Government of Western Australia
Department of Water

Water quality protection note 21
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Looking after all our water needs

Iron staining caused by irrigation systems

Purpose

Iron dissolved in groundwater delivered via irrigation systems can produce unsightly rust stains on buildings, paths, fences and plants in many areas, especially on the Perth coastal plain. It may also stain clothes washed in iron-rich water and plumbing fixtures such as basins and toilet bowls. These rust stains resist cleaning with soaps, detergents and bleach. This note discusses the causes of iron staining, ways to minimise it and measures that can be taken to remove the stains without contaminating water resources. These measures can also help limit water resource contamination by other metals.

Our water quality protection notes (WQPN) advise on environmental issues and make recommendations on best practice. Key supporting information is provided in appendices. This information includes this department's role, intended use of the note, sensitive water resources description, water resource buffers, relevant statutes and administering agencies, and provides information for assessing development proposals.

Appendices provide additional background and technical advice as follows:

A. Information on sensitive water resources, note limitations and updates.
B. Relevant statutes and administering agencies, followed by references and further reading, note disclaimer and how to provide feedback.

Scope

This note applies to staining caused by iron hydroxide from iron-rich groundwater commonly associated with organic sediments, acidic conditions, absence of dissolved oxygen and/or microbiological activity (iron bacteria). The result is rusty staining (reddish-brown sometimes accompanied by multi-coloured streaks) on any structure or plant receiving irrigation spray over an extended period. Associated black staining may be caused by the presence of soil carbon or manganese oxide.

Causes and effects of iron staining

Iron is the metal that is most abundant on Earth and is therefore very common in soils and groundwater. Dissolved iron occurs naturally in groundwater in concentrations of up to around 50 mg/L. Iron salts become increasingly soluble as groundwater becomes more acidic. In oxygen deprived and acidic groundwater (with a pH below 5), iron concentrations of between 1 and 20 mg/L are common (usually as stable carbonates). Iron is normally found dissolved in groundwater in the reduced ferrous form (Fe^{2+}) and oxidises to relatively insoluble ferric form (Fe^{3+}) when the pH of groundwater (alkalinity) is raised and it is exposed to oxygen in the air.

When acidic iron-rich groundwater is extracted and mixes with air, carbon dioxide and hydrogen sulfide (rotten egg gas) is frequently released, the pH rises and the iron is deposited as ferric hydroxide (rust) on any flat surface as water evaporates. Over time this oxide coating builds up causing discolouration particularly to light-coloured surfaces.

Iron may also be naturally present in groundwater as slimy, sometimes foul smelling bacteria filaments (such as *Acidithiobacillus ferrooxidans*). These bacteria are harmless, unlikely to settle out, and discolour the water brown, often with an oily sheen.

Iron deposits and iron bacteria may cause encrustations and blockage problems in irrigation systems, especially those that rely on small orifices for pressure control or delivery via water drippers. Iron scale may also affect heat transfer in hot water systems.

Iron staining is unsightly, but shouldn't cause serious harm to plants, animals or humans or structural damage. With high concentrations of iron (more than 20 mg/L) some plants with iron staining may experience a reduction in photosynthesis and vigour.

Areas where iron staining is likely

Acidic iron-rich groundwater is often found in the water-table close to present or past wetlands where organic carbon and sulfides are prevalent; the water table is shallow and contains little or no dissolved oxygen. Prior to drilling a well, it is wise to check with neighbours to see if they have experienced iron problems with their bore water. Old or damaged galvanised steel pipe-work may add to iron staining problems as acidic waters attack pipe walls.

Testing for iron presence in groundwater

A simple means of determining if a problem is likely to arise from established bores and wells is to take a filtered sample of groundwater in a clear open topped glass jar, agitate the water and let it stand overnight. If the water becomes discoloured brown, a stain becomes obvious near the waterline or rusty sediment is produced, it is likely the irrigated water will stain light coloured masonry, fences or pavements over time.

There are chemical test strips available (such as from the LaMotte Company) and field reagent tests (such as Palintest comparators) that can give a reasonable estimate of iron concentration using a colour comparison chart. Chemical analyses of water samples performed by a laboratory accredited by the National Association of Testing Authorities can accurately confirm the concentration of iron present in groundwater. Suitable laboratories may be located under analysts in the *Yellow Pages* telephone directory.

