CLIENTS | PEOPLE | PERFORMANCE

Avon Catchment Council

Report for IWM 004 - Transport Assets

Inventory of Water Corporation Pipelines in the Avon River Basin

June 2007

INFRASTRUCTURE | MINING & INDUSTRY | DEFENCE | PROPERTY & BUILDINGS | ENVIRONMENT

Contents

Table Index

Figure Index

Appendices

1. Introduction

1.1 Background

GHD were contracted by the Avon Catchment Council (ACC) to deliver the 2005-2006 Investment Plan Project; Protection of Transport Assets -- IWM004.

The scope of this project includes an assessment of the impact of salinity on transport assets within the Avon River basin and the development of options to better manage the impacts of salinity on roads, rail and airfields. The project includes geographic and technical aspects associated with the impact and management of salinity on key regional transport assets.

Outputs from the Protection of Transport Assets project include:

- *An Inventory of transport assets.*
- *A detailed assessment of roads at risk of salinity.*
- *An assessment of the impact of salinity on culvert materials and design.*
- *The development of a monitoring program.*
- *The provision of technical assistance in the development of demonstration sites throughout the region and the provision of associated extension material.*

1.2 Objective

GHD agreed to undertake a desktop analysis of salinity impacts Water Corporation pipelines in the region.

Presented is an inventory of water distribution assets within the Avon River basin and a desktop assessment of pipelines located in areas affected by salinity, according to the Land Monitor dataset. The analysis includes the Water Corporation distribution (major arterial pipelines) and reticulation pipelines (peripheral lines that service individual properties).

Development of the inventory of water distribution assets within the Avon River basin has included the following components:

- *Liaison with Water Corporation to obtain spatial data describing their scheme network.*
- *Geographic assessment (via GIS) of water distribution assets at risk of salinity using the land monitor risk assessment tool. Assessment was undertaken at a regional scale and reported at a Local Government Authority scale.*

1.3 Management Action Target

Completion of the Desktop Assessment of the *Impact of Salinity on Water Distribution Assets* does not respond to a specific Management Action Target but was produced at the request of the Avon Catchment Council.

2. Background - Impact of Salinity on Pipeline Assets

Presented in this section is an introduction to the potential impacts of salinity on pipeline infrastructure, intended as context to the desktop assessment undertaken.

Dryland salinity threatens a range of assets throughout Australia including: infrastructure, transport assets, agricultural land, the natural environment and water resources. The National Land and Water Resources Audit (NLWRA) undertaken in 2000 suggests that 4.36 million ha of land in Australia was affected by, or was at risk of becoming saline, and that this figure may increase to 8.8 million ha by the year 2050. The cost of salinity is estimated at $1 million per 500 ha of salt affected land, including impacts on a range of natural and man-made assets.

Salinity and waterlogging can increase the rate of degradation of pipes made of a variety of materials. According to the Water Corporation pipeline dataset, the following pipe materials are in existence within the ARB:

- Asbestos Cement (AC)
- Asbestos Cement Concrete Lined (ACL)
- Copper (CU)
- Ductile Iron (DI)
- Galvanised Steel (GS)
- High Density Polyethylene (HDPE)
- Medium Density Polyethylene (MDPE)
- Poly Vinyl Acetate (P)
- Reinforced Concrete (RC)
- Victaulic (a Onesteel trademark brand) (VIC)

Asbestos cement (including concrete lined asbestos cement), ductile iron, galvanised steel and reinforced concrete are all susceptible to premature degradation in the presence of salt and moisture. Degradation mechanisms vary depending on the material and environment, however longevity is typically greatly reduced under moist, saline conditions. Plastic pipes are largely inert and do not generally degrade under the influence of saline water, however much of the pipe networks is constructed of steel or concrete and some fittings and connections of plastic pipes are metallic.

Mechanisms of degradation are often complex and may include chemical and physical attack mechanisms. The severity of attack can be influenced by the presence of dissolved salts, pH and wetting and drying cycles. These issues are dealt within detail in GHD 2006, *Assessment of the Impact of Salinity on the Design and Construction of Culvert Materials.*

3. Data Sources

Documentation of data used in the desktop assessment of Water Corporation pipelines at risk of salinity is presented in this section.

Primary data sets used in the analysis include:

- *Land Monitor: Presence of salinity (1987-1992 and 1995-1998) supplied by the Department of Land Information (DLI) and sourced from the Department of Agriculture.*
- *Pipelines: Distribution mains and reticulation mains that comprise the Goldfields and Agricultural Water Supply (G&AWS) Scheme, supplied by the Water Corporation of WA.*

A number of complementary data sets were employed to enhance the desktop assessment of those pipelines at risk of salinity, including:

- *Digital aerial photography digital terrain model (DTM developed by GHD) derived from 10 m contour data,*
- *Surface water hydrology*
- *Local Government Authority boundaries.*

These data sets were sourced from the Department of Agriculture. Limited metadata was provided with data sourced from the Department of Agriculture, therefore the integrity of data sets sourced from this organisation cannot be guaranteed.

3.1 Land Monitor

Land Monitor is a digital data set derived from interpretation of satellite imagery used to identify areas currently impacted by salinity, in addition to Valley Hazard Mapping.

Land Monitor is the result of a multidisciplinary approach involving multi-date satellite imagery, geographic data (cadastre, hydrogeology, soils, contours) and ground truthing that has generated a tool for mapping, monitoring and predicting landscape scale issues related farming practices in rural areas. The area covered by Land Monitor analysis is 24 million hectares and is generated at a fine scale of 25 m pixels (Spies and Woodgate, 2005).

