A Review of the Leigh Creek Energy ISG Pre-Commercial Demonstration Facility

Part 2: Comments on Groundwater and Soil Vapour Monitoring Plan, Revision 2.02, 14th August 2018

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Summary

The monitoring network that has been installed for the ISG Pre-Commercial Demonstration at Leigh Creek is fit for the purpose for detecting the migration of chemicals of potential concern from the underground gasification cavity into surrounding strata and groundwater. The design of the monitoring network is consistent with world's best practice. Its coverage is comprehensive, including all identified geo-hydrological units at the site including units remote from the gasification that are unlikely to be affected. The location of monitoring sites will give early warning of any migration events and allow for effective remediation. The network takes account of the very low permeability of all strata near the gasification site with appropriate sampling procedures. Regulators and the public can have confidence that any excursions of COPC will be reported via the monitoring network.

Revision 2.02 of the Leigh Creek Energy Groundwater and Soil Vapour Monitoring Plan for the In-situ Gasification Pre-Commercial Demonstration has included newly acquired information which improves baseline information on water quality and groundwater pressure and adequately characterises the geohydrological units at the site. Groundwater quality monitoring targets have been confirmed and include the Quaternary Telford Gravels, and three horizons within the Main Series of the Leigh Creek Coal Measures, one at around 80-100m depth and two below 400m depth, above, in and below the Main Series coal seam.

Groundwater quality in the Telford Gravels and in the Main Series below 400m at the Pre-Commercial Demonstration site has been shown to be consistent with the water quality baseline established from year long monitoring at a location 600m away. Only 3-4 months of water quality data is available for the distinctive geohydrological unit at 80m depth in the Main Series overburden, and COPC are naturally present. As not enough data is available to confirm a baseline for these COPC, trend analysis will be used during monitoring of the gasification demonstration period. If an increase in COPC levels occurs in this period, the source of this increase will need to be identified through appropriate investigations.

A separate groundwater pressure monitoring network has been established around the proposed gasification chamber. Pressure gradients in the higher groundwater units show the groundwater flow is into the open pits to the north as anticipated. At deeper levels in the Main Series strata the network is responding to pressure changes being induced by drilling activity suggesting it will be effective in monitoring any changes associated with the gasification demonstration.

There is, quite rightly, a strong emphasis on preventing COPC escaping from the gasification chamber by maintaining a pressure differential between gasifier pressure and surrounding groundwater which lets groundwater flow continuously into the gasifier. It is likely that transient and unavoidable high gasifier pressure events will sometimes occur, and the corrective response of reducing gas pressure to reverse fluid flow back to the gasifier cavity which returns any dispersed COPC has been incorporated in standard operating procedures.

Groundwater sampling wells in very low permeability strata do not behave as they do in aquifers. Groundwater will not form a standing water level in the wells consistent with groundwater pressure. The monitoring wells will largely contain gas. If gases from the gasification chamber are diffusing through groundwater and reach monitoring wells, they will desorb into the gas volume above the water to equilibrate pressure/concentration. Although COPC migration is not associated with this process because of lower concentrations and diffusion rates, detection of syngas components will provide a guide to fluid movements within strata, and sampling of these gases has now been incorporated in the Water Sampling SOP document.

Introduction

Leigh Creek Energy (LCK) propose to demonstrate In Situ Gasification of coal (ISG) within PEL 650. Over the last three years Leigh Creek Energy have prepared and submitted documents to the South Australian government in support of this proposal which have been subjected to internal government departments' reviews and independent expert review. Following comments from government departments (DEM-ERD, DEW, EPA) on the Groundwater and Soil Vapour Monitoring Plan, Leigh Creek Energy have submitted a Revision 2.02 of the Plan.

Questions and comments from departments were addressed in Revision 2.02 of the plan and most of the suggestions have been incorporated in the revised Plan.

The revision includes the results of site work carried out since Revision 1 of the plan was submitted.

Groundwater monitoring

Leigh Creek Energy has chosen four geohydrological units to monitor water quality in. These are:

1. Telford Gravels – a surficial Quaternary deposit

And three units within the Leigh Creek Coal Measures

2. Main Series Overburden around 80m below ground level
3. Main Series Overburden at greater than 400m depth
4. Main Series coal seam and the underlying strata

The geohydrological model of the Leigh Creek Mine site identifies four water bearing units. The first is the surficial Quaternary gravels associated with the pre-mining surface drainage, and the second is sediments in the Upper Series, the third is a thick impervious sequence of the main and lower series rocks, and the fourth is the basement rocks underlying the coal measures. The Upper series sediments are not present at the PCD site, and basement is well below the level being gasified so these units are not relevant to any water monitoring activity. At the PCD site only the geohydrological units of the Quaternary gravels and the Main Series rocks are available.

