WATER
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Effects of Rainfall, Pines and Abstraction on Gnangara Mound Water Level Decline

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Introduction

In recent years, groundwater levels on Gnangara Mound have declined in response to drying climate, increased abstraction for public and private water supply, maturation of pine plantations and changed fire regime of native woodlands. The continued drop of water levels on the Mound is threatening the ecological function in areas of lakes/wetlands and there are concerns about the sustainability of the Gnangara groundwater resources.

A regional groundwater model (PRAMS) has been developed to assist assessing the sustainable resource of Gnangara Mound (Barr et al. 2003, CyMod 2004, Davidson and Yu 2004, Silberstein et al. 2004, Xu et al. 2004). The PRAMS model is proving a robust tool to evaluate the impacts of various factors that contributed to the water level declines.

This note summarises the simulation results using PRAMS model to quantify the effects of reduction in rainfall, pine plantation and groundwater abstraction on the decline of groundwater levels on the Gnangara Mound.

Methodology

DoE (Vogwill, 2004) has recently investigated the groundwater storage change in the central area (~1200 km2) of Gnangara Mound (Figure 1) since 1979 using observed hydrograph data from the monitoring bores and results are presented in Figure 2. Figure 2 shows that during 1985-93 there is relatively small change in the groundwater storage but after 1993, storage depletion increase gradually and accelerate since 1997.

No or little storage change during 1985-93 indicates that the groundwater system on the mound is in a ‘quasi’-steady state, namely recharge into the system is roughly equal to the discharge (including abstraction) from the system. Recharge and abstraction for the period is considered to be sustainable and is able to maintain the groundwater levels on the mound. Reduction in recharge or increase in abstraction will disturb this balance and cause groundwater level decline. Normalisation of the two components will approximately give the proportion of effects of reduction in recharge and increase in the abstraction on the decline in the groundwater levels.

The effects of abstraction in the water balance consist of two parts: direct abstraction from the superficial/Mirrabooka aquifers and abstraction from the confined aquifers. Direct abstraction from the superficial aquifer will have one to one effect on the water balance whilst the confined abstraction is reflected on the leakage from the superficial aquifer into the confined aquifers in the area.

Recharge to the superficial aquifers and leakage into the confined aquifer in the area can be estimated by groundwater simulation using PRAMS 3.0 (CyMod, 2004). In this study, analysis was undertaken for two periods 1985-1993 and 1993-2003. Using the water balance components for the period 1985-1993 as the basis, the relative contribution of reduction in recharge and increase in abstraction for the decline in water tables during the period of 1993-2003 is evaluated. Further analysis was then carried to determine the impacts of pine plantation on the recharge. This is done by comparing the recharge under the native woodlands and pine plantations. Reduction in recharge due to the pines is estimated by accumulating the difference in recharge between the pine and native woodlands.

Results

PRAMS modelling was undertaken for the period 1985-2003 and water balance analysis was performed for the period 1985-1993 and 1993-2003. The key components of water balance are given in Table 1.

Period	Recharge (GL/a)	Pumping from Superficial (GL/a)	Leakage into confined (GL/a)
1987-1993	216	40	25
1993-2003	170	55	30
Difference	-46	15	5

Table 1 Key water balance components for the periods of 1987-1992 and 1993-2003

Normalisation of the difference provides the relative contribution to the groundwater level decline on the Gnangara Mound (Figure 3). Figure 3 shows that the major cause for the groundwater decline is due to reduction in recharge which accounts for 70% of the decline. Increase in abstraction from the superficial aquifers accounts for 23% of the decline and increase in the confined abstraction accounts for only 7% of the decline. Figure 4 shows the abstraction from the superficial and Mirrabooka by the Corporation and private licensed abstraction over the period. Over the period 1993-2003, the Corporation's abstraction from the superficial aquifer slightly declined but the private licensed abstraction has increased by about 25 GL. Increase in the leakage into the confined is largely due to the increased abstraction from the Leederville and Yarragadee aquifers by the Corporation.

