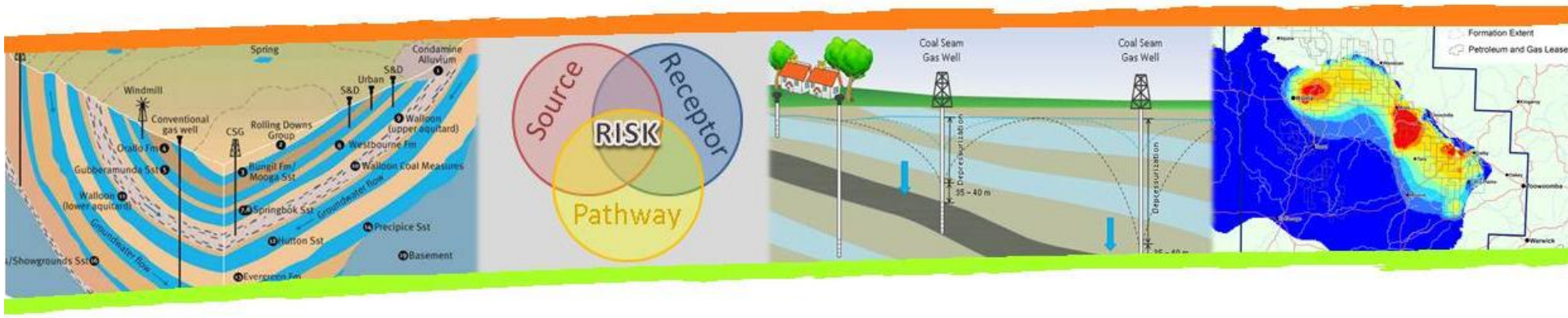
Assessment of Groundwater Risks of Coal Seam Gas Development in Queensland, Australia

Jos Beckers, Watertech 2013, 12 April, 2013



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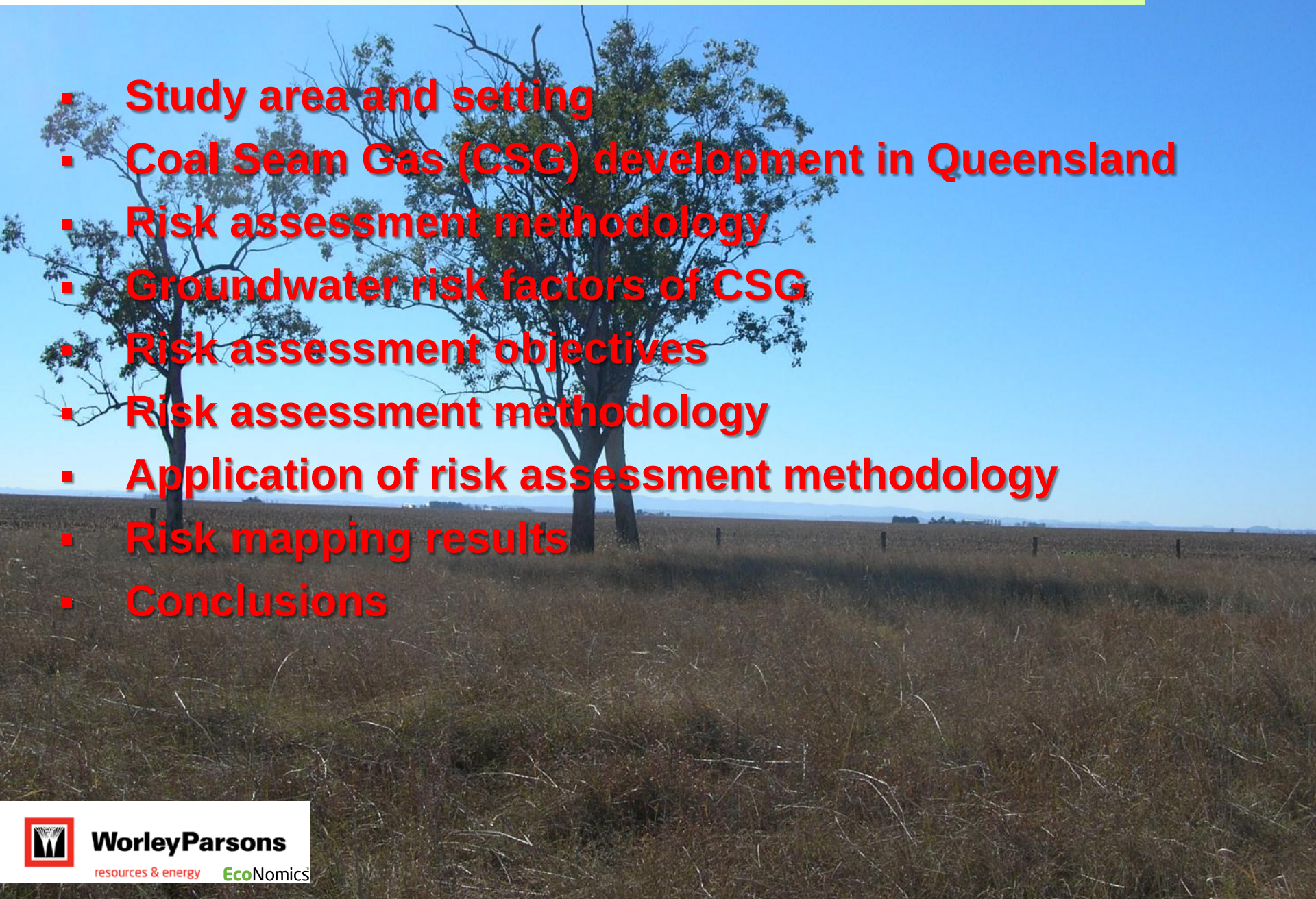
Queensland Government

Presentation Overview



- Study area and setting
- Coal Seam Gas (CSG) development in Queensland
- Risk assessment methodology
- Groundwater risk factors of CSG
- Risk assessment objectives
- Risk assessment methodology
- Application of risk assessment methodology
- Risk mapping results
- Conclusions

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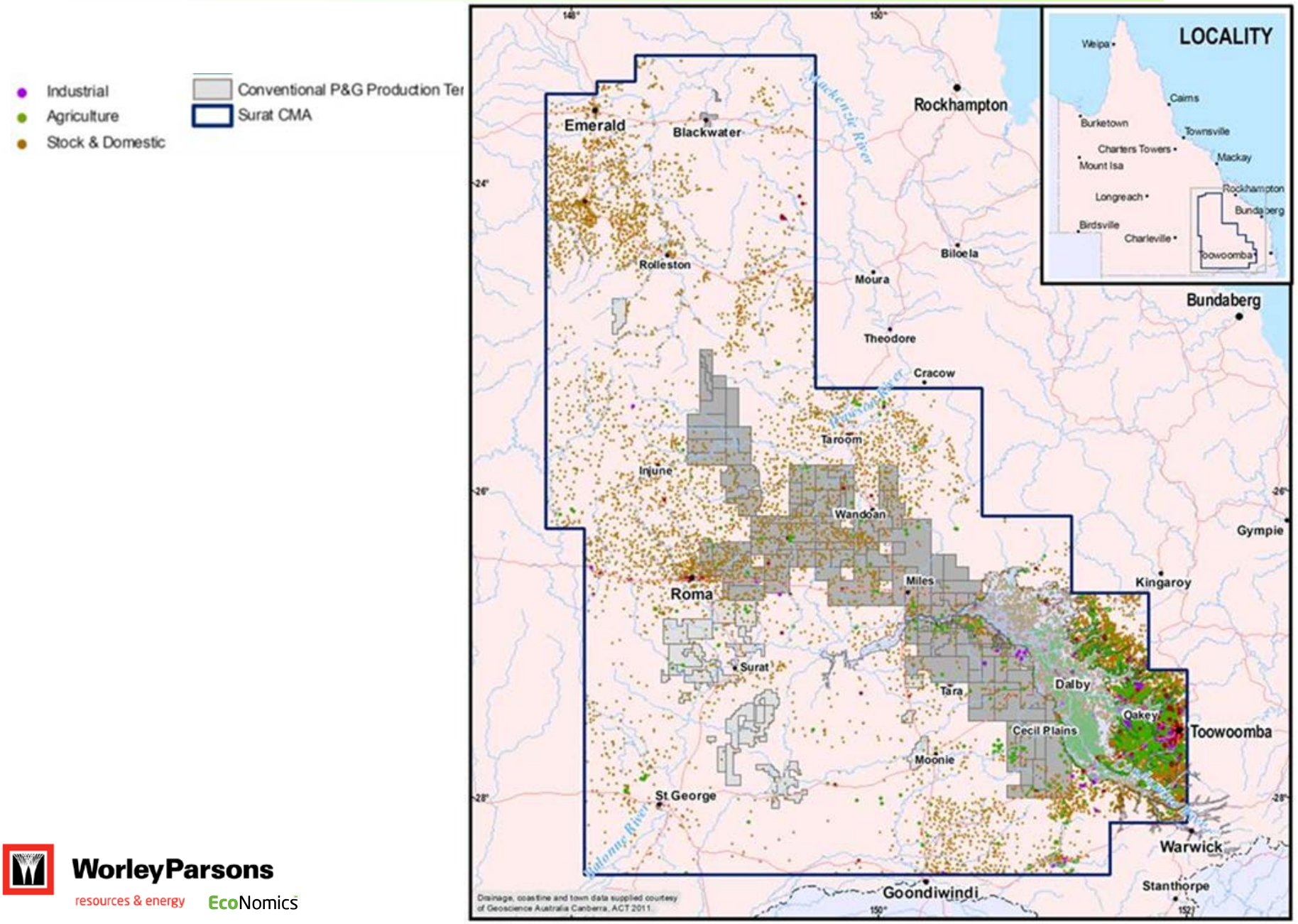
Study Area and Setting

- Approximately 300,000 km^2 study area – Surat Basin
  - LARP ~ 95,000 km^2
- Large sedimentary basin up to 2,500 m deep
- Part of Great Artesian Basin (GAB)
- Headwaters for Murray-Darling basin
- Groundwater use history since late 1800s
  - Flowing bores
  - Stock & Domestic Use (10,000s active bores)
  - Conventional gas since1960s
  - Irrigation (Condamine Alluvium) since 1970s
  - CSG industry
  - Mining