Analyses of additional water quality attributes such as pH, salinity, dissolved oxygen, water (carbonate) hardness, manganese, silica and sulfur may also be necessary when considering water treatment options. Professional advice on water sampling, preservation and testing is generally necessary to ensure accurate results.

Waters with iron concentrations above 1 mg/L (equivalent to one part per million) are most likely to produce iron staining.

Advice and recommendations

Minimising iron staining

1 Water should ideally be drawn from a source that has a low iron concentration (typically less than 1 mg/L). These waters are normally neutral to alkaline and contain some dissolved oxygen. Water in dams or surface waterways will rarely cause iron staining problems, as iron will normally drop out with sediment prior to water being extracted. Rainwater is also unlikely to exhibit iron staining problems, unless in contact with degraded steel tanks or pipework.

2 If irrigating with iron-rich groundwater, the system design should minimise spray onto paths, fences or buildings. Large droplet (low pressure) sprinklers should be used to limit overspray and water aeration. Alternatively initially painting surfaces a dark colour may make any staining less noticeable.

3 As soil strata are highly variable, groundwater at some depths may have less iron content than at others. If iron staining is visible in the local area, there is a high risk that a shallow bore will yield iron-rich groundwater. The bore driller should be asked if it is feasible to vary the drill depth and screen placement with an upper bentonite seal to minimise access of iron-rich water to the pump. Observation of the colour of soil encountered below the water table can assist the driller to set the optimum pump inlet screen level and avoid setting screens against organic-rich horizons. The national guidelines *Minimum construction requirements for water bores in Australia* (reference 2) provide useful advice on this topic.

4 The borehole should be chlorinated immediately following construction to minimise transmission of organic material and drilling fluids affected by iron bacteria. An alternative (more costly) option to reduce iron bacteria is to introduce steam and pasteurise the bore with groundwater maintained above 60^{o}C for at least 30 minutes. This method should not be applied to plastic-cased bores as the plastic may deform.

5 Appropriate placement of borehole screens and seals will reduce the risk of groundwater cascading within the bores that can promote aeration and formation of iron precipitates and bacterial infestations.

6 If severe iron encrustation of bore screens occurs, it can generally be reduced by using hydrochloric or phosphoric acid dosing in combination with agitation, then pumping the bore water to waste until iron and acid concentrations are acceptable. Repeat treatments may be periodically required. For bores exhibiting signs of bacterial infestation (often called *soft iron*), shock chlorination dosing at concentrations of 500 to 1000 mg/L can provide an effective treatment. Leave the chlorinated bore unused for 24 to 48 hours, and then pump the residue to a soak-pit. Pool test kits can be used to check water pH and chlorine concentration. Pool chlorine provides from 10 to 35 per cent of free chlorine.

7 The selected bore screen treatment should be checked to ensure it will not damage bore or pump components or contaminate local groundwater.

Treating extracted groundwater

8 Before deciding whether to remove iron from bore water or which treatment to apply, the intended use of the water should be considered so acceptable water quality can be

achieved (reference 1). Uses may include drinking water, animal water supplies, garden, lawn or crop watering, industrial process or cooling waters, domestic flushing or bathing waters; and fish, swimming or ornamental ponds.

9 Untreated groundwater should not be used for human consumption as health problems may arise (reference 4c). The main health concern is disease from pathogenic microbes, but groundwater may also contain toxic substances which are difficult to detect such as arsenic, heavy metals, petroleum and pesticide residues, especially in areas where there is a history of human activity. Care also should be taken that any treatment chemicals do not harm the user during their application, or later when the water is put to its intended purpose. Additional information is provided in WQPN 41 *Private water supplies*.

10 The following iron concentrations (reference 1) indicate groundwater suitability for various uses:

Use of water	**Guideline value for iron (mg/L)**	**Reference**
Aesthetic or recreation needs	0.3	1a
Aquaculture (fresh or marine)	Less than 10	
Ecosystems (in ponds)	Natural condition for pond species	
Irrigated vegetation	10 (for applications under 20 years); 0.2 (long term)	
Stock drinking water	Not generally toxic	
Drinking water food processing	0.3 (based on aesthetic factors)	1b
Industry (steam)	Range 1 to 0.01 (based on steam pressure)	1d
Industry (cooling)	<0.5	
Industry (textiles)	<0.1	

11 Groundwater with a dissolved iron content of less than 25 mg/L can be treated by speeding up the processes that occur in nature. Treatment involves dosing the groundwater with an alkali such as lime to raise its pH to between 6.5 and 7.5, then aerating the water by either pumping it into the air as a fountain or allowing it to cascade over a large surface such as baffle plates or rocks, and finally letting the water lie still for a period while the iron settles out as a sludge. This may be accomplished in a purpose-built tank or pond.

