7 Conclusions

This project phase successfully integrated species tolerance modelling with the Victoria-wide GDE mapping. The species tolerance model provided additional information to filter broad areas of forest, woodland, and plantation from the GDE maps, thus making a considerable further advance towards accurate delineation of terrestrial GDEs. Although there is potential for deep-rooted trees in the forest areas to access groundwater, little is known about the extent to which that would occur, and the forest/woodland areas are presently considered to be of secondary concern with respect to GDE importance, at least in relation to water management. The morphology of the remaining GDEs in many areas follows topographic lows and the topographic relationships can be used for further qualitative evaluation of the likelihood that a GDE is present in a particular area.

The species tolerance model provides a basis for assessment of GDE sensitivity. The model aggregates simulations of ecosystem attributes associated with conditions favourable for the presence of GDEs. The higher the species tolerance model value, the more likely the ecosystem will be affected by change in the groundwater resource. The potential terrestrial GDEs were classified by using the zonal median species tolerance model values for each GDE area. The median is less biased than the mean by extreme values in the distribution and is less affected by the varying GDE polygon size.

Mixed results were obtained from calculations of the change in NDVI between summer 1995 satellite data (pre- 1997-2009 drought; high water table) and summer 2002 satellite data (mid-1997-2009 drought; low water table). The calculated value is sensitive to image dates, as expected, so care needs to be applied when comparing values between zones. Furthermore, the calculated values are sensitive to local spatial and temporal climatic effects such as recent precipitation. However, some general trends were seen in the trial areas.

Available hydrogeologic data were too general to develop detailed groundwater flow visualizations to determine GDE sensitivity. Groundwater level trends were preferably calculated as depth below natural surface but depth below measurement point was used when the difference between measurement point and ground surface was not known. Declining trends in the unconfined aquifers or in confined aquifers that potentially discharge to the surface were used to indicate areas of sensitivity to decline in groundwater resources.

At the scale of the study, and without field investigations, the GDE sensitivity results are necessarily qualitative. GDE areas of greater concern with regard to sensitivity and response to change were identified in the trial areas, as summarized below.

7.1 Portland GMA Region

A number of potentially significant GDEs were noted in the Portland GMA region. Of these, the potential GDE areas at the periphery of Condah Swamp and Lake Condah, and along Condah Drain are considered highly sensitive based on the species tolerance model values, the relatively high groundwater extraction, and the declining groundwater levels in the lower mid-Tertiary aquifer.

Similar conditions to the Condah Swamp area are noted along the upper part of the Eumeralla River in the study area. There are fewer groundwater licences along this part of the Eumeralla River but there is essentially no groundwater monitoring data to evaluate trends or potential impacts to GDEs from climate change or groundwater use. Thus, this area is also considered to be possibly highly sensitive.

Areas of possible moderate sensitivity to change for GDEs include the Crawford River catchment and the lower Fitzroy River. The species tolerance model indicates potential sensitivity for GDEs along the Shaw River and between the Shaw and Moyne Rivers, although the limited groundwater level data do not show the declines seen near Condah Drain. Thus, the Shaw/Moyne River areas should be considered potentially moderately sensitive to change until greater understanding of the relationship of the hydrogeologic system and GDE locations is obtained.

Coastal areas, although potentially including GDEs, do not generally show groundwater level trends indicating negative effects of climate change or groundwater usage. However, bores are not specifically located to monitor GDE health.

7.2 Upper Loddon WSPA Region

Few potential GDEs are mapped in the Upper Loddon WSPA but the sensitivity evaluation suggests that possible narrow unmapped GDEs may be located along a number of incised creeks. NDVI difference values suggest these areas often had considerably lower NDVI in 2002 than in 1995, even though surrounding agricultural land shows higher NDVI values. The Upper Loddon is generally an area of groundwater recharge but the relief of the volcanic landscape and the likely variable permeability of the basalt flows and alluvial sediments, suggests that groundwater flow systems are most likely to be of local to intermediate scale but may support GDEs. These flow systems are probably less resilient to changing recharge or competing groundwater use than regional scale flow systems. Water levels are declining in some monitoring wells. There are some instances where areas of potential GDEs such as lakes or wetlands appear to have been cultivated during dry spells, so the natural ecological resources in those cases may already be lost. Thus, remaining potential GDEs, although small, appear sensitive to perturbation.

8 Recommendations

It is recommended that the trial area results of this study be evaluated to determine if sufficient concern regarding sensitive GDEs exists for follow-up investigation. The study should provide an initial basis for incorporating GDE considerations into water resource policies. The methodology is generally applicable to other areas but needs to be considered in light of the broad scale of the Victoria GDE mapping and the absence of field characterization or verification of GDE sensitivity.

Several refinements of the methodology could be made. It would be valuable to extend the NDVI difference process to multiple time periods, possibly using other satellite platform data sets. This would enable short term or local trends to be distinguished from longer term trends. Refinement of the species tolerance model data process would be useful to identify types of dependency (e.g. halophytic) and to integrate the species tolerance model into the GDE mapping to provide better, more detailed evaluation of potential GDE locations.

Ultimately, field study is needed to make more definitive statements regarding the presence and sensitivity of GDEs. This study serves to identify locations of potential concern within the trial areas and presents a viable methodology to apply to other areas of interest.