Australia Pacific LNG Upstream Phase 1

Subsidence, Aquitard Integrity and Aquifer Interconnectivity Project Plan

Q-LNG01-10-MP-0018

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1. Introduction

Conditions of the Federal Government's environmental approval of the gas field development (EPBC 2009/4974) require Australia Pacific LNG to:

- Stage 1 CSG Water Monitoring and Management Plan – Condition 50: provide a program and schedule for aquifer connectivity studies and monitoring of relevant aquifers to determine hydraulic connectivity
- Impact assessment, mitigation and monitoring – Condition 67:
  - undertake geodetic monitoring to quantify deformation at the land surface
  - modelling to estimate the potential hydrogeological implications of surface and subsurface deformation
  - measures for linking surface and sub-surface deformation arising from CSG activities

This plan provides the scope and program for the implementation of the Australia Pacific LNG subsidence, aquitard integrity and aquifer interconnectivity studies and monitoring programs. It outlines programs that are planned, some programs that are contingent on the findings of planned programs and some ad hoc activities. This plan should be read in conjunction with:

- *Australia Pacific LNG Upstream Phase 1 Groundwater Monitoring Plan (Q-LNG01-10-MP-0005)*
- *Australia Pacific LNG Upstream Phase 1 Aquifer Injection Feasibility Studies (Q-LNG01-95-MP-0146)*

1.1 Scales of Investigation

The subsidence and aquitard integrity programs will be undertaken at two spatial scales: regional and local. The local scale programs will be focussed on the existing operational gas field at Talinga, and the multi-well pilot activities currently being undertaken at Reedy Creek. Reedy Creek is the starting-point for the development of the gas fields in the western portion of Australia Pacific LNG's Walloon Coal Measure tenements. Development in the eastern portion of the fields will extend out from Talinga. These focus sites will contain groundwater monitoring bores in each of the aquifers (if present) and key aquitards, extensometers, tiltmeters and long term hydraulic testing facilities. The locations of Talinga and Reedy Creek are shown on Figure 1.

Regional scale programs, also broadly including the interconnectivity studies, will cover the full extent of the Australia Pacific LNG Walloon Coal Measure tenements (Figure 1).

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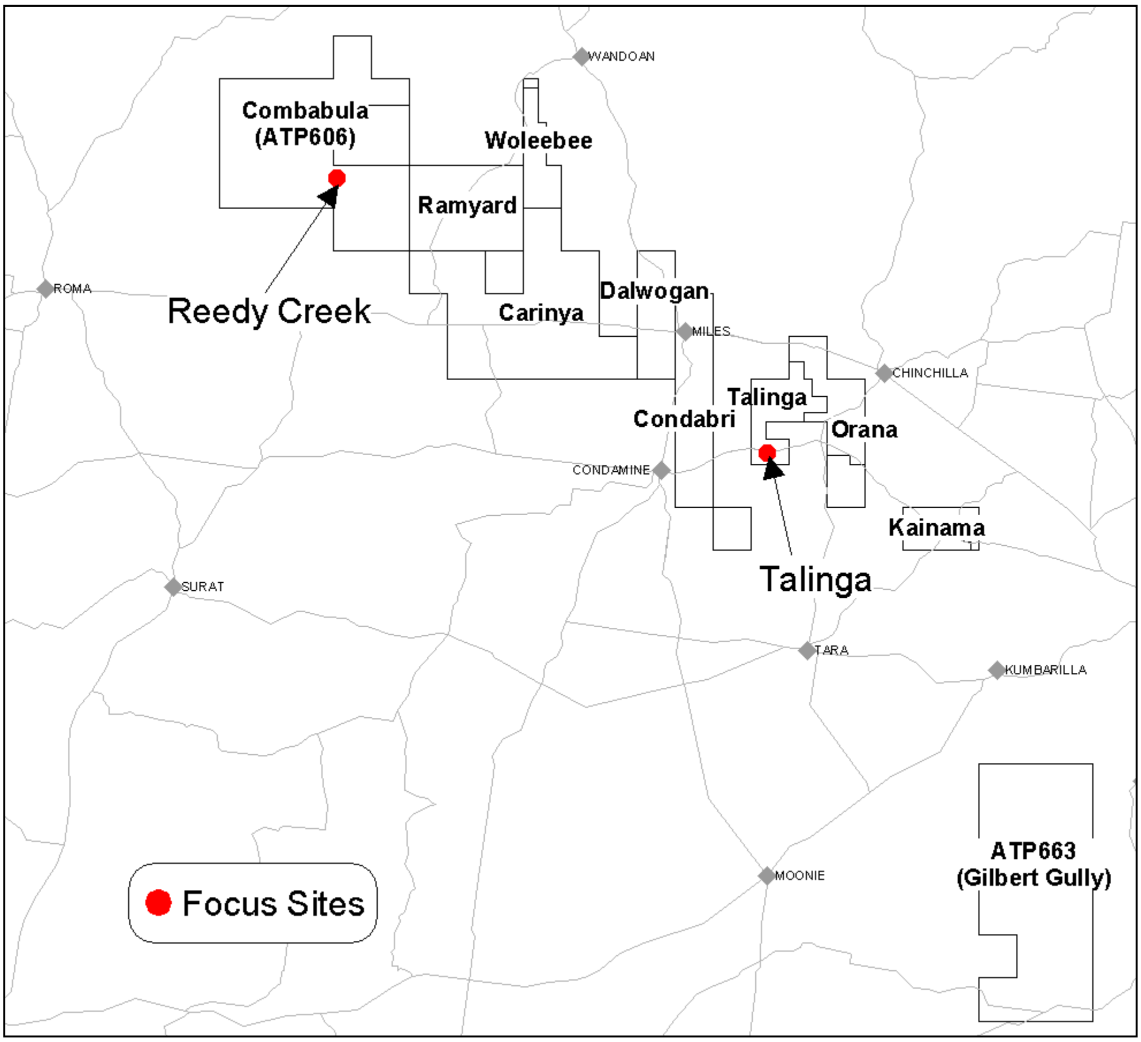
Figure 1 Australia Pacific LNG Walloon Coal Measure tenements