Further analysis was carried out estimate the recharge under native woodlands and pine plantations and results is shown in Figure 5. Averaged recharge in the native woodland is about 153 mm/a but only 65 mm/a under pines over the period 1993-2003. Over the central Gnangara mound, reduction in recharge due to the pines is estimated to be around 24 GL/a, namely another 22 GL/a reduction in recharge is due to rainfall. By normalising the reductions in recharge due to rainfall and pines and increases in abstraction and leakage, their contributions to the groundwater table decline can be obtained (Figure 6). Figure 6 shows that about 32% of the decline is due to rainfall reduction, 38% due to pine plantations and 23% due to the abstraction directly from the superficial aquifers and 7% from the confined abstraction largely due to the increased abstraction by the Corporation.

Lack of burning in the native woodlands also contributes to the reduction in groundwater recharge and hence groundwater decline. Unfortunately there is no simple way to estimate its contribution to the groundwater decline and hence hasn't been examined in this work.

Conclusion

Preliminary analysis has been undertaken using PRAMS 3.0 model to determine the relative contribution of reduction in rainfall, pines and increase in abstraction to the decline in the groundwater level on Gnangara Mound for the period 1993-2003 using the period 1987-1993 as the baseline. Results have demonstrated that the major cause for the groundwater decline is the lack of recharge due to the reduction in rainfall and maturity of the pine. Increase in abstraction has exacerbated the impacts. Modelling results indicates that about 32% of the decline is due to rainfall reduction, 38% due to pine plantations and 23% due to the increase abstraction from the superficial aquifer and 7% from the confined abstraction largely due to the increased abstraction by the Corporation.

References

Barr, A.D., Xu, C., and Silberstein, R.P. (2003), Construction of a vertical flux manager for the Swan Coastal Plain, In MODSIM 2003, Proceedings of International Congress on Modelling and Simulation, Townsville, Queensland, Post, D.A., ed., pp. 172-176.

CyMod (2004). Calibration of the coupled Perth Regional Aquifer Model PRAMS 3.0. Report to Water Corporation and Water and Rivers Commission.

Davidson, W. A. and Yu, X. (2004). PRAMS: Hydrogeology and Conceptual Model. Hydrogeology report 202, Department of Environment.

Silberstein, R., Barr, A., Hodgson, G., Pollock, D., Salama, R., and Hatton, T. (2004), A vertical flux model for the Perth groundwater region, Report to the Water Corporation of Western Australia

Vogwill R. (2004). Sensitivity of the water table in the Perth region to changes in climate, landuse and groundwater abstraction using the PRAMS model. Hydrogeological report series HR223, Water and Rivers Commission, DoE.

Xu, C., Canci, M., Martin, M., Donnelly, M. and Stokes, B. (2004), Application of the Vertical Flux Model, Part 2, Vertical Flux Model, Volume II, Perth Regional Aquifer Modelling System (PRAMS 3.0) Model Development, Report prepared by Water Corporation of Western Australia.

