SARFIIP SMM Investigations: Groundwater monitoring on Pike Floodplain and Katarapko Floodplain 2015

DEWNR Technical note 2015/27

Government of South Australia
Department of Environment, Water and Natural Resources

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Groundwater monitoring on Pike Floodplain and Katarapko Floodplain 2015

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December, 2015

DEWNR Technical note 2015/27

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ISBN 978-1-925369-62-5

Preferred way to cite this publication

Schneider I. & Costar A., 2015, *SARFIIP SMM Investigations: Groundwater monitoring on Pike Floodplain and Katarapko Floodplain 2015*, DEWNR Technical note 2015/27, Government of South Australia, through the Department of Environment, Water and Natural Resources, Adelaide

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1 Introduction

1.1 Project background

The South Australian Riverland Floodplains Integrated Infrastructure Program (SARFIIP) is a large-scale infrastructure project to enable floodplain inundation for the South Australian Riverland region between the border and Lock 1 with particular focus on the Pike and Katarapko Floodplains. Commencing in 2012, the program aims to restore the vegetation health of floodplains at Pike and Katarapko (or Katfish Reach study area). This program will build on the investment undertaken by the Riverine Recovery Project (RRP) at these sites and allow for an integrated approach to management that will deliver regional environmental benefits.

SARFIIP is being delivered for the Australian Government's Murray–Darling Basin Authority (MDBA) by the River Murray Operations and Major Projects (RMOMP) Branch of the Department of Environment, Water and Natural Resources (DEWNR), in partnership with the Science, Monitoring and Knowledge (SMK) Branch and Natural Resources SA Murray-Darling Basin (NRSAMDB). SMK will support RMOMP through the delivery of scientific and technical services to assist with the assessment of floodplain and salinity management options, including data management, field investigations and modelling. Collectively these tasks are referred to as the SARFIIP Science Program.

The SARFIIP Science Program incorporates a number of managed projects of work including: Preliminary Investigations (Project 1), Salinity Investigations (Project 4) and Salinity Knowledge, Data Analysis and Modelling (Project 6) all of which fall under the Salinity Management Measures (SMM) project delivered by RMOMP. Salinity Investigations is focused on a number of targeted groundwater field investigations while Salinity Knowledge, Data Analysis and Modelling primarily focuses on the construction of a Pike Floodplain numerical groundwater model to support concept design options. The targeted groundwater field investigations provide baseline data, enabling greater understanding of floodplain processes and thereby informing the floodplain hydrogeological conceptual model and numerical modelling requirements.

During the Peliminary Investigations phase, SMK and RMOMP identified a number of field tasks required to support numerical groundwater modelling and development of SMM concept design options. One task implemented in Project 1 during 2014 was a bore audit that provided a stocktake of groundwater well infrastructure it's status and condition across the study area. The results of the bore audit were then used to establish Salinity Investigations project tasks were critical to implementing a groundwater level monitoring and groundwater salinity sampling program.

This document details the groundwater monitoring and salinity sampling programs of work conducted during 2015–16 under the Salinity Investigations project and provides recommendations for future monitoring requirements during the detailed design phase of SMM. While the salinity sampling program provides a baseline of groundwater quality across the study area, the groundwater level monitoring builds on baseline measurements collected during the bore audit.

1.2 Study area

1.2.1 Pike Floodplain

Pike Floodplain is located south of the township of Renmark and consists of a large anabranch system of approximately 67 sq. kilometres (Fig. 1). Lock 5 is the closest of the River Murray locks located to the north of the floodplain.

The anabrach system is fed by Deep Creek and Margaret Dowling Creek, north of Lock 5, which provide regulated inflows to the floodplain. The system is made up of several creeks or anabraches namely: Mundic Creek, Pike Lagoon, Pike River (Upper, Mid and Lower), Snake Creek, Tanyacka Creek and Rumpagunyah Creek. Mundic Creek and Pike River are the largest with Pike River providing water for one of South Australia's oldest irrigation communities. Water volume for irrigation is regulated on Pike River downstream by Col Col Embankment.

The floodplain can be broken up into the Upper Pike Floodplain and Lower Pike Floodplain. The Upper Pike Floodplain can only be accessed by road via Mundic Creek Road in the north. Until recently (mid-2015), the floodplain could also be accessed in the east by Coombs Bridge however that bank has been removed. While technically both sections of the floodplain are islands, the Lower Pike Floodplain is considered a permanent island as access can only be achieved by water craft.

A series of levee banks or bridges allow access to the majority of the floodplain proper (i.e. Upper Pike Floodplain) which have been slowly upgraded. At present, the current and usable levee banks include: Bank B, Bank C, Bank D, Bank E , Bank F, Bank F1 and Bank G.

The Pike Floodplain is a high priority ecological and cultural area of the River Murray. The floodplain contains a variety of aquatic habitats but currently suffers from declining ecological health. Key threats to this ecosystem include highly saline groundwater close to the ground surface and altered flow regimes. Groundwater salinity impacts to the River Murray and Pike Floodplain are currently mitigated through the operation of the Pike River Salt Interception Scheme (SIS), which has four operational production wells located immediately south of the floodplain near the Lower Pike River.

Recent efforts to improve ecosystem health has included artificial inundation of Duck Hole, an adjacent wetland and the Inner Mundic Floodrunner on the north western Pike Floodplain.

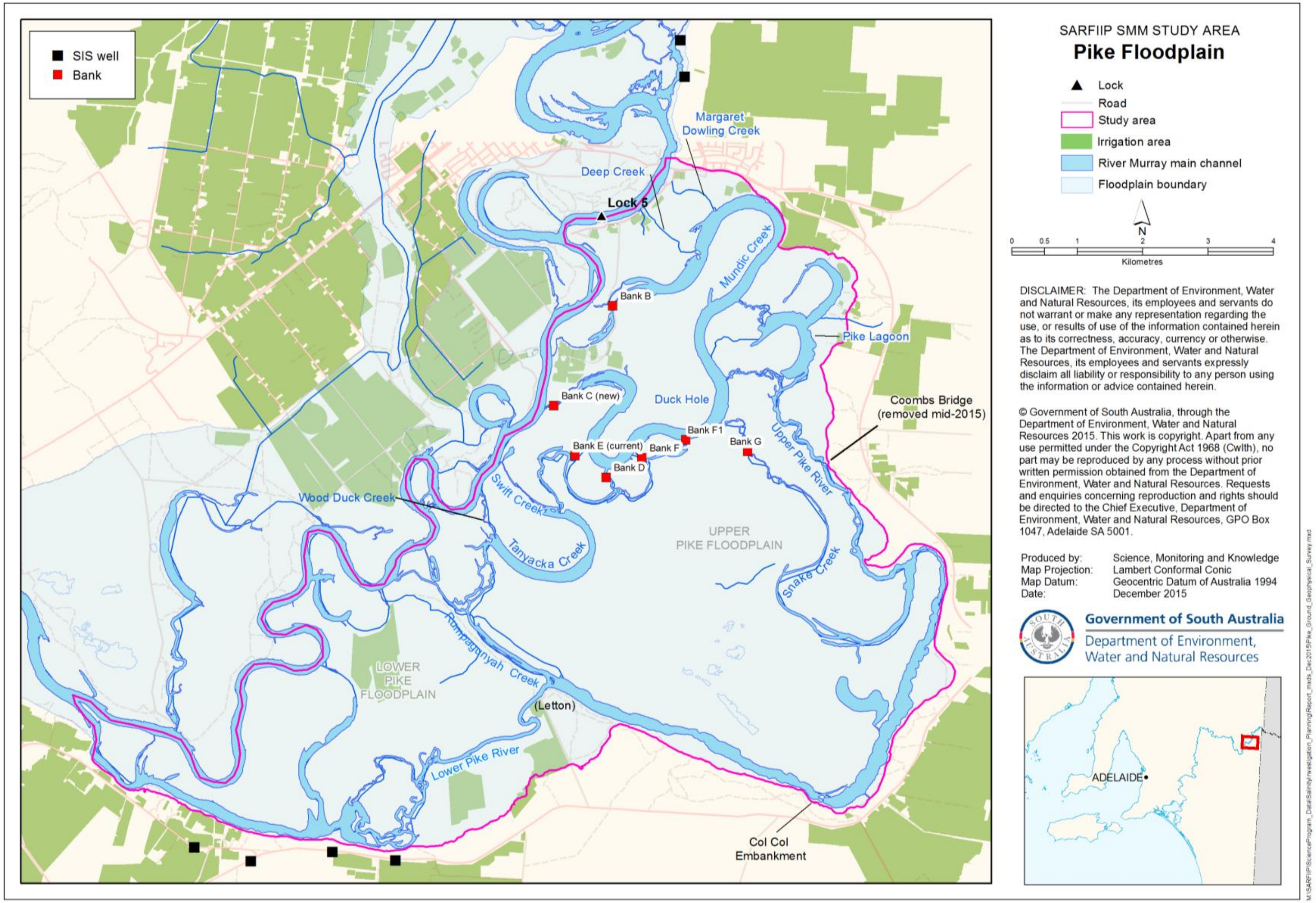

Figure 1 Location of Pike Floodplain and surrounding areas

1.2.2 Katarapko Floodplain

The Katarapko Floodplain is located between the townships of Berri and Loxton covering an area of approximately 90 sq. kilometres (Fig. 2). Lock 4 is the closest of the River Murray locks located in the north of the floodplain. The name Katfish Reach was established seven years ago and stands for Katarapko Native Fish Demonstration Reach Katfish Reach, and refers to the broad project area. Katarapko Floodplain refers to the geographical location which falls within the Katfish Reach project area. Most of the area is governed under the Murray River National Park (Katarapko) but also includes private and Crown Land, and the Gerard Aboriginal Reserve.

The anabrach system is fed by Bank J, Bank K and Bank N, north of Lock 4, which provide regulated inflows through a series of anabranches namely: Northern Arm, Bank K Creek, Eckert Creek, Southern Arm. These provide flows to the bulk of the system downstream whch include Eckert Wide Water, Ngak Indau wetland, Sawmill Creek, Eckert Creek (downstream), The Splash, Katarapko Creek, Piggy Creek and Carpark Lagoons. The Berri Saline Water Disposal Basin is located in the north of the project area.

A complex system of lakes called the Gurra Gurra Lakes is located in the north east of the project area and will be the subject of further investigation in the future.

Habitats within Katfish Reach include permanent flowing creeks, freshwater complexes, saline wetlands and floodplains which support a variety of wildlife which includes a number of threatened species. River regulation and historic land management practices have impacted on the health of this ecosystem.

Groundwater salinity impacts to the River Murray and Katarapko Floodplain are currently mitigated through the operation of the Bookpurnong and Loxton SIS's, which have approximately 27 operational production wells and a highland horizontal drainage well located adjacent to the study area.

Recent efforts to improve ecosystem health has included artificial inundation trails at a number Katarapko Floodplain sites including Ngak Indau Wetland, Piggy Creek and Carpark Lagoons.

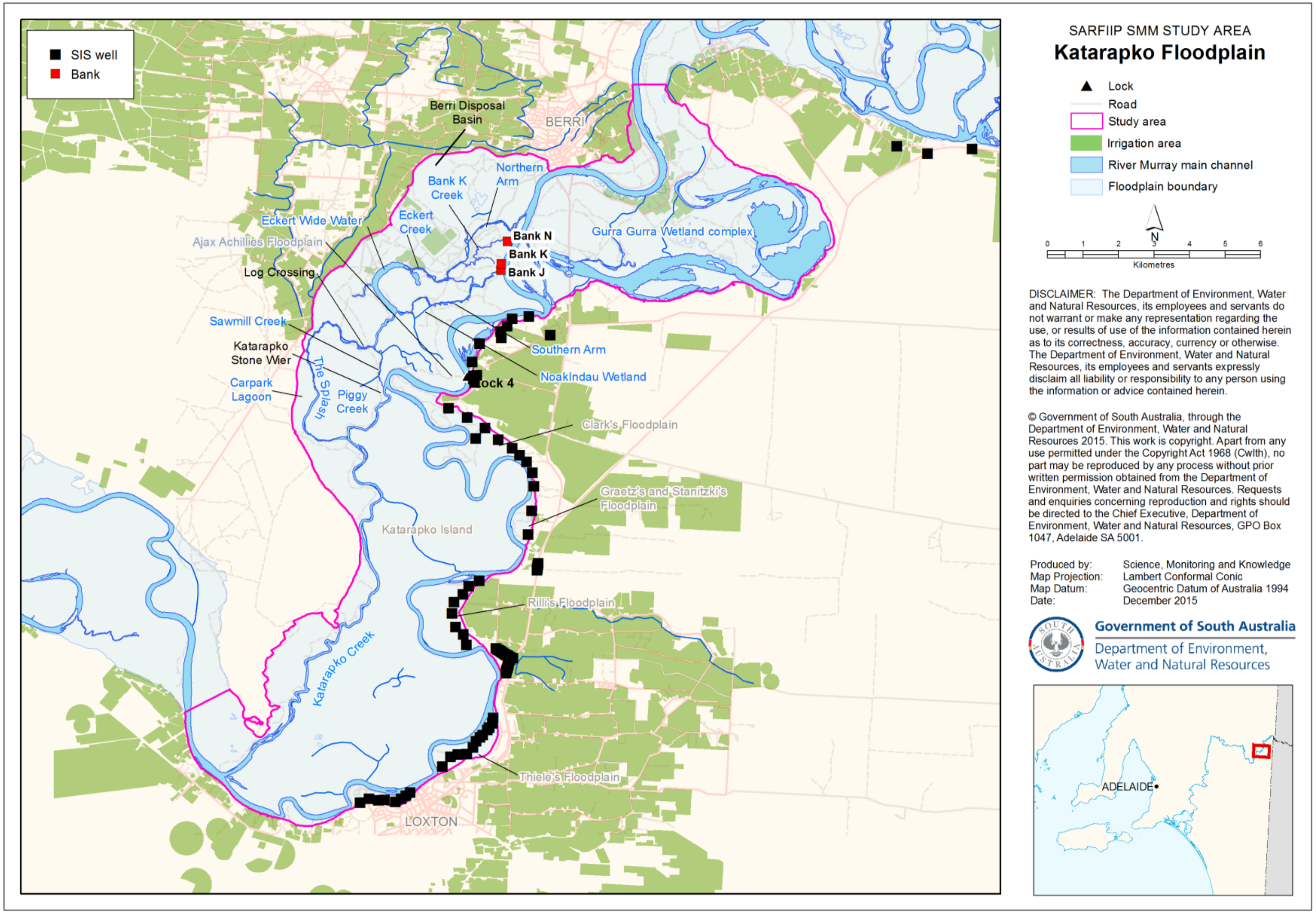

Figure 2 Location of Katarapko Floodplain and surrounding areas

2 Hydrogeology

2.1 Regional hydrogelogy

The Riverland of South Australia forms part of the Mallee region of the larger Murray Basin, a shallow geological basin that covers about 300 000 sq km, across the states of Victoria, South Australia and New South Wales. The Murray Basin is a closed groundwater basin containing Cenozoic unconsolidated sediments and sedimentary rock up to 600 metres in thickness, within which a number of regional aquifer systems have been identified (Evans and Kellett, 1989). From 65 million years ago (Pliocene) to the present, the depositional and erosional patterns of the western Murray Basin have been dominated by a combination of changing sea levels, cyclically driving sea inundation of the continent and incision of river valleys and minor tectonic movements (Drexel and Preiss, 1995).

Within South Australia and for the purposes of this report, there are four sequences of sedimentary rocks that are identified as aquifers. These include: the Renmark Group, Murray Group, Loxton Sands and lateral equivalents and the Monoman Formation (Fig. 3). Additionally, perched aquifer systems also exist within the Woorinen Formation found in some irrigation areas. A summary of the hydrostratigraphy is provided in Table 1.

Of importance to the area of investigation is that the Monoman Formation unconformably overlies the Loxton Sands near the Murray River. This depositional relationship evolved during the last glacial maximum (~65,000 years before present) in which the Loxton Sands were eroded by channel development and the Monoman Formation and later Coonambidgal Formation sediments subsequently deposited (Rogers, 1995). With respect to the regional hydrogeology, groundwater is interpreted to flow from the Loxton Sands into the Monoman Formation.

In-situ weathering and regolith development (e.g. crete-formation, mineral dissolution or oxidation or bio- or rhizoturbation) may affect the hydrogeological properties of the various hydrostratigraphic units. However, it is currently uncertain whether such processes have affected exposed strata significantly enough to warrant mapping weathering horizons as separate hydrostratigraphic entities.

Table 1 Summary of hydrostratigraphy of the investigation area (Summarised from Rogers, 1995; Rogers et al, 1995, Firman 1973 and Lawrence 1966 and Cowley and Barnett, 2007).

Period	Group name	Formation name	Lithology description	Depositional environment	Hydrogeological characteristics
Holocene		Coonambidgal Formation	Slightly micaceous silty clay. Variable amounts of silt sand and gravel.	Floodplain alluvial. Paired terraces evident along stream channels	Aquitard. Groundwater found in sandier units
Pleistocene		Monoman Formation	Coarse grained quartz sand, silts and alluvial clay	Alluvial	Aquifer
Middle Pleistocene to Holocene		Woorinen Formation	Pale reddish brown silty and clayey quartz sand with layers of pedogenic carbonate	Dunal	Perched aquifers present
Late Pliocene to Middle		Blanchetown Clay	Greenish grey sandy clay. Thin layers of limestone and quartz sand. Gypsiferous near top. Calcareous septarian nodules	Lacustrine. (Lake Bungunnia)	Aquitard
Late Pliocene to Middle		Chowilla Sand	Fine to medium grained quartz sand	Fluvial	Aquifer. Restricted to areas upstream from Berri
Early to Late Pliocene		Loxton Sands (inc. Parilla Sand)	Glauconitic micaceous and shelly fine sand, planar to cross-bedded fine to coarse sand and fine gravel and planar-bedded calcareous and micaceous, shelly medium to coarse grained sandstone. A sequence of clay and shells is found at the base. This sequence is referred to as the “Lower Loxton Shells and Clay” in Yan et al. 2005a	Shallow water and marginal marine transitioning to beach and coastal barrier. Regressional sequence. Parilla Sand is non-marine.	Aquifer (Lower Loxton shells and clay interpreted as an aquitard)
Late Miocene to Early Pliocene		Bookpurnong Formation	Marl, silty clay and minor fine sand	Shallow marine	Aquitard
Early Miocene		Winnambool Formation	Fossiliferous marl, glauconitic marly limestone and marly clay	Shallow, restricted marine and lagoon	Aquitard
Early Miocene		Geera Clay	Black and grey-green carbonaceous, pyritic clay	Marginal marine and tidal sediments	

Period	Group name	Formation name	Lithology description	Depositional environment	Hydrogeological characteristics
Early Miocene	Murray Group	Pata Formation	Bryozoan limestone and marl	Marine	Aquifer
Early Miocene	Murray Group	Morgan Subgroup	Low energy carbonate ramp sediments. Consists of the Cadell Formation (marl), Glenforslan Formation (carbonate sediments with abundant bryozoans and molluscs) and the Finniss Formation (carbonate clay)	Marine. Low energy carbonate ramp	Possible limestone aquifer. Clays may act as localised aquitards.
Early Miocene	Murray Group	Mannum Formation (Inc. Upper and Lower Mannum Frms.	Echinoidal and bryozoal calcareous sandstone and sandy limestone.	Shallow marine	Aquifer
Early Oligocene to Early Miocene	Murray Group	Ettrick Formation	Glauconitic and fossiliferous marl, calcareous clay and mudstone. Some silt and fine grained sand	Marine	Aquitard
Late Palaeocene to Middle Eocene	Renmark Group	Olney Formation	Thinly bedded carbonaceous sand, silt, clay and lignite	Fluvial, lacustrine and swamp environments	Aquifer. Basin wide.
Late Palaeocene to Middle Eocene	Renmark Group	Warina Sands	Medium to coarse-grained quartz sand. Minor thin lenticular inter-beds of carbonaceous silty clay	Non-marine	Aquifer. Restricted to deeper parts of the basin

