The De Grey Canning region

CSIRO has completed, for the Government of Western Australia and industry partners, an overview of the current and future climate and water resources of the Pilbara to aid water planning and management. These resources included regional surface water, groundwater and environmental water, and allowed local studies to be placed into a regional context. The Pilbara Water Resource Assessment covers an area of 288,479 km², which is about 11% of the state of Western Australia. This is one of the world's most important resource regions for high-grade iron ore deposits and offshore gas reserves. Irrigated agriculture may also expand to augment the area's long-term grazing industries.

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The area is flatter than the other three regions of the Assessment area, with tributaries of the De Grey River rising from the Chichester Range in the south-west before flowing across granitic and greenstone basement rocks, and reaching a narrow and flat coastal plain. The eastern half of the region has poorly defined drainages in the Great Sandy Desert and Little Sandy Desert.

Each summer, there is a chance that a tropical cyclone will cross the coast and cause wind and flood damage, while bringing widespread rain to replenish aquifers and support the flora and fauna in the region. The De Grey Canning region is part of the most tropical cyclone-prone region in the Southern Hemisphere, with a tropical cyclone impacting somewhere in the region once every 2 years, on average.

The region is semi-arid, with maximum temperatures in summer often exceeding 40 °C. The mean annual rainfall deficit (rainfall – Class A pan evaporation) ranges from 2600 mm in the north-east to more than 3100 mm in the south-east. Potential evaporation exceeds rainfall by 8 to 9 times in the north-east and almost 14 times in the south-east.

Rainfall is summer dominant, and is mainly associated with thunderstorms and occasional tropical cyclones and tropical depressions, which result in runoff once infiltration thresholds are exceeded. Some lower-intensity rainfall can occur in autumn and winter, which can be more effective for plant growth and recharge given the lower temperatures.

Most of the De Grey Canning region lies outside the Hamersley Basin and therefore lacks the major iron ore mines and associated infrastructure that occur in the other three regions of the Assessment area. The region contains diverse mineral deposits, including iron ore, gold, copper, uranium and manganese. There are several small towns and accommodation for mine-site workers, but the region has the lowest population density in the Pilbara.

The physiography is dominated by its underlying geology. The western half of the region is underlain by an ancient granite–greenstone terrane, which is usually topographically low, with rounded hills, and has few aquifers. The remainder of the region is underlain by the Canning Basin in the north-east, and the Yeneena and Officer basins in the south-east. The eastern half contains mainly sand dunes with poorly defined...
drainage lines and interconnected lakes, some of which are saline.

More recent shallow alluvial deposits coincide with the modern stream network. Alluvium and valleys become more extensive with distance down the De Grey River and its main upstream tributaries: the Shaw, Coongan, Nullagine, Davis and Oakover rivers.

Soil profiles in the region are weakly developed because of the hot, arid climate and sparse vegetative cover. More developed soil profiles are associated with alluvial deposits in the lower valleys.

**Water resources of the De Grey Canning region**

Recharge in the western two-thirds of the region, which has a well-defined drainage system, is mainly through streambeds. The amount of rainfall required to initiate streamflow, and how this may change under a future climate, are therefore very important. The amount and duration of streamflow also affect how much recharge occurs in this part of the region. The main water resource in this area is a paleochannel near the outlet of the De Grey River, which supplies water to the East Pilbara Water Supply Scheme.

There are very poorly defined drainage lines and large sandplains in the eastern third of the region. Recharge is probably both direct (also called diffuse) through these sandy soils and through the beds of poorly defined stems. This rainfall recharges two important sandstone aquifers in the Canning Basin: the brackish-to-saline Broome Sandstone and the underlying fresh Wallal Sandstone.

The extent to which the De Grey and west Canning Basin aquifers can be exploited is affected by the impact of extraction on valuable coastal groundwater-dependent ecosystems (GDEs). These include saline ecosystems associated with discharge from the Broome aquifer as well as freshwater ecosystems associated with the De Grey and Wallal aquifer systems.

Groundwater removed to access ore bodies in the eastern areas is used at mine sites. At some sites (e.g. Woodie Woodie), there is excess water and there is interest in using this for irrigated industries. In others (Kintyre, Nifty), there is no excess water after mine site use. Inland town and pastoral water supplies (residential and stock) are derived from often low-yielding alluvial deposits and fractured rocks.

**Hydrogeological provinces in the De Grey Canning region**

There are six hydrogeological provinces in the region (Figure 1): Granite Greenstone Terrane, Oakover, Paterson, Canning Basin, Coastal Plain and Chichester Range.

The **Granite Greenstone Terrane** province has a relatively high rainfall but no major aquifers to store the water. It receives runoff from the up-slope Chichester Range and experiences intense rainfall from tropical cyclones and thunderstorms. Its short streams are therefore relatively high yielding. Under a dry future climate, mean annual runoff is projected to decrease by about 41% and mean annual recharge from streambeds by about 14% compared with the baseline. Under a wet future climate, mean annual streamflow is projected to increase by about 20% and mean annual recharge by only 4%.

The **Oakover** province contains locally important aquifers associated with the karstic Carawine Dolomite, Permian glacial sediments and alluvium, which is recharged by the Oakover River. A future dry climate could reduce mean annual streamflow by 39% and mean annual recharge by about 25% compared with the baseline. A wet future climate could increase mean annual streamflow by about 18% and mean annual recharge by only about 8%.

The **Paterson** province contains no significant streams. Groundwater has been defined around the major mines or prospective mines – Nifty (copper), Telfer (gold and copper) and Kintyre (uranium). There are also poorly defined water prospects in Permian paleovalleys in the province.