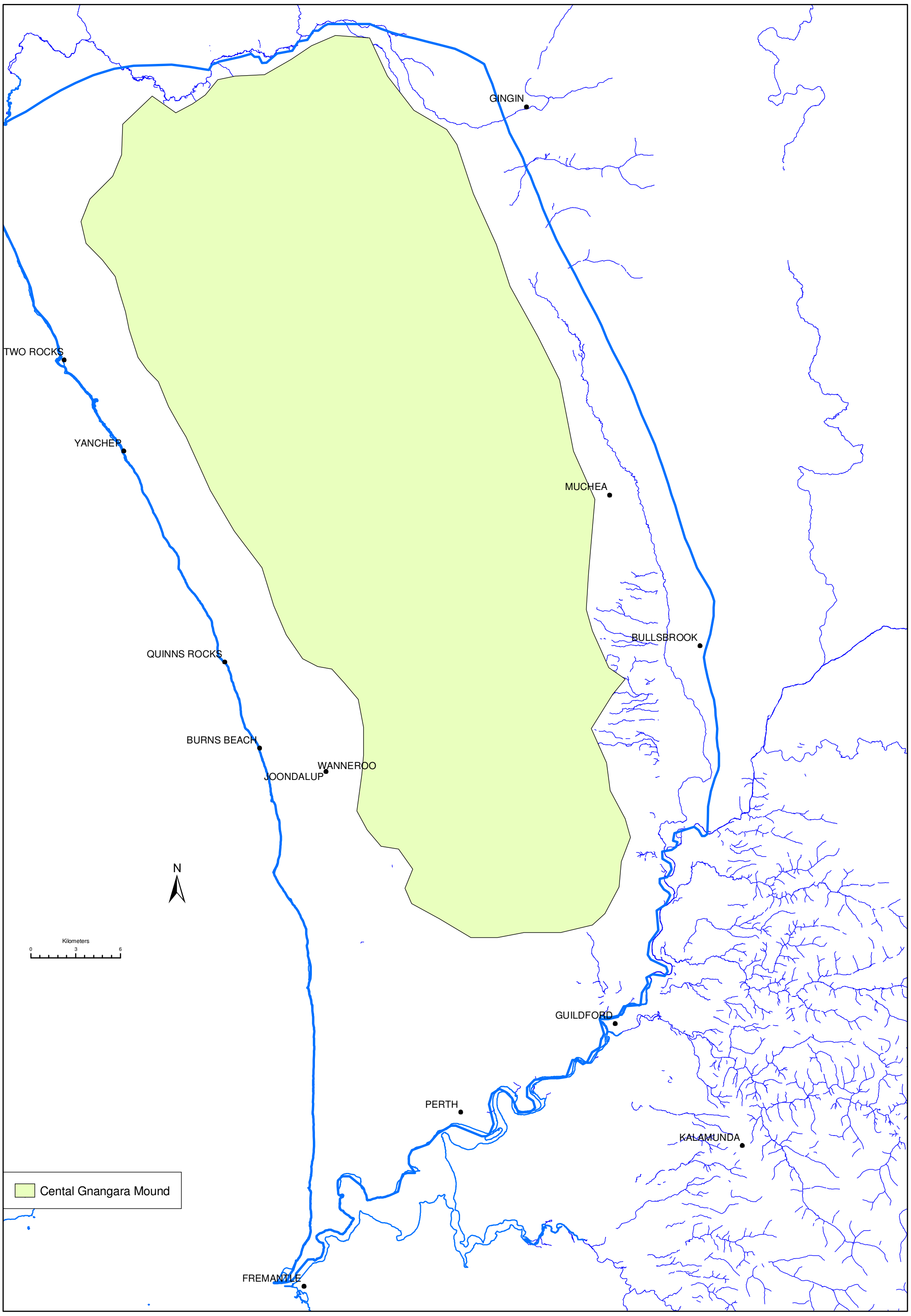

Figure 1 Central area of Gnangara Mound

Figure 2 Storage depletion in the central area of Gnangara Mound (DoE, 2004)

What causes water level declines on Gnangara mound for the period of 1993-2003
(baseline 1985-1993; PRAMS 3.0, Oct. 2004)

