Member of the Surbana Jurong Group

# Technical Memorandum

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| **Attachments** | n/a | | |

## 1. Introduction

This technical memorandum provides a hydrogeological review of existing information around Sunday Creek and Lake Moodemere on the Murray River near Rutherglen in Victoria (the Site). SMEC Australia (SMEC) was commissioned by Goulburn-Murray Water (GMW) to undertake a salinity and groundwater assessment as part of the Sunday Creek Reconfiguration Project. The project consists of:

- A new purpose built 36 ML/day electric pump station to extract water from the Murray River;
- A direct pipeline to transfer water from the pump station to Sunday Creek, enabling Lake Moodemere and its fringing marshes to be bypassed;
- A new embankment and regulating structure at Hells Gate, allowing the creek and Lake Moodemere to be operated independently of each other; and
- Decommissioning the old pump station and upgrading the existing Lake Moodemere regulator on the River Murray in line with modern standards and facilitate the ongoing management of water levels in the lake.

The project works proposed are to enable water management in Sunday Creek and Lake Moodemere to be operated independently, allowing Lake Moodemere to return to a more hydrologically diverse water regime. At present water from the Murray River is pumping into Lake Moodemere, keeping the lake at a level which spills into Sunday Creek through the Hells Gate Regulator. Water is then extracted from Sunday Creek for irrigation. There is a reliance on Lake Moodemere water levels for recreational activities during the summer months and part of the project planning is to maintain the lake's water level during this time for those activities. This memorandum will support referrals of the project under the Victorian *Environment Effects Act 1978*.

The salinity and groundwater assessment scope of work included:

- Review of existing registered groundwaters bores within the vicinity of the site;
- Review of the levels of the existing and proposed lake and creek levels;
- Assessment of data gaps; and
- Review of the likelihood of changes to the water regime resulting in detrimental increase in salinity in Lake Moodemere or Sunday Creek and potential mitigation measures.

Table 1 outlines the sections within this memorandum that the scope of work has been addressed.

*Table 1: Scope of work and relevant section of the memorandum*

| Scope of Work | Where Addressed in this Memorandum |
|---|---|
| Review all available data related to groundwater and salinity in the area. This will include geotechnical bore logs and any local or regional information | Section 3 |
| Complete a gap analysis to determine whether there is sufficient available information to complete an assessment to support the EE Act referral | Section 4 |
| Provide recommendation if additional data or field investigations are required | Section 4 |
| Complete an assessment to characterise the groundwater-surface water interaction | Section 4 |
| Assess the likelihood of changes to the watering regime resulting in increased salinity in Lake Moodemere or Sunday Creek | Section 4 |
| Present feasible mitigation measures or strategies if risk of a detrimental increase in salinity is identified | Not Required |

# 3. Information Sources

Hydrogeological information sources reviewed include:

- Minview data portal www.minview.geoscience.nsw.gov.au;
- WaterNSW portal realtimedata.waternsw.com.au/water.stm;
- Water Measurement Information System VIC portal data.water.vic.gov.au;
- Australian Groundwater Explorer bom.gov.au/water/groundwater/explorer/map.shtml;
- Visualising Victoria's Groundwater portal www.vvg.org.au; and
- GHD 2010 Report for Lake Moodemere Water Savings Project: Phase 2 – Water Resources Report.

## 3.1 Regional Geology and Hydrogeology

Lake Moodemere and Sunday Creek are located around 5 km south of the New South Wales town of Corowa and 5 km west of the Victorian town of Rutherglen. The area is covered by the Victorian geological survey on the Wangaratta 1:250:000 scale geological map sheet (VandenBerg, 1997) as shown on Figure 1.

The Site is located at the confluence of Groundwater Management Unit 015 and 016 of the NSW Water Sharing Plan for the Upper Murray Alluvial Groundwater Source (2012) and the Victorian Groundwater Resource Plan of the Goulburn-Murray Sedimentary Plain (2012). As such there may be differences in nomenclature for sedimentary units between the plans.

Surrounding the Site there are two main surficial Quaternary aged sediment units, the Coonambigal Formation and the Shepparton Formation, part of the regionally extensive Murray Basin sediments. The Coonambigal Formation is a Quaternary aged fluvial and lacustrine deposit consisting of clays and sands which overly the Quaternary aged fluvial sediments of the Shepparton Formation which consist of silts, sand and minor gravels. The Shepparton Formation usually forms the water table aquifer. It is separated between a shallow and deep component at 25 m for management purposes.

The Shepparton Formation overlies the Calivil Formation. The Calivil Formation is up to 80 m thick and consists of quartz sand and gravel, often yielding large volumes of high quality groundwater (MBDA, 2020). The Renmark Group is the basal aquifer within the Riverine Plains, it is composed of alluvial sands and gravels with interbedded carbonaceous clay-rich units and hydraulically connected with the overlying Calivil Formation. Palaeozoic bedrock is exposed to the north and east of the Site consisting of the Ordovician aged Pinnak Sandstone, of the Adaminaby Group, which comprises marine sandstones, mudstones, siltstones and minor chert.

The Murray River is in direct hydraulic connection with the groundwater. The groundwater is both gaining from and losing to the Murray River in response to seasonal variations. Rainfall and river flow are the major recharge sources for the aquifers at the Site as well as a minor contribution from localised irrigation return. Irrigation bores predominantly target the deeper Calivil aquifers whilst most stock and domestic bores extract groundwater from shallow Shepparton aquifers (Kalatunga, 2009).

The Shepparton Formation comprises low permeability clays and silts with lenses of sand. The clays are generally restricted to areas away from the main Murray River tract (Kalatunga, 2009) with the lower part of the formation having thick zones of sand and gravel. The Shepparton Formation generally has much lower aquifer transmissivities, up to about 250$m^2$/day and salinities of groundwater in both the Shepparton and Calivil Formations are generally fresh but there are some higher salinity levels in some bores (Kalatunga, 2009).

Figure 2 shows there are three main surface hydrogeological units forming extensive porous, extensive aquifers. At the Site the water table aquifer is considered regionally to be a low to moderately productive aquifer (Figure 3) with the water table yield, as shown on Figure 4, mapped as greater than 5 L/s. Figure 5 shows the regionally mapped water table salinity available from Geoscience Australia. There is a saline area shown beneath the southern parts of Lake Moodemere and Sunday Creek and this area extends south-west towards Ovens River. Figure 6 from MDBA (2020) shows the water table salinity is between 3000 mg/L and 14,000 mg/L. This mapped higher salinity is based on limited data points and may represent the variable salinity of groundwater the Shepparton or Calivil Formation as opposed to an area which may be defined as having uniformly higher salinity.


*Figure 1:* ***Regional geology and location of Lake Moodemere and Sunday Creek. Source: VandenBerg (1997)***