Study Area and Setting



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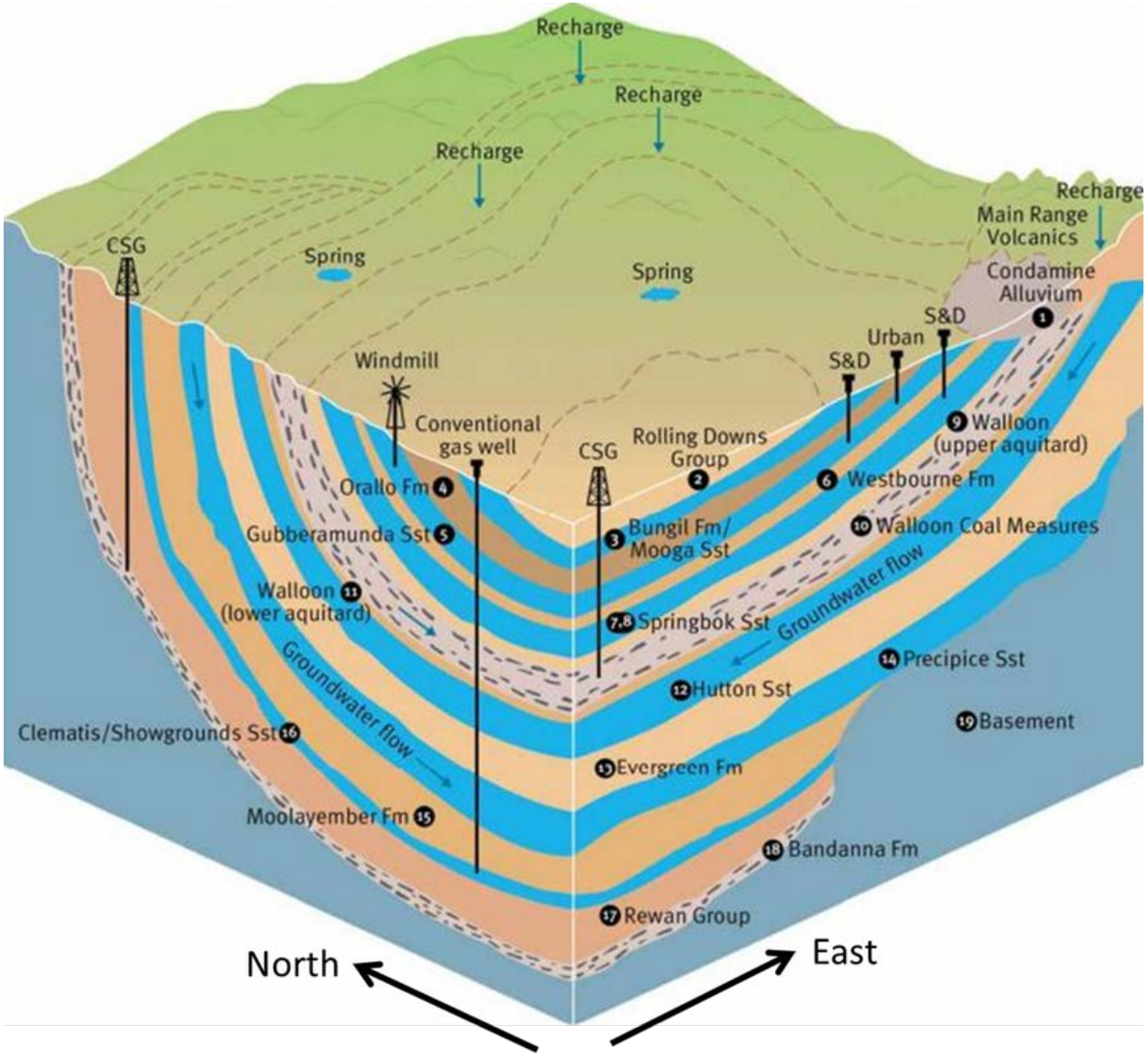
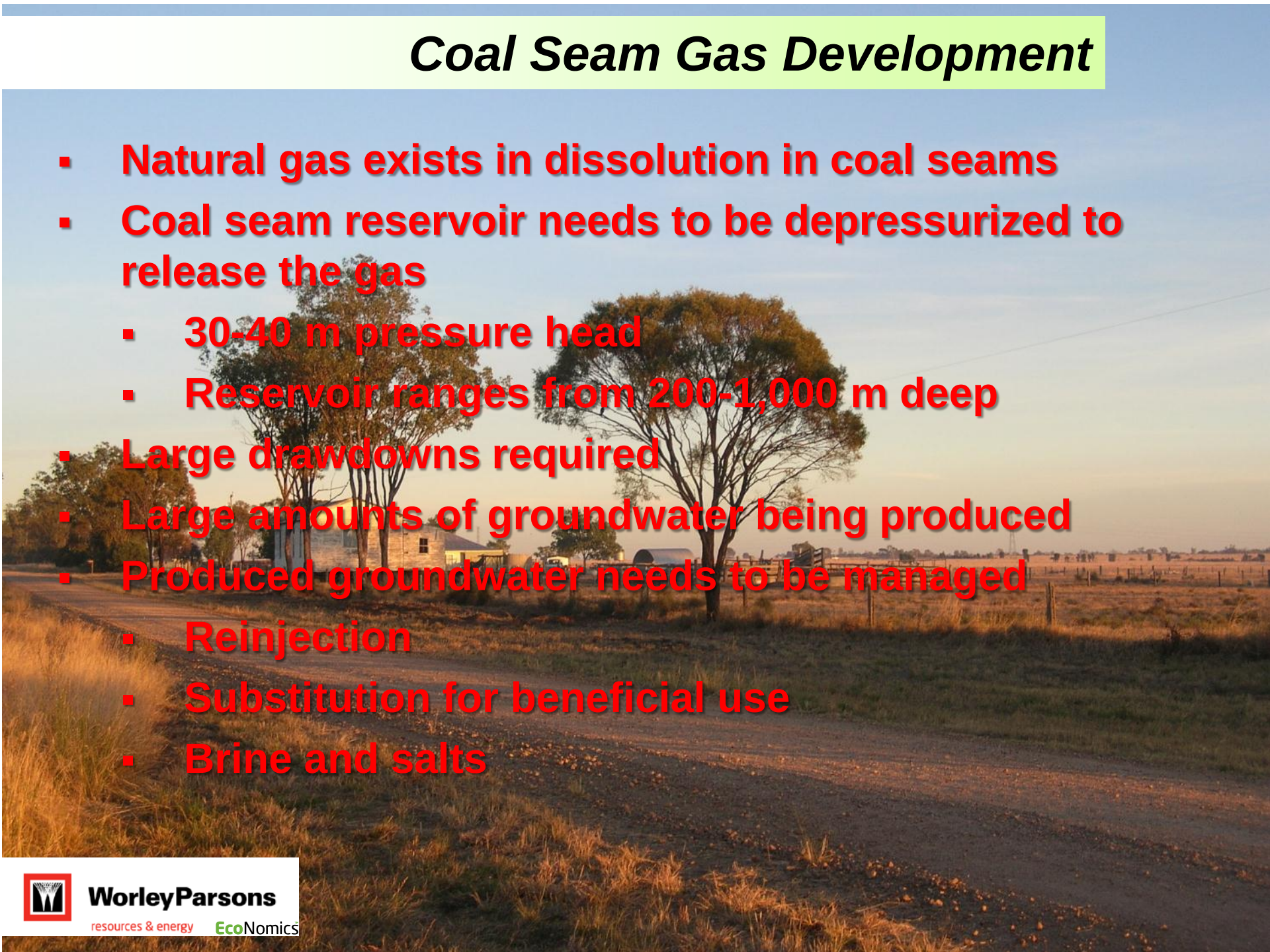
Study Area and Setting



Coal Seam Gas Development



- Natural gas exists in dissolution in coal seams
- Coal seam reservoir needs to be depressurized to release the gas
  - 30-40 m pressure head
  - Reservoir ranges from 200-1,000 m deep
- Large drawdowns required
- Large amounts of groundwater being produced
- Produced groundwater needs to be managed
  - Reinjection
  - Substitution for beneficial use
  - Brine and salts

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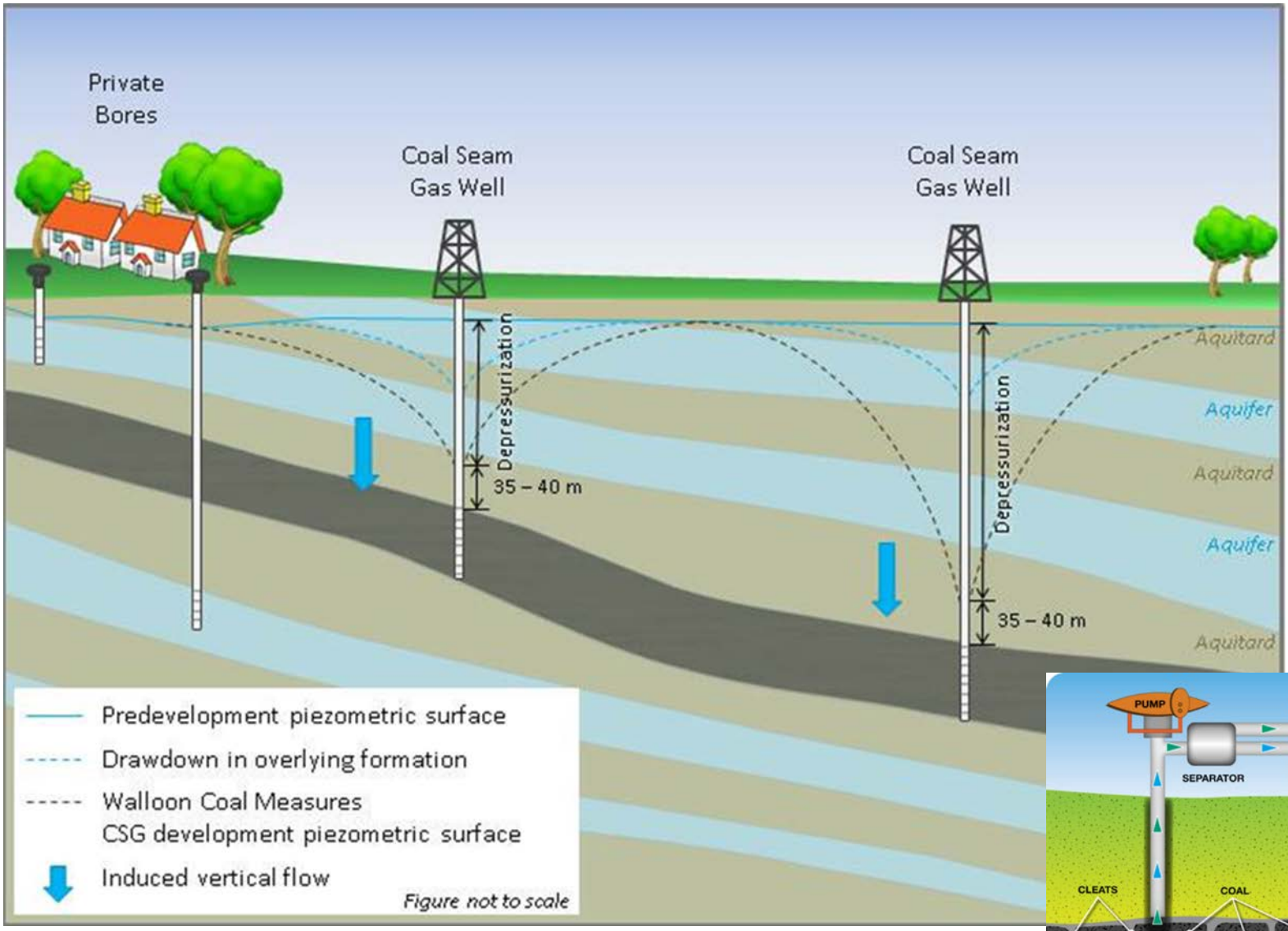
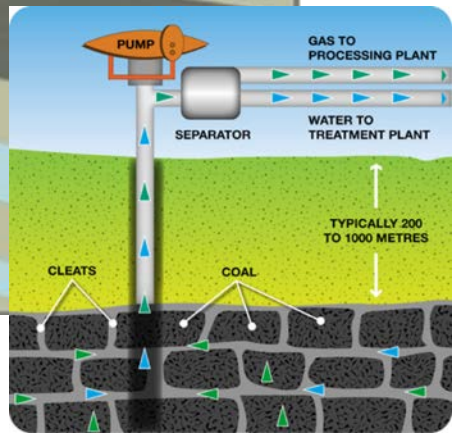
Coal Seam Gas Development





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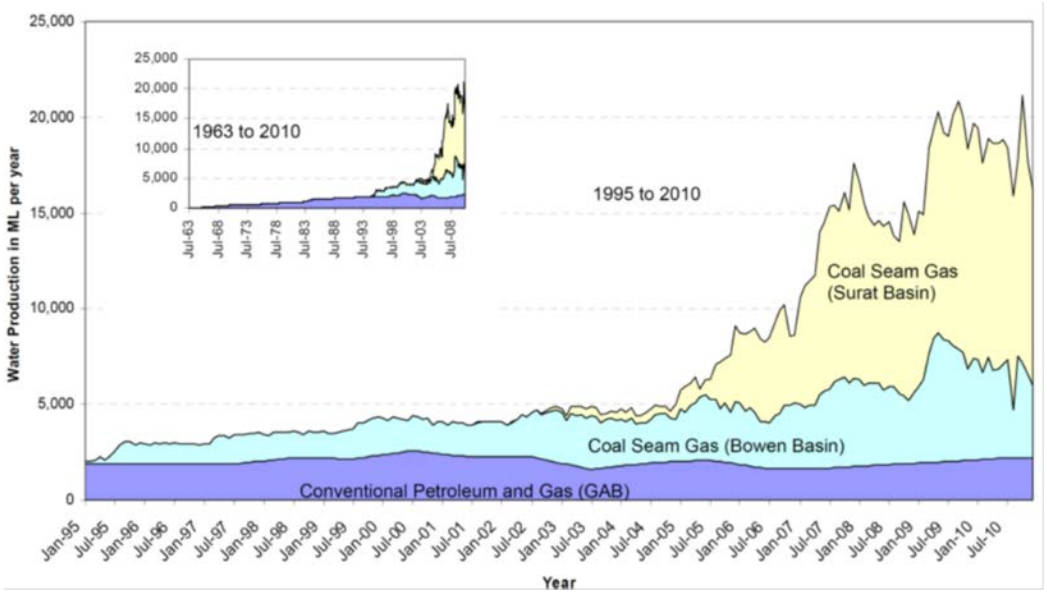
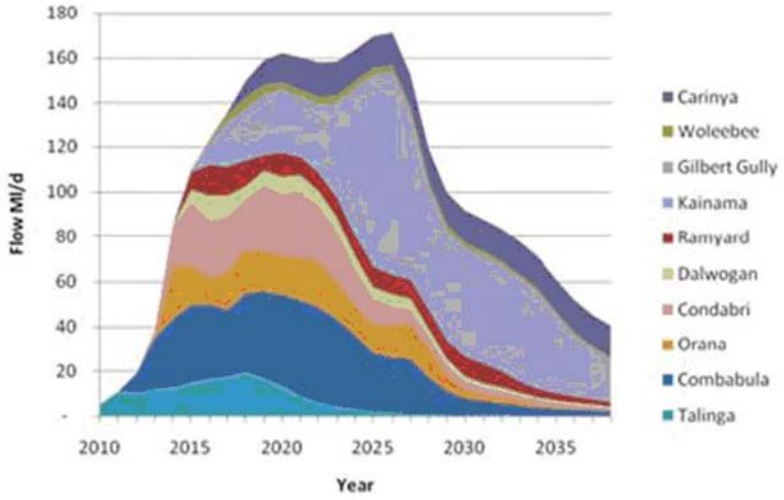
Coal Seam Gas Development