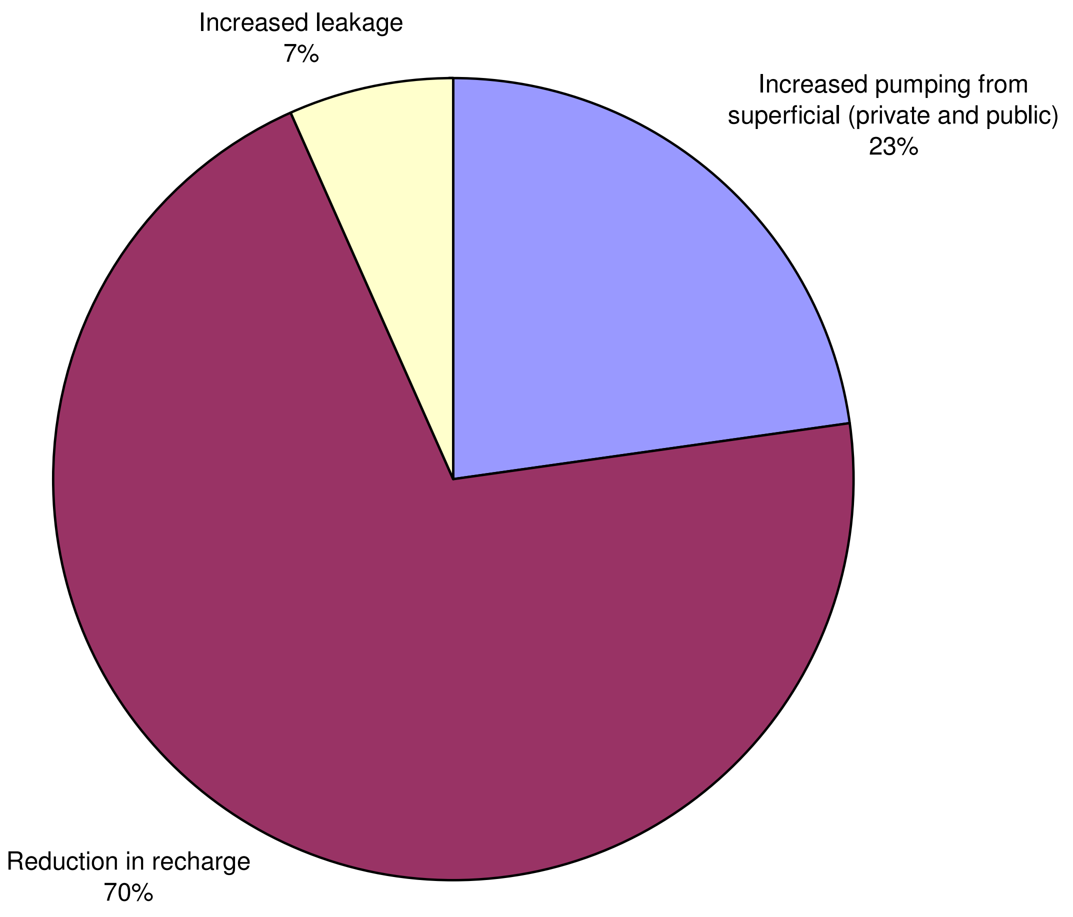

Figure 3 Contribution of reduction in recharge and increase in abstraction to groundwater decline