1.2 Plan Preparation

This plan has been prepared by the following team:

Role	Name	Position	Qualifications	Relevant Experience
Author	Ryan Morris	Senior Hydrogeologist	BScHons (Geology) RPGeo (Hydrogeology)	11 years
Author	Kathryn Harris	Hydrogeologist	BScHons (Geology)	5 years
Author	Thomas Flottmann	Principal Geologist	PhD (Geology)	22 years
Technical Review	Andrew Moser	Groundwater Manager Senior Hydrogeologist	BSc(Geology) RPGeo (Hydrogeology)	21 years

2. Subsidence

The release of groundwater from storage in confined aquifers results in a level of compression of the aquifer skeleton. Compression of the aquifer skeleton can cause subsidence at the ground surface if the overlying rock material is not sufficiently competent to buffer such movement. Potential impacts of differential land subsidence include compromising the geotechnical integrity of surface infrastructure, disruption of laser-levelled fields and, in if the magnitude were significant enough, interferance with surface drainage patterns. Current assessments of subsidence in respective EIS's are only a few centimetres, which would not result in any impacts.

The risk of compression is overwhelmingly influenced by the type of aquifer (and its compressibility) and the magnitude of the pressure reduction, rather than the volume of groundwater removed. Furthermore, the risk of surface subsidence from any compression is controlled by the bridging properties of overlying rock strata. Subsidence is most commonly associated with heavily-exploited unconsolidated aquifer systems comprising interbedded clay, sands and gravels. In these aquifers, much of the sedimentary sequence consists of highly compressible clays which, when drained, contribute to the majority of compaction (Freeze and Cherry 1979).

In contrast, groundwater in the Great Artesian Basin is stored in consolidated, confined, porous sandstone aquifers that have limited compressibility. Although groundwater extraction in the Great Artesian Basin has resulted in reduced hydraulic pressures (by up to 100m), the comparatively low compressibility of the sandstone aquifers has limited the change in aquifer thickness to immeasurable levels of less than 0.1% of the entire aquifer thickness (Hillier 2000). Furthermore, the geotechnical properties of the consolidate strata significantly reduce the potential for the transference of any compression to subsidence at ground surface.

To assess the potential risk of aquifer compression and land subsidence associated with the Australia Pacific LNG gas field development, a simplified analytical model was coupled with the numerical groundwater flow model (*WorleyParsons, 2010 Surat Basin Regional Numerical Groundwater Flow Model for the Australia Pacific LNG Environmental Impacts Assessment*) to calculate the potential compression that may occur. The process of aquifer compression and land subsidence is provided in the following text, with the methodology as it was applied thereafter.

2.1 Risk Assessment

At the water table (in an unconfined aquifer), groundwater is released from storage by gravity drainage. However, in a confined aquifer, groundwater is released from storage due to a reduction in hydrostatic pressure within the pore spaces which accompanies the withdrawal of groundwater from the aquifer. The total load above an aquifer is supported by a combination of the skeletal framework of the aquifer and by the pressure exerted by the associated pore water. Withdrawal of groundwater from the aquifer (such as will occur in CSG production) results in a decline in the pore pressure and subsequently more of the load must be supported by the aquifer skeleton. As a result, the rock particles become distorted and the aquifer skeleton is compressed, leading to a reduction in effective porosity and overall volume. Additionally, the decreased water pressure causes the pore water to expand slightly. Both the compression of the skeleton and expansion of the pore water cause water to be expelled from the aquifer. The volume of water that a permeable unit expels from

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storage per unit surface area and unit change in the hydraulic head is termed the storage coefficient and can be defined as:

$$S = \rho g b \left(\alpha + n\beta\right)$$

Where:

S: Storage co-efficient (dimensionless ratio)

ρ: Mass density of water (kg/m^3)

g: Acceleration due to gravity (m/s^2)

b: Thickness of aquifer formation (m)

α: Coefficient of compressibility of the aquifer formation (m^2/N)

n: Porosity

β: Fluid compressibility (m^2/N)

To assess the potential deformation across geological units as a consequence of associated water production (and the lowering of pressure head), the following formula can be employed:

$$\partial b = -\alpha b \rho g \partial h$$

Where:

∂b: Level of compaction or change in thickness of the aquifer (m)

α: Coefficient of compressibility of the aquifer formation (m^2/N)

b: Thickness of aquifer formation (m)

ρ: Mass density of water (kg/m^3)

g: Acceleration due to gravity (m/s^2)

∂h: Change in pressure head (m)

A simplification of the compaction formula (substituting the storage coefficient) can be defined as follows (Edgar and Case 2000):

$$\partial b = S \partial h$$

Where:

∂b: Level of compaction or change in thickness of the aquifer (m)

S: Storage co-efficient (dimensionless ratio)

∂h: Change in pressure head (m)

The storage co-efficient (S) is the product of the specific storage (Ss) and the aquifer thickness and is a commonly determined value in aquifer testing. In the current study, the specific storage (Ss) for each hydrostratigraphic unit was derived as part of the numerical model calibration, while the change in pressure head value (∂h) was the primary output of the numerical modelling.

Employing the simplified compaction formula (provided previously) and the output of the numerical model, the potential compaction of each hydrostratigraphic unit potentially affected by water production during the gas field development was estimated for the project case model (Australia Pacific LNG development only). The total estimated compaction, as a consequence of the operations, was projected by summing potential deformations in each hydrostratigraphic unit. To minimise the potential for biasing the results through the selection of a single time period only, this analysis was undertaken for ten year time slices from 2019 through to 2079 (beyond the end of gas production in the model). The maximum estimated compaction for each of the seven time slices was then combined to develop a time independent map of potential compaction, shown as Figure 2.

The risk of compaction is generally correlated with the coal seam elevation and requirements for depressurisation for optimal gas production. The greatest potential for compaction appears to be associated with those areas of comparatively deep coal seams and greater magnitudes of drawdown (that is, west of Condabri, between Kainama and Gilbert Gully and west of Carinya development areas – see Figure 1). It is important to note that these tenements will not be developed in the first five years of the project.

This compaction is unlikely to be expressed at the surface (as land subsidence) as the shallower consolidated and competent rock will to some extent operate as a bridge to prevent the downward movement. The distribution of the potential compaction does, however, identify areas of highest risk.