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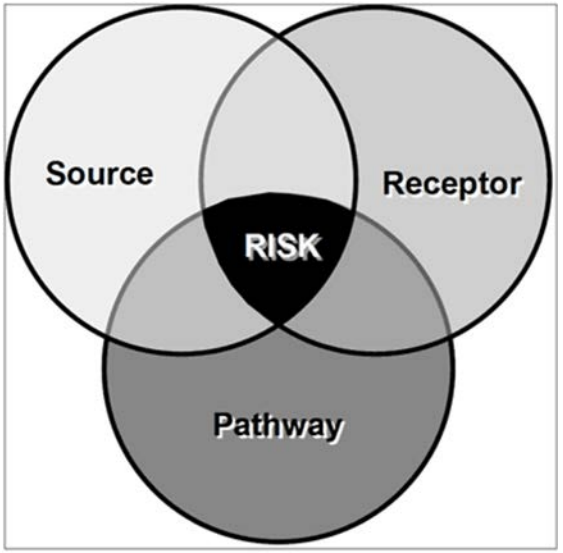
Groundwater Risk Factors

- CSG Development Hazards
- Non-CSG Hazards
- Pathways
- Receptors



Risk = Source x Pathway x Receptor

or equivalently

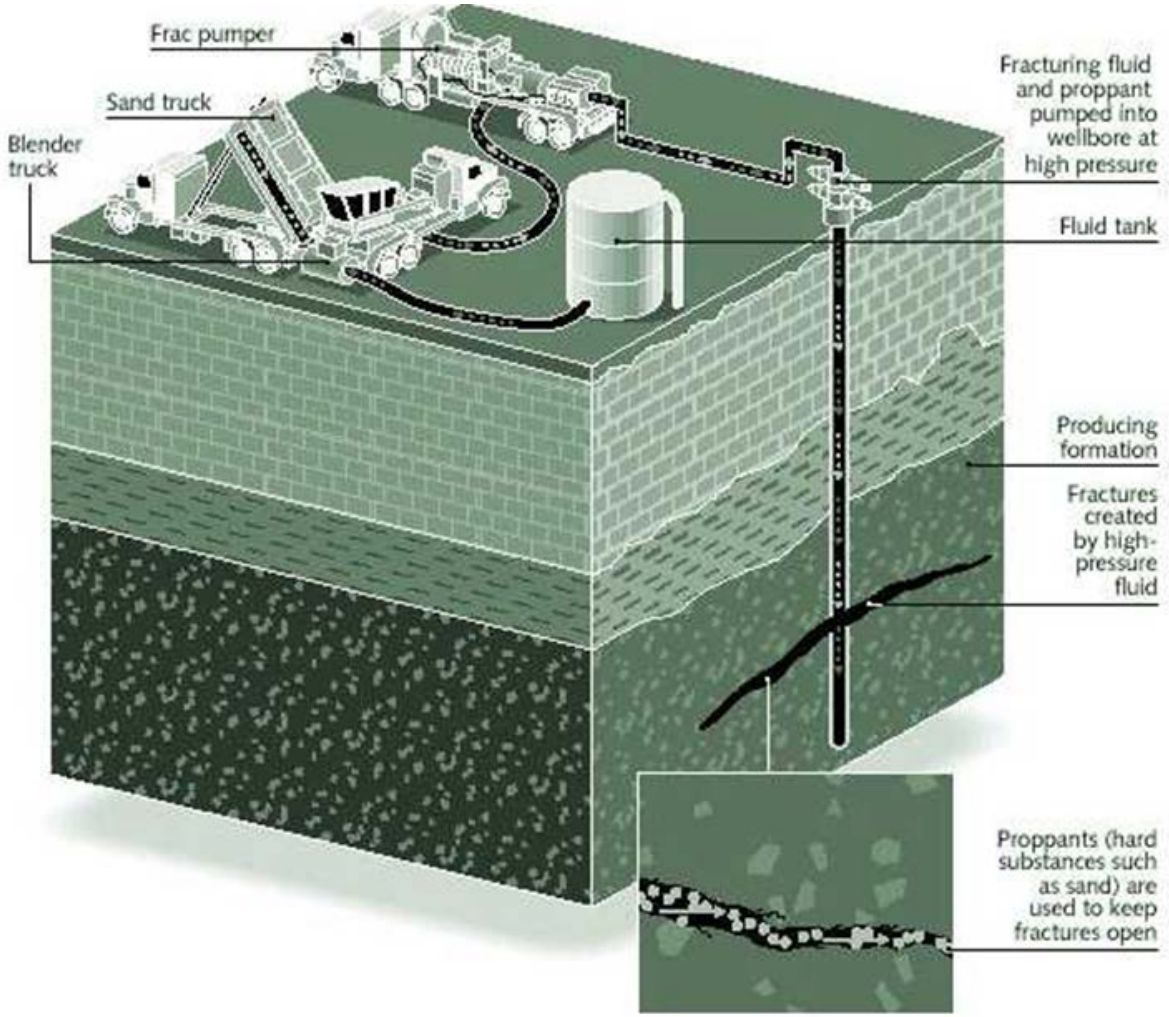
Risk = Hazard x Vulnerability x Consequence

CSG Development Hazards

- **Well construction and decommissioning**
  - **Surface activities**
  - **Land disturbance**

CSG Development Hazards

- **Hydraulic fracturing at CSG wells**



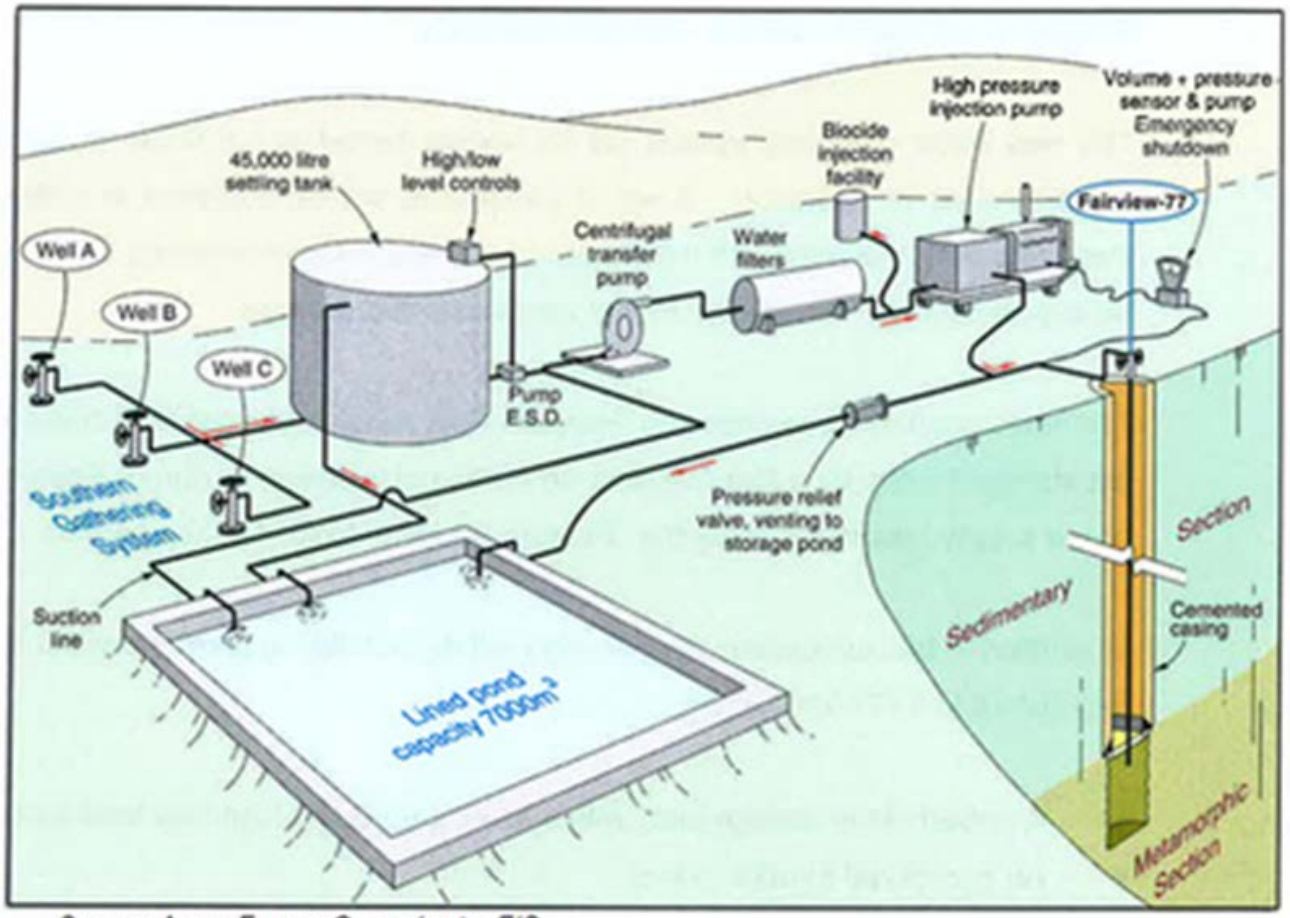
CSG Development Hazards

Gas Migration

- Some gasses might propagate to shallower formations through wellbores or via natural geological pathways (e.g., faults)

CSG Development Hazards

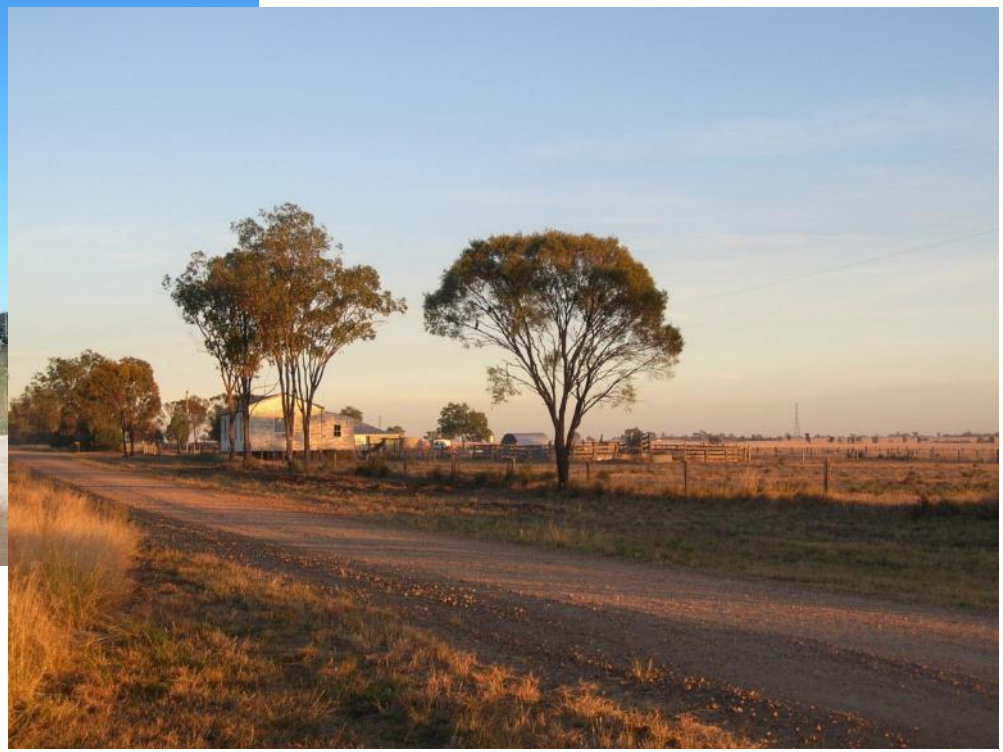
- **Produced water management**
  - Surface storage and handling of large amounts of water
  - Disposal of wastes
  - Brine; salts



Source: Arrow Energy Groundwater EIS

Non-CSG Hazards

- **Existing groundwater use**
  - Conventional petroleum and gas industry
  - S&D, town, agricultural and industrial use