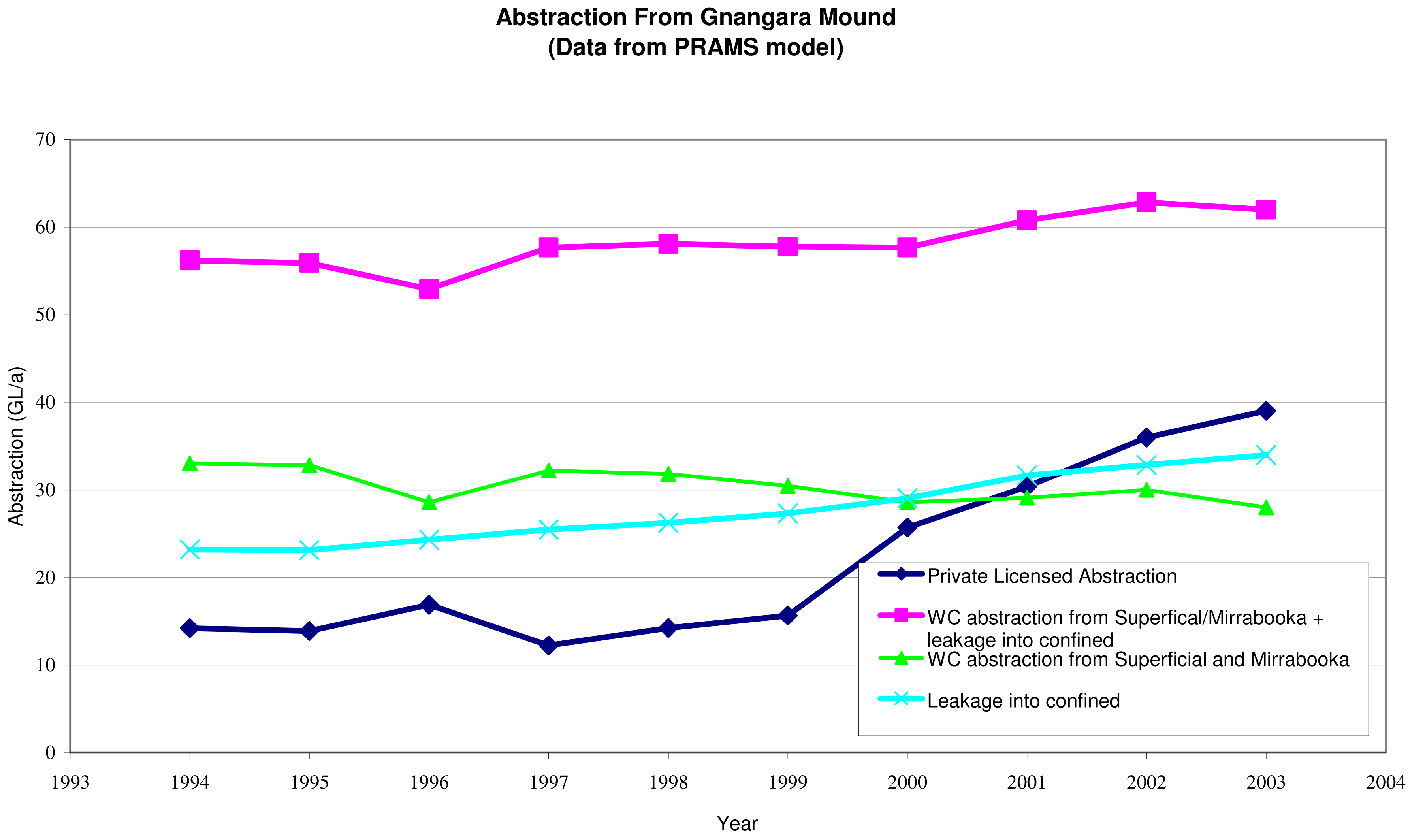

Figure 4 Increase in abstraction and leakage

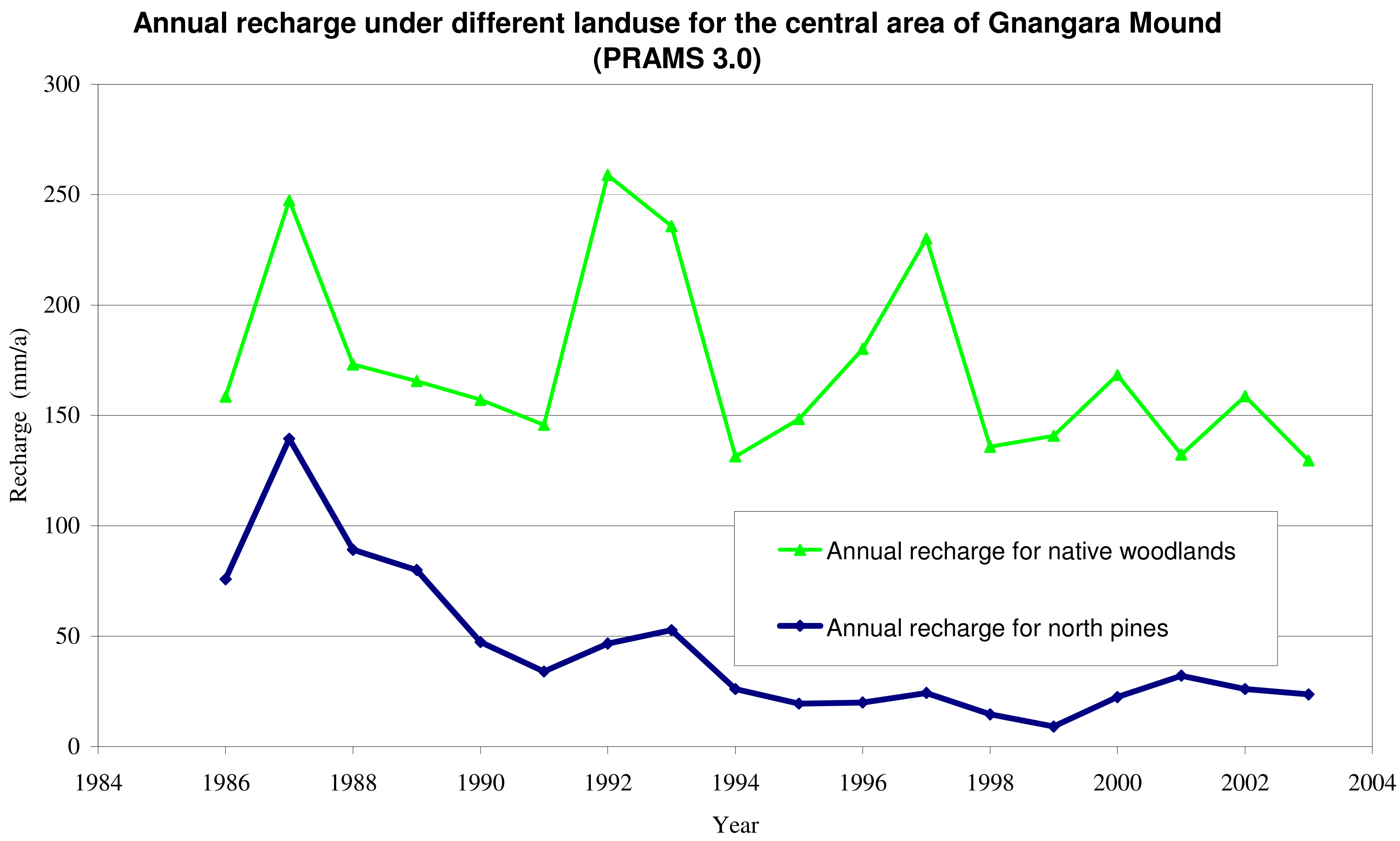

Figure 5 Recharge under