A combination of bands 4, 5 and 7 are used to investigate sequences of spring and summer data from the period 1988 – 2000 for optimal salt detection (Caccetta et al., 2000). To ensure that non-saline or areas of low productivity are not misinterpreted as saline, three consecutive years of imagery are used to identify areas that consistently map as saline (Allen and Beetson, 1999). The end result is a broad-scale salinity map that can be further used to predict the spread of salinity and identify areas at risk of salinity in rural areas where ground mapping is costly and time consuming.

The Land Monitor project has produced a digital coverage of salt-affected land for much of the south-west agricultural area of Western Australia.

Land Monitor assessment of salinity does not distinguish between areas of salinity and other areas of consistently low vegetative cover, such as white sand, buildings, dams and roaded catchments, which leads to potential misinterpretation. In an attempt to remove this "noise" from the Land Monitor data, the predicted area impacted by salinity was clipped to the areas within 2 metre elevation above of the flow path, as described for Valley Hazard Mapping. The resulting modified Land Monitor salinity coverage is considered more likely to represent areas impacted by valley floor salinity.

Previous assessment of the Land Monitor salinity coverage has indicated an 80% accuracy. It is considered that the Land Monitor data provides a reasonable interpretation of salinity on a large scale, such as over the extent of the Avon River basin or a similar large catchment. *(Caccetta et al., 2000)*

The Land Monitor data set is considered to be a first pass assessment of water distribution assets at risk of salinity.

The most recent Land Monitor data set does not cover the entire Avon River Basin. Table 3-1 provides details of those localities not completely covered by Land Monitor. The majority of the area not covered by land monitor data is located in the east of the catchment.

Table 3-1 Extent of Land Monitor coverage in the Avon River Basin

Shire Name	Proportion of Shire within ARB	Proportion of area within ARB covered by Land Monitor data
Coolgardie	31%	0%
Dundas	1%	0%
Kondinin	100%	57%
Lake Grace	96%	99%
Mukinbudin	92%	87%
Ravensthorpe	4%	46%
Westonia	99%	49%
Yilgarn	88%	26%

3.2 Pipelines

The pipeline dataset was sourced from the Water Corporation.

The data included Distribution and Reticulation pipelines that form the Goldfields and Agricultural Water Supply Scheme. The G&AWS is the branch of the Integrated Water Supply System (IWSS) that services the agricultural areas of the Avon River Basin and further east to the goldfields.

Initial analyses identified data integrity issues with the digital Pipeline coverage provided by Water Corporation, including duplicate lines with some duplicate pipelines described as both reticulation and distribution. This duplication was generally associated to locations where the reticulation network branches from the distribution pipes.

Many of the duplicate lines could not be resolved due to the large size of the dataset. As a result a small number of pipes will be double-counted when reticulation and distribution pipes are analysed in isolation, resulting in a minor over prediction of lengths of pipe.

3.3 Complementary Data

Other datasets were used to support the analysis including:

- *Digital aerial photography,*
- *10 m contour data,*
- *Surface water hydrology,*
- *250,000 Geological Series*
- *Local Government Authority boundaries,*

These data were supplied by the Department of Agriculture and Food. Limited metadata was supplied with these datasets, and therefore the age, source and integrity of datasets are largely unknown.

4. Methodology

The purpose of the Water Corporation pipeline inventory analysis is to determine the extent and spatial location of those water distribution assets, including reticulation and distribution pipelines, currently impacted by or at risk of becoming impacted by salinity.

Spatial analysis was undertaken using the ESRI ARC GIS 9 series platform.

The areas currently impacted by salinity as described by the Land Monitor dataset, including recent saline areas (1995-1998) and older saline areas (1987-1992), were amalgamated. This amalgamated dataset was clipped to remove areas that Land Monitor suggests are impacted by salinity, which occur outside of the Valley Floor Hazard area, two metres elevation above stream height. Areas designated as saline by Land Monitor, located more than two metres above stream height were removed as they were often considered to represent areas of high reflectivity that were not saline land (e.g. shed roofs, sand seams). Thus, their inclusion would give a false representation of the extent of salinity.

This amalgamated dataset describing the “current area of salinity” was used in the analysis for determining the length of water distribution assets likely to be currently impacted by salinity. The result is considered to be a relatively conservative estimate of the area impacted by salinity within the Avon River basin.

5. Results

The discussion of results is divided into four components:

1. Spatial location and analysis of the impact of salinity on the entire pipe network in the Avon River basin.
2. Breakdown of analysis into reticulation and distribution pipes impacted by salinity in the Avon River Basin.
3. Identification and analysis of 'peripheral' scheme areas impacted by salinity.
4. Analysis of the extent/location of steel and cemenet based pipes in the ARB.

5.1 Entire Pipe Network

The entire water pipe network within the Avon River basin was overlaid with the Land Monitor salinity data set, as a means of estimating the likely total length of pipe impacted by salinity within each Local Government Area. The complete analysis results are presented in Appendix A.