Non-CSG Hazards

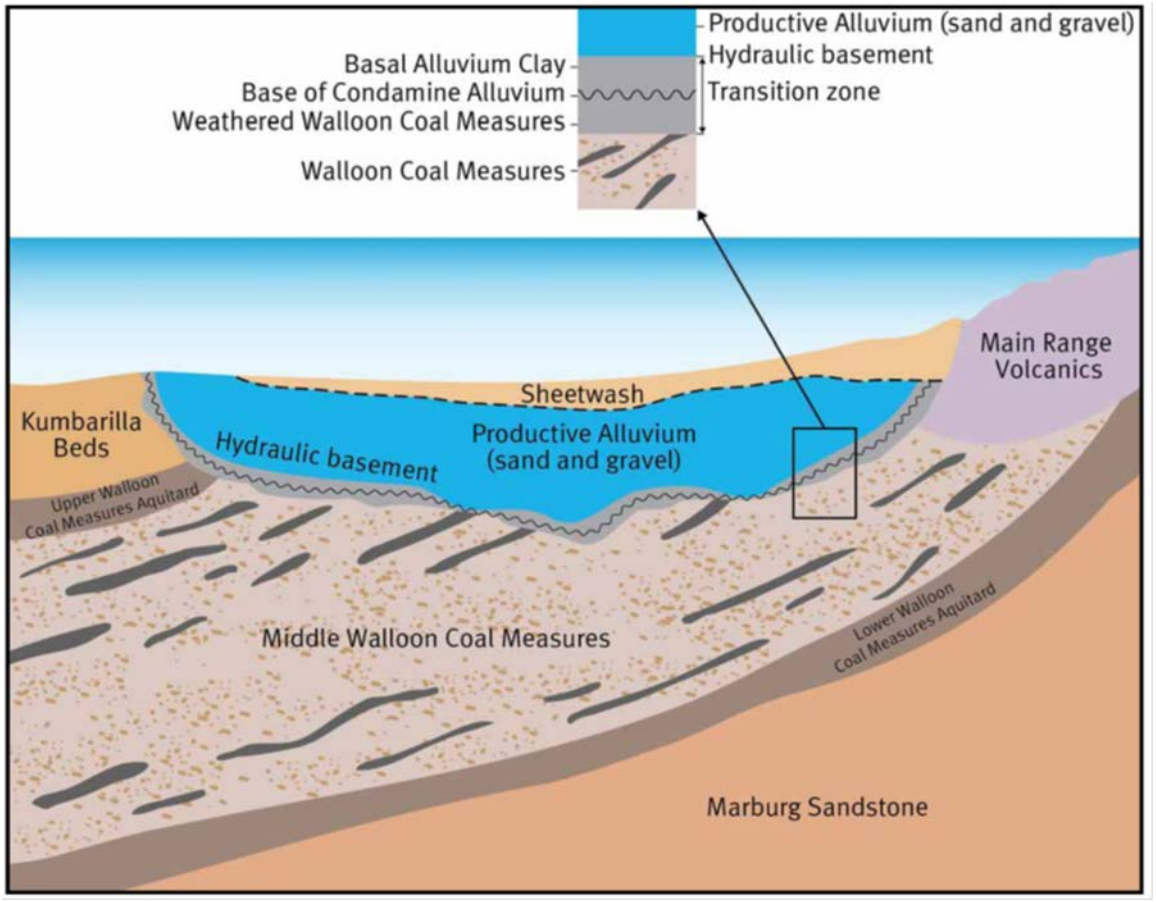
- **Land use change**

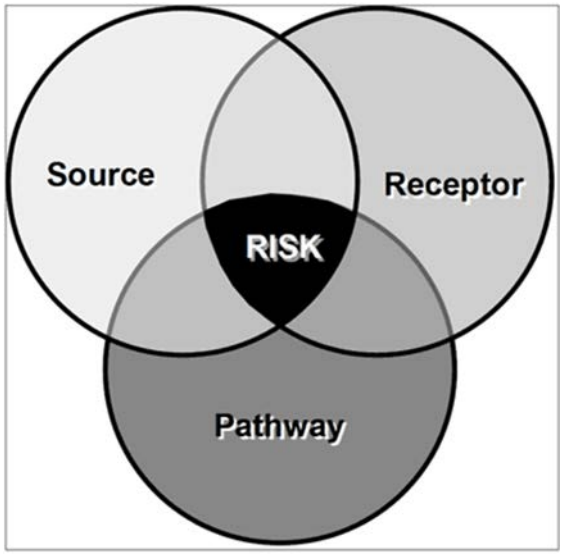
Non-CSG Hazards

- **Climate Variability and Change**

Groundwater Pathways

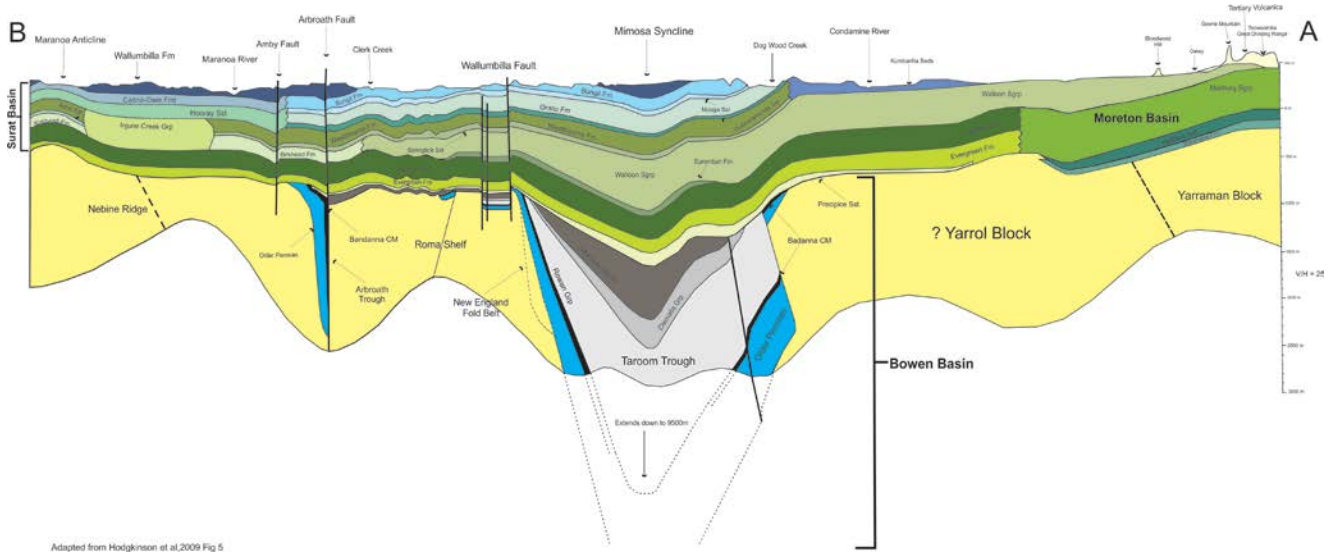
- **Proximity of aquifers to coal measures**





Groundwater Pathways

- **Aquifer and aquitard inter-connectivity and hydraulic properties**
- **Contained in regional cumulative effects groundwater model developed by Queensland Water Commission (QWC, 2012)**



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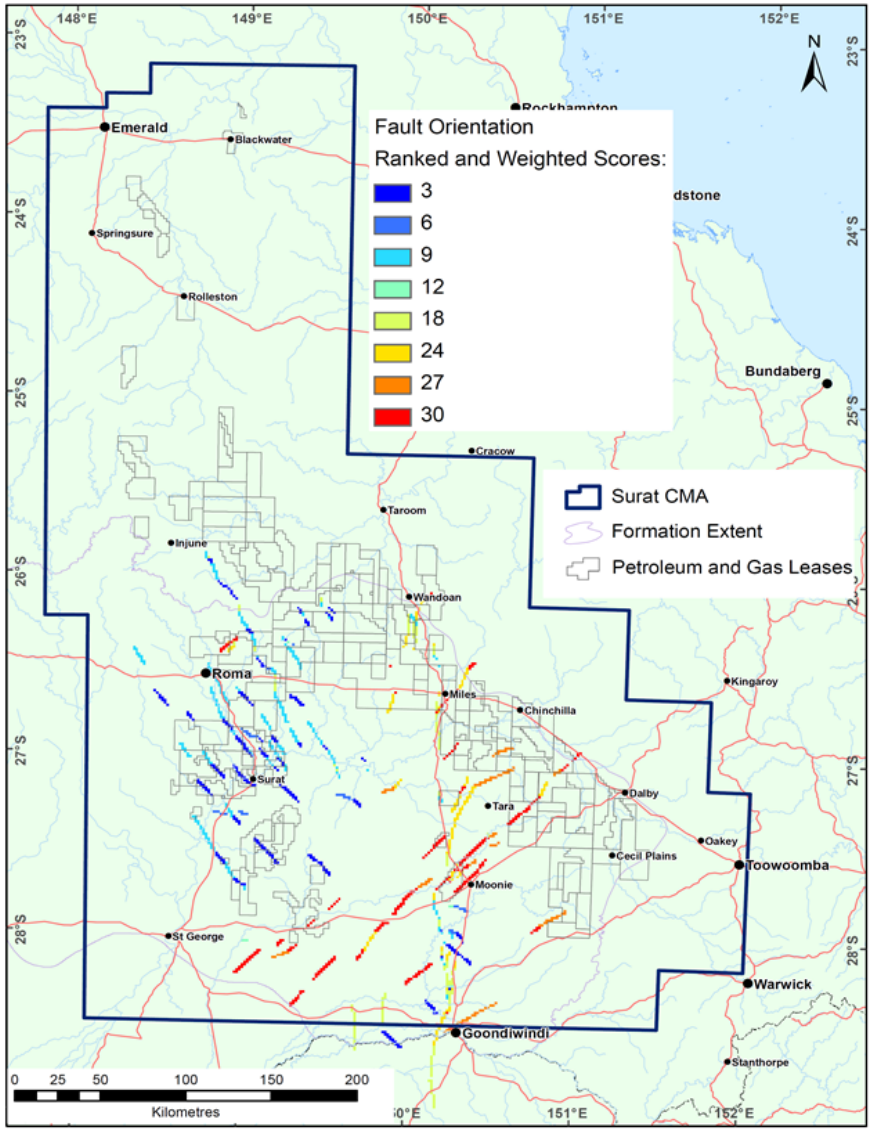
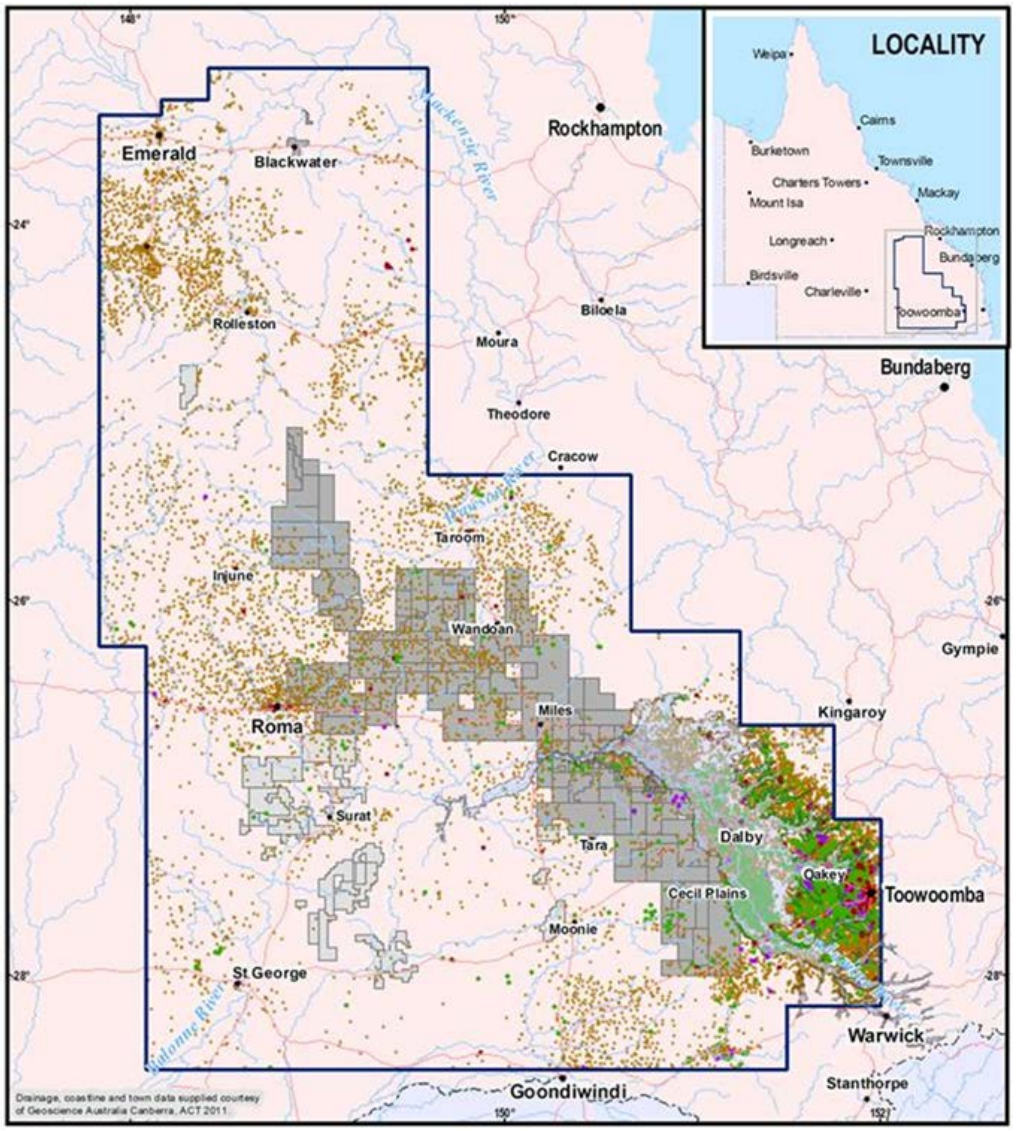
Groundwater Pathways