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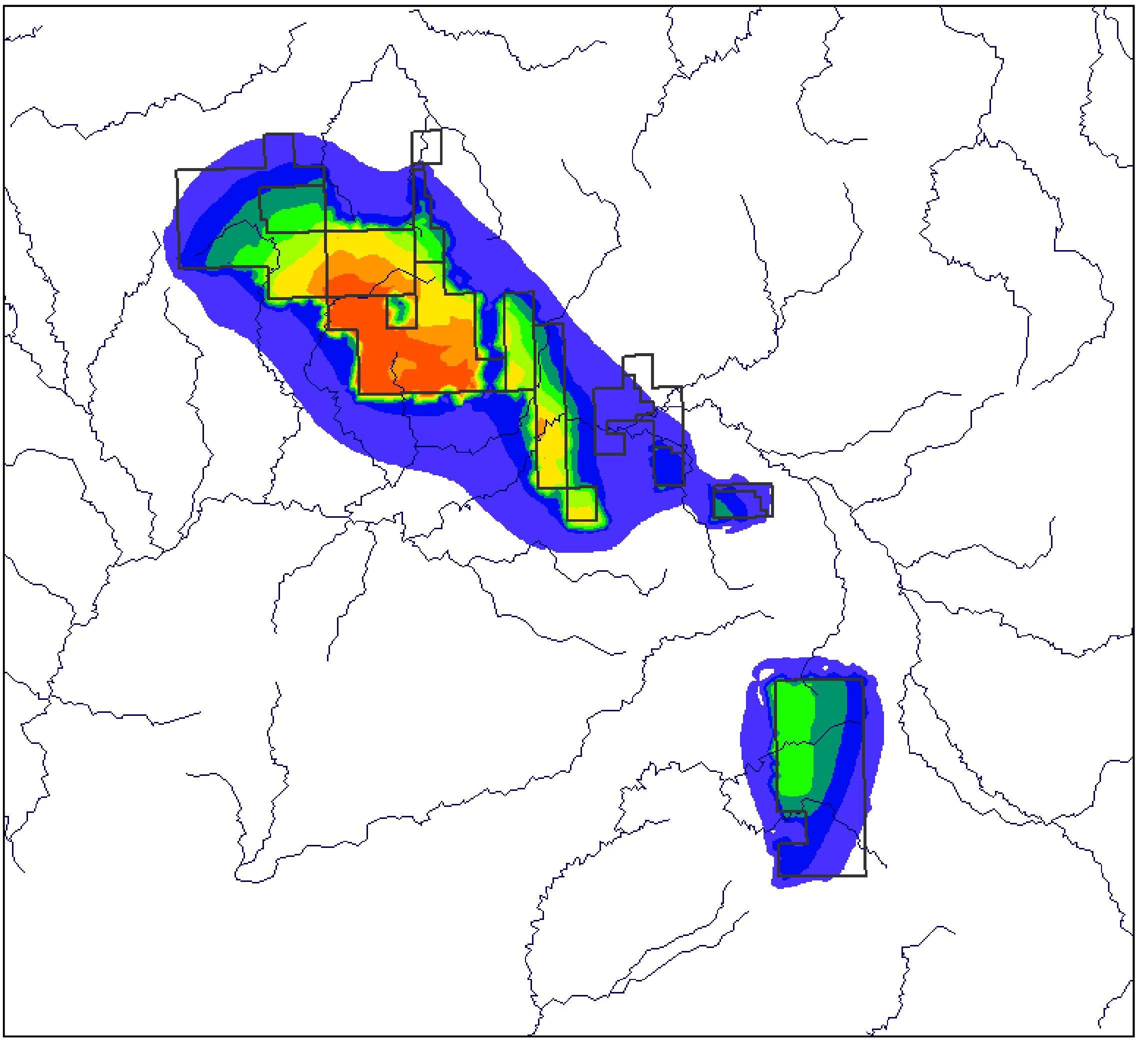
Figure 2 Time-independent risk of compaction (warm colours equate to higher risk)



2.2 Monitoring Program

A subsidence monitoring program has been developed to measure actual ground surface movement. The program has been developed at both a regional and local scale and comprises the following techniques:

- **Regional scale -** Subsidence measurements using Interferometric Synthetic Aperture Radar (InSAR)
- **Regional and local scale -** Geodetic surveys of permanent survey marks (PSMs)
- **Local scale -** Installation of tiltmeters

Each of these components of the monitoring program is discussed in the following sections

2.2.1 *InSAR*

InSAR (Interferometry for Synthetic Aperture Radar) technology is a measurement method capable of detecting ground motion with millimetric accuracy using data acquired by radar satellites. Measurements are taken from space covering large areas and do not require in-situ inspection for monitoring. The radar satellite images, unlike optical satellite images, provide an accurate measurement of the distance between the satellite and the ground. "Interferometry" means that there is a superposition of waves from two images in order to detect differences in distance measured in wavelength fractions. To detect ground motion, satellite images taken at different times are compared. For three-dimensional mapping, images taken from different angles are used to measure a stereoscopic effect (*Arnaud et. al. 2011 Ground motion measurement using radar satellite data for the mining sector*).

InSAR will be used to establish a baseline across the gas fields prior to the advent of significant CSG development. InSAR analysis will be undertaken for the period from January 2007 to January 2011 using historical data from the ALOS satellite. This period of analysis includes the existing, pre-approved Spring Gully (Bowen Basin) and Talinga (Surat Basin) projects and will include potential deformation associated with these early developments, and will also provide an understanding of surface deformation relating to non-CSG activities including:

- Landholder groundwater extraction;
- Agricultural practices;
- Erosion or deposition; and,
- Ground movement associated with major rainfall events

The extent of the survey is shown on Figure 3.

however it is important to note that data will only be provided to Australia Pacific LNG for the lease areas (shown in pink). The analysis will be undertaken in conjunction with the other major CSG companies operating in the Surat and southern Bowen Basins (Santos, QGC and Arrow). The companies are in the process of contracting the service provider (Altamira Information, Barcelona), and it is anticipated that the InSAR processing will commence in 2011.