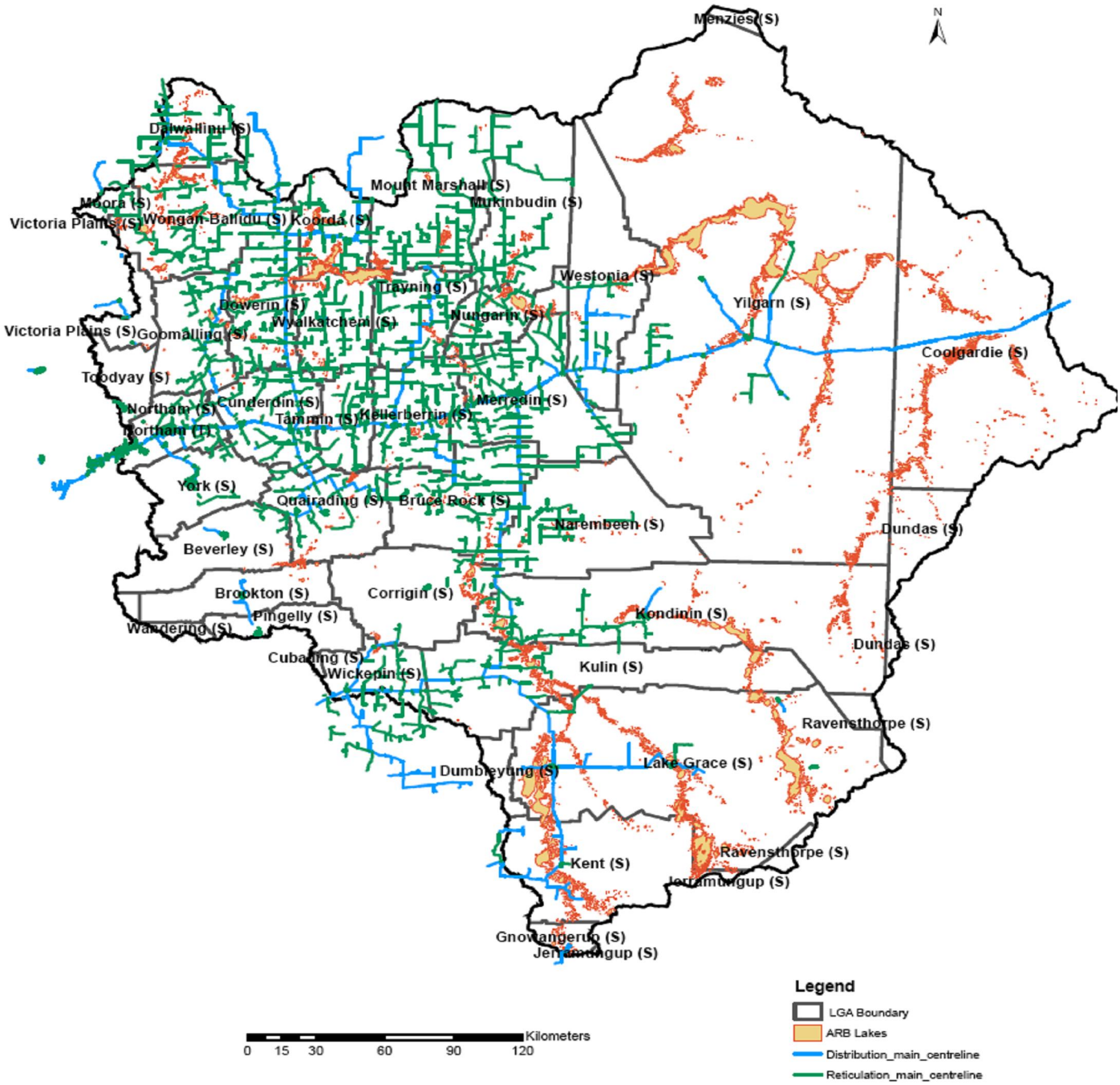
As previously mentioned, the Water Corporation describes pipes within the Avon River basin as being part of either the distribution or reticulation network. As the analysis was undertaken using the unverified Land Monitor assessment of salinity and a digital pipeline dataset provided by the Water Corporation of Western Australia, the results of the analysis should be used as a guide only. The numbers presented may not necessarily be an absolute description of the length of pipe impacted by salinity within each individual Local Government Area. However, the data is considered to provide a good overall estimate of the length of pipe currently impacted by salinity.

There are around 8,765 km of Water Corporation pipeline in the Avon River basin, of which, some 705 km is located in the shire of Merredin, which easily contains the greatest total length of pipeline. The shire of Mount Marshall has the second greatest length of pipe at around 482 km, whilst Wongan Hills, Kellerberrin, Bruce Rock and Cunderdin all have over 400 km of pipe. Figure 5-1 shows the network of pipes that comprise the G&AWS.

In the context of salinity damage, there are 402 km of pipeline in the ARB located in areas designated as saline by Land Monitor. The shires of Wongan Hills, Merredin, Lake Grace, Kondinin, Cunderdin and Tammin all have over 20 km of pipelines in areas that Land Monitor suggests are saline. Wongan Hills contains the greatest length of affected pipe, at just less than 40 kilometres. On average, there are about 11 km of affected pipe in each shire.

In terms of the proportion of affected pipeline in an LGA, the shires of Gnowangerup, Moora, Lake Grace, Kondinin, Kent, Tammin and Wongan Hills have the highest percentage of pipelines located within areas identified as saline by Land Monitor.

Figure 5-1 Water Corporation Pipelines in the Avon River Basin



Each of the aforementioned shires has at least 8% of its pipelines located in areas designated as saline. The average shire has 5% of the pipelines within its boundary located within areas designated as saline by Land Monitor. An analysis of the temporal progression of salinity was also undertaken to highlight shires where salinity impacting pipelines is an emerging problem.