An oxide-rich material will slowly build up as sediment in a tank or pond that will require occasional removal and disposal, (for example by application to land or burial). The clarified water should be tested and confirmed as having acceptable residual iron content before use.

12 Polyphosphate compounds added to cold iron-rich groundwater can be effective in coating iron, preventing its deposition. This form of treatment is most effective with iron concentrations from 1 to 3 mg/L and a water pH between 5 and 8. However if water is heated in hot water systems, the poly-phosphate is converted to phosphate that allows the iron to drop out as a solid. Phosphate is a nutrient that promotes algae growth and

therefore should not be added to systems where treated water discharge may harm waterways.

13 Sodium silicate (water glass) dosing can be effective for preventing iron deposition for ferrous iron concentrations up to 10 mg/L. The silicate is normally applied as a liquid using a metering pump on the discharge side of the water bore, using measures such as in pipe vanes to achieve effective mixing. This method may also be used to limit scale deposits in hot water systems.

A silicate dosing rate of approximately 75 mg/L is recommended for iron-rich groundwater concentrations above 5 mg/L. The sodium silicate is normally supplied as a concentrate and diluted according to supplier's instructions to suit the application. The treatment forms a stable iron-silicate complex that resists iron deposition.

Caution! Sodium silicate is caustic and will attack paint and metals, so care needs to be taken when handling the chemical. Protective safety equipment should be worn and any spillage flushed with water immediately. Excessive use of sodium silicate may also add to runoff problems with non-wetting or dispersive (clayey) soils.

14 Specialty water filters can be effective for iron concentrations up to 5 mg/L at neutral pH (around 7). These rely on 'water softening' chemical reactions (sodium ion exchange using coated resin beads or zeolite) to be effective. Such filters need backwashing to remove iron concentrates to maintain effectiveness. The waste residue should be disposed of at an authorised landfill.

15 For iron concentrations below 15 mg/L, an oxidising (catalyst) filter can also be effective. These consist of glauconite-derived 'green sand' pellets, or silica gel zeolite coated with manganese dioxide (MnO_2). The iron oxidises and forms a solid.

16 Iron bacteria may present clogging problems with filtration systems and water pH should be above 7. The dissolved oxygen concentration in the treated water may affect filter results. Filters have a specific operational life before they need to be regenerated or replaced. The chemical filters may be followed by a sand or fabric filter to remove any solid residues.

17 For high iron concentrations (between 10 and 50 mg/L) or where a significant portion of the iron is an organic complex, it may be necessary to add alum ($Al_2(SO_4)_3$) to assist in iron floc formation, before filtering out the residue. Alternatively a solution of chlorine bleach (NaOCl), potassium permanganate ($KMnO_4$) or hydrogen peroxide (H_2O_2) may be added to iron-rich water. A retention time of about 20 minutes is needed to convert the iron into its insoluble ferric form, prior to the particles being removed using a sand or fabric filter. The oxidation process operates most effectively at a pH of seven to eight.

18 Water treatment residues should be removed from the site for disposal at an approved location. Small quantities (less than 1 kL) of residue may be allowed to soak into the ground, provided the disposal point is not within 100 m of a water source or sensitive ecosystem, and offsite disposal is impractical.

Caution! Water treatment residues should never be discharged into drains or surface waters as they may cause downstream pollution.

Cleaning of discoloured paths and structures

19 There are a number of chemicals available from farm and chemical suppliers, pool shops and hardware stores that may be used to reduce or remove iron staining. The staining will be most easily removed from impervious surfaces (such as paintwork or hard rock), and most difficult to remove from porous surfaces (typically masonry and concrete), as the iron is likely to have formed in crevices below as well as on the surface.

