

## The use of land use planning strategies to protect groundwater used for potable (drinking water) supply

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**Abstract** Perth draws about 65% of its public water supply from groundwater located beneath the surrounding coastal plain, including about 25% from unconfined sand aquifers overlain by diverse land uses. This paper describes the setting for these key groundwater sources, and the modelling that defined the catchment boundaries. Source protection measures including statutory development controls, protection plans, environmental guidance, and community awareness programs are used to limit contamination risks. *Land Use and Water Management Strategies* (LUWMS) were prepared to guide land development regulators. Studies have been used to evaluate the effectiveness of LUWMS in preventing the establishment of detrimental land uses over the water source mounds, and assessed the contamination risks posed by established land uses. The reasons the studies were undertaken, their methodology, and evaluation of the threats posed by various land uses are described. The paper suggests how the study findings can be used to help protect drinking water aquifers/catchments.

**Key words** catchment; contamination; drinking water source; UWPCA; Land Use and Water Management Strategy (LUWMS); Statement of Planning Policy (SPP); unconfined aquifer; source protection and drinking water quality

### INTRODUCTION

The greater Perth Integrated Water Supply Scheme (IWSS) presently supplies water to 1.5 million people living in the south-west of Western Australia (WA). The scheme draws about 25% of its public water supplies from shallow groundwater aquifers beneath diverse surface land uses making protection of the water sources of paramount importance. Another 40% comes from underlying semi-confined and confined aquifers. The superficial aquifers also support conservation wetlands and private water supplies. The IWSS draws groundwater from the Gnangara mound, centred 40 kilometres north of Perth and the Jandakot mound, 15 km south of Perth. The *Australian Drinking Water Guidelines 2004* (ADWG, NHMRC, 2004) provide the framework used to manage drinking water quality, including a preventative risk-based multi-barrier quality *catchment to consumer* protection approach. Understanding the catchment, the hazards and events that could affect drinking water quality; then developing and implementing contamination prevention strategies and operational controls forms a primary protection barrier.

The catchment protection objective for the Gnangara and Jandakot aquifers is for water quality to be suitable for human consumption, when assessed against the ADWG

health criteria. The Department of Water (DOW) is responsible for public drinking water source protection throughout Western Australia.

In the late 1990s, the DOW's predecessor worked in partnership with the Western Australian Planning Commission (WAPC) to develop Land Use and Water Management Strategies (LUWMS) for the Gnangara (WAPC, 2001) and Jandakot (WAPC, 1998) mounds to incorporate water resource protection measures into land use planning processes. Between 2005 and 2007 detailed studies (Boyd, 2006, 2007) were undertaken of the effectiveness of the LUWMS in averting growth of detrimental land uses over the groundwater mounds. Risks posed by established land uses were also reassessed and given a hazard ranking.

The DOW uses a range of protection measures including gazetted public drinking water source protection areas (control areas), source protection plans, statutory controls for activities near wellheads, environmental guidance and community awareness programs, and supports land use planning controls to limit contamination risks. The LUWMS deal with the areas of the mounds covered by the proclaimed Gnangara (WAPC, 1995a) and Jandakot (WAPC, 1995b) Underground Water Pollution Control Areas (UWPCA). The LUWMS provide direction for resource managers, planners, land users, developers, conservation groups and the community in managing activities to achieve the lowest practical risk to groundwater quality.

## **STATUTORY PROCESSES USED TO PROTECT THE GNANGARA AND JANDAKOT UWPCA**

The Department of Water presently manages the UWPCA using the By-laws provided under the *Metropolitan Water Supply, Sewerage and Drainage (MWSSD) Act 1909*.

### **Creation of the Underground Water Pollution Control Areas**

The current boundaries of the Jandakot and Gnangara UWPCA were proclaimed under the *MWSSD Act* in 1998 and June 2007, respectively after undergoing detailed groundwater modelling and extensive public consultation. This proclamation triggers the application of By-laws to prevent deterioration of water quality and control development in each UWPCA. The State Government arranged amendment of the Metropolitan Regional Scheme (MRS) to incorporate the new boundaries and establish protective planning zones.

