6 Upper Loddon WSPA Results

6.1 Species Tolerance Model

The species tolerance model results for the North Central CMA region and Upper Loddon WSPA are shown in Figure 39. The colour-ramp indicates the maximum result from each of the 5 species tolerance properties expected to be found in GDE areas. Potential terrestrial GDE polygons within the Upper Loddon WSPA tend to be scattered and small, in spite of the presence of areas mapped as wetlands or subject to inundation (Figure 40). The potential GDE areas with the lowest 15 species tolerance classes are associated with forested areas that are considered generally unlikely to be groundwater dependent, although they may include sub-areas of deep-rooted or other groundwater dependent vegetation. Those classes have been excluded from the figure. Some of the remaining potential GDE areas also appear to be associated with non-native vegetation and would have to be evaluated directly to confirm groundwater dependency. The distribution of maximum species tolerance model results for the Upper Loddon region (Figure 41) does not show the bimodal distribution of the Portland GMA (Figure 14). The maximum species tolerance value within the Portland GMA was 45.

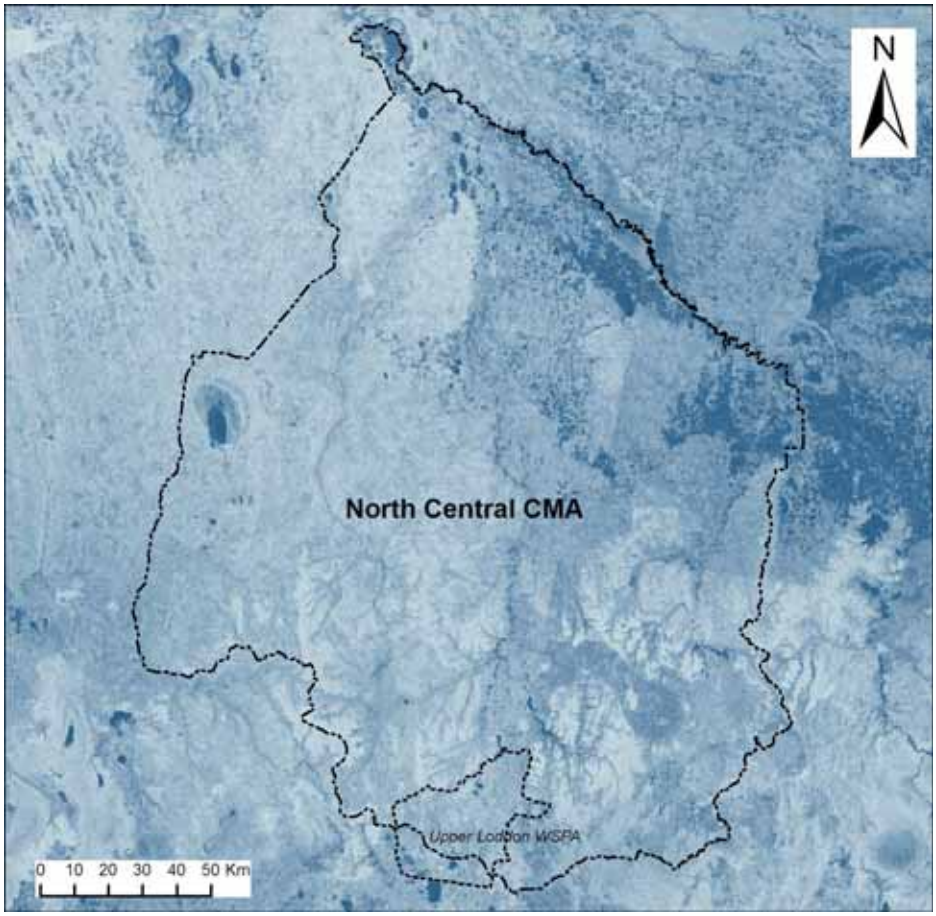

Figure 39 Species tolerance model for North Central CMA region and Upper Loddon WSPA showing maximum value for overlain tolerance models. Darker colours are higher values.

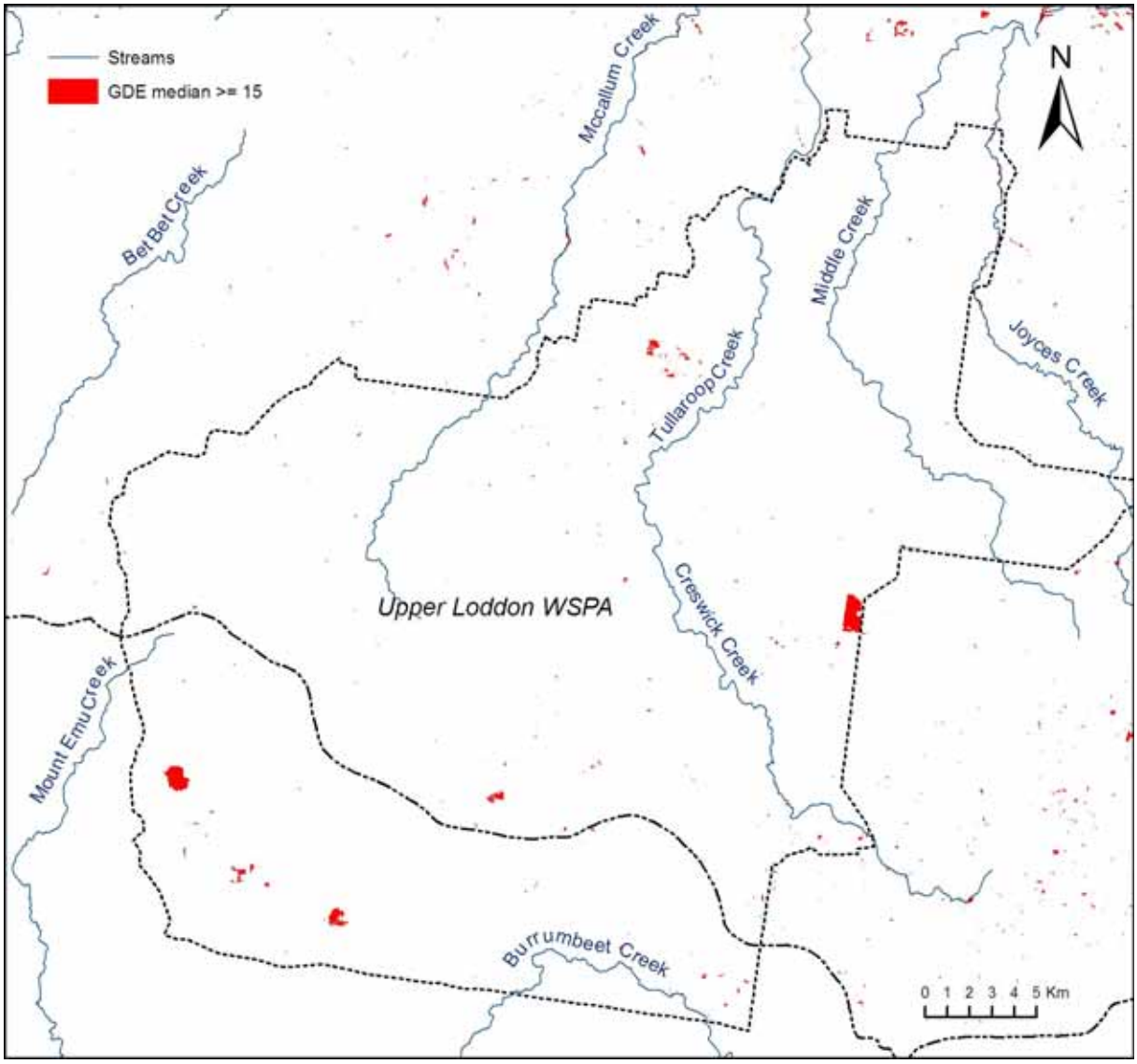

Figure 40 Potential terrestrial GDEs in the Upper Loddon WSPA region with median species tolerance values 15 or above.

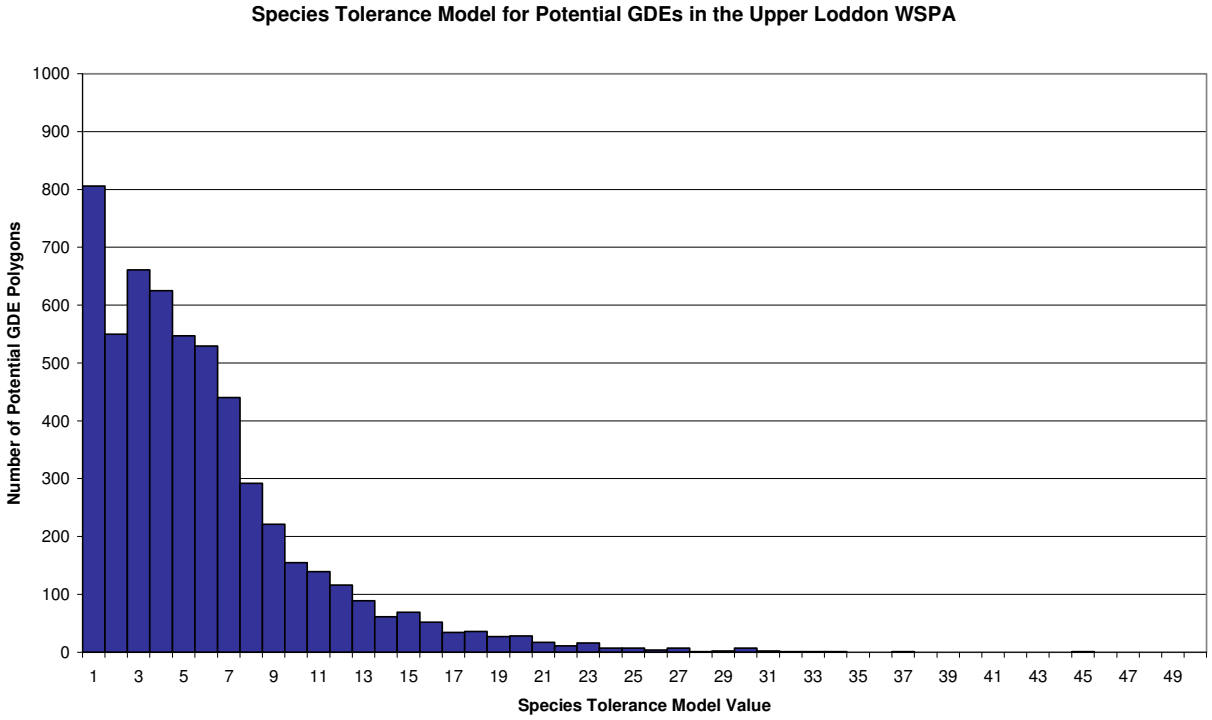

Figure 41 Histogram of median species tolerance model values for potential GDEs in the Upper Loddon WSPA region (compare with bimodal distribution of Portland GMA – Figure 14).