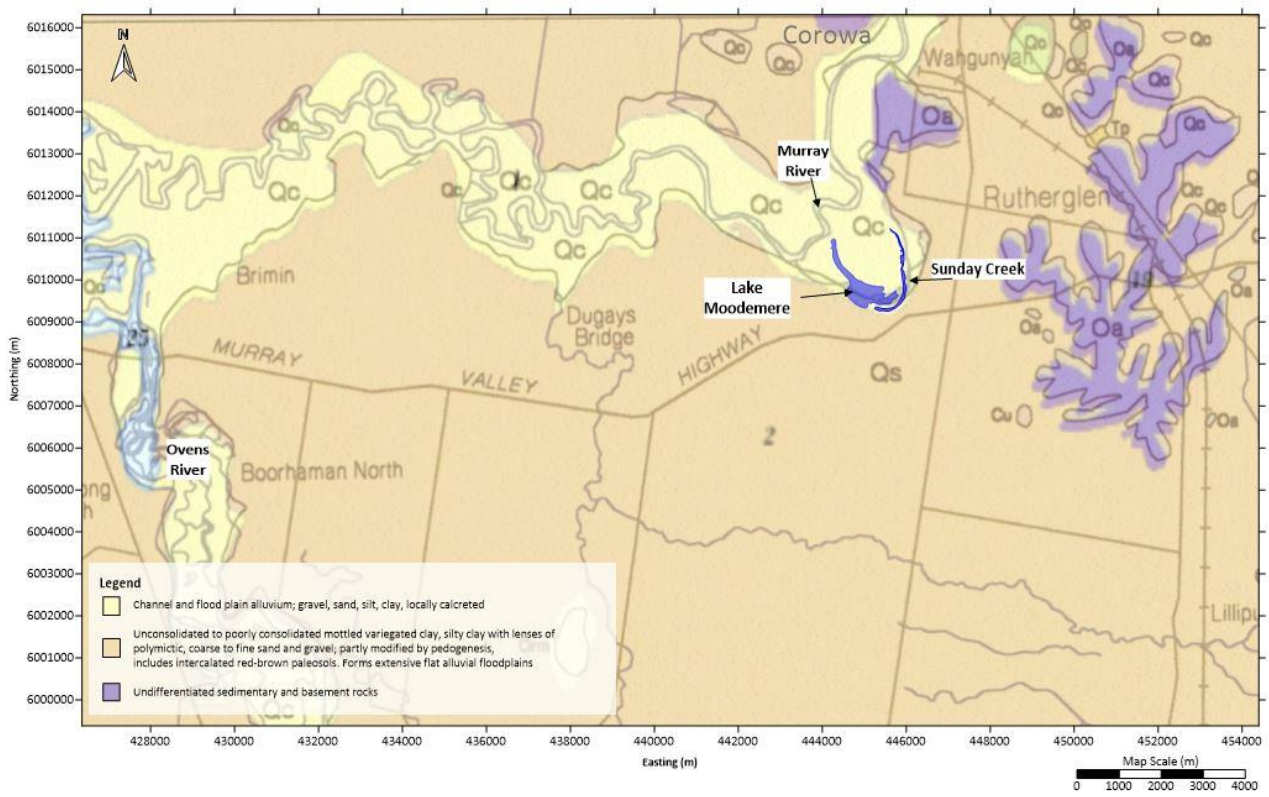


*Figure 2:* ***Regional surface hydrogeological units. Source: Portal.ga.gov.au***

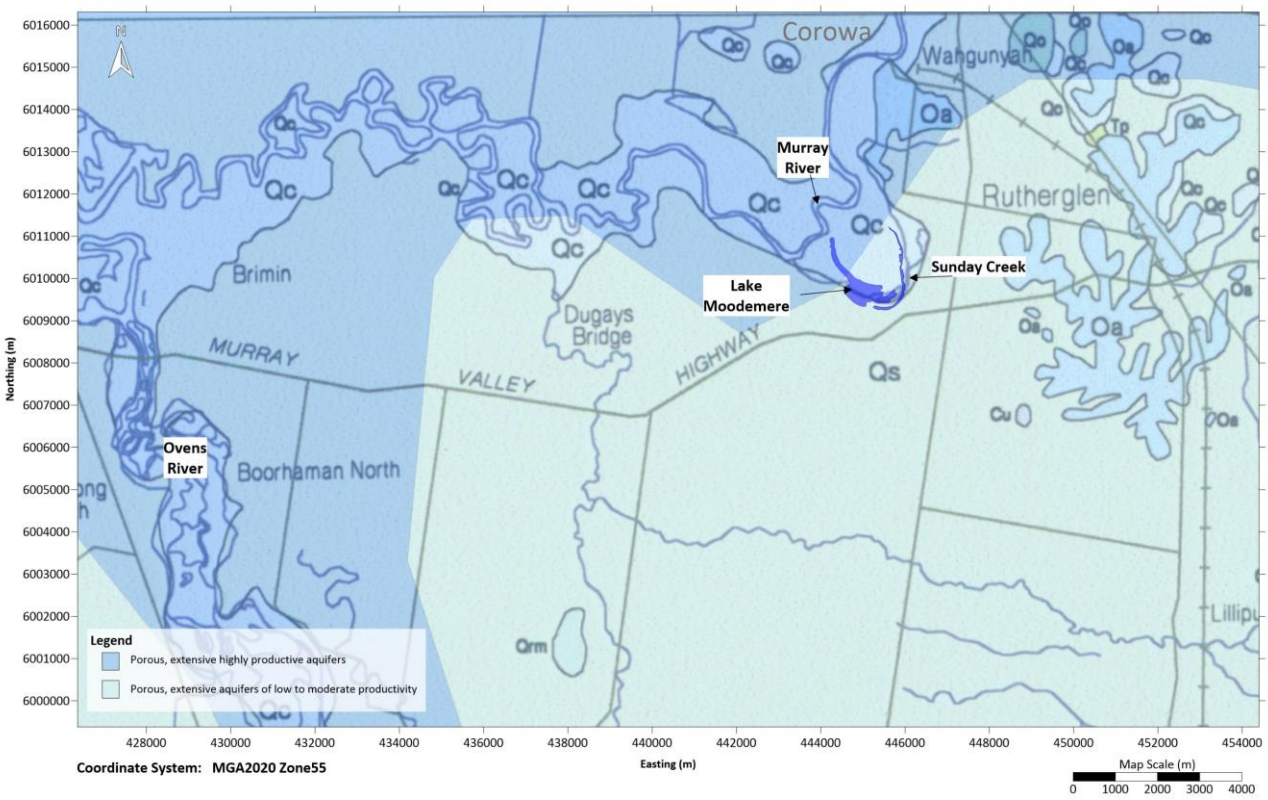


*Figure 3:* ***Regional hydrogeology of Australia. Source: Brodie et al (1998)***