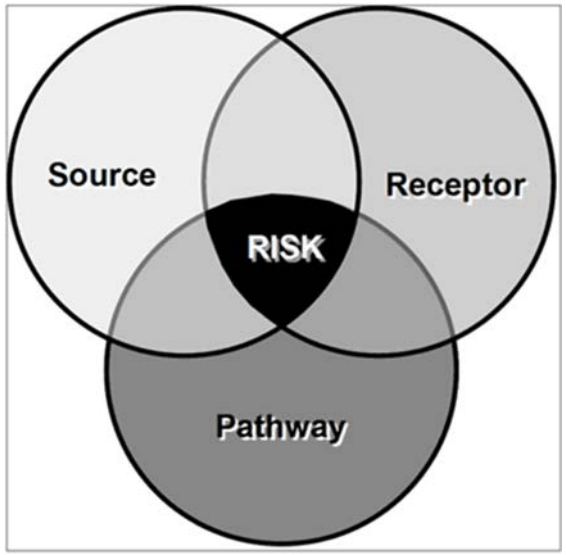
- **Fault and wellbore pathways not addressed by QWC**

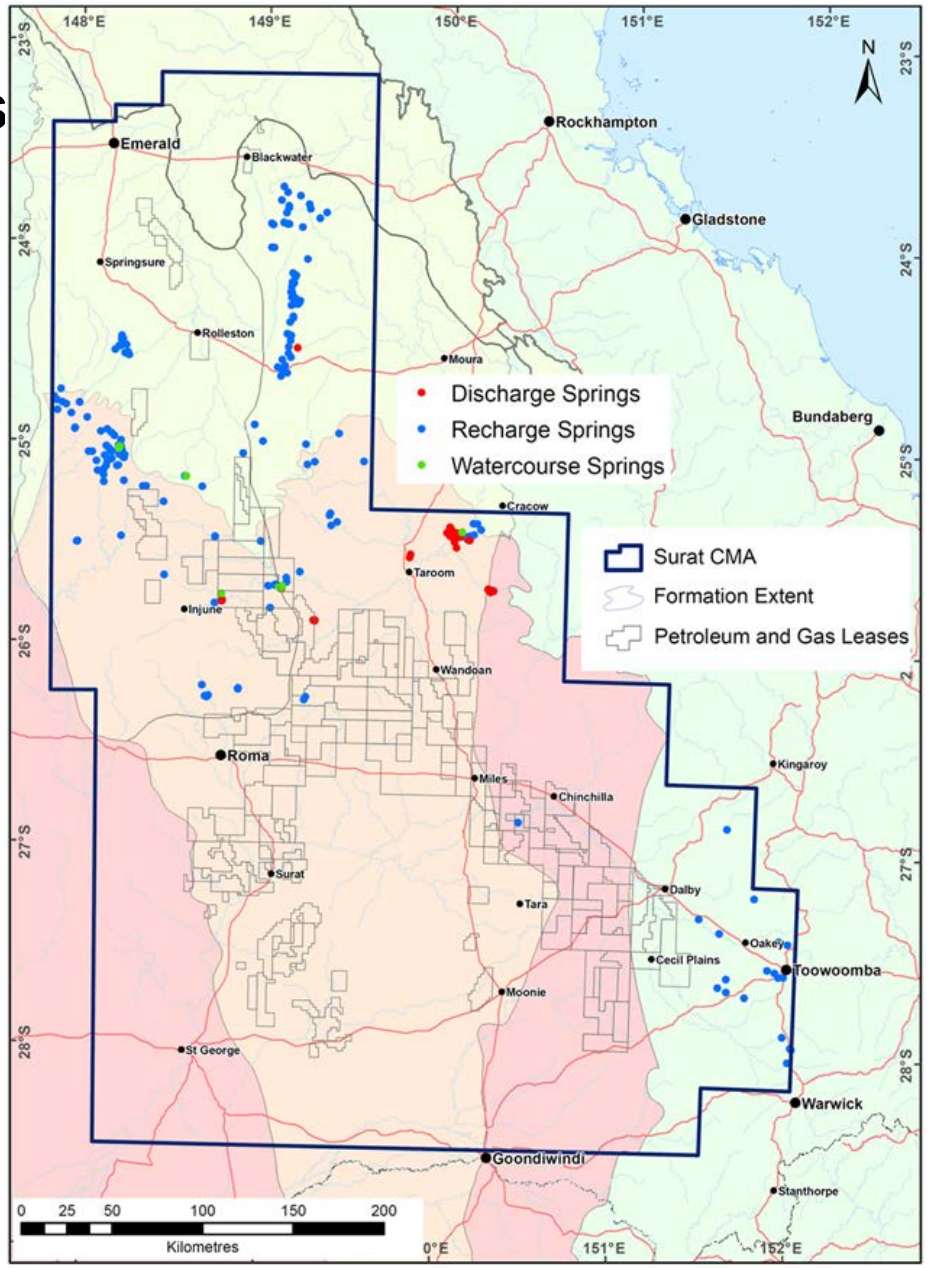




Groundwater Receptors

- Existing groundwater users
- Groundwater Dependent Ecosystems (springs)
- Aquifer sustainability





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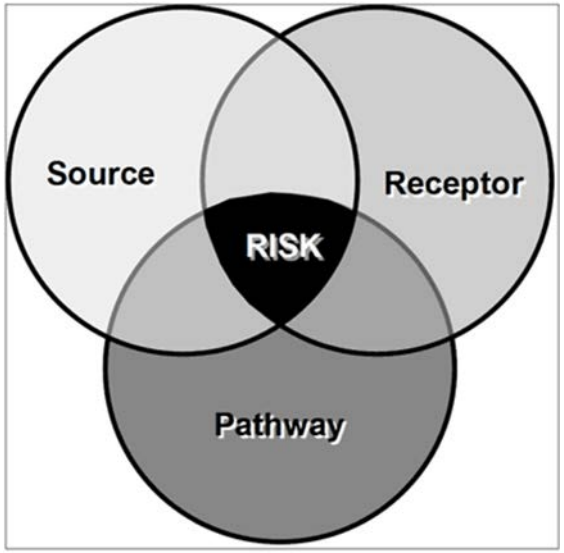
Risk Assessment Objectives

- Basic hazards associated with CSG development are known
- Potential cumulative effects of CSG water extraction have been addressed through QWC groundwater modelling
- But…significant uncertainties and different views about nature and extent of groundwater impacts remain:
- Hazards and vulnerabilities unaddressed in modelling to date require further investigation
    - Faults
    - Wellbore pathways
- Focus also needed on consequence of impacts for ecosystems, communities and agricultural/industrial interests reliant on groundwater (receptors)

Risk Assessment Methodology



Risk = Source x Pathway x Receptor

or equivalently

Risk = Hazard x Vulnerability x Consequence

Risk Assessment Methodology

- Multi-Criteria Analysis (MCA) to deal with different attributes within each component
- i.e. aquifer/aquitard, fault and wellbore pathways

$$\text{Vulnerability} = \sum_{a} V(x,y,z)_a = \sum_{a} Wt_a * Rnk(x,y,z)_a$$

$$\text{Consequence} = \sum_{a} C(x,y,z)_a = \sum_{a} Wt_a * Rnk(x,y,z)_a$$

- Weights and ranks for each attribute determined in consultation with project steering committee
  - Weights vary from 1 to 5
  - Ranks vary from 0 to 10

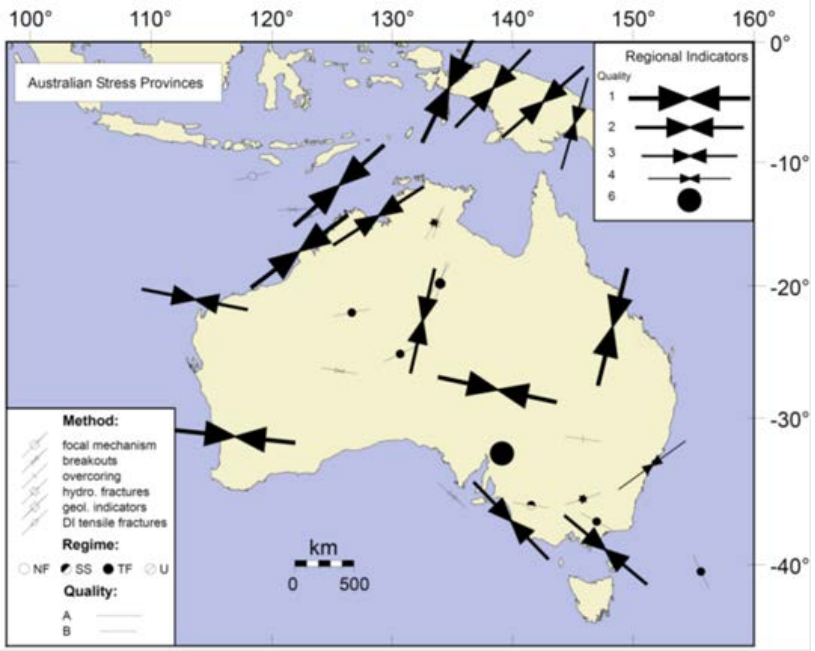
Risk Assessment Methodology

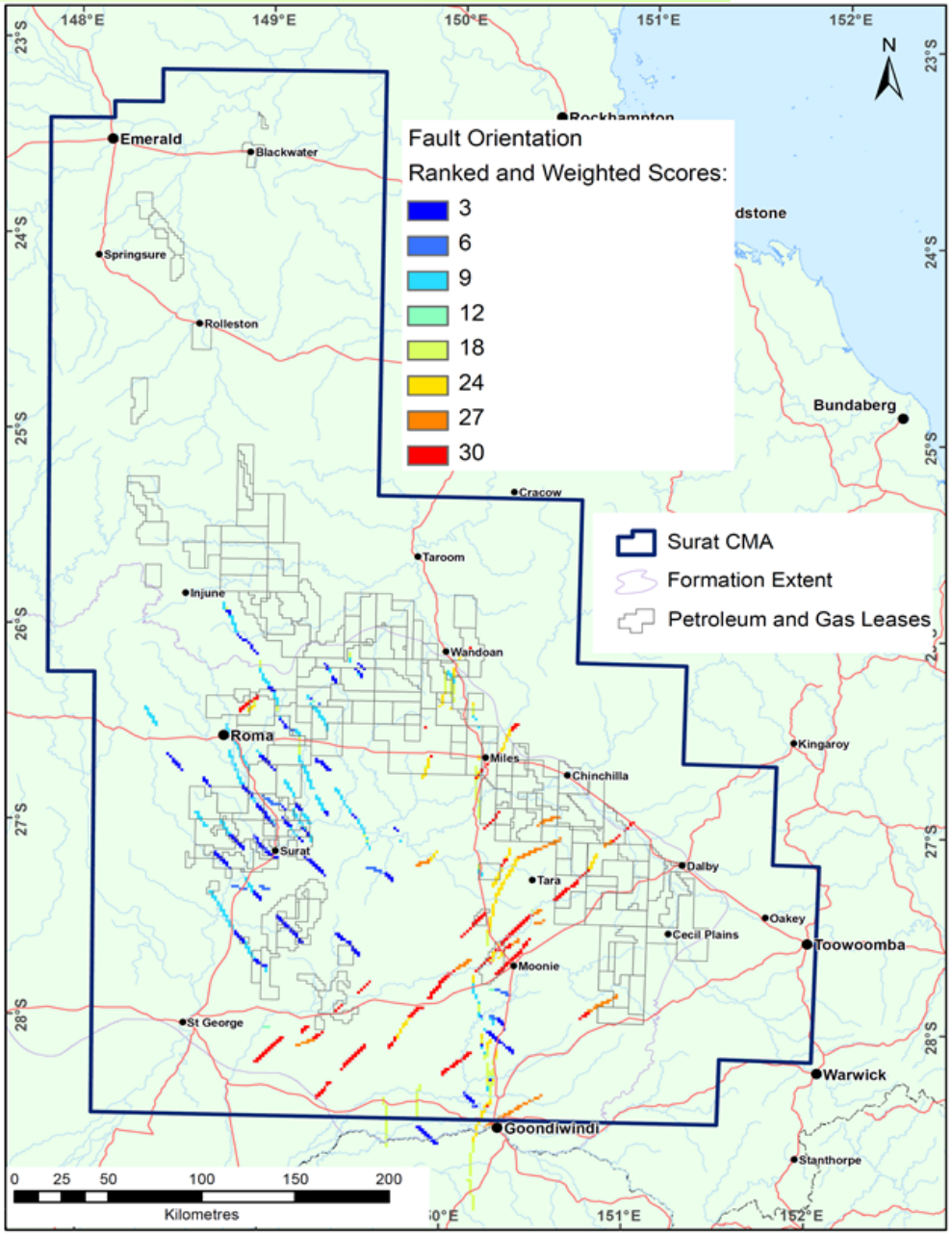
- Risk varies spatially in response to location of hazards and receptors and spatial variability in aquifer and aquitard pathways