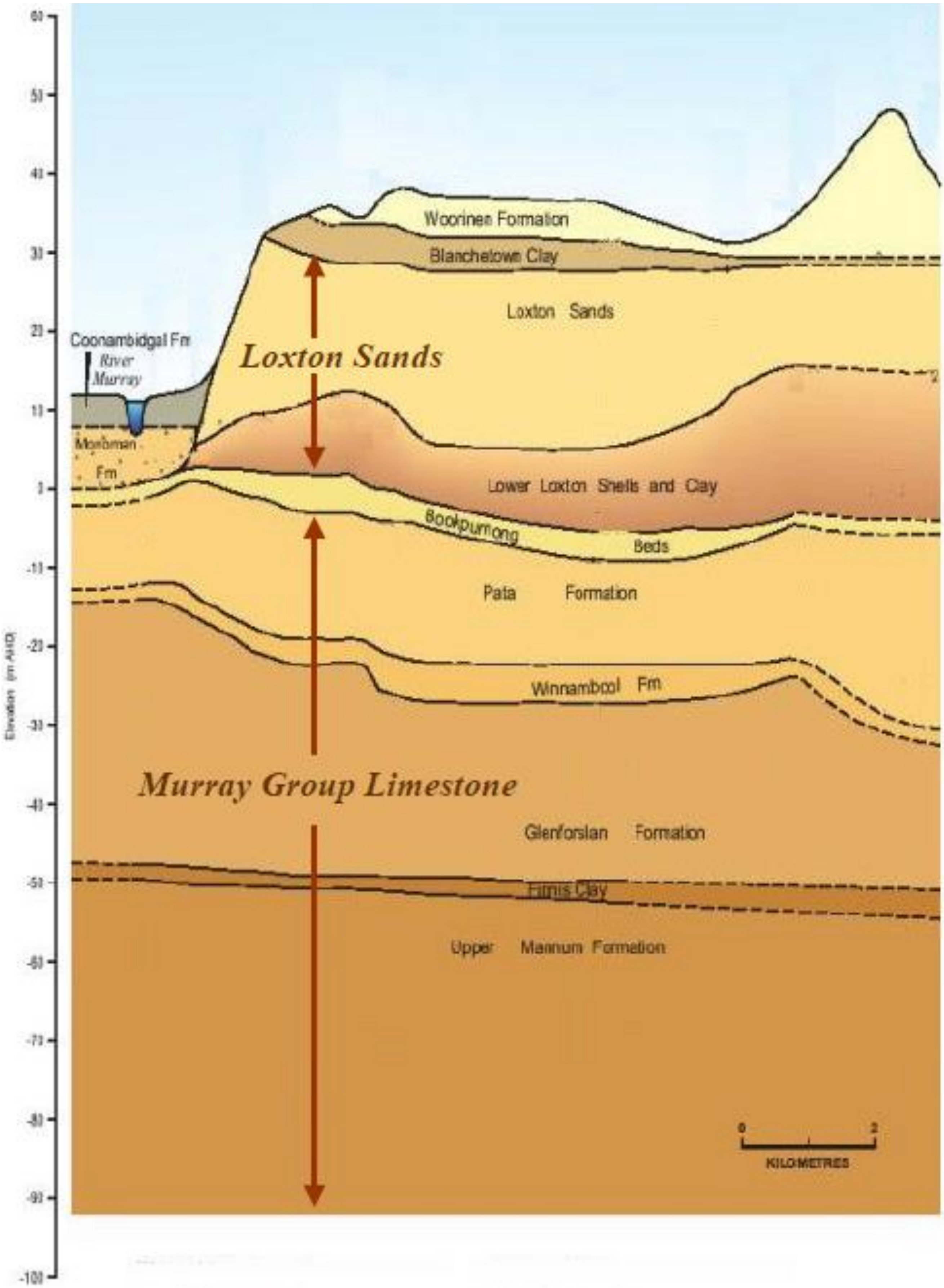

Figure 3 Hydrogeological cross-section of the Riverland environment (Yan et al, 2005a)

Table 2 below details the basic characteristics of each hydrogeological unit in the project area.

Table 2 Hydrogeological units of the study area

Hydrogeological Unit	Aquifer/Aquitard	Salinity Range (TDS mg/L)	Yield Range (L/s)
Coonambidgal Formation	Aquitard	NA	NA
Monoman Formation	Aquifer (floodplain)	7,000-60,000	0.5-10
Loxton Sand	Aquifer (highland)	7,000-40,000	0.5-5
Lower Loxton Clay	Aquitard	NA	NA
Bookpurnong Formation	Aquitard	NA	NA
Pata Formation (Murray Group)	Aquifer	10,000-30,000	0.5-1
Winnambool Formation (Murray Group)	Aquitard	NA	NA
Glenforslan Formation (Morgan Subgroup)	Aquifer	5,000-30,000	0.5-2
Finnis Formation (Morgan Subgroup)	Aquitard	NA	NA
Upper Mannum Formation (Murray Group)	Aquifer	3,000-25,000	5-10
Lower Mannum Formation (Murray Group)	Aquifer	NA	NA
Ettick Formation (Murray Group)	Aquitard	NA	NA
Renmark Group	Aquifer	NA	NA

Previously reported (Yan et. al., 2005b)

2.2 Floodplain hydrogeology

As discussed briefly in Section 2.1, the River Murray is located within a broad trench, formed during the last glacial maximum (~65,000 years BP), when sea levels were lower and the river accordingly cut deeper into the surrounding landscape. After sea levels rose, the trench gradually filled with the floodplain sediments of the Monoman Formation and Coonambidgal Formation (Rogers, 1995). The Monoman Formation is the major aquifer beneath the floodplain.

The Monoman Formation and Loxton Sands aquifers provide the majority of the salt load entering the River Murray because they are the main aquifer units in contact with surface water flow. Therefore, groundwater migration between the Loxton Sands and Monoman Formation is an important component in salt migration across the area. The hydraulic conductivity of the Loxton Sands and the hydraulic head difference between the river and nearby groundwater controls the flux of saline groundwater entering the River Murray. Consequently, these two aquifers are the primary targets for salt interception.

Figure 4 presents a schematic diagram of the conceptual hydrogeological model including a description of groundwater flow between the aquifers, the broader regional groundwater flow system, inter-aquifer flow and local recharge mechanisms.

2.2.1 Groundwater level

There is a substantial historical record of groundwater level data near the Pike Floodplain, although most data is restricted to the highland and irrigation areas where the Loxton Sands aquifer predominates. However there are still a number of observation wells completed in the Coonambidgal and Monoman Formations within the Pike Floodplain from which groundwater level data may be obtained.

On the Katarapko Floodplain, groundwater level monitoring is restricted to the eastern side of Katarapko Creek and is centred on the extensive SIS in the area. Groundwater well infrastructure itself is limited on the Katarapko Floodplain study area and where wells exist, they may be completed across both Coonambidgal and Monoman Formations.

Groundwater flow within the Monoman Formation and Loxton Sands broadly follows the stream and topographic gradient. Based on monitoring results over the past 12 months, depth to water (DTW) for the Monoman Formation/Loxton Sands aquifer has varied between 41.5 metres below ground surface (mbgs) (7029-1978) and 0.89 mbgs (702901217) within the Pike Floodplain study area. For the Katarapko Floodplain study area, water levels have ranged between 41.4 mbgs (7029-1424) and 3.01 mbgs (7029-1301) over the same period of time. Typically depth to water at the shallow end of the range is attributed to the Monoman Formation (i.e. the floodplain) where as the deeper measurements are measured on the highland and Loxton Sands aquifer. It is noted that irrigation drainage on the highlands may create perched lenses of groundwater that are not connected to the regional watertable.

Historical groundwater level measurements are stored in the state groundwater database (available online at WaterConnect).

2.2.2 Groundwater salinity

Measurements of groundwater salinity are limited and are generally only representative of salinity at the time of construction and well development. The salinity of groundwater sampled from shallow monitoring bores and drilling across the floodplain typically ranges from 7 000 to 40 000 mg/L (12 200 to 60 500 µS/cm) but can be as high as 75 000 mg/L(107 150 µS/cm).

Historical salinity measurements are stored in the state groundwater database (available online at WaterConnect).

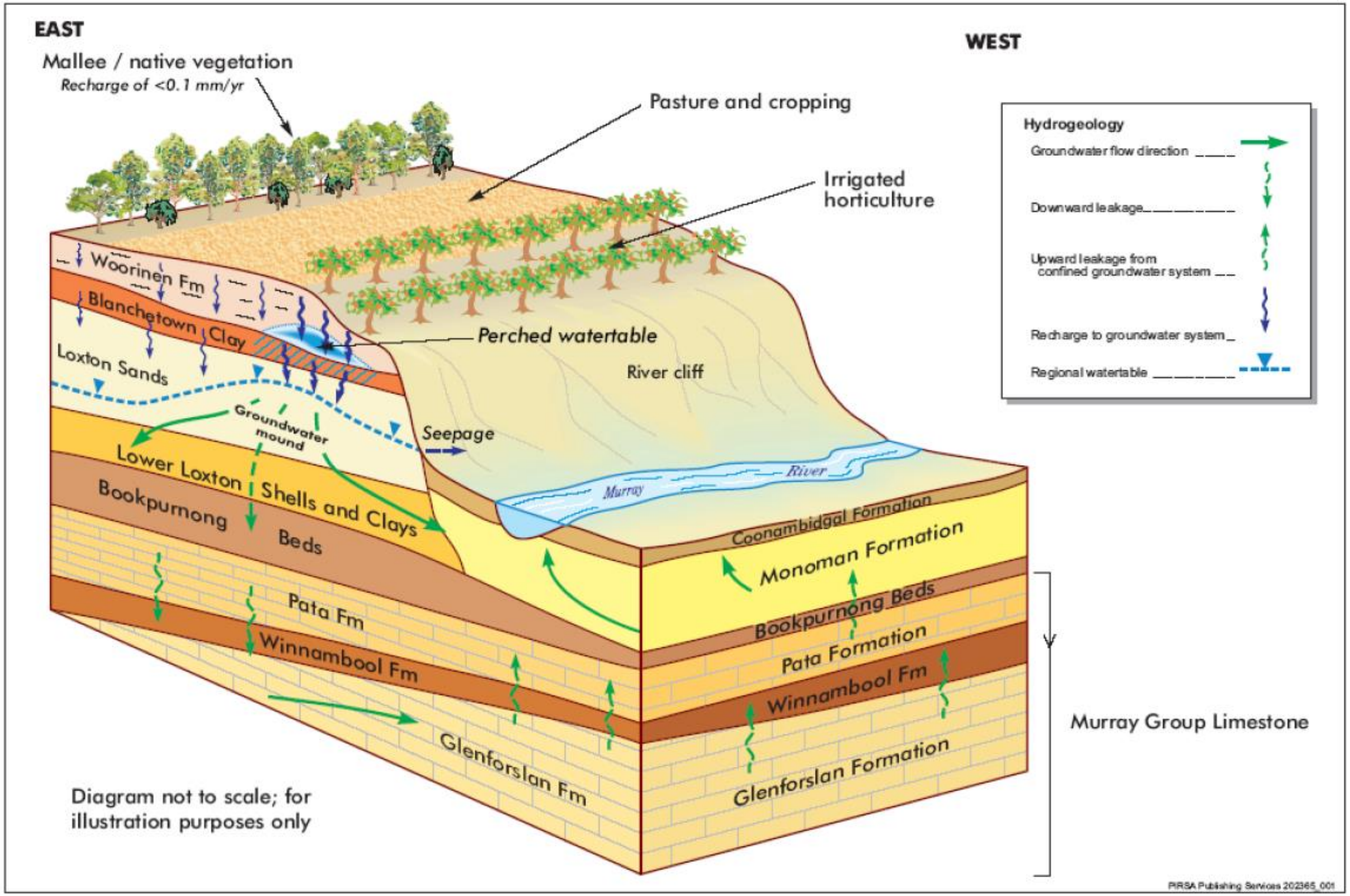

Figure 4 **Hydrogeological conceptual processes of the Riverland environment (Yan et al, 2005a)**

2.3 Groundwater well networks and monitoring

A number of groundwater monitoring networks were active (or current) near the study area in 2014. Their primary functions were to monitor irrigation areas that are located on the highland adjacent to the floodplain or for monitoring of SIS's. Consequently, few of these monitoring networks included wells located on the Pike Floodplain. The one pre-2015 monitoring network that did include wells located on the Pike Floodplain is the Pike Murtho Irrigation Area monitoring well network. In 2015, the groundwater monitoring networks were rationalised leading to some network closure, well optimisation in remaining networks and reductions in measurement frequency.

Good quality, long term monitoring data is generally restricted to water levels collected from wells completed in shallow aquifers. Salinity data in contrast, is limited and typically consists of one sample collected during the well construction stage. Table 3a provides a collation of the known historical (pre-2015) groundwater monitoring networks in close proximity to the Pike and Katarapko Floodplains. Table 3b presents information on the current (late-2015) groundwater monitoring networks near the study areas. It should be noted that wells on the Pike Floodplain that were monitored under the (pre-2015) Pike Murtho Irrigation Areas network are no longer currently monitored.

Table 3a Details of relevant historical (pre-2015) groundwater monitoring networks

Name	Closest Floodplain Study Area	No of Wells	Water Level Data Length of record	Salinity Data	Location Description
Pike Murtho Irrigation Areas	Pike	139	Since 1968	0	The network stretches north of Renmark along the River Murray to Murtho Forest and south to the Gurra Gurra Wetland complex. Some FP study area monitoring but mainly restricted to highland areas northeast and southwest of Pike. Those wells that are located on the FP monitor groundwater in both the Monoman and Coonambidgal formations.
Renmark-Cooltong Irrigation Areas	Pike	219	Since 1955	0	Centred on Renmark. The network stretches north past Cooltong and south to an area located just north of Pike FP study area. No FP study area monitoring.
Berri-Barmera Irrigation Areas	Katarapko	128	Since 1955	0	Centred on Berri and Barmera. The network stretches west to Loveday and south to the community of Gerard. No FP study area monitoring.
Bookpurnong SIS	Katarapko	31	Since 2001	0	Centred on Bookpurnong and restricted to the highland area east of the River Murray and north of Loxton. No FP study area monitoring.
Gurra Gurra Wetland Complex	Katarapko	13	Since 1983	0	Centred on the Gurra Gurra Wetland complex
Loxton Irrigation Areas	Katarapko	49		0	Restricted to highland area east of FP study area and east of Loxton.
Loxton SIS	Katarapko	119	Since 1990	0	Network extends north of Loxton to Rilli's FP and SW to Pyap. Some FP monitoring mainly Rilli's FP and limited wells west of the River Murray on Katarapko Island.. Also included is one well west of Katarapko Ck. No FP study area monitoring apart for two wells to the south.

As available online October 2014 from the state groundwater database on WaterConnect. Note that changes to networks including closure and reductions in number of wells across networks occurred during 2015 as part of an optimisation project.

Table 3b Details of relevant current (late-2015) groundwater monitoring networks

Name	Closest Floodplain Study Area	No of Wells	Wells with Current Water Level Status	Salinity Status	Location Description
Pike Murtho Irrigation Areas	Pike	127	57	0	Centred on Renmark. The network stretches NE of Renmark to just south of Murtho and just over the border into VIC and as far south as the Gurra Gurra Wetlands complex and Yamba. No current FP study area monitoring.
Berri and Renmark Irrigation Areas	Pike & Katarapko	341	82	0	Centred on Renmark and Berri. Network stretches north of Renmark as far as Cooltong, south of Renmark to the River Murray, north of Berri toward Monash and west of Berri toward Loveday. No current FP study area monitoring.
Loxton-Bookpurnong Irrigation Areas	Katarapko	186	77	0	Centred on Berri and Loxton. Network stretches from an area south of Berri inclusive of the Gurru Gurra Wetlands complex to Pyap. The network also extends to the south and approximately 10km east of Loxton. There is minor historical monitoring in the southern part of the Katarapko FP.
Waikerie Moorook Irrigation Areas	Katarapko	227	120	0	Centred on Waikerie. The network stretches east towards Loxton, north of Overland Corner and west toward Morgan. No current FP study area monitoring.

3 SARFIIP SMM groundwater monitoring

3.1 Groundwater level

A key requirement for numerical groundwater modelling is having sufficient time series groundwater level (or head) and salinity data to calibrate and compare against modelled outputs. The scarcity of time series groundwater level data, and limited or absent groundwater salinity data available on the floodplains, triggered the need for targeted groundwater monitoring and salinity sampling during the concept design phase of SMM. Given the relative ease of manual groundwater level monitoring, wells located on the floodplains were targeted for monthly measurements and formed project specific interim monitoring networks called the Pike Floodplain monitoring network and Katarapko Floodplain monitoring network. Monthly monitoring started in April–May 2015 and, with the exception of a data collection break during the Phase 1 and Phase 2 drilling program, has been on-going until February 2016.

As discussed earlier in this report, a bore audit was conducted in 2014 which surveyed wells on the floodplains of Pike and Katarapko Floodplain study areas. The audit (which included a broader area than the floodplain) identified 99 wells located on the Pike Floodplain study area and 257 wells on the Katarapko Floodplain study area (excluding wells not located). Of these, 57 wells located on the Pike Floodplain and 26 wells on the Katarapko Floodplain formed the basis of the monthly floodplain monitoring network.

The initial monitoring network selection was expanded to include new wells drilled and constructed as part of Phase 1 (Sep-Oct 2015) and Phase 2 (Oct–Nov 2015) SARFIIP SMM drilling program and piezometers installed as part of the SARFIIP SMM soil survey. This expanded the Pike Floodplain monitoring network by 48 wells to 105 wells (Fig. 5) and the Katarapko Floodplain monitoring network by eight wells to 34 wells (Fig. 6). In summary, the expansion of the networks comprised the addition of:

- Twelve 50 mm floodplain piezometers (< 2 m deep)
- Five 100 mm floodplain observation wells sreening the Coonambidgal Formation (< 5 m deep)
- Thirty 80 mm floodplain observation wells screening the Monoman Formation (< 25 m deep)including one observation well penetrating the deeper Pata Formation and one highland observation well penetrating the Loxton Sands
- One 200 mm highland production well screening the Loxton Sands

Additional works were incorporated into this task shorly after it was initiated which included additional monitoring. Firstly the pre-feasibility SMM concept design options engineer suggested some additional monitoring which included the deeper Murray Group wells that surround the floodplains of Pike and Katarapko. The Murray Group monitoring network consisted of 27 wells and monitors the water level of the Murray Group Formation which forms the regional aquifer system that underlies the Monoman Formation (Fig. 7).

Then in October 2015, RMOMP advised SMK of an artificial watering or inundation trial in the Duck Hole Wetland located adjacent to Mundic Creek on the Pike Floodplain. A request was made to monitor groundwater levels on a weekly basis before, during and for some time after the trail. Wells selected for this weekly monitoring included the recently drilled wells constructed in September 2015 as part of the Phase 1 drilling works.

A local groundwater monitoring network of 11 wells was created to monitor groundwater response to a localised pumping and inundation event on the north western Pike Floodplain. This event saw the Duck Hole waterbody, an adjacent wetland and the Inner Mundic Flood Runner inundated with water from Mundic Creek for environmental purposes. While all monitored wells exist within the broader Pike Floodplain monitoring network, a targeted weekly monitoring frequency was identified for the duration of the inundation and recession.

