8 Conclusions and Recommendations

The GDE mapping method and GIS products produced under this research project are innovative developments for water resource management across the state of Victoria. Protection of GDEs is a stated priority of both National and State groundwater management programs. However, a sound assessment of where GDEs are likely to occur in the landscape has not existed previously. With the GDE mapping data and supporting information now available through this project, state and regional agencies charged with the responsibility of protecting GDEs have a starting point from which to work.

While the maps provide for the first time prediction of where GDE sites are possible in the landscape at a regional scale, it is clear from the study that there are myriad different GDE types and levels of groundwater dependency. Many of the locations identified by the mapping process are likely to contain well adapted, water-efficient, indigenous vegetation that is able to draw on shallow or deep water sources and, so, able to maintain a perennial ET profile. There are locations that would be best described as 'springs' or 'soaks', places in the landscape where groundwater naturally emerges and supports more abundant, perennial vegetation types that are naturally more dependent upon groundwater. Importantly, the maps show where GDEs are not present in the landscape, ruling out large areas from having to be considered for protection management in relation to groundwater.

The methodology developed is expected to overestimate the extent of terrestrial GDEs. There are locations that appear to fulfil the definition of a GDE (as defined by the mapping model) and are identified as a potential GDE landscape, but may not be using groundwater. Two prominent examples of such are:

1. Riparian zones along sections of rivers and creeks that have deep water tables where the stream is a losing stream and the riparian vegetation is able to access water, either from bank storage, or by intercepting leakage from the stream in the unsaturated (vadose) zone above the groundwater system.

2. Forested regions that are accessing large unsaturated regolith water stores or where the vegetation type does not show significant photosynthetic response to variations in water availability. In general upland forests and woodlands tend to be identified as potential GDEs but it is considered most unlikely that they are universally accessing groundwater.

8.1 Limitations of the maps

In developing this first generation of regional GDE maps for Victoria, several limitations of the method were identified.

The remote sensing analysis aims to identify differences in vegetation response to water availability. It relies on a good understanding of the ground processes and climate so that some inferences can be made about moisture availability. The current maps provide an understanding of landscapes that potentially use groundwater, however without ground data, actual rates of groundwater use cannot be determined. The GIS layer produced does not contain information regarding the degree of dependency on groundwater or the amount of groundwater used. The maps should not be used as an absolute assessment of where GDEs exist or how much groundwater is being used by terrestrial vegetation, unless integrated with site specific hydrogeological and plant water use assessments.

Field checking (qualitative or detailed quantitative measurements made at specific sites) has not yet occurred and is not part of the scope of this project. This is highly recommended and would help greatly to further develop the remote sensing data sets and improve confidence in the output maps. Such work can be strongly aligned to high priority GMAs and Victorian Flagship areas for biodiversity protection.

As discussed within this report, groundwater use by vegetation may be perennial, seasonal, or restricted to dry periods. Even for the same species, the amount of groundwater use will vary depending on specific circumstances. Factors that may affect the amount of groundwater required include the occurrence of summer storms, local groundwater system relationships, groundwater salinities, plant physiology, general health of the vegetation and unsaturated regolith water stores.

It is also possible that due to any number of environmental conditions and influences, a GDE region may be under stress and will not have the normal, constant growth patterns for the year in which the standard deviation was determined.

Remote sensing cannot see below the uppermost surface, whether this is a thick tree canopy or grasses at ground level. Depending on vegetation density, the response is determined by the uppermost canopies. If any reflected radiation comes from below this canopy, whether it be bare soil or lower levels of vegetation, then it is blended with the uppermost canopy. The current maps need to be used in association with a field based understanding of the vegetation assemblage in question. It is possible that some small surface water features will be masked out along the smaller streams due to overhead canopy and there will, instead, be reliance upon on identifying photosynthetic activity to infer the availability of water.

The current generation of Victorian GDE maps was developed by stratification of climate zones within each CMA boundary, rather than using the biophysical zone boundaries (for example, the basalt plains biophysical zone crosses CMA boundaries). It may be of benefit to undertake a trial that stratifies the climate zones within the biophysical zone boundaries, as each type of land-systems could be expected to have a similar response. By ignoring these differences, we might be mixing responses and losing some details the method could have otherwise identified.

While MODIS is useful for its temporal resolution and shows the variation in vegetation response over time, the 250m spatial resolution means that smaller features cannot be identified. Also, the compositing process introduces some anomalies that should be removed before calculating standard deviation for each pixel (i.e. cloud and high zenith view angle).

In regards to the Landsat data, it was not possible to remove the effect of shadow associated with cloud cover across large areas or the impact of small scale storm events within the Landsat images. This resulted in some areas requiring the use of images flown on different dates, leading to edge effects and linear artefacts in the processed image. Care is needed in the Landsat image date selection process to reduce the Landsat run boundary edge effects.

Forest areas are also problematic, particularly if they are in more elevated and dissected terrain. In some forests, outputs appear to be related to be a product of landscape or slope rather than a vegetation response. This could be an artefact of solar illumination at 10am (approximately the time that the satellite passes over) on the hills and valleys. Alternatively it could be the effect of topography on soil development, where greater moisture availability occurs on southern and eastern slopes, producing higher biomass and leading to formation of a deeper soil profile compared to the drier northern and western slopes. These issues need to be explored in future project development.