Caution! The following recommendations concerning chemical cleansers have been derived from a literature search on the topic. They have not been tested in practice by the Department of Water. The department has reproduced this information in good faith, but provides no warranty as to the chemical's effectiveness, nor does it accept any responsibility for harm resulting from their application. The user should make appropriate investigations with product suppliers on the suitability and risks associated with the use of chemical cleansers in any specific situation.

20 Commercial cleansers suitable for removing rust (as well as calcium deposits) often contain phosphoric acid (tri-sodium phosphate), ammonium bifluoride (NH_4 HF_2) or oxalic acid ($C_2H_2O_4$) as a 12 per cent solution. Protective clothing, gloves, goggles, masks and footwear are essential as these chemicals injure sensitive areas such as the skin and eyes and be poisonous (if ingested or fumes inhaled). These cleansers dissolve the iron and are reported to be effective. For cleaning brickwork, a ten per cent hydrochloric acid solution may prove effective. The cleansers are soluble in water, but should not pose a contamination risk to drinking water if used with care. Surface iron oxide may be removed from smooth surfaces by soaking a cloth in the cleaner and rubbing; and from rough surfaces by pouring on the cleanser, then scrubbing with a brush. Any residue should be flushed off the treated surface with a water jet.

Caution! Care should be taken when applying these stain removers as they are often corrosive and may cause injury and damage the surface being cleaned. The product supplier's recommendations should be carefully followed for safety precautions. If oxalic acid is used, a respirator with carbon filter should also be used.

21 For situations where the iron has become ingrained in a porous surface such as masonry or concrete, it may be necessary to apply the sodium hydrosulfite solution ($Na_2S_2O_4$) as a poultice or paste. A sodium hydrosulfite paste can be made by mixing one part ammonium citrate or sodium citrate, six parts warm water and six parts glycerine.

The area should be initially wet, then a moist poultice applied and maintained for two to three days. Subsequently remove the poultice and flush with clean water. Repeat as necessary until the level of staining is acceptable.

22 Alternatively, mix a saturated solution of sodium hydrosulfite with Fuller's earth absorptive clay. Apply as a poultice for one or two days. Remove and flush well with clean water. Repeat as necessary until the desired result is obtained. This method is not suitable for enclosed situations (such as living areas) as the poultice gives off sulfur dioxide gas that can irritate the eyes and airways.

23 Where a resultant rough surface is not a problem, such as on paths and walls, rust coatings may be removed by high pressure water jetting or sand blasting.

Appendix A: Information on sensitive water resources, note limitations and updates

Sensitive water resources

Our water resources sustain ecosystems, aquatic recreation and aesthetic values as well as providing drinking, industry and irrigation supplies. Along with breathable air, uncontaminated water is essential for viable communities. Natural water resources should remain within defined quality limits to retain their ecological, social and economic values. Hence they require appropriate protection measures to minimise contamination risks.

Information on water quality parameters and processes to maintain water values are published in the Australian Government's national water quality management strategy papers. These papers are available online at <www.environment.gov.au> select *water > water policy and programs > water quality.*

The Department of Water strives to improve community awareness of catchment protection measures (for both surface water and groundwater) as part of a multi-barrier protection approach to sustain acceptable water resource quality. Human activity and many land uses pose a risk to water quality if contaminants in significant quantities are washed or leached into water resources.

Sensitive waters include estuaries, natural waterways, wetlands and groundwater. These waters support one or more of the environmental values described below.

Public drinking water sources

Overview

Public drinking water source area (PDWSA) is the collective name given to any area proclaimed to manage and protect a community drinking water source. PDWSA include underground water pollution control areas, water reserves and catchment areas administered by the Department of Water under the provisions of the *Metropolitan Water Supply, Sewerage and Drainage Act 1909* or the *Country Areas Water Supply Act 1947*.

For online information on the location of PDWSA, see <www.water.wa.gov.au> select *tools and data > maps and atlases > geographic data atlas*, then open *environment > public drinking water source areas.*

Within PDWSA, priority areas are defined (P1, P2 or P3) via publicly consulted drinking water source protection plans or land use and water management strategies. Priority areas are used to guide land planning, rezoning and development approval processes. Priority areas are assigned considering the current local planning scheme zoning, land tenure, the water source's strategic value and its vulnerability to harm. Each priority area is managed using a specific risk-based strategy to provide for effective water resource protection. The Department of Water develops these documents in consultation with other government agencies, landowners, industry and the community.

