Glenkara Estate *In Situ* Desalination Trial, Joel South: Progress Report 1, October 2008.

Joel South site:
At the Joel South site, there are two semi-confined quartz gravel aquifers between 19 and 26m bgl, and 29 and 32m bgl, separated by a thin (2-3m thick) clay layer. The upper aquifer is semi-confined beneath clays with sand and gravel lenses. These Tertiary and Quaternary age deposits form part of the Deep Leads aquifer system in the region. The borehole in which the ISD test was carried out was drilled in early August 2008, using rotary mud drilling. This was constructed with 300mm diameter casing and screen to ~26m bgl to provide groundwater feed to the unit. A length of 175mm diameter casing was fitted below this, and this was attached to a 2.5m long 125mm (5") steel screen within the lower aquifer unit. The upper 300mm screen formed a groundwater feed zone for the RO process within the upper aquifer, and the lower 125mm screen allowed concentrates (residual fluids after RO treatment) to return to the lower aquifer (Figure 1).

Hydrogeology

Landsborough-Navarre area lies within the Midlands area, a division of the Western Highlands. The stratigraphy of the region is relatively simple with only a limited number of geological formations occurring.

Lower Palaeozoic rocks make up most of the region and these form the basement rock. These rocks predominantly consist of Cambro-Ordovician shales, siltstone and sandstone, and are extensively folded and faulted and are kilometers in thickness. In places where intrusion by Devonian age granites has occured the sedimentary rocks have been metamorphosed to schist, gneiss, slate and hornfels.

Overlying the basement rocks in places are Tertiary age sediments locally known as Deep Lead deposits. These sediments are river channel deposits, consisting of sand, gravel and clay. They are not laterally continuous across the region but are restricted to channels that were incised into Paleozoic bedock surface (Figure 2).

The main lead systems on average are less than one kilometer in width and up to 60-80m in thickness along their central axis. A Deep Lead in the vicinity of Landsborough (Landsborough/Malakoff Lead) has its upper reaches to the southeast of Landsborough township near Shay's Flat. It runs northwestward through the township almost following the course of Howards Creek. It is postulated to join another small lead running westward from Navarre just north of Tulkara. Macumber (2004) reports that the northwest deep Lead (Shay's Flat -Tulkara) is much deeper and represent the more dominant part of the Wimmera River in the past. A second deep lead runs from Crowlands to Joel South. The recent drill records including from the trial suggest that the trial site is within this palaeochannel (Figure 2).

The Tertiary sediments are overlain by Quaternary age deposits equivalent to the Shepparton Formation found in the Murray Basin to the north of the trial site. These sediments have been deposited under alluvial or lacustrine conditions and are dominantly clay, silt and minor sand. The thickness of quaternary deposits can range from 0 -20m (SKM 2004). These deposits form a confining layer for the Tertiary asand/gravel Deep Lead aquifer.