It is anticipated that the InSAR analysis will be repeated every five years.

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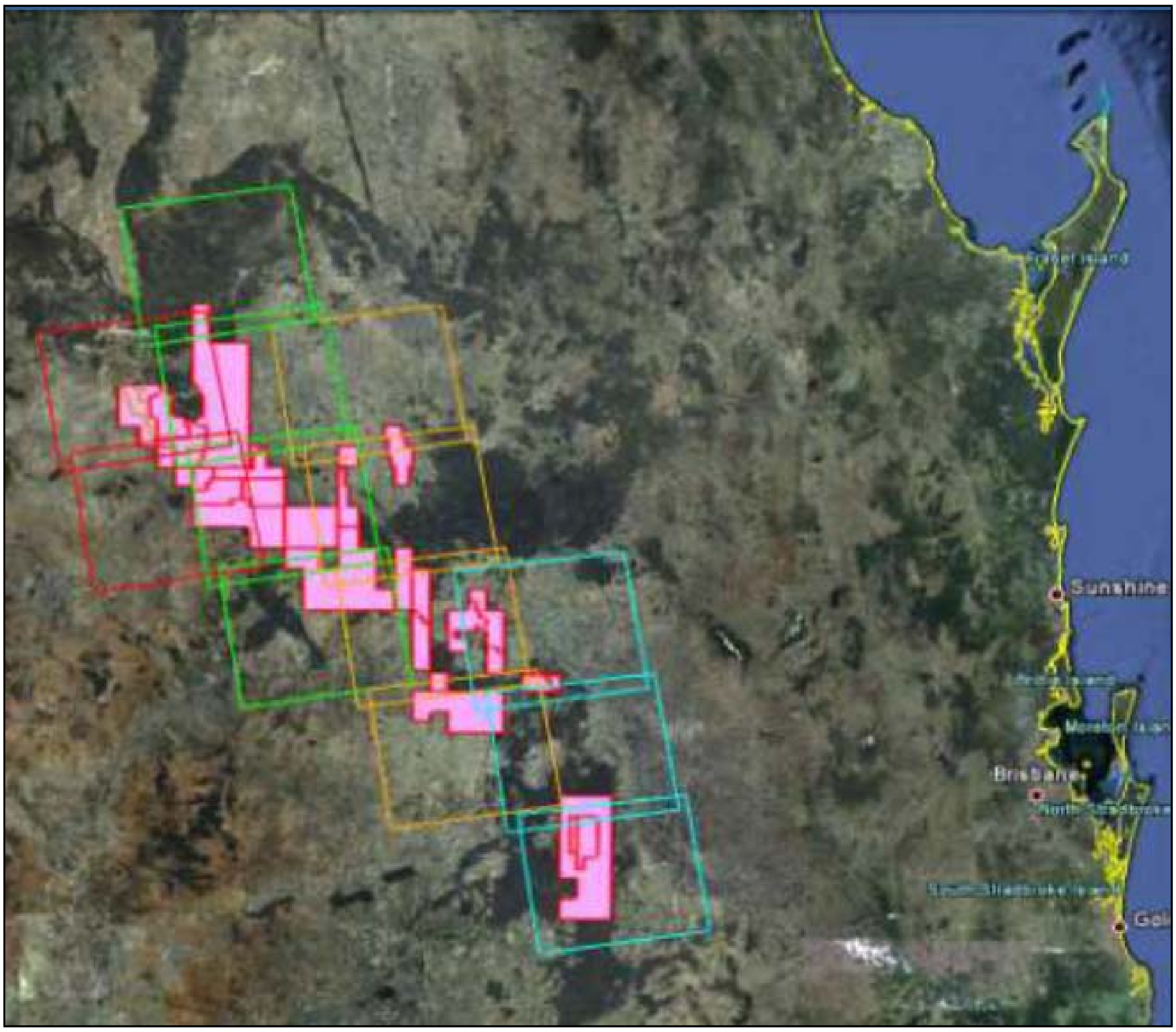
Figure 3 Extent of InSAR analysis of APLNG tenure, including satellite scenes