6.2 NDVI Difference

The calculated NDVI difference between 1995 and 2002 for the North Central CMA region is shown in Figure 42. A strong effect of differing image dates is seen across the region (see Figure 9). The Upper Loddon WSPA study area falls within 2 different zones of image date combinations and the relative values within each zone can be compared (Figure 43). There is a general trend from a greater increase in NDVI between 1995 and 2002 near the divide to a smaller increase further north. Treed areas in the northern Upper Loddon WSPA generally show a decrease in NDVI between images (higher difference value).

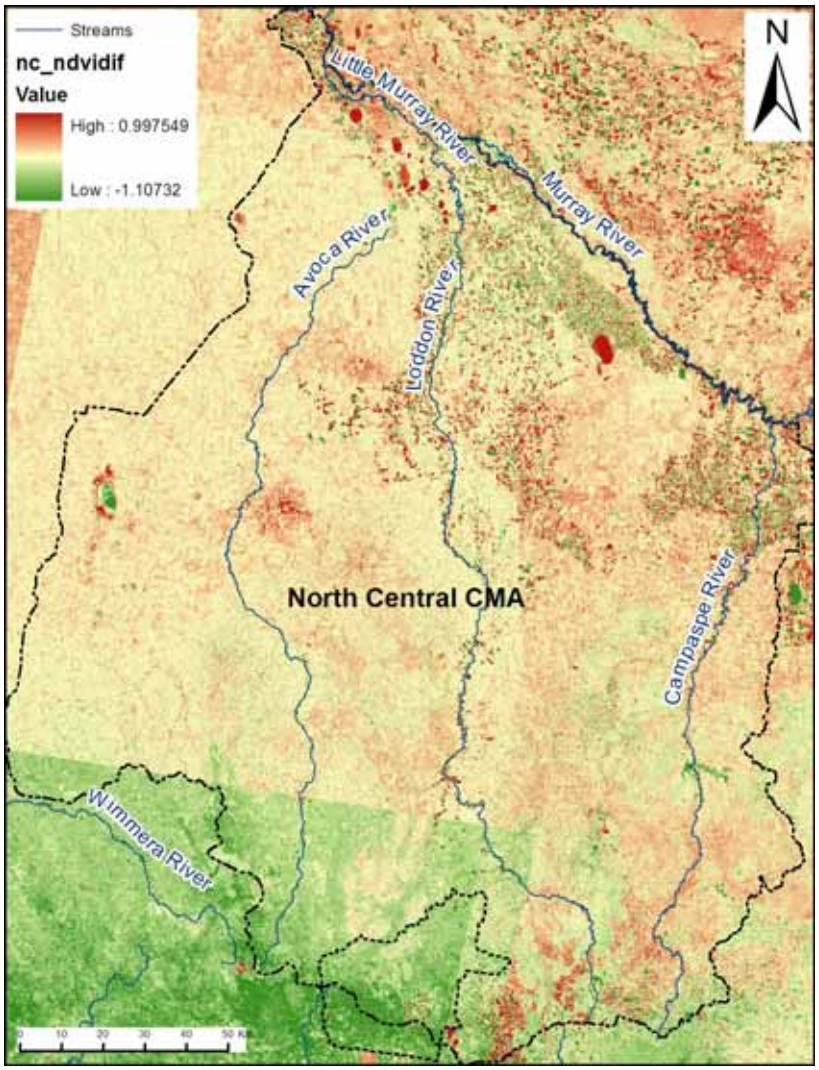

Figure 42 Difference in NDVI value between 1995 and 2002 in the North Central CMA region. Positive values indicate a decrease in NDVI from 1995 to 2002 and negative values indicate an increase.

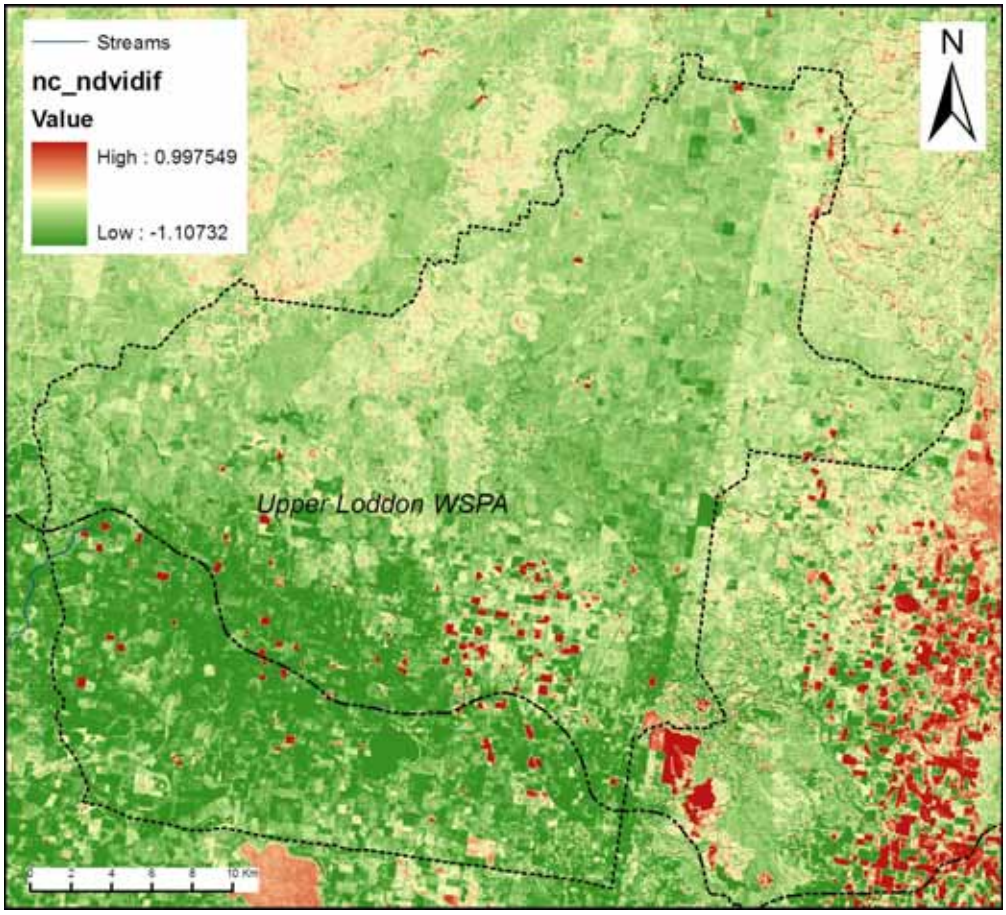

Figure 43 Difference in NDVI value between 1995 and 2002 in the Upper Loddon WSPA study area. Positive values indicate a decrease in NDVI from 1995 to 2002 and negative values indicate an increase.

6.3 Hydrogeologic Interpretation

This section describes the hydrogeologic evaluation and integrates the results of the species tolerance and NDVI difference mapping. The assessment is performed generally by catchment areas as described previously (see Figure 11). The Bet Bet Creek catchment will be omitted because only very few small areas of potential GDEs with higher species tolerance values are found there.

The Upper Loddon WSPA is located along the surface water divide of the Loddon River and Mount Emu Creek catchments and thus probably includes areas of regional groundwater recharge, particularly from the scoriaceous volcanics, including numerous scoria cones. Thus shallow groundwater availability to support GDEs would likely be associated with shallow local flow systems and GDEs would likely be relatively small. This is consistent with the limited extent of mapped GDEs. However, it is possible that the regional scale mapping exercise missed some small GDE areas. Importantly, GDEs associated with local flow systems presumably are quite sensitive to climatic effects.

6.3.1 Middle and Joyces Creek Catchments

Middle Creek and Joyces Creek are tributaries of the Loddon River with catchments that include the north eastern part of the Upper Loddon WSPA. Several potential small GDEs are mapped along Joyces Creek between Campbelltown and Strathlea. Bore 116580 is located approximately 1.5 km west of Joyces Creek and is about 20 m above stream level. The water level in this bore was 7-8 m below the top of the bore casing in the late 1980s but is currently

nearly 14 m below, and declining (Figure 44). This suggests that groundwater may discharge to Joyces Creek but declining water levels could threaten GDEs along the stream.

Nested bores SP068254, SP068255, SP069539, less than 1 km east of Middle Creek show a downward hydraulic gradient within the Newer Volcanics basalt aquifer and to the Calivil Formation (deep lead) aquifer of SP069539 (Figure 45). The data record is too short to determine trends in the water levels. Water levels are declining in Bore 320252, located very close to Middle Creek (with bore elevation near stream level) exhibits declining water levels deep enough that the groundwater most likely does not directly support the surface ecosystems at this locality (Figure 46).

