soil drainage by the addition of organic matter or imported soil. The alternative is to avoid growing salt sensitive plants (eg. azaleas, roses, fruit trees), which tend to be unsuited to poorly drained soils in any case.

Foliar Injury

Foliar injury occurs due to excess quantities of sodium and chloride in the irrigation water being absorbed through leaves wet by sprinkler irrigation. (Note that sodium and chlorides are components of the total dissolved solids or salinity. They are monitored individually.)

Monitoring data for ion concentrations from Bendigo WRP indicates that chloride concentration is 250-310 mg/L and sodium concentration is 100-240 mg/L. (Note that consideration of this water source only provides a worst case assessment for foliar injury, which is an acute impact. Chloride and sodium concentrations in the BML stream are lower, so in general the combined stream will contain lower concentrations than considered here.)

Plants vary in their susceptibility to foliar injury. Tolerance levels of some agricultural crops are presented in the *National Guidelines for Water Recycling*, as follows:

Table D Approximate sodium and chloride concentrations that can cause foliar injury in crop plants from saline sprinkling water

Sensitive	Moderately sensitive	Moderately tolerant	Tolerant
Sodium (mg/L)			
<115	115-230	230-460	>460
Chloride (mg/L)			
<175	175-350	350-700	>700
Almond	Pepper	Barley	Cauliflower
Apricot	Potato	Maize	Cotton
Citrus	Tomato	Cucumber	Sugar beet
Plum		Lucerne	Sunflower
Grape		Safflower	
		Sesame	
		Sorghum	

Plants in the sensitive range (eg. citrus, apricot, almond) and the moderately sensitive range (eg. potato, tomato) are at risk of foliar injury.

Risk to these plants can be managed by:

- Avoiding spray irrigation onto plant leaves during the heat of the day;
- Ensuring water does not come into contact with plant leaves, through use of drip/micro-spray, sub-surface irrigation or a hand-held hose directed at the plant base.

Customers will be made aware of these management techniques through the HEMPs.

Cadmium Impacts

Increased salinity concentrations in water can increase uptake of cadmium already in the soil by some plants used for food, potentially making the crop unsuitable for human consumption. According to Appendix 4.6 of the *National Guidelines for Water Recycling*, there can be an increased risk of cadmium contamination of produce if irrigation water salinity is > 1100 mg/L TDS, in combination with other factors. The recycled water to be supplied in this scheme is well below this salinity level.

Sodicity Impacts

Sodicity is a chemical imbalance in the soil, which causes dispersion of clay particles and loss of soil structure. It can be caused through application of water with a high Sodium Absorption Ratio (SAR) or it can occur naturally in soils. Monitoring data for the Bendigo WRP indicates SAR is typically 5 - 6. This results in a low risk of increasing soil sodicity, hence the soil structure is unlikely to be adversely altered by the recycled water.

Stock Drinking

The "Australian and New Zealand Guidelines for Fresh and Marine Water Quality" (ANZECC & ARMCANZ, 2000) provide tolerance levels of livestock to drinking water salinity. Data is provided for beef cattle, dairy cattle, sheep, horses, pigs and poultry. The most sensitive of

these is poultry, preferring salinity levels between 0 – 2000 mg/L TDS. The recycled water to be supplied is comfortably within this range, and is therefore appropriate for stock drinking.

Note that recycled water is not suitable for drinking by pigs. This is due to the risk of “pork measles” rather than salinity.

Potential Off-site Impacts

Impact on surface waters

Salt can migrate to surface waters via direct irrigation runoff or by rainfall runoff picking up salt from the soil.

Direct irrigation runoff can be prevented by irrigating according to plant demand.

The assessment of osmotic impact (see above), indicated that soil salinity is unlikely to increase due to the use of recycled water. Therefore the salinity of rainfall runoff will not be altered.

The risk to surface waters due to salinity is very low.