Table 5-1 Breakdown of Pipes Affected by Salinity That developed Post 1995

	Total Length of Pipe in Saline Areas that Developed Post 1995 (metres)	Total Length of Pipe In Saline Areas (metres)	Percentage of All Pipe in Saline Areas that Developed Post 1995
Shire of Yilgarn	9461	11731	81%
Shire of Westonia	9129	12729	72%
Shire of Nungarin	8298	14856	56%
Shire of Narembeen	8448	15472	55%
Shire of Mukinbudin	966	1983	49%
Shire of Victoria Plains	40	86	47%
Shire of Merredin	15523	34644	45%
Shire of Wyalkatchem	3286	7608	43%
Shire of Trayning	7603	18059	42%
Shire of Bruce Rock	6586	15795	42%
Shire of Tammin	8280	20013	41%
Shire of Quairading	3036	8592	35%
Shire of Kellerberrin	6659	18981	35%
Shire of Dalwallinu	2798	9348	30%
Shire of Kent	2451	10484	23%
Shire of Lake Grace	5013	23922	21%
Shire of Wongan-Ballidu	7799	39831	20%
Shire of Mount Marshall	338	1791	19%
Shire of Koorda	1851	10957	17%
Shire of Cunderdin	4669	28478	16%
Shire of Moora	874	5904	15%
Shire of Gnowangerup	345	2578	13%
Shire of Kondinin	2898	21709	13%
Shire of Dowerin	972	8965	11%
Shire of Beverley	237	2242	11%
Shire of Northam	649	7618	9%
Shire of York	121	1735	7%
Shire of Goomalling	1165	17280	7%
Shire of Corrigin	456	6804	7%
Shire of Wickepin	858	13512	6%
Shire of Brookton	78	1578	5%
Shire of Kulin	185	6697	3%
Town of Northam	0	176	0%
Shire of Coolgardie	0	0	#DIV/0!
Shire of Cuballing	#N/A	#N/A	#N/A
Shire of Dumbleyung	#N/A	#N/A	#N/A
Shire of Pingelly	0	0	#DIV/0!
Shire of Toodyay	0	0	#DIV/0!

Top 5 shires in terms of percentage of pipes in saline areas that developed post 1995.
Top 6 shires in terms of total length of pipe in saline areas.

The above table indicates that shires located in the eastern reaches of the ARB have experienced a considerable rise in the prevalence of salinity since 1995. Salinity has largely expressed itself in the shires of Yilgarn, Westonia, Mukinbudin, Nungarin and Narembeen, in the period of time post 1995. Of the pipes located in saline areas in the shire of Yilgarn, 81% are situated in areas that have only become saline since 1995. Given that the shires of Yilgarn and Mukinbudin currently have some of the lowest percentages of salinity-affected pipes, there is potential that these shires will experience an increase in the effects of salinity on Water Corporation assets in the future.

Table 5-1 suggests that salinity in the southern and western parts of the catchment has reached a more developed state than the northeastern reaches. Pipelines in salinity affected areas that developed post 1995 in the shires of Kulin, Brookton and Wickepin account for 6 %, or less of the total length of pipes located in saline areas in these shires.

Whilst the above trends are based on a relatively cursory analysis, they are generally consistent with expectations, based on existing knowledge. For example, in the western portion of the catchment, Land Monitor analysis suggests that salinity developed reasonably early in comparison to the eastern areas of the Avon River Basin. This is to be expected given the area was cleared earlier than the eastern wheatbelt and it had a comparatively shallow depth to groundwater at the time of clearing.

In summary, the above data analysis indicates that salinity impacts water distribution assets to different extents in different areas of the ARB. LGAs located within the North East of the Avon River Basin generally experience emerging issues associated with salinity impacting water distribution assets, whilst within the west and the southern parts of the Avon River basin, salinity is more likely to be reaching equilibrium. LGAs in the southern and western reaches of the catchment generally possess a greater proportion of pipeline that is affected by salinity.

5.2 Analysis of Reticulation and Distribution Pipelines

As previously mentioned, the pipelines that constitute the G&AWS are divided into distribution and reticulation pipelines. Distribution pipelines comprise major pipes that form the backbone of the delivery network. Conversely, reticulation pipelines are smaller pipes that branch from the distribution pipes and deliver water to more specific locations, sometimes to only one landholder at the limit of their extent.

A breakdown of the pipeline analysis is thought to be of value in that it provides an idea of the spatial distribution of the reticulation and distribution network. In addition, this analysis highlights those LGAs that have a significant length of reticulation pipes located in areas affected by salinity.

The output of this analysis is presented in Appendix B, and an abridged version of this information is presented overleaf.

	Distribution Pipelines			Reticulation Pipelines		
	Total Length of Pipe in LGA (m)	Total Length of Pipe Affected by Salinity (m)	% of Pipes In Saline Areas	Total Length of Pipe in LGA (m)	Total Length of Pipe Affected by Salinity (m)	% of Pipes In Saline Areas
Shire of Beverley	8706	17	0%	62605	2226	4%
Shire of Brookton	29928	1520	5%	17589	58	0%
Shire of Bruce Rock	57441	695	1%	414982	15100	4%
Shire of Coolgardie	76995	0	0%	14	0	0%
Shire of Corrigin	18949	404	2%	76139	6400	8%
Shire of Cunderdin	124316	15206	12%	297121	13272	4%
Shire of Dalwallinu	54983	1971	4%	146299	7377	5%
Shire of Dowerin	77124	2050	3%	311804	6915	2%
Shire of Gnowangerup	8176	2578	32%	#N/A	#N/A	#N/A
Shire of Goomalling	55421	5906	11%	228930	11374	5%
Shire of Kellerberrin	95749	8638	9%	327069	10343	3%
Shire of Kent	102087	10208	10%	6590	276	4%
Shire of Kondinin	34729	472	1%	253307	21237	8%
Shire of Koorda	54440	2639	5%	180075	8318	5%
Shire of Kulin	63356	600	1%	208339	6097	3%
Shire of Lake Grace	179466	14224	8%	77841	9698	12%
Shire of Merredin	117335	6618	6%	587569	28026	5%
Shire of Moora	#N/A	#N/A	#N/A	58568	5904	10%
Shire of Mount Marshall	3091	0	0%	479403	1791	0%
Shire of Mukinbudin	#N/A	#N/A	#N/A	325161	1983	1%
Shire of Narembeen	17440	1500	9%	233484	13972	6%
Shire of Northam	100387	2655	3%	214854	4963	2%
Shire of Nungarin	5110	125	2%	228248	14731	6%
Shire of Pingelly	4154	0	0%	24154	0	0%
Shire of Quairading	86131	2818	3%	191813	5774	3%
Shire of Tammin	26488	9522	36%	187513	10490	6%
Shire of Toodyay	#N/A	#N/A	#N/A	22532	0	0%
Shire of Trayning	65155	8025	12%	276471	10035	4%
Shire of Victoria Plains	1102	0	0%	3074	86	3%
Shire of Westonia	132476	8886	7%	107573	3843	4%
Shire of Wickepin	75840	5217	7%	142420	8295	6%
Shire of Wongan-Ballidu	67378	3210	5%	408728	36621	9%
Shire of Wyalkatchem	8074	116	1%	276762	7491	3%
Shire of Yilgarn	237734	9548	4%	157242	2183	1%
Shire of York	23559	485	2%	129341	1250	1%
Town of Northam	#N/A	#N/A	#N/A	88730	176	0%
AVERAGE of LGAs	62916	3933	6%	192924	7894	4%
SUM of LGAs	2013320	125853	6%	6752341	276305	4%