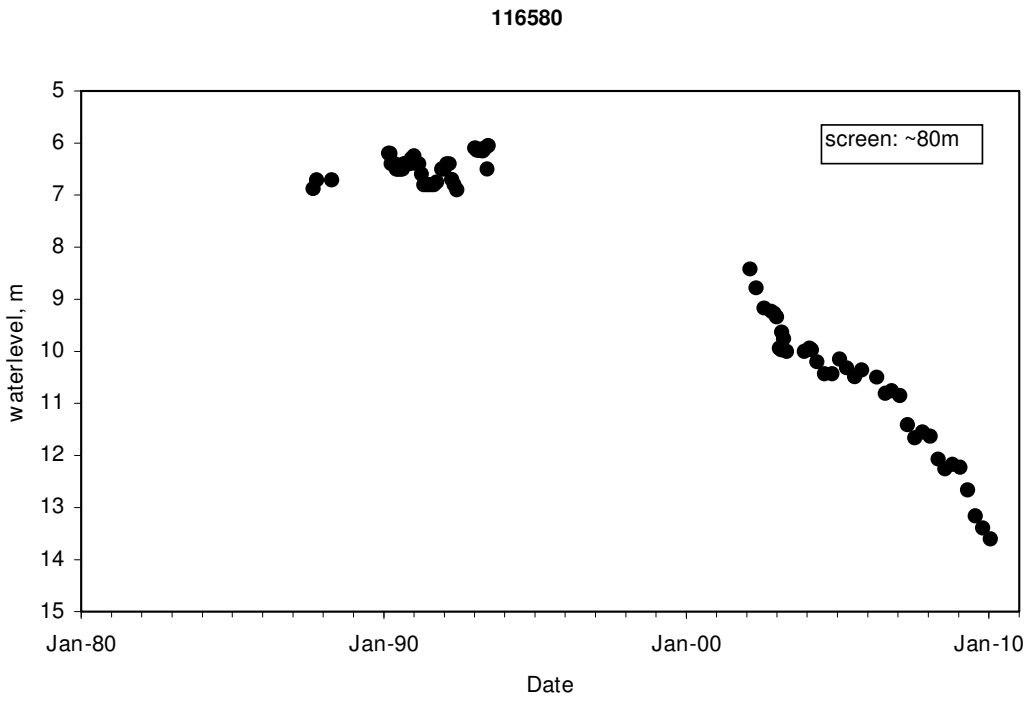

Figure 44 Hydrograph of depth to groundwater in bore 116580, west of Joyces Creek, in the Loddon River Catchment. Height of reference point above ground surface not recorded (see Figure 48 for location).

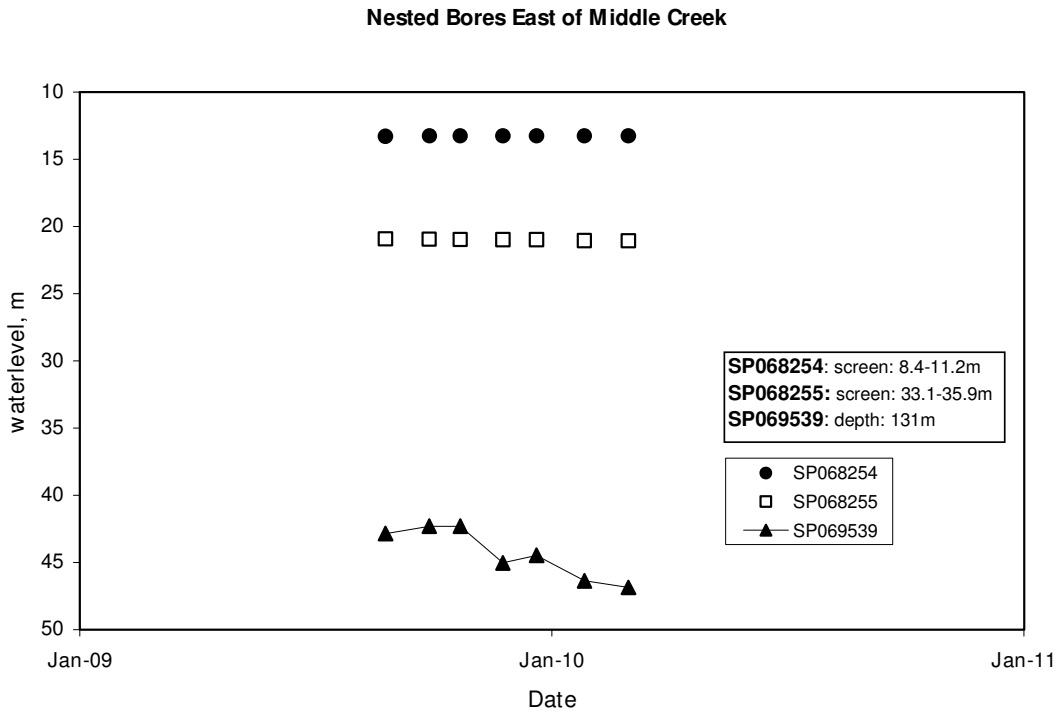

Figure 45 Hydrograph of nested bores east of Middle Creek, in the Loddon River catchment, showing downward hydraulic gradient (see Figure 49 for location).

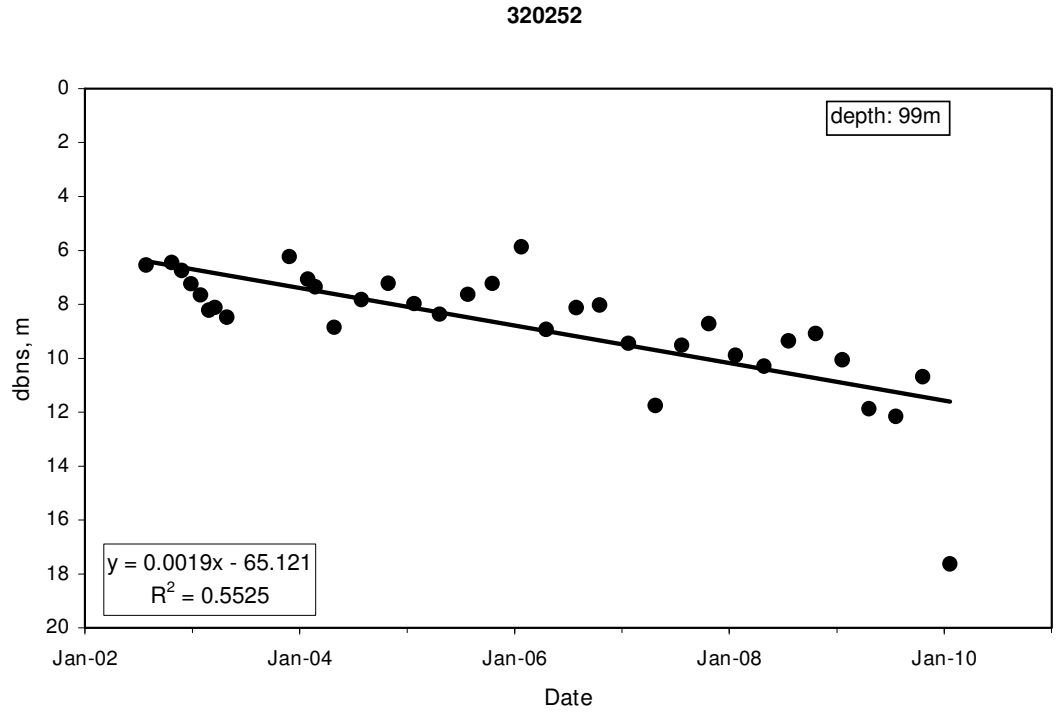

Figure 46 Hydrograph of depth to groundwater in bore 320252, near Middle Creek, in the Loddon River Catchment (see Figure 49 for location).

Further south along Middle Creek, toward the divide from the bores discussed above, bores 138655 and 138656 show a declining trend with the decline in the shallow bore, 138655, less steep than in the deeper bore 38655 (Figure 47). Until 2009 the hydraulic gradient was upward but since then the gradient has been downward. One possible hypothesis for this is that the deeper aquifer is registering a greater impact from regional groundwater pumping. The apparent variability in water level in the shallow bore was greater until ~2008, possibly influenced by local pumping, but the response has been smoother since then. Although there are no nearby mapped potential GDEs along Middle Creek, the bores are close to the divide with the Tullaroop Creek catchment and the trends suggest possible impacts on GDEs in that catchment.

The change in NDVI within potential GDEs along Joyces Creek in Figure 48 shows a large decline in NDVI between 1995 and 2002 for these GDE areas. This suggests the possibility of water stress for the natural vegetation.

Few potential GDEs are mapped in these Upper Loddon catchments but the hydrogeologic data indicate generally declining water levels that could negatively impact any GDEs. The level of agriculture is intensive, so few natural areas remain – possibly increasing the value of the remnant ecosystems.

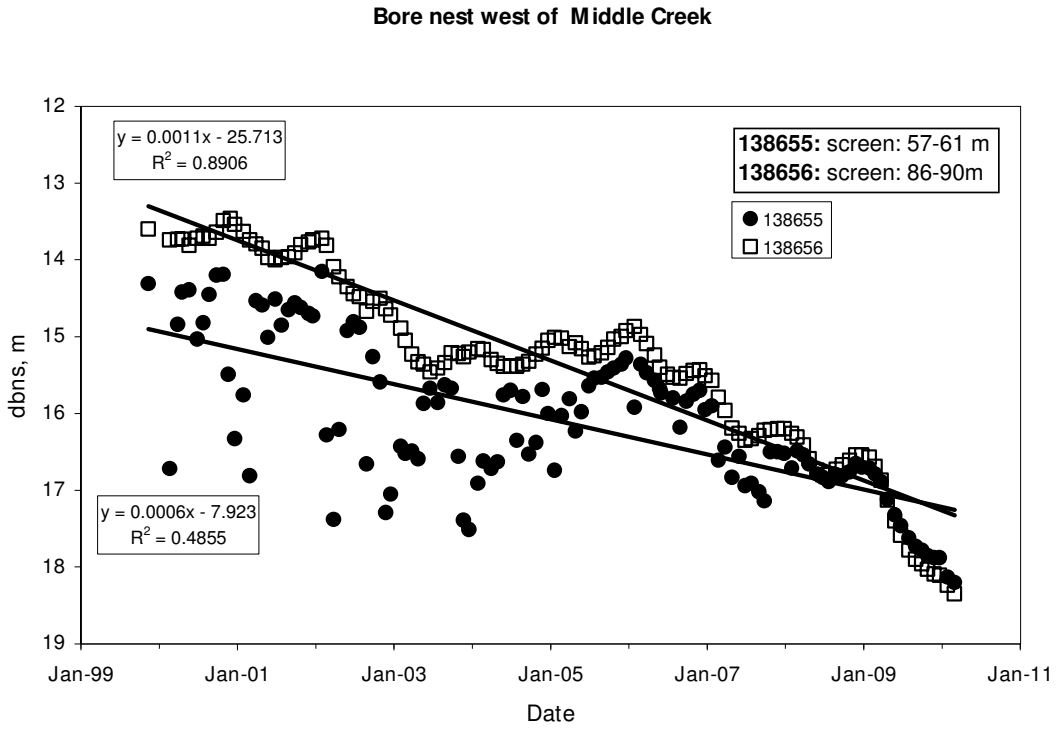

Figure 47 Hydrograph of nested bores west of Middle Creek, in the Loddon River catchment, showing upward hydraulic gradient prior to 2009 and current downward gradient (see Figure 49 for location).