### **Land use and water management strategies**

The land use and water management strategies for Gnangara (WAPC, 2001) and Jandakot (WAPC, 1998) include recognition of the need for long term water source protection; integration of the planning, environmental and legal issues; constraints on land uses, provision of Government infrastructure to support urban expansion, supply of basic raw materials, and protection of important wetlands and remnant vegetation.

Classification of land within the UWPCA follows the recommendations of the Gnangara (WAPC, 2001) and Jandakot (WAPC, 1998) LUWMS. These processes were supported by the findings of State Parliamentary select committees reports (WALA, 1994; WALC, 2000) on source protection. The LUWMS also identified

revised boundaries for the UWPCA based on groundwater modelling (Dames & Moore, 1996a,b, 1998).

The need to protect Perth's groundwater resources through the land planning framework is also acknowledged in The State Planning Strategy 1997 (WAPC, 1997).

### **Statements of Planning Policy**

Statements of Planning Policy (SPP) are prepared by the WAPC (see Section 25 of the *Planning and Development Act 2005*) to guide local government planners. The WAPC prepared SPP 2.7 *Public Drinking Water Source Policy* (WAPC, 2003) to ensure the LUWMS are used in subdivision and development planning decisions. SPP 2.7 is a general policy relating to protecting proclaimed public drinking water source protection areas and requires that LUWMS identify specific source protection areas for each UWPCA. Land is assigned a protection priority classification of P1, P2 or P3. The P classification is based on the strategic importance of the land or water source, the local planning scheme zoning, form of land tenure, and existing approved land uses/activities. P classifications are explained in the DoW's *Land Use Compatibility in PDWSA Policy* (DoW, 2004) (based on the Planning Regulation's *Model Scheme Text*) which describes the suitability of specific land uses for approval.

Another water quality protection measure described in SPP 2.7 (WAPC, 2003) and the LUWMS is that within the Perth Metropolitan Region, P1 protection areas should be defined as *Water Catchments Reservations* and P2 areas as *Rural-Water Protection Zones* or be covered by a Special Control Area (SCA) for water protection in any corresponding Local Government planning schemes.

SCA planning provisions provide for the referral of development proposals to the DOW for assessment and advice. SPP 2.7 (WAPC, 2003) also recommends that local government planning schemes and decisions on land use development be consistent with LUWMS and SPP 2.2 *Gnangara Groundwater Protection* (WAPC, 1995a) and SPP 2.3 *Jandakot Groundwater Protection Policy* (WAPC, 1998). SPP 2.2 (WAPC, 1995a) has the objective to ensuring land uses on Crown land (*i.e.* land with a P1 classification) in the Gnangara UWPCA are compatible with water quality protection objectives. SPP 2.3 (WAPC, 1998) has the objective to protect water quality in the Jandakot UWPCA. These SPP require the WAPC and local government authorities to give protection of UWPCA due regard when making planning decisions.

This approach has been supported in practice by the planning approvals process in WA. Land development proposals that have been inconsistent with the objectives of LUWMS have generally been rejected by the WAPC and this has been supported by the State Administrative Appeals Tribunal. Proposals inconsistent with LUWMS (which are publicly consulted documents) are seen to be contrary to proper and orderly planning and are likely to have detrimental effects on groundwater quality. Therefore they are incompatible with the State Government endorsed sustainability principles.

### **Gnangara and Jandakot UWPCA physiography**

The Gnangara and Jandakot UWPCA are dominated by the coastal dune system of the Swan Coastal Plain (Davidson, 1995). The UWPCA are covered by gently rolling leached sand plains of the Bassendean Dune System. The Jandakot dunes are partially

underlain by Guildford clays. The western portion of the Gnangara UWPCA consists of calcareous sand remnants of the Spearwood Dune System. Wetlands occupy the inter-dune swales of the Bassendean Dune System and the depressions between the Spearwood and Bassendean Dune Systems. These incorporate lacustrine deposits of peat, peaty clay and clay.