Top 6 Shires by total length of pipe in LGA

Top 5 shires by either total length, or percentage of pipe in salt affected areas

In terms of distribution pipes, the shires of Tammin, Gnowangerup, Cunderdin, Trayning, and Goomalling have the highest percentage of pipes located in areas designated as saline by Land Monitor. 36 % of the distribution pipes in Tammin lie in saline areas, 34 % in Gnowangerup and 12 % in Cunderdin. When considering the magnitude of distribution pipes affected, Cunderdin contains the most pipes in saline areas, at 15.2 km. The shires of Kent, Lake Grace, Tammin and Yilgarn also have significant lengths of Water Corporation pipe in saline areas. The location of distribution pipes in saline areas is a concern in that these pipes are necessary to distribute water to reticulation networks further down the line. Thus, their functionality is not restricted to the immediate areas that they serve, but rather, extends to areas 'downstream'.

It should be noted that a large proportion of the distribution pipes located in saline areas (according to Land Monitor data) in the shires of Tammin and Cunderdin are more than likely located in the salt-affected sites adjacent to the Great Eastern Highway. Concrete supports are generally employed to raise the pipes in this area above the level of saline flows, and as such, the accelerated degradation of the pipes themselves as a result of saline conditions, is usually not such a pressing concern. However, the decay of the supports is heightened under such conditions and their maintenance/ replacement is a further action required of the Water Corporation. Also an issue where pipelines go underground at road crossings and for scour valve pits. Also deterioration of thrust blocks at change of direction.

The LGAs that present the greatest length of reticulation pipe in saline areas, according to Land Monitor, include:

1. Wongan Hills (36.6 km)
2. Merredin (28 km)
3. Kondinin (21.24 km)
4. Bruce Rock (15 km)
5. Nungarin (14.7 km)

The following shires have the greatest percentage of their reticulation pipes located in areas designated as saline by Land Monitor:

1. Lake Grace (12%)
2. Moora (10%)
3. Wongan Hills (9%)
4. Corrigin (8%)
5. Kondinin (8%)

The most significant inference that can be gleaned from the above analysis, in conjunction with Table 5-1, is that there appears to be potential for salinity to encroach on a significant length of reticulation pipe in the future.

The above figures show that both Bruce Rock and Merredin already have more than 15 km of reticulation pipe located in saline areas, and yet, when these figures are viewed in percentage terms, they represent a relatively small proportion of all pipes within each LGA. If salinity in these shires develops in a comparable way to the shires of Lake Grace, Moora and Wongan Hills, then it is reasonable to assume that a significant length of reticulation pipes will become affected by salinity.

Further evidence for the potential advancement of salt-affected pipes stems from the fact that, as Table 5-2 indicates, salinity in some shires is developing at a different rate to others.

Table 5-2 Top 6 LGAs in terms of % of pipes located in saline areas that developed post 1995

Top 6 LGAs by % of pipes in saline areas that developed post 1995			
DISTRIBUTION PIPES		RETICULATION PIIPES	
Bruce Rock	90	Westonia	87
Yilgarn	91	Yilgarn	79
Westonia	65	Narembeen	58
Merredin	64	Nungarin	56
Nungarin	60	Trayning	56
Tammin	49	Mukinbudin	49

Importantly, the shires that have developed a large proportion of their salinity post 1995 currently don't have significant proportions of their pipelines located in saline areas. For example, 87% of Westonia's reticulation pipelines that are located in salinity-affected areas are in sites that only became saline after 1995. This suggests that salinity is still progressing in this LGA and has the potential to increase further. At present, only four percent of the reticulation pipes in the Westonia shire are affected by salinity. If this figure were to increase to a figure of eight percent (which is consistent with shires that experience advanced salinity) this presents a further 3.8 km of pipe that would be situated in saline areas.

The above comparisons assume that the experience of shires with well-developed salinity will similarly translate to those LGAs where salinity is only just beginning to express itself. To some degree, this is a reasonable extrapolation, but ultimately, the length of pipe in a given LGA that will be placed at risk of saline degradation, will be dependent upon: the equilibrium level of salinity in the concerned catchments and the location of the pipe within the LGA (i.e. whether pipes are located in the valley floors, which are prone to salinisation, or if they are located higher up in their respective catchments).

5.3 Analysis of 'Peripheral' Scheme Areas Affected by Salinity

The identification of outlying, peripheral scheme areas is a somewhat subjective exercise, but the following criteria were applied in an attempt to formalise the process of selecting lengths of pipe to be classified as 'peripheral':

- The concerned pipe is a reticulation main;
- The pipe should be at the end of a line and not supply water to subsequent pipelines, which in turn service additional users; and
- The pipe should be a considerable distance from a distribution main.