The **Canning Basin** province contains very substantial water resources associated with the Wallal Sandstone aquifer, which is recharged by rain falling on sandy dunes and poorly defined drainage lines in the Great Sandy Desert. The shallower Broome Sandstone aquifer contains more saline water, which supports coastal GDEs.

The **Coastal Plain** province is a narrow zone around the De Grey River outlet, which has a low-lying landscape. Little runoff is generated in this province, with many rivers gaining water from adjacent aquifers. It contains important water resources associated with a paleochannel near the De Grey River outlet and important GDEs associated with the river. Under a wet future climate, the mean annual runoff in this province may increase by about 19%, but it may decrease by about 44% under a dry future climate.

In the **Chichester Range** province, most rivers arise from the Chichester Range in the west of the region. Under a dry future climate, mean annual runoff may decrease by 36%, but recharge from the streambed may decrease by only 8%. The projected increase in mean annual runoff under a wet future climate is 27%, but mean annual recharge is modelled to only increase by 2%, indicating that the additional runoff is expected to leave the range without infiltrating.
Key points

- The De Grey Canning region has an extreme climate characterised by hot summers, high potential evaporation and intermittent intense rainfall. Increased rainfall in recent decades, especially in the east, is associated with tropical cyclones and tropical lows. Thunderstorms are also a significant contributor to rainfall across the region.

- The major water resources in the region are groundwater contained within the Wallal and Broome sandstones in the Canning Basin, alluvial aquifers in the Lower De Grey Valley and aquifers in inland karstic dolomite deposits. Groundwater also occurs in paleovalleys and in shallow alluvial deposits associated with modern drainage lines. Only the coastal alluvial aquifers are heavily used.

- Future climates are expected to become 1.5 to 2.2 °C hotter (by 2030 and 2050, respectively) than the 1961 to 2012 average climate, but it is not clear whether it will be wetter or drier.

- Of 18 global climate models, those projecting a drier future climate are further from the mean that those projecting a wetter climate. The above-average rainfalls in recent decades may result from natural variability, aerosols emanating from South-East Asia or climate change.

- When estimated on a catchment basis, streamflow is initiated after rainfall exceeds 21 to 29 mm per event. On average, 18 to 50 mm (7% to 12%) of mean annual rainfall becomes runoff. There is negligible stream discharge to the ocean from the eastern half of the region.

- Leakage from streambeds (localised recharge) is the main mechanism for recharging alluvial and underlying aquifers. The area and duration of riverbed inundation determine the amount of localised recharge. Stream leakage estimated from rainfall–runoff models is between 2 and 3 mm or only 8% to 9% of streamflow volumes. Streambed leakage changes less than runoff on a proportional basis under both wet and dry future climates.

- Unlike adjacent regions, diffuse recharge is important because it recharges the Wallal and Broome sandstone aquifers in the Canning Basin. Between 77 and 107 GL/year of recharge is estimated to occur under dry and wet climate scenarios, respectively.

- Mean annual runoff increases by up to 18% under a wet future climate scenario with 2050 conditions, but decreases by up to 39% under a dry future climate scenario, relative to the historical baseline period of 1961 to 2012. For each 1% change in rainfall, runoff changes by about 3%, but the ratio of these changes (i.e. rainfall–runoff elasticity) ranges from about 2 to 5 across the region.

- Because of climatic conditions, groundwater resources in the Pilbara have an important environmental value, supporting multiple terrestrial ecosystems.

- GDEs and groundwater-dependent terrestrial vegetation comprise less than 0.5% of the region but have important environmental, social and cultural values. Satellite remote sensing over a 24-year period (1988 to 2011) indicated that GDEs varied but were never lost or gained. Their spatial extent varied most in the Chichester Range and Oakover provinces.

- GDEs are ultimately groundwater discharge zones and can be supported by various groundwater systems: those that form regional (e.g. Canning Basin or karstified formations of Carawine Dolomite) and local aquifers (paleochannels), and those that do not form an aquifer (e.g. shallow alluvial systems or fractured zone along dykes or faults).

- Compared with other GDE types, GDEs sustained by regional groundwater discharge are the least sensitive to climate variability. GDEs associated with groundwater discharge from local aquifers are sensitive to extreme climate variability, such as during 1990–1992, when annual rainfall was less than 200 mm and its low intensity limited recharge.

- The GDEs most sensitive to climate variability are those associated with groundwater systems that do not form aquifers (e.g. shallow alluvial systems, break-of-slope).

- The strong interdependence of geology, topography, soil and vegetation associations, hydrology and aquifers has enabled six hydrogeological provinces to be defined to help identify repeating patterns in the water resources of the region (Figure 1).

- Most water resources in the region are low salinity, and there is sufficient fresh water in this and adjacent regions to meet residential, mining, dust suppression and stock watering demands.
Basis of the Assessment

Weather observations were more plentiful and widespread in the 1950s and 1960s, when there were sheep stations throughout the region. More recently, mining companies have been recording climate data in the Great and Little Sandy Deserts. However, these latter monitoring data are not yet long term and may not have the longevity of past gauging if they cease when mining moves or ends. Long-term surface water gauging is especially limited in the upper De Grey catchment and non-existent in the area with poorly defined drainages (about a third of the region).

Groundwater and GDE investigations are numerous and intensive at several locations, as evidenced by reports to environmental and water regulators. Recent investigations of the West Canning Basin will greatly expand the understanding of this area. Isotopic and geochemical analyses will help determine recharge locations and rates.

The Assessment has used the available long-term data and specific studies to provide a regional narrative. This enables intensive local studies to be placed within a broader context. There are local groundwater models around the De Grey borefield and West Canning Basin, and others by mining companies for the mined areas. Some groundwater resources are little known, especially the paleovalleys in the south and east.