- Risk calculations are therefore performed in a mapping environment (GIS)

Risk Assessment Methodology

- Fault pathways
  - Ranking based on fault orientation relative to tectonic stress regime





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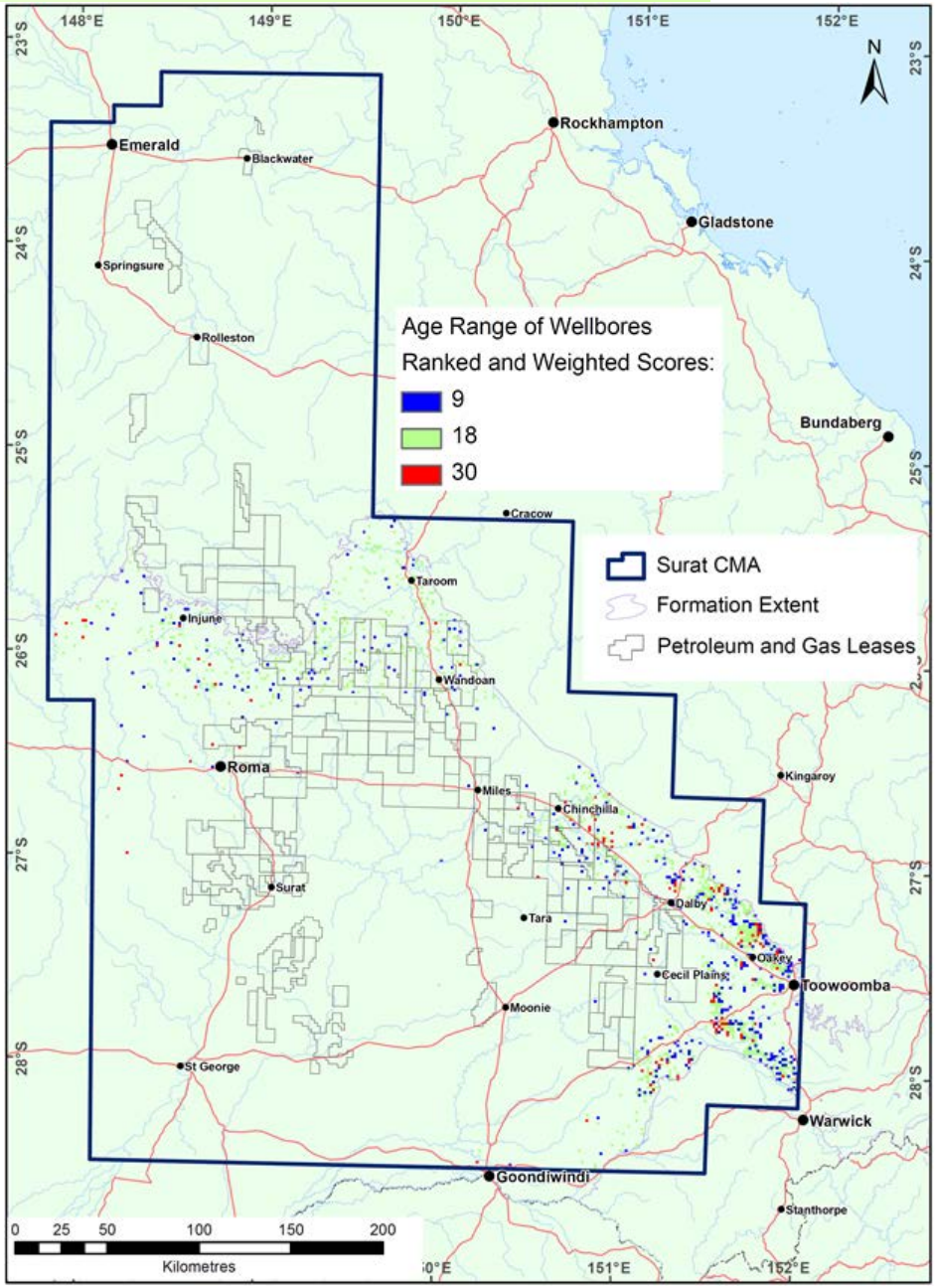
Risk Assessment Methodology

- Wellbore pathways
  - Ranking based on wellbore age



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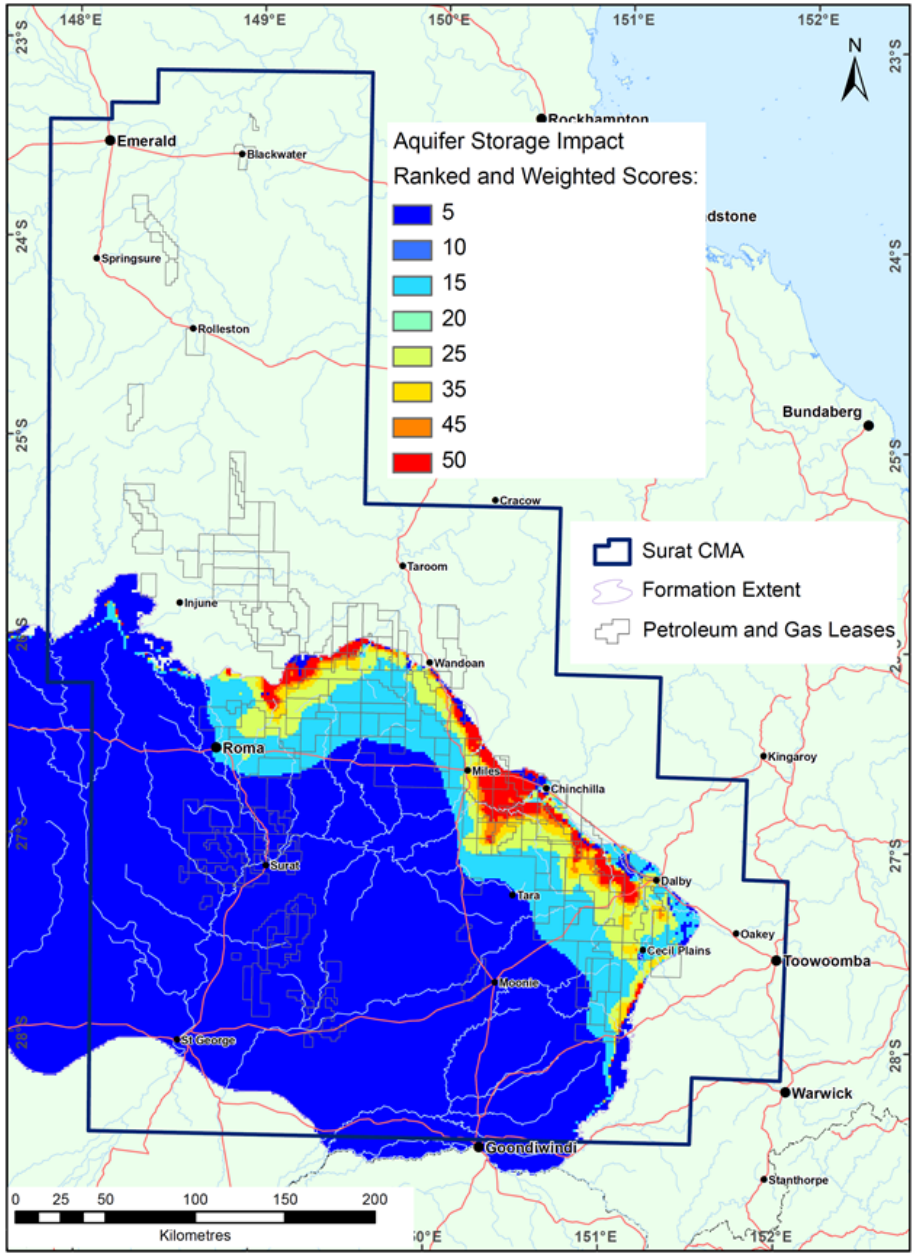
Risk Assessment Methodology

- Aquifer sustainability
  - Ranking based on available drawdown



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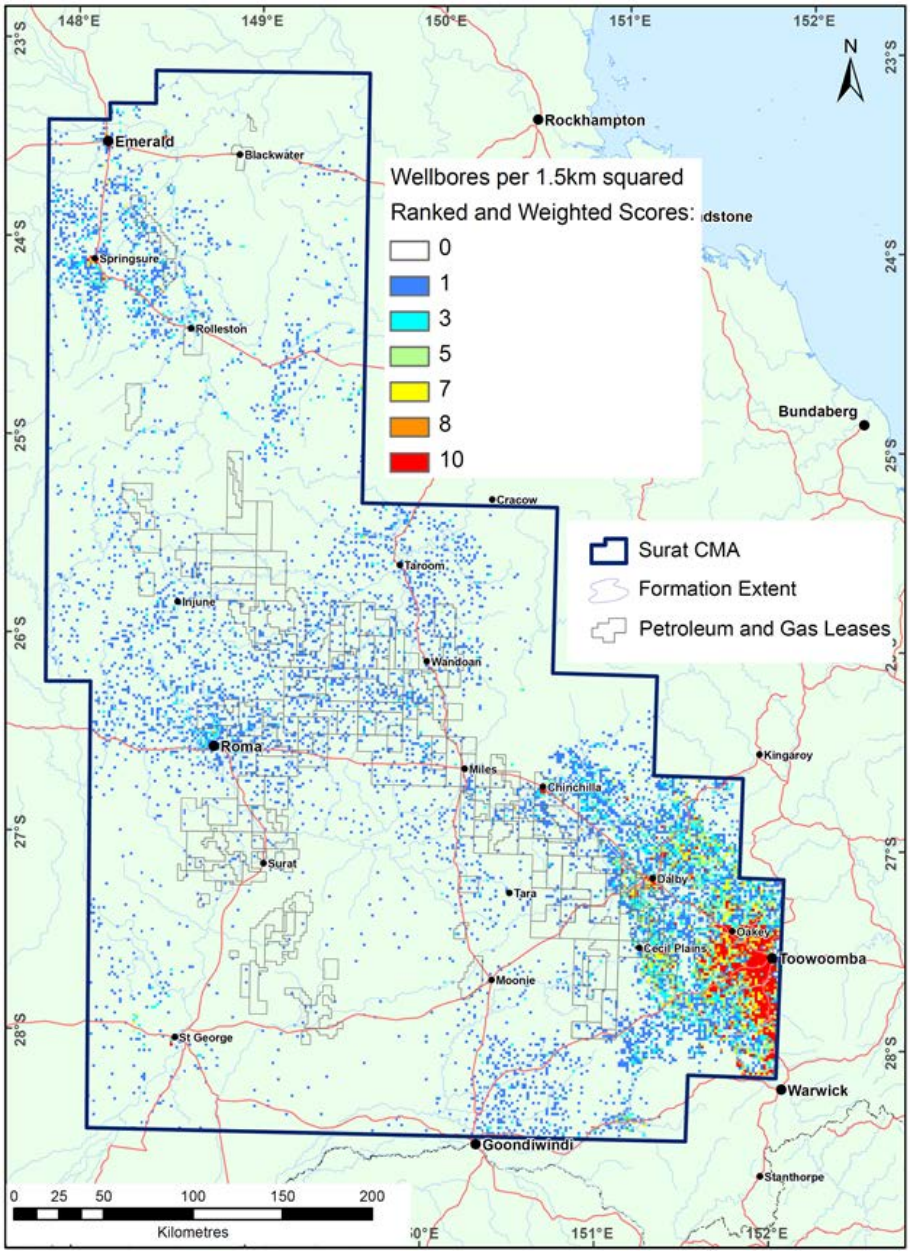
Risk Assessment Methodology