A small area of Guildford clay exists on the central eastern boundary of the UWPCA. State Forest covers over 75% of the Gnangara UWPCA of which about 200 km<sup>2</sup> has been planted with pines and the rest is natural bushland (WAPC, 2001). There are also plots of remnant vegetation preserved in parks and recreation reservations. About 10% of the UWPCA has been cleared of native vegetation and developed for urban and rural land use and activities. Much of the Jandakot UWPCA has been cleared for rural and urban habitation and the little natural vegetation that remains is preserved in declared conservation areas.

### Gnangara and Jandakot UWPCA hydrogeology

The Gnangara and Jandakot mounds are located within the central part of the Perth Sedimentary Basin (Davidson, 1995). The superficial sediments are underlain by semi-confined and confined sedimentary formations to a depth of about 10 000 m. The aquifers within the formations are vulnerable to contamination from inappropriate land uses because of the leached sand soils, direct rainfall recharge, shallow depth to water tables and for the Gnangara Mound, hydraulic connection between aquifers.

### Water quality

Raw water quality of the Gnangara and Jandakot wellfields is regularly monitored in accordance with ADWG (NHMRC, 2004). Parameters monitored include microbiological indicators, health-related chemicals and physical/chemical aesthetic quality parameters (Table 1).

**Table 1** Superficial aquifers physical and chemical quality data from 2000 onwards.

Parameter	ADWG criterion	Gnangara UWPCA			Jandakot UWPCA		
		Min	Max	Median	Min	Max	Median
pH	6.5-8.5 (A)	4.7	7.8	5.9	5.7	7.6	6.9
Colour (HU)	15 (A)	2	190	55	1	180	65
Cl (mg/L)	250 (A)	38	165	74	37	370	94
E.Cond (mS/m)	91 (A)	21	86	43	20	155	56
Al (mg/L)	0.2 (A)	ND	6.6	0.42	ND	3.6	0.17
Fe (mg/L)	0.3 (A)	0.018	13.0	0.8	0.1	3.4	0.6
Mn (mg/L)	0.1 (A)	0.002	0.18	0.008	0.008	0.05	0.018
Kjeldahl N (mg/L)	NC	0.08	1.4	0.55	0.042	1.9	0.62
NO <sub>2</sub> / NO <sub>3</sub> (mg/L)	50 (H)	0.002	2.6	0.01	ND	0.2	0.006
P (soluble) (mg/L)	NC	ND	0.63	0.026	0.017	1.0	0.1
SO <sub>4</sub> (sol) (mg/L)	500 (H)	0.3	200	21	1.2	74	14
Turbidity (NTU)	5 (A)	ND	370	8	0.1	170	19

Sources: Water Corporation ODSS database

Legend: H = health criterion, A = aesthetic criterion, NC = not cited, ND = not detected

Raw water from the Gnangara and Jandakot groundwater system has consistently been of good quality and generally meets ADWG (NHMRC, 2004) quality criteria.

The exceptions for the Gngangara UWPCA are aluminium, colour, iron, pH and turbidity, and for the Jandakot UWPCA, colour and iron. The elevated levels of these parameters relate to natural occurrence and are not considered a result of land use impacts. Analyses of the regular and on-going monitoring programs indicate values of all parameters are within the naturally occurring range for these localities, and no adverse trends are evident.

### **IWSS groundwater treatment prior to delivery to consumers**

Groundwater treatment applied includes pH adjustment, aeration, chemical coagulation and settling, sand and coal bed filtration, fluoridation and chlorine disinfection. The treated water is tested for conformity with the ADWG (NHMRC, 2004) before delivery to consumers.