P1 areas are defined to ensure human activity does not degrade a water source. These areas are declared over land where the provision of high-quality drinking water for public use is the primary beneficial land value. P1 areas typically cover land controlled by the state government or one of its agencies. These areas are managed under the principle of *risk avoidance*, so most land development and human activity is normally opposed.

P2 areas are defined to ensure there is *no increased risk of pollution* to the water source once a source protection plan has been published. These areas are declared over land where low-intensity development exists (involving rural usage such as dry land grazing or cropping). Protection of public water supply sources is a high priority in P2 areas. These areas are managed in accordance with the principle of *risk minimisation*, and so the intensity of development should be restricted (via management conditions) and activities with a low water contamination risk are normally considered acceptable.

P3 areas are defined to *manage the risk of pollution* to the water source. These areas are declared over land where public water supply sources must co-exist with other land uses such as residential, commercial and/or light industrial development. Protection of P3 areas is mainly achieved through land use management measures e.g. contamination barriers. Environmental guidance (such as these notes) or site-specific development approval conditions are used to limit the water resources contamination risk from the land use or activity. If, however, the water source becomes contaminated, then water supplied from P3 sources may need to be more intensively treated or an alternative water supply source commissioned.

Additional protection zones are defined close to the point where drinking water is extracted or stored. These zones are called *wellhead protection zones* (WHPZ) and *reservoir protection zones* (RPZ). Statutory land use constraints apply to activities within these zones surrounding sources to safeguard these waters most vulnerable to contamination.

WHPZ are assigned around water production wells based on hydrological factors. Statutory land use restrictions apply within these zones as groundwater moves rapidly towards wells due to aquifer depressurisation by pumping. Any contaminants leaching from the ground surface in a WHPZ could rapidly migrate into scheme water supplies (before effective remedial action can occur). In sedimentary basins, WHPZ are usually circular, with a radius of 500 metres in P1 areas and 300 metres in P2 and P3 areas. These zones do not extend outside PDWSA boundaries.

RPZ are defined over and around public water supply storage or pipe-head reservoirs. Statutory access and land use restrictions apply in RPZ. The aim is to restrict the likelihood of contaminants being deposited or washing into water sources in any runoff. RPZ are normally within state-controlled areas encompassing land up to two kilometres measured outward from the reservoir top water-level and include the inundated area when the reservoir is full.

For additional explanatory information on PDWSA, see Water quality protection note (WQPN) 25 *Land use compatibility in public drinking water source areas,* WQPN 36 *Protecting public drinking water source areas,* WQPN 75 *Proclaimed public drinking water source areas,* note 76 *Land use planning in PDWSA* and WQPN 77 *Risk assessment in PDWSA.* These notes are available online at <www.water.wa.gov.au> select *publications > find a publication > series browse.*

Established activities within PDWSAs

Many land use activities were approved and established before publication of a source protection plan or land use and water management strategy.

Activity operators should ensure that modern environmental facilities and practices are progressively implemented and maintained so that the water resource contamination risk is minimised (within practicable and economic constraints).

New or expanded activities in PDWSA

Any development proposals that could affect a drinking water source should be referred to this department's local regional office with detailed supporting information for an assessment and written response.

The development proposal may be:

- approved (with or without conditions)
- delayed pending receipt of additional information before a decision is made
- opposed due to a statutory or policy conflict or inadequate protective measures provided to safeguard the water source.

To assist the assessment, operators should demonstrate that under all operating conditions the facilities and processes used on-site do not pose a significant water contamination risk.

Buffers to water supply sources

Native vegetation buffers should be used to separate compatible land use areas from the sources of drinking water including the full supply margins of reservoirs, their primary feeder streams and/or production bores. Advice on suitable buffer forms and dimensions is provided in WQPN 6 *Vegetated buffers to sensitive water resources*.

Within clearing control catchments

Controls on vegetation clearing for salinity management in country areas are provided under part IIA of the *Country Areas Water Supply Act 1947*.

These controls apply in the Wellington Dam, Harris River Dam, Mundaring Weir and Denmark River catchment areas and the Kent River and Warren River water reserves.

Details of clearing controls may be obtained from our regional offices, see online information at <www.water.wa.gov.au>, select *Contact us*.

