REPORT

Coolimba Power Station Project
Surface Water Assessment

Prepared for

Aviva Corporation Limited

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Executive Summary

Aviva Corporation Ltd (Aviva) proposes to develop the Coolimba Power Station Project (CPS project), located 8km south-west of Eneabba, Western Australia, approximately 270km north of Perth. The project will involve developing the Coolimba Power Station, which is to be supplied by the adjacent sub-bituminous coal deposit (the Central West Coal Deposit), a related project proposed by Aviva. Coolimba Power Pty Ltd, a wholly owned subsidiary of Aviva Corporation Limited, will construct and operate the Coolimba Power Station, at the south west corner of the coal mine. The anticipated life of the mine is approximately 30 years. The Coolimba Power Station project will disturb an area of 483ha, 50ha of which is vegetated.

Existing Surface Water Environment

The project area is located in the Lake Indoon catchment, which drains south-west towards Lake Indoon. Lake Indoon catchment covers an area of approximately 373km^2, comprises three main catchment areas, and is drained by Erindoon and Bindoon Creeks. The proposed power station is located either side of Bindoon Creek and between Bindoon and Erindoon Creeks.

Rainfall and runoff

The closest rain gauged location to the project area is at Eneabba. Mean annual rainfall, obtained from climatic data recorded at the meteorological station at Eneabba (since 1964), is 505mm and mean annual evaporation is 2,439mm. The area experiences considerable variation in annual rainfall from less than 300mm to in excess of 850mm.

Infiltration tests were performed in various locations in the catchment and found to range from 110–1000mm/hr. The infiltration rates generally exceed the rainfall intensities for the area. This means that surface water runoff is only occurring sporadically as a result of high intensity rainfall events.

There are two sites with limited stream flow data (1969-1975). These records are inadequate to be used for stream flow calibration purposes. The estimation of runoff volumes from the various sub-catchments into Lake Indoon can not be estimated with a reasonable degree of accuracy. To establish the baseline runoff volumes, a surface water monitoring program collecting stream flow data is required.

Surface water Quality

There is little surface water quality data available for this catchment. The Department of Water has three sampling sites in the catchment. Two along Bindoon Creek which becomes Lake Indoon Creek in its downstream portion (indicated in Figure 2-1) and Lake Indoon itself. The samples taken at Lake Indoon indicate that the water quality in the lake is within the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (2000) for wetlands.

Environmental Issues and Impacts

The proposed Power Station site is located adjacent to the southern end of the mine path. The power generation facilities occupy the northern part of the plant site, while the southern part houses several evaporation ponds. This cluster of development will isolate and obstruct the surface runoff from the upstream catchment. This surface runoff will need to be diverted around the facilities. The hydraulic flood modelling also indicates that the north-east corner of the raised foundation of the Power Station site encroaches into the 100 year ARI floodplain of Erindoon Creek, and increases water levels at this location due to decreased drainage surface area. This imposes a minor inundation risk to the Power Station and a potential damage risk to the plant facilities. This increase in water levels at the plant location may alter flow patterns in the catchment downstream of the pit (in terms of peak discharge rate, flow volume and water quality) which will impact on the downstream ecosystems.

Two issues regarding the impact of the project on the regional surface runoff regime are:

- The Lake Logue-Indoon System is listed on the Directory of Important Wetlands in Australia. The project is located within the Lake Logue-Indoon catchment and therefore may impact on the Lake

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Logue-Indoon System, especially its groundwater-dependant ecosystem (GDE), due to the diversion of Erindoon Creek around the pit. This impact is expected to be minimal.

- The Eneabba Public Drinking Water Supply Area is located to the east and upstream of the project area, but does not intersect the project area, and is unlikely to be impacted.

Certain areas within the Lake Indoon catchment will be occupied by the development, such as the storage ponds. This development will impede and isolate surface flow from the rest of the catchment. This surface flow is effectively lost to the natural system.

Approximately 11GL per annum will be required by the Power Station for process and cooling, with 8GL being provided by dewatering the adjacent coal mine and 3GL per annum likely to be sourced from the Yarragadee or Cattamarra aquifer. The raw mine water is expected to have an average salinity of 2,500mg/L Total Dissolved Solids (TDS) and a pH of approximately 7. Water sourced from dewatering the mine will be transported from the raw water storage pond to the Power Station via a water pipeline. Following treatment, the water will be used both as process water and cooling water for the Power Station operation. Most of the water is consumed in the cooling towers, where water is evaporated and expelled to atmosphere in order to reject low temperature waste heat from the Power Station. The process water within the water/steam circuit of the power plant is largely recirculated in a closed loop system.

The waste water sources that are directed to the evaporation pond in general contain a concentrated form of the dissolved natural contaminants carried into the plant. These contaminants generally consist of salts, carbonates, silicates, sulphates and other elements at trace levels. The salts and other minor constituents are concentrated in the evaporation ponds. Residue that remains after the water has been evaporated will be returned along with the ash to the mine and covered as part of the ongoing mine backfill operation. The proposed evaporation ponds will occupy approximately 150ha, will be approximately 1.5m deep (1.2m working depth) and be lined with an impermeable liner to ensure no leaching of water to the external environment. The resulting capacity of the ponds will be approximately 8GL of water.

On the water quality aspects, the area of disturbed ground associated with the power station may increase the sediment load carried by natural drainage channels in the project area. This includes the initial waste rock dump, ROM pad, haul road, lay-by area and stock piles. Water quality may also be chemically affected by runoff from fuel from and workshop area.

Terrenus Earth Sciences (TES) in its report “Geochemical Assessment of Overburden, Potential Coal Reject and Coal Combustion Ash for the Central West Coal Project and Coolimba Power Station (October 2008)” has determined that almost all potential reject materials (including coal) are expected to be potentially acid forming (PAF). The assessment recommended all potential coal reject materials will need to be carefully managed to minimise oxidation, generation of acid and potential release of metals (and salts) into the environment. TES recommended encapsulation of PAF material within NAF material to effectively remove it from oxidising environments and the hydrologic cycle of the project area as one possible management measure. TES also recommends leachate and site water derived from, or in contact with, spoil piles reject materials or other mineral waste should be monitored to ensure the soluble metals and salt concentrations are below regulatory guidelines or licence conditions (TES, 2008).

CPS is required to operate with zero discharge of wastewater from the various processes associated with power generation such as clarification, RO treatment, Cooling Tower and Demin Plant. This does not include other wastewater such as treated sewage, runoff from a large on-site coal stockpile and stormwater runoff from other hardstand areas of the power station, which will be discharged into two sediment ponds to remove any excessive sediment load and allowed to discharge into the environment.

The statistical analysis of the SILO generated long term rainfall data (1889-2007) for Eneabba suggests that annual rainfall has been declining over the past 40 years. The analysis of seasonal rainfall data identifies a decline in winter rainfall from the 1960’s to 2007, whilst summer rainfall trend is increasing slightly although the impact of this on annual rainfall trends is minimal. The reduction in rainfall will result in a reduction of water in the catchment area, which may affect GDE’s. Dewatering of the mine to supply the power station is expected to exacerbate the impact on GDE’s.

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Surface Water Management and Mitigation of Imapcts

To address the defined issues and mitigate the potential impacts of the project, a Surface Water Management Plan has been formulated. The main objectives for the Surface Water Management Plan include:

- Managing the quantity and quality of water entering the water courses, so that existing and potential environmental values, including ecosystem maintenance are maintained, and discharges do not adversely affect environmental values, health, welfare or amenity of people and land uses.
- Minimization of the impact on the natural hydrological regime in terms of maximum flood water level, peak flow rates and flow volume.
- Minimization of inundation and damage to access roads and other power station infrastructure.

Stormwater management, surface water discharges and activities that discharge to the environment are managed under a licence issued by the DEC under the Environmental Protection Act. Coolimba Power Pty Ltd is committed to managing these aspects of surface waters to meet licence requirements and the following standards:

- DoW Water Quality Protection Guidelines.
- ANZECC and ARMCANZ guidelines for the protection of marine and freshwater ecosystems.

A more permanent diversion drain along the south end of the power station will be constructed to divert water around the power station site. This drain crosses the 75m Power and Gas Corridor Easement for the Coolimba Power Station. The hydraulic flood modelling shows that the flood level at the north-east corner of the power station site, in a 100 yr ARI event, is RL 77mAHD. The power station platform level is set at RL 83mAHD, hence having minimal flood risk. In general, all diversion channels will be progressively removed when they are not needed any more. At closure, the drainage channels disturbed by the development of the power plant during its life should be reinstated, and the development footprint rehabilitated as close as possible, to the original surface flow regime.

Sediment ponds are required to reduce the sediment load in runoff from disturbed ground associated with the development of the project. In disturbed areas the sediment ponds will be positioned at the exit points to catch and treat the water before it is released into the environment. The sediment ponds will be designed to contain a 100 year ARI peak runoff volume and provide sufficient resident time to remove the additional sediment load. Sufficient real estate has been allocated for this purpose.

It has been planned that water from pit dewatering will be used by the proposed power station, mainly for its cooling system. The 8 GL/annum of water from the dewatering will be entirely consumed by the power station. A holding reservoir may be needed to allow fines settlement and to act as a regulating reservoir to buffer the seasonal fluctuation of water source to supply the relatively constant water demand rate. Based on this planning, the issue of disposing of this water into the environment will not arise. It is understood that the dewatering will commence prior to the excavation of pit and operation of Power Station. This water will not be able to be consumed by the power station for a significant long period. It may be impractical to hold this water for later use as the holding capacity will have to be extreme large. Therefore, this water will have to be treated (if necessary), and discharged into the downstream environment.

The Power Plant will be wet-cooled which will consume more than 11 GL/annum. This water demand will be partly fulfilled by the 8 GL/annum of water from the dewatering of the CWC open pit, supplemented by other water sources such as groundwater abstraction from the Cattamarra and Yarragadee aquifers, or by the excess water from the nearby Iluka Mineral Sand Mining Project. A water balance study has been carried out to demonstrate that the water management strategy is capable of maintaining a sustainable water balance for the two projects. The results of the predictive simulation show the supplementary water supply fluctuating in response to the pit-dewatering pattern. The long term average Yarragadee supply requirement is 98L/s (3.1GL/a). The maximum supply rate required is approximately 450L/s in the start-up period when the pit-dewatering rate is low. This provides a guide when designing the capacity of water supply system (borefield and delivery pipeline) from the alternative water source. There is an opportunity to reduce this design supply rate if there is a ramping-up of water demand in the start-up period.

It is proposed that the wastewater generated by the power plant will be disposed of by a number of evaporation ponds. The same water balance model was used to determine the required evaporation pond sizes to contain the wastewater without spilling into the environment. The optimal configuration of evaporation pond is 4 ponds @ 810m X 450m X 2m deep. This is equivalent to a total area of approximately 146ha. The simulated pond storage is the nett storage capacity required to contain the peak level in annual cycle and extreme precipitation. A 500mm freeboard over this storage capacity is required by the Department of Minerals and Energy (DME) “Guidelines on the Safe Design and Operating Standards for Tailings Storage”. Therefore the design pond sizes will be 4 number of evaporation ponds at 810m X 450m X 2.5m (including 500mm freeboard). An area of approximately 150m^2 has been allocated south of the power station for this purpose.

To safeguard the downstream environment form any adverse impact from the development of the power station, a Surface Water Monitoring Program will be implemented. The monitoring program aims at monitoring the impact of process operations on the surface water flow regime and water quality in the streams and in Lake Indoon. Regular water quality sampling and testing at strategic locations will be carried out to monitor any changes in the water quality over time and spatially (comparing locations upstream and downstream of the mine). For the quantitative aspects, continuously recording stream gauges at strategic confluence and corresponding rainfall intensity recording gauges (i.e. tipping bucket gauges) within the project area will be installed to collect hydrological data. This data will help to monitor any changes in surface water hydrological regime. It can also be used to finetune the hydrologic and hydraulic model, to enable more accurate prediction of hydrological events and better management of their impacts in the future. The Surface Water Monitoring Program will be detailed in the Environmental Management Plan (EMP).

The declining trend in annual rainfall depth detected in the statistical analysis of the long term record of Eneabba will be taken into consideration when designing for the infrastructure of the mine site. As lower rainfall produces less runoff, there is an opportunity to reduce the design capacity of surface water drainage infrastructures such as channel sections, pond sizes and dewatering facilities. On the other hand, lower rainfall depth also means less recharge to the groundwater system; hence the water resources availability from pit dewatering could change with time.

Section 1 Introduction

1.1 Project Background

Aviva Corporation Ltd (Aviva) proposes to develop the Coolimba Power Station Project (the CPS project), located 8km south-west of Eneabba, Western Australia, approximately 270km north of Perth. Parts of the project area have been cleared for farming. A portion of original Banksia heathland remains in the project area (Dames and Moore, 1999).

The project will involve developing the Coolimba Power Station, which is to be supplied by the adjacent sub-bituminous coal deposit (the Central West Coal Deposit), a related project proposed by Aviva. Coolimba Power Pty Ltd, a wholly owned subsidiary of Aviva Corporation Limited, will construct and operate the Coolimba Power Station, at the south west corner of the coal mine. The anticipated life of the mine is approximately 30 years. The Coolimba Power Station project will disturb an area of 483ha, 50ha of which is vegetated.

1.2 Objectives

The objectives of this study are; to perform a surface water assessment on the project area, identify any potential impact on the surround environment and outline a Surface Water Management Plan for the project.

1.3 Surface Water Issues

Several surface water issues pertinent to the project area have been identified. These are:

- The disturbed area associated with constructing and operating the power station may increase the sediment load carried by natural drainage channels in the project area. Water quality may also be chemically affected by runoff from; workshop areas, retention ponds and process water dams.
- The Lake Logue-Indoon System is listed on the Directory of Important Wetlands in Australia. The project is located within the Lake Logue-Indoon catchment and therefore may impact on the Lake Logue-Indoon System due to the diversion of Erindoon Creek around the pit. This impact is expected to be minimal.
- The Eneabba Public Drinking Water Supply Area is located to the east and upstream of the project area, but does not intersect the project Area, and is unlikely to be impacted.
- The project is also expected to have some Acid Rock Drainage (ARD) issues, associated with runoff from activities that expose Potentially Acid Forming (PAF) material.

1.4 Scope of Works

The scope of the surface water study for the Coolimba Power Project consists of the following tasks:

- *Review and adaptation of findings on surface hydrology characterisation.* The characterisation of the pre-disturbance catchment is included in the Central West Coal Project EIA Proposal (Proposal No. 3047413). The results of the baseline watershed hydrology assessment for the Central West Coal Project will be reviewed and adapted for the Coolimba Power Project.
- *Assessment of potential impacts of the Project on surface hydrology.* The potential impacts of the Project on surface hydrology will be assessed. The impacts will be identified based on the project description (i.e. plant layout, plant design, and proposed construction and operational activities) and the outcomes from the baseline surface runoff characterisation. The potential off-site surface water issues associated with the establishment of the easements include higher runoff coefficients and sediment loading from the cleared areas and the interception of water courses. These impacts will be assessed and any required management measures will be suggested. An assessment of

the cumulative impacts of the Central West Coal Project and the Coolimba Power Station will also be conducted.

- *Review of the conceptual surface water management system for the plant site.* It is anticipated that PB Power will include the design of a surface water management system for the power station as part of the overall plant design. A key component of the surface water management system is an evaporation pond to collect all wastewater generated by the power station so as to achieve a "zero waste discharge" target. The review of the conceptual surface water management system would involve a water balance analysis of the evaporation pond and checking sizing of the pond. Runoff from the large coal stockpile can also be an issue in the proposed Surface Water Management System and necessary control measures will be recommended.

- *Water Balance Study (variation order).* As the water from the CWC pit dewatering will be used by the CPS plant, it is inevitable that the water balance for these two projects will be interlinked. Therefore, an integrated water balance model will be developed which encompasses two sub-systems for the two projects and the interaction between them. The CWC sub-system will be based on the characterisation of the mine site water balance that includes climatic and hydrological characteristics, dewatering needs, mine operation water demand, proposed water delivery and storage infrastructures. The CPS sub-system will be based on the characterisation of the Power Station water balance that includes water demand, water recycling and reuse, surface runoff and containment ponds.

Section 2 Data Review

2.1 Location

The project is located 6 km south-west of Eneabba and 120 km south of the Port of Geraldton. It is anticipated that the project will utilise existing infrastructure, as it is located adjacent to the Brand Highway (Figure 2-10). The project area is also within 3 km of the Eneabba-Geraldton railway line, 4 km from the Dampier to Bunbury Natural Gas Pipeline and proximal to abundant groundwater resources and existing high voltage power reticulation (ACL, 2004).

2.2 Topography

Available information on the existing surface water environment was obtained from topographic maps provided, observations made during the site visit and acquired digital topographic data. A Digital Elevation Map (DEM) of the project area was supplied by Landgate. Contours were produced for the DEM, which were used to define the overall project catchment and delineate this catchment into smaller sub-catchments. These contours were interpolated to create the topographic grid for the hydraulic model.

2.2.1 Project Area Hydrology

The area covered by the project development is encompassed by Lake Indoon catchment, which drains to the west and north-west towards Lake Indoon and covers an area of approximately 373km^2. Lake Indoon catchment is drained by ephemeral streams which only run during periods of heavy rainfall. The two main creeks in the area are Bindoon Creek in the south of the catchment and Erindoon Creek which runs through the centre of the catchment.

The project area is located within the Lake Indoon catchment. Lake Logue, which is adjacent to Lake Indoon, is in a separate catchment in a low-lying area. Land between the two lakes is relatively flat and Lake Indoon and Lake Logue may be hydraulically connected during heavy rainfall where high water levels may join the two.

The power easement required by the Coolimba Power Station encroaches into an adjacent catchment at the south-east corner of Lake Indoon catchment, which drains to the south-east. Lake Indoon catchment has been divided up into three broad sub-catchments, namely sub-catchment A, B and C (Figure 2-1). The proportion of the adjacent catchment affected by the power and gas corridor is labelled as sub-catchment D.

Interaction between natural surface water bodies and the shallow groundwater system in the area not well understood. There is debate on wether lake Indoon receives a component of recharge from the underlying aquifer system (Dames and Moore, 1999).

2.2.2 Landform and Soil

Soils in the project area have a particularly high infiltration rate and rainfall runoff is expected to be reduced as a result. Towards the end of the surface water assessment, soil infiltration testing and soil profile investigations were conducted in the project area from the 8th to the 12th of October by D.C. Blanford and Associates Pty Ltd (DCB), accompanied by a URS employee. Soils in the area were observed by DCB to have complex profiles with high spatial variability. Prominent features observed which may have a large impact on rainfall runoff include;

- the presence of well drained shallow to deep, fine to coarse grained sands with dispersive characteristics, which are the dominant soil type;
- high soil ferricrete content in various stages of weathering, whose associated clays form a widespread impermeable layer at varying depths ranging from outcrops to over 3m deep;
- resultant duplex soils, due to the joint presence of the above soil types; and
- the presence of cryptogamic soils, which have the ability to hold moisture and increase runoff.

Drainage in the area was observed to be characterised by contemporary surface drainage lines overlying remnants of a much larger active dynamic palaeo drainage system (DCB, Pers Comm, 2008). The palaeo drainage system is formed by a highly transmissive coarse gravel layer underlain by the impervious clay-rich ferricrete layer and was inferred to be perched, fed mostly by meteoric waters (DCB, Pers Comm, 2008).

The well drained sandy soil has a very high infiltration rate in locations where cryptogams are absent. The presence of cryptogamic soils can dramatically increase rainfall runoff proportional to the runoff-generating area they cover. Clay rich ferricrete has the potential to act as a massive water store, both as outcrop or as a layer deeper in the soil profile, due to its high primary and secondary porosity. At the point of saturation the ferricrete becomes impermeable and runoff is dramatically increased in the catchment. In addition, the varying depth of the impermeable layer in the duplex soil profile means surface water which has infiltrated upstream has a potential to reoccur at the surface further downstream. This means that although infiltration testing was performed in the project area, the estimation of the quantity of rainfall runoff during an extreme rainfall event in the project area is highly complicated. This problem is addressed later within Section *4.1.2 Rainfall Runoff Estimation*.

2.3 Rainfall

Climatic data, including recorded historic monthly rainfall data from the Eneabba Meteorological Station was acquired from the Bureau of Meteorology (2008). Hydrological data, including the Department of Water gauging and sampling sites at Lake Indoon, Lake Indoon Creek and Bindoon Creek downstream of the project area was supplied by the Department of Water.