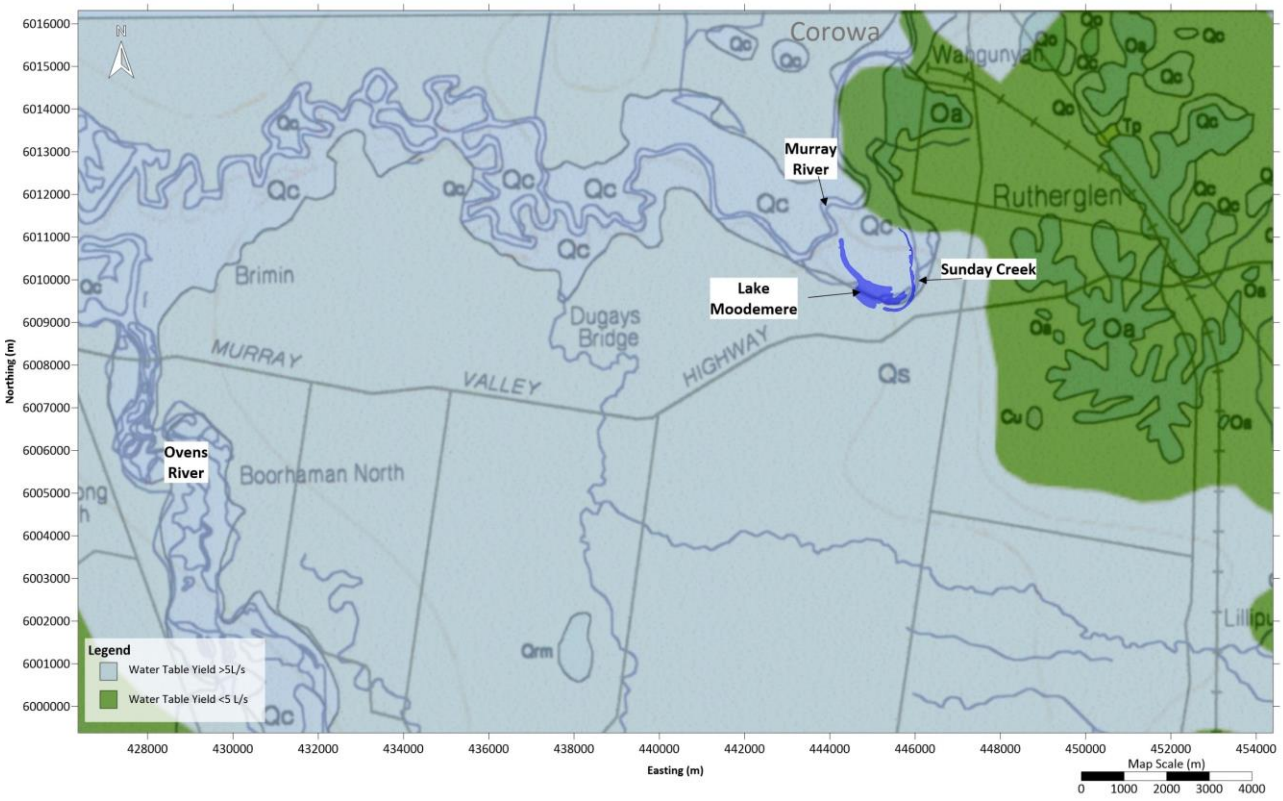


*Figure 4:* ***Water table yield. Source: Portal.ga.gov.au***

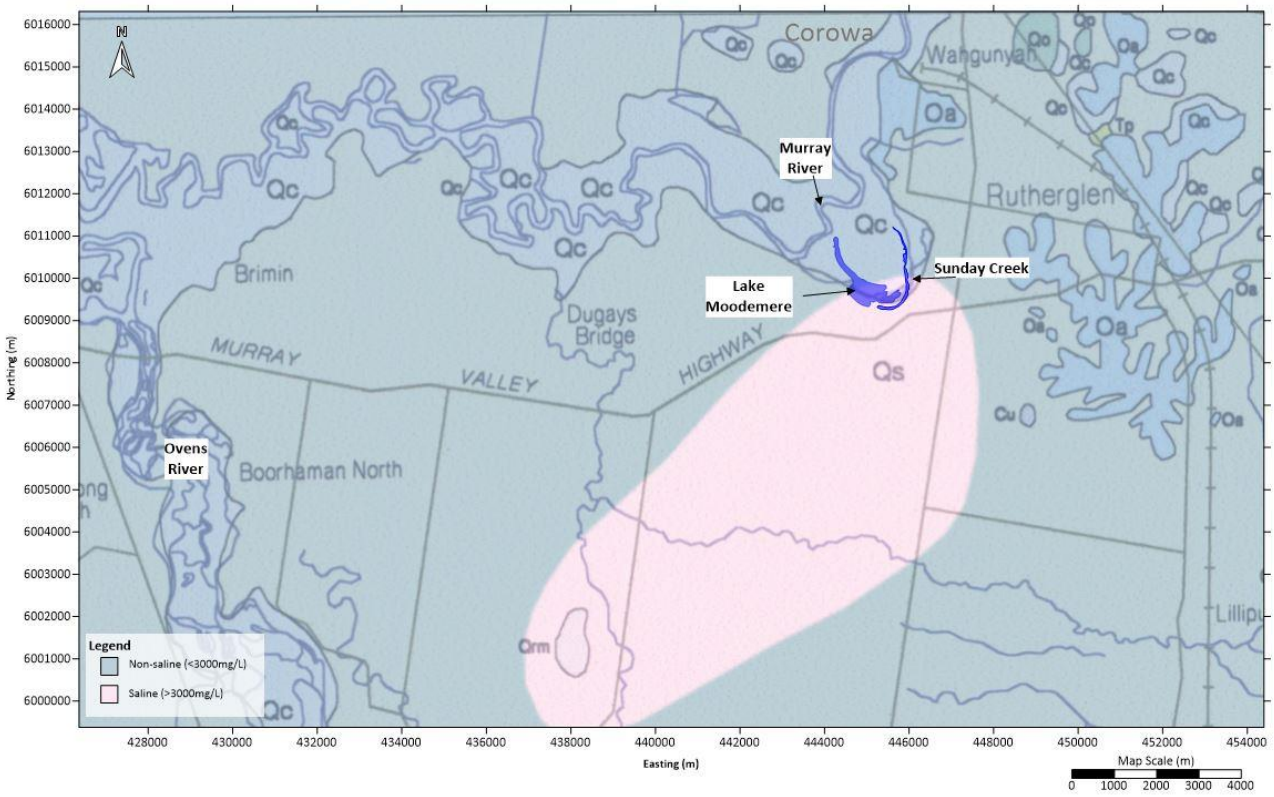


*Figure 5:* ***Water table salinity. Source: Portal.ga.gov.au***

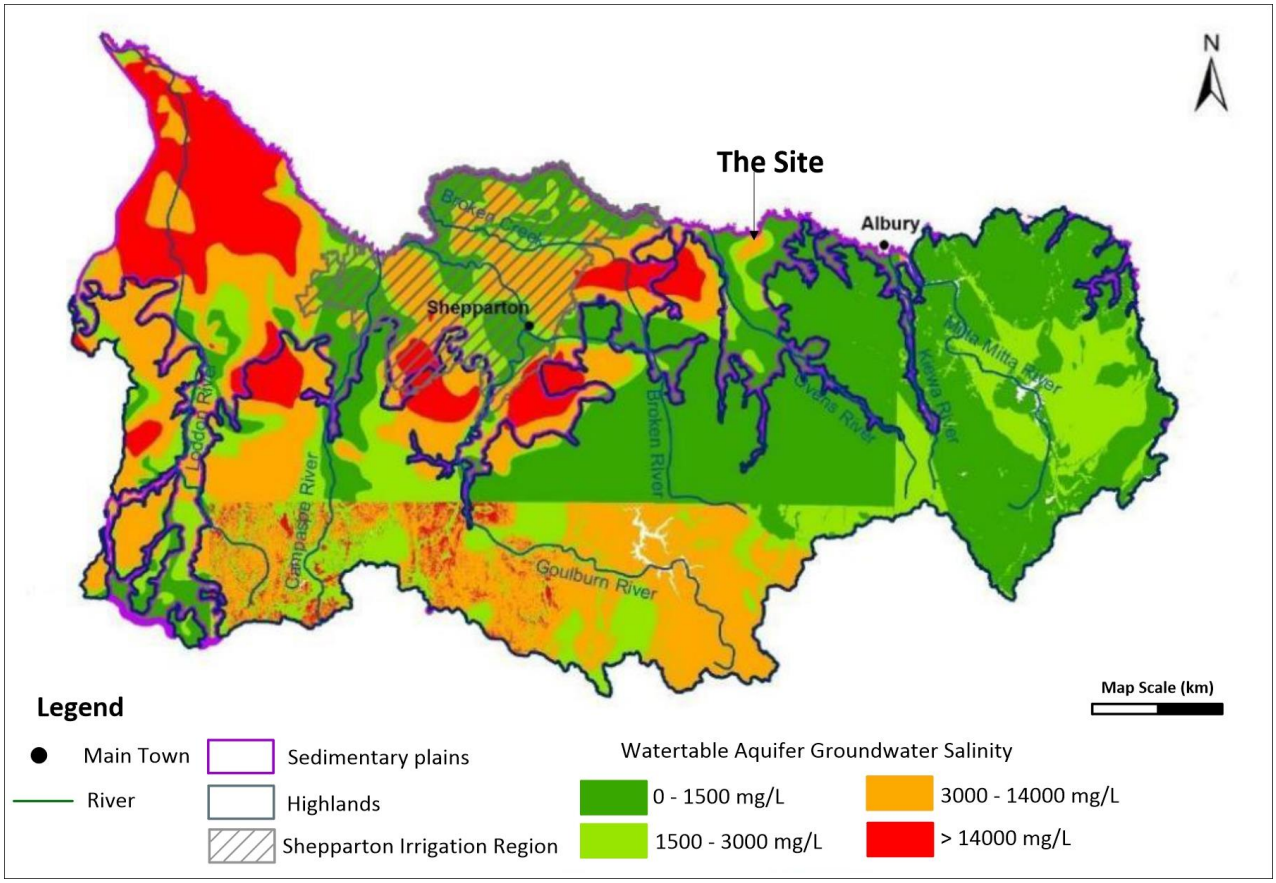


***Figure 6: Water table salinity in the Goulburn-Murray Water Resource Plan area. Adapted from: MDBA (2020)***

## 3.2 Registered Bores

A review of the information portals found around 91 registered groundwater bores within the vicinity of the Site which are shown on Figure 7. The records of many of the registered groundwater bores are incomplete and are missing details of lithology, water level and or construction information. The thickness of the unconsolidated sediments from available bore information ranges from less than 10 m to around 91 m in the vicinity of the site.