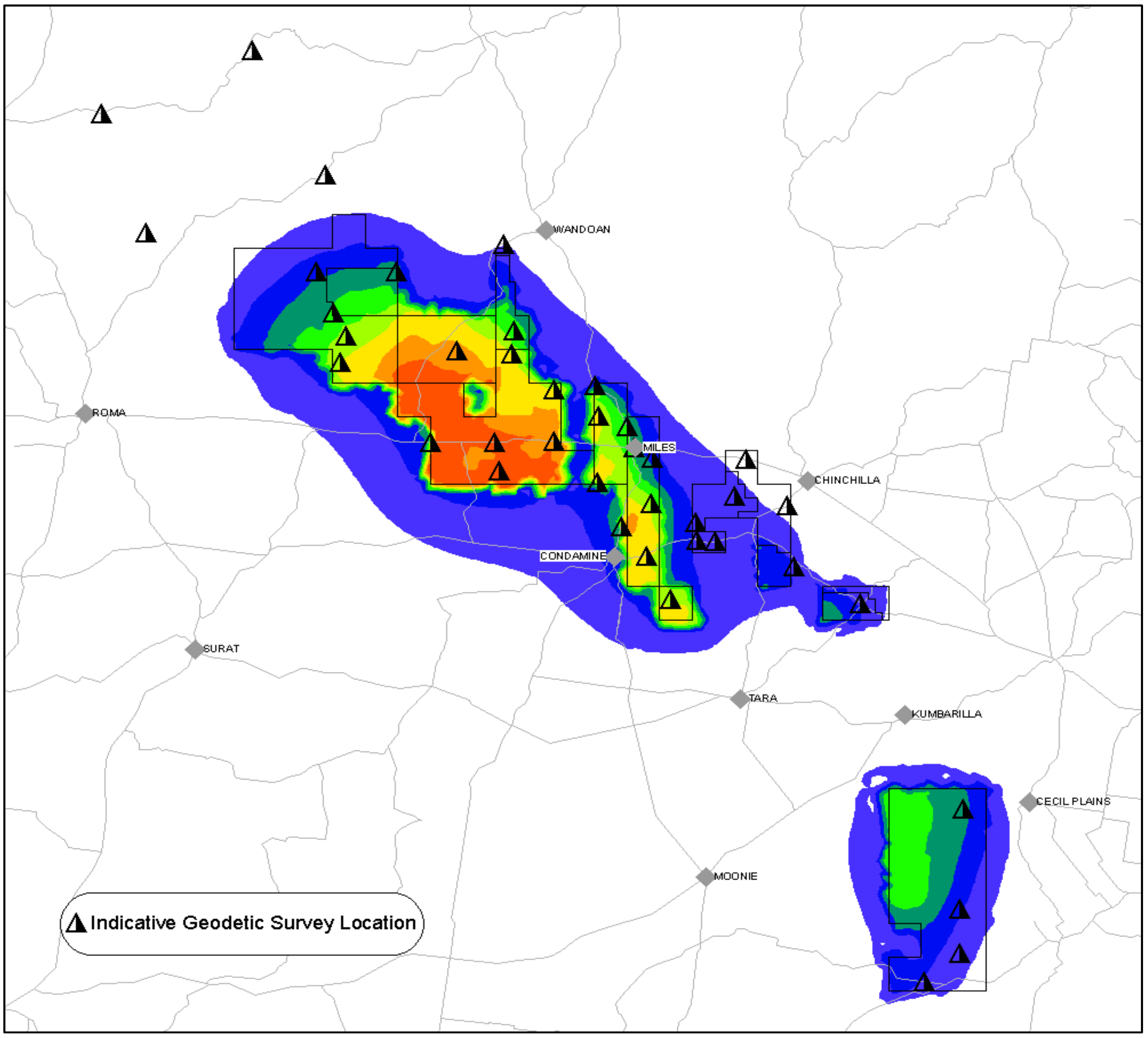
2.2.2 *Geodetic Surveys*

A search of the Queensland Surveyor General's database of permanent survey marks (PSMs) around the gas fields indicates a large number of PSMs through Australia Pacific LNG tenements, many of which have a high degree of accuracy. Selected PSMs from this network will be augmented with benchmarks set up by Australia Pacific LNG for periodic surveying. Where necessary, the temporary benchmarks will be made more permanent.

Figure 4 shows an indicative network of survey benchmarks that will be used for on-going geodetic surveys to assess surface deformation. This network of PSMs is denser in the areas of existing development and extended multi-well pilot testing.

As all of these locations are existing PSMs, current elevations will provide a baseline against which future measurements can be compared. Since development has not commenced across most of the gas fields, and highest risk areas are late in the development, regular monitoring of PSMs will commence at two yearly intervals, unless groundwater monitoring data indicates drawdown effects relating to CSG activities, in which case the regularity will increase. New locations will be established and re-measurement of the existing PSMs will be undertaken in the first quarter of 2012.

Figure 4 Indicative locations for geodetic surveys



2.2.3 *Tiltmeter Monitoring*

A tiltmeter is a geotechnical instrument used to measure very small changes from the horizontal level and can thus be used to assess surface deformation. Australia Pacific LNG will be installing an array of biaxial tiltmeters across the southern part of the Talinga tenement (already in production) and at the Reedy Creek multi-well extended pilot (pilot production recently commenced). Biaxial tiltmeters measure changes in two orientations perpendicular to each other and can therefore be used to assess surface deformation.

Approximately ten biaxial tiltmeters will be installed at each of the sites, generally on a rough grid spacing between the CSG production wells, but also in a transect between production wells and in relatively background locations. Locations for the tiltmeters have been identified and disturbance approvals are underway for their installation later in 2011.