The Telford Gravels are an identifiable hydrological unit targeted with monitoring wells to detect COPC originating from the gasification chamber. The purpose of monitoring is to identify any migration of COPC. Because the surficial deposits are isolated from the gasification chamber by hundreds of metres of impervious strata, monitoring is checking for localised bypass migration pathways such as permeable faults or boreholes that would allow COPC movement through 500m of impervious strata, and would then be distributed through the permeable gravels.

The Main Series rocks and coal seams all have extremely low permeability, and do not contain groundwater in quantities that support typical groundwater monitoring methods. Groundwater inflow to monitoring wells will not be sufficient to establish a standing water level in wells which matches the groundwater pressure, which could result in the creation of fluid (and COPC) flow pathways not naturally present. Natural rock mass permeability is so low it is unlikely that fluids could migrate through strata to monitoring points established within the coal seam, below or above it. Fluid (and COPC) movements are most likely through local discontinuities such as faults or fracture zones if present, and not in relation to the vicinity of the gasification chamber and monitoring points. Despite these difficulties, monitoring wells in the coal seam and in the overburden at greater depth than 400m are the best way of identifying if COPC transport is occurring.

The reason for the monitoring wells being located in the Main Series overburden around 80m below ground level is not obvious. The groundwater quality obtained from these levels

differs from other parts of the Main Series in having higher Total Dissolved Solids and lower COPC and probably represents an independent geohydrological unit isolated from groundwater 400m lower in the sequence. Different water quality found at 80m versus that at 400+m suggests that there is very little linkage between the two horizons. Migration of COPC from the gasifier would be restricted to localised bypass pathways, but the low permeability of the rock mass means that any migrating COPC would not be detected unless the monitoring well actually intersected one of these localised pathways. It appears highly unlikely that this series of monitoring wells would detect any COPC migration that was not obvious in other places, and even if COPC migration did occur, the monitoring wells would be unlikely to intersect it.

Baseline groundwater quality

Groundwater quality has been monitored for around a year in local wells in the Telford Gravels. The Main Series also has a year's monitoring of groundwater quality at one location for the coal seam overburden at greater than 400m depth, and within the Main Series coal seam and underlying strata. This sampling was located around 600m from the Pre-Commercial Demonstration site and provides a good basis for baseline groundwater quality values for these three geohydrological units.

Sampling has been possible since April 2018 at the Pre-Commercial Demonstration site with construction of a range of different monitoring wells. This has indicated that groundwater quality in and around the Main Series coal seam and in the Telford Gravels at the Pre-Commercial Demonstration site is consistent with results from the year-long monitoring nearby.

It has been identified that there is significant difference in water quality between the shallow monitoring wells (80m below ground level) in the Main Series overburden, and deeper monitoring wells in the Main Series overburden at 400 plus metres depth. These have been differentiated and have independent networks of monitoring wells. There is only 3-4 months of water quality data in the 80m deep geohydrological unit, which is not enough to confirm baseline conditions. It is proposed to use trend analyses on these wells to identify any impact of the Pre-Commercial Demonstration. If a trend of increase in levels of COPC occurs it can be demonstrated that this is from naturally occurring COPC and not from the gasification chamber, through the nature of COPC species present, and extent of COPC dispersion within the whole monitoring network.

Groundwater pressure

Groundwater pressure is unlikely to be available from the water quality sampling wells in the Main Series strata, as water inflow is too slow to re-establish standing water levels between sampling events. To overcome this, a separate series of wells has been constructed to measure groundwater pressure. These generally have six grouted pressure/temperature sensors located in the Main Series geohydrological units around 100m depth, and below 400m in the Main Series coal seam and immediate overburden.

Monitoring wells in the Telford Gravels and the shallower 80mbgl wells in the Main Series overburden show the expected groundwater pressure gradient directed to open cut pits to the north (Figures 3-6,3-7 of report). The pressure data from monitoring wells at depth, above, within and below the Main Series coal seam have been affected by drilling activities which appears to have created a slightly higher pore pressure region around the proposed gasification chamber site (Figures 4-3,4-4,4-5 of report). Drilling activity has been continuous for some months.