### **Review of risks to public drinking water supply quality**

Between 2005 and 2007 reviews of the risks to water quality in Gngangara (Boyd, 2007) and Jandakot (Boyd, 2006) UWPCA were undertaken to assess the affect of implementing the Gngangara (WAPC, 2001) and Jandakot (WAPC, 1998) LUWMS developed almost a decade earlier. The review included a study of the extent of recent land use changes, the risks posed by established land activities, with the aim of establishing priorities for future management of the UWPCA. Initial risk assessments for Jandakot and Gngangara UWPCA were completed in 1995 (WAPC, 1995) and 2001 (WAPC, 2001), respectively. The Department of Water requested Water Corporation undertake the reviews as it is the licensed IWSS water service provider.

### **Hazard identification and risk assessment**

Hazards associated with land uses and activities in the study area were identified as part of the review process using the methodology described in the ADWG (NHMRC, 2004) Chapter 3. The risk posed by each hazard was qualitatively assessed and a catchment management priority of *High*, *Medium* or *Low* assigned based on the likelihood and consequences of the source being contaminated, taking into account current catchment preventive and management strategies (see Table 2).

### **Evaluation of the effectiveness of the Gngangara and Jandakot LUWMS**

Land use information within the study areas was compiled from a number of sources. Data was obtained from existing State agency and Water Corporation land and water databases, geographic information systems and aerial photography, and enhanced by field-based property surveys and on-site inspection of selected sites. The land precinct format set out in the Gngangara (WAPC, 2001) and Jandakot (WAPC, 1998) LUWMS for grouping properties was used to assess and review current land use and contamination risks. All study data gathered was incorporated into Microsoft Access and Excel databases for analysis.

Current risks to water quality from activities within Jandakot and Gngangara UWPCA were identified and reviewed against previous assessments. Progress with implementation of the LUWMS recommendations was reviewed (Boyd, 2006, 2007). The review methodology included:

- Compiling and categorising land use and activity perceived risks in each

precinct.

- Evaluating past (pre-LUWMS) land use, current land uses and apparent changes.
- Assessing risks posed by land uses for their potential impact on groundwater quality and assigning a priority risk ranking.
- Determining land use conformity with assigned water protection areas (P1, 2 or 3).
- Reviewing and documenting progress with implementation of the LUWMS recommendations.
- Documenting results from land use and activity surveys, risk review and implementation progress in Source Protection Reviews for each UWPCA.
- Identifying actions needed to ensure long-term protection of the drinking water supply sources of the Jandakot and Gngangara Mounds.

**Table 2** Gngangara (G) and Jandakot (J) UWPCA established land use summary.

Land use	Contamination hazard	Priority*
Farmland intensive (market garden, orchards, piggery, poultry, turf / plant nurseries) (G, J)	Nutrients, pathogens, pesticides	High
Industry -waste recycling (G, J)	Nutrients, metals	High
Service stations (G, J)	Glycol, surfactants, total petroleum hydrocarbons (TPH)	High
Waste disposal sites (closed) & soil blending (G, J)	Nutrients, pathogens, metals, organic chemicals	High
Public utilities - transport depots (G, J)	Chemicals, TPH	High
Industry - extractive (G, J)	Nutrients, TPH	Medium
Industry - food processors –unsewered (G, J)	Nutrients	Medium
Industry -service & general (drycleaners, building products, pest control, vehicle servicing/ repairs, warehousing) (G, J)	Chemicals	Medium
Kennels and catteries (J)	Nutrients, pathogens	Medium
Education facilities (G)	Nutrients, pesticides	Medium
Recreational parks (including equestrian, golf, gun and motor sport clubs) (G, J)	Metals, nutrients, pathogens, pesticides, TPH	Medium
Community ornamental water features (G)	Nutrients	Medium
Extractive industry (sand mining) (G, J)	Nutrients, TPH	Medium
Farmland - low intensity (special rural dwellings, pasture, poultry, stables) (G, J)	Nutrients, pathogens, pesticides	Medium
Public utilities (construction, gas-fired power station, sewerage systems, roads, water treatment plant) (G, J)	Pathogens, TPH	Medium
Telecommunications base (G)	Chemicals, pesticides	Medium
Defence airbase (G)	Chemicals, nutrients, TPH, pesticides	Medium
Sewered urban –houses, shops (G, J)	Nutrients, pathogens, pesticides	Medium
Forestry (pine plantation) (G)	Acid soils, nutrients, pesticides	Medium
Conservation wetlands (G, J)	Acid sulphate soils	Low