3. Aquitard Integrity Monitoring

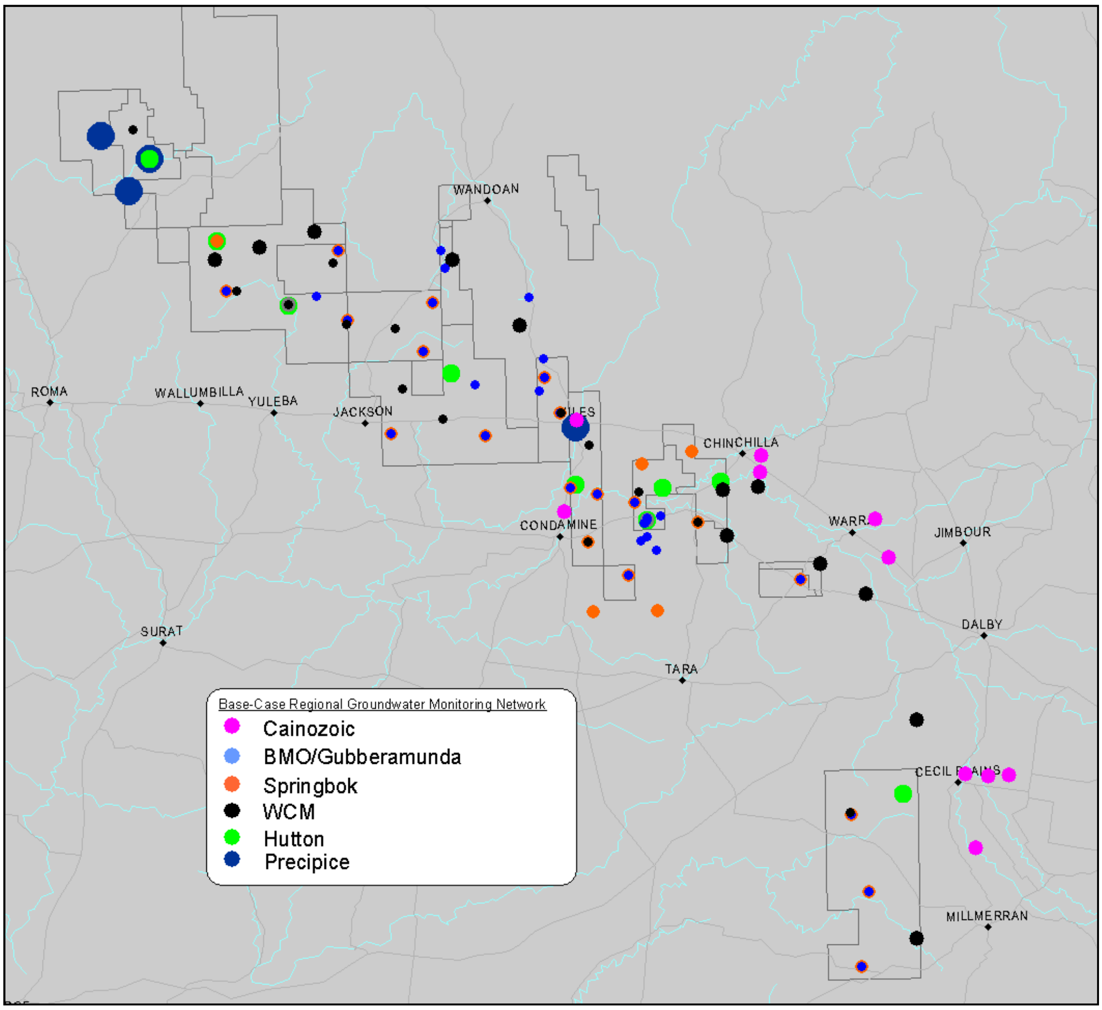
3.1 Nested Monitoring Bores

Comparison of groundwater levels between adjacent (nested) monitoring bores into different aquifers provides a degree of understanding of the interconnectivity of the aquifer overlying and underlying an aquitard. Should monitoring in bores above and below an aquitard show similar trends and levels, it may indicate the possibility of hydraulic connection, and possibly trigger a more detailed assessment.

Australia Pacific LNG has a defined groundwater monitoring program and schedule (*Australia Pacific LNG Upstream Phase 1 Groundwater Monitoring Plan, Q-LNG01-10-MP-0005*) which includes approximately 35 nested sites with individual monitoring bores providing water levels above and below at least one aquitard (predominantly the Westbourne Formation). Although there is less intense monitoring of the deeper formations, a similar methodology is applicable to Hutton Sandstone bore hydrographs, where groundwater levels recorded by dataloggers / pressure transducers can be compared with regional and local trends in other aquifers and the coal measures.

Figure 5 show the base case Australia Pacific LNG groundwater monitoring network. Each bore is shown as a dot, with the size and colour corresponding to the aquifer with which it is associated. Where multiple bores are located at a single site (nested bores), they appear as rings.

Figure 5 Australia Pacific LNG groundwater monitoring network



3.2 Extensometers

An extensometer is a geotechnical device that is used to measure small changes across the length over which it is anchored. By measuring the change in length of the formation, the extensometer will provide a direct measurement of the amount of compression/compaction that has occurred within the measured unit. This can be compared with nested monitoring bore water levels and water production/reservoir pressure data to assess the effects of CSG production on aquitard integrity.

Monitoring bores have been completed at Talinga (Talinga-SC1-Wb) and at Reedy Creek (Reedy Creek-SC1-Wb) for the installation of the extensometers. Because the Westbourne Formation at Reedy Creek is artesian, alternative designs for the extensometer headframe are currently being considered, however the location of this extensometer may yet be moved. The extensometers will be installed at the same time as the tiltmeters, later in 2011 or early 2012.

3.3 Periodic Hydraulic Testing of Aquitards

Dedicated monitoring bores have been installed at Talinga (Talinga-SC2-Wb) and at Reedy Creek (Reedy Creek-SC2-Wb) for the purpose of periodic hydraulic testing. The bore at Talinga essentially fully penetrates the Westbourne Formation, whereas the Reedy Creek bore is partially penetrating across approximately 75% of the formation.

The rationale behind this exercise is that significant changes in aquitard integrity may manifest as changes in hydraulic conductivity over time. Hydraulic testing (rising head testing) was conducted on these bores to establish baseline hydraulic conductivities against which future measurements can be compared. Because Reedy Creek-SC2-Wb is artesian, a flow recovery test was also undertaken on this bore as this will be the method used going forward. The baseline values of hydraulic conductivities obtained were:

- Talinga-SC2-Wb: 10^{-3} m/day
- Reedy Creek-SC2-Wb: 10^{-3} m/day (rising head)/ 10^{-3} m/day (flow recovery)

Hydraulic testing will be repeated annually.

Changes in aquitard integrity may also result in the groundwater level in the aquitard monitoring bore equilibrating to that of the overlying or underlying aquifer. Pressure transducers with dataloggers have been installed in the Westbourne Formation monitoring bores to monitor for these impacts.

3.4 Potential Activity - Geomechanical Modelling

The potential pressure differentials induced within the Walloon Coal Measures by CSG production and between the coal measures and the over- and underlying formations may induce forces (stresses) that may lead to deformation should the rock strength be exceeded. Rock deformation can manifest itself in regional subsidence, or can be localized along pre-existing features such as faults. Although, aquifer injection pressures will be less than the fracture pressure of the target formation, aquifer injection will introduce regional pressure differentials and associated stresses.

There are a number of existing datasets and softwares that could be used to develop a geomechanical model to assess the potential for mechanical deformation and fault activation due to CSG production and aquifer injection. This would only be undertaken if the InSAR analysis indicates that CSG extraction is likely to be responsible for surface subsidence otherwise there would be no stress regime to apply to the model, and therefore no potential for geomechanical movement. The modelling may indicate if the existing data would have sufficient resolution to identify the cause of the surface subsidence, and therefore direct other investigations.

3.5 Modelling to Assess the Potential Hydrogeological Implications of Surface and Subsurface Deformation

The Queensland Water Commission (QWC) is currently compiling a cumulative effects numerical groundwater flow model, to which Australia Pacific LNG has provided data and other input. The primary purpose of the QWC model is to project potential drawdown effects associated with CSG production.

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The model is based on the CSG industry's current understanding of hydrostratigraphic morphology and hydraulic properties. It is intended that the model will be regularly updated (e.g. every 3 years) as more data is acquired and understanding of the potential effects of CSG production are measured. Should monitoring of aquitard integrity and geomechanical modelling (if undertaken) indicate potential interconnections between aquifers (either natural or induced by CSG), this will affect the hydraulic parameters of the aquitards, which will then be used to parameterise the updated QWC numerical model.