The SARFIIP SMM design engineer (concept design options and detailed design), Australian Water Environments (AWE), also monitored a selection of wells across the Pike Floodplain and adjacent highland, only five of which had not included in the Pike Floodplain monitoring network. Of those five, four are included in the Pike and Murtho Irrigation Areas state monitoring network (Fig. 8). In addition, a number of groundwater level loggers were temporarily installed by the SARFIIP SMM design engineer to assist with SMM concept design options reporting.

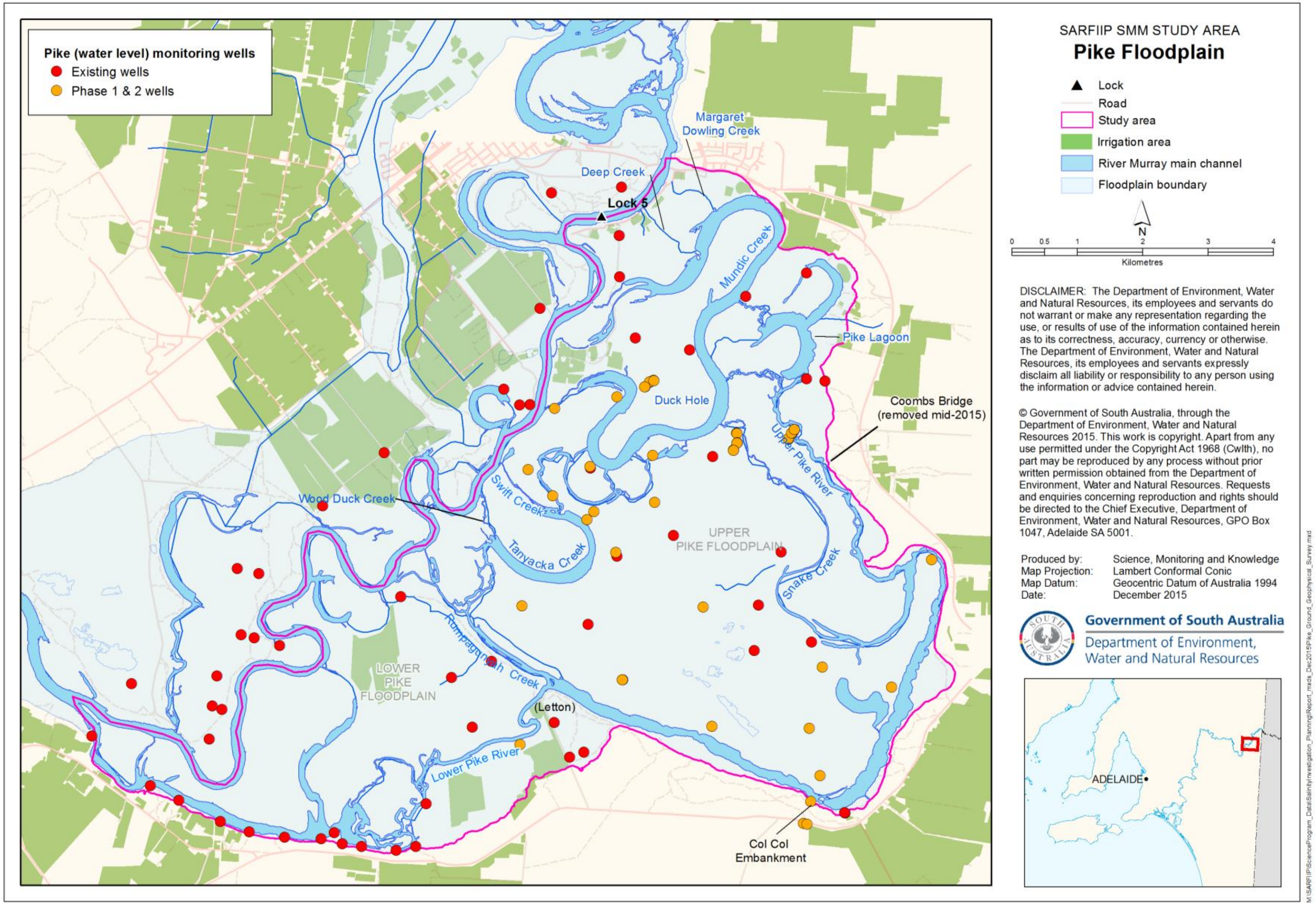

Figure 5 Pike Floodplain 2015 groundwater level monitoring network for the SARFIIP SMM project

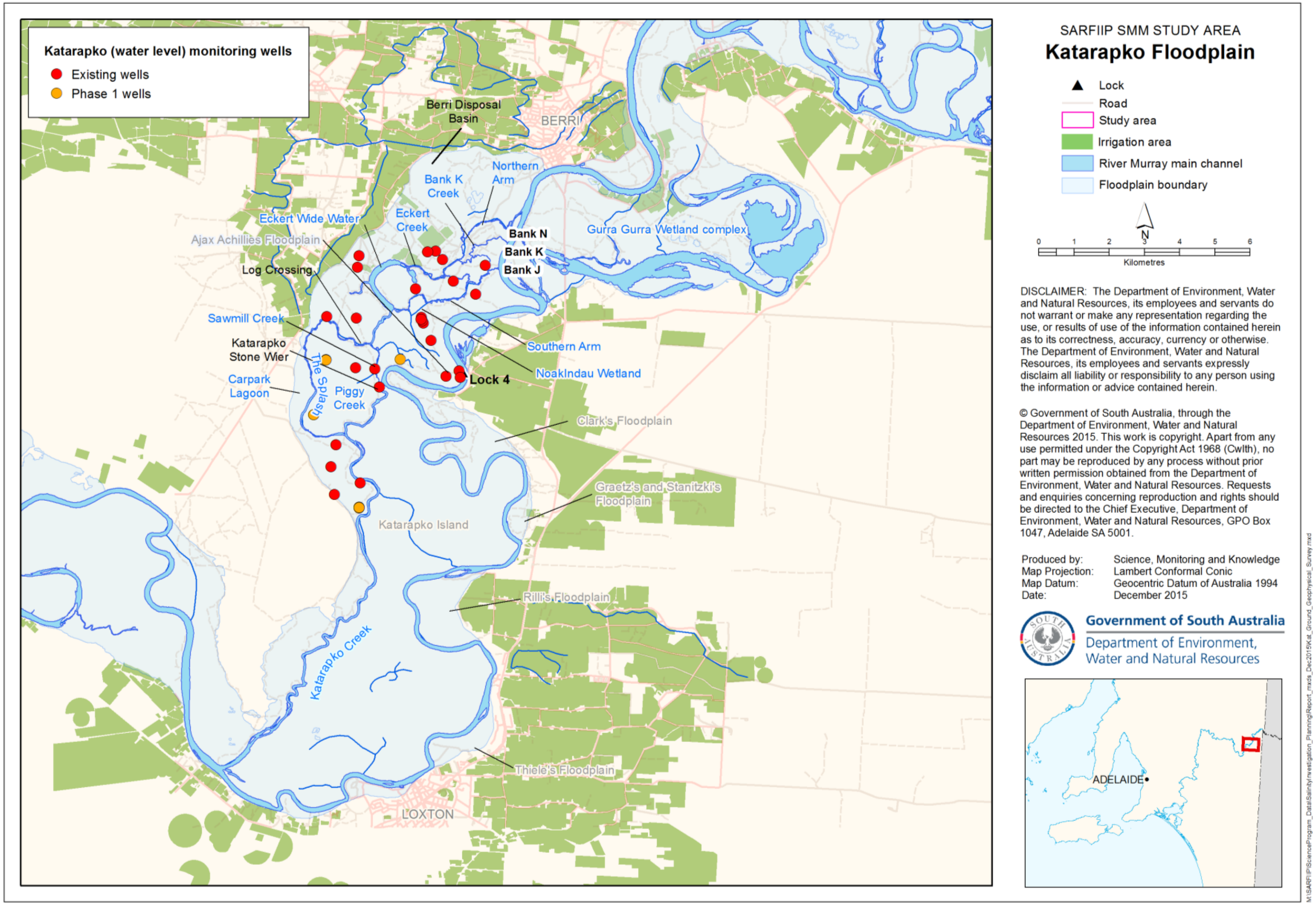

Figure 6 Katarapko Floodplain 2015 groundwater level monitoring network for the SARFIIP SMM project

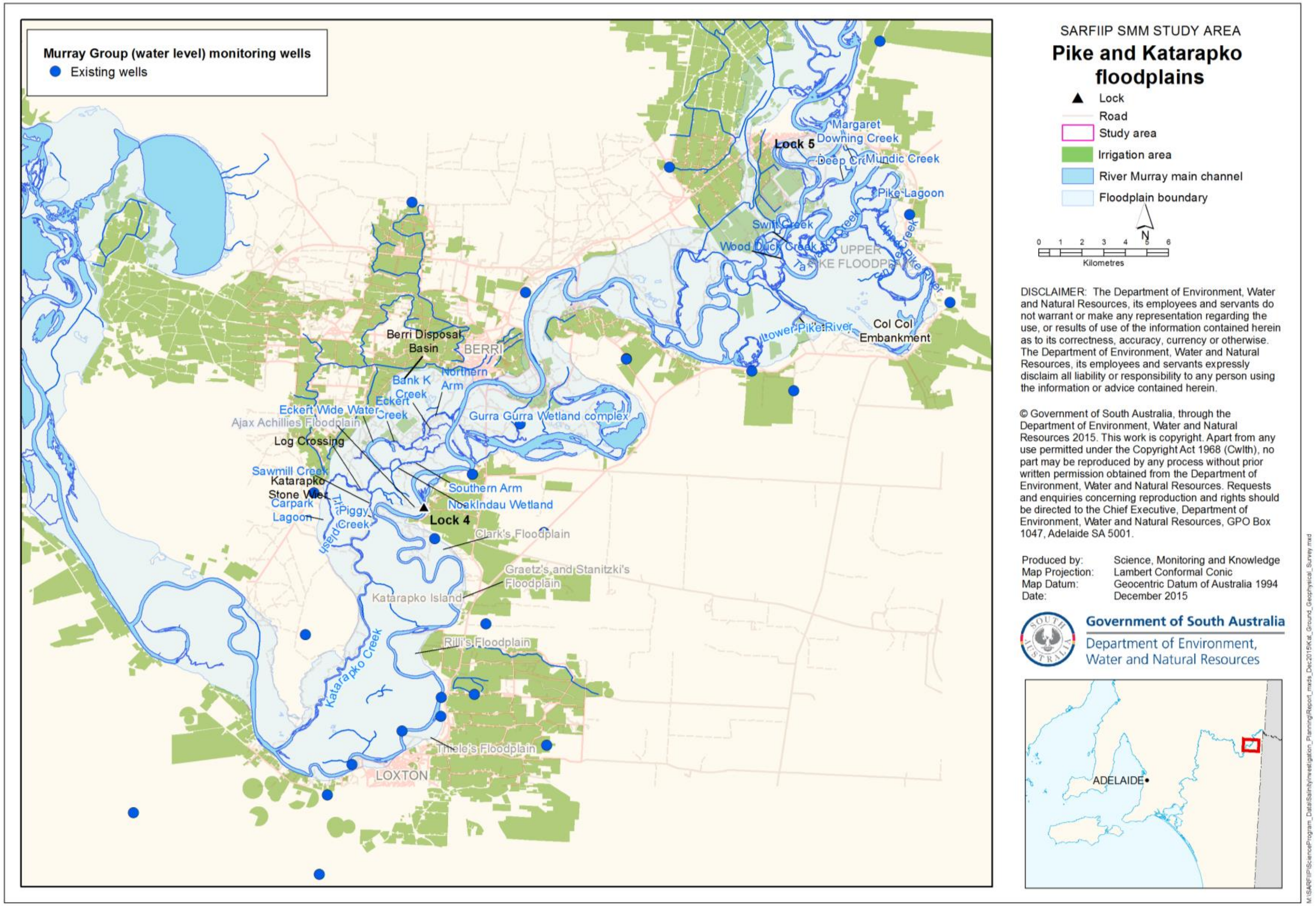

Figure 7 Murray Group 2015 groundwater level monitoring network for the SARFIIP SMM project

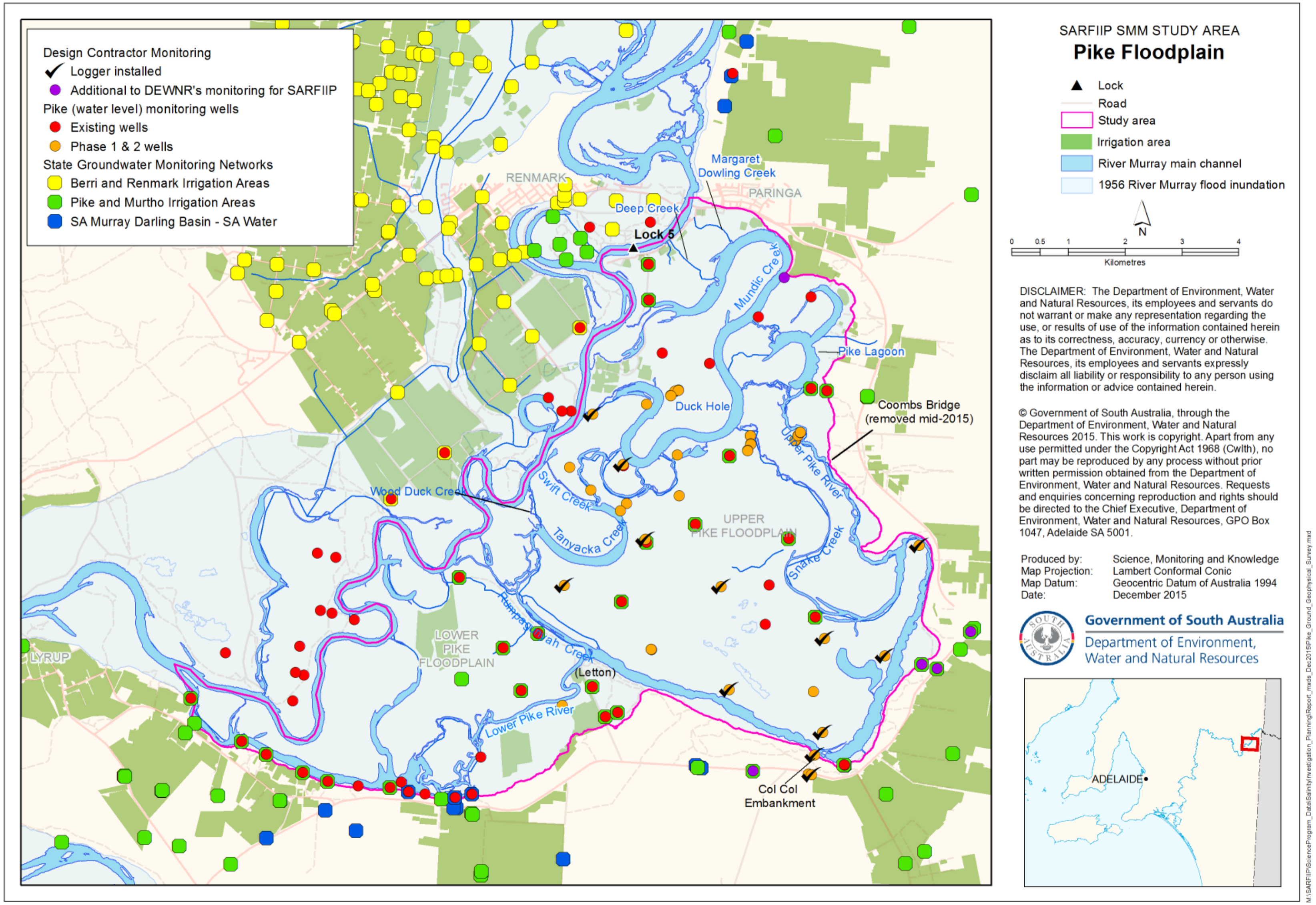

Figure 8 Pike Floodplain 2015 groundwater level monitoring network, water level loggers and state networks

3.1.1 Groundwater level monitoring methodology

Groundwater levels are monitored using a groundwater level probe. The probe has an electronic sensor attached to a measured tape and sounds when water is detected. The groundwater level probe is lowered into the well and a water level is measured from a reference point which the is typically the top of the casing (TOC) and the measured level is referred to as depth to water (DTW). It is imperative that the same reference point is used for measurement each time a well is visited. Once an accurate x, y and z location survey has been completed or the measurement of the reference point above ground (or below ground in some circumstances) this vertical measurement can be applied to the DTW to produce a standing water level (SWL). If the locational survey is measured to metres Australian Height Datum (m AHD) then a reduced SWL (or RSWL) can be generated which gives the elevation of the water level (Fig. 9).

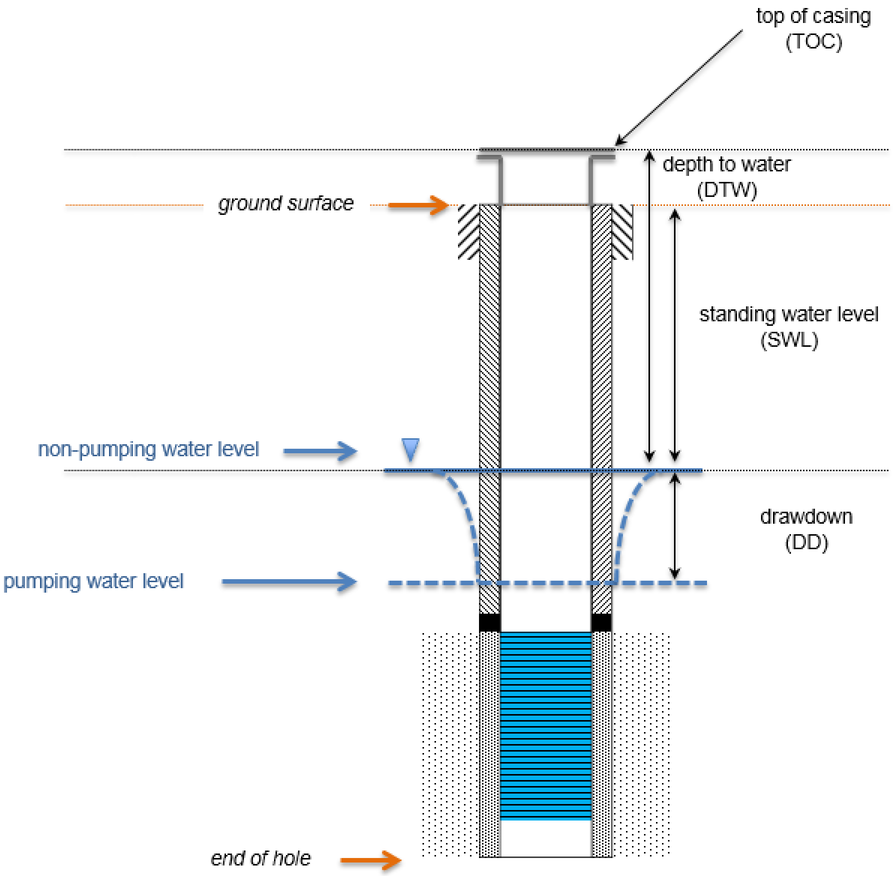

Figure 9 Basic terms for groundwater level montoring

All water levels are uploaded to the state groundwater database for project and public use, available at WaterConnect (see Appendix C for instructions on use)

The relevant frequency for each monitoring network was selected to provide a useful density of water level information to support groundwater model development and infrastructure programs. A target monthly monitoring frequency was selected for the groundwater monitoring networks, with the exception of the Duck Hole monitoring network where weekly frequency was required. Data from the regular groundwater monitoring provides:

- Condition and status of that data point/well
- Improved resolution of groundwater response to seasonal and local influences
- Confidence when planning and designing a drilling and sampling programs
- Baseline data to underpin development and refinement of potentiometric surfaces to aid initial groundwater modelling.

