5. Summary

Data for subsurface resources, including petroleum, geothermal energy, CGS, UGS and groundwater were compiled and assessed from various sources. This information was integrated into a GIS-based framework to analyse resource distribution and potential interactions. At a regional scale, the overlap of subsurface resources follows 3 key stratigraphically controlled categories (Figure 54):

1. **Within the Permian intervals below the Kockatea Shale**: petroleum, CGS, UGS and geothermal resources show high-interaction potential.
2. **Within the Triassic-Lower Jurassic Cattamarra Coal Measures-Eneabba/Lesueur interval:** groundwater, petroleum and CGS resources show medium to low interaction potential.
3. **Within the Upper Jurassic-Cenozoic interval:** groundwater resources show low interaction potential, but increasing demand for future domestic, agricultural and industrial use.

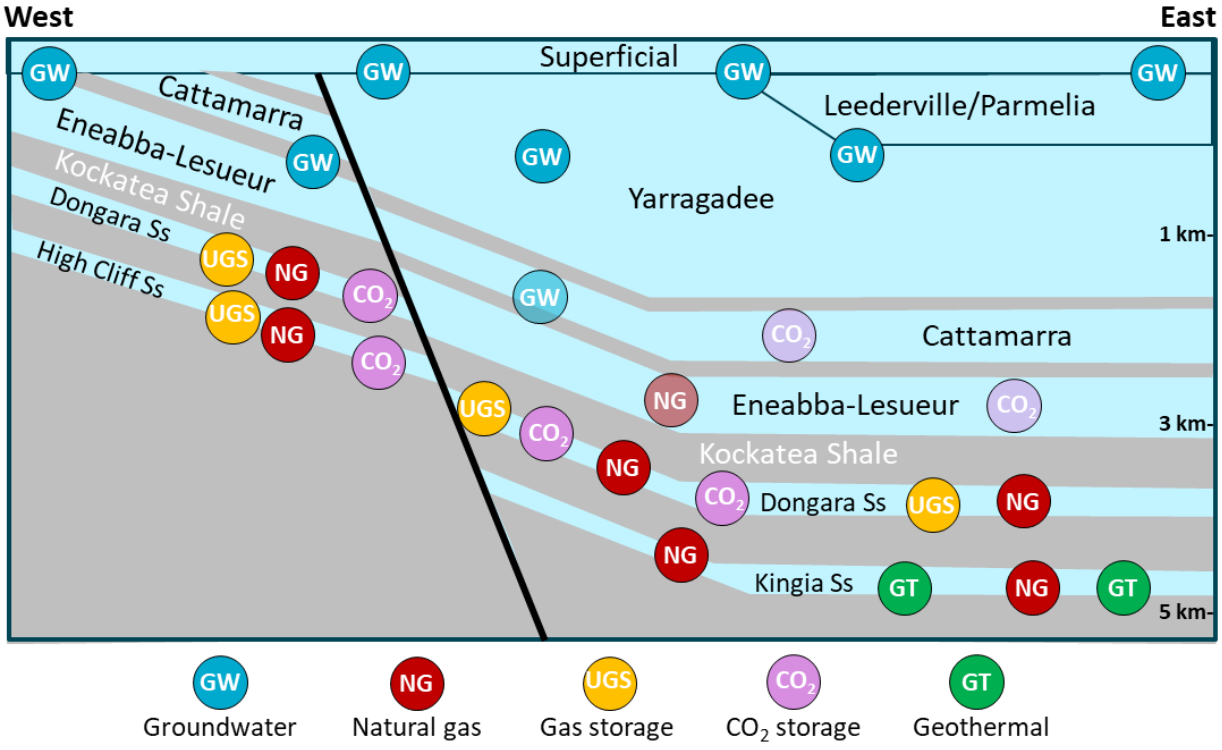

Figure 54. Formations targeted by different subsurface developments in the northern Perth Basin suggesting potential overlap of natural gas, CO_2 storage, UGS and geothermal resources below the Kockatea Shale, and b) limited overlap of groundwater, natural gas and CO_2 storage in the Cattamarra Coal Measures-Eneabba/Lesueur interval. Faded colours imply limited suitability.

The interactions between deep subsurface resources and groundwater in the northern Perth Basin are generally limited, as most petroleum, CGS, UGS and geothermal resources are stratigraphically separated from key aquifers by sealing formations. However, localised interaction pathways could exist where structural permeability is enhanced. In areas with high fault displacement or legacy well networks, there is potential for upward migration of fluids, which requires careful assessment

to mitigate risks to groundwater quality and availability. While the primary groundwater sources (Yarragadee, Leederville-Parmelia and Superficial aquifers) remain largely unaffected by deep resource development, industrial water use and future groundwater allocations must be considered alongside subsurface energy projects to ensure sustainable water resources management.

5.1. Petroleum, CGS, UGS and geothermal resources below the Kockatea Shale

The Permian interval below the Kockatea Shale has the highest potential for resource interaction, where petroleum, geothermal, UGS and CGS prospects largely overlap to form a northern interaction hotspot, extending from the Allanooka Terrace and northern Dandaragan Trough, and continuing south, in a narrower corridor, along the Cadda Terrace (Figure 55).

In general, this zone of high resource interaction aligns with the western flank of the northern Perth Basin, where these resources are at the appropriate depths (< ~ 4000 m) for development.

- CGS and petroleum resources exhibit strong spatial overlap in the Permian intervals due to their shared reliance on high-quality reservoir formations and regional sealing units.
- Geothermal and UGS act as secondary interacting resources.
- Currently, no commercial CGS or geothermal projects are operational in the northern Perth Basin, leading to significant uncertainty about the viability, extent and economic feasibility of these resources.
- Groundwater suitability is absent in Permian intervals, as no aquifers under the Kockatea Shale are currently considered viable for groundwater extraction.