The water level, tiltmeter, extensometer, InSAR and geodetic survey monitoring data will be assessed in conjunction with CSG production activity, aquifer injection activities and detailed geophysical logging to attempt to establish natural or CSG related aquifer interconnectivity and geomechanical characteristics. This will allow extrapolation of the monitoring results to other parts of the gas fields or direct further modelling or other investigations.

Combining potential relationships between the geomechanical and geophysical properties of the formations and the output of the QWC numerical groundwater flow model will allow risks associated with maintenance of aquitard integrity and subsidence to be assessed in tenements prior to their development. The initial data assessment will be undertaken prior to the submission of the Stage 2 CSG Water Monitoring and Management Plan.

4. Interconnectivity Studies

4.1 Nested Monitoring Bores

As discussed in Section 3.1, Australia Pacific LNG has commenced and will continue the installation of nested monitoring bores across its tenements. By comparing water levels between bores nested in different aquifers, the degree of connectivity between the aquifers can be assessed. This is particularly pertinent for the monitoring of the Springbok Sandstone since this aquifer directly overlies the Walloon Coal Measures. Due to the relatively short vertical separation between the top producing coals and the Springbok Sandstone, observation of potential drawdown effects will be first realised in the Springbok Sandstone, which will provide an indication of the degree of risk to aquifers with a greater degree of vertical separation. Monitoring of the Hutton Sandstone will provide a similar profile for the aquifers underlying the reservoir.

4.2 Springbok Sandstone Detailed Characterisation

Drilling and advanced wireline logging of CSG exploration holes and production wells has suggested that the Springbok Sandstone is not sandstone but rather forms a heterogeneous unit comprising lithologies such as coal, siltstone, shale and sandstone. Since the lithology is highly variable, there is an associated high degree of variability in the permeability/hydraulic conductivity of the formation.

A detailed re-characterisation of the permeability of the Springbok Sandstone is currently being undertaken. The proposed testing program is key in differentiating those intervals of the Springbok with aquifer qualities versus intervals with aquitard characteristics to assist in understanding the variation in hydraulic connectivity between the two formations.

The Springbok Sandstone characterisation studies comprise:

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- Laboratory testing of approximately 200 core samples for permeability to both air and brine
- Applying the Klinkenberg correction to make the results applicable to groundwater
- Collection of specialised geophysical wireline logs across the majority of CSG exploration and production holes
- Calibration of horizontal permeability calculated from geophysical log responses, specifically neutron and density logs, to the Klinkenberg-corrected data
- Development of vertical profiles of horizontal permeability through the Springbok Sandstone and upper Walloons Coal Measures
- Assessment of the profile for aquifer versus aquitard properties

The Springbok Sandstone characterisation studies commenced in late 2010. Samples are currently with the laboratory for analysis, with geophysical log calibration an ongoing exercise. It is expected that the study will be completed during 2012, with the results used for risk assessments thereafter, including revisiting the groundwater monitoring bore locations.

4.3 Aquitard Laboratory Testing

Because of the low permeability of aquitard material, traditional falling head permeameter tests undertaken by geotechnical laboratories have proved unsuccessful. During early 2011 the University of New South Wales commissioned a centrifuge permeameter, which will overcome the limitations of the traditional falling head permeameter and allow testing of aquitard materials. UNSW has confirmed that the centrifuge permeameter will be available for commercial use, subject to applicability testing.

Where practicable, core samples from the major aquitards (Westbourne Formation, Eurombah Formation and Evergreen Formation) and the interstitial mudstone and siltstones of the Walloon Coal Measures will be collected during drilling activities. These samples will be preserved for testing of vertical hydraulic conductivity using the centrifuge permeameter. Samples are anticipated to be collected from:

- Evergreen Formation: Reedy Creek-MB3-H; exploration coreholes;
- Eurombah Formation and interstitial Walloon Coal Measures: CSG exploration coreholes; and,
- Westbourne Formation: Reedy Creek-SC2-Wb; Talinga-SC2-Wb (bores completed, with sample preserved).

More information regarding the centrifuge permeameter can be found at:

(http://www.connectedwaters.unsw.edu.au/news/centrifugepermeametercommissioned.html)

4.4 Field Hydraulic Testing

Laboratory testing of aquitard core material is useful to provide a lower estimate of vertical hydraulic conductivity. . Field hydraulic testing is also proposed to take into account in-situ structural features or variations that may vary the bulk effectiveness of the aquitard, and assess the spatial extent of these features.

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All groundwater monitoring and test bores installed by Australia Pacific LNG are hydraulically tested by test pumping or rising/falling head tests. This testing ranges from several hours to a number of days, depending on the purpose and characteristics of the bore. Injection trials scheduled to be undertaken in three different aquifers across four locations and will run for between approximately 30 days and one year (*Australia Pacific LNG Upstream Phase 1 Aquifer Injection Feasibility Studies Q-LNG01-95-MP-0146*). At most of the injection sites there will be monitoring of the overlying and underlying aquifers, including the Walloon Coal Measures at two of the sites.

Australia Pacific LNG groundwater monitoring bores are usually pump tested for approximately 5 hours after completion of drilling activities at the nested site. Although the testing is short-term, direct connection of the aquifers through fractures or other pathways in the aquitards would manifest as declining water levels in the other bores in the nest.

Injection trial bores are test pumped prior to injection, with monitoring of other bores at the same site (in same and different aquifers) and at more distant locations. The injection trial testing duration will range from approximately 8 hours to several days, depending on estimated response times in monitoring bores and the ability to dispose of extracted water. Injection trials will continue for between an estimated 30 days and one year per injection bore.

Analysis of monitoring data from aquifers above or below the aquitard(s) during hydraulic testing will allow vertical hydraulic conductivities to be estimated and therefore the degree of connection to be assessed.

Hydraulic testing of monitoring bores commenced in 2010, and will continue until monitoring bore drilling has been completed (estimated 2014). It is anticipated that the testing of the injection trial bores will commence in late 2011 and will continue through 2012.