Eight sites that contain a significant area of salinity, in addition to a length of pipeline identified as 'peripheral' are presented in Figure 5-2 overleaf. These sites are located in the shires of Lake Grace, Kondinin, Narembeen, Merredin, Trayning, Koorda, Wongan – Ballidu and Goomalling.

A large proportion of the pipes in the locations displayed in Figure 5-2 are either asbestos cement or steel, both of which are susceptible to accelerated degradation in saline conditions. A large majority of the asbestos cement pipes in question were installed in the 1960's and 1970's, although in Kondinin, most of the asbestos cement pipes were installed in 1955. Steel pipes are generally of the same vintage but in Wongan Hills, some of the steel pipes located in the area highlighted in Figure 5-2 were installed in 1919.

In most cases, some pipelines were constructed more recently in each of the highlighted areas (whether these pipes were replacing old ones, or simply extending the network is unclear). As a general rule, these new pipes are made of PVC or MDPE, which are less susceptible to degradation in the adverse conditions presented by saline sites. The majority of the peripheral reticulation pipe network identified in Kondinin consists of PVC and MDPE pipes.

Interestingly, the life expectancy of the Water Corporation pipes, (which is included as an attribute in the Water Corporation pipeline data that was supplied to GHD) as predicted by the Water Corp, does not vary according to the location of the pipe. Therefore, pipes located in saline areas are given the same estimated life expectancy as those located high up in a catchment, away from rising groundwater. The analysis undertaken as part of this study may enable the life expectancy of pipes in saline areas to be revised accordingly. This is considered to be important data to be captured in the Water Corporation asset management systems.

Avon River Basin - Peripheral Pipelines In Saline Areas

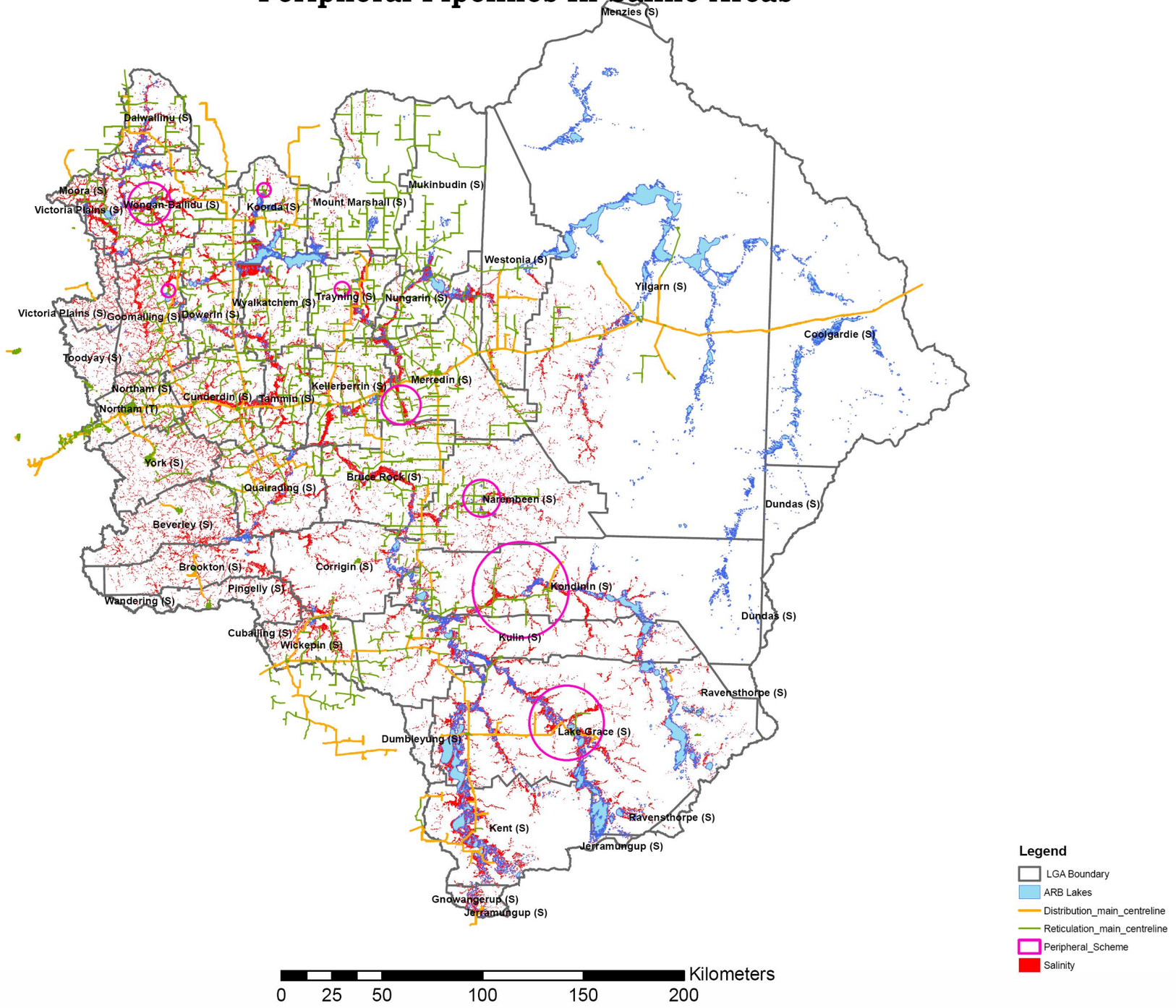


Figure 5-2 Avon River Basin – Peripheral Pipelines Located In Saline Areas

5.4 Extent and Location of Steel and Concrete Pipes

5.4.1 Reticulation Pipes

The majority (78.7%) of reticulation pipes are comprised of steel or cement-based pipes. This equates to some 5628.8 km of pipe network. Around 1529 km, or 21.3% of reticulation pipeline is PVC, HDPE or MDPE pipe.