3.2 Salinity monitoring

Sampling an aquifer for groundwater quality (including salinity) is a more involved process than measuring groundwater level. Collection of a representative sample typically requires the purging of a minimum of three casing volumes of groundwater from the well and the stablilisation of parameters including EC, pH, DO, ORP and temperature.

In October 2015 following the completion of Phase 1 drilling works, a groundwater sampling program was implemented on the 24 new groundwater monitoring wells (nineteen on Pike Floodplain, Fig. 10; five on Katarapko Floodplain, Fig. 11) and an additional five existing wells located around the eastern edge of the Pike Floodplain (Fig. 10). Purging of a minimum three casing volumes was carried out and sampling took place when parameters had stabilised. The five existing wells located on the highland adjacent the Pike Floodplain were selected to provide representative salinity conditions for the Loxton Sands aquifer, whereas the nineteen floodplain locations aimed to provide representative salinity condition for the Coonambidgal Formation, Monoman Formation and Pata Formation (of the Murray Group).

Samples collected for salinity analysis are delivered to the DEWNR laboratory located in Regency Park, Adelaide where the sample was analysed and the measurement uploaded to the state groundwater database and available at WaterConnect (see Appendix C for instructions on use)

The sampling program primarly collected samples for salinity analysis, but also provided samples for the ARC Linkage Project which is a three year research project between Flinders University (SA), Monash University (Vic) and DEWNR that investigates freshwater lens dynamics on floodplains.

Manual groundwater sonding measuring electrical conductivity (a proxy for salinity) was also conducted on selected wells that were designed with long (> 10 metre) screens. This data was useful for targeted sampling of the groundwater column in these wells so that a sample of the freshwater lens (typically located at the top) could be sampled discretely along with background groundwater (typically towards the bottom of the profile).

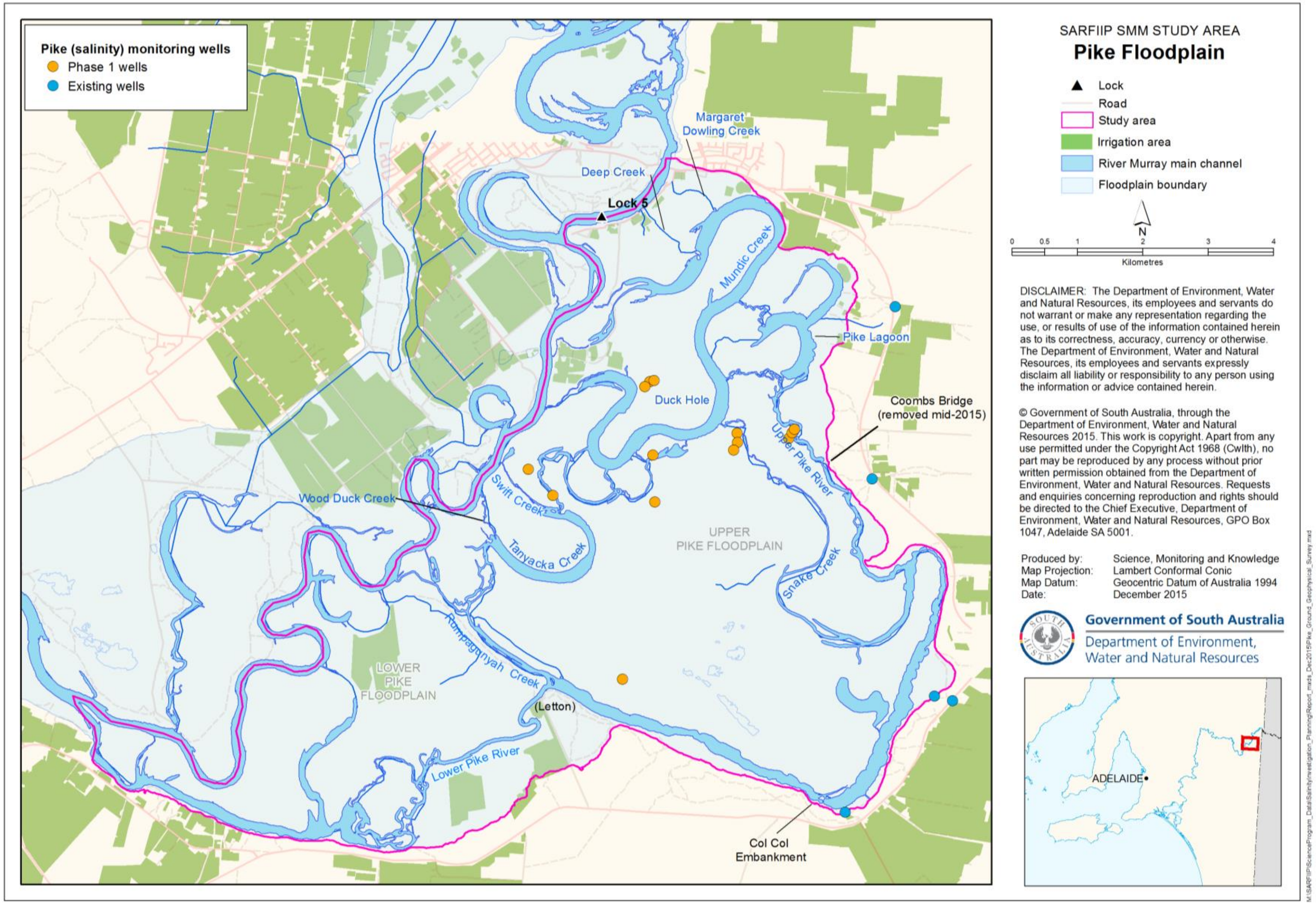

Figure 10 Pike Floodplain groundwater salinity sampling locations

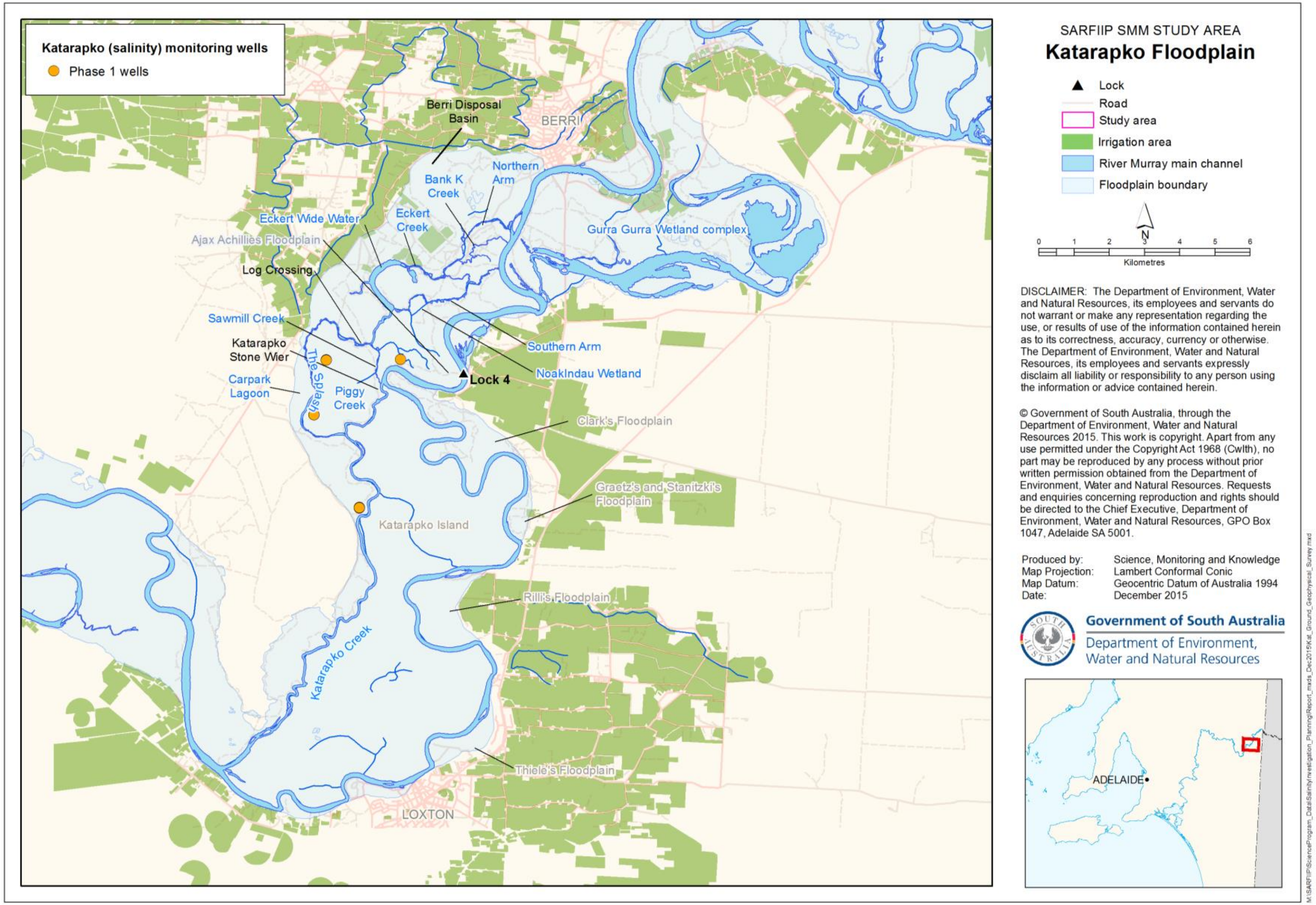

Figure 11 Katarapko Floodplain groundwater salinity sampling locations

4 Results

A total of 166 wells are being monitored for groundwater level (or DTW) across four networks: Pike Floodplain network, Katarapko Floodplain network, deeper Murray Group network and Duck Hole Wetland network. Data was collected on average each month and a summary is provided below in Table 4. Individual well details are provided in Appendix A.

Table 4 Summary of groundwater level monitoring networks

Monitoring Network	No Monitoring Wells	No Wells Located on Island	Target Monitoring Frequency
Pike Floodplain (expanded)	57 (105)	4	1 month
Katarapko Floodplain (expanded)	26 (34)		1 month
Murray Group	27	1	1 month
Duck Hole Wetland	11		1 week

Note: Duck Hole Wetland network is a subset of the Pike Flooplain monitoring network

4.1 Pike Floodplain groundwater level monitoring network

A summary of groundwater level monitoring activity undertaken for the Pike Floodplain network is provided below in Table 5. In total, six monitoring rounds have been undertaken for the Pike Floodplain to date.

Table 5 Summary of Pike Floodplain groundwater level monitoring

Monitoring Rounds 2015	Monitoring Dates	No Wells Monitored	Island Wells Monitored	Comment
February	11/2/15 – 12/2/15	57	4	
March	-	-	-	Deferred due to EM-31 survey
April	27/4/15 – 29/4/15	53	-	Delayed due to weather delay. Boat not available to access island wells
May	-	-	-	Weather delay, rescheduled to 1/6/15
June	1/6/15 -16/6/15	53	-	Boat not available to access island wells
July	-	-	-	Deferred due to Phase 1 drilling
August	19/8/15	8	-	Deferred due to Phase 1 drilling
September	-	-	-	Deferred due to Phase 1 drilling
October	-	-	-	Deferred due to Phase 2 drilling
November	9/11/15 - 10/11/15	61	-	Incomplete adhoc monitoring due to Phase 2 drilling
December	9/12/15 - ongoing	57	-	In progress

Four groundwater wells are located on the island (Lower Pike Floodplain). Due to access constraints, these wells have not been monitored since February 2015. Wells located on the island include: 7029-1187, 7029-1188, 7029-1189 and 7029-1190

Groundwater monitoring post June 2015 was impacted by resources being used for the Phase 1 and Phase 2 drilling preparation and supervision.

An artificial inundation trial to Duck Hole and the adjacent wetland commenced on 19 October 2015 and continued for Duck Hole until 5 November 2015 and until 20 November 2015 for the wetland. Pumping to the Inner Mundic Flood Runner commenced on 17 November and continued until 20 November. Monitoring groundwater level for the 11 selected wells occurred on a weekly basis where possible.

4.2 Katarapko Floodplain goundwater level monitoring network

A summary of groundwater level monitoring activity undertaken for the Katarapko Floodplain network is provided below in Table 6. In total, four monitoring rounds were undertaken for the Katarapko Floodplain.

Table 6 Summary of Katarapko Floodplain groundwater level monitoring

Monitoring Rounds 2015	Monitoring Dates	No Wells Monitored	Island Wells Monitored	Comment
May	5/5/15 – 6/5/15	25	0	Initial well selection + new well
June	26/6/15	25		7029-653 not monitored
August	20/8/15 – 21/8/15	28	0	Commenced monitoring P1 piezometers
December	17/12/15 – ongoing	25		In progress

During the initial monitoring round, a new well was located and surveyed. Survey details have been incorporated into the Katarapko bore audit report, details registered in the state groundwater database and the well has been incorporated into the Katarapko Floodplain groundwater level monitoring network for regular monitoring.

Existing well 7029-653 was monitored during the May round and the water in this well was found to be oily and pungent. Monitoring of this well ceased following the May monitoring round and remedial options are being considered to allow continued monitoring of this well.

Well 7029-2107 is located within the Lock 4 compound and may have incurred additional damage since the bore audit. The well has bent PVC casing and is blocked. Whilst level appears to fluctuate, the depth of the blockage has changed from 4.21 mbTOC at the time of the audit to the current depth of 3.71 mbTOC.

4.3 Murray Group groundwater level monitoring network

A summary of groundwater monitoring activity undertaken for the Murray Group monitoring network is provided below in Table 7. The initial monitoring round was completed on 30 March 2015.

Table 7 Summary of Murray Group groundwater level monitoring

Monitoring Rounds 2015	Monitoring Dates	No Wells Monitored	Island Wells Monitored	Comment
March/April	27/3/15 – 31/3/15	27	1	Boat not available to access island wells
May				Weather delays, rescheduled to 1/6/15
June	2/6/15 – 12/6/15	26		Scheduled to commence 29/6/15
August	21/8/15 – 24/8/15	4		
December	16/12/15 - ongoing	3		In progress

The initial Murray Group monitoring was integrated with initial capture of well survey data, to be completed during the second round, scheduled to commence on 1 June, 2015. The scheduled May monitoring of the Pike Floodplain monitoring network was postponed until June because of weather delays, with 10 mm of rain recorded at the proposed monitoring time.

Well 7028-628 was confirmed to be blocked during the intial monitoring round and was removed from the Murray Group monitoring network.

Island well 7029-796 was opportunitstically monitored in March 2015 with the assistance of DEWNR's Resource Monitoring Unit during a routine surface water monitoring activity near the site. Ongoing monitoring of this well is subject to boat access constraints.

A partial monitoring round commenced during August 2015 but was discontinued due to resourcing comitments associated with the SARFIIP drilling programs.

4.4 Groundwater sampling program

In October 2015, a groundwater sampling program was undertaken to collect groundwater samples primarily for groundwater salinity analysis, however (as discussed above) the event was coupled with the ARC Linkage Project which also collected samples for major ion, stable isotopes of water, radiocarbon and tritium analysis.

One rationale for construction of groundwater wells under Phase 1 of the drilling program was to target and monitor freshwater lenses particularly their boundaries. On the Pike Floodplain, Sites 1a, 2 and 12 were set up as multi well sites along transects away from known freshwater lens areas (Fig. 12) coupled with a Cooonambidgal Formation well constructed adjacent to each Monoman Formation well. At these sites the Monoman Formation wells were constructed with long screens (typically > 10 m), which are ideal for profiling groundwater salinity, enabling detection of the freshwater lens which are thought to exist at the very top of the Monoman Formation aquifer.

Prior to sampling these multi site wells, an electrical conductivity (EC) sonde was used to profile groundwater EC against depth (Figs. 13a, b, c; 14a, b, c; 15a, b, c). Note that these figures show groundwater EC with depth relative to the watertable i.e. not absolute depth. Once the freshwater lens interface was detected, groundwater sampling targeted both the freshwater lens and the deeper more regionally characteristic saline groundwater.