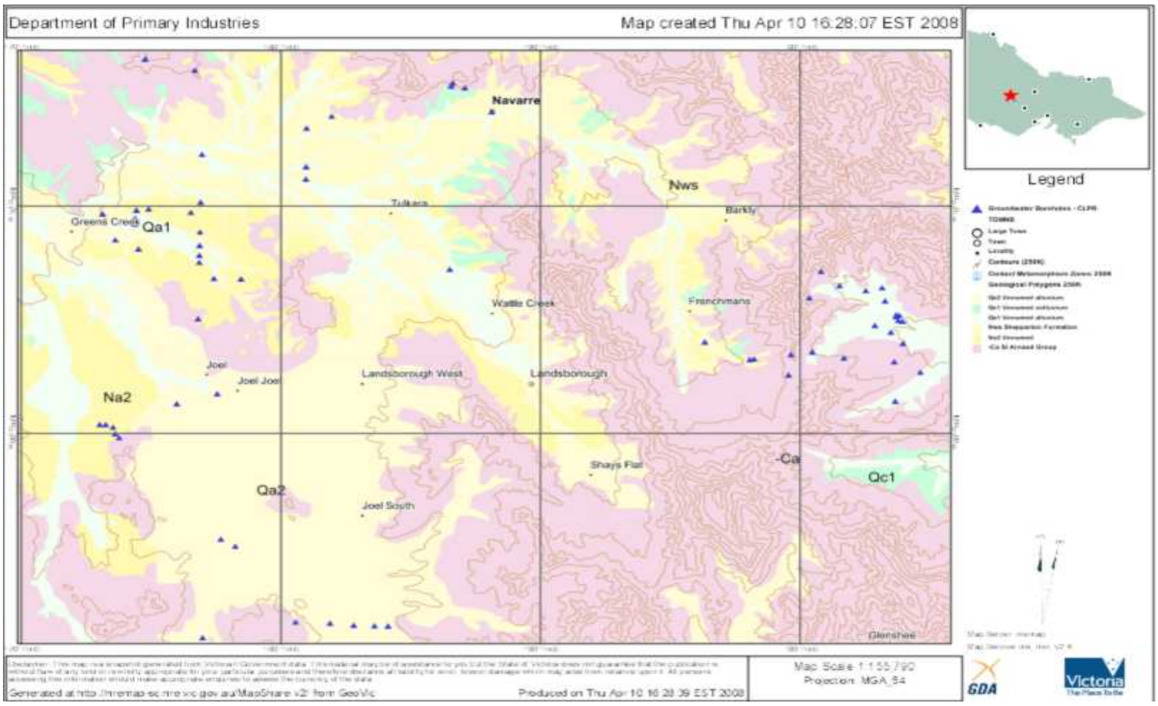

Figure 2: Geology Map of the trial site (Source: Department of Primary Industries Victoria)

ISD System:

The configuration of the ISD borehole and system is shown in Figure 1. A Grundfos SP8A-37 submersible pump was emplaced between 17-20m below surface above the RO pressure vessel which contained four DOW Filmtec XLE440 (8”) RO elements. The pressure vessel was at a level between 20-25m below surface within the 300mm diameter casing and upper screen (Figure 1 and Photos 1-). A 1” steel rod for carrying permeate to the surface extended from the pressure vessel to the slip plate at the surface, suspending the whole system from the top of the casing. A 1” steel rod (concentrate return line) extended from the base of the pressure vessel, passing through a solid state steel-backed rubber k-packer within the 175mm casing between 27 and 28m bgl, the rod extending to a depth of just over 31m bgl within the lower screened section of the bore (Figure 1). The packer sealed the casing between the upper feed screen and the lower screen which delivered concentrates to the lower aquifer. Maric flow control valves were placed immediately above the pressure vessel (feed line) and immediately below the pressure vessel (concentrate line), to provide sufficient flowrate and pressure to drive the RO process and lift permeate to the surface, and deliver concentrates at a specific flowrate to the lower aquifer. The ISD system was designed for a feed flow of 10KL/h, giving approximately 4KL/h of high quality permeate.

ISD Trial:

An automatic monitoring and control (AMC) system was used at the surface to control the whole downhole process. A programmable logic controller (PLC) recorded permeate flowrate, Electrical Conductivity (EC) and system pressures, and this data was accessed via a data modem. The PLC controlled the ISD system, and also controlled an in situ membrane washing system scheduled to be carried out each day for ~ 40 minutes. The latter system was set up to backwash the pressure vessel with 500ppm sodium metabisulphite solution (steriliser or biostat) to minimise biofouling, and to attempt to remove any aquifer solids (eg clays) which had accumulated on the top of the upper RO element. The biostat solution was recycled through a 10µ filter.

The ISD system initially produced around 5KL/h of permeate at system pressures somewhat lower than those expected from RO simulations using Filmtec ROSA 6.1 model software. Advice from DOW representatives indicated that new membranes often showed this behaviour, showing fouling factors of 1, or even 1.5 in extreme cases, although membranes settled back into normal operating conditions within a few weeks. This indeed did occur in early September 2008. The actual and modelled RO conditions shown at the end of September 2008 when conditions had stabilised are shown in Table 1.