4.5 Isotopic Characterisation of Aquifers and Aquitards

Australia Pacific LNG has entered into a research alliance with the Commonwealth Scientific and Industrial Research Organisation (CSIRO) entitled Gas Industry Social and Environmental Research Alliance (GISERA) that will support the sustainable development of the CSG industry. A number of GISERA projects relate to groundwater activities, however a specific project has been developed to characterise the individual aquifers, and to a lesser extend the aquitards, in terms of stable and radiogenic isotopes. The purpose of this characterisation is:

- To “fingerprint” each of the aquifers in terms of isotopic composition;
- To determine the source aquifers of springs that support EPBC listed species emanating from Great Artesian Basin sediments; and,
- To attempt to quantify any fluid flux across the aquitards.

The suite of isotopes is likely to include:

- Oxygen-18 and deuterium;
- Carbon-13;
- Carbon-14;

- Chlorine-36; and,
- Helium-4.

GISERA was launched in July 2011. The project kick-off meeting for the isotope studies was held in early August 2011. Sample collection has already commenced, and samples will continue to be collected during the groundwater monitoring program from selected bores.

4.6 Ad Hoc Assessment - Formation Pressure Testing

The petroleum industry uses a number of tools to assess formation pressures in a well prior to casing. These tools include:

- Drill stem tests (DST);
- Modular formation tester (MFT) ; and,
- Modular Formation Dynamics tester (MDT).

In theory, the formation pressure in a vertical wellbore should follow a defined gradient – the hydrostatic pressure gradient. In some cases, formations may be over- or under-pressured relative to the hydrostatic pressure gradient. Deviations from the hydrostatic pressure gradient may be natural, however they are more likely to be anthropogenically induced, either related to pumping (e.g. groundwater use or CSG production) or injection.

In producing CSG gas fields, a pressure profile through the Walloon Coal Measures, with comparison to the hydrostatic pressure gradient will provide an indication of the interconnectivity of the individual coal seams, and other parts of the sequence should they be measured. An example of this type of analysis is shown in Figure 6.

A defined program of pressure profiling *will not* be developed and undertaken, rather data collected for reservoir characterisation during exploration activities will be utilised. This assessment will utilise previously collected data such as that shown in Figure 6 and any new data collected in the future.

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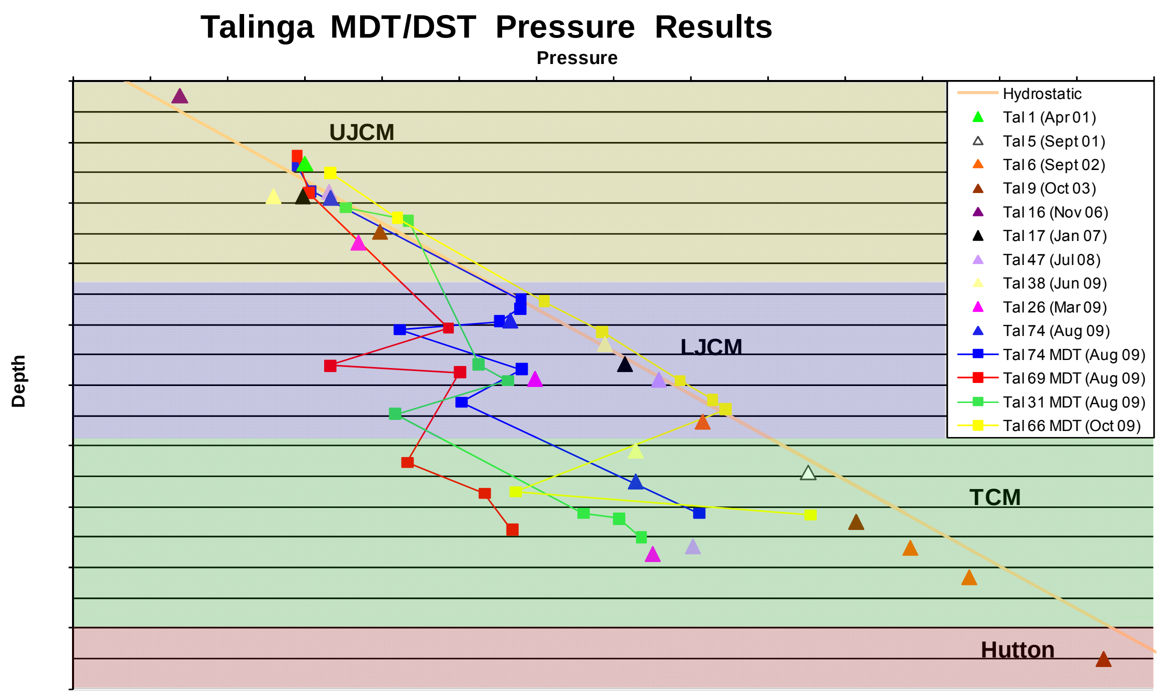
Figure 6 Example of pressure profile data from a producing gas field*



* The Talinga field has been in production since approximately 2008. A groundwater monitoring bore installed into the Springbok Sandstone during early 2011 is artesian (8.5m above ground level).

5. Schedule for Implementation

The implementation schedule for the subsidence and aquitard integrity monitoring and aquifer interconnectivity studies can be summarised as follows:

Task	Start Date	Regularity
Subsidence Monitoring		
InSAR	Q4 2011	Approx 5 years
Geodetic Surveys	Baseline collected/ New locations Q1 2012	2 years
Tiltmeters	Q1 2012	On-going
Aquitard Integrity Monitoring		
Nested Monitoring Bores	Commenced 2010	On-going
Extensometers	2012	On-going
Repeated Hydraulic Testing	2011	Annually
Geomechanical Modelling	2012	One-off
Modelling to Assess Potential Hydrogeological Implications	2012	3 yearly
Interconnectivity Studies		

Nested Monitoring Bores	Commenced 2010	On-going
Springbok Sandstone Characterisation	Commenced 2010	On-going
Aquitard Laboratory Testing	Commence Q4 2011	One-off
Field Hydraulic Testing	Commenced 2010	During monitoring bore installation program (complete 2014)
Isotopic Characterisation	Commence Q3 2011	One-off, unless significant impacts observed
Formation Pressure Testing	Commenced 2008	Ad hoc