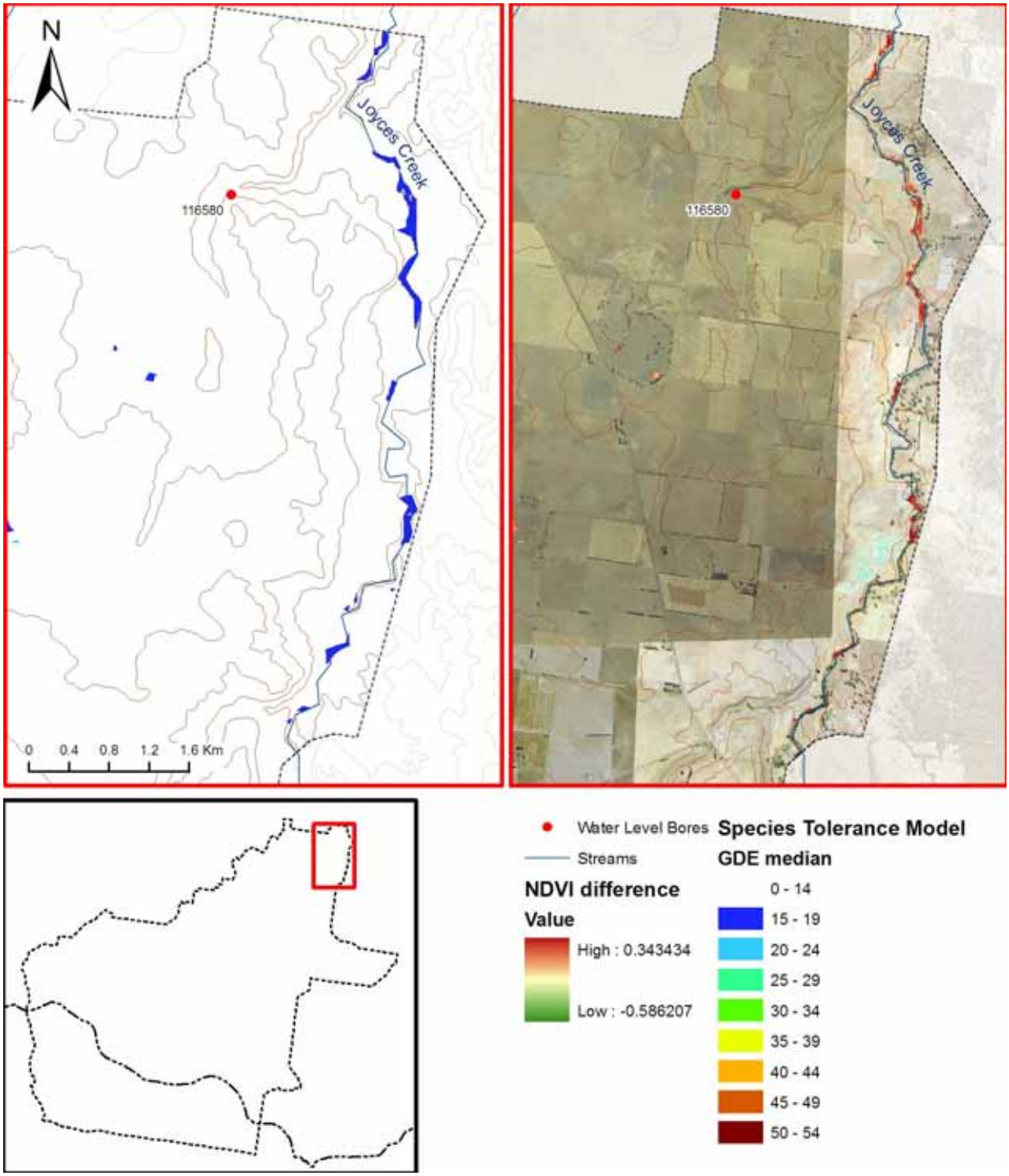

Figure 48 Species tolerance model results and NDVI difference for the lower part of Joyces Creek in the Loddon River catchment

6.3.2 Tullaroop Creek Catchment

The Tullaroop Creek Catchment is the largest in the Upper Loddon WSPA. Tullaroop Creek flows northward through an incised valley into Tullaroop Reservoir then on to the Loddon River. Potential GDEs with higher species tolerance model values are found along the lower part of Tullaroop Creek, in a few tributaries, and within a depression west of Tullaroop Creek (Merrin Merrin Swamp) (Figure 49). A few of the mapped areas, like the larger one on the far eastern side of the Upper Loddon WSPA, appear to be forests or tree plantations with no apparent correlation with groundwater discharge.

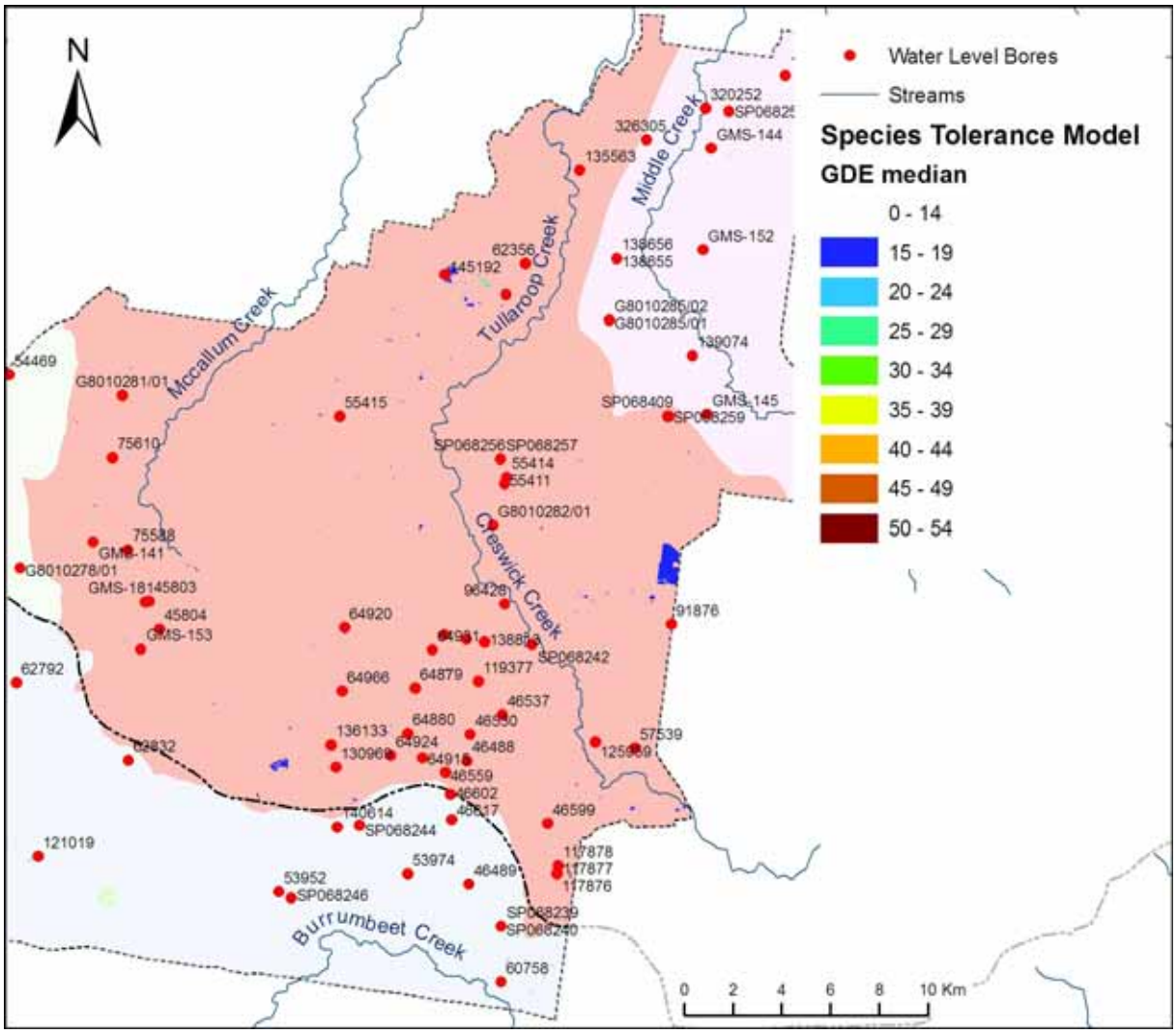

Figure 49 Species tolerance model results for potential GDEs in the Tullaroop Creek Catchment and monitoring bore locations

The mapped potential GDEs along Tullaroop Creek in the northern part of the study area and Merrin Merrin Swamp to the west are shown in Figure 50. The NDVI difference indicates a large decline in NDVI between 1995 and 2002 in the depression of Merrin Merrin Swamp and further upstream along Tullaroop Creek, with an increase in NDVI downstream. This suggests increased drought-related water stress. The possible GDE areas at Merrin Merrin Swamp show minimal indication of green vegetation in the aerial photograph and thus any remaining groundwater dependent vegetation would be expected to be highly sensitive to decreased water availability. It should be noted that a number of areas of greener vegetation not mapped as potential GDEs are seen along Tullaroop Creek. It appears that the statewide GDE mapping may have underestimated the presence of narrow riparian bands of possible GDEs along the creeks in this area. This is likely due to the influence of remote sensing measurements from nearby agricultural land and insufficient resolution to identify smaller features.

Bore 135563 is located east of Tullaroop Creek at an elevation of between 30 m and 40 m above the stream level. The water level in the bore is approximately 21 m below the measuring point, therefore discharge to the creek is plausible (Figure 51). Only limited water level data is available for this bore, so long term trends are not known. Bore 62356, west of Tullaroop Creek, is also located at an elevation of about 40 m above the creek and has a water level of about 19-20 m above creek level (Figure 52). The water level in this bore is trending slowly deeper, but at a rate that indicates no immediate threat to GDEs.