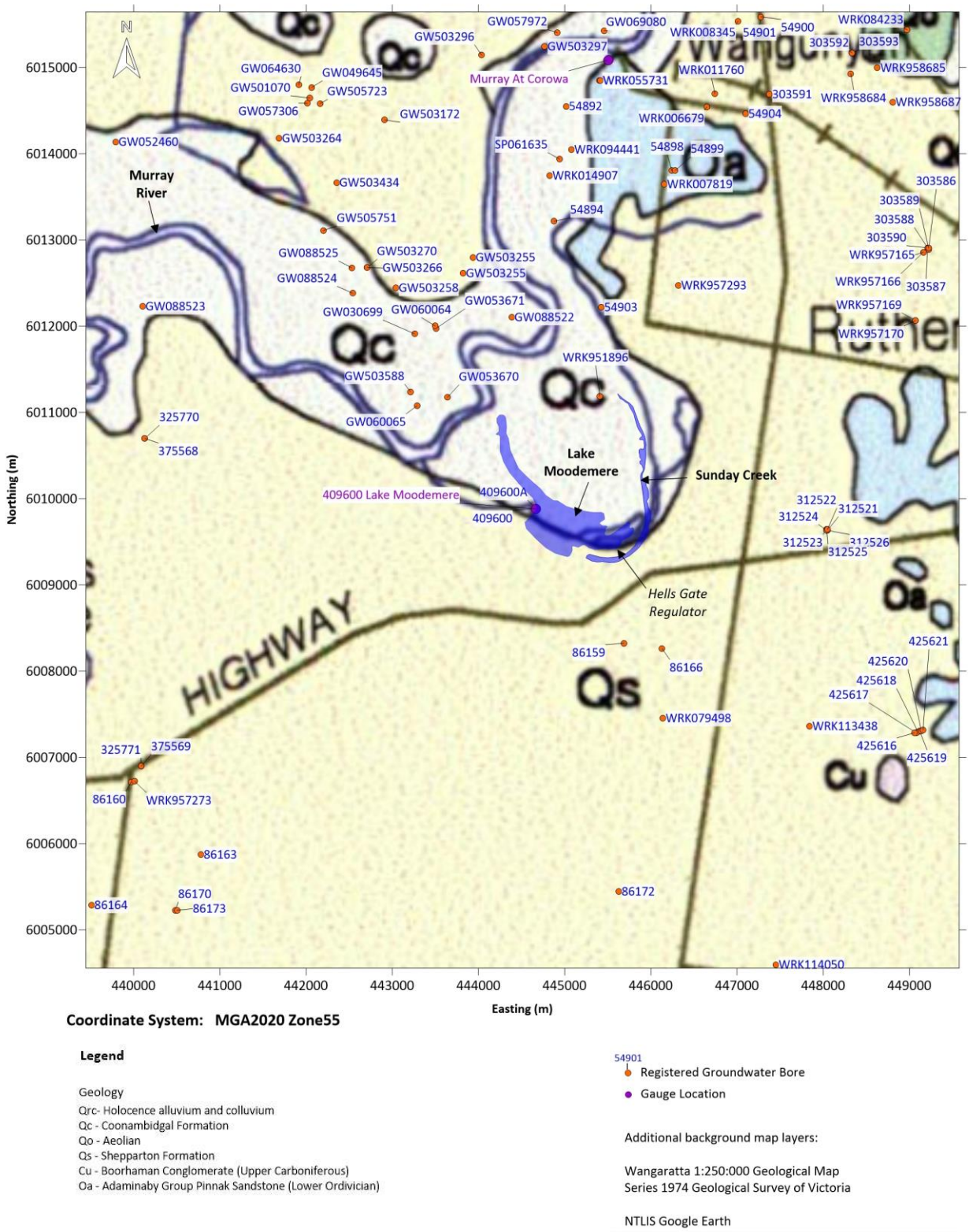


*Figure 7:* ***Site location with registered groundwater bores, gauge locations and surface geology after Vandenberg (1997)***

## 3.3 Water Levels

### 3.3.1 Lake and River Levels

Figure 7 presents a time series summary of the mean water level in the Murray River, the water level in Lake Moodemere and available daily rainfall data. Data for the Murray River is available from WaterNSW gauge data at Corowa (ID409002). The water level in Lake Moodemere between April 1956 and May 2006, generally as monthly levels, has been compiled by GHD (2010) and combined with the real time data that is available from Water Measurement Information System VIC (ID409600) from July 2010. The monthly cumulative rainfall departure is also shown on Figure 7 along with Lake Moodemere's dry level.

The data shows an apparent connection between flow in the Murray River and changes in Lake Moodemere water levels. GHD (2010) reports that the Lake fills by gravity when flow in the Murray reached a certain volume and that pumping from the Murray River to Lake Moodemere occurred when the water level in the lake dropped below 128.6 mAHD. It is understood that pumping generally occurs during summer, with some pumping in spring and autumn.

GHD (2010) report that Lake Moodemere flows into Sunday Creek when the lake level exceeds 128.6 mAHD, overcoming the height of the barrier at the Hells Gate Regulator. The operating range for the water level in Sunday Creek, for the proposed works is 128.7 to 128.9 mAHD, similar to the average water level current in Lake Moodemere.

The transfer of water from the river to lake Moodemere has been occurring for several decades and there are no available records of water levels prior to the start of the scheme. Water is extracted by irrigators from Sunday Creek. Lake Moodemere has been used as an off-river storage for water for irrigation. The storage volume of the lake is assumed by GHD (2010) to be around 14,000,000 $m^3$ compared to the storage volume of Sunday Creek at around 700,000 $m^3$. The level of hydraulic connectivity between the river, lake and the creek has not been directly assessed but it is assumed there is a connection.