Impact on groundwater

The water table in the vicinity of Bendigo is relatively close to the surface, particularly in lower lying areas where it can be within 2m. This shallow groundwater is also relatively saline at >~ 6,000 mg/L TDS. Due to this existing high salinity level in the groundwater, there is a low risk of an adverse impact on its beneficial use.

Summary and Conclusion

Table E Salinity – Summary and Conclusion

Potential Salinity Impact	Associated Risk	Management Required
<i>On-site (plant and stock health)</i>		
Increasing Soil Salinity (Osmotic Effect)	Low (with exception of limited areas of impermeable soils)	Improve impermeable soils, or avoid irrigating salt sensitive plants on impermeable soils.
Foliar Injury	Low (except for some sensitive plants)	Avoid sprinkler irrigation direct to plant leaves in the heat of the day.
Sodicity	Low	No specific practices.
Cadmium Uptake	Low	No specific practices.
Stock Drinking	Low	No specific practices.
<i>Off-site environment</i>		
Surface Waters	Low	Prevent irrigation runoff.
Groundwater	Low	No specific practices.

Generally the risks related to the salinity of the recycled water are low. This is particularly the case in relation to stock health and the off-site environment. There are potentially some

issues for customers growing sensitive plants, particularly customers using sprinkler irrigation, and for those irrigating impermeable soils. Customers will be advised to:

- Avoid sprinkler irrigation direct to plant leaves in the heat of the day – relevant to salt sensitive plants only;
- Where impermeable soils (e.g. heavy clays) exist to improve soil drainage (eg. via addition of organic matter or imported soil) or avoid irrigation of salt sensitive plants.

These recommended management practices will be detailed in the HEMPs and customer site management plans. An information sheet will also be available detailing the sensitivity of various plants to salinity.

2.2.2 Nutrients

The nutrient levels in the recycled water sources are:

- Bendigo WRP – 6.3 mg/L total nitrogen, 0.33 mg/L total phosphorus.
- BML – <0.5 mg/L total nitrogen, 0.01 mg/L total phosphorus.

When the Bendigo WRP stream is mixed with BML water at 2:1, the resulting nutrient levels will be approximately 4.5 mg/L total nitrogen and 0.22 mg/L total phosphorus.

Nutrients are required for healthy plant growth and are therefore beneficial to the customer. However an excess build up of nutrients in the soil can result in migration to surface waters and groundwater causing algal blooms and associated water quality problems.

Nutrient balances for various types of end use are provided in the table below.

Table F Nutrient Balances

	Residential gardens, annual pasture, broadacre crops.		Public open space and recreation areas.		Perennial pasture, lucerne.	
	N	P	N	P	N	P
Recycled Water Nutrients (mg/L)	4.5	0.22	4.5	0.22	4.5	0.22
Water application rate (ML/ha/year)	3.0		5.0		7.5	
Nutrient applied (kg/ha/year)	13.5	0.66	22.5	1.1	33.8	1.65
Plant uptake (kg/ha/year)	50	5	50 - 100	5 - 10	250	25

The nutrients applied in the recycled water are well below plant uptake rates. The risk of excess build up in the soil is very low. Customers will be advised through the HEMPs and customer site management plans about the nutrient levels in the recycled water. This enables them to adjust their fertiliser use.

Blue Green Algae

Nutrients naturally occur in all waterways and are essential for ecosystem health and function. However, elevated nutrient levels can stimulate excessive growth of algae. In low numbers algae do not pose a threat to humans or the healthy functioning of wetlands or riverine ecosystems. Algal blooms, especially those involving toxic blue green algae can threaten human and stock health, recreational uses, industry, and aquatic ecosystems.

The risk of toxic algal blooms in recycled water storages has been assessed, and is documented in the following papers:

- “Spring Gully Reservoir Risk Assessment”, included in this Appendix D of the REIP
- “On-site Storage of Recycled Water: Discussion Paper”, included in this Appendix D of the REIP

These documents include proposed management controls for storage of recycled water.