The project area is in close proximity to Eneabba and the site can expect similar climatic conditions. The recorded historic climatic data recorded at the meteorological station at Eneabba (008225) from 1964 to the 5th of November 2008 is adopted for this hydrological study. The Decile 1, 5, 9 and Mean Monthly Rainfall are as shown in Table 2-1 and Figure 2-2 below. There is no evaporation record at this station.

Table 2-1 Monthly Rainfall – Eneabba (1964 – 5th Nov 2008)

Month	Monthly Rainfall (mm)			
	Decile 1	**Decile 5**	**Decile 9**	**Mean**
Jan	0	0.5	25.1	7.1
Feb	0	4.7	38.7	13.9
Mar	0.4	6.6	28.2	12.8
Apr	3.1	23.6	55.8	27.3
May	25.7	65.2	126.6	71.2
Jun	41.2	98.6	156.1	104.1
Jul	43.7	91	151	94.8
Aug	35.4	73.3	117.8	75.4
Sep	21.8	43.2	69	45.4
Oct	6.9	22.2	40.7	24.5
Nov	1.2	9.8	26	14.5
Dec	0	3	30.2	9.8
Annual	**380.2**	**484.5**	**616.2**	**505.4**

2.4 Potential Changes in Rainfall Patterns

This section uses SILO long term daily rainfall records interpolated for the project site to assess and identify possible trends in rainfall patterns using several statistical methods of analysis. Annual trends as well as seasonal trends were assessed and summarised with a view to identifying potential changes in rainfall patterns in the near future.

SILO data drill, developed by the Queensland's Department of Natural Resources and Mines, is a facility for extracting data from an archive of interpolated rainfall and climate surfaces. These surfaces are constructed by spatially interpolated observed data collected by the Australian Bureau of Meteorology (BoM). This data interpolation was used by this assessment to estimate a long term rainfall record at Eneabba, the closest SILO location to the project site, from 1889 to 2007.

2.4.1 Long Term Rainfall Trends (1889-2007)

Annual rainfall data for Eneabba suggests significant annual variability. The mean annual recorded rainfall for Eneabba (1964 - 5th Nov 2008) is 505.4mm, a minimum annual rainfall of 296.6mm and a maximum rainfall of 850.6mm. The mean annual evaporation for Eneabba, using SILO interpolations, is 2,439mm (Figure 2-2). Eneabba receives 86% of mean annual rainfall in winter months (May to October). Mean annual rainfall in Eneabba is approximately 22% of the mean annual pan evaporation. Mean monthly rainfall in the winter months from June to July generally exceeds evaporation (Figure 2-3).

2.4.2 Annual Rainfall

To determine long term changes in rainfall patterns the BoM uses a 30 year moving average statistic. The long term SILO rainfall record was analysed using the 30 year moving average to detect long term rainfall trends. The results of this analysis are shown in Figure 2-4. It shows a general downward trend in the 30 year moving average.

To accentuate this result the same SILO rainfall record was analysed using the 10 year moving average. The result is shown in Figure 2-5. It shows a similar trend of decreasing annual rainfall in the last decade in particular.

The long term SILO rainfall data has been plotted with mean annual rainfall and the cumulative deviation from the mean (CDFM) in Figure 2-6. The CDFM was generated from the long term SILO rainfall data and shows an increasing rainfall trend from 1904 to 1968. From 1968 to 2000 there is a steady decrease in rainfall and from 2000 to 2007 there is a steep decline in the rainfall trend.

2.4.3 Identification of seasonal changes (summer & winter)

This analysis will determine seasonal rainfall trends and help identify where rainfall patterns are changing and influencing the annual trend.

Summer Rainfall Trends

Summer rainfall has been calculated by adding SILO rainfall during November and December of the first year and SILO rainfall from January to April in the succeeding year. Summer rainfall from 1889 to 2007 has been plotted in Figure 2-7. Eneabba receives an average summer rainfall of 75 mm. The ten year moving average trend line shows a slight upward trend in summer rainfall for Eneabba over the past 118 years (Figure 2-7). The summer season rainfall varies from 7 mm to 289 mm.

The CDFM for summer rainfall was established from the SILO data. The results from this analysis are shown in Figure 2-8 and suggest that annual rainfall has increased from 1912 to 2000 but declined from 2000 to 2007.

Winter Rainfall Trends

On average Eneabba receives 464 mm from May to October. Winter rainfall, as calculated from the SILO rainfall data, ranges from 231 mm to 845 mm. The long-term SILO winter rainfall data (1889 to 2007) was used to establish the CDFM for Winter Rainfall (Figure 2-10). The CDFM technique shows that winter rainfall trend has been erratic with rainfall increasing from 1904 to 1934, decreasing from 1934 to 1944 then increasing until 1968. Rainfall then exhibits a downward trend from 1968 to present. The ten year moving average trend line shown in Figure 2-9 also shows a similar pattern in rainfall and in particular shows a downward trend in the winter rainfall received by Eneabba from 1963 to present.

2.4.4 Summary

The statistical analysis of the SILO generated long term rainfall data (1889-2007) for Eneabba suggests that annual rainfall has been declining over the past 40 years. The subsequent analysis of seasonal rainfall data identifies a steady decline in winter rainfall from the 1960's to 2007 as the main cause for the annual decreasing trend. Analysis of summer rainfall would suggest that the long term rainfall trend is increasing slightly although the impact this has on annual rainfall trends is minimal. Both winter and summer rainfall trends decrease sharply from 2000 to present, which is reflected in the annual rainfall trend.

The analysis of the historical rainfall data for Eneabba suggests that since 1975 the annual rainfall is predominantly bellow the long term average mainly due to the same trend in winter rainfall. If this decline continues, it may have an adverse effect on the volume of runoff being supplied to Lake Indoon, which may be compounded in the future by the effects of dewatering of the mine pit for power station supply. The CDFM graph indicates a significant variability in annual rainfall, and shows successive years of above average rainfall are followed by successive years of below average rainfall.

2.5 Water Quality

There is little Surface Water quality data available for this catchment. The Department of Water (DoW) has a water quality sampling site at Lake Indoon, Lake Indoon Creek and Bindoon Creek (Figure 2-1), downstream of the project area, where instantaneous stream gauges were used to record discharge at these sites once every month to three months. The status and record period for these sites are given in Table 4.5.

Table 2-2 DoW Water Quality Sampling Sites

Location	DoW Ref #	Status	Record period
Indoon Creek	6171014	Inactive	1969 – 1975
Bindoon Creek	6171027	Inactive	1973 – 1975
Lake Indoon	6171226	Active	Since 2/12/2006

Chloride, water temperature and discharge rates were collected at the Lake Indoon Creek sampling site from 1969 to 1975 and chloride, water temperature, instantaneous discharge rates and conductivity data was collected from Bindoon Creek from 1973 to 1975. The instantaneous discharge rates vs. rainfall for both Lake Indoon Creek and Bindoon Creek are plotted (Figure 2-11 and Figure 2-12). DoW ceased collecting data from these sites in 1975. The DoW database indicates the sampling sites are inactive.

The only water quality data collected at the two presently inactive sites was Chloride concentration. Over the period of 1969 to 1975 the minimum load was 121 mg/L with a maximum of 2,487 mg/L. The Lake Indoon site has a single water quality record shown in Table 4.6

Table 2-3 Water Quality at Lake Indoon

Description	Measurement
As	< 0.001 mg/L
Cd	0.0001 mg/L
Chlorophyll a	0.012 mg/L
Chlorophyll b	< 0.001 mg/L
Chlorophyll c	0.002 mg/L

Description	Measurement
Chlorophyta	8753 cells/mL
Cr	< 0.01 mg/L
Cryptophyta	31310 cells/mL
Cu	0.002 mg/L
Cyanophyta	4040 cells/mL
Diatoms (planktonia)	4713 cells/mL
Hg	< 0.0001
N (NOx)	0.052
N (TKN)	6.2 mg/L
N (TN)	6.2 mg/L
P (TP)	0.1 mg/L
PO4	0.006 mg/l
Pb	< 0.001 mg/L
Phaephytin a	0.003
Phytoplankton	49153 cells/mL
TSS	31 mg/L
Zn	< 0.001 mg/L

This data indicates that the water quality in Lake Indoon is within the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (2000) for wetlands.

Dames and Moore prepared a Final Void Closure and Rehabilitation Strategy for RGC Mineral Sands Ltd in 1999 for the Eneabba West Mine. This report contains a small amount of water quality data, mostly obtained from production and observation bores associated with the Mine. Dames and Moore (1999) observed most surface water bodies at Eneabba West were eutrophic because of excessive concentrations of phosphorous (Rockwater, 1990). Blooms of *Anabaena cirinalis, A. spirordes* and *Nodularia spunigens* developed in storage water ponds during March 1990. This was supported by an observation by McComb and Davis (1992), that surface water bodies in the Eneabba area (and over much of the Swan Coastal Plain) were predisposed to eutrophication due to: poor nutrient-retaining properties of the soil, morphological features, highly seasonal rainfall and past land use. These blue green algae are potentially toxic to birds and animals and require a total phosphorous content in excess of 0.05mg/L to bloom (Dames and Moore, 1999). The eutrophic ponds at Eneabba West were dominantly fed by inflow from the shallow aquifer. The high phosphorous of groundwater in the area, together with the area's environmental conditions should be taken into account when storing water to later be released into the environment.

Another water quality problem observed by Dames and Moore (1999) for the Eneabba West Mine was Mine dredging operations encountered a lot of problems with suspended sediments in the dredge pond. Fines at Eneabba West were principally composed of smectite (Sheng, 1997) which does not settle readily and remains in suspension for prolonged period of time. The lithological composition of excavated material will have to be taken into account in designing surface water management measures for runoff.

2.6 Streamflow

Figure 2-11 represents the temporal correlation between instantaneous streamflow rate at the Indoon Creek sampling site and recorded rainfall at Eneabba, which is the closest rainfall gauging station to the stream gauging sites. As is shown in Figure 2-11, increased recorded rainfall does not consistently correlate with high instantaneous flow rates at the Indoon Creek site. This may be a symptom of the difference in the timing of high flow rates and rainfall intensity experienced between the gauging station sites and the Eneabba rain gauge; however the close proximity of the rainfall gauge to the catchment means a closer correlation is expected. This may also indicate considerable variation in the runoff properties of the Lake Indoon catchment, particularly with regards to soil infiltration variability during different climatic conditions.

The Bindoon Creek site flow rate versus rainfall (Figure 2-12) shows a more consistent correlation between recorded rainfall amounts and flow rates. This agrees with field observations, that sub-catchment C of the project area regularly experiences surface flow and is more responsive in terms of rainfall runoff than the rest of the Lake Indoon catchment.

The streamflow and rainfall gauged data available are insufficient to conduct a detailed analysis on surface water yield and recorded runoff rates. The lack of data means it is also not possible to calibrate the hydrological model used for this surface water analysis. There is limited evidence that suggests surface water flows are substantial in heavy rainfall events. Cyclone Vance passed across the area between the 18th and 20th of March 1999, and dumped 137mm of rainfall at Eneabba (Dames and Moore, 1999). Vance was estimated to be equivalent to a 40 year ARI event. An ephemeral stream in the north of the catchment was observed to have a width of 500m and a maximum depth of 2m during the event (Dames and Moore, 1999).

Section 2 Data Review

Section 3 Site Visit

A site visit was conducted from the 24th to the 25th January 2007 to help understand the project area's hydrological regime. The visit had several key objectives:

- Enhance understanding of the local hydrological regime.
- Identify key hydrological features i.e. key flow paths, infrastructure.
- Identify potential obstructions to flows.
- Identify previous flood levels - i.e. Deposited debris from previous floods.

The site visit involved a tour of a working Mineral Sands Operation located to the east of the proposed mine site to help understand how surface runoff generated from the steep scarp located at the outer area of the catchment flowed through the minesite and was attenuated by natural depressions and bunding in the area of the operation. The area had little slope and may have allowed for considerable retention of flows. Soils were generally sandy suggesting potentially high infiltration rates.

The proposed pit areas were also visited to visualise the surrounding topography and assess the definition of drainage lines that intersected the pit and were likely to require a degree of management during operations. Lake Indoon, which is the final discharge point for the catchment during normal circumstances, was also visited. The area surrounding the proposed pit was relatively flat with sandy loam soils. The drainage lines were narrow and shallow or poorly defined.

Erindoon Creek, which flows in a south westerly direction to lake Indoon to the south of the proposed site was well defined and there was evidence of relatively high velocity flows occurring such as bank erosion and erosion of soils around culverts and some overtopping of culverts.

No significant obstructions to flow were identified at the locations visited. There was no evidence to help identify previous flood levels at the proposed minesite.

Section 4 Baseline Surface Water Assessment

This section aims to establish the baseline surface water runoff characteristics of the project area during a high magnitude design rainfall event, namely the 100 year ARI (Average Recurrence Interval) event. The task was broken down into two parts, namely; Rainfall Runoff Estimation and Project Area Drainage Assessment.

The project area catchment was defined and then delineated into smaller sub-catchments. A hydrologic model was created using XP-RAFTS to obtain estimated rainfall runoff excess hydrographs for each sub-catchment for the 100 year ARI event. These were input into a MIKE 21 hydraulic model in order to assess drainage in the project area during the 100 year ARI event.

4.1 Rainfall Runoff Estimation

4.1.1 Method of Estimation

Several tasks were completed in order to obtain rainfall runoff hydrographs for the 100 year ARI design rainfall event. These tasks included;

1) delineating sub-catchments within this larger project area catchments, based on runoff-controlling features and the location of the project development area;

2) obtaining sub-catchment parameters;

3) building these parameters into a hydrologic model;

4) comparing peak discharges obtained by the model against peak discharges obtained by the Rational Method; and

5) obtaining hydrographs for the 100 year ARI design event.

An additional task for this estimation involved applying the infiltration testing results to the hydrologic model to produce hydrographs which are representative of the project area. This task was performed as a revision of the analysis after infiltration test results became available.

4.1.2 Project Area Sub-catchment Delineation

Roughly, the project area can be sub-divided into four sub-catchments, namely sub-catchment A, sub-catchment B, sub-catchment C and sub-catchment D. Sub-catchment A,B and C collectively make up the Lake Indoon catchment and are defined by three main drainage channels, including Erindoon Creek and Bindoon Creek (Figure 2-1). Sub-catchment B is the main central catchment which drains through almost the entire minesite via Erindoon Creek. It is flanked by the two narrow sub-catchments A and C on both sides. Sub-catchment D is the catchment area upstream of the power and gas corridor required for the power station. Table 4-1 displays the areas of each sub-catchment.

Table 4-1 Project Sub-catchment Areas

Sub-catchment ID	Area (km2)
A	99.32
B	200.55
C	72.98
D	9.12

These large sub-catchments can be delineated further to improve accuracy of the rainfall runoff estimation, based on;

- landform;
- the location of the Brand Highway; and
- the location of power station infrastructure.

Landform

Two distinct landforms have been identified within Lake Indoon catchment. Land in the west or upstream portion of the catchment is steeper, mostly cleared pasture land and rocky outcrop, which is likely to produce larger volumes of surface runoff from significant rainfall events.

The eastern low lying areas of the catchment are sandy with flatter gradients. This landform is likely to 'soak' up a greater proportion of runoff before it crosses the Brand Highway, due to its particularly high infiltration rate. This control is addressed by subdividing sub-catchment A and B into upper and lower catchments based on soil and land cover type.

Brand Highway Location

The Brandy Highway transects sub-catchments A and B in the north-south direction and would provide a level of hydraulic control to surface flow. The location of the highway was also used to further sub-divide the sub-catchments.

Mine Development Location

The proposed location of the mine pit requires the creation of a pit sub-catchment, and for all upstream catchment areas to terminate upstream of the mine pit and power station, in order to calculate surface water runoff input into these areas (Figure 4-1).

4.1.3 Sub-catchment Parameters

Runoff parameters for each sub-catchment were compiled to estimate rainfall runoff excess for the project area. These included:

- Area
- Percent impervious
- Loss parameters
- Vectored slope
- Roughness
- Mainstream channel length
- Mainstream channel slope
- Mainstream channel cross-sectional profile

Aerial photography provided to URS by Aviva Ltd, digital elevation data supplied by Landgate and field data provided by the site visit were used to establish percent impervious, sub-catchment vectored slope averaged over the whole sub-catchment, roughness and mainstream channel length and slope.

Typical rainfall loss parameters designated by AR&R (1998) for Western Australian Zone 3 (Wheatbelt - 10-890mm average annual rainfall), were adopted prior to the results of the infiltration testing becoming available. As is shown in Plate 1 the project area, in particular the lower lying portion of Lake Indoon catchment, is dominated by sandy soil with a high infiltration rate. This may not be represented well by using the AR&R rainfall loss parameters, which are a standardised, conservative estimate applied to the whole region (AR&R, 1998). The rainfall loss parameters were reviewed using the results of the soil infiltration test in Section 4.1.8.

A representative mainstream channel cross sectional profile was developed from data gathered from the site visit and applied to all drainage paths (Plate 2), as no survey data for the main drainage channels was available.

4.1.4 Building the Hydrologic Model

A hydrologic model was developed to calculate rainfall runoff hydrographs for the project area using XP-RAFTS. The software incorporates standard AR&R 1987 Intensity-Frequency-Duration (IFD) data to produce design rainfall temporal patterns for anywhere in Australia.

The model is based on the Initial/Continuing loss model, out of the three loss models available in XP-RAFTS. This loss model combines catchment storage, soil infiltration processes and evapotranspiration processes into two general loss parameters (initial and continuing loss) for each sub-catchment.

The model was developed by creating representative nodes for each sub-catchment, which were linked by a series of channels that adopted the representative cross section described in the previous section. Each sub-catchment node was separated into different land cover types with different percent impervious loss conditions, overall sub-catchment slope and Manning's n. A list of input parameters for each sub-catchment represented in the model is displayed in Appendix A.

The model can be calibrated against two or more recorded rainfall events to assure the accuracy of rainfall runoff estimation specific to the project area. For calibration to be carried out, it is necessary to locate continuous stream gauging data and corresponding rainfall records, with recorded rainfall intensity (i.e. a temporal pattern), for two or more defined rainfall events. The instantaneous discharge rates data (in section 2.5), cannot be used to calibrate the rainfall runoff model developed for this project, which requires a continuous record for the duration of the event calibrated. Due to this constraint the model used for this assessment could not be calibrated.

4.1.5 Design Event Hydrographs

The effects of development associated with the project were assessed based on rainfall produced by the 100 year ARI design rainfall event. This is the standard design event used for the purposes of a PER. Other design events may be examined at a later detailed design phase. Rainfall intensities for the site were produced using parameters obtained from Volume 2 of "Australian Rainfall and Runoff, 1987 (AR&R). Rainfall intensities (mm/hour) for different durations and ARIs between 1 and 100 years were then computed for the project area and are displayed in Table 4-2.

Table 4-2 Design Rainfall Intensity (mm/h) for the Project Area

Duration (hr)	Average Rainfall Intensity, $I_{d,y}$ for ARI (yr), (mm/h)						
	1yr	2yr	5yr	10yr	20yr	50yr	100yr
0.5	25.3	32.8	41.9	47.9	56	68	78
1	16.5	21.4	27.1	30.9	36.2	43.6	49.7
6	4.6	5.9	7.6	8.7	10.3	12.5	14.3
12	2.8	3.6	4.6	5.3	6.3	7.7	8.8
24	1.8	2.3	2.9	3.3	3.9	4.6	5.3
48	1.1	1.5	1.8	2	2.3	2.7	3.1
72	0.8	1.1	1.3	1.5	1.7	1.9	2.2

AR&R parameters were used to produce hydrographs for the 100 year ARI event for a range of typical event durations. The peak of each hydrograph was then compared to distinguish overall which duration produced the highest peak discharge critical for the project area. Catchment A critical duration was closer to 3 hours while Catchment C had a critical duration of 12 hours. Catchment B, which is the catchment which directly impacts the project area, has a critical duration of 6 hours, and it was this duration that was chosen as the overall critical duration. The resultant hydrographs are displayed in Figure 4-2.

4.1.6 Infiltration Test Results Review

Infiltration rates gained from several on site infiltration tests were applied directly to the model as proportional loss rates for each sub-catchment, based on testing location. The location of each infiltration test site is displayed on Figure 4-1. The infiltration tests were performed using a constant head infiltrometer and a single 5 to 6 minute test time (Table 4-3).

Table 4-3 Infiltration Test Results

Site Name	Northing	Easting	Infiltration Rate (mm/hr)
AV-2	6690053	0330411	1008
AV-3	6688500	0329362	520
AV-4	6687570	0329380	377
AV-10	6686348	0330318	110
Woolmulla Rd, east of Erindoon Rd	6678088	0329260	216
East of Brand Highway	6693787	0331056	1404

The application of these loss rates resulted in a dramatic reduction in rainfall runoff peak discharge (Table 4-4) and volume (Figure 4-3).