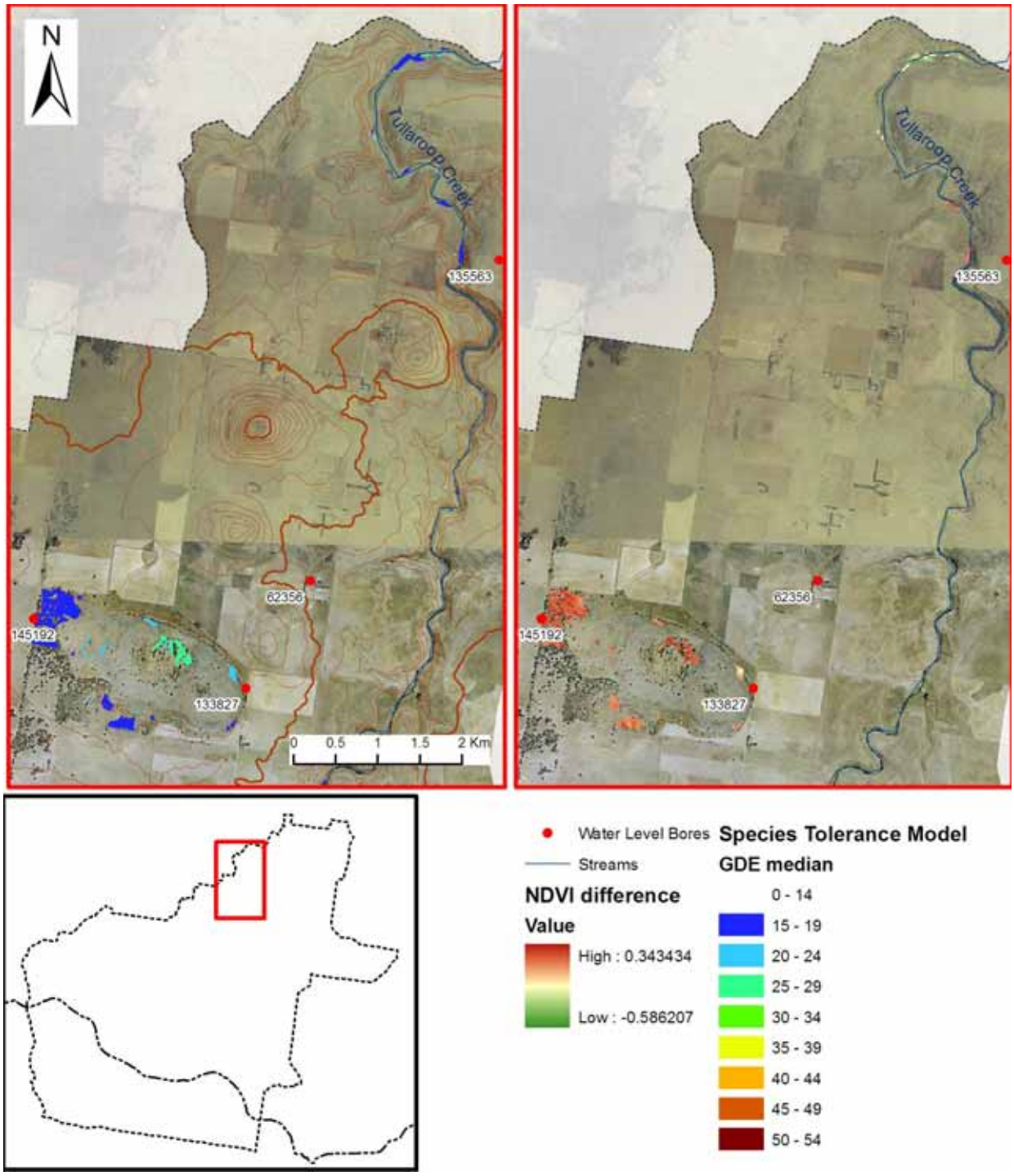

Figure 50 Species tolerance model results and NDVI difference for the lower part of Tullaroop Creek and Merrin Merrin Swamp

Merrin Merrin Swamp has a number of mapped potential GDEs with moderately high species tolerance model values. On the January 2000 air photo, the surface appears dry with only scattered vegetation. Bore 133827, on the east side of the depression, shows a water table varying between 1 m and 5 m from the surface and thus potentially supporting GDE vegetation (Figure 53). On the west side of the depression, bore 145192 has a somewhat deeper screened interval and a lower water table, approximately 15 m below natural surface and declining slowly (Figure 54). This suggests that the ecosystem is supported by a local, shallow flow system that is largely isolated from the somewhat deeper aquifer.

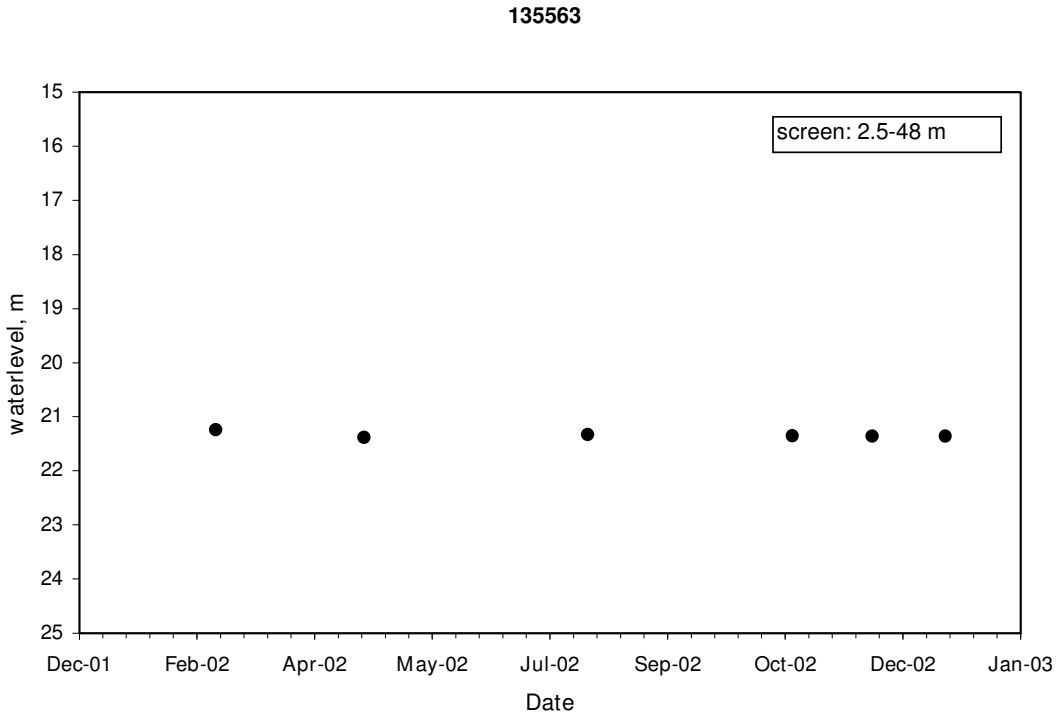

Figure 51 Hydrograph of depth to groundwater in bore 135563, in the Tullaroop Creek catchment (see Figure 50 for location).

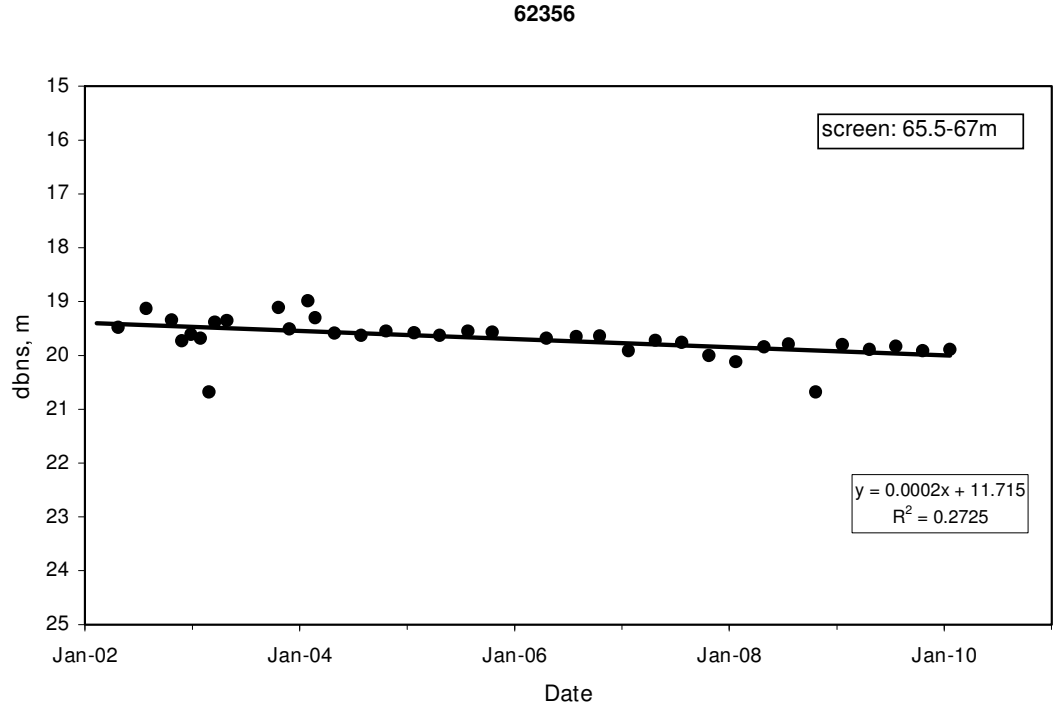

Figure 52 Hydrograph of depth to groundwater in bore 62336, in the Tullaroop Creek catchment (see Figure 50 for location).