Figure 55A and Figure 55B provide conceptual views of overlapping resource interactions in key areas, including:

- the northern hotspot near the Allanooka, Beharra Springs, Donkey Creek and Irwin Terraces (Figure 55A and Figure 55E)
- the north-south corridor, from Donkey Creek Terrace to the Beermullah Trough, where petroleum and CGS suitability remain high on the western flank of the basin (Figure 55B).

While geothermal potential is highest in the northern part of this region, constrained by elevated temperatures in the Kingia Sandstone, petroleum and CGS suitability extend across a wider area within multiple Permian formations, including the Wagina and Dongara formations (Figure 47A–D).

Given the strong overlap of resources below the Kockatea Shale, future resource development in this interval will require coordinated subsurface planning. Petroleum and CGS operations will likely be the dominant users of these formations. The potential for geothermal activities remains uncertain due to current data limitations and the lack of active projects. Further technical assessments and regulatory frameworks will be necessary to resolve resource competition and optimise multi-use subsurface strategies in this highly prospective region.

5.2. Groundwater, petroleum and CGS in the Cattamarra Coal Measures, Eneabba, and Lesueur interval

The Triassic-Lower Jurassic interval, which includes the Cattamarra Coal Measures, Eneabba Formation and Lesueur Sandstone, exhibits moderate to low resource interactions, primarily between CGS and petroleum. These interactions form a north-south corridor extending from the Allanooka Terrace to the Mandurah Terrace (Figure 55).

In general, this zone of resource interaction also aligns with the western flank of the northern Perth Basin.

- CGS is the dominant interacting resource in this interval, overlapping extensively with petroleum prospects.
- Groundwater resources are present in this interval but mainly occur in the shallowest portions of the formation toward the west, where they do not significantly overlap with petroleum or CGS resources.

Figure 55C and Figure 55D illustrate the conceptual distribution of overlapping resources.

- In the Allanooka, Beharra Springs, Donkey Creek and Irwin Terraces area (Figure 55C), CGS exhibits spatial overlap with petroleum resources, while groundwater resources remain distributed in overlying formations. No significant interaction occurs between groundwater and petroleum or CGS within this interval.
- Along the north-south corridor (Figure 55D), CGS overlaps with petroleum in the deeper part of the basin (for example, the Coomallo Trough), while groundwater is present in the shallowest part of the interval closer to the coast.

Development of petroleum and CGS within the Cattamarra-Eneabba/Lesueur interval is relatively limited and mostly located west of the Dandaragan Trough axis (Figure 55D and Figure 55E). Groundwater production from these formations is largely restricted to western areas where they are shallow, minimising the potential for conflicts with deeper resource operations (Figure 55D).

While resource interaction in the Triassic-Lower Jurassic interval is lower than in the Permian interval, CGS and petroleum remain the most relevant interacting subsurface resources. Groundwater production from these formations is minimal and occurs in specific shallow areas, reducing the likelihood of direct resource conflicts. However, broader groundwater management concerns must be addressed, particularly regarding industrial water use and future groundwater allocations. Moving forward, integrating groundwater protection measures with petroleum and CGS development plans will be essential to ensure long-term resource sustainability and regulatory alignment.

5.3. Groundwater resources within the Upper Jurassic-Cenozoic interval

The Upper Jurassic-Cenozoic interval, which includes the Yarragadee Formation, Parmelia Formation, Leederville Formation and superficial deposits, represents the primary groundwater resource in the northern Perth Basin. These aquifers support town water supply, agriculture,

mining and petroleum industries, making groundwater a critical economic and environmental asset for the region (Figure 53).

Groundwater resources are widespread across the northern Perth Basin, but are mostly restricted to shallow depths, generally less than 1000 m (Figure 49, Figure 55C and Figure 55D). The distribution of key aquifers varies across the basin:

- In the northern part of the basin (Figure 55C), groundwater suitability is primarily associated with the Yarragadee Formation, where it is shallow and subcropping. Additional groundwater resources are present in the Leederville-Parmelia formations, which is largely confined east of the basin axis, and in the Superficial aquifers, which occur at shallow depths along the western flanks of the basin.
- In the central region of the basin (Figure 55D), groundwater resources follow similar patterns, with the addition of the Triassic and Lower Jurassic aquifers (Lesueur, Eneabba and Cattamarra formations). These subcrop along the western flank of the basin, particularly in areas such as the Cadda Terrace.

The Upper Jurassic-Cenozoic groundwater resources are generally stratigraphically isolated from deeper subsurface resource units. Thick regional seals and aquitards, such as the Kockatea Shale and Cadda Formation, typically prevent hydraulic connectivity between deep petroleum, CGS, UGS, and geothermal formations and the overlying aquifers.

However, localised migration pathways could exist where faults or well networks enhance structural permeability. Areas with high fault displacement may create potential conduits for fluid movement, particularly where faults juxtapose reservoir units against aquifers. Additionally, older or abandoned wells could act as vertical conduits, increasing the potential for interaction between deep and shallow groundwater systems.

Given the importance of groundwater resources for regional water supply, careful management is required to ensure sustainable use while mitigating risks from subsurface resource development. Although direct competition between groundwater and deeper petroleum or CGS operations is unlikely, resource extraction industries (including oil, gas, and CGS projects) could rely on groundwater for operational use. Future assessments should focus on monitoring well integrity, fault-related permeability and groundwater extraction impacts to ensure sustainable groundwater management. Understanding these hydrogeological interactions is necessary for balancing resource development while safeguarding regional water supplies for both industry and local communities.