The high variation seen between the infiltration rates at each test site indicates infiltration rates for the project area are highly spatially variable. While it is clear soils in the project area have a high infiltration capacity, there is also a likelihood that soils may be closer to saturation at the onset of a severe rainfall event, such as the 100 year ARI event. It was observed that the test site at Woolmulla Road east of Erindoon Road was located in shallow duplex soils which were very wet at the time of testing, and may be taken as close to saturated conditions (DCB, Pers Comm, 2008).

Table 4-4 Peak Discharge Rates (100 yr ARI) for Critical storm durations

Catchment	Sub-catchment ID	AR&R Peak Discharge in m^3/s	Peak Discharge using Infiltration in m^3/s
A	**A**	431	6.4
B	**B1L**	64.0	1.21
	B1U	218.3	2.04
	B2	14.4	0.18
	B3	4.4	0.06
	B4	12.7	0.27
	B5	37.0	0.49
	B6	76.1	0.91
	B7	231.6	2.89
	B8	47.3	0.84
	Pit	16.4	0.20
C	**CL**	9.6	0.19
	CU	107.5	2.52
	Lake Indoon	0.4	0.02

Based on observation, combined with the results of the infiltration test, rainfall losses are expected to be greater than those recommended by AR&R, but less than would be achieved by applying the infiltration test results as raw loss values.

To improve the accuracy of the rainfall – runoff estimate additional monitoring of rainfall and stream flow is required.

For the purpose of this assessment, the AR&R conservative overestimate was used, in order to accentuate the hydraulic characteristics of the project area. To improve the accuracy of the rainfall runoff estimate for the project area, the hydrologic model needs to be calibrated against recorded data.

4.2 Project Area Drainage Assessment

MIKE 21 by DHI Software was used to create a hydraulic model which represents overland flows in the project area. Rainfall runoff excess hydrographs for the 100 year ARI generated using XP-RAFTS were applied to the hydraulic model (Figure 4-2). An existing case model was created to demonstrate the distribution of flood waters from a generated 100 year ARI flood event in the project area prior to the proposed development.

4.2.1 Software

MIKE 21 is a hydrodynamic model which is widely used for the simulation of surface water levels and flows. MIKE 21 simulates unsteady two dimensional flows in one vertically homogeneous fluid layer using a so-called Alternating Direction Implicit technique to integrate the conservation of mass and momentum equations, and resolves the equations matrices that results for each direction and each individual grid line by a Double Sweep algorithm.

4.2.2 Topography

The 15m by 15m topographic grid that forms the basis for the model, was interpolated from contours created from the DEM supplied by Landgate. The resultant grid is displayed in Figure 4-4. The topographic grid therefore represents the project area in its undeveloped state. Due to the conceptual nature of this model, the Brand Highway, Erindoon Road, creek crossings and the access road to be installed along the western side of the pit were not included. The original DEM used to create the model is accurate to within 0.2m, however the data underwent two interpolations which may reduce its accuracy.

The purpose of the existing case model is to establish the baseline drainage profile of the project site in order to assess changes in drainage of the project site as a result of development of the mine and power station. The model area includes the power station pad. Further modelling may be required at a design phase to test the impacts and functions of development associated with the project.

4.2.3 Roughness

A map of Manning's M values corresponding to the geographic location of the topographic grid was created to simulate spatially varying roughness values (Figure 4-5). Four different types of land cover were identified and each was assigned a roughness coefficient Manning's n value based on the estimations of n values provided by Chow (1959). Manning's M values were then obtained from the inverse of these values (Table 4-6).

Table 4-5 Roughness Values

Land Cover	Manning's n	Manning's M (1/n)
Dense Brush	0.07	14.29
Medium Brush	0.045	22.22
Sand	0.025	40.00
Streams, roads, hardstand	0.02	50.00

4.2.4 Initial Surface Water Level

Lake Indoon is the downstream collection point for the project area catchment. Water levels in Lake Indoon at the time of a 100 year ARI event would have a potentially large effect on surface water levels in the project area. No recorded water levels at Lake Indoon could be obtained for this surface water analysis making it difficult to set a reasonable tailwater condition. Instead a worst case scenario initial tailwater condition was set by artificially filling the lake and the surrounding low lying area with water to a level of 42mAHD and keeping the rest of the model dry. This was used as the initial surface water level for the model.

4.2.5 Boundary Conditions

Rainfall runoff hydrographs for the 100 year ARI 6 hour (critical) duration rainfall event were input within the main drainage channels. Hydrographs were produced for a period of 12 hours to include the falling limb of all hydrographs, in order to represent the full volume of rainfall runoff produced for the event.

4.2.6 Drainage Assessment

Baseline maximum water depth results are displayed in Figure 4-6. Significant volumes of water (over 200mm) are restricted to the major channels in the project area upstream of the proposed mine pit. Downstream of the pit, water has collected in the low lying and less well drained areas. The conservative tailwater set for the model is not considered to have had a great effect on water draining from the area directly downstream of the proposed mine pit, as water is still able to drain from this area throughout the model simulation duration.

Section 4 Baseline Surface Water Assessment

Section 5 Surface Water Impact Assessment

5.1 Project Infrastructure

Digital overlays containing the project infrastructure layout, including the pit outline, ROM and Process Plant and initial waste dump (as per January 2008) were supplied by Aviva. Coolimba proposes to construct a CCS (Carbon Capture and Storage) ready coal-fired Power Station adjacent to the proven coal resource at the Central West Coal Mine. The Power Station will not only provide up to 450 MW of base load power generation capacity using the CWC coal resource as fuel, but will also provide up to 358 MW of peak load capacity from gas-fired turbines. Electricity generated from the gas-fired turbines will provide energy during periods of peak demand on the grid, and to backup the coal-fired generators during outages.

The Power Station will be connected to the SWIS via a double circuit 330kV transmission line supported by approximately eighty 40m high lattice towers spaced at approximately 250m intervals. The towers will be aligned within a 20km long, 100m wide easement linking the Power Station to the proposed Eneabba 330kV substation. The infrastructure corridor is routed south around the South Eneabba Nature Reserve. The width of the easement will be reduced during the detailed design phase.

The coal will be transported to the plant via a conveyor belt linking the coal product stockpiles on the adjoining mine site to the coal day-bins at the Power Station. The coal will be crushed and sized before the Power Station takes delivery of the coal. Coal will be extracted from the coal day-bins and fed to the boiler where it is combusted to heat water and produce steam.

Approximately 11GL per annum will be required by the Power Station for process and cooling, with 8GL being provided by dewatering the adjacent coal mine and 3GL per annum likely to be sourced from the Yarragadee or Cattamarra aquifer. The raw mine water is expected to have an average salinity of 2,500mg/L Total Dissolved Solids (TDS) and a pH of approximately 7. Water sourced from dewatering the mine will be transported from the raw water storage pond to the Power Station via a water pipeline. Following treatment, the water will be used both as process water and cooling water for the Power Station operation. Most of the water is consumed in the cooling towers, where water is evaporated and expelled to atmosphere in order to reject low temperature waste heat from the Power Station. The process water within the water/steam circuit of the power plant is largely recirculated in a closed loop system.

The waste water sources that are directed to the evaporation pond in general contain a concentrated form of the dissolved natural contaminants carried into the plant. These contaminants generally consist of salts, carbonates, silicates, sulphates and other elements at trace levels. The salts and other minor constituents are concentrated in the evaporation ponds. Residue that remains after the water has been evaporated will be returned along with the ash to the mine and covered as part of the ongoing mine backfill operation. The proposed evaporation ponds will occupy approximately 150ha, will be approximately 1.5m deep (1.2m working depth) and be lined with an impermeable liner to ensure no leaching of water to the external environment. The resulting capacity of the ponds will be approximately 8GL of water.

Natural gas which will fire the gas turbines will be sourced via an underground pipeline placed within the infrastructure corridor which links the Power Station to the nearby Parmelia Natural Gas Pipeline or the Dampier to Bunbury Natural Gas Pipeline.

The footprint of the Power Station and the easement is approximately 483 hectares (ha) of which 431ha is cleared farm land and 52ha is uncleared land (including portions on the southern boundary of the South Eneabba Nature Reserve).

The key characteristics of the proposal are listed in Table 3.1

Section 5 Surface Water Impact Assessment

Table 3.1 Key Project Characteristics

Element	Description
General Project	
Operating life of power station (excluding construction and closure activities)	Approximately 30 years
Entire project area footprint	Approximately 483 hectares
Annual Water Supply Requirement	Up to 11GL
Evaporation pond area	150 hectares
Workforce during construction	Approximately 600
Workforce during operation	Approximately 50
Coal-fired Component	
Coal-fired turbine electrical output	up to 450MW gross
Number of generating units	up to 3
Nominal unit output	150 to 220MW nominal gross output
Load Profile	Base Load
Main Fuel	Coal from Central West's coal deposit
Annual coal consumption	Approximately 2.3 million tonnes
Start up fuel	Gas or Liquid fuel (diesel)
Condenser cooling	Water cooled (with possible hybrid optimisations)
Gas-fired element	
Station electrical output	up to 358MW net
Number of generating units	up to 2
Nominal unit output	up to 180MW nominal net output
Load Profile	Peaking Load
Main Fuel	Gas
Annual gas consumption	Approximately 11PJ at 25% capacity factor

The construction works include minor alterations to the public highway network. A number of internal access roads will be developed for the Project. These will include roads around the Power Station site and link roads between the Power Station and the Coal Mine Project. The link road to the coal mine will be used to maintain the coal conveyor and transport ash back to the mine site for disposal in the mine backfill. Any construction or modification of internal access roads and the external highway network will be accompanied by the appropriate attention to water management. This includes providing adequate drainage diversion and management measures to handle the increase in hardstand area and the associated run-off.

Of the Project Area's 483ha footprint, approximately 184ha will be allocated to the provision of an infrastructure corridor. The Project has defined a 100m wide infrastructure corridor which will safely accommodate:

- The 40m high transmission towers located approximately every 250m which carry the 330kV transmission lines to the external grid/network at the Eneabba substation;
- The approximate 300 - 400mm diameter gas pipeline lateral (final size to be confirmed), buried to a depth of approximately 750mm.
- The easement also includes an un-sealed observation track which will provide access to the infrastructure within the easement

The required clearing is likely to be substantially narrower than the 100m allocated. The allocation of 100m for the corridor allows flexibility to place the towers and the pipeline with minimal disturbance to any physical/natural features of significance. The infrastructure corridor extends a distance of approximately 20km. Where the easement meets the Brand Highway, the route will either head north-east towards the Parmelia Gas Pipeline or continue further east to connect to the Dampier to Bunbury Gas Pipeline. The transmission lines will be aligned from this point to connect to the yet to be constructed 330kV Eneabba Substation. It is anticipated that Western Power will position this 330kV substation along the existing power line route and adjacent to the existing 132kV substation.

The corridor predominantly traverses cleared private land, and minimal clearing of vegetation will be necessary when preparing the corridor except for a small section (maximum 46.3ha) proximate to the southern border of, and within, the South Eneabba Nature Reserve. Approximately 30ha of the area allocated to the corridor will be within the nature reserve.

Storm water from practically recoverable areas such as the turbine hall roof will be collected and diverted into the Power Station raw water storage pond, so as to contribute to the plant's water supply. Storm water from non-contaminated sealed areas of the Power Station that are not practically recoverable (e.g. roads) will be allowed to run-off to the surroundings.

Water streams potentially containing oil or other contaminants (e.g. from transformer bunds) will be passed through an oil/water separator prior to being discharged to the evaporation ponds. Oily water will be diverted to an oily waters waste tank (or covered pit). This tank will be evacuated by truck for off site disposal as required.

Where run-off of non-process water from coal or lime sand stockpiles occurs, drainage channels will be constructed to direct the water to a series of settling ponds. The settling ponds will be sized to store a capacity of water equivalent to a 1:100 year, 72 hour rainfall event. In the event of an extreme rainfall event occurring coincident with high levels in the settling ponds, some excess storm water run-off may be discharged to the environment. This will be storm water runoff rather than overflow from the settling pond(s). This possibility will be minimised through the construction of settling ponds with adequate capacity.

5.2 Impacts on Project Area Drainage

Impacts of the proposed power station on drainage in the project area were evaluated by altering the topographic grid within the model to represent the finished development levels of the power station pad.

The pad associated with the power station has been built into each development stage model at a height of 83mAHD. The results are displayed in Figure 6-2. The construction of the power station pad is outside of the 100 year ARI flood plain.

5.3 Impact of Project on Surface Runoff Regimes

Certain areas within the Lake Indoon catchment will be occupied by development which impedes and isolates surface flow from the rest of the catchment. These developments include evaporation and storage ponds, estimated to have a surface area of 1.46km^2, which at the time the assessment was performed fell completely within sub-catchment B.

This surface flow is effectively lost to the natural system. The amount of surface rainfall runoff lost to the system can be quantified by calculating the comparative loss from each catchment area. This is done in Table 5-1.

Table 5-1 Runoff Loss Calculations

	Total Area (km2)	Area Loss (km2)	Percent Loss %
Catchment A	99.32	0	0
Catchment B	200.55	1.46	0.73
Catchment C	72.99	0	0

Runoff from the sub-catchment area directly upstream of the power station (2.87km^2) will be diverted to nearby Bindoon Creek (sub-catchment C) to minimise the amount of ground disturbance caused by the mining operation. This means that 1.43% of surface flows from Erindoon Creek are now being diverted into Bindoon Creek.

The power and gas corridor easement required for the operation of the Coolimba Power Station is 75m wide and approximately 20km long according to current design. The catchment size upstream of this easement will contribute runoff across the disturbed ground created by the easement (sub-catchment D) is 9.12km^2.

5.4 Other Surface Water Related Impacts

Acid sulphate soil

There is also the potential for the presence of acid sulphate soils to occur in the vicinity of the project area. The DoE (2004a) defines acid sulphate soils as “soils that contain iron sulphides which, when drained or disturbed and exposed to oxygen, produce sulphuric acid and result in the release of soluble iron, sulphate, aluminium and other toxic metals”. This should be taken into consideration at the planning stage before any excavation begins on the project site.

Acid Rock Drainage

Terrenus Earth Sciences (TES) (2008) has determined that almost all potential reject materials (including coal) are expected to be potentially acid forming (PAF).

Section 6 Surface Water Management Plan

6.1 Diversion of Surface Water

As discussed in Section 5, the finished pad level of the power plant will disrupt the baseline surface water movement during the 100 year ARI event. In order to divert this surface water flow around the power station pad, a diversion drain will need to be constructed within the mine lease. The hydraulic model was used to assess the effectiveness of the diversion drain and refine the diversion accordingly. At the conclusion of the life of the power station, surface water drainage channels on site are to be reinstated as close to their original condition as possible.

The surface water diversion drain was designed based on the results of the simulation and then modelled. The location of the diversion drain is shown in Figure 6-1 on all three development stages. Detailed design of diversion drain is required.

A number of internal access roads will be developed for the Project. These will include roads around the Power Station site and link roads between the Power Station and the Coal Mine Project. These access roads have not currently been simulated in the modelling environment, as their preliminary design was not available at the time of the assessment. Their potential effects on flood levels upstream and downstream of the roads and on flood levels at the power station pad are currently unknown.

6.1.1 Surface Water Diversion

Surface water diversion includes a 2km long drain (Drain 1 – Figure 6-1) on the south side of the power station, with an overall slope of 0.008m/m and a cross sectional area of 45m^2. The maximum water level obtained from the 100 year ARI in this channel was 0.44m (Figure 6-2), which indicates the maximum wetted cross sectional area of the drain is about 6.6m^2.

At present diversion Drain 1 crosses the 75m Power and Gas Corridor Easement for the Coolimba Power Station (Figure 6-1). Drain 1 is designed to drain to the west to minimise the amount of excavation works required, however Drain 1 could potentially be constructed to drain to the east and join Drain 2, so as not to obstruct this easement.

These conceptual designs are based on the very conservative AR&R flood peak estimates and will need to be revised (reduced) once more accurate streamflow data is available.

6.2 Management of Acid Rock Drainage Runoff

Terrenus Earth Sciences (TES) (2008) has determined that almost all potential reject materials (including coal) are expected to be potentially acid forming (PAF). The assessment recommended all potential coal reject materials will need to be carefully managed to minimise oxidation, generation of acid and potential release of metals (and salts) into the environment. TES recommended encapsulation of PAF material within NAF material to effectively remove it from oxidising environments and the hydrologic cycle of the project area as one possible management measure. TES also recommends leachate and site water derived from, or in contact with, spoil piles reject materials or other mineral waste should be monitored to ensure the soluble metals and salt concentrations are below regulatory guidelines or licence conditions (TES, 2008).

6.3 Detention Ponds

Sediment ponds are required to reduce the sediment load in runoff from the waste rock dump and other disturbed areas associated with the development of the project. An appropriate sediment control facility is required for each drainage channel that intersects disturbed/developed areas.

The waste water sources that are directed to the evaporation pond in general contain a concentrated form of the dissolved natural contaminants carried into the plant. These contaminants generally consist of salts, carbonates, silicates, sulphates and other elements at trace levels. The salts and other minor constituents are concentrated in the evaporation ponds. Residue that remains after the water has been evaporated will be returned along with the ash to the mine and covered as part of the ongoing mine backfill operation. The proposed evaporation ponds will occupy approximately 150ha, will be approximately 1.5m deep (1.2m working depth) and be lined with an impermeable liner to ensure no leaching of water to the external environment. The resulting capacity of the ponds will be approximately 8GL of water.

Section 6 Surface Water Management Plan

Section 7 Conclusions and Recommendations

7.1 Conclusions

The Lake Logue-Indoon System is listed on the Directory of Important Wetlands in Australia. The project is located within the Lake Logue-Indoon System catchment area. Due to the diversion of surface flows around the power station, away from Erindoon Creek into Bindoon Creek, the project will impact the catchment, however; this impact is predicted to be minimal, since water is being diverted not taken from the creek system. One of the main concerns related to creek diversion is increased infiltration along water courses caused by disturbance of ground may reduce surface water flows downstream of the project. Minimal reductions in rainfall runoff may also occur associated with rainfall capture in ponds.

Results of hydraulic modelling simulations of the 100 year ARI event, indicates changes to conveyance due to surface water diversion will result in changes to surface water distribution and water velocities immediately upstream and downstream of the diversion works. These changes are not extensive and are confined to the areas adjacent to the diversion works. Appropriate erosion control should be addressed during the detailed design of the diversion works. Full remediation of the original drainage channels is required at mine closure.

The areas of disturbed ground are likely to increase the sediment load carried by streamflow. Water quality may also change due to runoff from ROM stockpiles, waste stockpiles, workshop areas, retention ponds and process water dams. The effects of this should be minimised by effective design of erosion control around diversion drains, stockpiles and bunds, and the inclusion of sedimentation and evaporation ponds where required.

The Eneabba Public Drinking Water Supply Area is located to the east and upstream of the project area, but does not intersect the project area, and is unlikely to be impacted.

Terrenus Earth Sciences (TES) (2008) has determined that almost all potential reject materials (including coal) are expected to be potentially acid forming (PAF). The assessment recommended all potential coal reject materials will need to be carefully managed to minimise oxidation, generation of acid and potential release of metals (and salts) into the environment. TES recommended encapsulation of PAF material within NAF material as one possible management measure. TES also recommends leachate and site water derived from, or in contact with, spoil piles reject materials or other mineral waste should be monitored to ensure the soluble metals and salt concentrations are below regulatory guidelines or licence conditions.

7.2 Recommendations for Surface Water Management

Surface water management for the project area must take into account the effects of the power station infrastructure on changes in drainage and surface water velocity profiles, in order to manage effects such as erosion, increased sedimentation, reductions in amount of water available to the natural system and decreased water quality. Recommendations for surface water management include:

- Undertake further investigation and analysis to ascertain accurate rainfall runoff volumes for design purposes. Such as installing stream gauges, rainfall gauges and v-notch weirs in the drainage channels.
- Establish permanent water quality and quantity monitoring stations in the catchment, including stream gauges and corresponding rainfall intensity recording gauges (i.e. tipping bucket gauge) within the project area to calibrate the rainfall runoff model against in the future. This will also aid in the accurate estimation of rainfall yield.
- Examine the hydraulic effects of any new access roads required by the development on the catchment.
- Conduct modelling based on final design of power station (including access roads and associated creek crossings) to obtain final design flood levels.
- All development pads must be constructed to the 100 year flood level plus 500mm freeboard.