The distribution of plastic reticulation pipes across the ARB would best be described as a 'smattering'. There are significant lengths of PVC, HDPE and MDPE pipe in the shires of Mount Marshall, Mukinbudin, Kondinin, Wongan Hills, Westonia, Merredin and Narembeen as evidenced in Table 5-3.

Table 5-3 Length of PVC, MDPE & HDPE Pipe in Selected Shires in the ARB

Shire	Length of PVC, MDPE, HDPE Pipe in LGA (km)
Kondinin	129
Merredin	114
Mount Marshall	220
Mukinbudin	110
Narembeen	60
Westonia	53
Wongan Hills	110

There appears to be a general trend toward the replacement of steel and concrete reticulation pipes with pipes that are likely to achieve greater longevity. The above shires, which contain the majority of PVC, MDPE and HDPE pipelines are generally located on the margins of the scheme and the pipes have been installed relatively recently. However, these pipes are obviously not suitable for use in some applications e.g. high-pressure applications.

6. Discussion

Water distribution assets in the Avon River Basin are extensive and very important to the economy, livelihood and standard of living in the region.

Damage to pipeline assets associated with salinity and rising water tables can be severe and potentially costly in terms of the replacement and maintenance of pipelines. The extent of salinity within the region is generally accepted to be increasing and consequently, the length of pipe likely to be impacted by salinity in the future is also anticipated to increase.

There are approximately 8,765 km of pipelines within the Avon River basin, of which, 402 km (4.6 %) are situated in areas described as saline by the Land Monitor dataset. Approximately 126 km of distribution pipelines are located in areas impacted by salinity (according to Land Monitor data) and a further 276 km of reticulation pipelines are in areas considered to be saline.

The Local Government Authorities of Lake Grace, Merredin, Wongan-Ballidu, Kondinin, Cunderdin, Narembeen and Tammin are the worst impacted in terms of the length of Water Corporation pipelines intersecting Land Monitor saline areas. In terms of the proportion of pipelines affected in an LGA, Gnowangerup, Kondinin, Kent, Moora, Lake Grace, Tammin and Wongan-Ballidu are the worst affected.

The analysis also indicates that shires located east of the medium watershed (including Yilgarn, Westonia, Mukinbudin, Narembeen and Nungarin) have experienced a significant increase in the impact of salinity on pipelines post 1995. However, to date, a relatively low proportion of pipes in these shires have been impacted by salinity in comparison to other LGAs.

The desktop analysis undertaken relies heavily on the Land Monitor data set, which is derived from the interpretation of satellite imagery. This data has inherent errors, which should be taken into account when considering outcomes from the analysis.

There are a number of areas of peripheral scheme that intersect sites identified as saline by Land Monitor. The viability of these lengths of pipeline, in light of their maintenance costs is somewhat questionable, given that they serve relatively few people. Some parts of the pipelines that were labelled peripheral consist of plastic pipes that are largely resistant to the adverse environmental conditions associated with saline sites. Whether this course of action is a strategy of the Water Corporation is unknown.

The vast majority of pipes within the ARB are made of materials that are susceptible to premature degradation in the presence of salt and moisture. There appears to have been a trend toward the installation of plastic pipes that are largely immune to the action of salt in recent years. However, these pipes still only account for just over 20 % of all pipes in the region.

This analysis has indicated that salinity presents a significant threat to the longevity of pipelines in the ARB and that the length of pipe affected by saline flows and rising water tables is expected to increase in coming years.

7. References

Allen & B. Beetson (1999) The Land Monitor Project; A Multi-agency project of the Western Australian Salinity Action Plan supported by the Natural Heritage Trust. *Proceedings of WALIS Forum 1999*, Perth, WA, March 1999, pp. 74-77.

Caccetta, P. A., Allan, A. and Watson, I. (2000), *The Land Monitor project*, Proceedings of the Tenth Australasian Remote Sensing Conference.

GHD 2006. *Assessment of the Impact of Salinity on the Design and Construction of Culvert Materials*, Avon Catchment Council, Northam WA.

McRobert, J., Foley, G., *The Impacts of Waterlogging and Salinity on Road Assets: a Western Australian Case Study*, 1999, ARRB Transport Research, Vermont South Victoria

Salinity and Rising Water Tables – Risk to Road Assets, 2004, prepared by ARRB Transport Research for Austroads, Sydney NSW

Spies, B. and Woodgate, P. (2005). *Salinity mapping methods in the Australian context.* Department of the Environment and Heritage; Agriculture, Fisheries and Forestry, June, 2005.