8.2 Recommended usage of the maps in current form

The GIS layer produced can be used with other spatial data to gain an understanding of where GDEs may be present. Using the data layer as an initial guide, other data such as air photographs, geology, geomorphology, vegetation type, surface hydrology, groundwater flow system or soil mapping can be used to focus in on specific features of interest. In particular, expert inspection of air photo or satellite imagery and topographic and geology or GFS maps is recommended to screen out upland forested areas that are unlikely to access groundwater. As an initial step, the most likely, and potentially highest-value GDEs are expected to occur in the groundwater interactive landscapes (generally shallow water table) so those areas should be the focus. Figure xx shows a section of the North East CMA region, classified by the groundwater interactive attribute. The shallow water table class excludes areas of upland forest and highlights the areas of greater interest.

One of the most likely scenarios for the need to regulate and protect an identified GDE asset is groundwater extraction. Overlaying the mapping product on GFS and groundwater management data (bore locations, pumping volumes, groundwater depths, management area boundaries etc.) can reveal whether the identified GDE feature is likely to be at risk to groundwater level decline as a result of human activity.

The maps can be used as a field guide for inspectors or diversions officers when assessing groundwater licenses for both regulatory and environmental authorities. For example, in the case of an extraction license application adjacent to an identified GDE, the inspector can ask for an assessment of the potential impact as part of the license requirement. Finding cost-effective and sufficiently reliable means of achieving this within the license approval process will need to be investigated.

The maps provide the first cut prediction of where groundwater is predicted to support surface ecology. They also provide additional information to assist the development of management plans aiming to preserve key environment assets.

The maps form a basis for more detailed catchment or local scale evaluation of the presence and sensitivity of potential GDEs. The remote sensing methodology can be optimized for particular catchments by more detailed analysis of aridity zones, vegetation characteristics (including tolerances), iterative adjustment of classification levels for the data sets, more detailed land-use analysis, and by development of training data from local field studies.

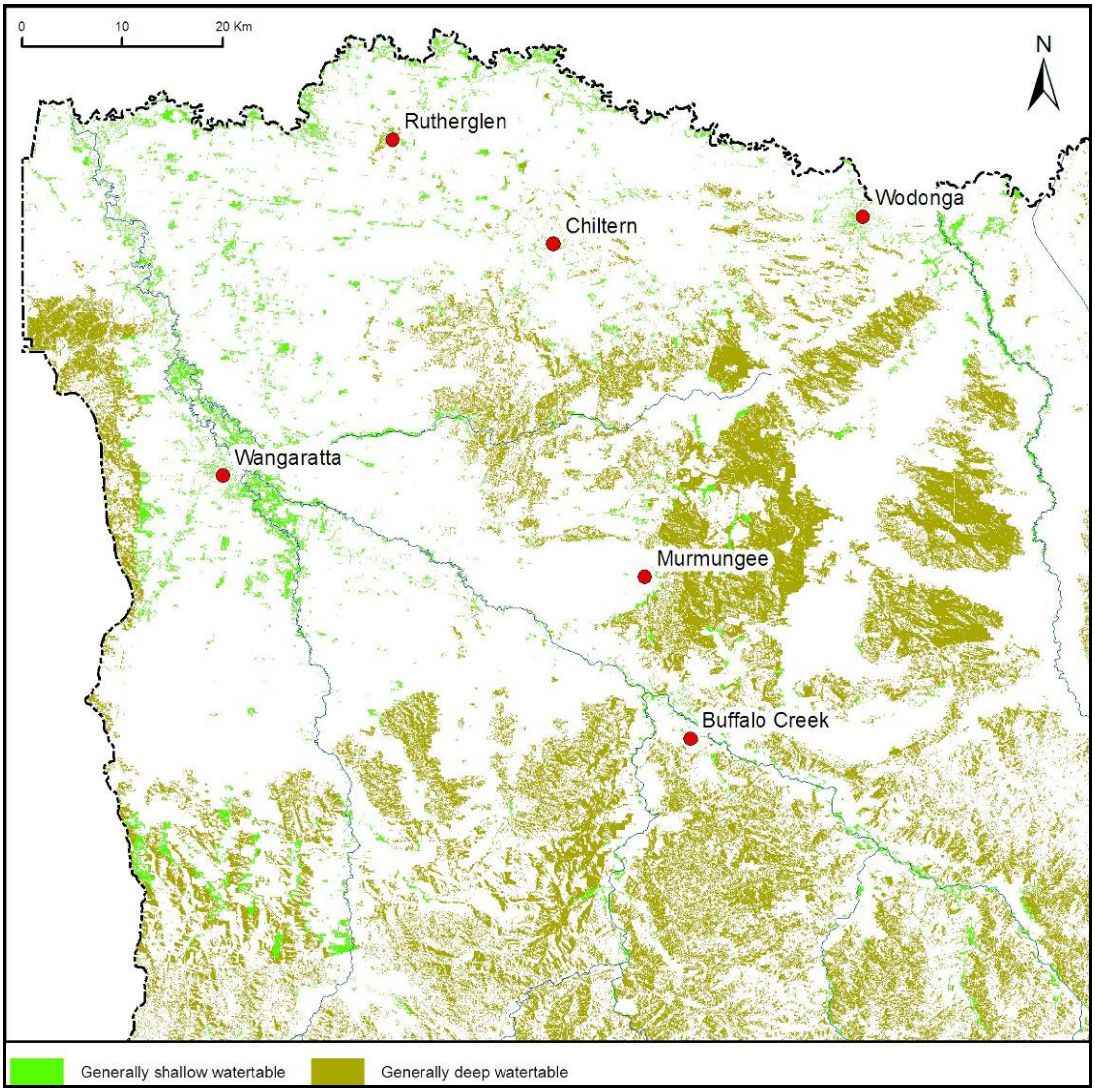

Figure 24. Potential terrestrial GDEs in a section of the North East CMA region, classified by groundwater interactive landscape. The areas of greatest interest are expected to be in the shallow water table zones