Section 7 Conclusions and Recommendations

- All development located within the 100 year ARI flood plain must incorporate mitigation measures to divert surface flow and minimise the impact of the development on the upstream and downstream flow regimes.
- Locate and size sedimentation and water treatment ponds downstream of any developed area intersecting surface flow, so that the water re-entering the natural system conforms to recommended water quality guidelines, and erosion is minimised.
- Establish a water quality monitoring program, aimed at monitoring the impact of mine development and process operations on water quality in streams and in Lake Indoon.

Section 8 References

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Section 9 Limitations

URS Australia Pty Ltd (URS) has prepared this report in accordance with the usual care and thoroughness of the consulting profession for the use of Central West Coal Pty. Ltd. and only those third parties who have been authorised in writing by URS to rely on the report. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report. It is prepared in accordance with the scope of work and for the purpose outlined in the Proposal dated 9 October 2007.

The methodology adopted and sources of information used by URS are outlined in this report. URS has made no independent verification of this information beyond the agreed scope of works and URS assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that information contained in this report as provided to URS was false.

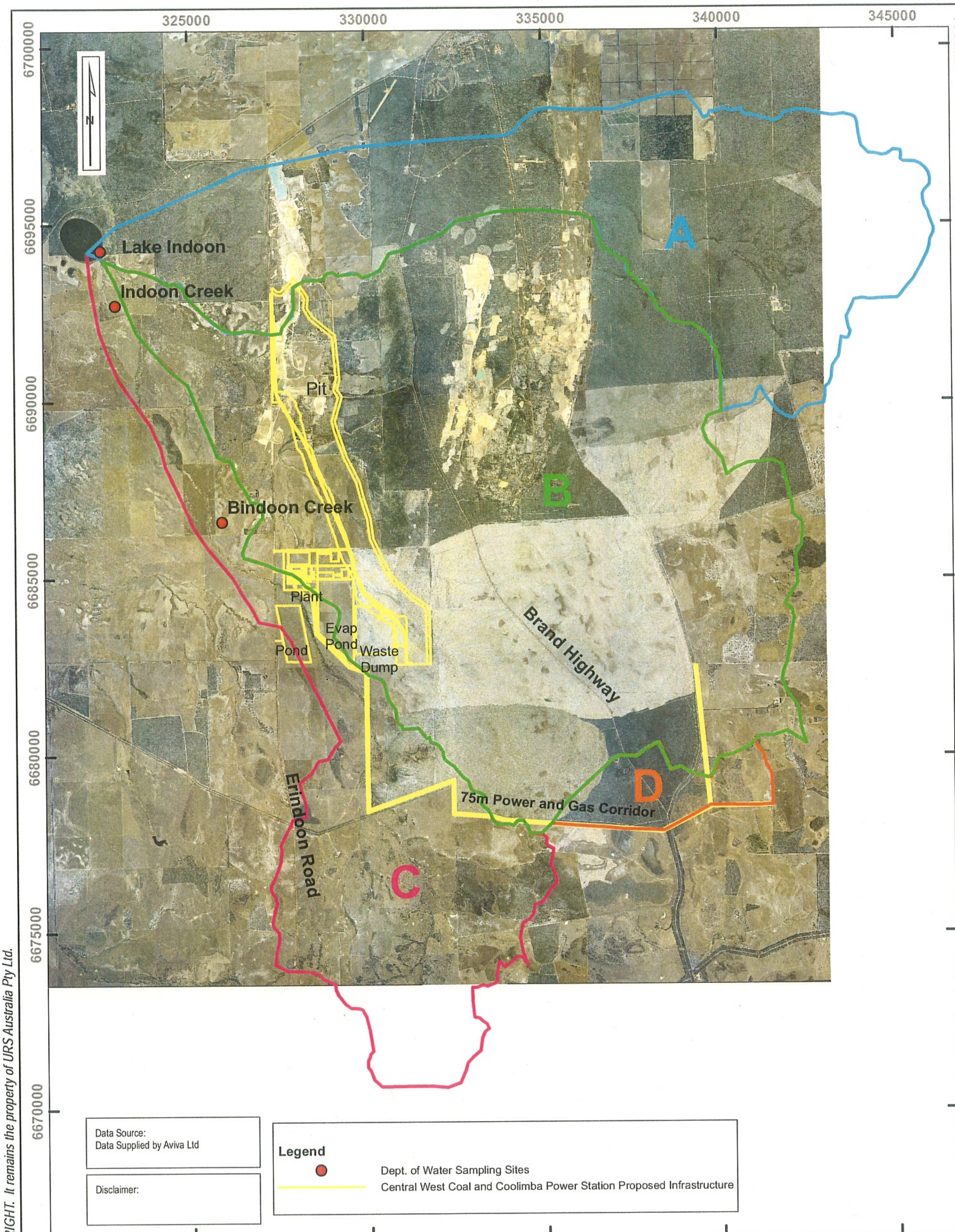
This report was prepared between August to November 2008 and is based on the conditions encountered and information reviewed at the time of preparation. URS disclaims responsibility for any changes that may have occurred after this time.

This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

Figures

Appendix A

Appendix A - XP-RAFTS Parameters



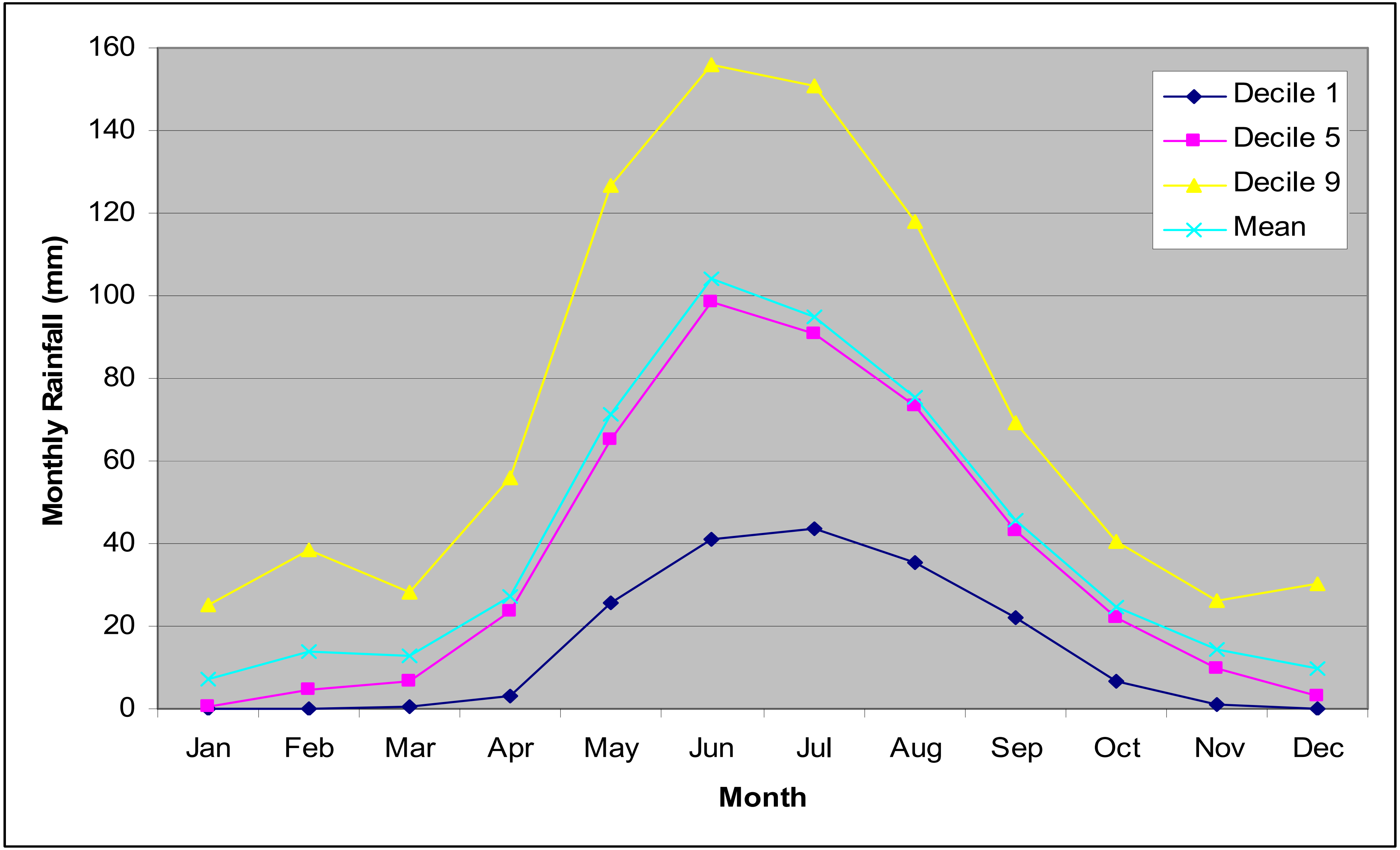
Data Source:
Data Supplied by Aviva Ltd

Disclaimer:

Legend

- Dept. of Water Sampling Sites
- Central West Coal and Coolimba Power Station Proposed Infrastructure

Client: Aviva Ltd	Project: Coolimba Power Station Project Surface Water Assessment		Title: Project Area Catchment Definition
URS	Scale: 1:0	Drawn: MOS	Datum: GDA94
	Date: 19/11/2008	Approved: BE	Projection: MGA50
	Job No.: 42906631	File No.: CWC_Hydrology.mxd	Figure 2-1 — Rev. A — A4



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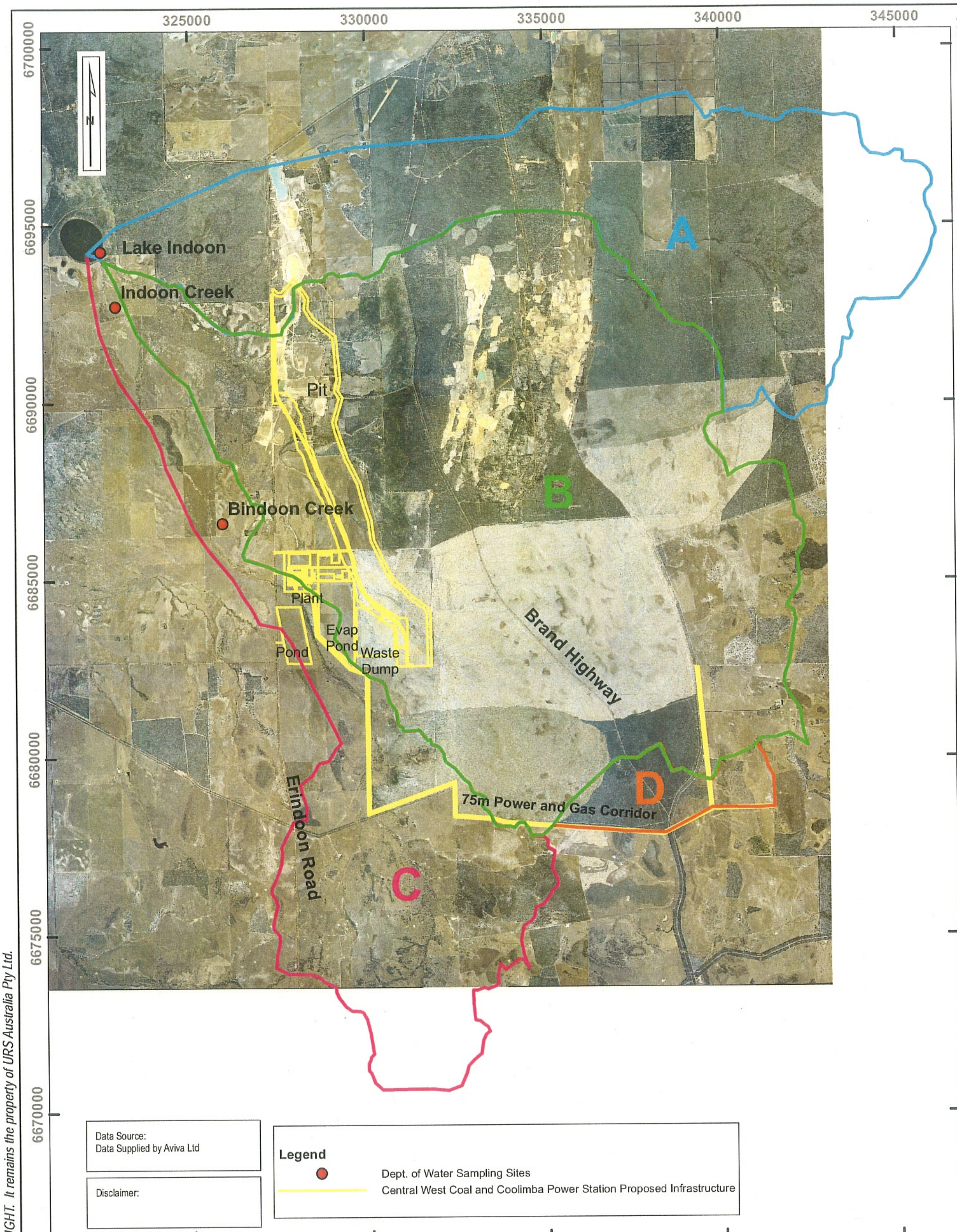
URS	Drawn: MOS	Approved: BE	Date: 27/01/09	
	Job No: 42906631	File No:		Figure: 2-2



Data Source:
Data Supplied by Aviva Ltd

Disclaimer:

Legend

- Dept. of Water Sampling Sites
- Central West Coal and Coolimba Power Station Proposed Infrastructure

Client: Aviva Ltd	Project: Coolimba Power Station Project Surface Water Assessment		Title: Project Area Catchment Definition
URS	Scale: 1:0	Drawn: MOS	Datum: GDA94
	Date: 19/11/2008	Approved: BE	Projection: MGA50
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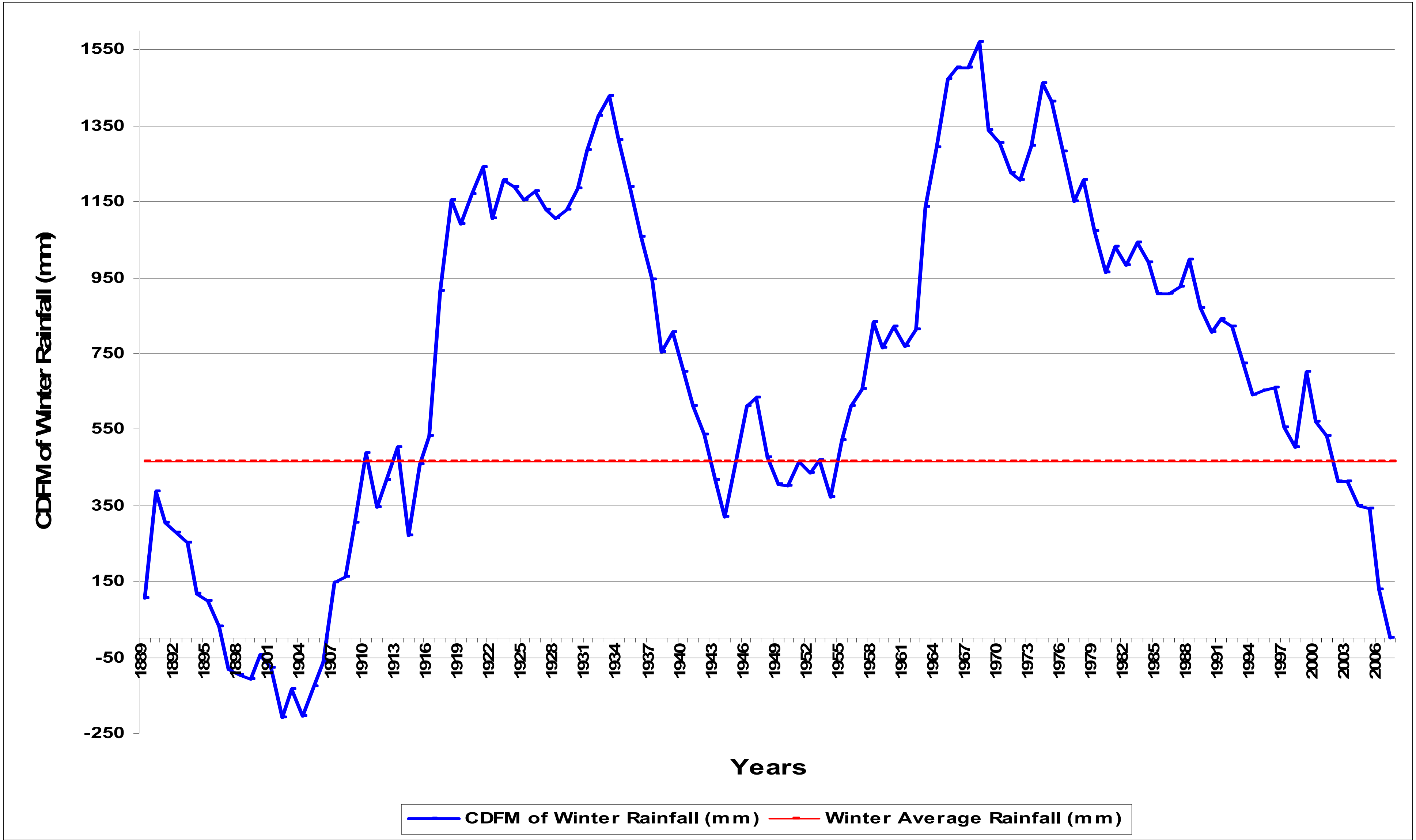

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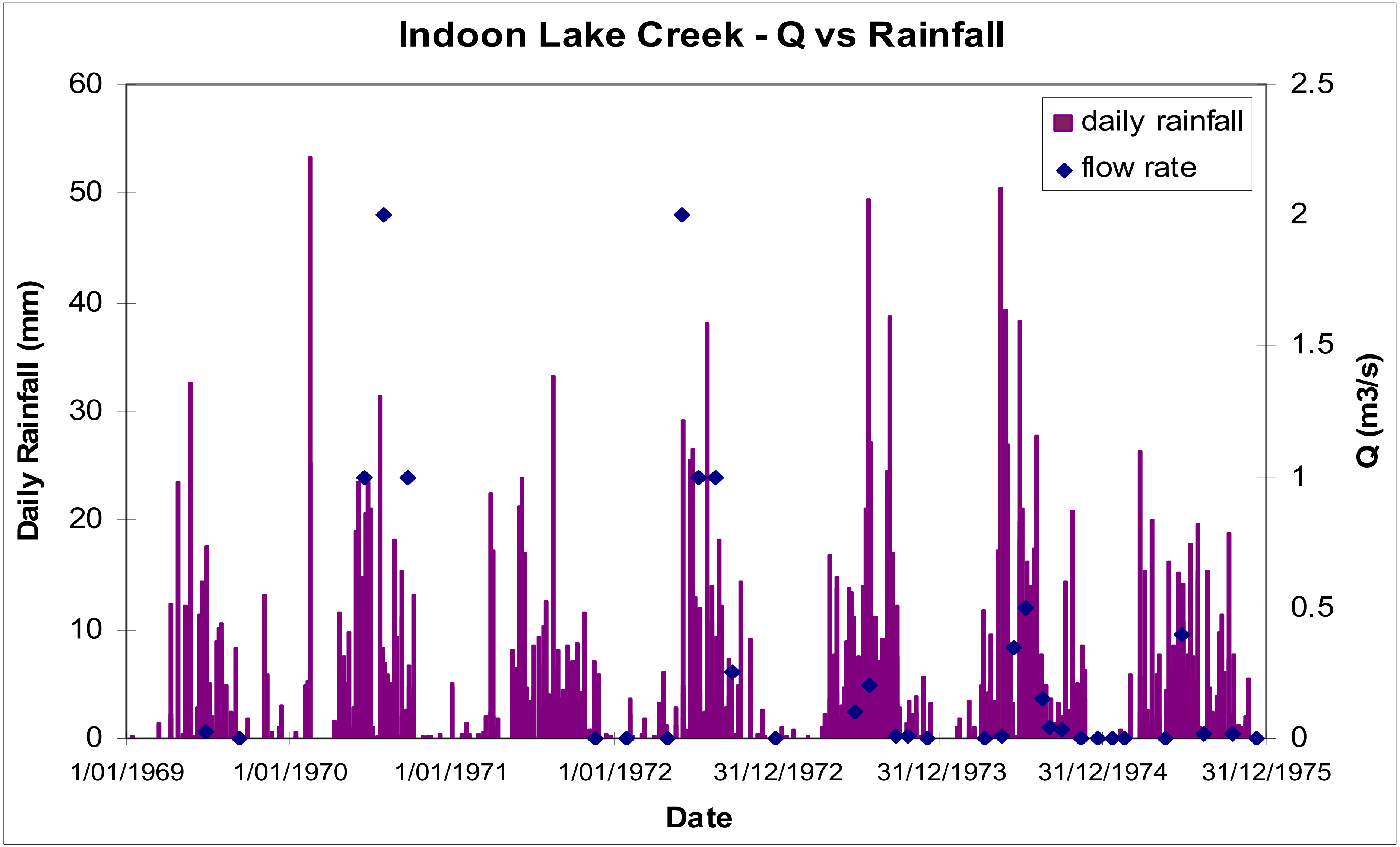