Private water supply sources

Private water sources vulnerable to contamination include:

- drinking water sources for people or domesticated animals
- commercial or industrial water supply sources (requiring specific qualities that support activities such as aquaculture, cooling, food and mineral processing or crop irrigation)
- urban or municipal irrigation sources (where water quality may affect vegetation performance or people's health and wellbeing).

Underground ecosystems

Important underground ecological functions that may be at risk of contamination include groundwater- and cave-dwelling animals and microorganisms (generally located within soils that have open pore spaces such as sand, gravel and limestone).

Waterway ecological and social values

Waterways that have high social and conservation significance are described in the Western Australian Environmental Protection Authority (EPA) Guidance statement 33 *Environmental guidance for planning and development*, section B5.2.2. This statement is available online at <www.epa.wa.gov.au> select *policies and guidelines* > *environmental assessment guidelines* > *guidance statements.*

The Department of Water manages natural waterways under Section 9 of the *Water Agencies (Powers) Act 1984* and the *Rights in Water and Irrigation Act 1914*. For online information, see <www.water.wa.gov.au> and select *managing water*. Apart from aquatic ecosystems and water sources, waterways provide social values including aesthetic appeal, drainage pathways and recreational opportunities for watercraft use, fishing, tourism, swimming and related aquatic activities. Engineered drains and constructed water features are normally not assigned ecological values because their primary function and operational factors outweigh their ecological value.

This department also administers the *Waterways Conservation Act 1976* which defines Western Australian waterways subject to specific regulatory controls. Currently proclaimed waterways include the Avon River, Peel-Harvey Inlet, Leschenault Inlet, Wilson Inlet and Albany waterways management areas.

Within the Swan-Canning Estuary catchment

The Swan River Trust is responsible for the protection and management of the Swan-Canning River system. The trust safeguards ecological and social values under the *Swan and Canning Rivers Management Act 2006.* Written approval is needed for any land- or water-based development within the Swan, Canning, Helena or Southern rivers and their associated foreshore areas within the *Swan River Trust development control area (DCA*). Human activity and development close to these areas are likely to have an effect on the waters of the river system. Development proposals within or abutting the DCA should be referred to the trust for assessment.

Developments outside the DCA, but near river tributaries or drainage systems should also be referred to the trust for assessment and advice. This is because water quality within the area may be affected by chemicals leached into groundwater flow. For detailed information, see online advice at <www.swanrivertrust.wa.gov.au>, phone 9278 0900 or email: planning@swanrivertrust.wa.gov.au .

Wetland ecology

Many important wetlands have been given conservation status under the Ramsar Convention (described online at <www.ramsar.org>), Japan and Australia migratory bird agreement (JAMBA), China and Australia migratory bird agreement (CAMBA), and Republic of Korea and Australia migratory bird agreement (ROKAMBA).

Wetlands are also protected under various national and Western Australian government policies. Conservation wetland data to guide land planning and development activities is provided via the following publications:

- *Directory of important wetlands in Australia* defines wetlands scheduled by the Australian Government. It is available online at <www.environment.gov.au> select *water* > *water topics* > *wetlands.*

- Wetlands with defined high conservation significance are described in the EPA (WA) guidance statement 33 *Environmental guidance for planning and development* (section B4.2.2). This statement is available online at <www.epa.wa.gov.au> select *policies and guidelines* > *environmental assessment guidelines* > *guidance statements.*

The Department of Parks and Wildlife is the custodian of the state wetland datasets, and is responsible for maintaining and updating relevant information. These datasets are available www.dpaw.wa.gov.au.

Wetlands datasets identified for conservation value or for resource enhancement include:

- *Geomorphic wetlands of the Swan Coastal Plain*
- *South coast significant wetlands*
- *Geomorphic wetlands Augusta to Walpole* (this dataset awaits detailed evaluation).

Wetlands that are highly disturbed by land use, or have been landscaped to provide a social amenity or drainage control function in urban settings, may not be assigned conservation values unless they are actively managed to maintain these values.

Note limitations

Many Western Australian aquifers, waterways and wetlands await detailed scientific evaluation, present data on their quality is sparse and their values remain unclassified. Unless demonstrated otherwise, any natural waters that are slightly disturbed by human activity are considered to have sensitive environmental values. Community support for these water values, the setting of practical management objectives, provision of sustainable protection services and effective implementation are vital to protecting or restoring water resources for both current needs and those of future generations.