\* Priority (for management) is based on residual risk shown as High, Medium or Low

## CONCLUSIONS AND OBSERVED TRENDS

### Gngangara UWPCA

There has been no observed increase in the overall risk to drinking water quality of the groundwater system within the Gngangara UWPCA since the initial assessments undertaken in the 1990s as part of the production of the Gngangara LUWMS (Dames &

Moore, 1996a). The four wellfields within the UWPCA that supply scheme water did not show evidence of significant contamination. Groundwater quality has benefited from having the majority of the UWPCA in Government ownership, limiting development to the southern part only. State Forest No. 65 covers over 75% of the UWPCA, where the main established activities are extractive industry and pine plantations. Controlling land use and activities through Water Catchments Reservations and Rural-Water Protection Zones gazetted within the Metropolitan Region Scheme, creation of special planning control areas and purchase of potentially contaminating sites by the Western Australian Planning Commission are considered to be major initiatives in improving protection of groundwater quality.

The extensive consultation process associated with the production of the LUWMS also provided community awareness of the need to protect the local groundwater resources. Although private land ownership is less than 15% of the UWPCA, there were some risks to drinking water quality identified. The industrialised area of Malaga, residential areas of Alexander Heights, Ballajura, Ellenbrook and Henley Brook, intensive rural activities in Landsdale, Gnangara Road Special Rural Area and Lake Pinjar Special Control Area were considered to present contamination hazards to the shallow groundwater aquifer.

### **Jandakot UWPCA**

There was no observed increase in the overall risk to drinking water quality of the groundwater system within the Jandakot UWPCA since the initial LUWMS (WAPC, 1995) assessment. Groundwater has consistently been of good quality and no adverse trends were evident. Even with a large portion of the study area in private ownership (77%), there has been no evidence of significant pathogen or nutrient contamination of the wellfield. It was concluded that amendment of the Metropolitan Regional Scheme and implementation of the *Jandakot Groundwater Protection Policy* in 1998 have been significant influences in ensuring the protection of local groundwater resources. The new zones, and controls and principles of the protection policy have been successfully incorporated into local government agency planning schemes and rural strategies. The most significant risks to drinking water quality identified in the study area were intensive animal husbandry and agriculture within the Urban Deferred and Rural-Water Protection zones. Residues from manures at a past soil blending site and a closed landfill may still pose hazards.

### **Response to the UWPCA risk review**

Land use development controls appear to have worked well in preventing growth in contamination risks to Perth's superficial groundwater sources. However a number of long-established land uses require attention to reduce water contamination risks.

With recent lower rainfall recharge of aquifers and consequent declines in water tables there have also been emergent problems with sustaining scheme water production and groundwater dependant ecosystems. The State Government's response to recent studies includes consideration of:

- Pine plantation removal on the Gnangara mound and native vegetation replacement.
- New water resource management legislation is anticipated in 2008, including a

suite of tools to regulate high-risk land uses discharging to the environment.

- Increased publicity on land use risks via source protection signage, guidance program and community liaison.
- A land use sustainability review of the Gnamagara mound concluding in mid 2009.
- Commercial and local government bores metered on both groundwater mounds.
- More field surveillance resources and audits of environmental management at high contamination risk premises.
- The Water Corporation and Department of Water are evaluating the use of sentinel monitoring of superficial aquifer between high risk land uses and production bores.
- Review of DOW's public drinking water source area land use compatibility policy to ensure land use constraints are matched to perceived water contamination risks.
- A review and update of the Jandakot and Gnamagara LUWMS are expected within the next five years.
- Scientific investigation of comparative land usage eg contamination risk of medium-density sewerred residential land compared to low intensity rural land use (principally pastoral).

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