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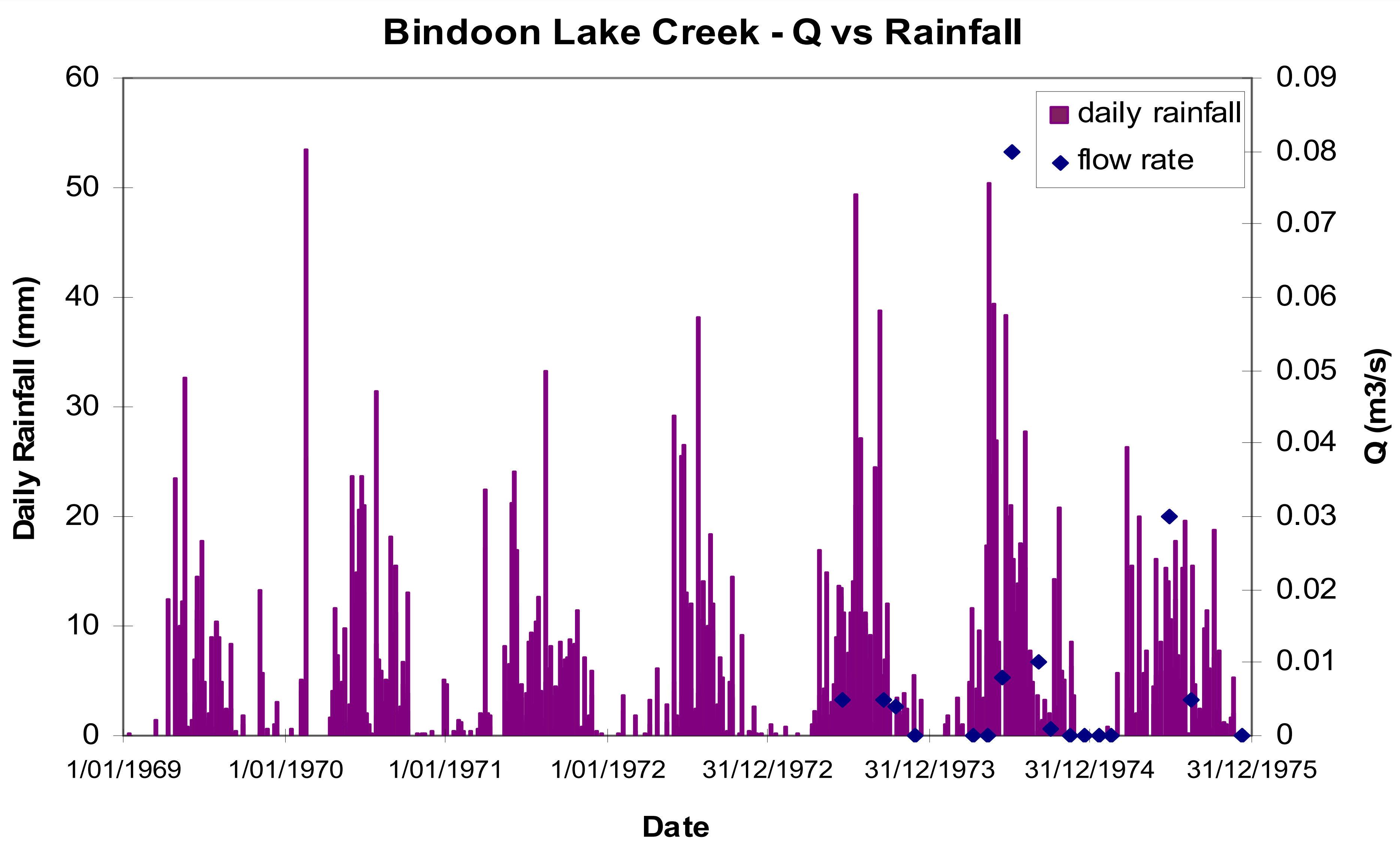

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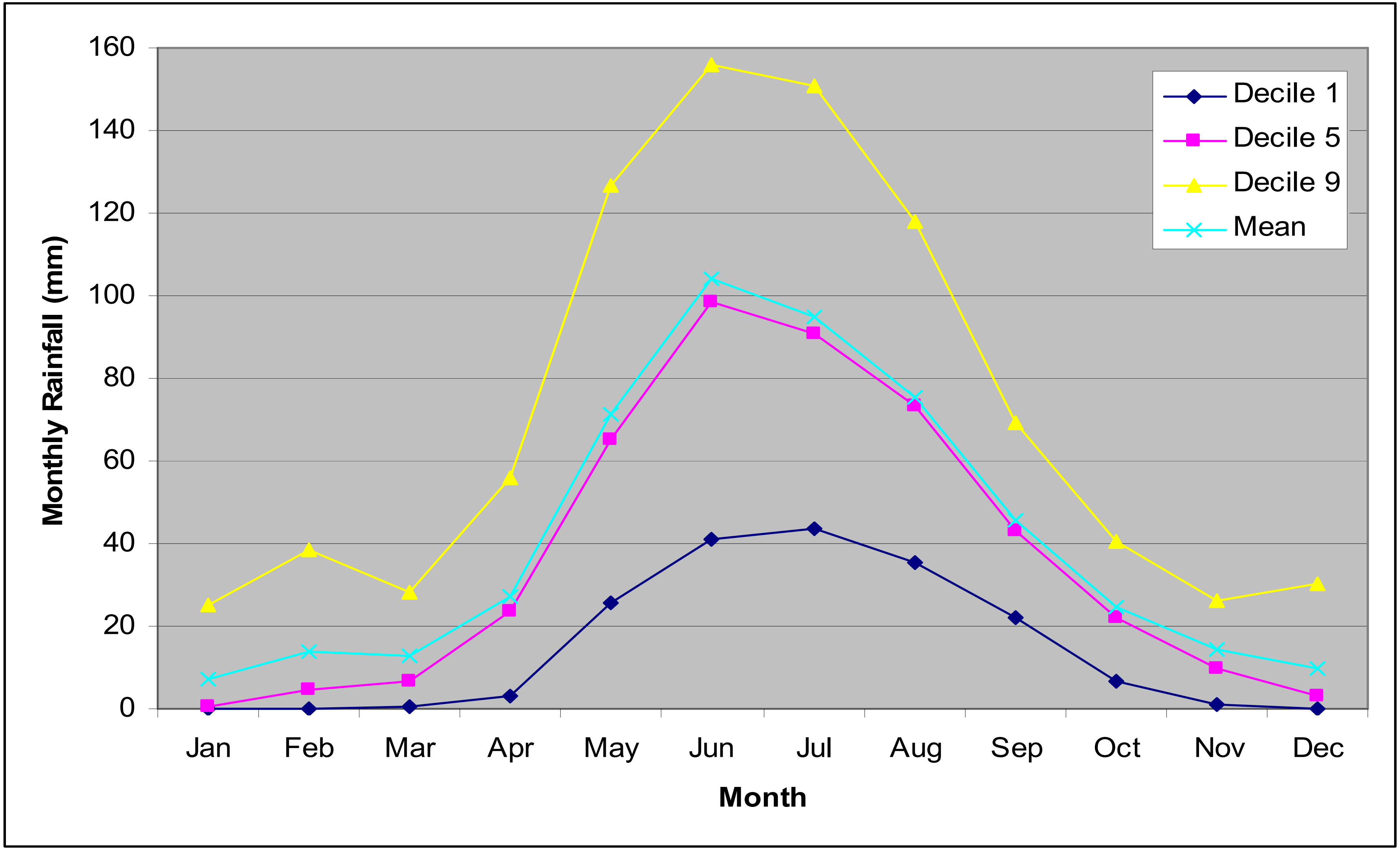

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URS	Drawn: MOS	Approved: BE	Date: 27/01/09	
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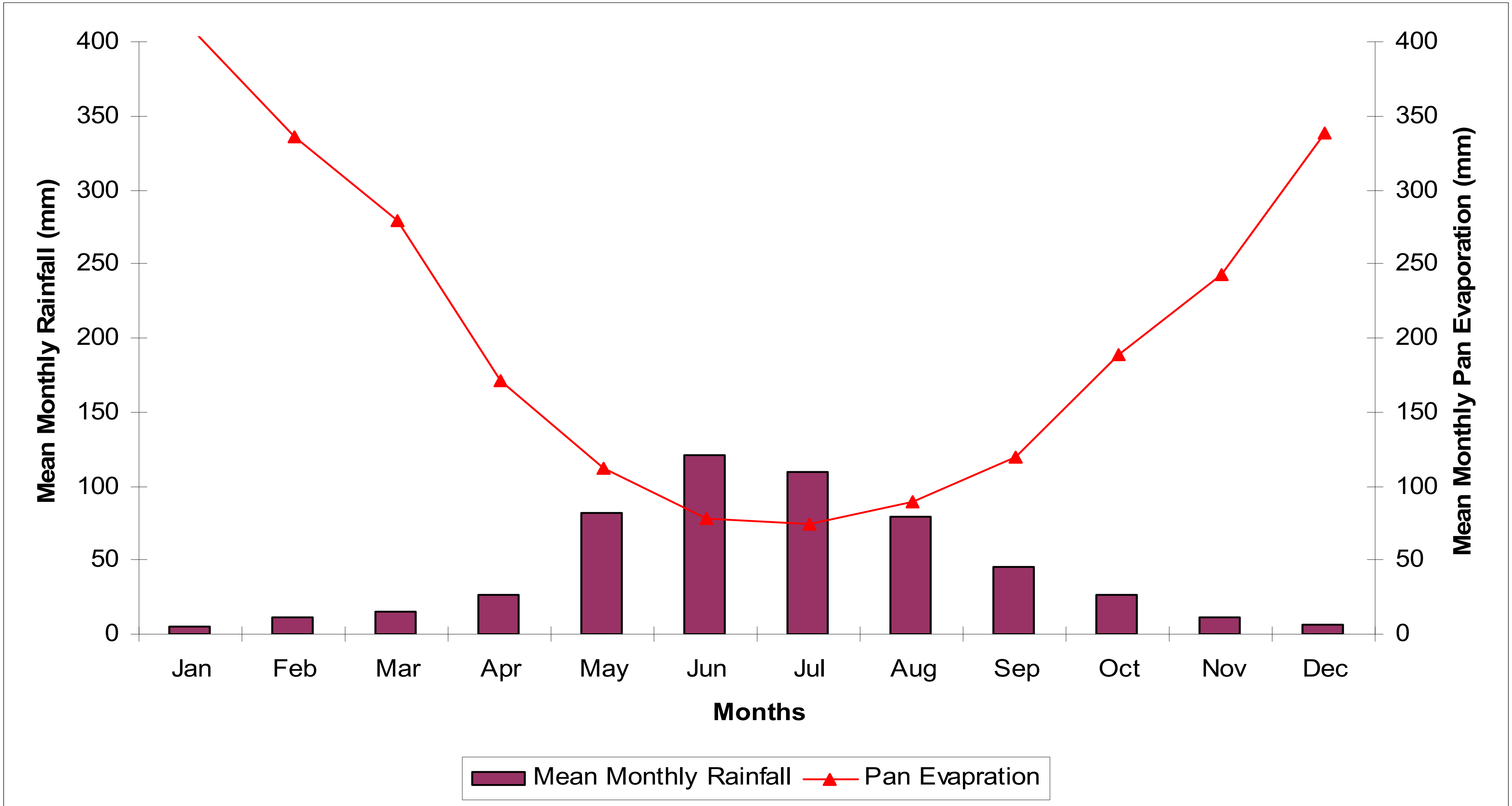

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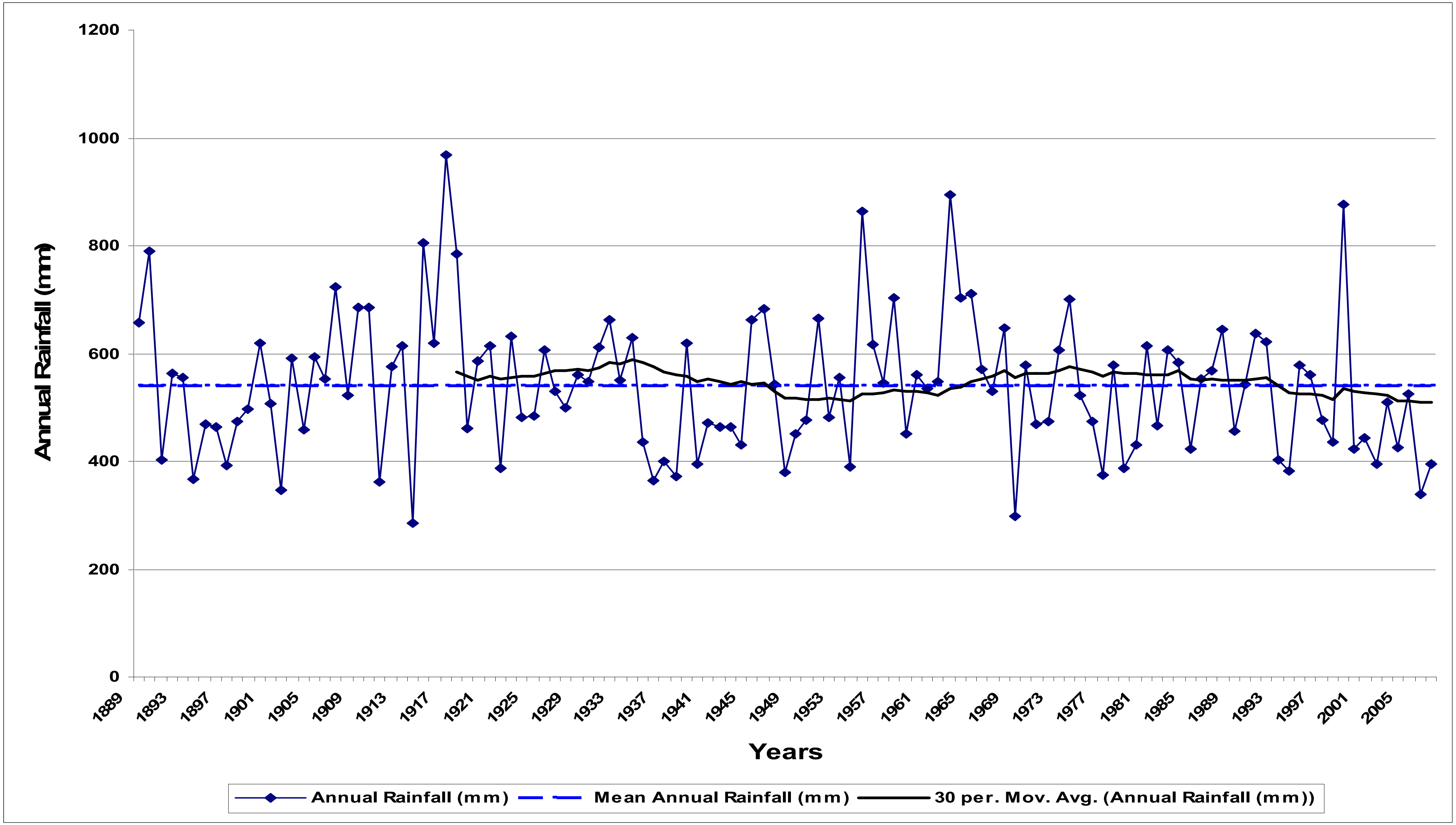

Client: Aviva Ltd	Project: Coolimba Power Station Project Surface Water Assessment			Title: Annual Rainfall Trend with 30 Years Moving Average for Eneabba
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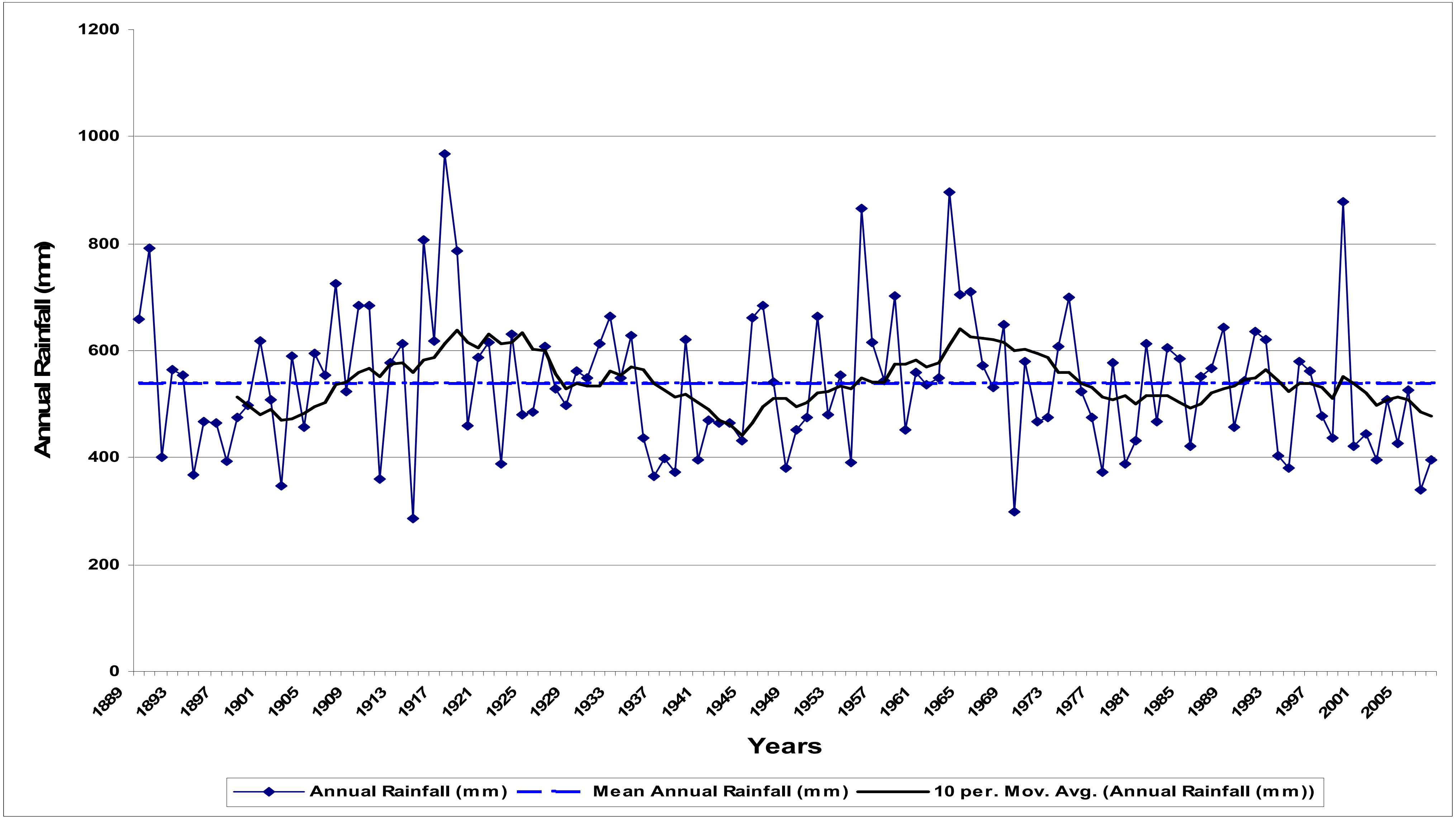