	Measured behaviour in. Late Sept 08	Expected (modelled) system behaviour
Feed TDS	3200mg/L	3208mg/L
Feed flow	10 KL/h	10KL/h
Feed pressure	1100KPa	1100KPa
Concentrate TDS	5100mg/L	5449mg/L
Concentrate flow	5.9 KL/h	5.82KL/h
Concentrate pressure	970KPa	970KPa
Permeate TDS	100mg/L	89mg/L
Permeate flow	4.1KL/h	4.18KL/h
Permeate backpressure	100KPa	100KPa
Recovery	41%	42%
Average flux		26 lmh

Table 1. Actual and predicted performance of ISD during the Joel South trial.

The ISD system has been runnning continuously (except for periods when the backwash was being carried out) for all of September and to early November 2008. Permeate flowrates have consistently been just over 4KL/h over most of this period and the pressure difference between feed and concentrate lines has remained stable. Nearly 6ML of permeate have been produced over the trial period. Permeate TDS is slightly higher than expected, and concentrate TDS somewhat lower than anticipated from the model (Table 1). The consistent permeate flows and pressure difference within the vessel suggest that the backwash system is minimising biofouling, although these are being monitored carefully. The consistent clarity of backwash fluids returning to the surface suggests minimal amounts of solids are accumulating within the upper RO element. Mineral scaling (precipitation of mineral solids as the salinity of the residual fluids increases during the RO process) is not anticipated under the conditions at Joel South, and no antiscalent is used in the process.

The groundwater feed TDS has remained consistently at 3200mg/L ±100mg/L, and the concentrate TDS at ~5000mg/L over the trial. This indicates that the groundwater feed and concentrate fluids remain separate in the two aquifers. The TDS in the monitoring bore screened in the lower aquifer remained steady at 3500mg/L, indicating no impact of 9 weeks operation of ISD at this location 50m from the ISD bore. Impacts are anticipated to occur over the next month. Approximately 9ML of concentrates have been delivered to the lower aquifer over the trial so far (to 14 October). Prediction of the long term impacts of concentrate returns to the lower aquifer using a numerical groundwater model for continuous ISD operation over 10 years shows that the main part of the returned concentrates forms a stable "bubble" of residual fluids extending only 50m from the ISD borehole, and a dispersed front extends from this to a distance of only 250m in the general direction of groundwater flow. These impacts are very low, considering that the highest salinity within the bubble is only ~1.5 times the background groundwater salinity.

Storage and delivery of permeate:

Storage of permeate at Joel South has been difficult, because flows are too low for the nearby pumping station to deliver the water via a pipeline some 13km to the Glenkara vineyard. To avoid the high expense of constructing a surface water storage, a process known as Aquifer Storage and Recovery (ASR) is being used, which injects permeate under gravity into the Glenkara production bore 1 adjacent to the pumping station and Wimmera River, for later recovery from the gravel aquifer via production borehole 1 using a high-rate pump. Approximately 6ML of permeate have been delivered to production bore 1 to early November 2008. A part of this was recovered from borehole

1 from where it was pumped through the pipeline to the winery over a 2 hour period on 15 October 2008. The salinity of this recovered water was 100mg/L as TDS, the same as that of the permeate, over the entire 2 hour period as expected. Approximately 20% blending of permeate with groundwater was expected to occur, which increases the pH of fluids to 6.2, and TDS to just below 600mg/L. The sodium adsorption ratio (SAR) of the blended water is ~4, indicating low sodium hazard to soils at Glenkara. Some lime addition (15mg/L as $Ca(OH)_2$ is anticipated to raise the pH to an optimum 7.5.

ISD System Expansion:

Given the successful testing of the ISD system at Joel South, a larger ISD application has been designed using six ISD boreholes and a smaller number of ASR bores, at the request of the Glenkara vineyard management. Based on the performance of the preliminary trial, giving a design flow rate of 25ML/unit/annum, compared with the current production of over 30ML/unit/annum. Blending of the produced water (TDS ~100mg/L) with 20% groundwater from Glenkara production borehole 1, would allow an increase in the volume of water for use in irrigation of the vineyard, at appropriate conditions specified for SAR and pH by soils and irrigation specialists.