pines and native woodlands

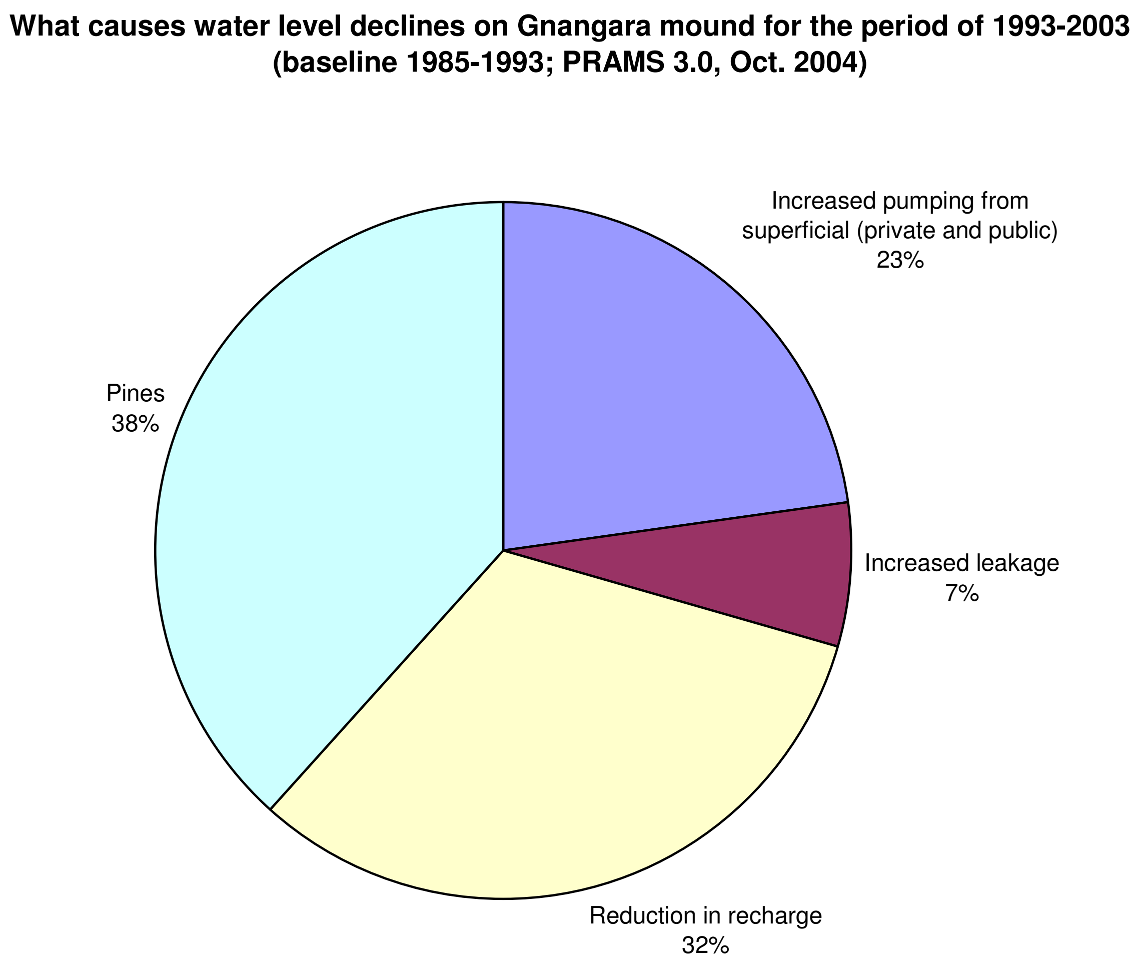

Figure 6 Contribution to groundwater level decline by rainfall, pines and abstraction