Appendix A

Length of Pipe Impacted by Salinity – Shires of the Avon River Basin

	Total Length of Pipeline (metres)	Total Length of Pipe In Saline Areas (metres)	Percentage of Pipes in Saline Areas
Shire of Beverley	71311	2242	3%
Shire of Brookton	47516	1578	3%
Shire of Bruce Rock	472423	15795	3%
Shire of Coolgardie	77009	0	0%
Shire of Corrigin	95088	6804	7%
Shire of Cuballing	#N/A	#N/A	#N/A
Shire of Cunderdin	421437	28478	7%
Shire of Dalwallinu	201281	9348	5%
Shire of Dowerin	388928	8965	2%
Shire of Dumbleyung	#N/A	#N/A	#N/A
Shire of Gnowangerup	8176	2578	32%
Shire of Goomalling	284352	17280	6%
Shire of Kellerberrin	422818	18981	4%
Shire of Kent	108677	10484	10%
Shire of Kondinin	288036	21709	8%
Shire of Koorda	234515	10957	5%
Shire of Kulin	271694	6697	2%
Shire of Lake Grace	257308	23922	9%
Shire of Merredin	704903	34644	5%
Shire of Moora	58568	5904	10%
Shire of Mount Marshall	482494	1791	0%
Shire of Mukinbudin	325161	1983	1%
Shire of Narembeen	250924	15472	6%
Shire of Northam	315240	7618	2%
Shire of Nungarin	233358	14856	6%
Shire of Pingelly	28309	0	0%
Shire of Quairading	277944	8592	3%
Shire of Tammin	214001	20013	9%
Shire of Toodyay	22532	0	0%
Shire of Trayning	341626	18059	5%
Shire of Victoria Plains	4176	86	2%
Shire of Westonia	240049	12729	5%
Shire of Wickepin	218260	13512	6%
Shire of Wongan-Ballidu	476107	39831	8%
Shire of Wyalkatchem	284836	7608	3%
Shire of Yilgarn	394976	11731	3%
Shire of York	152900	1735	1%
Town of Northam	88730	176	0%
All LGAs	8765661	402158	5%

Top 7 Shires by Percentage of Pipeline Located in Land Monitor Saline Areas

Appendix B

Length of Distribution and Reticulation Pipes Impacted by Salinity – Shires of the Avon River Basin

Water Corporation Pipelines - Distribution and Reticulation Pipelines in Saline Areas										
	DISTRIBUTION PIPELINES					RETICULATION PIPELINES				
SHIRE	Total	Salinity 1987 - 1992	Salinity 1995 - 1998	Total Salinity	% after 1995	Total	Salinity 1987 - 1992	Salinity 1995 - 1998	Total Salinity	% after 1995
Shire of Beverley	8706	17	0	17	0%	62605	1988	237	2226	11%
Shire of Brookton	29928	1442	78	1520	5%	17589	58	0	58	0%
Shire of Bruce Rock	57441	72	623	695	90%	414982	9136	5964	15100	39%
Shire of Coolgardie	76995	0	0	0	#DIV/0!	14	0	0	0	~
Shire of Corrigin	18949	241	163	404	40%	76139	6106	293	6400	5%
Shire of Cunderdin	124316	12626	2580	15206	17%	297121	11183	2090	13272	16%
Shire of Dalwallinu	54983	1655	316	1971	16%	146299	4895	2483	7377	34%
Shire of Dowerin	77124	1963	88	2050	4%	311804	6031	884	6915	13%
Shire of Gnowangerup	8176	2233	345	2578	13%	#N/A	#N/A	#N/A	#N/A	#N/A
Shire of Goomalling	55421	5669	237	5906	4%	228930	10446	928	11374	8%
Shire of Kellerberrin	95749	6167	2470	8638	29%	327069	6155	4189	10343	40%
Shire of Kent	102087	7758	2450	10208	24%	6590	276	1	276	0%
Shire of Kondinin	34729	301	171	472	36%	253307	18510	2727	21237	13%
Shire of Koorda	54440	2451	188	2639	7%	180075	6655	1663	8318	20%
Shire of Kulin	63356	575	25	600	4%	208339	5937	160	6097	3%
Shire of Lake Grace	179466	12002	2222	14224	16%	77841	6908	2791	9698	29%
Shire of Merredin	117335	2362	4256	6618	64%	587569	16758	11267	28026	40%
Shire of Moora	#N/A	#N/A	#N/A	#N/A	#N/A	58568	5029	874	5904	15%
Shire of Mount Marshall	3091	0	0	0	~	479403	1454	338	1791	19%
Shire of Mukinbudin	#N/A	#N/A	#N/A	#N/A	#N/A	325161	1017	966	1983	49%
Shire of Narembeen	17440	1150	350	1500	23%	233484	5874	8098	13972	58%
Shire of Northam	100387	2422	232	2655	9%	214854	4547	416	4963	8%
Shire of Nungarin	5110	50	75	125	60%	228248	6508	8223	14731	56%
Shire of Pingelly	4154	0	0	0	~	24154	0	0	0	~
Shire of Quairading	86131	1741	1077	2818	38%	191813	3815	1959	5774	34%
Shire of Tammin	26488	4810	4713	9522	49%	187513	6923	3567	10490	34%
Shire of Toodyay	#N/A	#N/A	#N/A	#N/A	#N/A	22532	0	0	0	~
Shire of Trayning	65155	6018	2006	8025	25%	276471	4438	5596	10035	56%
Shire of Victoria Plains	1102	0	0	0	~	3074	46	40	86	47%
Shire of Westonia	132476	3094	5791	8886	65%	107573	505	3338	3843	87%
Shire of Wickepin	75840	4759	458	5217	9%	142420	7895	400	8295	5%
Shire of Wongan-Ballidu	67378	3160	50	3210	2%	408728	28872	7749	36621	21%
Shire of Wyalkatchem	8074	116	0	116	0%	276762	4206	3286	7491	44%
Shire of Yilgarn	237734	1801	7747	9548	81%	157242	469	1714	2183	79%
Shire of York	23559	443	42	485	9%	129341	1171	79	1250	6%
Town of Northam	#N/A	#N/A	#N/A	#N/A	#N/A	88730	176	0	176	0%
AVERAGE	62916	2722	1211	3933	26%	192924	5542	2352	7894	28%

GHD Pty Ltd ABN 39 008 488 373

GHD House, 239 Adelaide Tce. Perth, WA 6004
P.O. Box Y3106, Perth WA 6832
T: 61 8 6222 8222 F: 61 8 6222 8555 E: permail@ghd.com.au

Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
	B Seaby M Giraudo	G Love		M. Goldstone		17/07/07