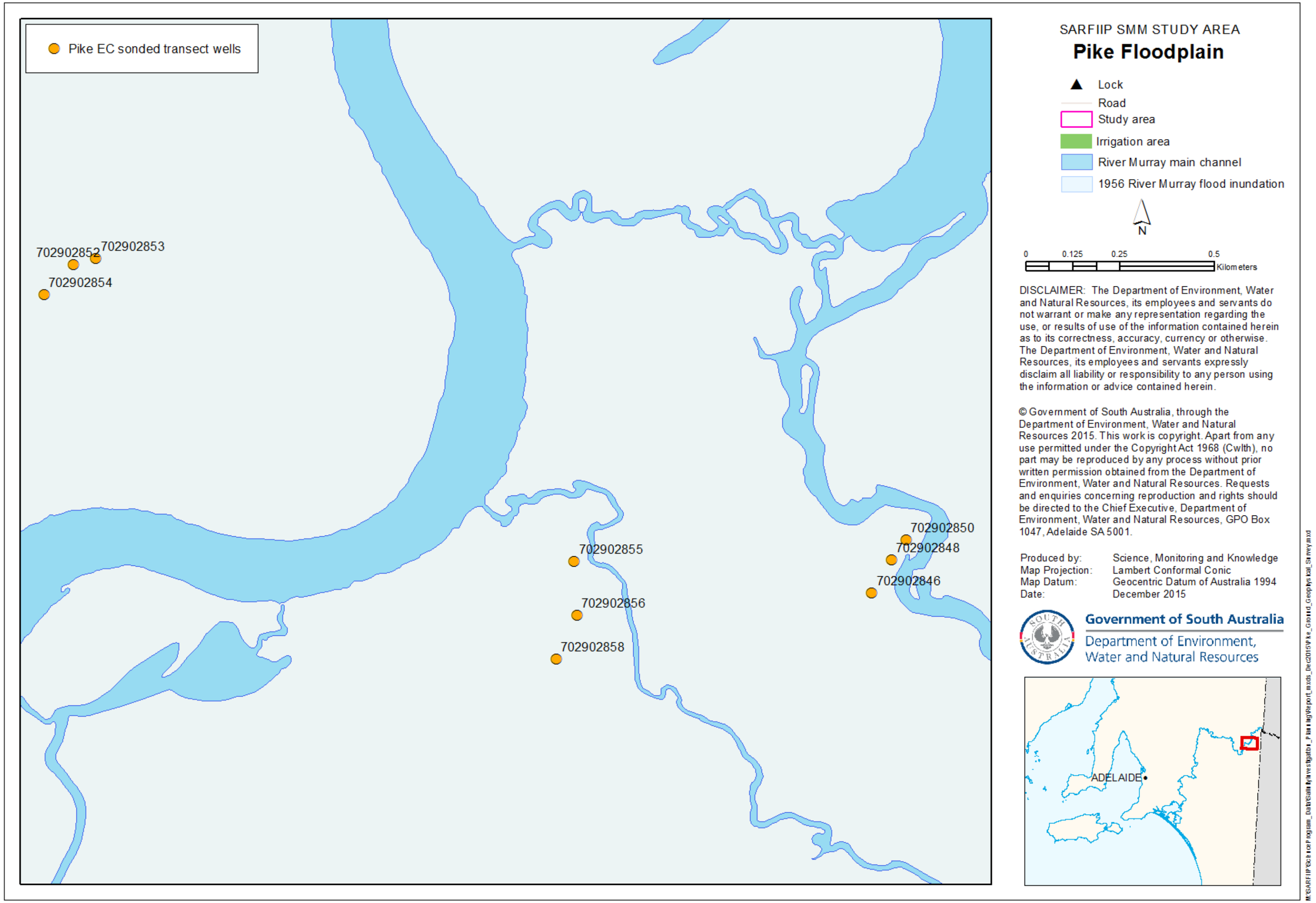

Figure 12 Pike Floodplain EC transect sonded wells

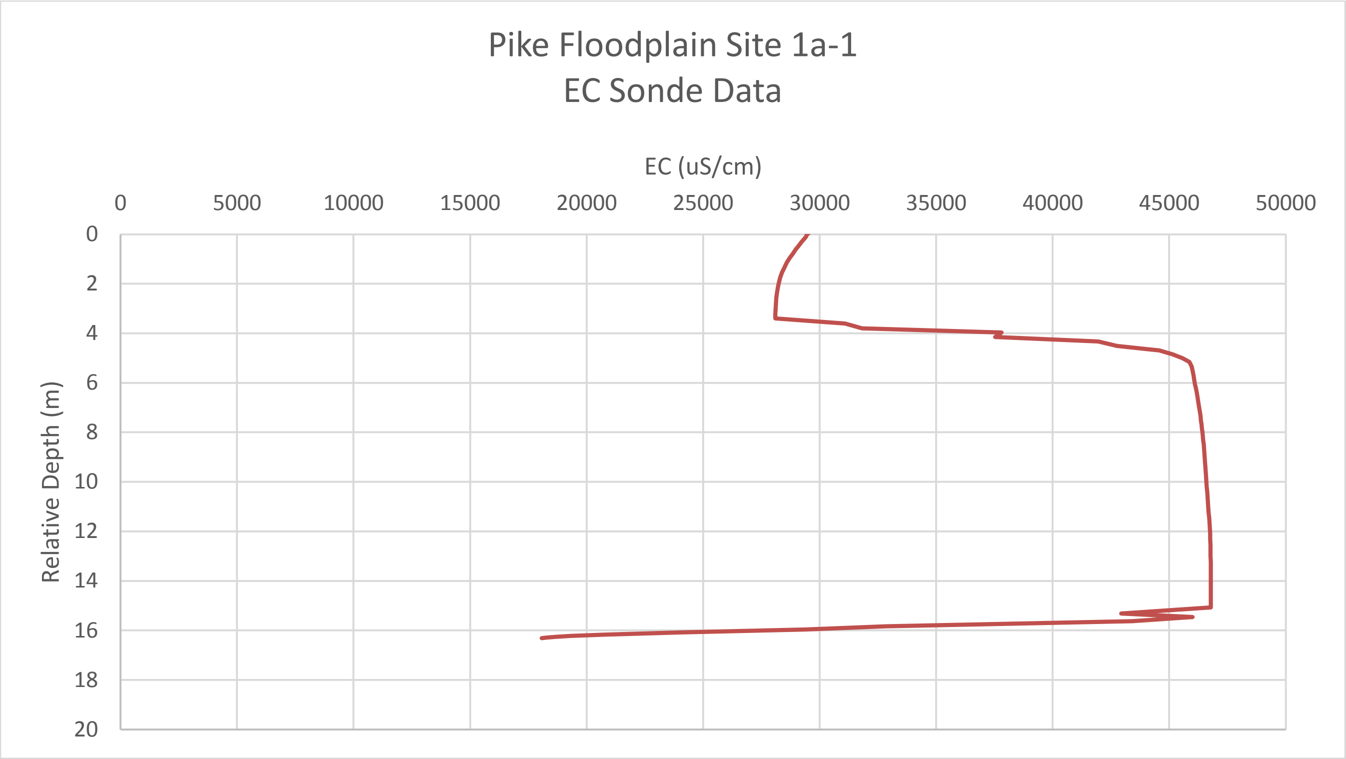

Figure 13a Pike Floodplain Site 1a-1 EC sonde data

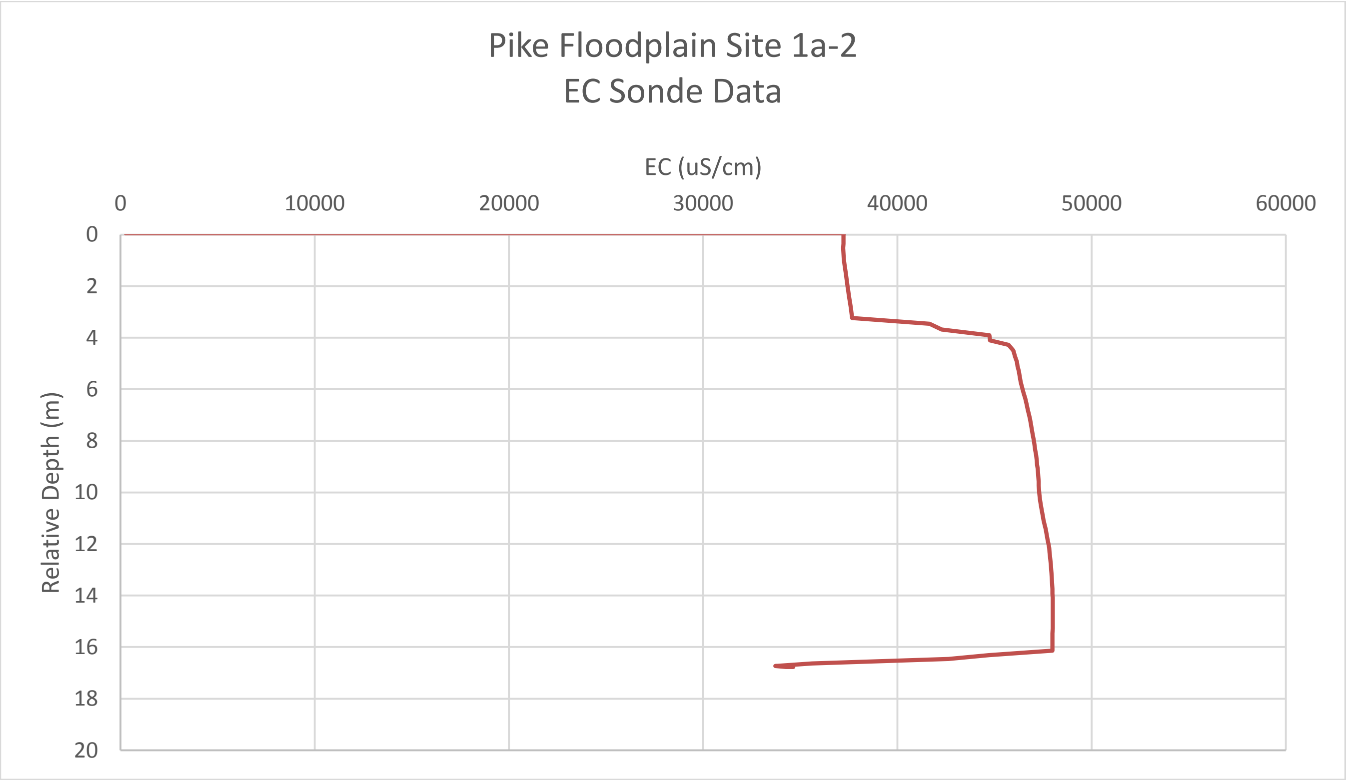

Figure 13b Pike Floodplain Site 1a-2 EC sonde data

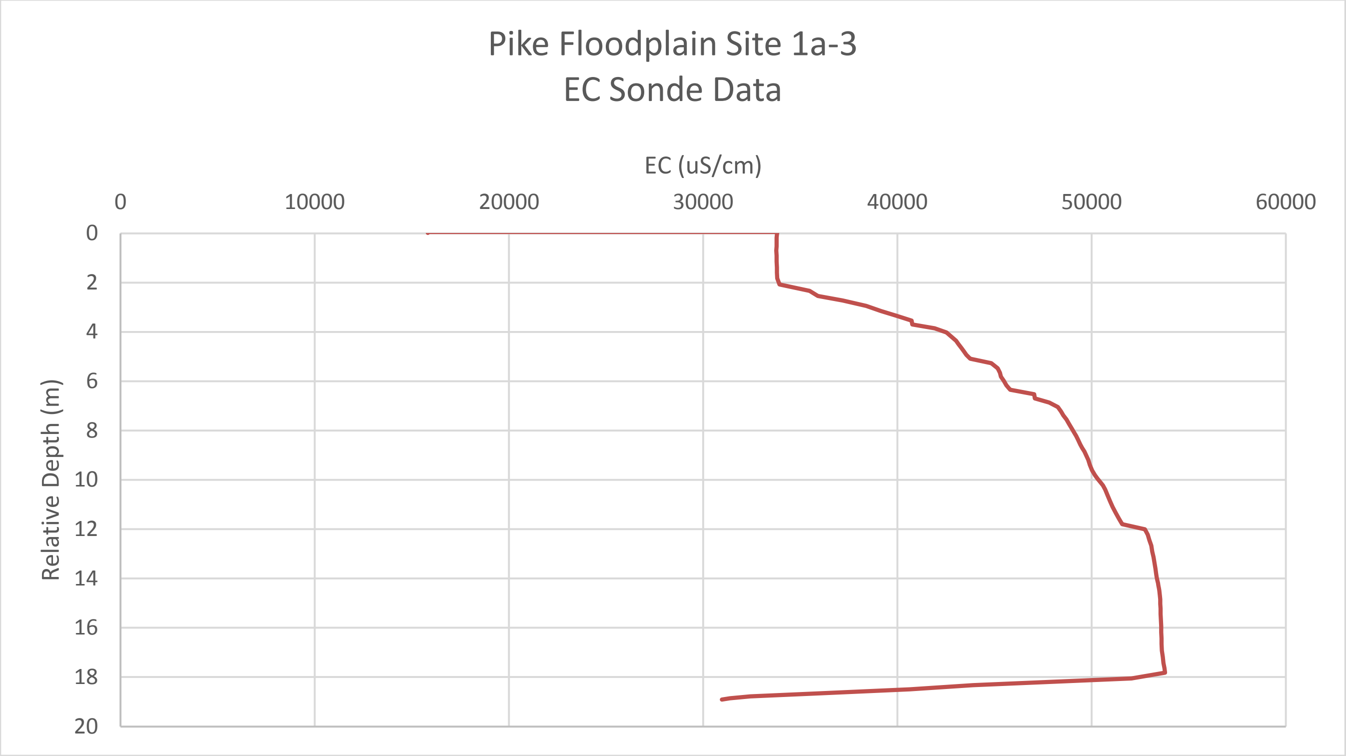

Figure 13c Pike Floodplain Site 1a-3 EC sonde data

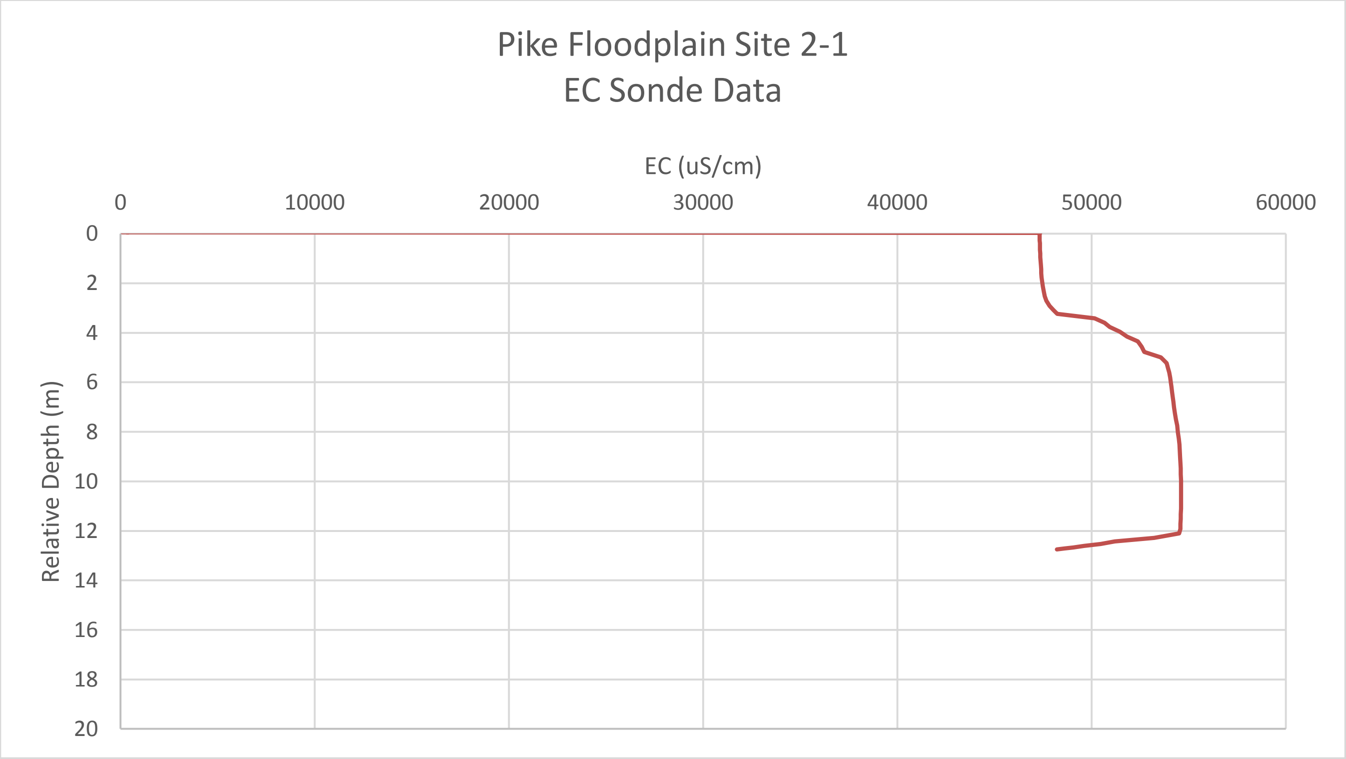

Figure 14a Pike Floodplain Site 2-1 EC sonde data

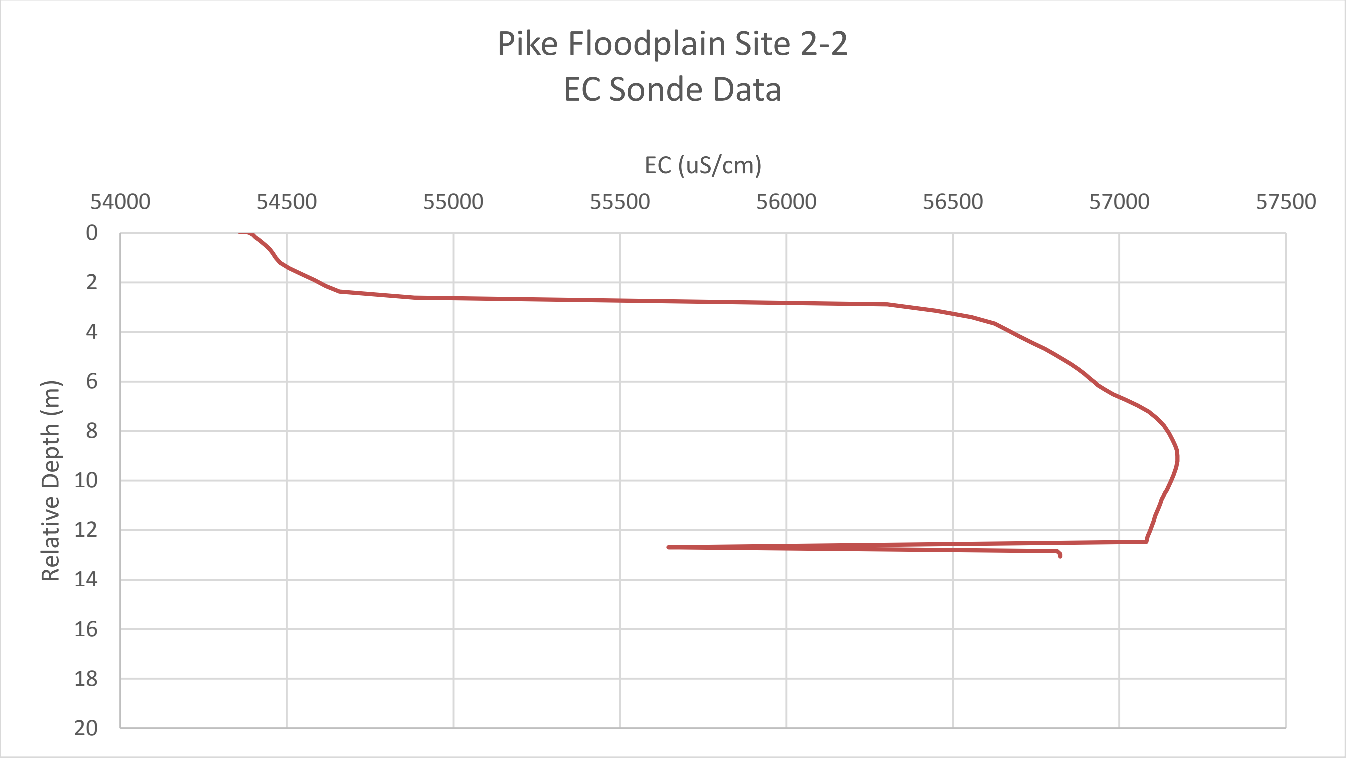

Figure 14b Pike Floodplain Site 2-2 EC sonde data

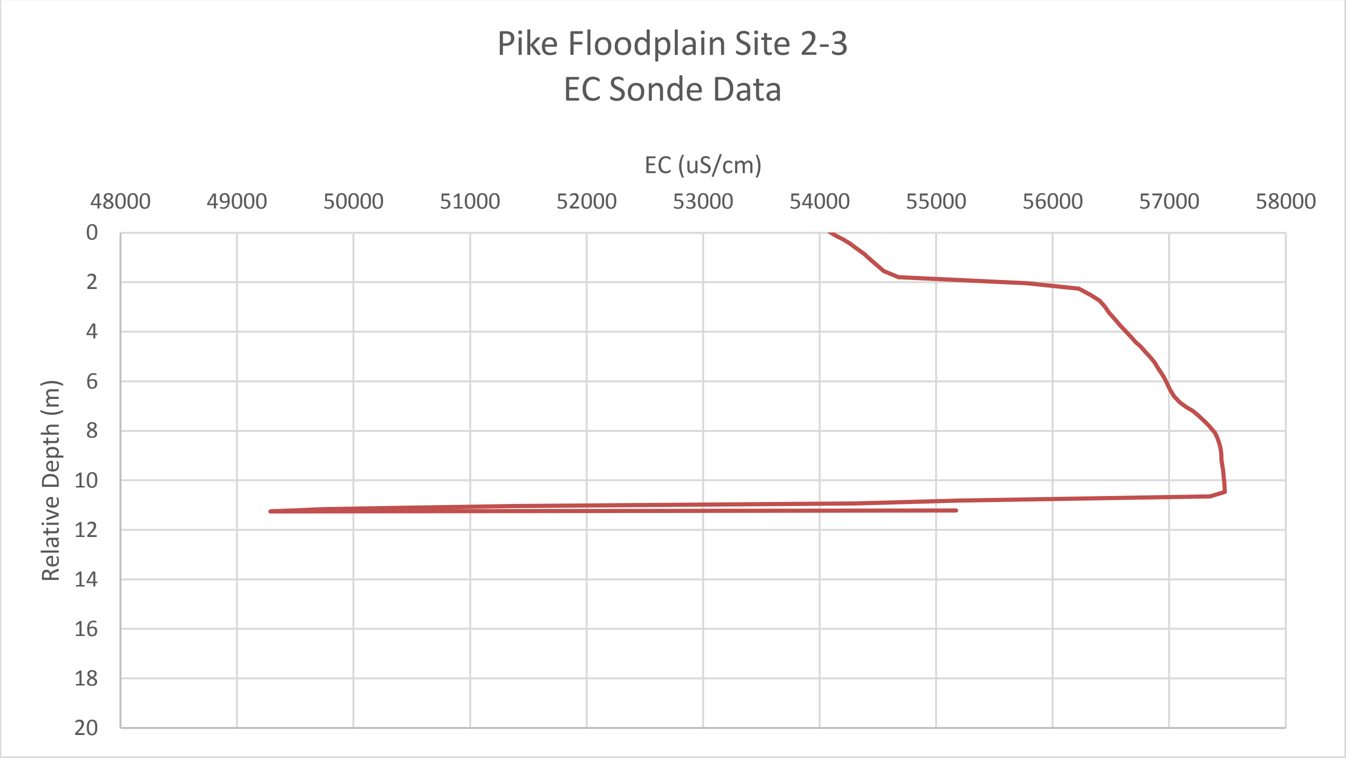

Figure 14c Pike Floodplain Site 2-3 EC sonde data

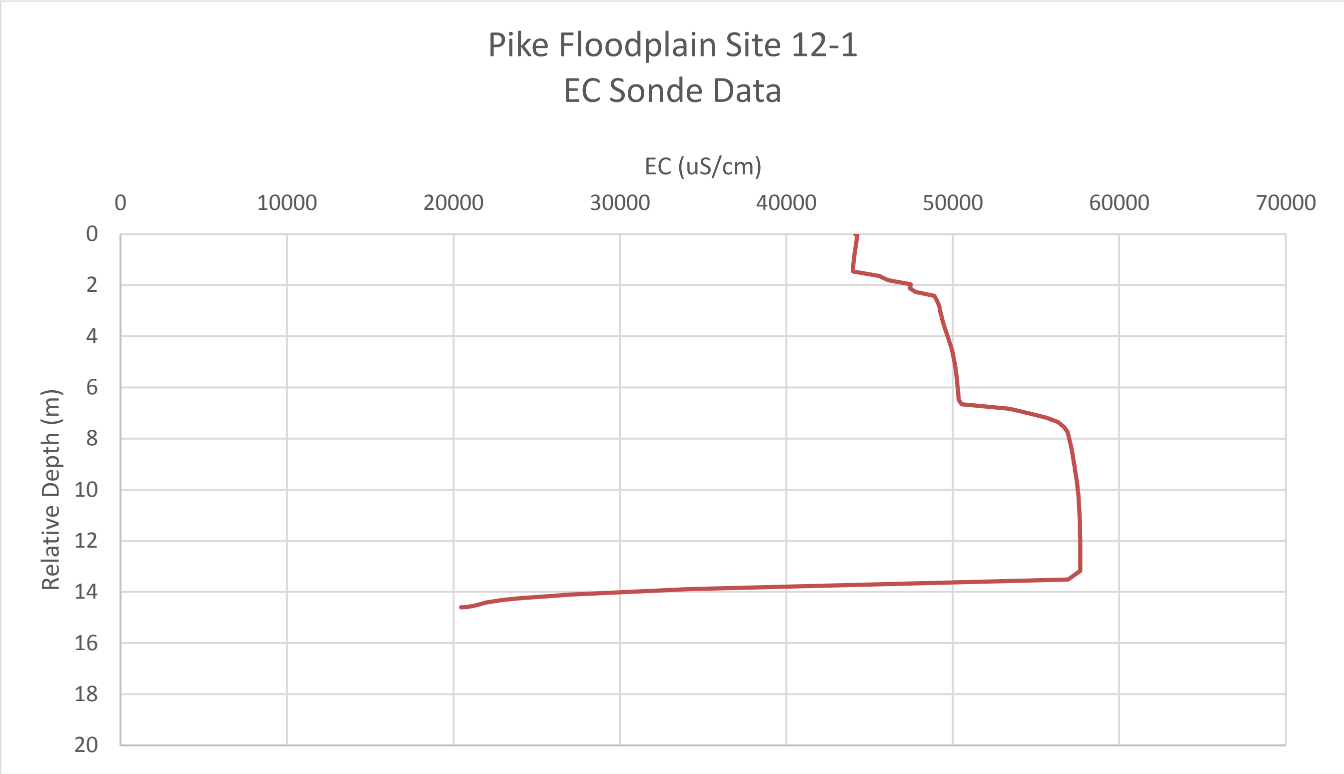

Figure 15a Pike Floodplain Site 12-1 EC sonde data

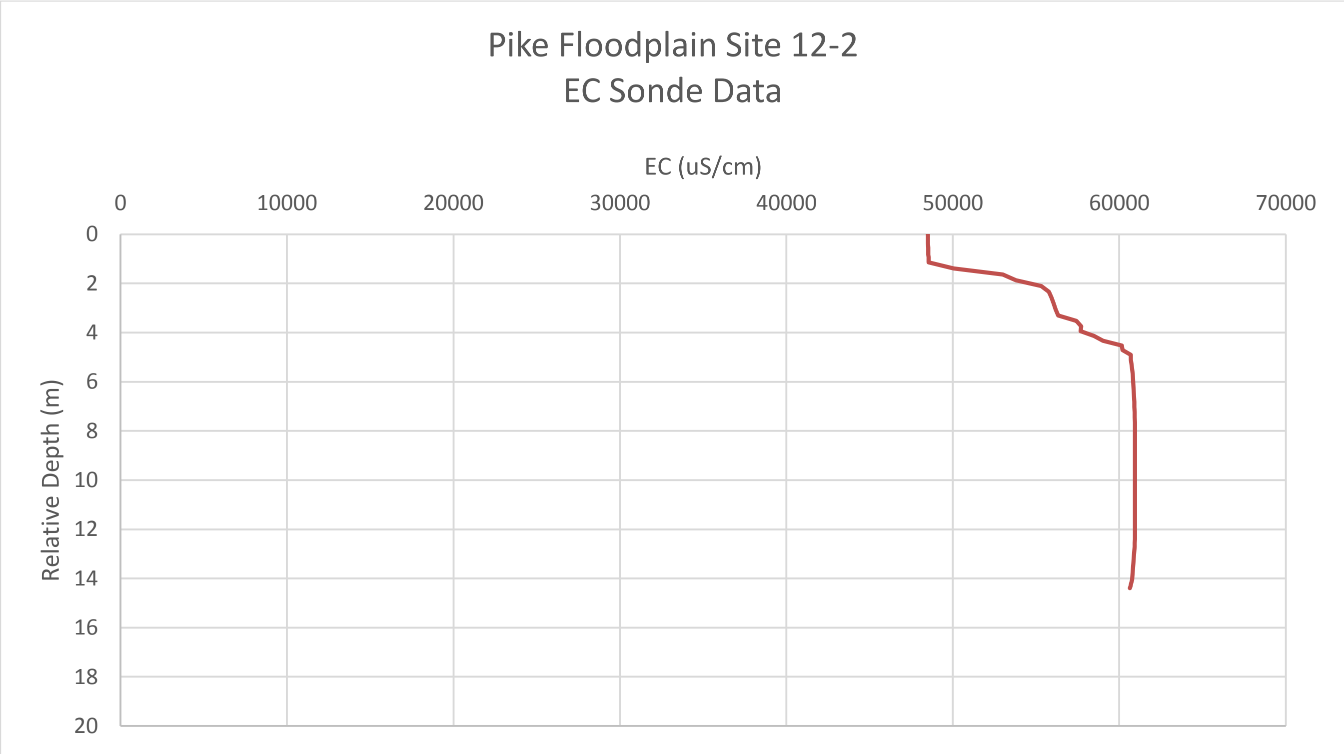

Figure 15b Pike Floodplain Site 12-2 EC sonde data