Step changes in pressure recorded by transducers in different wells and depths sometimes coincide suggesting that local drilling is simultaneously affecting pore pressure in a number

of wells. For example, at the beginning of July all the transducers in MW04, MW05, and the coal seam level in MW01 made step changes in pressure. Coal seam level transducers in MW02 and MW04 simultaneously recoded pressure change at the beginning of March. The detection of these changes confirms the pressure monitoring network is responding to local pressure effects and will report any groundwater pressure changes which occur during the Pre-Commercial Demonstration.

SEO Objectives and Assessment

Purpose and objectives (page 41)

The groundwater assessment criteria for the Environmental Objective 2 '*No sustained change to background groundwater quality at the boundary of the gasifier buffer zone'* includes reference in Assessment Criteria to monitoring groundwater to detect changes, and also '*Real time monitoring demonstrates that the gasifier chamber is operated at a pressure below that of the groundwater pressure at all time'*.

If a gasification chamber pressure is kept below that of the surrounding groundwater it should prevent loss of COPC from the chamber to surrounding strata and ensure water quality at the buffer boundary is not changed. However the reverse proposition eg 'If gasifier pressure exceeds that of surrounding groundwater water quality at the boundary of the buffer zone will be changed' cannot be supported. It is not expected that short periods of higher pressure would cause any significant environmental issues. It is not possible to prevent all transient high pressure events, (as pointed out in the footnote on page 41 of the report), but any advection of COPC out of the chamber during higher pressure has been shown to be reversable when gasifier pressure is reduced to increase groundwater inflow to a gasifier

This can be addressed by inclusion in the 'Guide to how Objectives can be achieved' box by including a comment such as

'If transient events of gasifier pressure greater than surrounding groundwater pressure are detected, gasifier pressure will be reduced to increase groundwater inflow to the gasifier and restore groundwater quality in the vicinity of the gasifier'

However, reference is already made to this in section *4.8 Non-compliance* regarding groundwater pressure pages 63,64, and maybe that is enough without making additional changes on page 41.

Groundwater sampling

A Groundwater sampling SOP has been included as Appendix H of the report.

As mentioned above, groundwater monitoring wells in extremely low permeability formations behave differently to those in aquifers. Water inflow to monitoring wells will be slow and standing water levels consistent with groundwater pressure are unlikely to be established between sampling events. It is indicated that these wells will usually be capped. The sampling method proposed will required opening of these capped wells.

When wells are capped, any gas that desorbs from the water in the standpipe accumulates in the gas volume above the water level. Around an underground gasifier, gases diffuse into surrounding groundwater and diffusion is driven by concentration differences, and each gas behaves independently of others. In this way gas from the gasifier diffuses through groundwater away from the gasification chamber and can travel to monitoring wells. When the gas enters into a monitoring well standpipe, it encounters a gas occupied space above the water where its concentration may be low, so gas moves into this space in an attempt to

equilibrate its pressure in the various locations. In this way gases produced from the coal gasification that are not naturally in groundwater can be found in the gas overlying water in monitoring wells.

This process has only been observed for the major syngas components such as hydrogen, methane, carbon monoxide and carbon dioxide. Volatile organic compounds and COPC have not been seen in this setting as diffusion is concentration driven and they are in relatively low concentrations in syngas, and larger molecules diffusion rates are slower than the major syngas components.

The process is limited by two factors. If connectivity between pores containing water is poor, that is, there is low permeability in strata, the rate of diffusion is reduced. Gas molecule diffusion is through water, and when water is flowing into a gasifier because of the pressure differential between the gasifier and groundwater, diffusing gas is swept back into the gasification chamber with the water.

It is not known how far gases will diffuse in the very low permeability Main Series strata. It may be so slow, no gas may ever reach a monitoring well. If it was seen in the gas space overlying water in a capped monitoring well, it would give some indication of the gas fluid behaviour in the strata around the gasifier.

Procedures to test gas composition in wells using gas sensors when regular water sampling is being done, have been included in the independent Water Sampling SOP.

Soil Vapour Monitoring

The ‘Environmental objectives’, ‘Assessment criteria’, and ‘Guide to how objectives can be achieved’ address the important issues of environmental impact which could arise from potentially harmful gasification products occurring at the surface above the underground operations.

A robust monitoring network and sampling routine for soil vapour has been established, which will not only investigate for the presence of COPC, but will also look for other benign indicators of gasification. No distinction was made in the ‘objectives’ between these benign products and potentially harmful products. Although it is clear that an appropriate emphasis is given in the ‘assessment criteria’, it would have been useful if this distinction was clearer in the ‘Environmental objective’ column.