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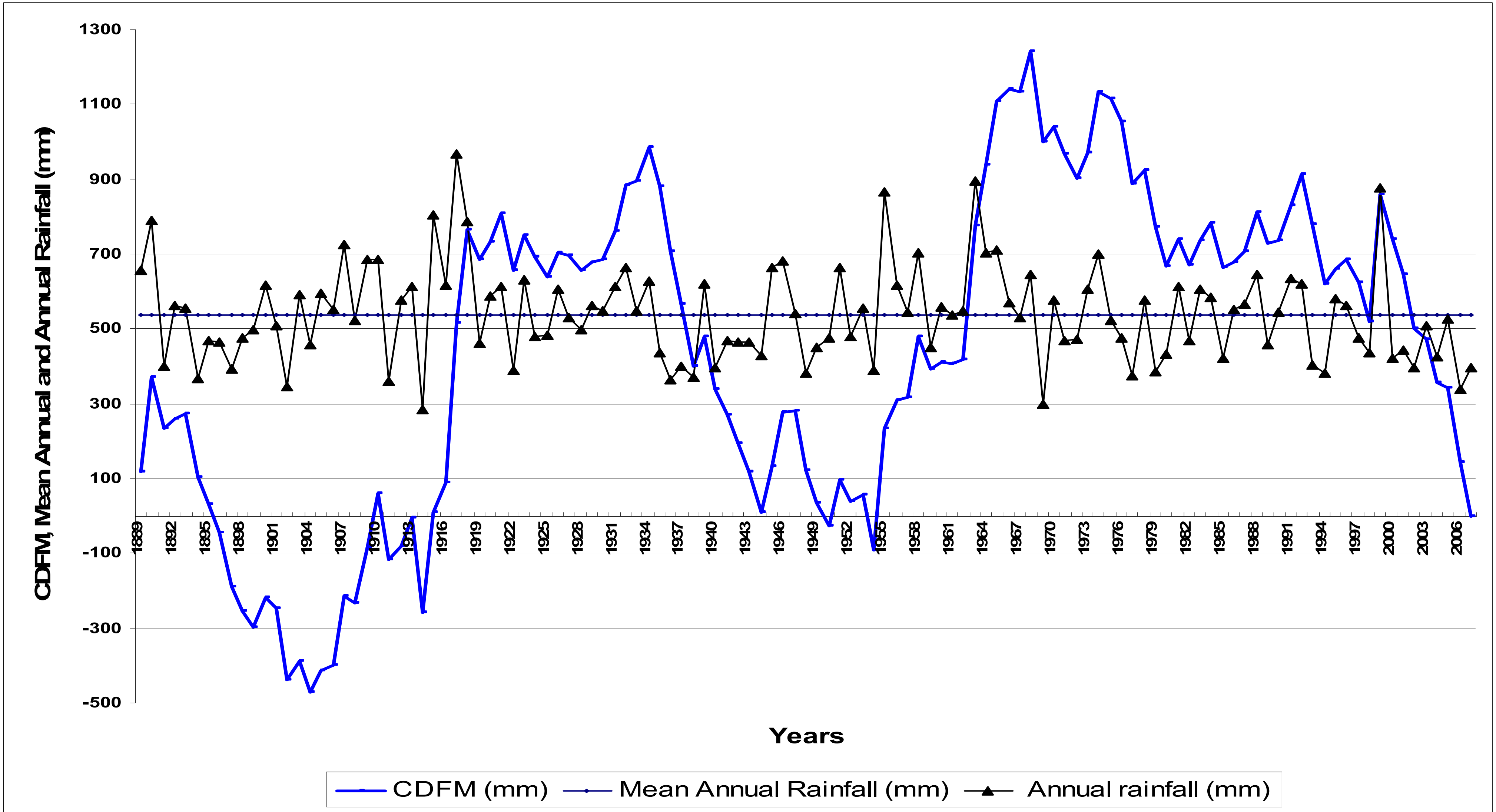

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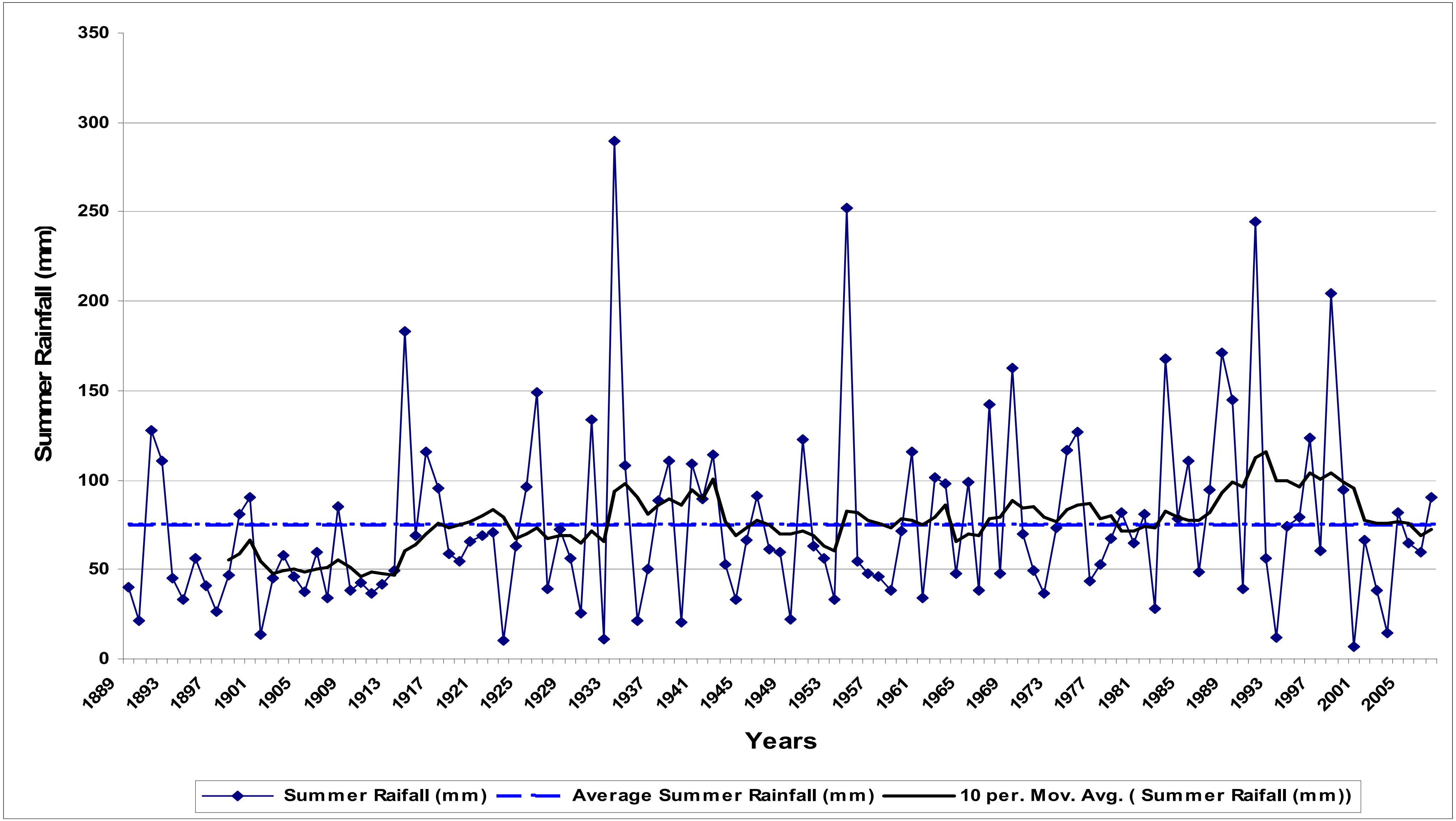

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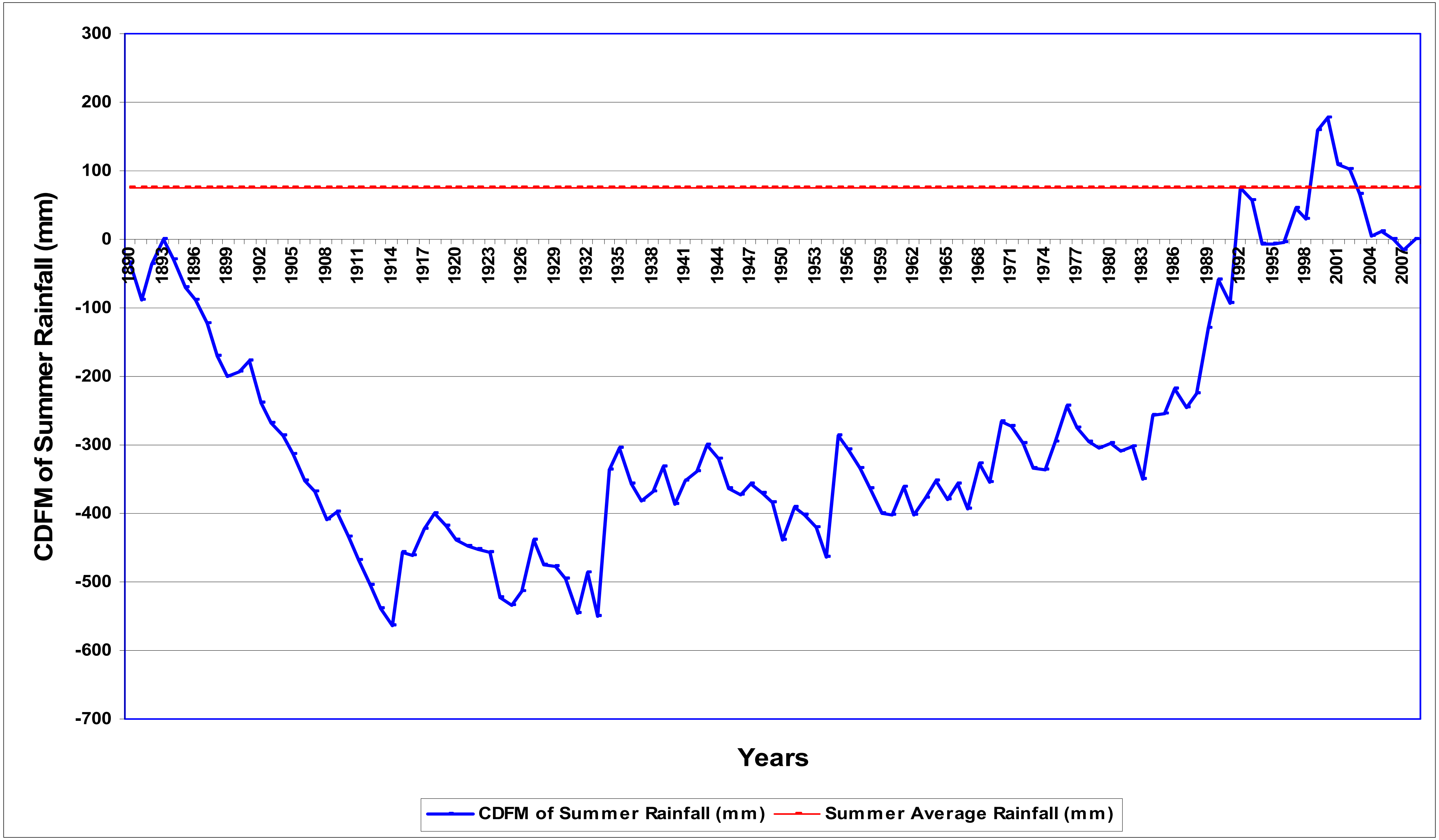

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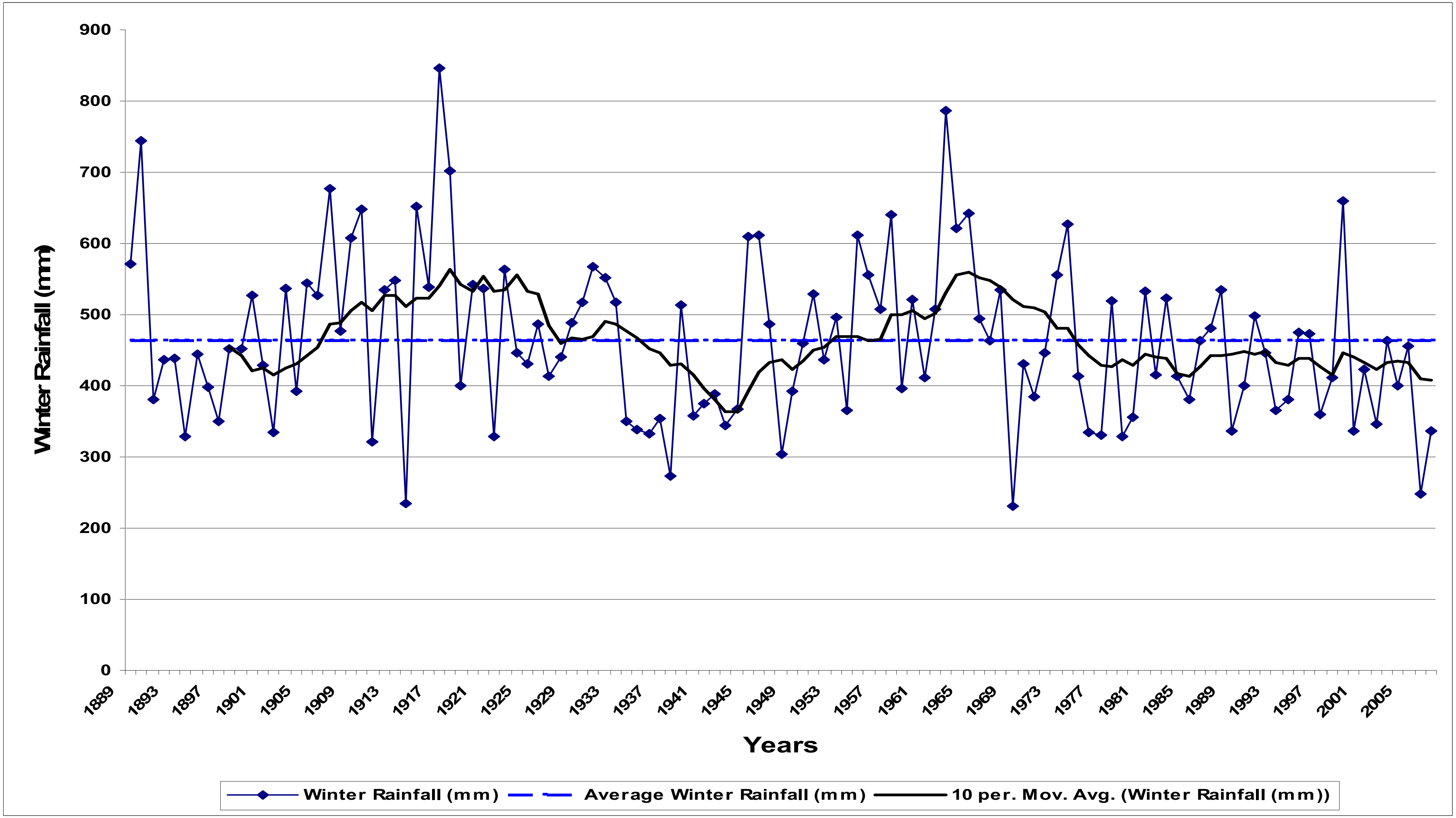


Client: Aviva Ltd

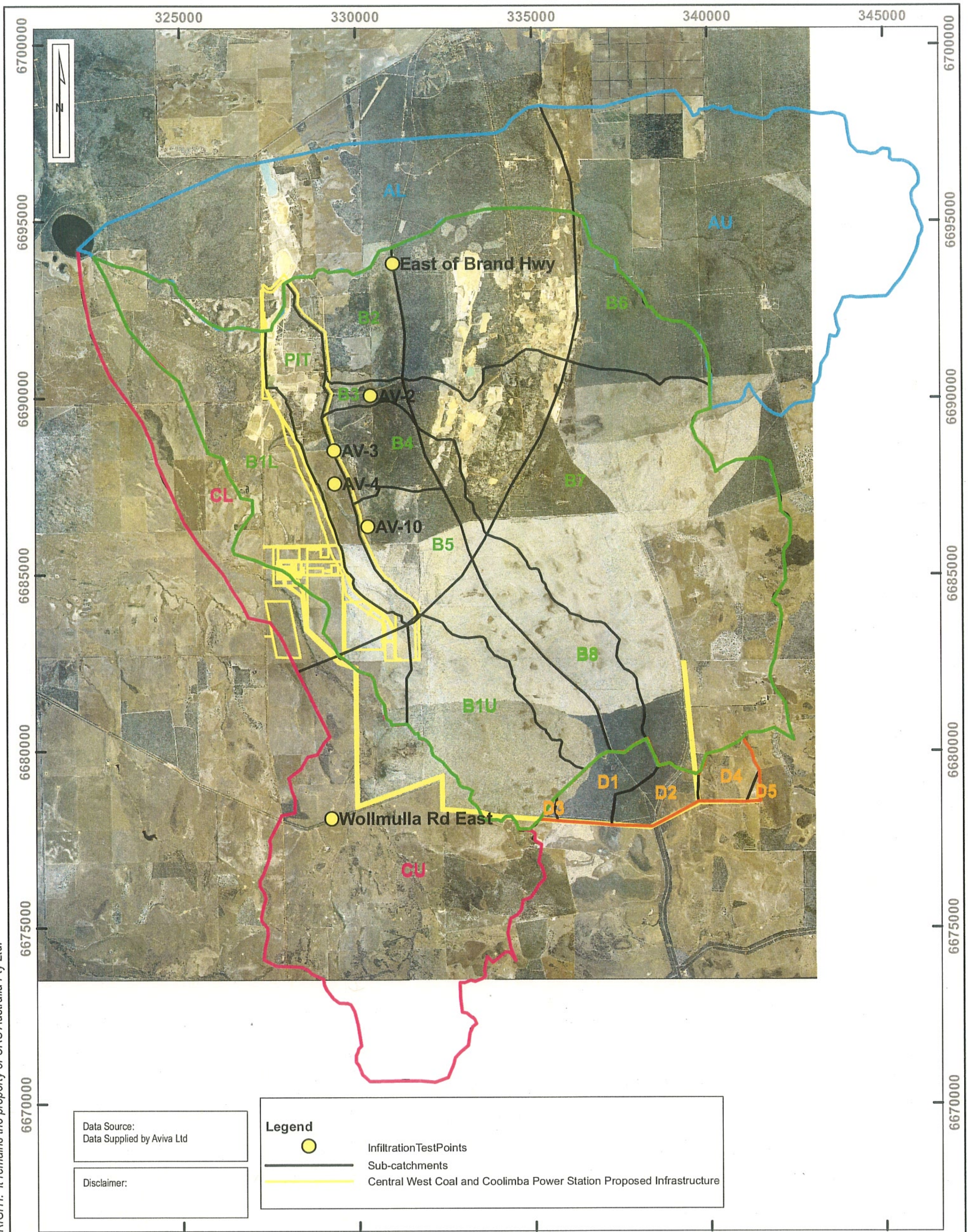
Project: Coolimba Power Station Project
Surface Water Assessment

Title: Winter Rainfall Trend for Eneabba

Drawn: MOS | Approved: BE | Date: 27/01/09

Job No: 42906631 | File No:

Figure: 2-9



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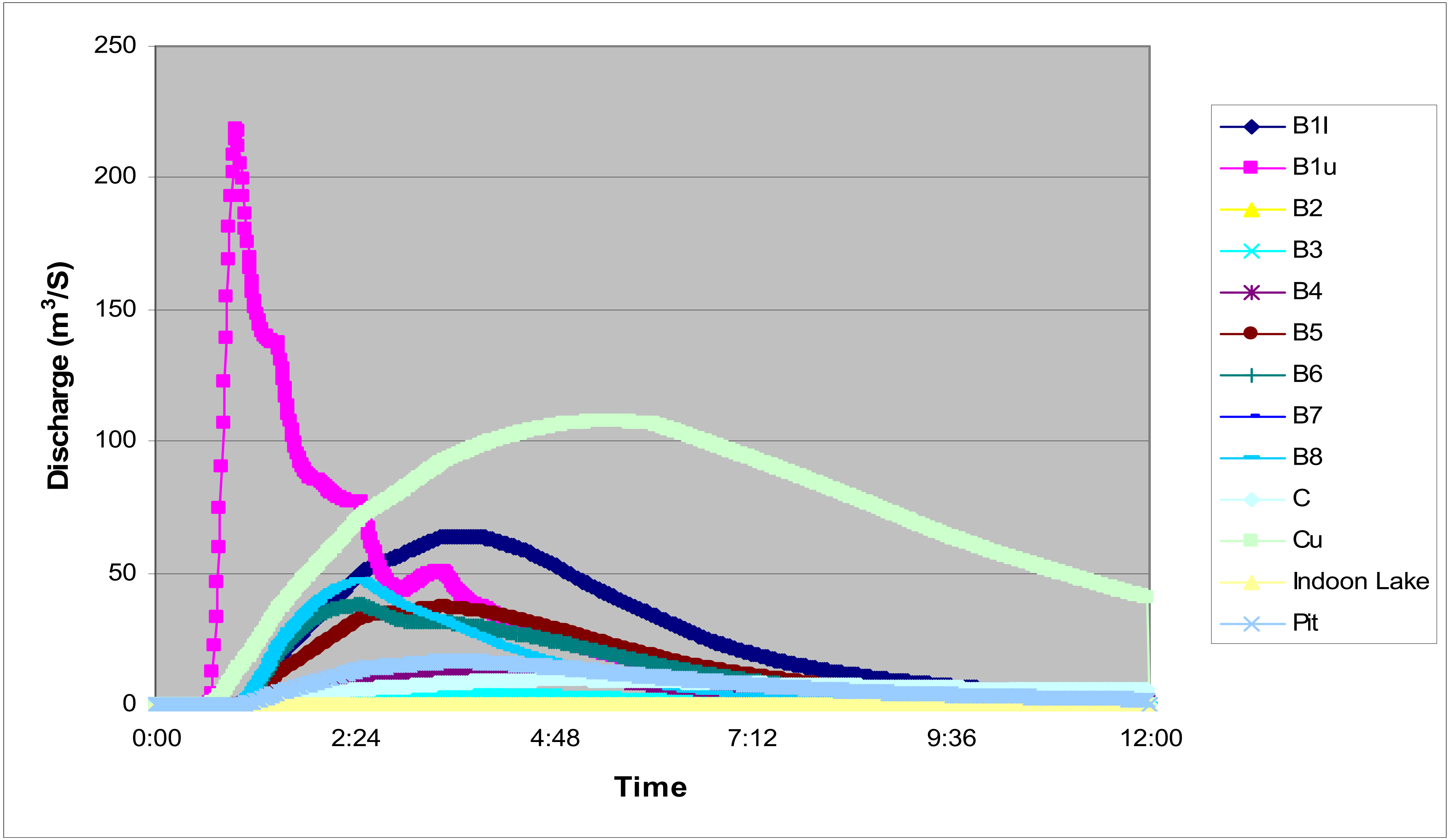