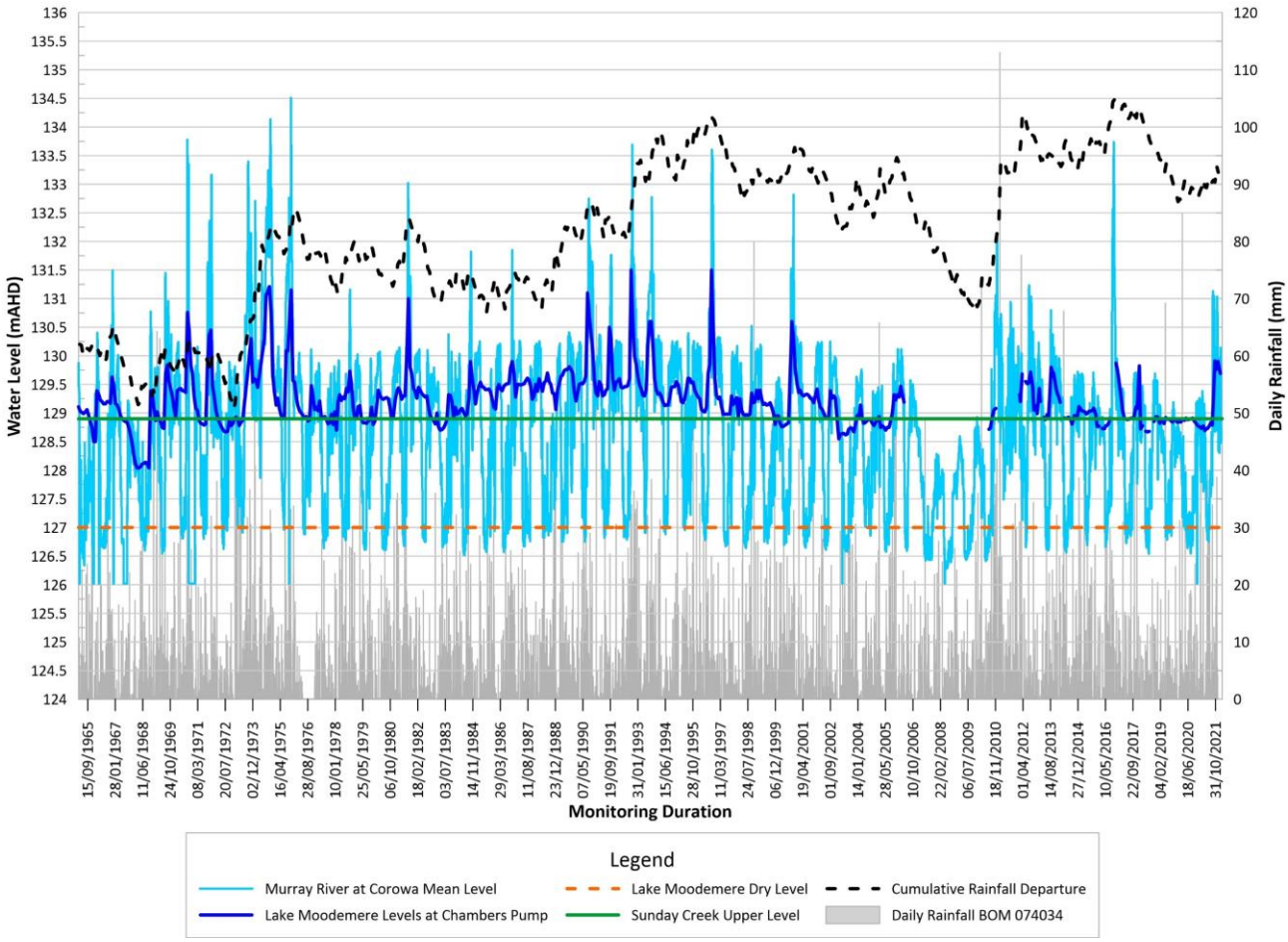


*Figure 8:* ***Water levels in Lake Moodemere with daily rainfall and the mean water level in the Murray River***

### 3.3.2 Groundwater Levels and Quality

Figure 9 presents the groundwater levels, in mAHD, from the available registered bore information along with the recorded total depth in metres below ground surface. There is limited groundwater level information and for some of the groundwater levels there is no recorded lithology or screened interval, as shown in Table 1. Registered bores GW503266 and GW503270, near the Murray River, are screened at different depths within alluvial sediments and show the groundwater level in the deeper sand layer (of GW503266) is higher than the shallower screened bore (GW503270), suggesting the clay layers within the Shepparton Formation may produce semi confined conditions.

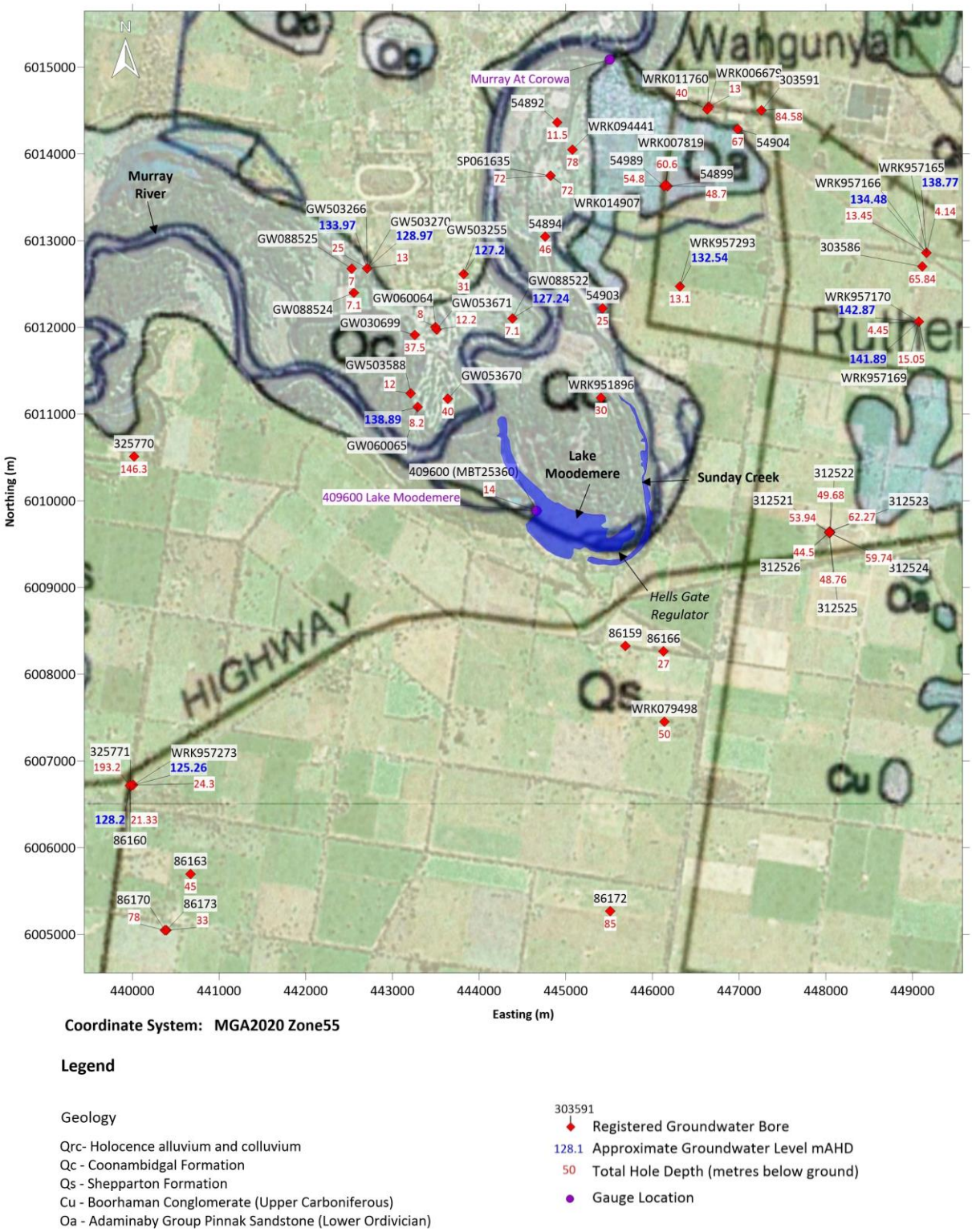


*Figure 9:* ***Registered groundwater bores with groundwater level in mAHD and total depth in metres below ground level***