This note provides a general guide on environmental issues, and offers solutions based on data searches, professional judgement and precedents. Recommendations made in this note do not override any statutory obligation or government policy statement. Alternative practical environmental solutions suited to local conditions may be considered. This note's recommendations shall not be used as this department's policy position on a specific matter, unless confirmed in writing. In addition, regulatory agencies should not use this note's recommendations in place of site-specific development conditions based on a project's assessed environmental risks. Any regulatory conditions should consider local environmental values, the safeguards in place and take a precautionary approach.

Where a conflict arises between this note's recommendations and any activity that may affect a sensitive water resource, this note may be used to assist stakeholder negotiations. The negotiated outcome should not result in a greater water quality contamination risk than would apply if the recommended protection measures were used.

Water quality protection note updates

This note will be updated as new information is received, industry/activity standards change and resources permit. The currently approved version is available online at <www.water.wa.gov.au> select *publications* > *find a publication* > *series browse* > *water quality protection notes.*

Appendix B: Statutory approvals covering this activity include-

What's regulated?	Western Australian statutes	Regulatory body/ agency
Community health issues	*Health Act 1911*	Department of Health <www.health.wa.gov.au> Local Government (council)
Transport, storage and handling of fuels, solvents, explosive and other dangerous goods	*Dangerous Goods Safety Act 2004* Dangerous goods safety regulations 2007	Department of Mines and Petroleum, Resources Safety Division <www.dmp.wa.gov.au>
Licence to take surface water and groundwater	*Rights in Water and Irrigation Act 1914*	Department of Water, regional office <www.water.wa.gov.au>
Emergency response planning	*Fire and Emergency Services Authority of WA Act 1998*	Department of Fire and Emergency Services <www.dfes.wa.gov.au>

Relevant statutes are available from the *State Law Publisher* at <www.slp.wa.gov.au>.

References and further reading

1 Australian Government - National Water Quality Management Strategy papers, available online at <www.environment.gov.au> select *water > water policy and programs > water quality > national water quality management strategy:*

a *Paper 4 Australian and New Zealand guidelines for fresh and marine water quality,* 2000

b Paper 6 *Australian drinking water guidelines,* 2011

c Paper 7 *Australian guidelines for water quality monitoring and reporting,* 2000

d *Australian water quality guidelines for fresh and marine waters 1992* (printed version only available - contact your library service).

2 Australian Government - Land and Water Biodiversity Committee publications available online at <www.iah.org.au/pdfs/mcrwba.pdf>

Minimum construction requirements for water bores in Australia, 2003.

3 Chemistry Centre of Western Australia publications available online at <www.chemcentre.wa.gov.au>

Iron staining (undated guidance paper).

4 Department of Water (WA) publications available online at <www.water.wa.gov.au>

a *Perth groundwater atlas* (current edition); select *tools and data > maps and atlases*

b Water quality protection notes on various related topics; select *publications > find a publication > series browse*

c W*ater quality information sheet -Safe use of bore water in rural areas.*

5 Herman G M, *Iron and manganese in household water* HE –394, North Carolina Cooperative Extension Service 1996; available online at <www.bae.ncsu.edu> search *he394.*

6 LaMotte Company publications available online at <www.lamotte.com/>.

7 Palintest Ltd publications available online at <www.palintest.com>.

8 Ramachandran and Beaudoin, Institute for Research in Construction (Canada) publications available online at <http://irc.nrc-cnrc.gc.ca/cbd> - Canadian Building digest CBD –153 *Removal of stains from concrete surfaces* 1972.

9 Seelig, Derickson and Bergsrud, *Iron and manganese removal* North Dakota State University 1992; see <www.ndsu.edu> search *ae1030w*.

10 Standards Australia publication available for purchase at <www.saiglobal.com> select *publications*

AS 5667 *Water Quality – Sampling.*

11 Varner, Skipton, DeLynn Hay, Jasa- University of Nebraska-Lincoln *Drinking water: Iron and Manganese,* 1996; available online at <http://ianrpubs.unl.edu/water/> search *topic.*

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Feedback

We welcome your thoughts on this note. Feedback will help us prepare future versions. To comment on this note or seek any clarification, please contact our water source protection planning branch (details below), citing the note topic and version.

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