Client: Aviva Ltd	Project: Coolimba Power Station Project Surface Water Assessment			Title: XP-RAFTS Runoff Hydrographs for the 100yr ARI 6hr Design Event
URS	Drawn: MOS	Approved: BE	Date: 27/01/09	
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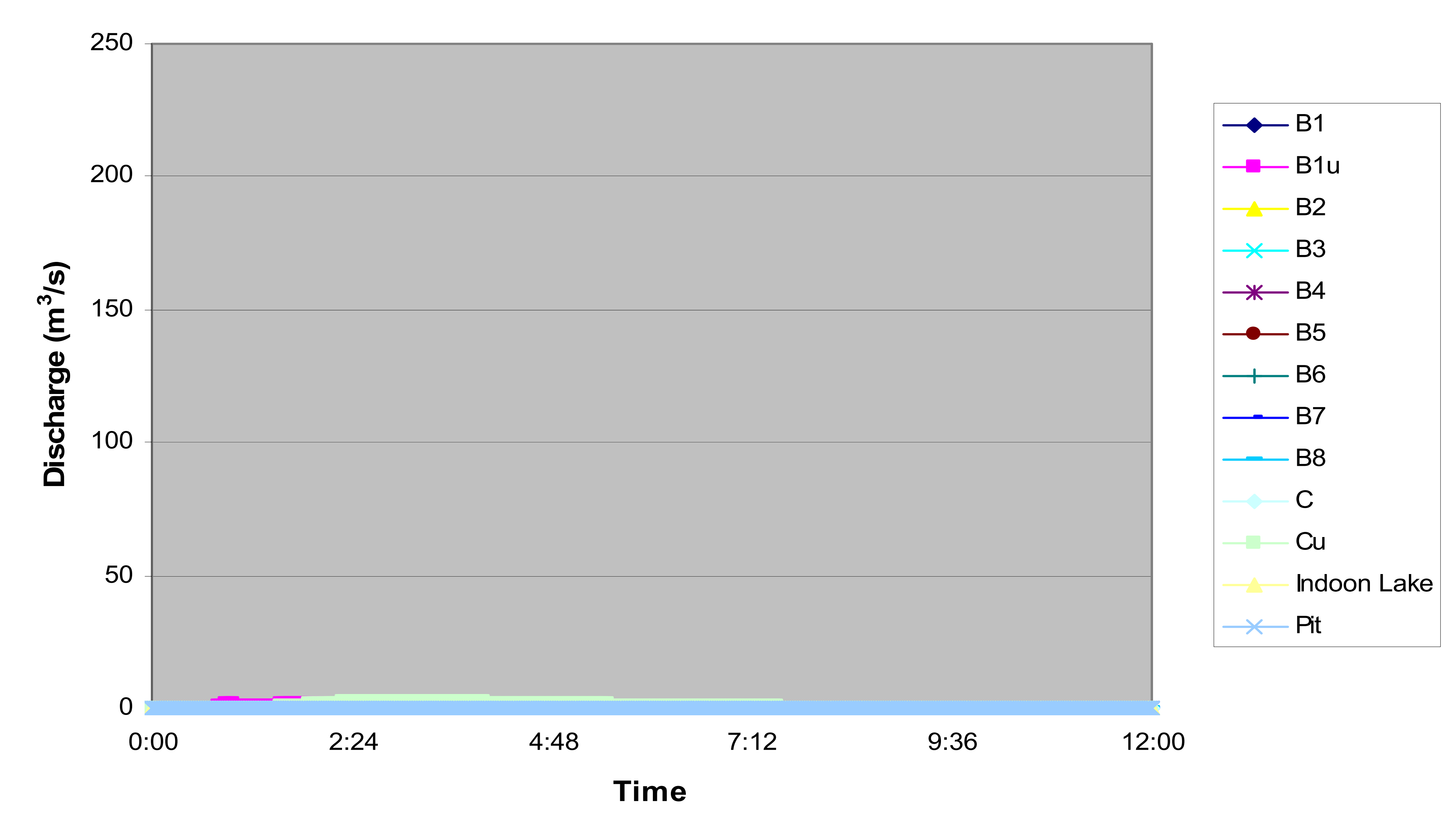

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URS	Drawn: MOS / Approved: BE / Date: 27/01/09	
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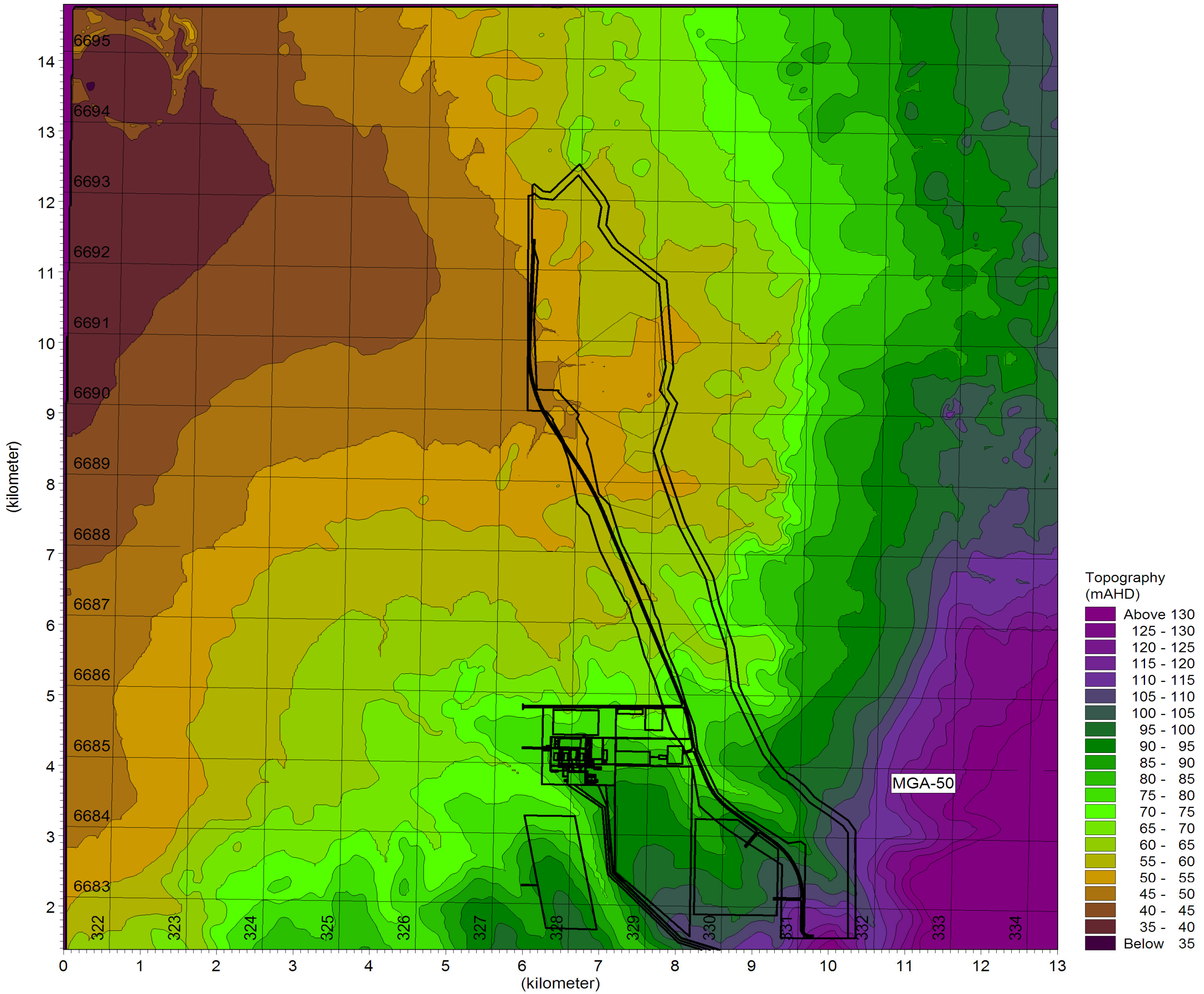

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Aviva Ltd	Coolimba Power Station Project Surface Water Assessment			MIKE 21 Topographic Grid
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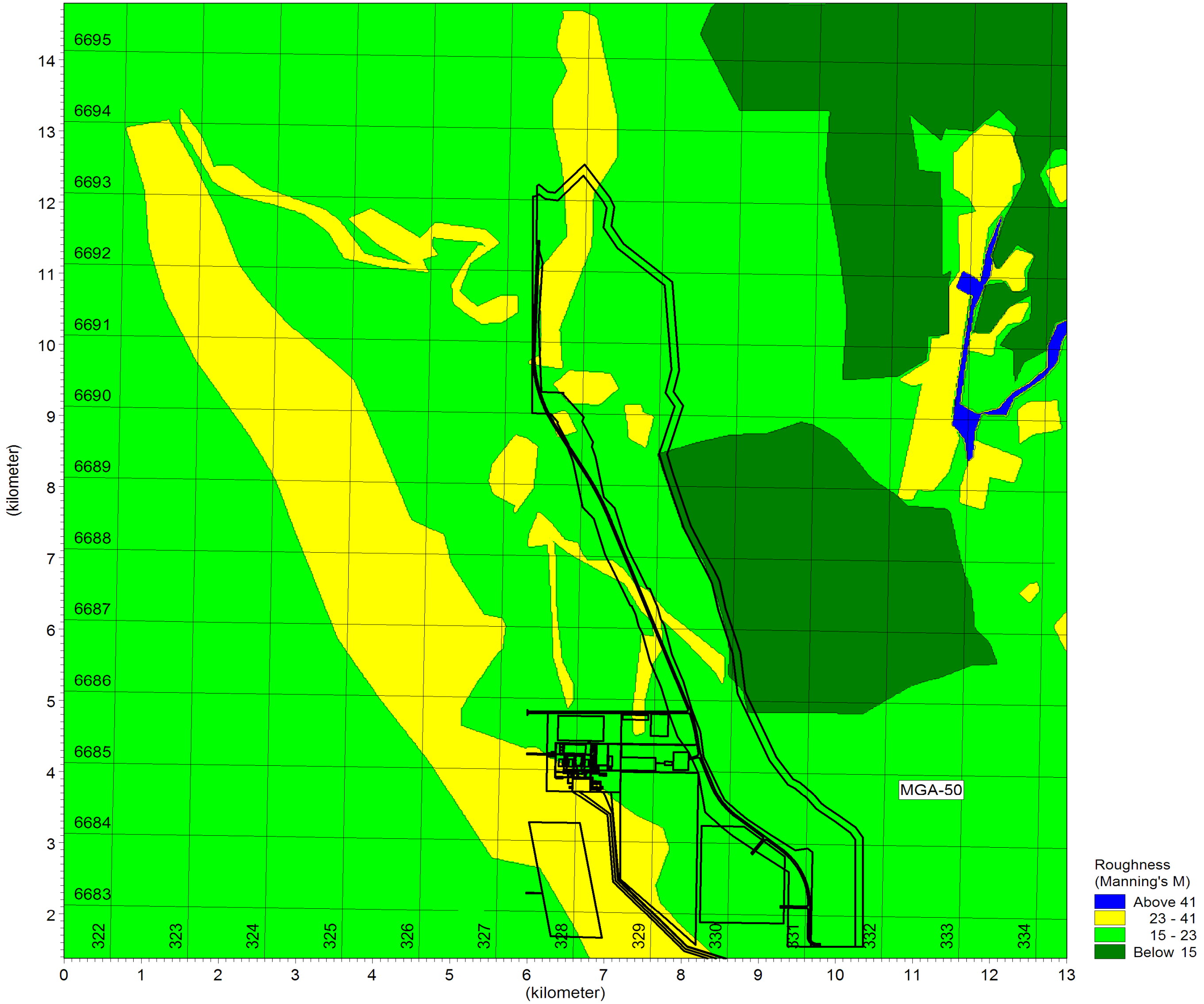

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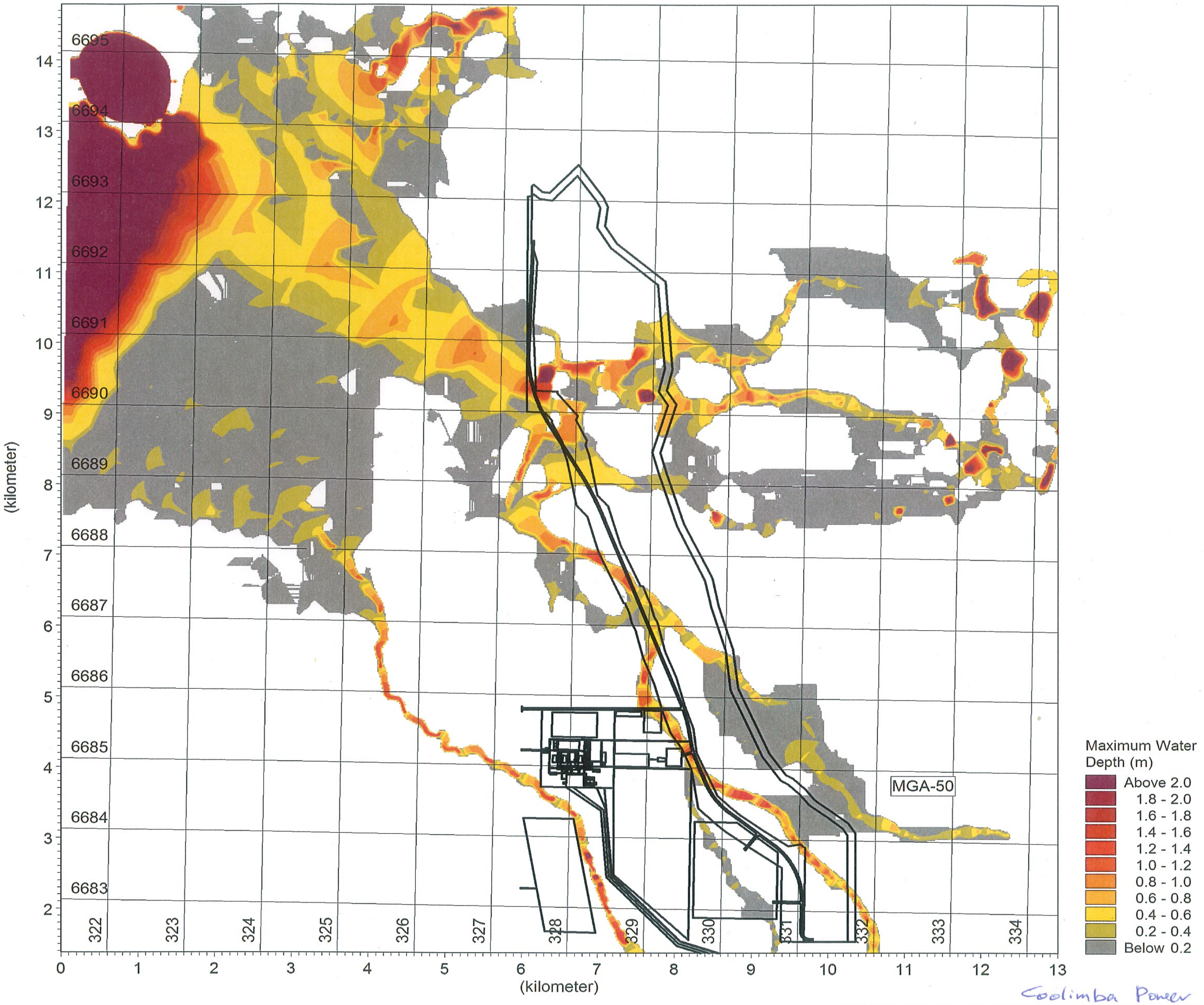
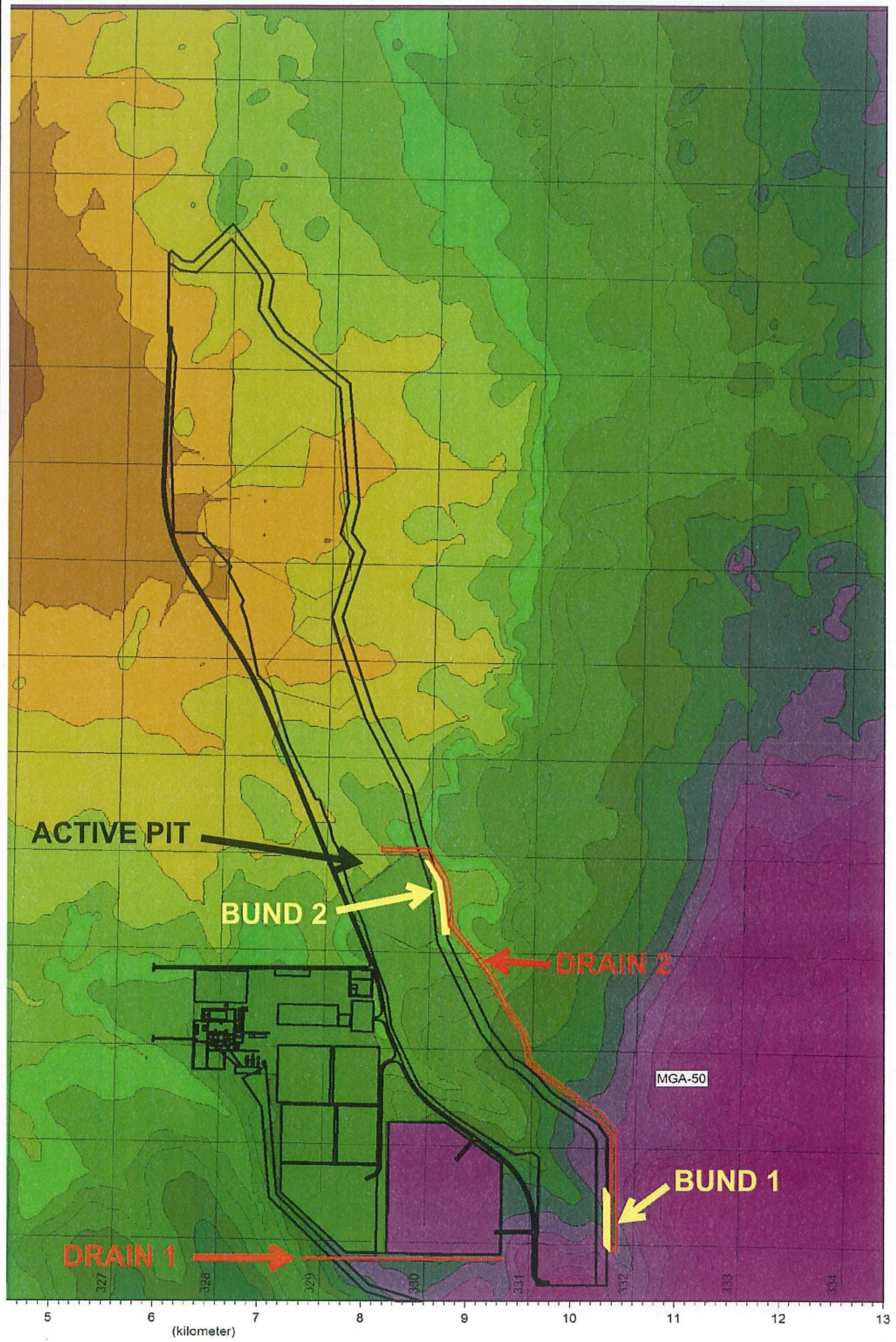
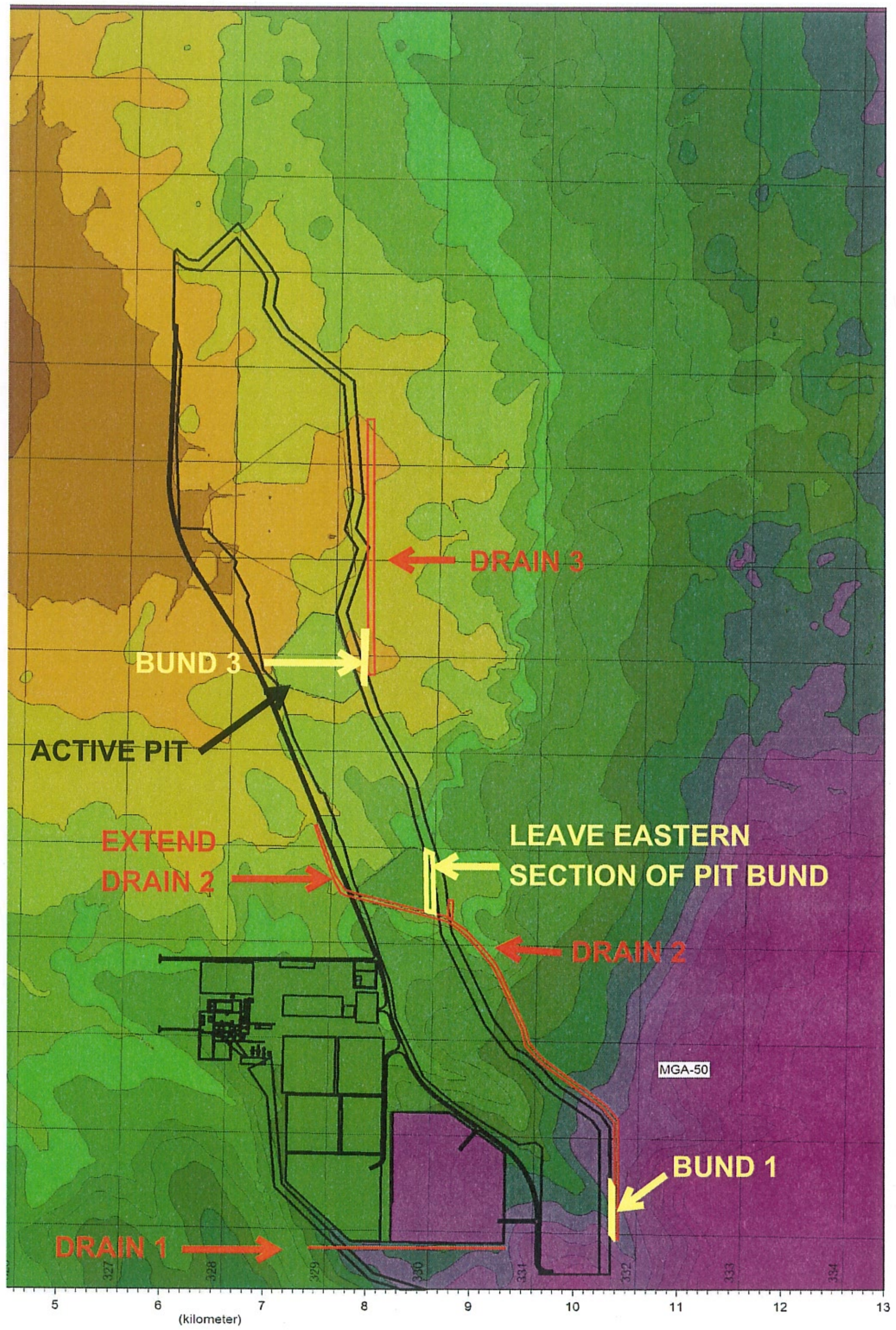