*Table 2: Registered groundwater bore details summary*

| Bore ID | Total Depth | Screen Interval | Lithology | Groundwater Level | Quality |
|---|---|---|---|---|---|
| WRK957166 | 4.14 | Not Recorded | Not Recorded | 138.77 | Not Recorded |
| WRK957170 | 4.45 | Not Recorded | Not Recorded | 142.87 | Not Recorded |
| GW088525 | 7 | 4.3 to 5.3 | Sand with clay | Not Recorded | Not Recorded |
| GW088522 | 7.1 | 6.1 to 7.1 | Fine sand | 127.24 | Not Recorded |
| GW088524 | 7.1 | 6.1 to 7.1 | Coarse sand | Not Recorded | Not Recorded |
| GW060065 | 8.2 | 6.22 to 8.2 | Clay grey | 138.89 | Not Recorded |
| GW503588 | 12 | 8 to 12 | Sand gravel | Not Recorded | Not Recorded |
| GW053671 | 12.2 | 10.1 to 11.9 | Sandy clay | Not Recorded | Not Recorded |
| GW503270 | 13 | 0 to 13 | Clay and sand | 128.97 | Not Recorded |
| WRK006679 | 13 | 10 to 13 | Sand | Not Recorded | Not Recorded |
| WRK957293 | 13.1 | Not Recorded | Not Recorded | 132.54 | Not Recorded |
| WRK957165 | 13.45 | Not Recorded | Not Recorded | 134.48 | Not Recorded |
| WRK957169 | 15.05 | Not Recorded | Not Recorded | 141.98 | Not Recorded |
| 86160 | 21.33 | Not Recorded | Shepparton | Not Recorded | Not Recorded |
| WRK957273 | 24.3 | 18.28 to 21.33 | Not Recorded | 125.26 | Not Recorded |
| GW503266 | 25 | 21 to 23 | Sand | 133.97 | Not Recorded |
| 54903 | 25 | 22 to 24 | Shepparton | Not Recorded | Not Recorded |
| 86166 | 27 | 25 to 29 | Not Recorded | Not Recorded | Sodium 1300 mg/L, Chloride 2500 mg/L |
| WRK951896 | 30 | 15 to 30 | Sand | Not Recorded | Not Recorded |
| GW503255 | 31 | 6 to 7.3 | Grey brown clay | 127.2 | Good |
| 86163 | 45 | 24.38 to 28.95 | Not Recorded | Not Recorded | Chloride is 2810 mg/L |
| WRK079498 | 50 | 27 to 29 | Sandy with some clay | Not Recorded | Not Recorded |
| WRK007819 | 60.6 | 30 to 60.6 | Mudstone | Not Recorded | Not Recorded |
| SP061635 / WRK014907 | 72 | 30 to 48 | Shale | Not Recorded | Not Recorded |
| 86170 | 78 | 75-78 | Shepparton | Not Recorded | Chloride 1300 mg/L |
| WRK094441 | 78 | 54 to 78 | Mudstone | Not Recorded | Not Recorded |
| 325771 | 193.2 | Not Recorded | Not Recorded | Not Recorded | 1300 µS/cm |

Figure 10 shows the available groundwater level data with the recorded water levels in Lake Moodemere, the mean water level in the Murray River and key levels of the proposed works. Shallow groundwater bores close to the river show a groundwater level that reflects a direct hydraulic connection with the river. The groundwater levels at GW088522, which is close to the Murray River, follows a similar trend of increases as observed in the Murray River and Lake Moodemere levels. Groundwater levels that are above the river level likely represent deeper, semi confined, aquifers of the Shepparton or Calivil Formation. Groundwater levels in the bedrock aquifers may also be elevated above the river level.

At bore 86160, which is around 5.4 km south-west of Lake Moodemere towards Norong the groundwater level is similar to the level of the Lake and Murray River at around 128 mAHD. WRK957273, which is nearby 86160, and is presumed to be screened at a slightly deeper interval than 85160, shows a groundwater level around 125 mAHD, suggesting a downward gradient, however groundwater levels may also be influenced by localised extraction for irrigation.

The monitored data shows increases and decreases in level that appear to correlate to change in the level of river and lake and or long term weather trends. The mean water level in the Murray River regularly falls below Lake Moodemere's dry level.

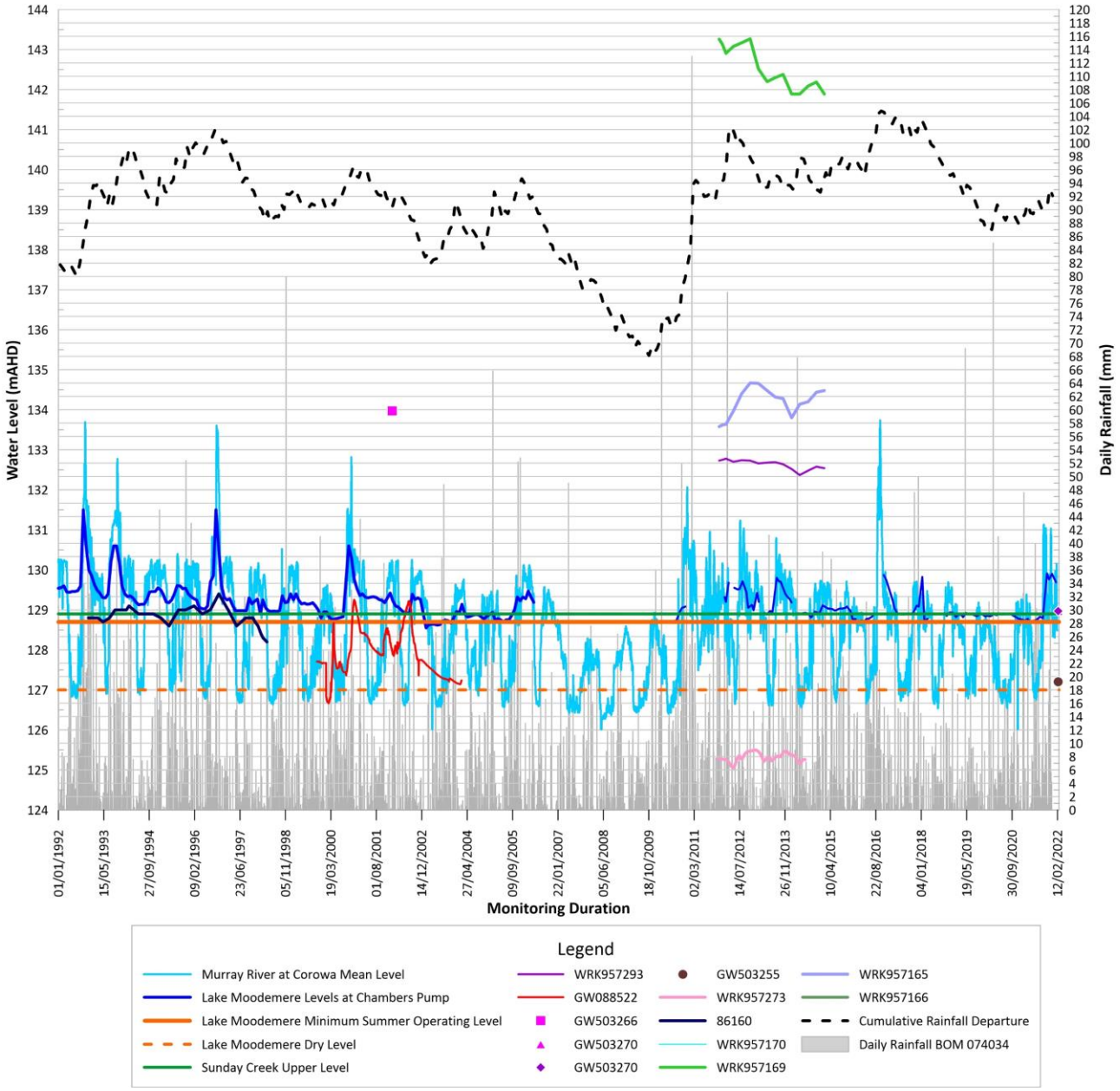


*Figure 10:* ***Time series plot of groundwater levels, Lake Moodemere level and the mean water level in the Murray River***

The available groundwater quality and yield information is shown on Figure 11, with the regional water table salinity map from Geoscience Australia. It appears that three bores may be responsible for the interpolated saline area and that the true extent of the saline area and or its interconnection is unknown. Based on the approximate level of 86166 the top of the screen interval would be around 125.1 mAHD for the available water quality result which shows the high chloride level. Localised irrigation return may also contribute to water table salinity impacts due to high connectivity between surface and groundwater.