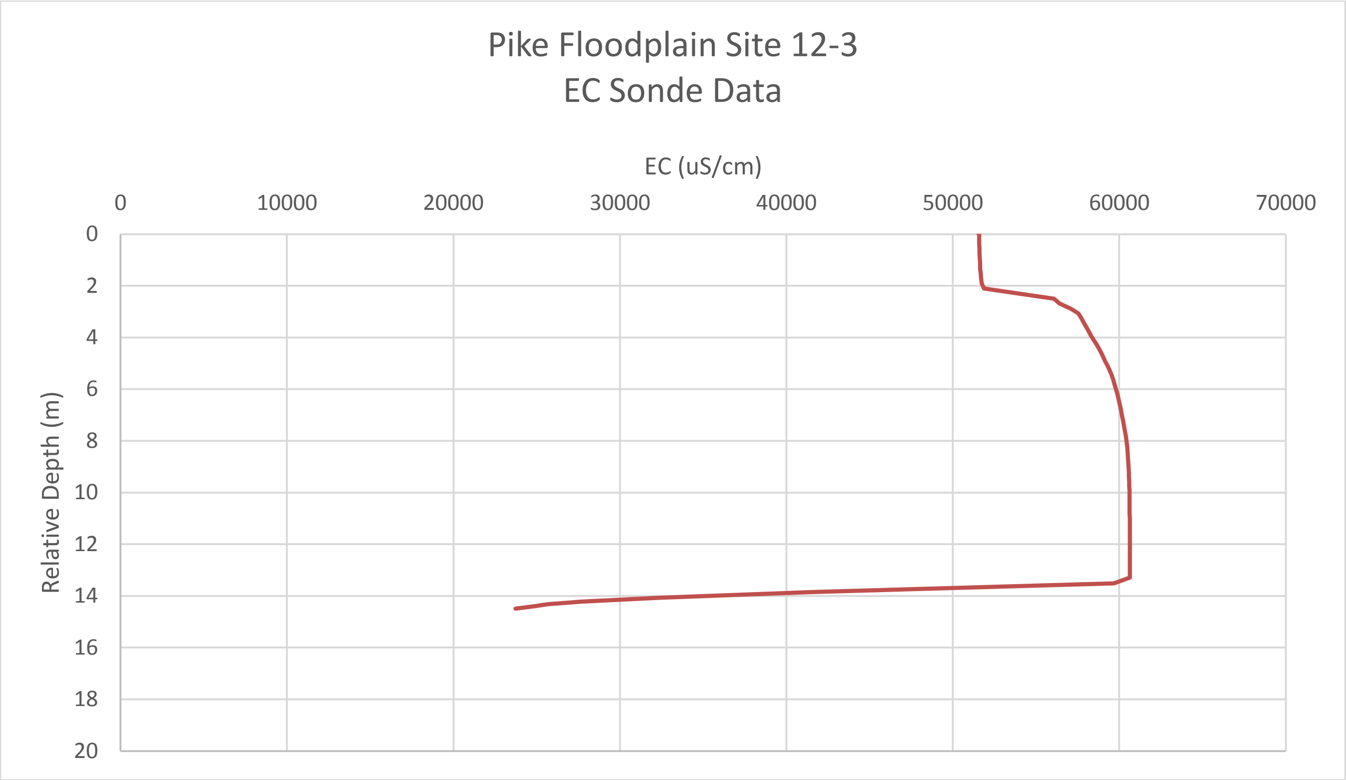

Figure 15c Pike Floodplain Site 12-3 EC sonde data

A summary of sonde EC to sampled EC is provided for each of the transects below (Figs. 16, 17 and 18).

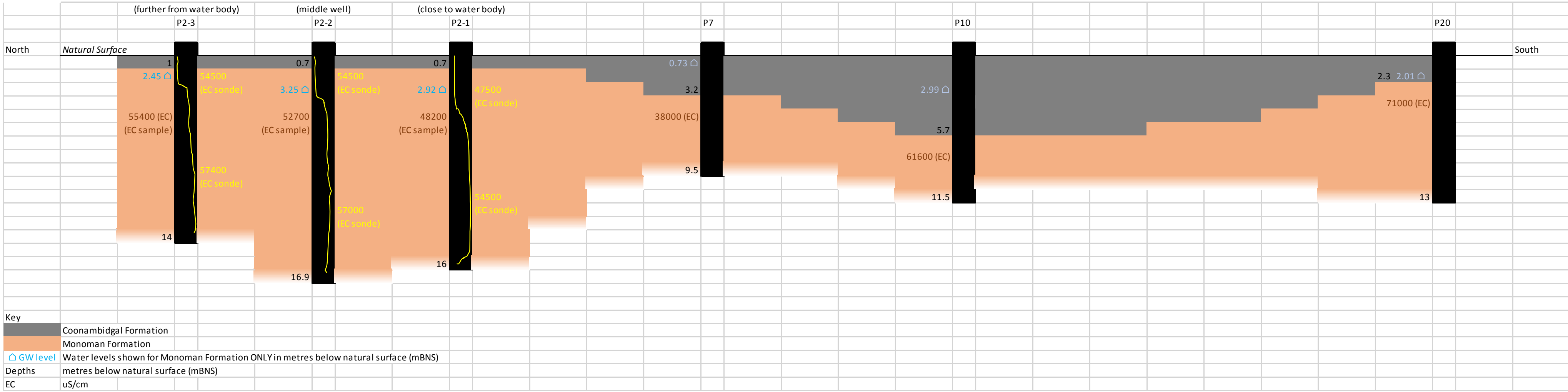

Figure 16 Pike Floodplain Site 1a cross-section including Sites 7, 10 and 20

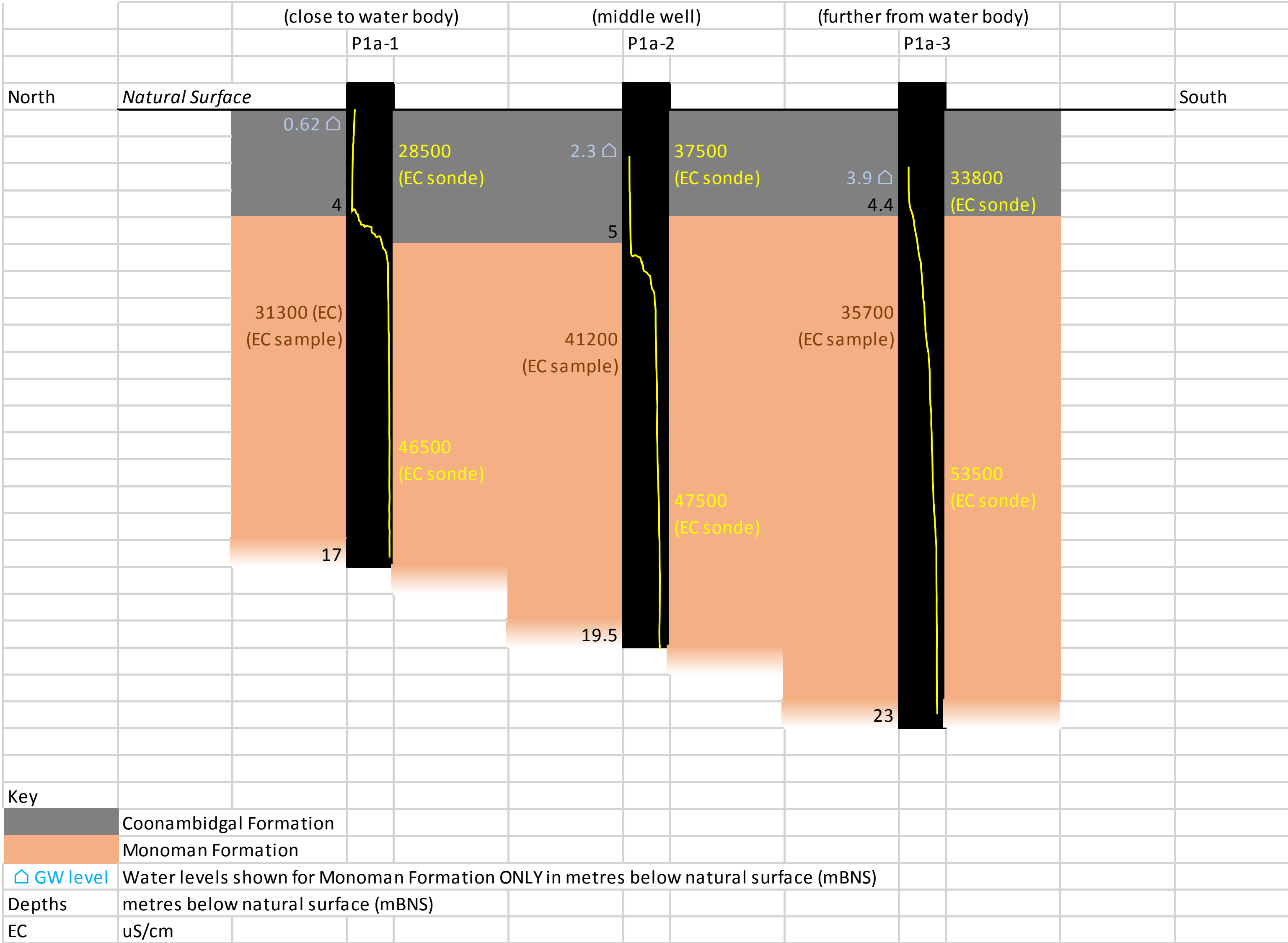

Figure 17 Pike Floodplain Site 2

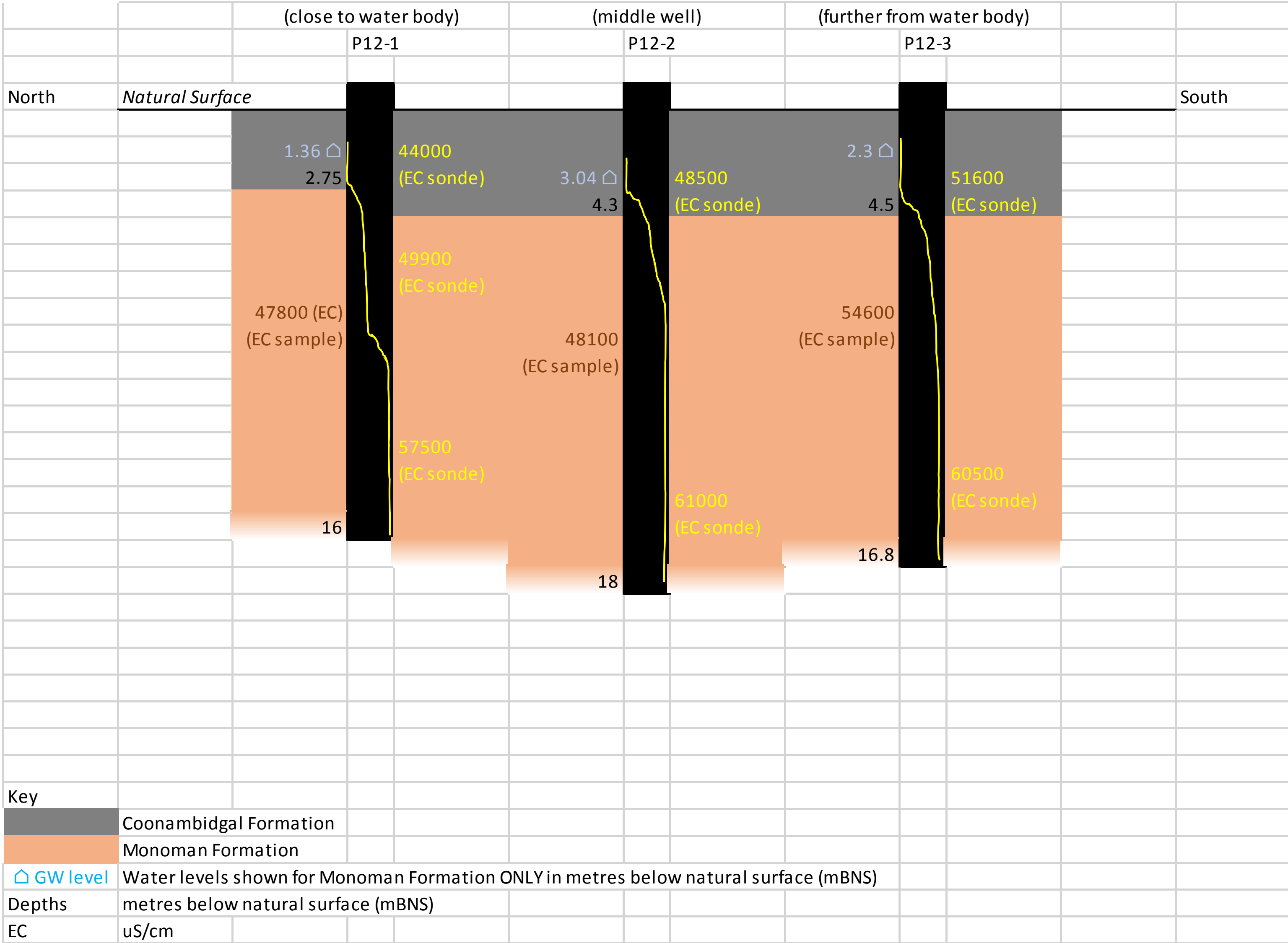

Figure 18 Pike Floodplain Site 2

5 Conclusions and recommendations

Curently, 166 wells are included in SARFIIP SMM Salinity Investigations project specific monitoring networks to support numerical floodplain modelling and the SMM concept design options. The monitoring networks include:

- Pike Floodplain monitoring network
- Katarapko Floodplain monitoring network
- Murray Group monitoring network.