Coolimba Power Station Project

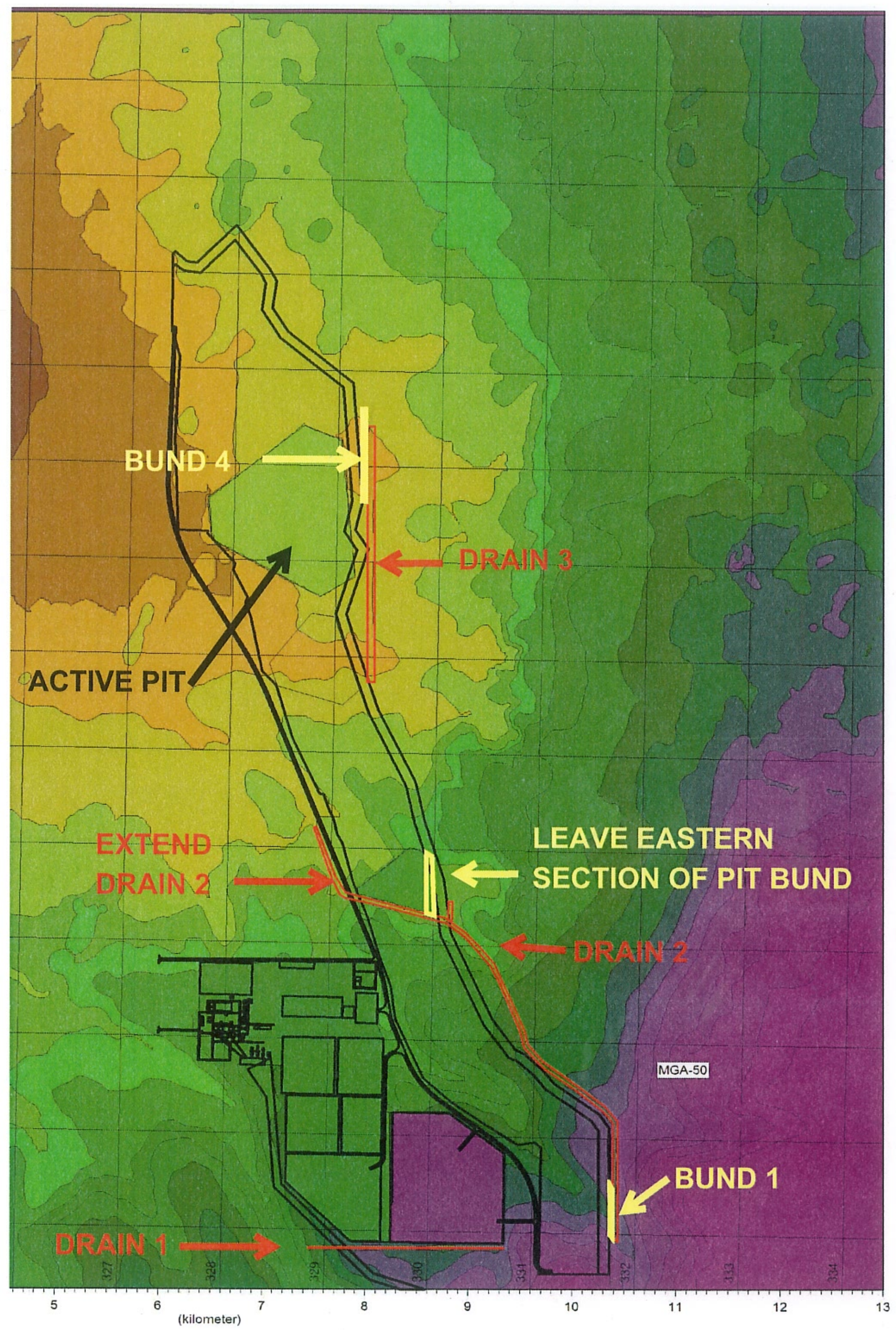
Client	Project	Title
Aviva Ltd	~~Central West Coal Project~~ Surface Water Assessment	Baseline Max Water Depth 100yr ARI 6hr Duration
URS	Drawn: MOS; Approved: BE; Date: 03/10/2008; Job No.: 42906631; File No.	Figure: 4-6; Rev. -; A3



Surface Water Diversion Stage 1



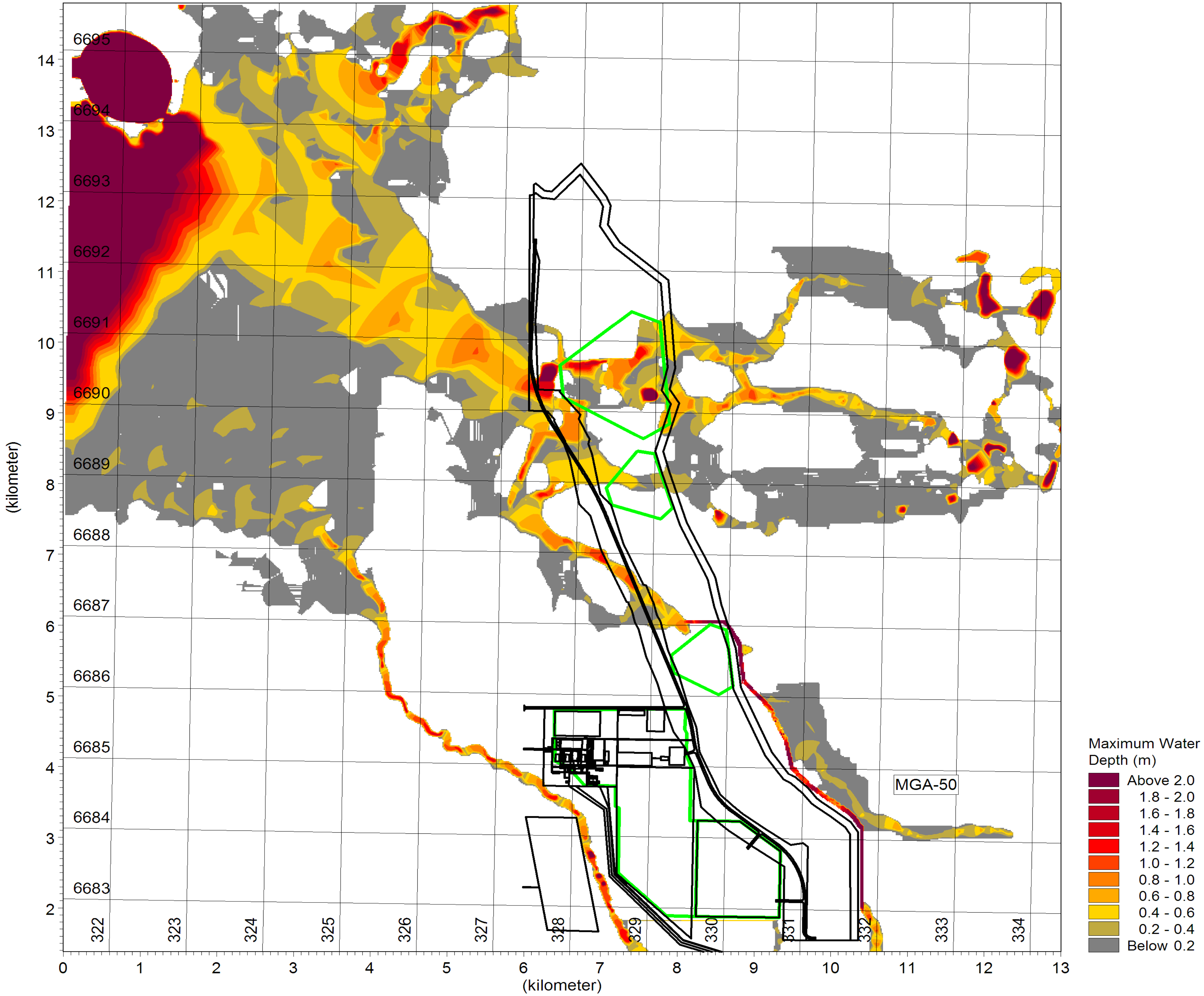
Surface Water Diversion Stage 2



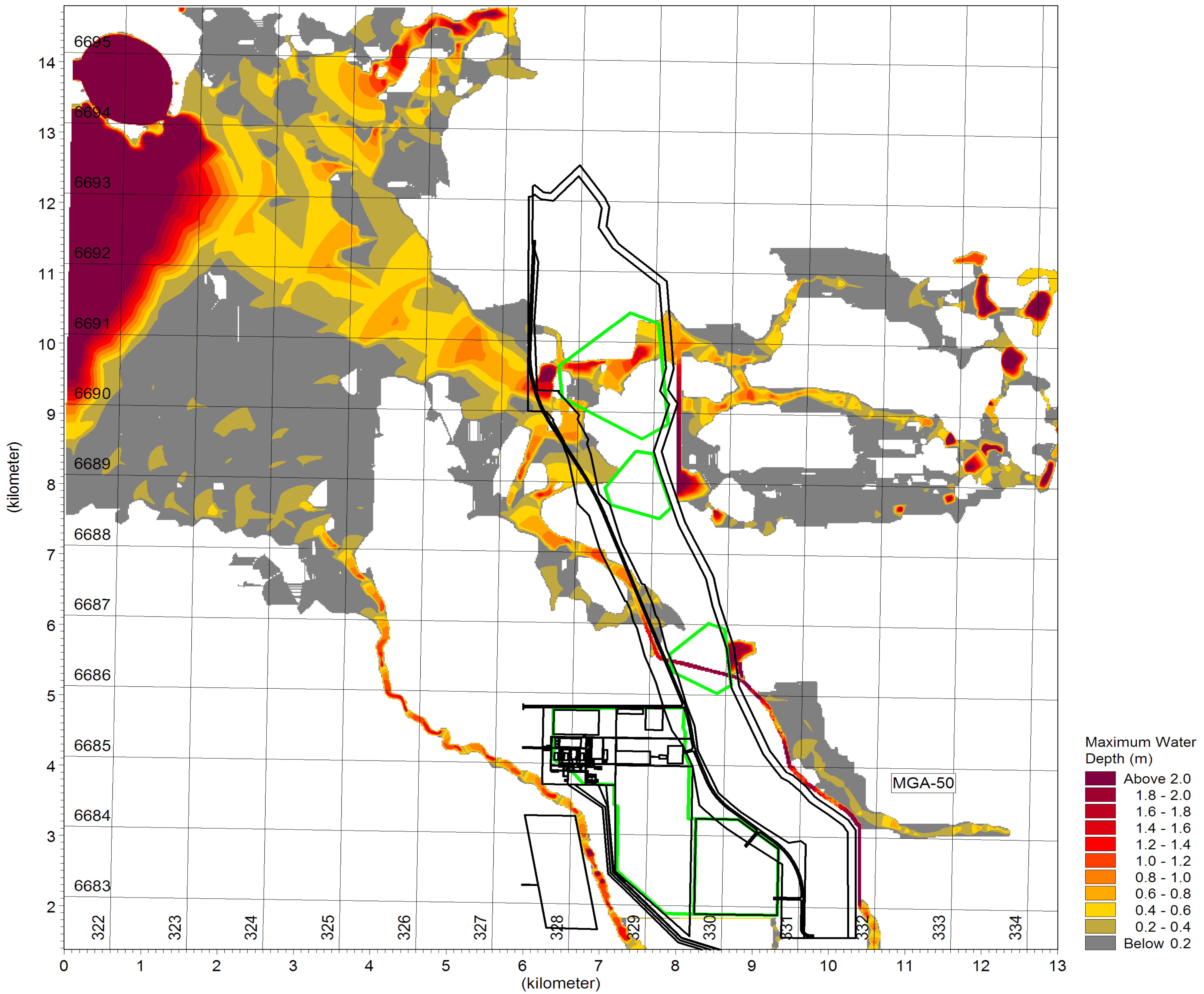
Surface Water Diversion Stage 3

Coolimba Power Station Project.

Client	Project			Title	
Aviva Ltd	~~Central West Coal Project~~ - Surface Water Analysis			Preliminary Design of Surface Water Diversion	
URS	Drawn: MOS	Approved: BE	Date: 08/10/2008	Figure: 6-1	Rev. -
	Job No.: 42906631	File No.			A3



Client: Aviva Ltd	Project: Coolimba Power Station Project		Title: Diversion Max Water Depth - 100yr ARI 6hr Duration
URS	Drawn: MOS	Approved: BE	Date: 19/11/2008
	Job No.: 42906631	File No.	Figure: 6-2
			Rev. -
			A3



Client	Project			Title	
Aviva Ltd	Coolimba Power Station Project			Diversion Stage2 Max Water Depth - 100yr ARI 6hr Duration	
URS	Drawn: MOS	Approved: BE	Date: 03/10/2008	Figure: 6-3	Rev. -
	Job No.: 42906631	File No.			A3

Plate 4-1

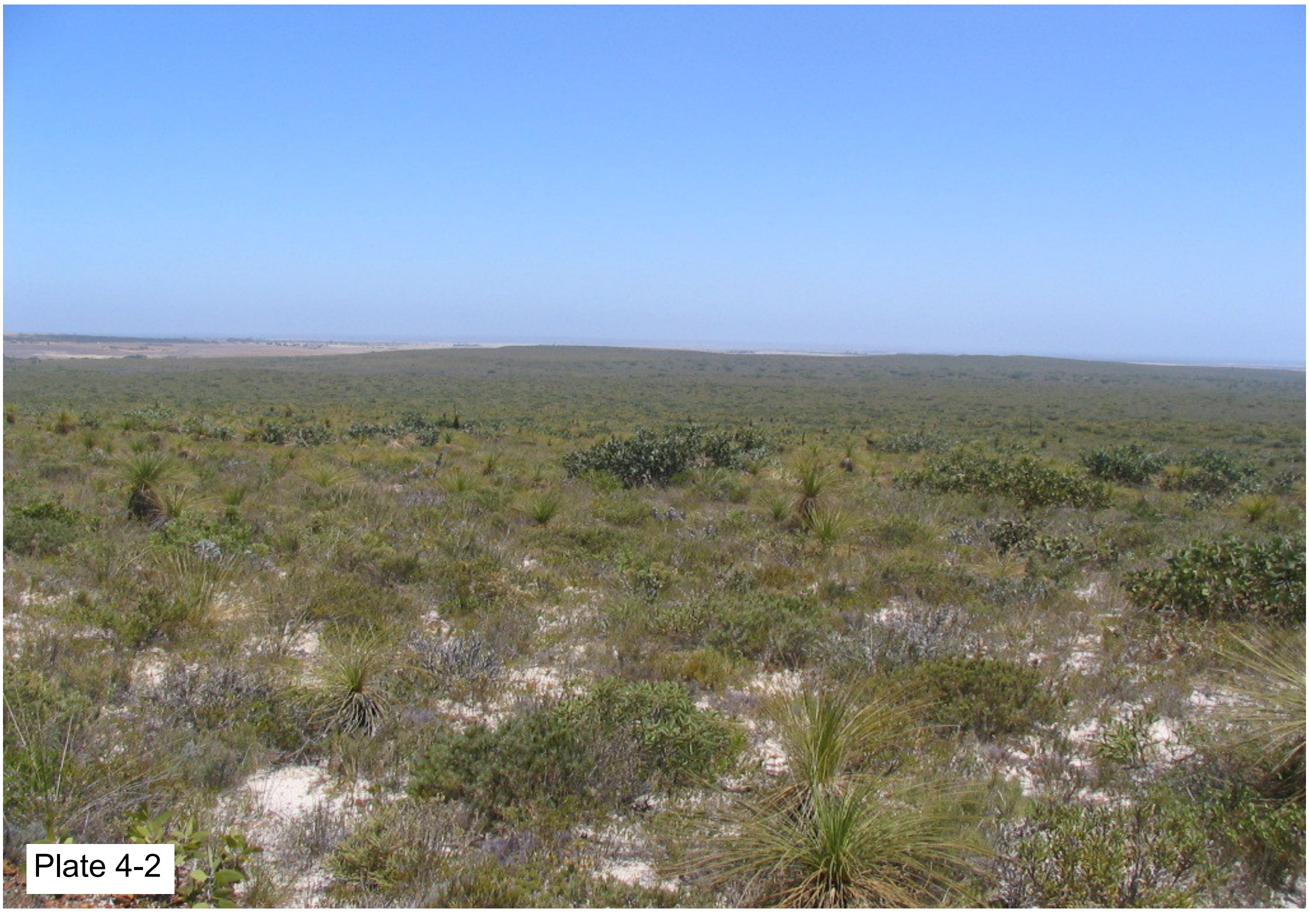


Plate 4-2

Client:	Project:	Title:	
Aviva Ltd	Coolimba Power Station Project Surface Water Assessment	4-1 Typical Land Surface 4-2 Typical Natural Drainage Channel	
URS	Drawn: MOS · Approved: BE · Date: 27/01/09	Plates: 4-1 and 4-2	Rev. A
	Job No. 42906631 · File No.		A4