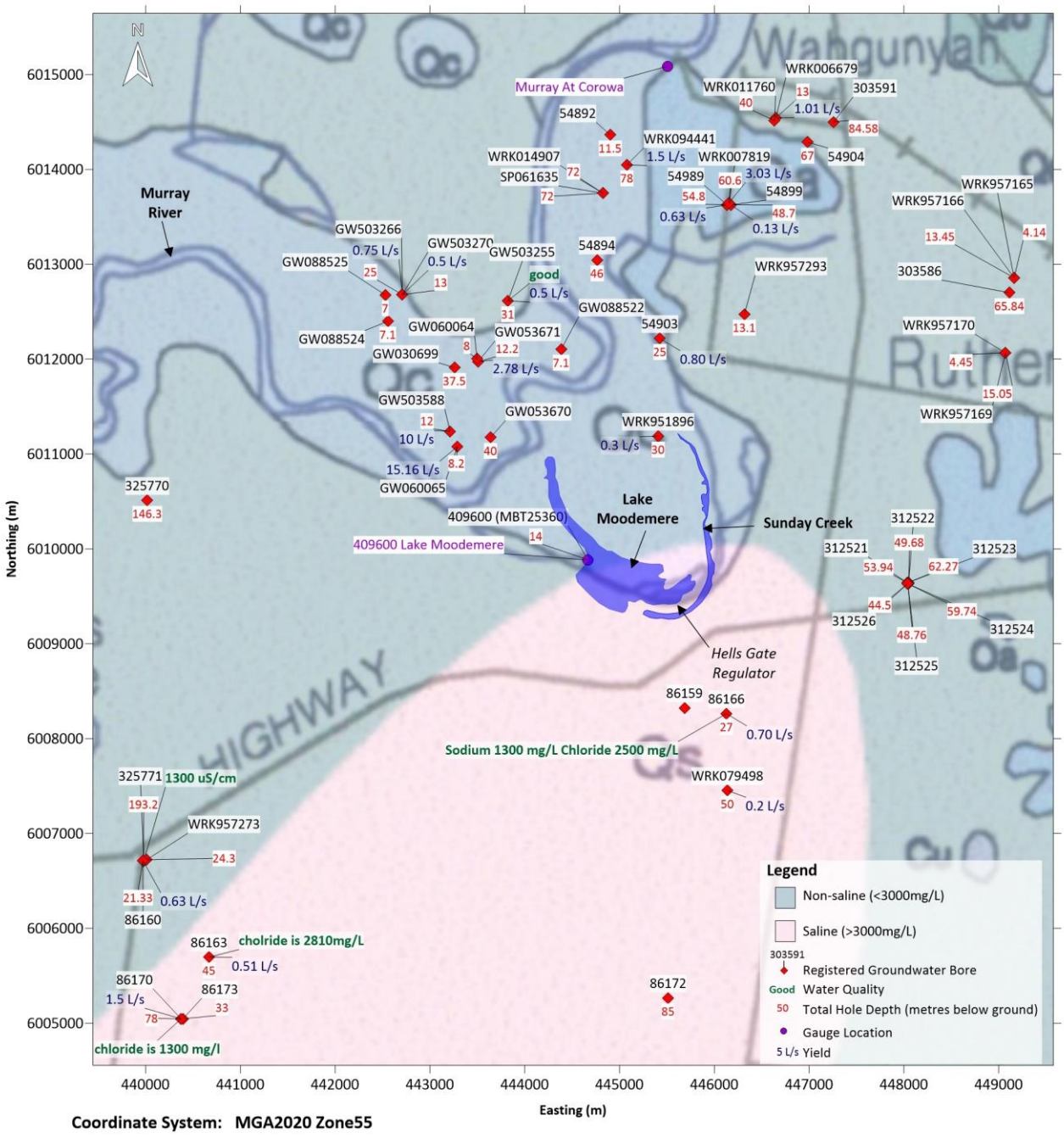


*Figure 11:* ***Available groundwater quality data***

## 3.4 Survey

A 1 m resolution digital elevation model dataset (collected in November 2020) is available from elevation.fsdf.org.au and a shaded relief colour map that is derived from this dataset is shown on Figure 12. At the site the ground surface elevation ranges from 125 to 130 mAHD. At the southern part of the site the elevation increases rapidly on the banks of the lake to around 145 mAHD. The lidar data collected shows the surface of the lake in November 2020 was around 128.8 mAHD, with the Murray River around 128.3 mAHD and Sunday Creek around 128.6 mAHD. As lidar doesn't penetrate the water surface, the bathymetry survey, which was conducted, by Water Technology in August 2011 across 17 transects, was used to assess the approximate base elevation of Lake Moodemere and Sunday Creek.

The basal level of the lake varies from 128.5 mAHD to 127 mAHD with a more incised channel towards the southern side (Figure 13). Sunday Creek is a narrow-incised channel and varies in its basal depth from 128.5 mADH to 127.4 mAHD. The narrow land bridge between Lake Moodemere and Sunday Creek, where the Hells Gate Regulator is located, ranges in height from around 128.8 mAHD to 130 mAHD.

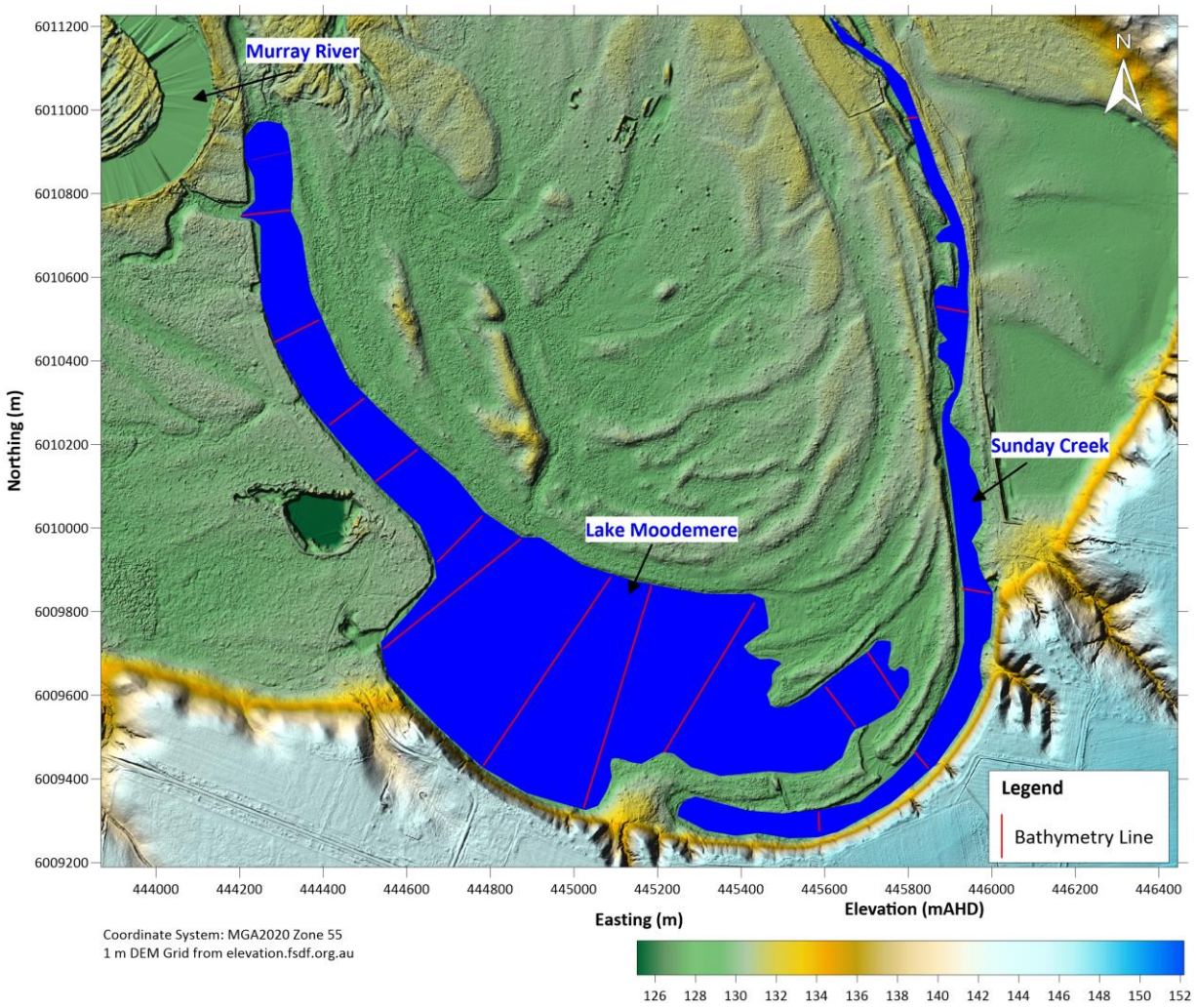


*Figure 12:* ***1m Digital elevation grid of the site showing bathymetry survey lines (red)***