- Value of resource
  - Ranking based on wellbore density
  - Similar rankings for water use purpose and water use volumes



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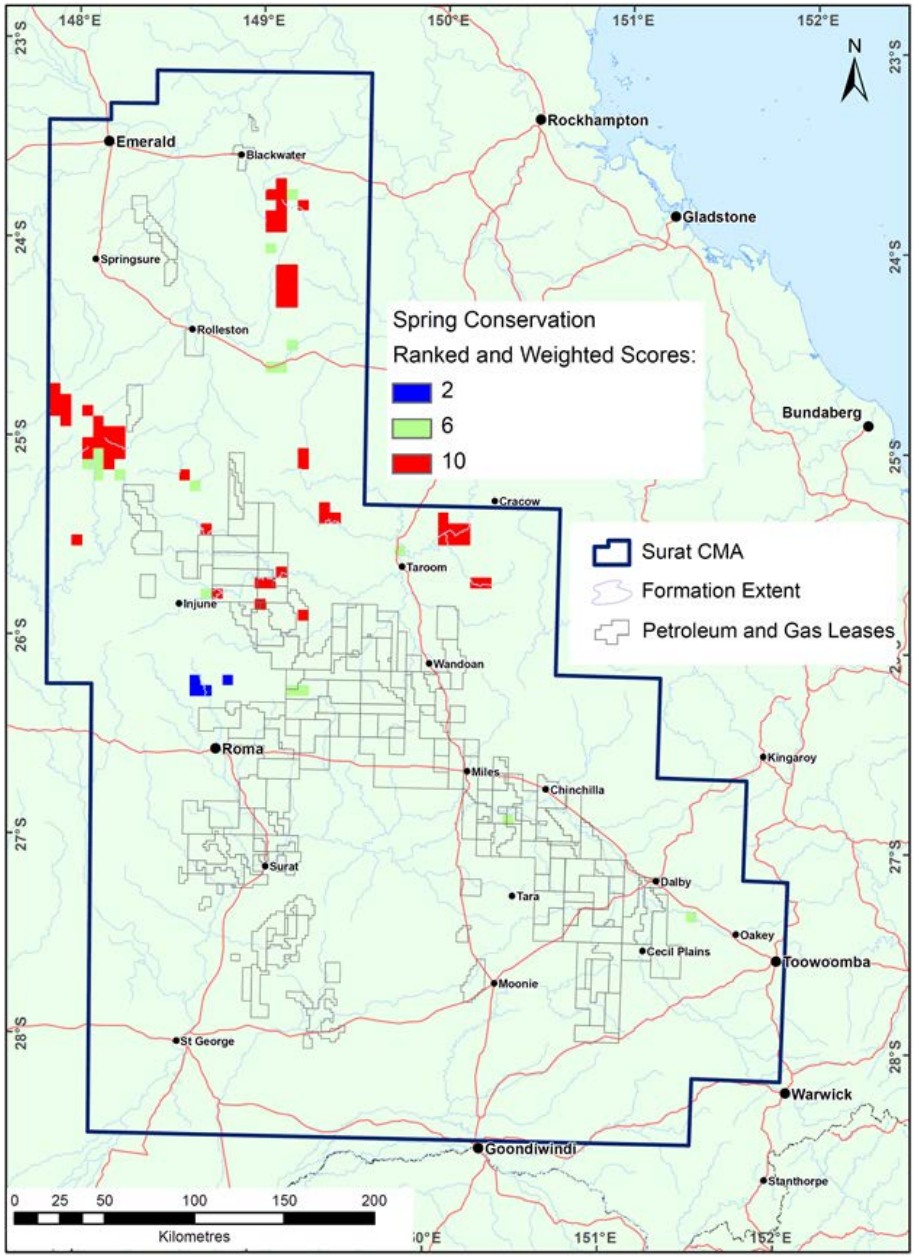
Risk Assessment Methodology

- Value of springs
  - Conservation ranking based on Fensham et al. (2010)
  - Takes into account presence of endemic species and degree of degradation



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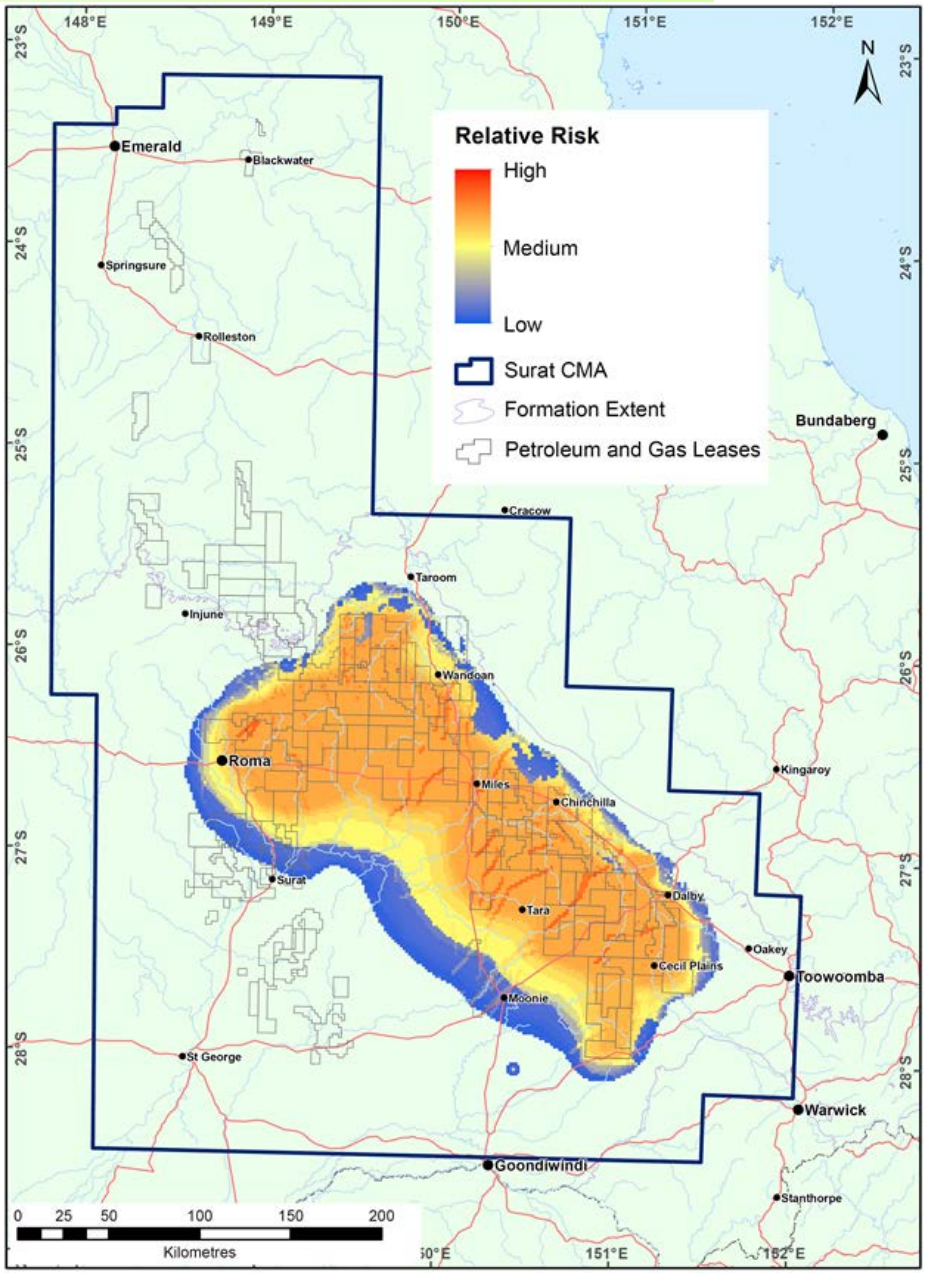
Risk Mapping Results

- Risk mapping interpretation:
  - Risk is relative, rated from low to high
  - Risk can be compared across aquifers and locations, but not between different receptor types because they represent different values

Risk Mapping Results

- CSG Water Extraction Hazard – Risk to Aquifer Storage
  - Walloon Coal Measures
  - Interval of CSG water extraction
  - Medium-high risk predominantly driven by groundwater drawdown
  - Faults and wellbores may increase risk locally



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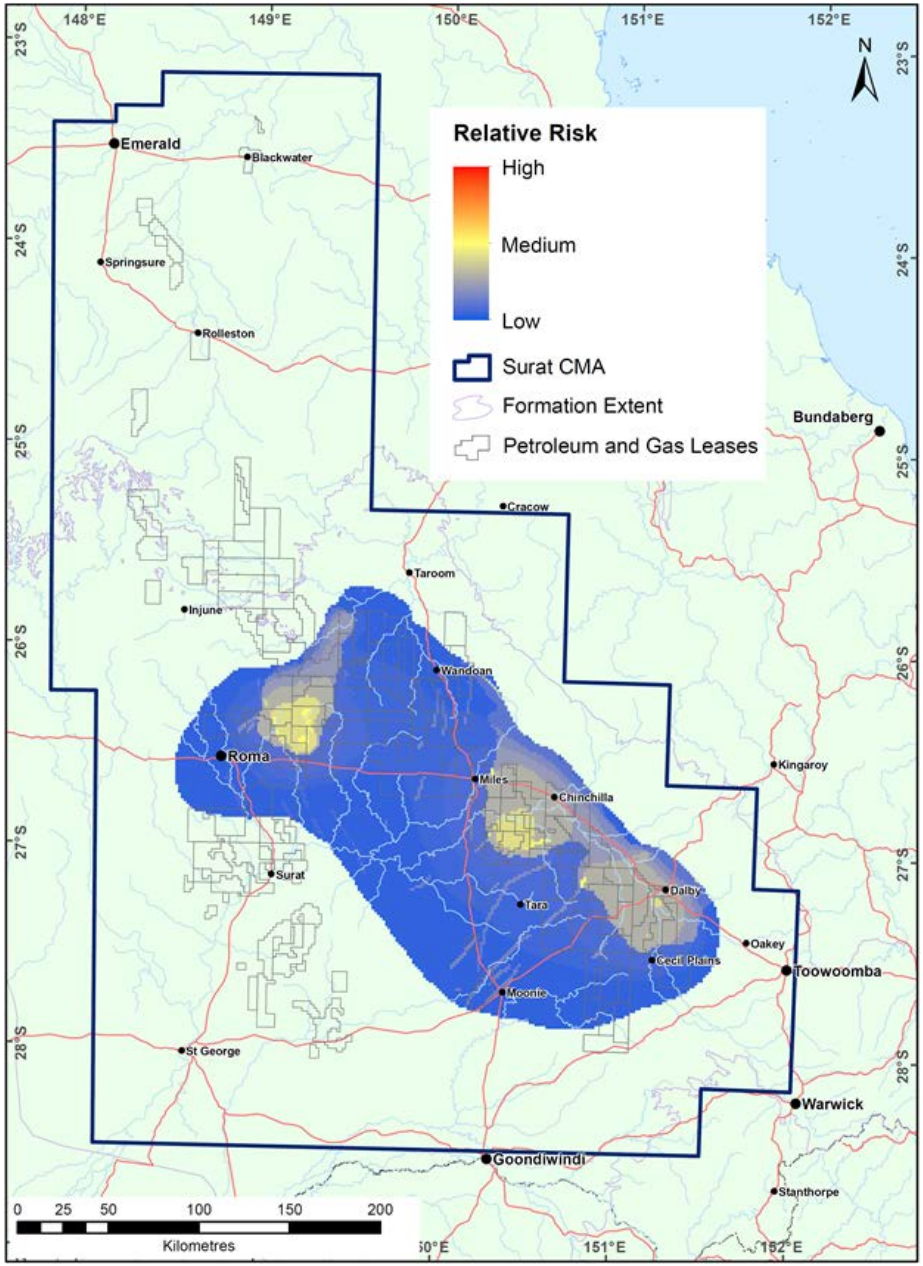
Risk Mapping Results

- CSG Water Extraction Hazard – Risk to Aquifer Storage
  - Hutton/Marburg Sandstone
  - First aquifer below WCM
  - Medium risk in three areas related to CSG development in Surat Basin
  - Faults may increase risk locally
  - Wellbores do not affect risk profile due to limited overlap of bores with CSG development