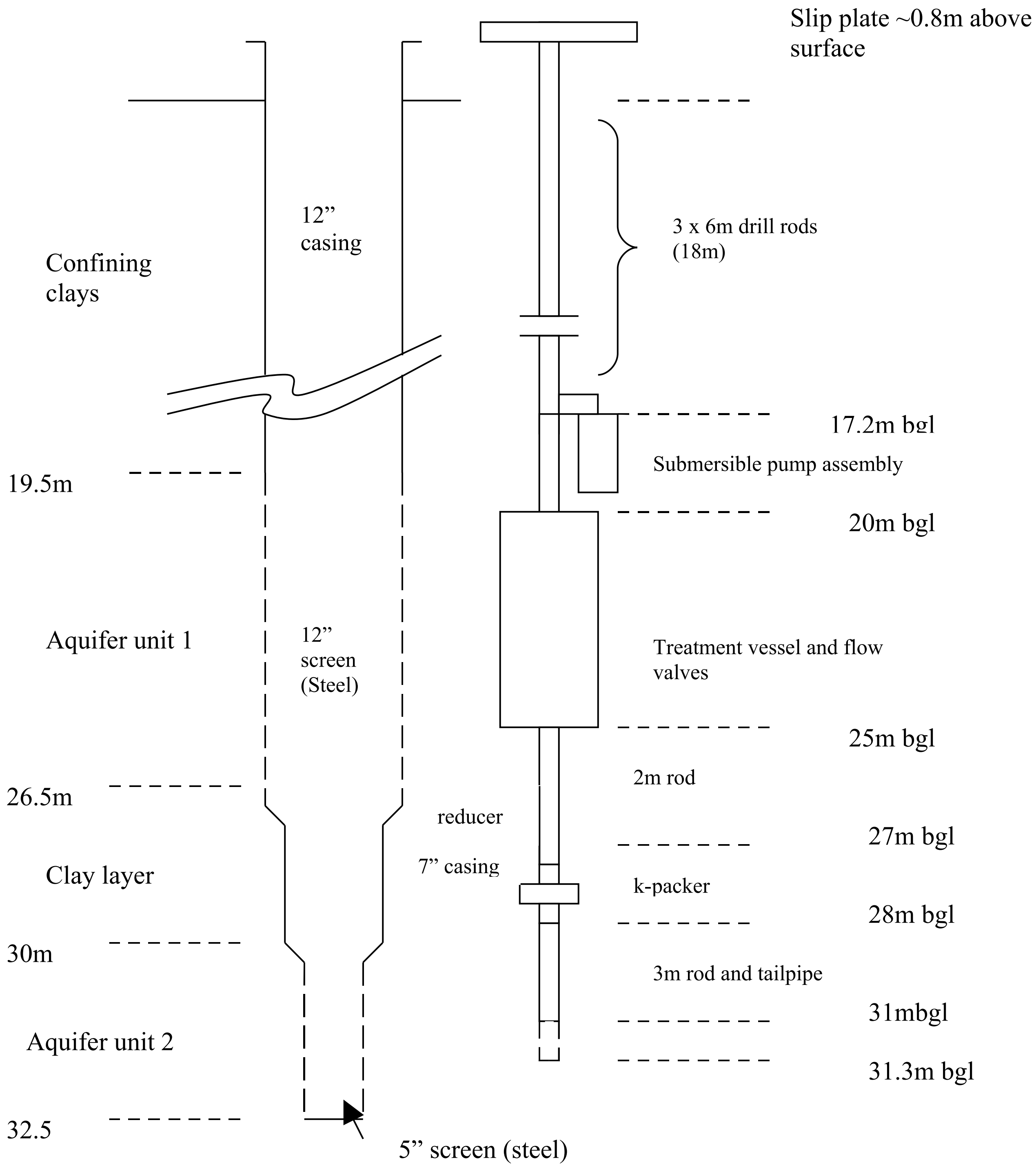

Figure 1. Configuration of ISD bore and downhole ISD system.

Photo 1: Crated ISD system (main treatment vessel, pump, steel rods and spare RO membrane element delivered to the Joel South site.