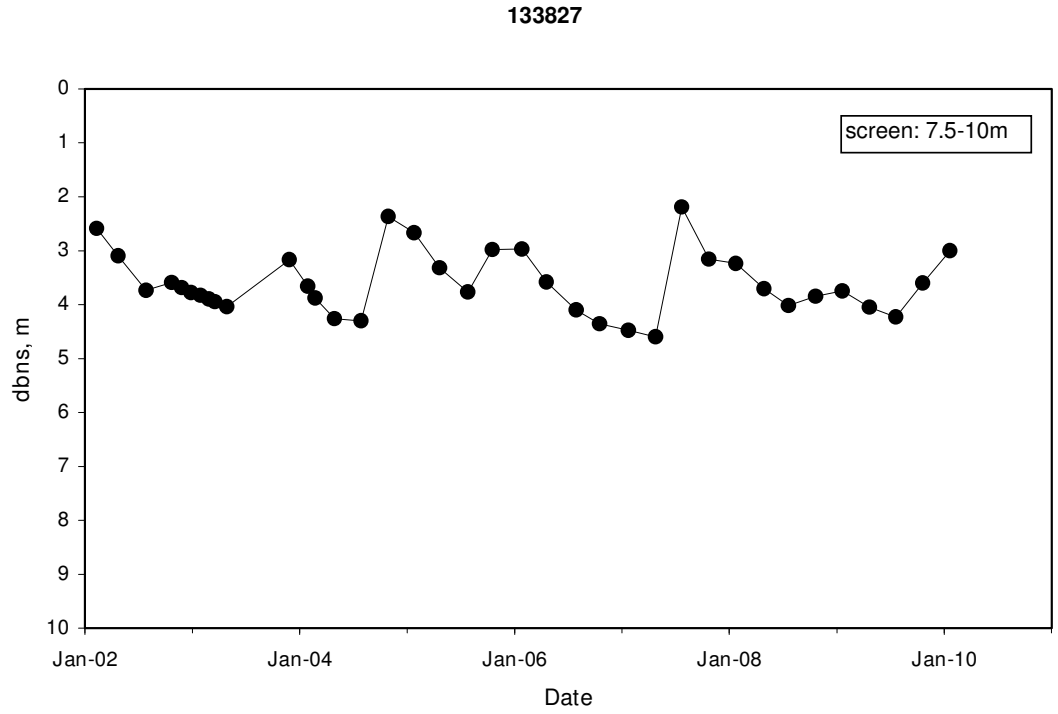

Figure 53 Hydrograph of depth to groundwater in bore 133827, near Merrin Merrin Swamp, in the Tullaroop Creek catchment (see Figure 50 for location).

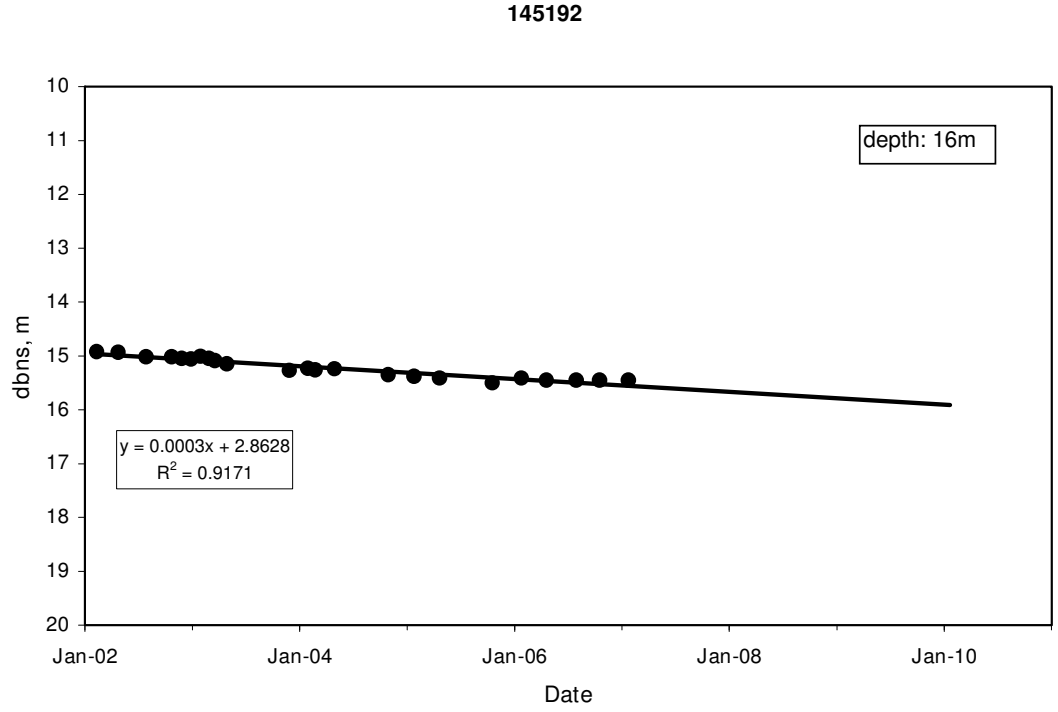

Figure 54 Hydrograph of depth to groundwater in bore 145192, near Merrin Merrin Swamp, in the Tullaroop Creek catchment (see Figure 50 for location).

Further upstream between Creswick Creek and Tourello/Birch Creeks, near the town of Clunes, a number of bores suggest possible groundwater discharge to the creeks, but declining water

levels indicate possible impacts to GDEs. Few GDEs are mapped in this area but narrow vegetation bands along the creeks suggest that GDEs could be present (Figure 55).

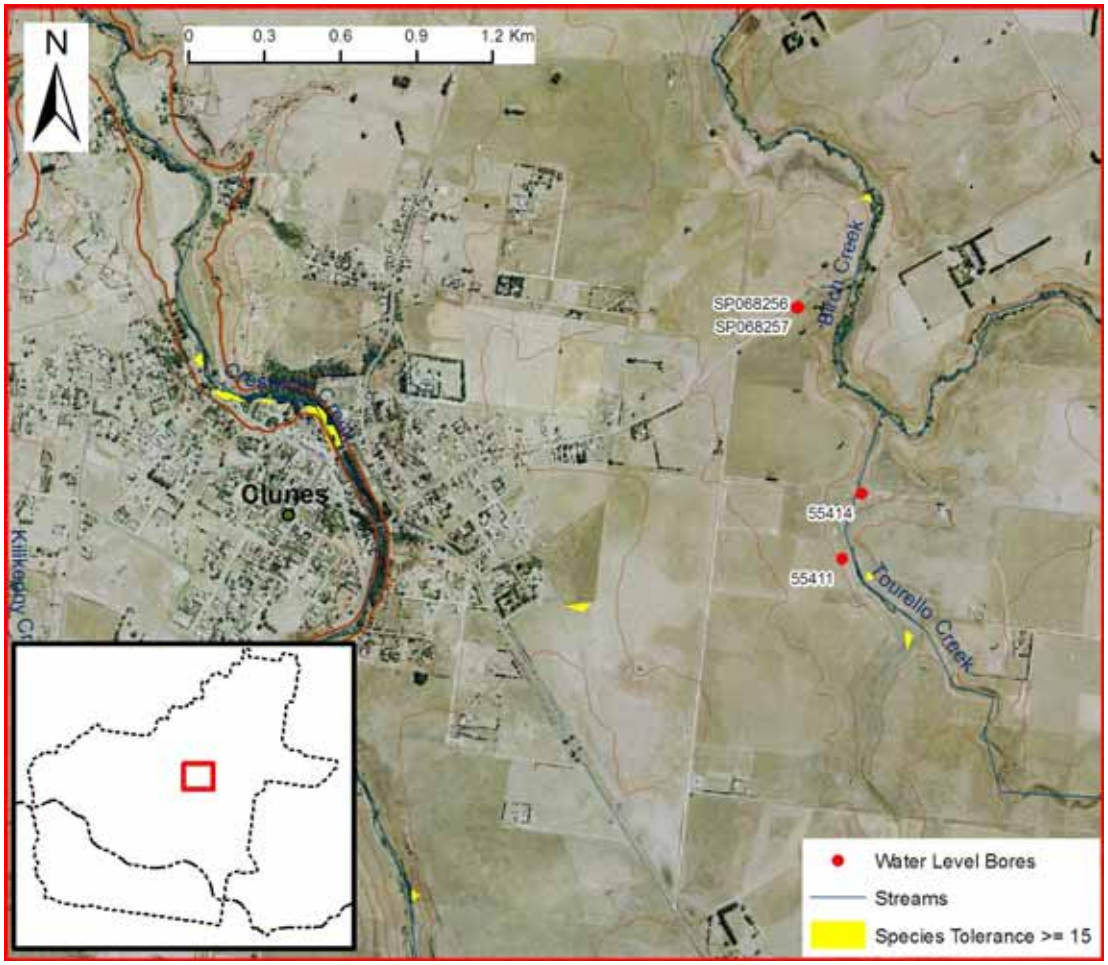

Figure 55 Location of water level bores and potential GDEs between Creswick Creek and Tourello/Birch Creeks, near Clunes

Bores 55411 and 55414 are both located near Tourello Creek with bore 55414 approximately 275 m further downstream. The data record is not continuous but both bores showed water levels above ground surface until 2000, whereas the data since 2005 shows water levels have dropped down to almost 4 m below ground level (Figure 56). There could still be discharge to the creek because (i) bore 55411 is located approximately 4 m above the creek level, and (ii) discharge could occur further downstream. However, the change suggests that the groundwater may have lower ability to support riparian or aquatic GDEs.

Bore 8010282/01 is located further south at a higher elevation. The water level trend shows a significant decline since 2004 from about 20 m to about 25 m below ground surface (Figure 57). Bores SP08256 and SP08257 form a recently installed, co-located bore nest approximately 17 m above Birch Creek. The data record is too short to establish trends but currently the vertical hydraulic gradient is upward, supporting the possibility of groundwater discharge to the creek (Figure 58).