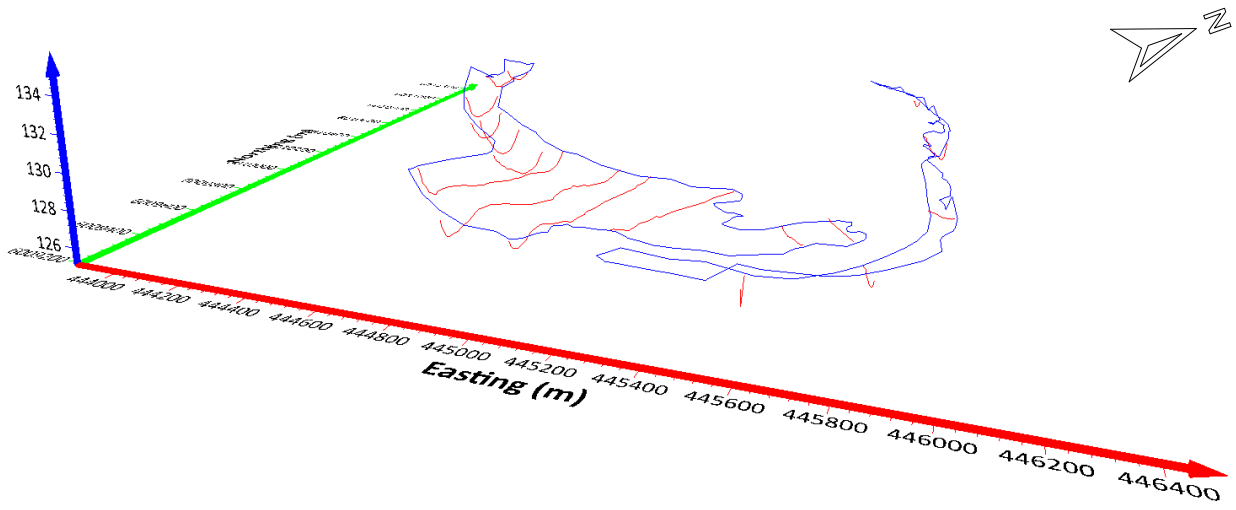


*Figure 13:* ***3D view of bathometry transects results at 1:50 Vertical exaggeration at Lake Moodemere and Sunday Creek***

# 4. Assessment

## 4.1 Data Gaps

The available dataset is limited in that there are no hydraulic permeability results for groundwater bores around the Site and the groundwater level data is sporadic. Within Moodemere nature conservation reserve there is limited understanding of the depth to groundwater, water quality and the water table response to river stage height, lake levels and rainfall. There is one registered bore in the nature reserve area, and it does not have a recorded water level. Groundwater quality results are limited and there is no available water quality data for Lake Moodemere however the water quality of the Murray River is a suitable proxy.

There is sufficient available information to complete a preliminary assessment of surface water – groundwater interaction for salinity risk to support the EE Act referral.

## 4.2 Proposed changes

It is proposed that the water levels in Lake Moodemere will be maintained at a minimum level of 128.7 mAHD between the start of September to the end of January each year through pumping transfer from the Murray River. This is understood to primarily be to support the lake's recreational activities. Outside of this time the water level in the lake will be allowed to fluctuate naturally.

The land bridge where the Hells Gate Regulator is shall be raised to disconnect Sunday Creek from being filled by Lake Moodemere. Sunday Creek is proposed to be the off-river storage and transfer area for the local irrigators. Water will be pumped from the Murray River directly to Sunday Creek which shall be kept at an operating range of 128.7 to 128.9 mAHD.

## 4.3 Summary of Findings

From the desktop review of existing information, it appears that Lake Moodemere, Sunday Creek and the Murray River are hydraulically connected to some level. The degree of connection is not well understood. There may be strong connections where sands and gravels are more dominant and poorer where clays lenses occur. It is unlikely that the lake and the vegetated area of the nature reserve is hydraulically disconnected from the shallow groundwater table. The Murray River is the main source of recharge to the shallow aquifer and as its level fluctuates, variation in the groundwater table would be expected. Direct rainfall and surface water run-off into the catchment also recharge the shallow water table.

The mean water level of the Murray River shows cycles of decline which are below 127 mAHD dry level. The lake shows periods of dry or lower levels during winter months. When the water level in the Murray River reaches 130 mAHD flow occurs into Lake Moodemere. The proposed changes will return some of the natural variation to the area that would have been present prior to the irrigation scheme. The lake will still be topped up for several months of the year and Sunday Creek will be continuously topped up. Sunday Creek will form a hydraulic barrier and there is likely be some leakage back to the lake and to the Murray River. With the lake being topped up during the summer months there is unlikely to be much in the way of a significant change to the hydrogeological regime of the area.

Within the Shepparton Formation aquifer there are more saline layers. The lake acts as a freshwater lens over these layers. During the period where the Lake is filled the lens is replenished and the constant filling of Sunday Creek will also provide replenishment such that it is considered unlikely that the potentially higher salinity groundwater from deeper depths would reach the surface. Water quality in the Murray River, at the Corowa gauge, is available from Water NSW and shows an average electrical conductivity of 54 µS/cm with a range of 20 µS/cm to 145 µS/cm for the data available between March 2002 and March 2022. This is considered to be of low salinity, with the equivalent of around 0.032 grams of salt per litre.

Low water levels in the Lake Moodemere may in shallower parts of the lake result in the salt concentrations increasing from the evaporation of the lake water during the winter months. However, evaporation rates during winter are generally lower than the summer months. Each time the water level in the lake returns there is flushing and recharge with fresh water. The salt load of the volume of water held in storage when Lake Moodemere at 128.7 mAHD is considerable low, given the low salinity of the Murray River water that is transferred.

The reconfiguration project will annually top up Lake Moodemere for four months each year and this will result in more regular cycles of water level change. This is not likely to result in increased salinity in Lake Moodemere or Sunday Creek or result in significant changes in regional groundwater levels in the shallow aquifer. The main benefit of

this project is the water saving, as less water extraction from the Murray River leads to less losses to evaporation. This will provide more water recharge to the shallow groundwater table aquifer and have downstream benefits, including improving downstream salinity. The proposed changes to the water regime will provide 'flushes' of fresh water to Lake Moodemere and the concentration of salts in the lake will be similar to what is present in the Murray River. When the lake draws down, during the autumn and winter months, salt concentrations in the remaining water will increase due to evaporation but are not anticipated to reach levels that would affect vegetation and would be moderated naturally by rainfall and runoff events.

SMEC's ecological assessment finds their may be vegetation changes in the nature reserve, and there is the potential for threatened fauna species to be present for which targeted surveys to assess species utilisation of and presence within the impacted areas is recommended. Further work to hydrogeologically model the area for surface - groundwater interactions may be required to understand the potential impacts of the reconfiguration to these species, should they be identified.

## 4.4 Recommendations

The following recommendations are made for consideration:

- Establish water level gauging points along Sunday Creek; and
- Undertake hydrogeological modelling contingent to the collection of additional groundwater level and gauge monitoring results.

## 4.5 References


- Brodie, R.S., Kilgour, B., Jacobson, G., Lau, J.E. (1998): Hydrogeology Map of Australia (Jacobson G. and Lau J.E. Hydrogeology Map). dataset. http://pid.geoscience.gov.au/dataset/ga/32368
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- Murray-Darling Basin Authority (2020). Groundwater report cards: For sustainable diversion limit resources units under the Murray-Darling Basin Plan. MDBA publication no: 41/20
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