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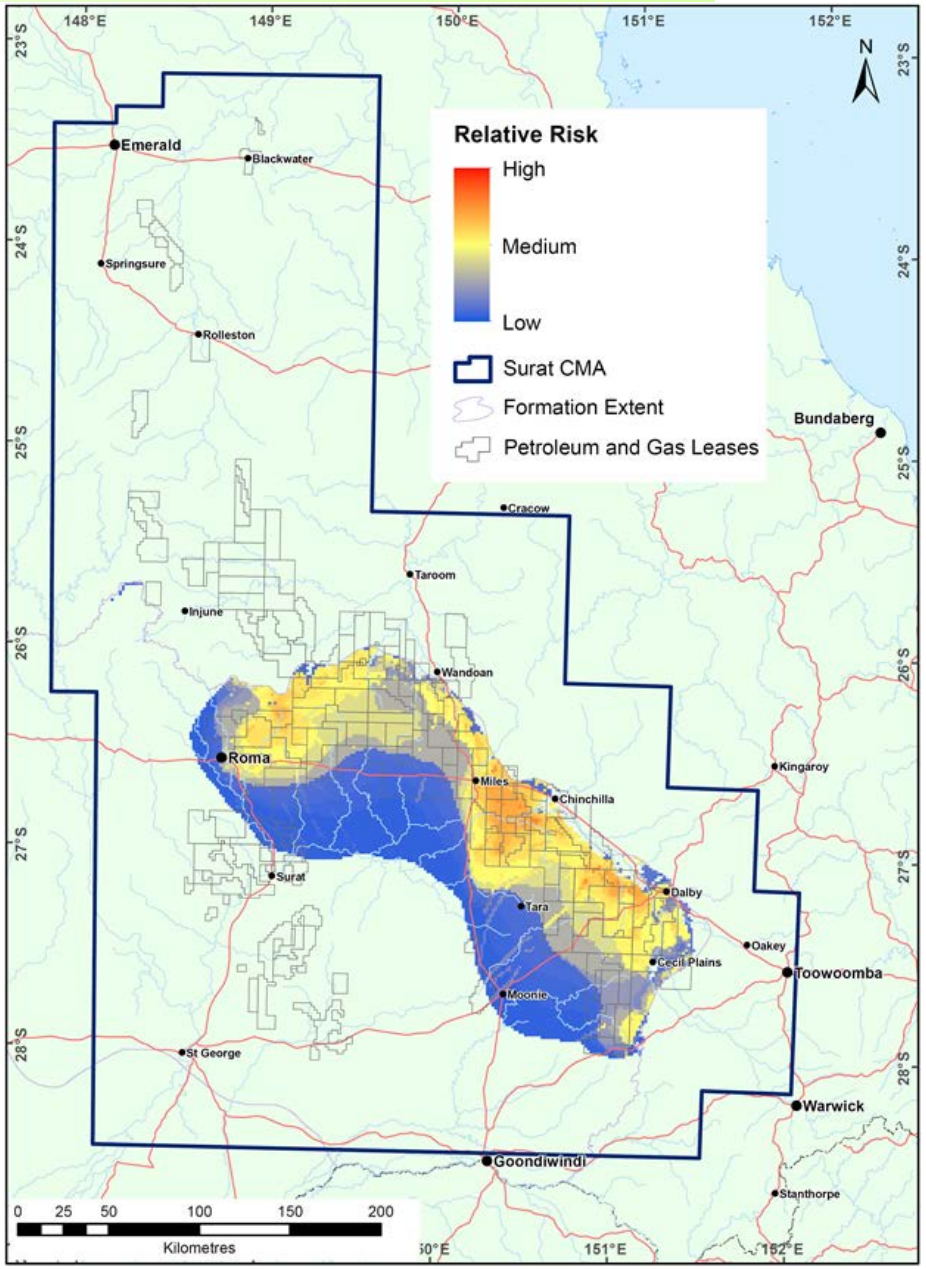
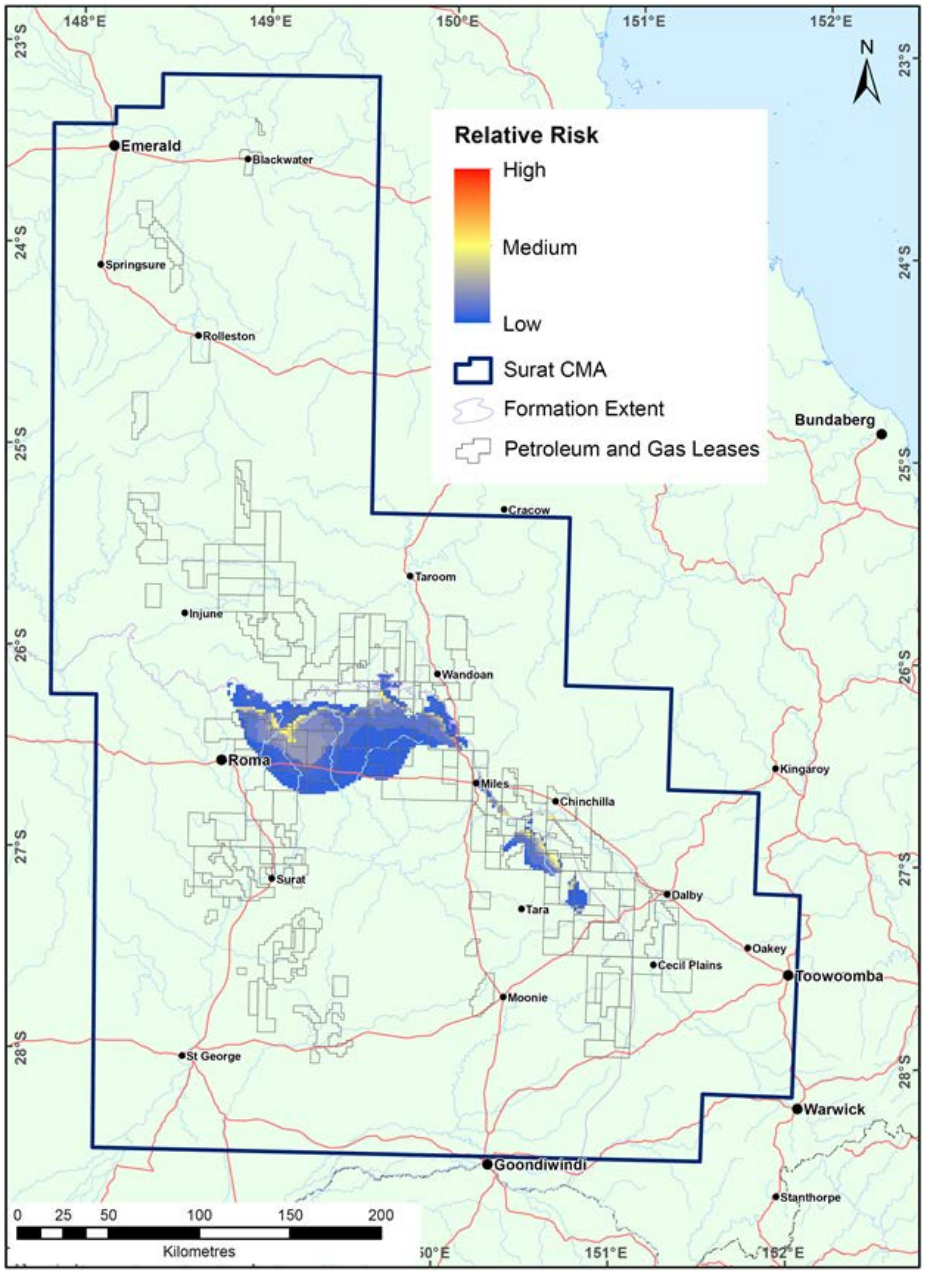
Risk Mapping Results

- CSG Water Extraction Hazard – Risk to Aquifer Storage
  - Lower Springbok Sandstone
  - First aquifer above Walloon Coal Measures
  - Medium to high risk scores in three areas
  - Results driven by groundwater drawdown and limited available drawdown near formation subcrop edge.
  - Faults and wellbores may increase risk locally



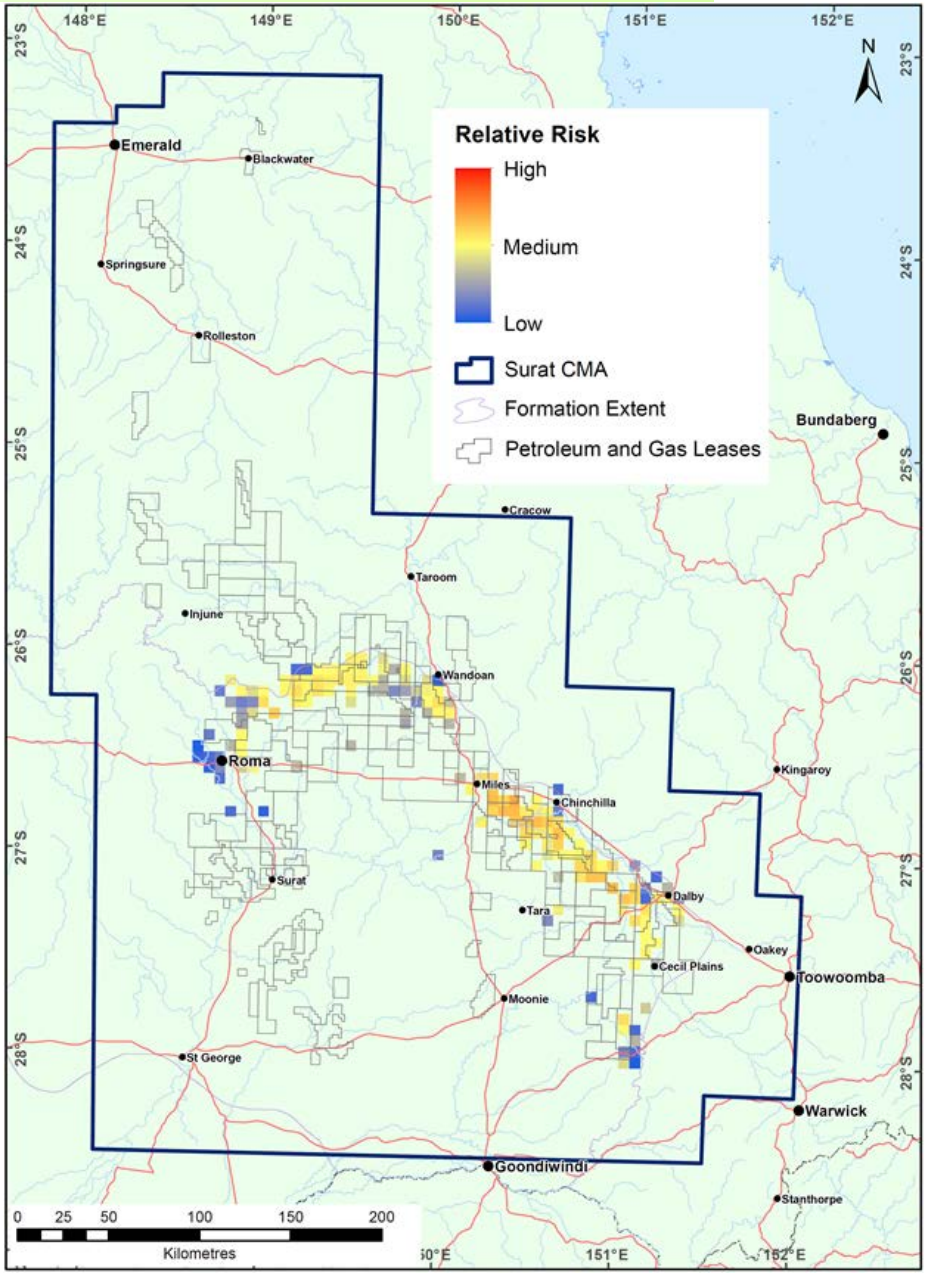
Risk Mapping Results

- CSG Water Extraction Hazard – Risk to Aquifer Storage
  - Gubberamunda Sandstone
  - Third aquifer above Walloon Coal Measures
  - Risk lower compared to Lower & Upper Springbok Sandstone due to greater distance from WCM
  - Wellbores do not play appreciative role in risk profile
  - No mapped faults above lower Springbok hence no associated risk increase



Risk Mapping Results

- CSG Water Extraction Hazard – Risk to Groundwater Users
  - Lower Springbok Sandstone
  - First aquifer above Walloon Coal Measures
  - Relative risk to groundwater users is generally highest along the centreline of CSG tenements in the Surat Basin



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Conclusions

- Study has provided a foundation methodology, focused on the hazards that result from the production of CSG water
- Methodology has capacity to be:
  - Expanded to include other hazards (e.g. hydraulic fracturing)
  - Refined with respect to weighting and ranking values
  - Re-run as new data is acquired
- This will refine and improve risk mapping results over time

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Conclusions

- The risk assessment results can guide the development of a regional monitoring regime
- Areas of highest risk might be targeted for adaptive management or for focused studies to identify whether risk is being actualized
- The ultimate goal of these activities should be to manage and minimize risk to potential receptors from CSG water extraction
- Methodology is adaptable to other areas (e.g. shale gas)

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Thank You

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