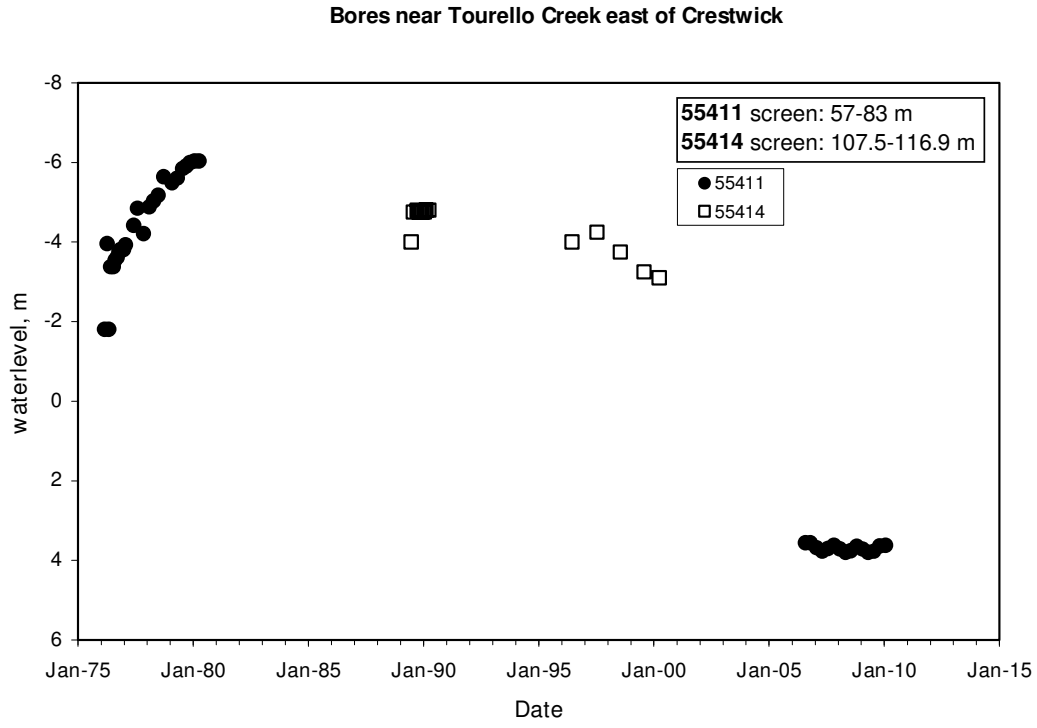

Figure 56 Hydrograph of bores near Tourello Creek, east of Creswick in the Tullaroop Creek catchment, showing change from an artesian head above surface level to a head below surface (see Figure 55 for location).

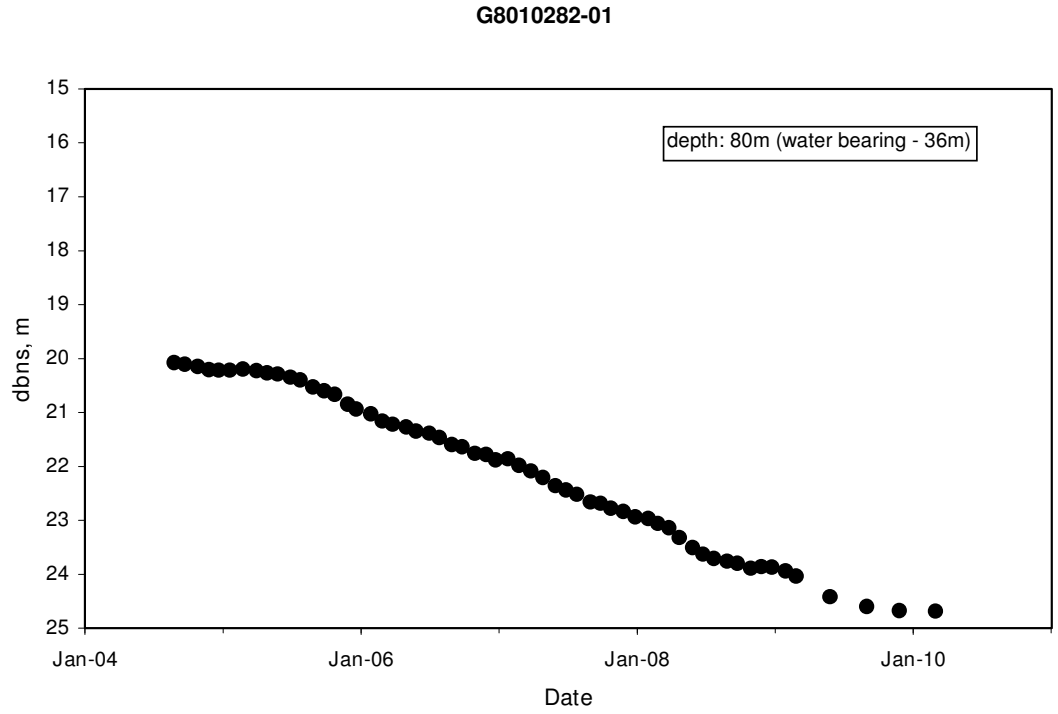

Figure 57 Hydrograph of depth to groundwater in bore G8010282/01, near Tourello Creek, in the Tullaroop Creek catchment

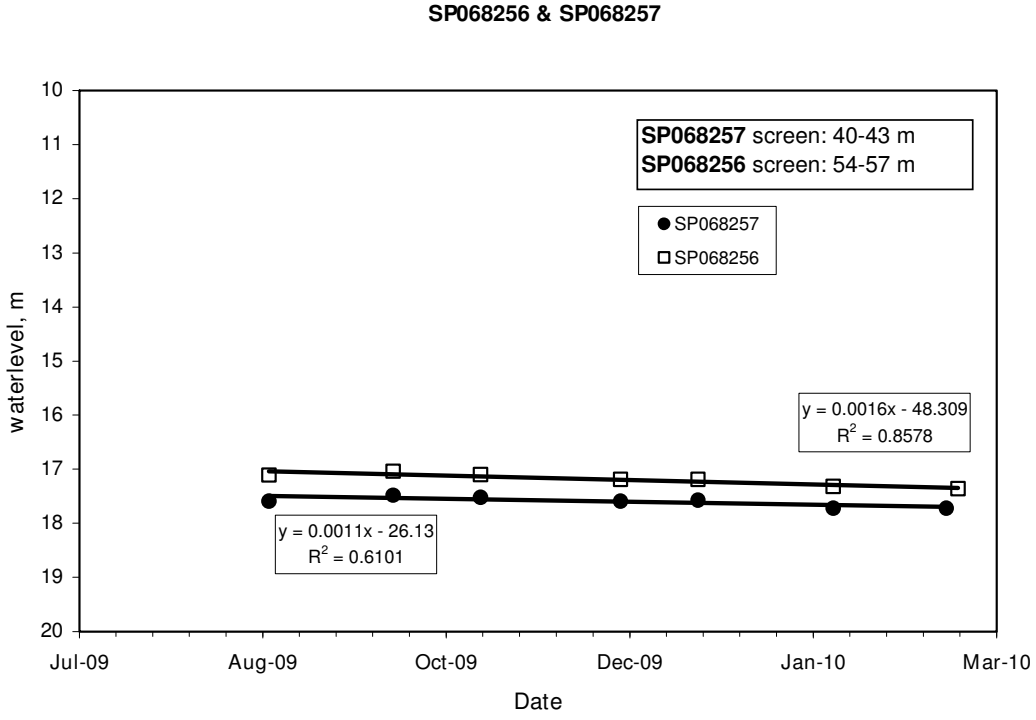

Figure 58 Hydrograph of depths to groundwater in bore nest SP068256 and SP068257, near Birch Creek in the Tullaroop Creek catchment, showing upward hydraulic gradient (see Figure 55 for location).

6.3.3 Mount Emu Creek Catchment

The Mount Emu Creek Catchment is located within the Glenelg Hopkins CMA region, south of the surface water divide that separates it from the Loddon catchment. A few areas of potentially significant GDEs are mapped within the catchment (Figure 59).

Water levels in monitoring bores in this catchment are generally declining (e.g. Figure 60). Hydraulic gradients are generally downward. Figure 61 shows a substantial downward gradient between the Newer Volcanics and the deep lead to the extent that the former behaves as a perched groundwater system.

The NDVI difference for potential GDEs in the western part of the catchment is shown in Figure 62. The potential GDEs are generally found in round depressions but the change in NDVI between 1995 and 2002 is variable. It appears from inspection of aerial photographs and satellite images that there has been increased cropping at these locations – possibly associated with the drier conditions creating greater opportunity to sow crops. If that is the case, then negative impacts are due to interrelated climatic and land use changes.

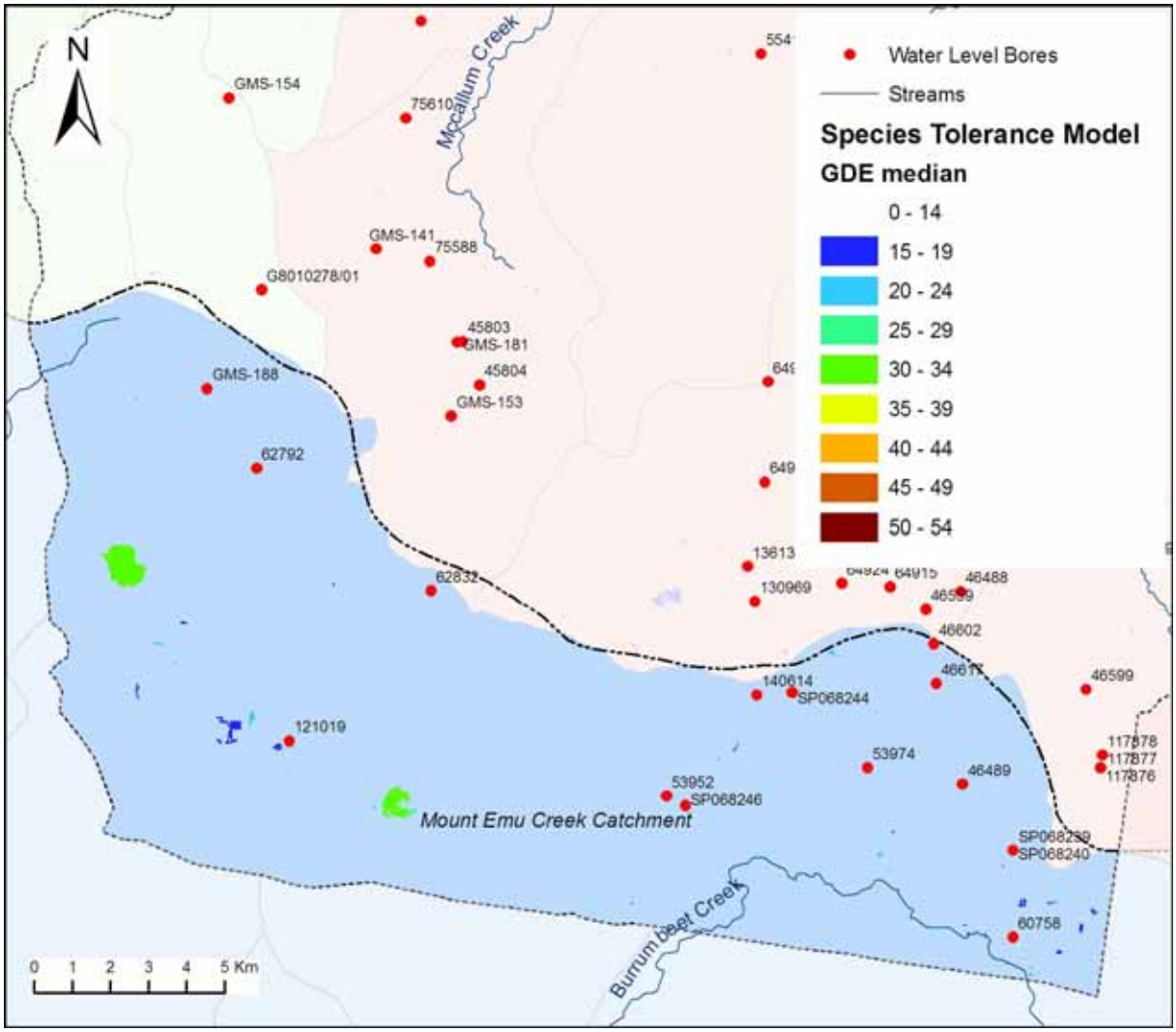

Figure 59 Species tolerance model results for potential GDEs in the Mount Emu Creek Catchment and monitoring bore locations