All data, both water level and salinity, was uploaded into the state groundwater database within a few days of collection and available online at WaterConnect.

Planned groundwater network monitoring during March and April was impacted due to resourcing issues with other program elements (ground-based geophysical, soil and cultural surveys and Phase 1 and Phase 2 drilling programs) and inclement weather, resulting in the re-scheduling of monitoring activities. A number of scheduled monitoring rounds were not completed during times of heavy resource commitment.

Significant expansion of the Pike Floodplain and Katarapko Floodplain monitoring networks has occurred through the drilling programs, with the addition of 56 new wells.

In order to capture short to medium term monitoring requirements (to the end of 2016) of the detailed design phase of SMM, it is recommended that:

- Groundwater level monitoring continues until the end of February 2016 (end of summer)
- Following the review of monitoring requirements with the SMM design engineer where an initial rationalisation of groundwater level monitoring occurred (Appendix B), monitoring frequency for this groundwater level network be reduced from monthly to three-monthly enabling the capture of seasonal trends. Given the lack of water level variation in the Murray Group, frequency of monitoring Murray Group wells be reduced to six-monthly.
- A second groundwater salinity sampling program planned for early 2016 proceeds in order to capture baseline salinity conditions for the Phase 2A wells, and to establish a length of record for wells sampled during October 2015.
- Groundwater salinity sampling occurs at six monthly intervals to capture pre and post winter conditions of Phase 1 and Phase 2 wells (and any additional wells identified by the ecology team or design contractor) to inform conceptual understanding through time series data collection
- Manual sonding of wells with long (>10 m) screens must occur prior to sampling, followed by discrete sampling of stratified groundwater (if required) since groundwater salinity sampling conducted during October 2015 identified that salinity stratification occurs within the floodplain. Due to this stratification, it is also receommended that sonding be conducted at regular times through out the year to monitor movement and stratification of lenses
- Groundwater level loggers installed by the SMM design engineer be downloaded to assess the condition of each logger and the interpreted data used to inform a rationalisation of logger network distribution for the project
- Groundwater level loggers installed by the SMM design engineer be replaced with state assets prior to the commencement of inundation trials
- Pike Floodplain groundwater monitoring be aligned with routine surface water monitoring activities undertaken by RMU to enable efficient access to monitoring island wells
- Resources are provisioned to conduct groundwater network monitoring activities to ensure adequate data for SMM detailed design.

In addition, all monitoring activities should be reviewed in early 2016 to ensure the requirements for the detailed design phase of SMM can be met. Considerations will include proposed inundation extents, SMM design options, numerical groundwater modelling requirements and state monitoring needs. The networks should then be reviewed on a continual basis. Furthermore, such reviews should incorporate sensitivity analyses from the Pike Floodplain numerical groundwater model to assess where data is needed to reduce model uncertainty. The optimistation metholodolgy employed by SMK for all state groundwater monitoring networks should also be used where appropriate.

6 References

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7 Appendix A: SARFIIP 2015 groundwater monitoring wells

Unit No	Zone	Easting	Northing	Latest RSWL Date	RSWL (mAHD)	Lastest EC Date	EC (µS/cm)
692900370	54	448413	6184951	22-Dec-15	14.31	23-May-80	14838
702900616	54	455938	6200173	17-Dec-15	13.95	26-Sep-80	25367
702900617	54	466662	6198942	22-Dec-15	16.01	06-Jun-94	61900
702900619	54	455907	6193602	17-Dec-15	12.75	12-Sep-80	30211
702900621	54	457342	6186262	22-Dec-15	15.2	21-Jun-85	6516
702900622	54	457174	6182586	22-Dec-15	15.34	17-Jun-80	29493
702900626	54	482746	6214556	21-Dec-15	22.67	09-Jun-94	32800
702900627	54	471528	6216119	21-Dec-15	20.86	15-Oct-84	27421
702900628	54	459715	6213829	30-Aug-11	17.94	01-Oct-80	27604
702900653	54	457579	6196146	05-May-15	15.77	10-Sep-80	60100
702900796	54	460620	6189413	20-Apr-15	9.96	14-Feb-89	18000
702900955	54	462383	6190195	22-Dec-15	11.3	14-Aug-84	16301
702900960	54	465198	6209963	21-Dec-15	17.14	23-Mar-86	30100
702901009	54	462355	6191057	22-Dec-15	11.5	14-Jan-88	41900
702901010	54	467350	6189130	22-Dec-15	19.47	26-Aug-91	43600
702901040	54	476164	6207178	22-Dec-15	13.5	16-Nov-88	70627
702901043	54	463868	6191295	22-Dec-15	16.79	11-Oct-88	35000
702901045	54	464221	6194564	22-Dec-15	16.26	21-Oct-88	40000
702901128	54	475041	6207156	22-Dec-15	12.83	28-Mar-90	10000
702901129	54	474710	6207211	22-Dec-15	13.29	30-Mar-90	45000
702901130	54	475865	6207102	22-Dec-15	13.17		
702901131	54	473609	6207258	22-Dec-15	13.47	04-Apr-90	11000
702901132	54	473157	6207392	22-Dec-15	14.09	05-Apr-90	11000
702901133	54	472054	6207880	22-Dec-15	13.29	10-Apr-90	28000
702901134	54	472502	6207676	22-Dec-15	13.85	10-Jan-91	41000
702901136	54	471119	6208585	22-Dec-15	13.74	03-May-90	26000
702901184	54	478652	6208758	21-Dec-15	13.67	30-Jan-92	49300
702901185	54	478438	6208671	21-Dec-15		30-Jan-92	48100
702901186	54	478176	6209184	21-Dec-15	13.38	30-Jan-92	51100
702901187	54	476928	6209047	26-Sep-14	13.27	30-Jan-92	42500
702901188	54	477167	6210065	26-Sep-14			
702901189	54	476565	6209784	26-Sep-14	13.18	30-Jan-92	47900
702901190	54	475723	6210978	26-Sep-14		30-Jan-92	40400
702901192	54	480368	6213384	09-Dec-15		30-Jan-92	49600
702901193	54	479836	6212143	09-Dec-15		30-Jan-92	47000
702901194	54	478992	6211778	09-Dec-15		30-Jan-92	42700
702901195	54	478609	6210711	09-Dec-15		30-Jan-92	14760
702901196	54	481497	6211985	09-Dec-15	13.96	30-Jan-92	46700
702901197	54	482037	6210632	09-Dec-15		30-Jan-92	48800
702901198	54	482022	6214628	21-Dec-15	14.65	30-Jan-92	39400
702901199	54	481739	6214650	21-Dec-15	14.57	30-Jan-92	45000
702901200	54	478755	6216678	16-Dec-15		30-Jan-92	1650
702901201	54	478792	6216046	16-Dec-15		16-Sep-05	45000
702901208	54	482695	6208053	21-Dec-15	14.05	16-Oct-15	77800
702901222	54	477841	6206125	22-Dec-15	21.37		
702901231	54	470025	6207163	22-Dec-15	18.01	14-Oct-02	28009
702901310	54	465292	6203892	22-Dec-15	14.23	14-Oct-02	37394
702901324	54	460073	6203214	23-Dec-15	12.55	07-May-02	80778
702901328	54	459842	6203183	23-Dec-15	12.68	07-May-02	65440
702901354	54	470025	6207157	22-Dec-15	17.8	25-Nov-01	28100
702901355	54	482691	6208059	21-Dec-15	17.58	18-Nov-01	108700
702901541	54	484847	6210593	21-Dec-15	20.56		
702901425	54	463205	6201443	22-Dec-15	16.77	15-Mar-02	21500
702901429	54	463206	6201444	22-Dec-15	15.34	16-Mar-02	23100

Unit No	Zone	Easting	Northing	Latest RSWL Date	RSWL (mAHD)	Lastest EC Date	EC (μS/cm)
702901440	54	461633	6198362	22-Dec-15	12.78	09-Apr-02	42400
702901569	54	458393	6187736	23-Dec-15	15.04	13-Dec-01	17060
702901580	54	457900	6202964	17-Dec-15		19-Nov-02	5860
702901581	54	461500	6202890	23-Dec-15		18-Nov-02	25300
702901582	54	461278	6202057	23-Dec-15	11.56	19-Nov-02	39500
702901588	54	457076	6201179	17-Dec-15	6.88	19-Nov-02	66700
702901589	54	460279	6202984	23-Dec-15	11.95	18-Nov-02	64200
702901592	54	473083	6209105	21-Dec-15	12.93	17-Nov-02	58200
702901596	54	458687	6199273	17-Dec-15	9.65	20-Nov-02	2230
702901597	54	457541	6197562	17-Dec-15	10.08	21-Nov-02	51000
702901598	54	458297	6196517	17-Dec-15		21-Nov-02	2670
702901600	54	460074	6200674	17-Dec-15	9.14	19-Nov-02	3070
702901602	54	460561	6199680	17-Dec-15	14.04	19-Nov-02	4970
702901606	54	457983	6199782	17-Dec-15	7.35	19-Nov-02	60600
702901609	54	478509	6213104	21-Dec-15	14.76	17-Nov-02	22700
702901610	54	481167	6210453	09-Dec-15	13.79	17-Nov-02	84600
702901611	54	481193	6211150	09-Dec-15	13.86	17-Nov-02	68000
702901612	54	481649	6216263	21-Dec-15	14.64	17-Nov-02	59300
702901625	54	473915	6210130	21-Dec-15	11.32	17-Nov-02	2300
702901799	54	477682	6217272	21-Dec-15	14.23	04-Feb-04	43050
702901809	54	479926	6214990	21-Dec-15	14.19	22-Jan-04	57572
702901810	54	479085	6215126	21-Dec-15	14.01	22-Jan-04	76914
702901811	54	480740	6215857	21-Dec-15		22-Jan-04	49473
702902107	54	460927	6199850	23-Dec-15		19-May-05	34600
702902108	54	460969	6199670	17-Dec-15	10.54	19-May-05	31000
702902179	54	459837	6201157	17-Dec-15	8.96		
702902180	54	459768	6201317	17-Dec-15	7.99		
702902181	54	459793	6201212	17-Dec-15	8.88		
702902182	54	459756	6201257	17-Dec-15	7.95		
702902276	54	477607	6215497	21-Dec-15	13.5	06-Jun-06	9650
702902277	54	475347	6213162	21-Dec-15	14.29	06-Jun-06	28100
702902278	54	474452	6212296	21-Dec-15	13.35	06-Jun-06	68100
702902330	54	477121	6214230	21-Dec-15	13.28	04-Sep-07	20550
702902332	54	477532	6214017	21-Dec-15		04-Sep-07	1660
702902333	54	477375	6214003	21-Dec-15	13.63	04-Sep-07	40900
702902391	54	480925	6222479	16-Dec-15	23.42		
702902420	54	478746	6217420	21-Dec-15	14.89		
702902615	54	475856	6206917	22-Dec-15	18.6	13-May-10	75900
702902702	54	471684	6209419	21-Dec-15			
702902705	54	472981	6209608	21-Dec-15	12.95		
702902706	54	473316	6210261	21-Dec-15	12.98		
702902707	54	473516	6210225	21-Dec-15	13.06		
702902708	54	473202	6211267	21-Dec-15	12.95		
702902709	54	473535	6211208	21-Dec-15	12.94		
702902733	54	475334	6207131	22-Dec-15		05-Feb-12	87200
702902734	54	474152	6207206	22-Dec-15		06-Feb-12	59800
702902735	54	476284	6207838	22-Dec-15			
702902736	54	474906	6207316	22-Dec-15		03-Feb-12	73300
702902704	54	472935	6209147	21-Dec-15	12.95		
702902792	54	472916	6208641	21-Dec-15	-0.83		
702902794	54	460616	6202391	23-Dec-15			
702902795	54	457929	6201189	17-Dec-15			
702902807	54	459563	6202111	23-Dec-15			
702902808	54	457443	6196927	17-Dec-15			

Unit No	Zone	Easting	Northing	Latest RSWL Date	RSWL (mAHD)	Lastest EC Date	EC (μS/cm)
702902857	54	480729	6213611	09-Dec-15	14.15	13-Oct-15	54000
702902858	54	480684	6213495	09-Dec-15	14.12	13-Oct-15	54600
702902859	54	480685	6213492	09-Dec-15	14.12	13-Oct-15	56900
702902809	54	457874	6202635	17-Dec-15			
702902819	54	481598	6213862	09-Dec-15	14.34		
702902820	54	481558	6213803	09-Dec-15	15.12		
702902821	54	481510	6213715	09-Dec-15	14.48		
702902822	54	479279	6214390	21-Dec-15	15.73		
702902823	54	479346	6214463	21-Dec-15			
702902854	54	479270	6214387	21-Dec-15	14.13	13-Oct-15	48200
702902824	54	479403	6214496	21-Dec-15			
702902825	54	479450	6213348	15-Dec-15	13.92		
702902826	54	480680	6213501	09-Dec-15			
702902827	54	480719	6213756	09-Dec-15	14.22		
702902828	54	480729	6213609	09-Dec-15			
702902829	54	479190	6209897	09-Dec-15	14.23		
702902831	54	457133	6199961	17-Dec-15			
702902832	54	456864	6198376	17-Dec-15			
702902833	54	458304	6195831	17-Dec-15	10.99		
702902836	54	459232	6200090	17-Dec-15	10.43	12-Oct-15	44000
702902837	54	458303	6195810	17-Dec-15	9.87	12-Oct-15	38400
702902838	54	458304	6195815	17-Dec-15	9.77	12-Oct-15	51200
702902839	54	457129	6199953	17-Dec-15	10.16	12-Oct-15	12400
702902840	54	456869	6198381	17-Dec-15	9.91	12-Oct-15	47200
702902841	54	477561	6213030	09-Dec-15	13.13	15-Oct-15	45400
702902842	54	477962	6212650	09-Dec-15	13.17	15-Oct-15	48800
702902843	54	479452	6213341	15-Dec-15	13.92	14-Oct-15	38000
702902844	54	479178	6209897	09-Dec-15	13.43	15-Oct-15	71000
702902845	54	479526	6212632	09-Dec-15	13.49	24-Sep-15	61600
702902846	54	481513	6213719	09-Dec-15	14.43	13-Oct-15	35700
702902847	54	481509	6213721	09-Dec-15	14.42	13-Oct-15	48900
702902848	54	481562	6213810	09-Dec-15	14.43	13-Oct-15	41200
702902849	54	481557	6213806	09-Dec-15	14.39	13-Oct-15	52800
702902850	54	481597	6213863	09-Dec-15	14.48	13-Oct-15	31300
702902851	54	481594	6213863	09-Dec-15	14.36	13-Oct-15	75200
702902852	54	479343	6214473	21-Dec-15	14.11	13-Oct-15	52700
702902853	54	479403	6214492	21-Dec-15	14.12	13-Oct-15	55400
702902856	54	480732	6213613	09-Dec-15	14.14	13-Oct-15	48100
702902818	54	458527	6199779	17-Dec-15	-3.72		
702902867	54	478505	6212310	09-Dec-15	13.31	02-Nov-15	61800
702902830	54	482081	6209316	09-Dec-15	14.44		
702902880	54	482134	6207850	21-Dec-15	14.91	29-Oct-15	76300
702902855	54	480719	6213757	09-Dec-15	14.25	13-Oct-15	47800
702902864	54	482028	6207865	21-Dec-15	14.87	29-Oct-15	82400
702902865	54	478604	6212443	09-Dec-15	13.29	01-Nov-15	65600
702902866	54	480352	6211076	09-Dec-15	13.72	02-Nov-15	67500
702902868	54	482223	6210262	09-Dec-15	13.99	01-Nov-15	80600
702902869	54	482282	6208601	09-Dec-15	13.92	01-Nov-15	89900
702902870	54	483797	6211998	09-Dec-15	14.78	01-Nov-15	48500
702902871	54	480596	6209253	09-Dec-15	13.69	31-Oct-15	78000
702902872	54	478508	6213133	21-Dec-15	13.41	02-Nov-15	59200
702902873	54	477576	6210934	09-Dec-15	13.05	31-Oct-15	81600
702902874	54	478554	6214213	21-Dec-15	13.89	02-Nov-15	33000
702902875	54	482158	6208194	21-Dec-15	13.57	29-Oct-15	82900

Unit No	Zone	Easting	Northing	Latest RSWL Date	RSWL (mAHD)	Lastest EC Date	EC (μS/cm)
702902876	54	477919	6213982	21-Dec-15	13.11	02-Nov-15	51400
702902877	54	483304	6210020	09-Dec-15	14.22	02-Nov-15	92500
702902878	54	478969	6211835	09-Dec-15	13.33	30-Oct-15	67600
702902879	54	477669	6208822	21-Dec-15	13.44	30-Oct-15	86500

