**RESEARCH GAPS**

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Groundwater Investigations

- Review available literature and studies of the Condamine Alluvium area and adjacent areas where CSG activities are likely to impact on the CA and comparable information from all reputable sources and list relevant risks towards which the studies are to be done
- Comprehensive baseline water quality analyses for all hydrogeological layers within the above mentioned area at multiple sites accounting for water quality variation as per DPI Eastern Downs Land Management Manual Salinity Yield Matrix
- Map bottom of Condamine Alluvium and top of Walloons and including intervening strata for the above mentioned area
- Determine vertical and horizontal permeability and specific storage for all formations over multiple locations for the above mentioned area
- Draw down Walloons at chosen sites and conduct multi nest piezometric analyses over the above mentioned area
- Assess all the various formations for suitability for reinjection or other forms of replenishment over the above mentioned area

Substitution of Allocation Investigations

- Review available literature and studies in relation to RO and comparable information from all reputable sources and list relevant risks towards which the studies are to be done
- Investigate all currently operating Surat Basin company RO techniques and data to analyse treated water quality, potential quality and identify current best practice
- Desktop investigation using groundwater model data from above to determine whether substitution of allocation will offset predicted damage to non-target aquifers in the area
- Review by independent and appropriately qualified independent experts of Arrow's beneficial water reuse trials at Arrow's farm, Theten and any relevant and comparable CSG treated water farming operations elsewhere. Water quality and quantity, pre and post soil analyses, crop performance data and control data to be included

Soil Investigations

- Review available literature and studies of the area and list relevant risk towards which the studies are to be done
- Investigate interaction of all the various soil types in the region (e.g., Anchorfield, Hazelmere, Mywybilla etc. as per DPI Eastern Darling Downs Land Management

Manual) with treated and untreated CSG water to determine impacts and suitability of treated water for irrigation

- Investigate impacts of compaction from CSG activities on soils and resulting effects on crops
- Investigate the impact of soil movement (particularly reactive black vertosols) on integrity of aboveground (wellheads) and buried (pipelines of all sizes and types) infrastructure
- Audit all existing buried infrastructure for subsidence in all comparable areas in QLD and elsewhere
- Determine the ability of the various vertosol soil types encountered to be successfully rehabilitated to their previous use and suitability class and determine the long term impact on crop yield

Land Use Investigations

- Determine the current land uses and review the literature to establish current and evolving farming techniques for the area mentioned in the Groundwater Investigations section
- Desktop investigation of impact of gas field development on current land use and current and evolving farming techniques and intensive cropping land use (this must include all aspects of production field development and so should be done over a large area, not 1 farm e.g., the area between the Condamine River and Nangwee and including the Horrane Trough) All constraints must be applied – legislative, OH&S etc. Substitution of allocation layer able to be included
- Map the area within Arrow tenure where pad drilling is possible and identify all constraints to pad drilling
- Map the area within the Surat Basin where directional drilling techniques are possible and identify all constraints to directional drilling
- Review the literature and investigate the relative risk of all types of non-vertical drilling on the geological formations in the areas identified above (e.g., increased surface area contact creating higher incidence of water and gas migration, capacity to seal the well etc.)

CSG Infrastructure Integrity Investigations

- Review available literature and studies of the area and comparable information from all reputable sources and list the relevant risks towards which the studies are to be done
- Current production wells within the Surat Basin to be audited for integrity (steel casings, concrete sleeve, wellhead infrastructure etc.)
- Investigate the potential for gas and water migration through existing monitoring bores and third party water bores in the Surat Basin
- Locate all coal core holes in the Surat Basin and assess for water and gas leakage. Plug and abandon correctly as required
- Audit all Surat Basin CSG produced water and brine storage dams for leakage

Health Investigations

- Review available literature and studies of the area and comparable information from all reputable sources and list the relevant risks towards which the studies are to be done
- An appropriate air quality monitoring network must be installed in the Surat Basin. Currently, the nearest stations are at Toowoomba and Charleville?
- Determine the current and predicted fugitive emissions for all CSG related compounds in the Surat Basin
- Assess the incidence of temperature inversions and impacts on fugitive gas emissions, noise and dust in the area
- Determine all health risks and impacts from full scale CSG field development using the desktop gas field developed for the land use assessment for the Horrane Trough and weather and emissions data from above for the sensitive receptors in the same area

Economic Investigations

- Review available literature and studies of the area and comparable information from all reputable sources and list the relevant risks towards which the studies are to be done
- An independent economic cost benefit analysis of Arrow's proposed Surat Gas Project must be undertaken. Arrow's CBA in their EIS is inadequate and incomplete. CBA to be determined at the state level and must include costs for agriculture, environment, state and local infrastructure etc. and must extend for the duration that costs are incurred
- Valuation studies to be done on impact to intensive cropping property values using information provided from groundwater, soil and land use investigations

Other Investigations

- Arrow's EIS states that any or all petroleum activities are potentially notifiable activities. Determine the impact of listing on EMR or CLR on property values, organic status and on land used for food production
- Audit Surat Basin companies and state government records to assess the incidence, frequency, timing and quantities of accidental and intentional leaks and venting of CSG water and gas
- All Surat Basin companies to be directed to provide data for amounts of produced CSG water over project life, details of impacts to existing water bores, details of CSG water management strategies accounting for all produced water and details of 'make good' strategies for the entire extent of time that landowner bores are impaired