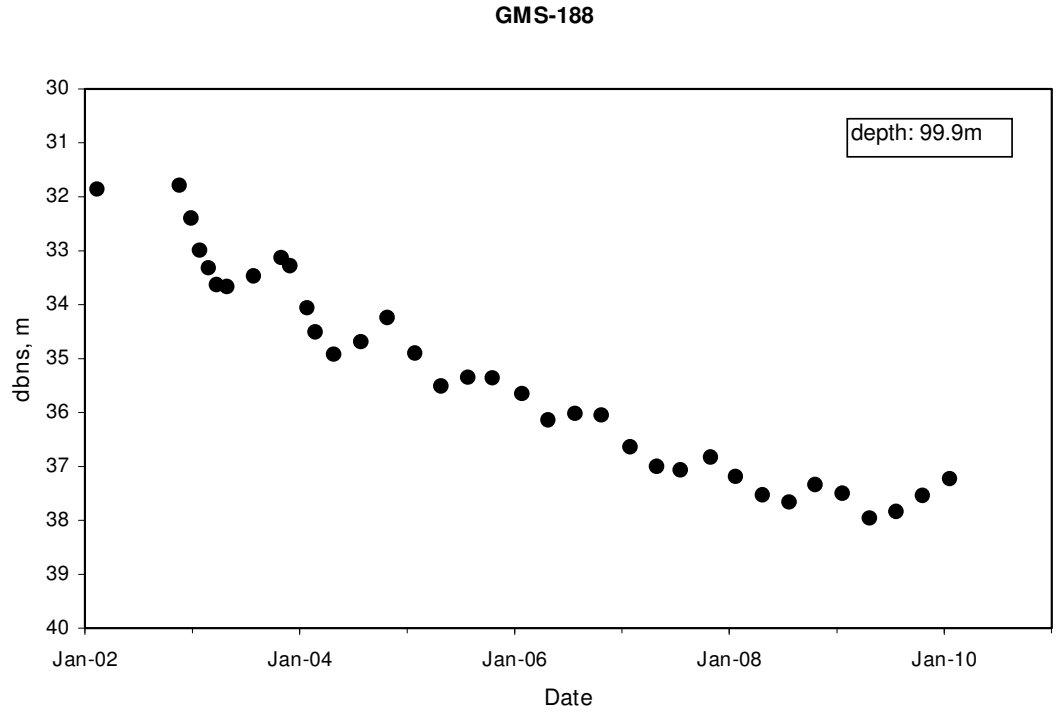

Figure 60 Hydrograph of bore in the western Mount Emu Creek catchment showing declining water levels (see Figures 59 and 62 for location).

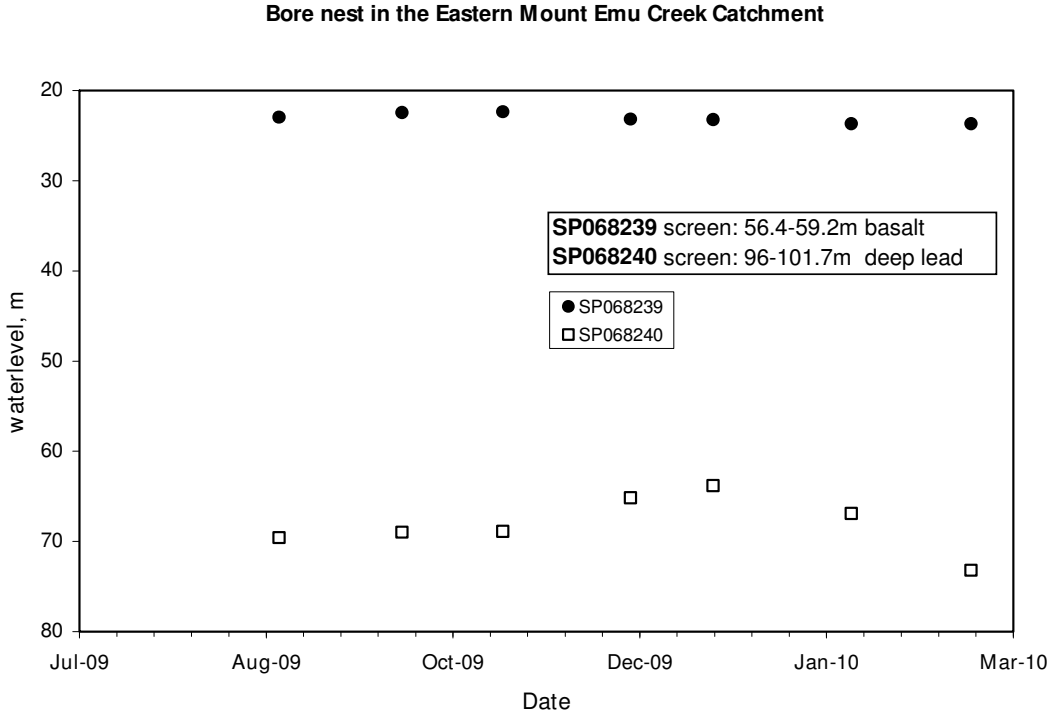

Figure 61 Hydrograph of bores in the Mount Emu Creek catchment showing a marked downward hydraulic gradient from the Newer Volcanics basalt to the deep lead (see Figures 59 and 62 for location).

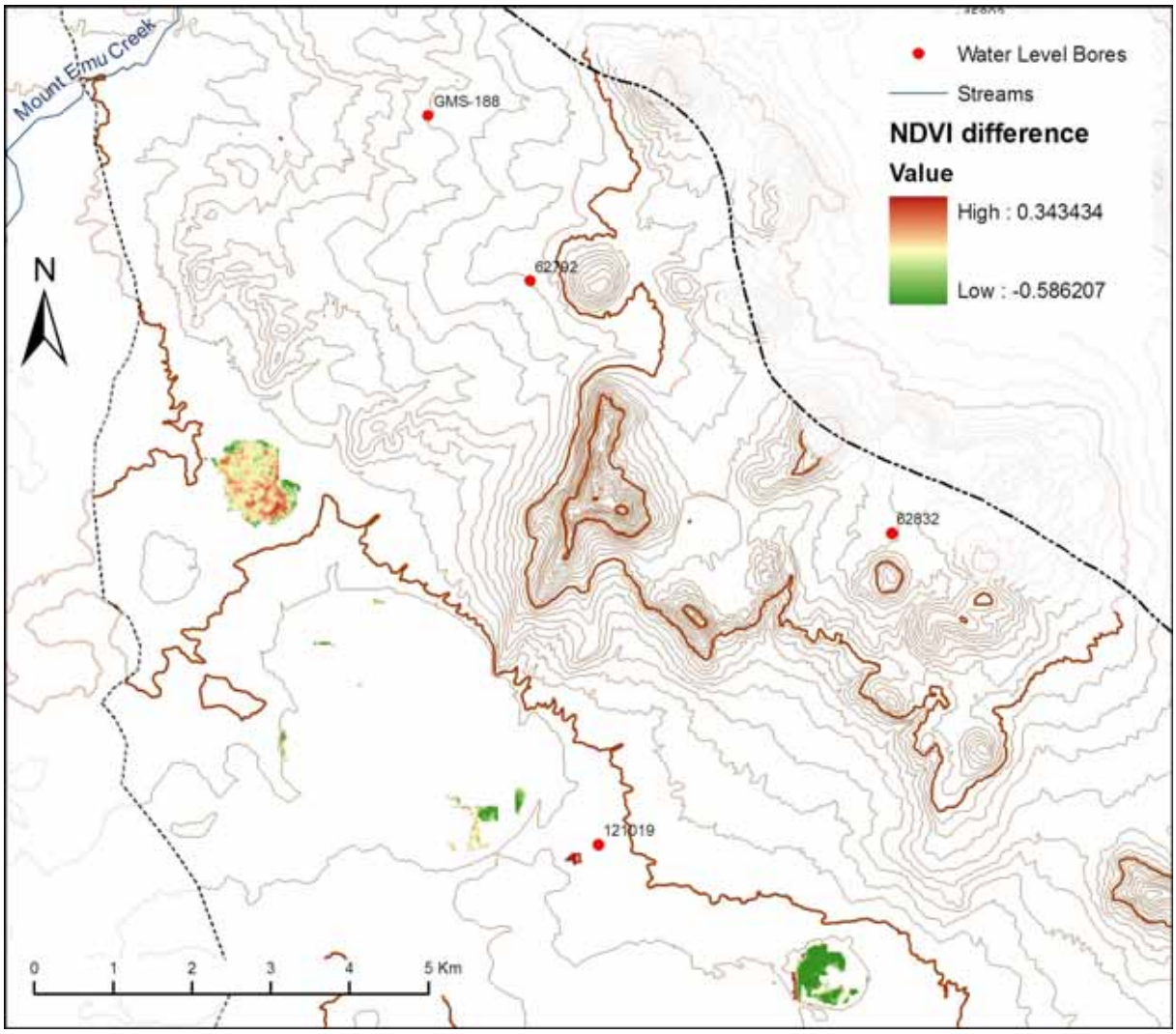

Figure 62 NDVI difference for potential GDEs with species tolerance scores of 15 or above in the Mount Emu Creek catchment. High difference indicates higher NDVI in 1995 compared to 2002.