8 Appendix B: SARFIIP 2016 groundwater monitoring wells

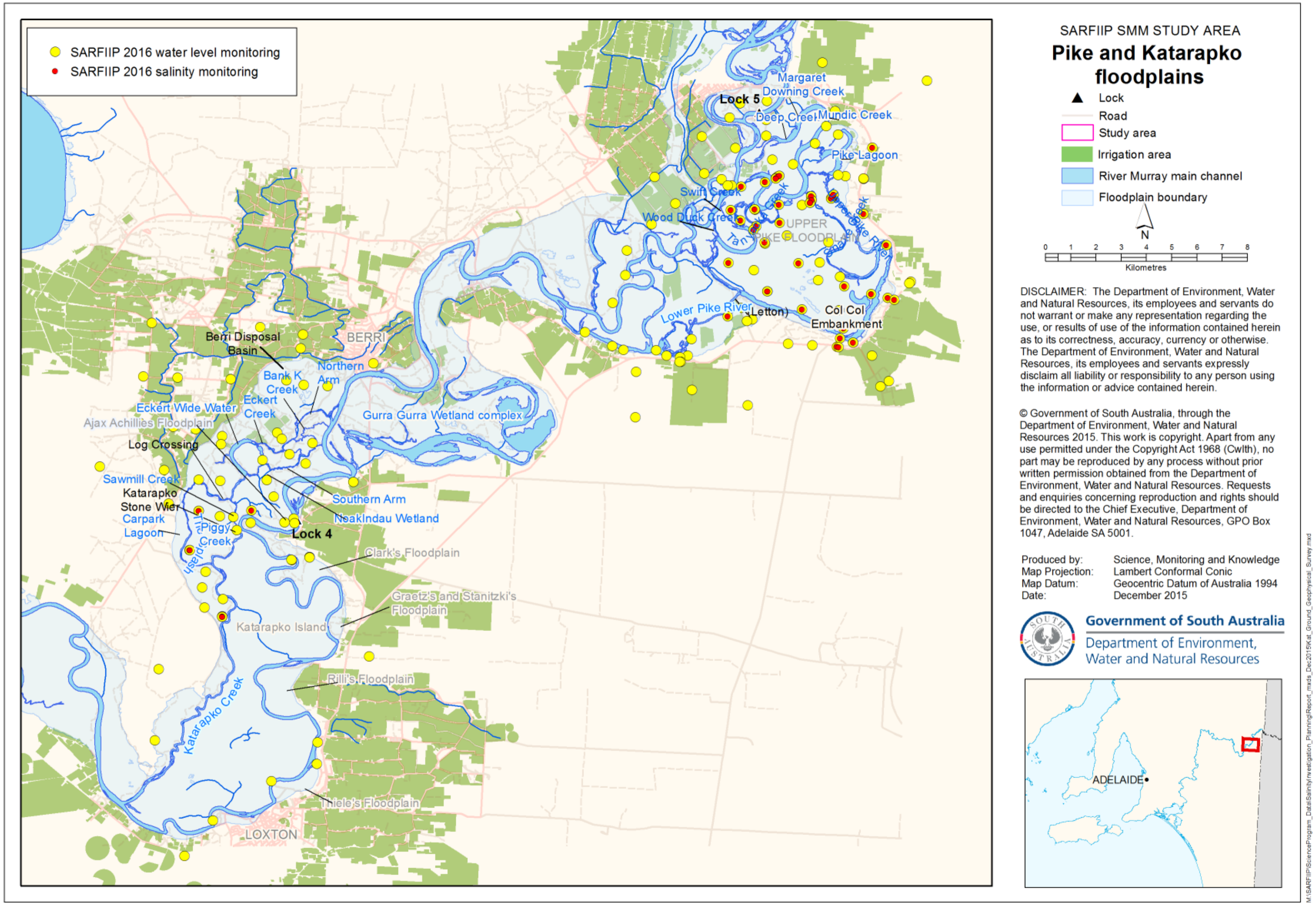


Figure App B. 1 Pike and Katarapko Floodplains 2016 monitoring

Unit No	Zone	Easting	Northing	Latest RSWL Date	RSWL (mAHD)	Lastest EC Date	EC (µS/cm)
692900829	54	453122	6201478	20/03/2014	15.5	24/03/1999	43700
702900616	54	455938	6200173	17/12/2015	13.95	26/09/1980	25367
702900619	54	455907	6193602	17/12/2015	12.75	12/09/1980	30211
702900620	54	455914	6190763	11/06/2014	11.44	27/01/1981	21454
702900621	54	457342	6186262	22/12/2015	15.2	21/06/1985	6516
702900626	54	482746	6214556	21/12/2015	22.67	9/06/1994	32800
702900653	54	457579	6196146	5/05/2015	15.77	10/09/1980	60100
702900658	54	454640	6205152	4/01/1990	20.35	6/11/1979	2530
702900659	54	456006	6205182	31/01/1996	20.17	6/11/1979	21000
702900662	54	460882	6207169	8/01/1985	21.5	6/11/1979	2629
702900664	54	456843	6203176	31/01/1996	20.02	6/11/1979	5062
702900665	54	455949	6203213	4/01/1990	30.02		
702900666	54	454592	6203309	4/01/1990	21.32	15/08/1979	1850
702900674	54	455674	6201492	18/01/1988	18.95		
702900759	54	476431	6214417	8/01/1998			
702900762	54	474461	6214177	7/11/2006			
702900763	54	476251	6215881	7/11/2006			
702900770	54	477305	6216682	23/04/1975	13.77		
702900796	54	460620	6189413	20/04/2015	9.96	14/02/1989	18000
702900929	54	459169	6207351	2/11/2015	18.98		
702900930	54	454862	6207288	2/11/2015	17.83	1/05/1984	7600
702900931	54	458112	6205228	1/07/2003			
702900938	54	461977	6205177	30/06/2003	13.27	15/06/1984	30255
702900942	54	463730	6206174	4/01/1990	14.63	19/06/1984	4000
702900955	54	462383	6190195	22/12/2015	11.3	14/08/1984	16301
702901009	54	462355	6191057	22/12/2015	11.5	14/01/1988	41900
702901040	54	476164	6207178	22/12/2015	13.5	16/11/1988	70627
702901045	54	464221	6194564	22/12/2015	16.26	21/10/1988	40000
702901130	54	475865	6207102	22/12/2015	13.17		
702901131	54	473609	6207258	22/12/2015	13.47	4/04/1990	11000
702901132	54	473157	6207392	22/12/2015	14.09	5/04/1990	11000
702901133	54	472054	6207880	22/12/2015	13.29	10/04/1990	28000
702901137	54	474161	6206421	10/07/2015	14.7		
702901176	54	460328	6205320	26/03/1992	13.37	25/01/1991	45100
702901177	54	461028	6205176	26/03/1992	13.53	25/01/1991	69500
702901184	54	478652	6208758	21/12/2015	13.67	30/01/1992	49300
702901185	54	478438	6208671	21/12/2015		30/01/1992	48100
702901186	54	478176	6209184	21/12/2015	13.38	30/01/1992	51100
702901192	54	480368	6213384	9/12/2015		30/01/1992	49600
702901193	54	479836	6212143	9/12/2015		30/01/1992	47000
702901194	54	478992	6211778	9/12/2015		30/01/1992	42700
702901195	54	478609	6210711	9/12/2015		30/01/1992	14760
702901196	54	481497	6211985	9/12/2015	13.96	30/01/1992	46700
702901197	54	482037	6210632	9/12/2015		30/01/1992	48800
702901198	54	482022	6214628	21/12/2015	14.65	30/01/1992	39400
702901199	54	481739	6214650	21/12/2015	14.57	30/01/1992	45000
702901200	54	478755	6216678	16/12/2015		30/01/1992	1650
702901201	54	478792	6216046	16/12/2015		16/09/2005	45000
702901208	54	482695	6208053	21/12/2015	14.05	16/10/2015	77800
702901211	54	483962	6209902	6/11/2015	15.49	16/10/2015	57900
702901212	54	478657	6205343	6/11/2015	15.51	12/11/1992	70000
702901213	54	483872	6206386	4/11/2015	16.54	24/11/1992	65000
702901214	54	483465	6207581	4/11/2015	15.86	13/11/1992	45000
702901216	54	484201	6206609	4/11/2015	15.83		

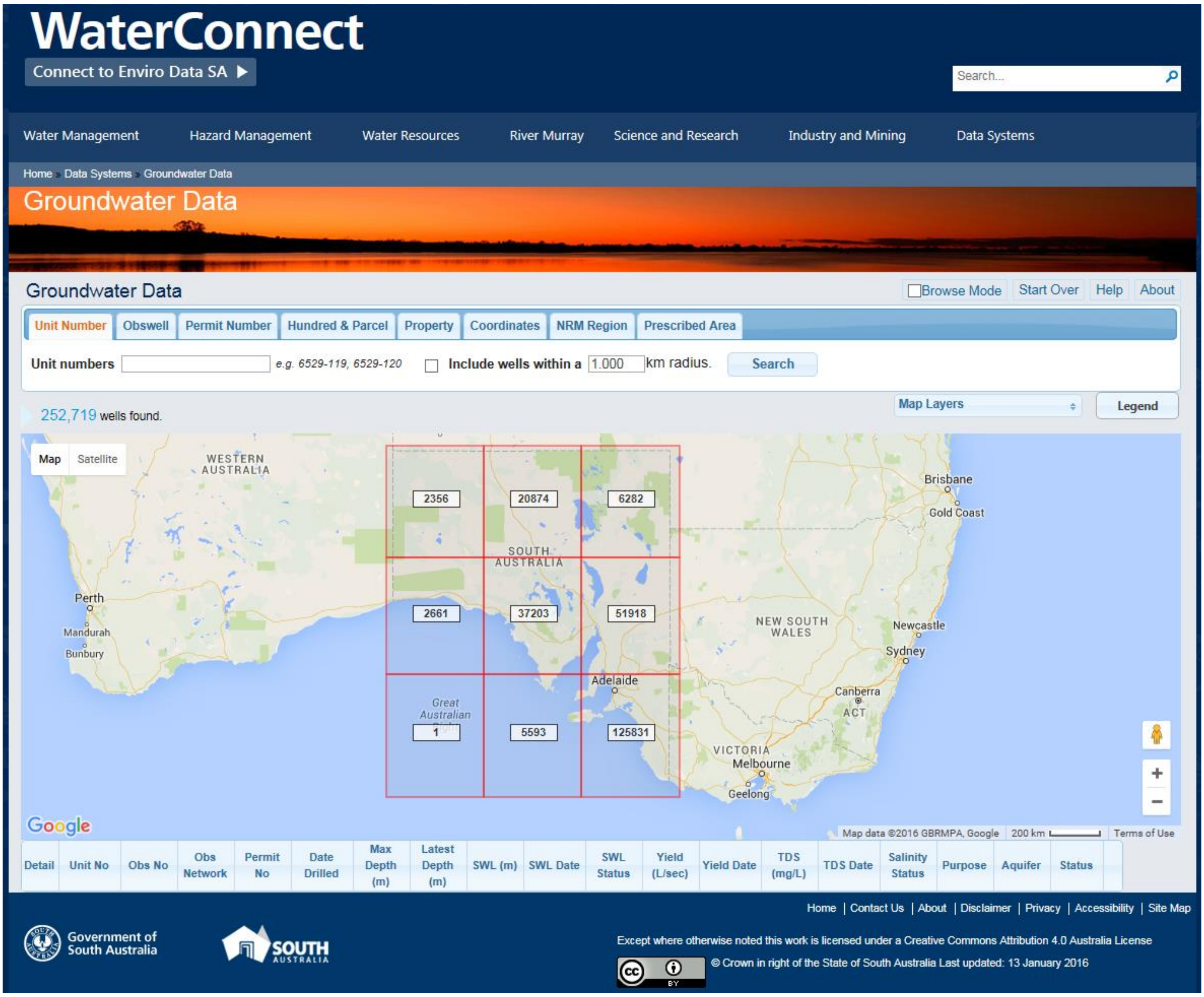
Unit No	Zone	Easting	Northing	Latest RSWL Date	RSWL (mAHD)	Lastest EC Date	EC (µS/cm)
702901225	54	474226	6204626	6/11/2015	15.25		
702901302	54	461634	6198370	30/10/2014	9.92	4/10/1998	49700
702901324	54	460073	6203214	23/12/2015	12.55	7/05/2002	80778
702901351	54	480860	6219068	5/11/2015	16.58	12/11/2001	20230
702901355	54	482691	6208059	21/12/2015	17.58	18/11/2001	108700
702901425	54	463205	6201443	22/12/2015	16.77	15/03/2002	21500
702901429	54	463206	6201444	22/12/2015	15.34	16/03/2002	23100
702901440	54	461633	6198362	22/12/2015	12.78	9/04/2002	42400
702901441	54	461630	6198358	30/10/2014	14.4	24/01/2001	42100
702901541	54	484847	6210593	21/12/2015	20.56		
702901569	54	458393	6187736	23/12/2015	15.04	13/12/2001	17060
702901580	54	457900	6202964	17/12/2015		19/11/2002	5860
702901581	54	461500	6202890	23/12/2015		18/11/2002	25300
702901582	54	461278	6202057	23/12/2015	11.56	19/11/2002	39500
702901588	54	457076	6201179	17/12/2015	6.88	19/11/2002	66700
702901589	54	460279	6202984	23/12/2015	11.95	18/11/2002	64200
702901592	54	473083	6209105	21/12/2015	12.93	17/11/2002	58200
702901596	54	458687	6199273	17/12/2015	9.65	20/11/2002	2230
702901597	54	457541	6197562	17/12/2015	10.08	21/11/2002	51000
702901598	54	458297	6196517	17/12/2015		21/11/2002	2670
702901600	54	460074	6200674	17/12/2015	9.14	19/11/2002	3070
702901601	54	459222	6199600	29/10/2014	13.69	20/11/2002	720
702901602	54	460561	6199680	17/12/2015	14.04	19/11/2002	4970
702901606	54	457983	6199782	17/12/2015	7.35	19/11/2002	60600
702901609	54	478509	6213104	21/12/2015	14.76	17/11/2002	22700
702901610	54	481167	6210453	9/12/2015	13.79	17/11/2002	84600
702901611	54	481193	6211150	9/12/2015	13.86	17/11/2002	68000
702901612	54	481649	6216263	21/12/2015	14.64	17/11/2002	59300
702901799	54	477682	6217272	21/12/2015	14.23	4/02/2004	43050
702901809	54	479926	6214990	21/12/2015	14.19	22/01/2004	57572
702901810	54	479085	6215126	21/12/2015	14.01	22/01/2004	76914
702901811	54	480740	6215857	21/12/2015		22/01/2004	49473
702901812	54	481157	6216573	27/08/2004	14.77	22/01/2004	45663
702901979	54	485051	6218584	5/11/2015	16.89	25/06/2004	13120
702901980	54	482744	6214569	4/11/2015	15.46	26/06/2004	41100
702901984	54	484788	6210523	4/11/2015	15.66	3/09/2004	90000
702901989	54	484237	6209845	4/11/2015	15.7	16/10/2015	55700
702901993	54	480118	6207866	10/07/2015	14.92	31/08/2004	67700
702901999	54	481090	6207860	6/11/2015	14.74	8/09/2004	91400
702902001	54	476409	6205828	10/07/2015	15.31	28/06/2004	55500
702902107	54	460927	6199850	23/12/2015		19/05/2005	34600
702902108	54	460969	6199670	17/12/2015	10.54	19/05/2005	31000
702902109	54	460931	6198213	26/09/2014	10.99	19/05/2005	52600
702902110	54	460923	6198214	26/09/2014	10.26	19/05/2005	28200
702902180	54	459768	6201317	17/12/2015	7.99		
702902276	54	477607	6215497	21/12/2015	13.5	6/06/2006	9650
702902277	54	475347	6213162	21/12/2015	14.29	6/06/2006	28100
702902278	54	474452	6212296	21/12/2015	13.35	6/06/2006	68100
702902330	54	477121	6214230	21/12/2015	13.28	4/09/2007	20550
702902332	54	477532	6214017	21/12/2015		4/09/2007	1660
702902333	54	477375	6214003	21/12/2015	13.63	4/09/2007	40900
702902412	54	483029	6215821	15/10/2015	15.73	15/10/2015	44300
702902413	54	481467	6217187	29/08/2014	15.83		
702902416	54	482821	6213171	15/10/2015	15.03	15/10/2015	43200

Unit No	Zone	Easting	Northing	Latest RSWL Date	RSWL (mAHD)	Lastest EC Date	EC (µS/cm)
702902420	54	478746	6217420	21/12/2015	14.89		
702902614	54	475906	6206919	10/07/2015	13.81		
702902615	54	475856	6206917	22/12/2015	18.6	13/05/2010	75900
702902672	54	460826	6206615				
702902707	54	473516	6210225		13.06		
702902709	54	473535	6211208		12.94		
702902733	54	475334	6207131			5/02/2012	87200
702902735	54	476284	6207838				
702902736	54	474906	6207316			3/02/2012	73300
702902794	54	460616	6202391				
702902795	54	457929	6201189				
702902807	54	459563	6202111				
702902808	54	457443	6196927				
702902809	54	457874	6202635				
702902818	54	458527	6199779		-3.72		
702902819	54	481594	6213861		14.34		
702902820	54	481558	6213805		15.12		
702902821	54	481511	6213712		14.48		
702902822	54	479273	6214390		15.73		
702902823	54	479344	6214465				
702902824	54	479402	6214496				
702902825	54	479450	6213345		13.92		
702902826	54	480680	6213499				
702902827	54	480716	6213758		14.22		
702902828	54	480729	6213609				
702902829	54	479187	6209896		14.23		
702902830	54	482077	6209313		14.44		
702902831	54	457132	6199955				
702902832	54	456865	6198375				
702902833	54	458303	6195831		10.99		
702902836	54	459231	6200090		10.43	12/10/2015	44000
702902837	54	458301	6195810		9.87	12/10/2015	38400
702902838	54	458303	6195815		9.77	12/10/2015	51200
702902839	54	457132	6199953		10.16	12/10/2015	12400
702902840	54	456868	6198383		9.91	12/10/2015	47200
702902841	54	477560	6213027		13.13	15/10/2015	45400
702902842	54	477960	6212646		13.17	15/10/2015	48800
702902843	54	479178	6209897		13.92	14/10/2015	38000
702902844	54	479178	6209897		13.43	15/10/2015	71000
702902845	54	479524	6212633		13.49	24/09/2015	61600
702902846	54	481511	6213717		14.43	13/10/2015	35700
702902847	54	481509	6213719		14.42	13/10/2015	48900
702902848	54	481559	6213808		14.43	13/10/2015	41200
702902849	54	481557	6213806		14.39	13/10/2015	52800
702902850	54	481594	6213863		14.48	13/10/2015	31300
702902851	54	481591	6213864		14.36	13/10/2015	75200
702902852	54	479344	6214469		14.11	13/10/2015	52700
702902853	54	479403	6214489		14.12	13/10/2015	55400
702902854	54	479271	6214386		14.13	13/10/2015	48200
702902855	54	480717	6213756		14.25	13/10/2015	47800
702902856	54	480732	6213613		14.14	13/10/2015	48100
702902857	54	480730	6213611		14.15	13/10/2015	54000
702902858	54	480684	6213495		14.12	13/10/2015	54600
702902859	54	480685	6213491		14.12	13/10/2015	56900

Unit No	Zone	Easting	Northing	Latest RSWL Date	RSWL (mAHD)	Lastest EC Date	EC (µS/cm)
702902864	54	482070	6207859		14.87	29/10/2015	82400
702902865	54	478601	6212443		13.29	1/11/2015	65600
702902866	54	480351	6211076		13.72	2/11/2015	67500
702902867	54	478502	6212309		13.31	2/11/2015	61800
702902868	54	482223	6210258		13.99	1/11/2015	80600
702902869	54	482283	6208602		13.92	1/11/2015	89900
702902870	54	483799	6211995		14.78	1/11/2015	48500
702902871	54	480589	6209262		13.69	31/10/2015	78000
702902872	54	478504	6213122		13.41	2/11/2015	59200
702902873	54	477581	6210939		13.05	31/10/2015	81600
702902874	54	478853	6214213		13.89	2/11/2015	33000
702902875	54	482162	6208200		13.57	29/10/2015	82900
702902876	54	477914	6213982		13.11	2/11/2015	51400
702902877	54	483300	6210016		14.22	2/11/2015	92500
702902878	54	478969	6211833		13.33	30/10/2015	67600
702902879	54	477670	6208823		13.44	30/10/2015	86500
702902880	54	482124	6207848		14.91	29/10/2015	76300

9 Appendix C: Instructions on how to access the state groundwater database: WaterConnect

- URL: www.waterconnect.sa.gov.au
- From “Data Systems” select “Groundwater Data”
- Click “Groundwater Data” link



Search by Unit Number, Obswell network, Permit Number, Hundred & Parcel, Property, Coordinates, NRM Region, Prescribed Area or use the interactive map.

Government of South Australia
Department of Environment,
Water and Natural Resources