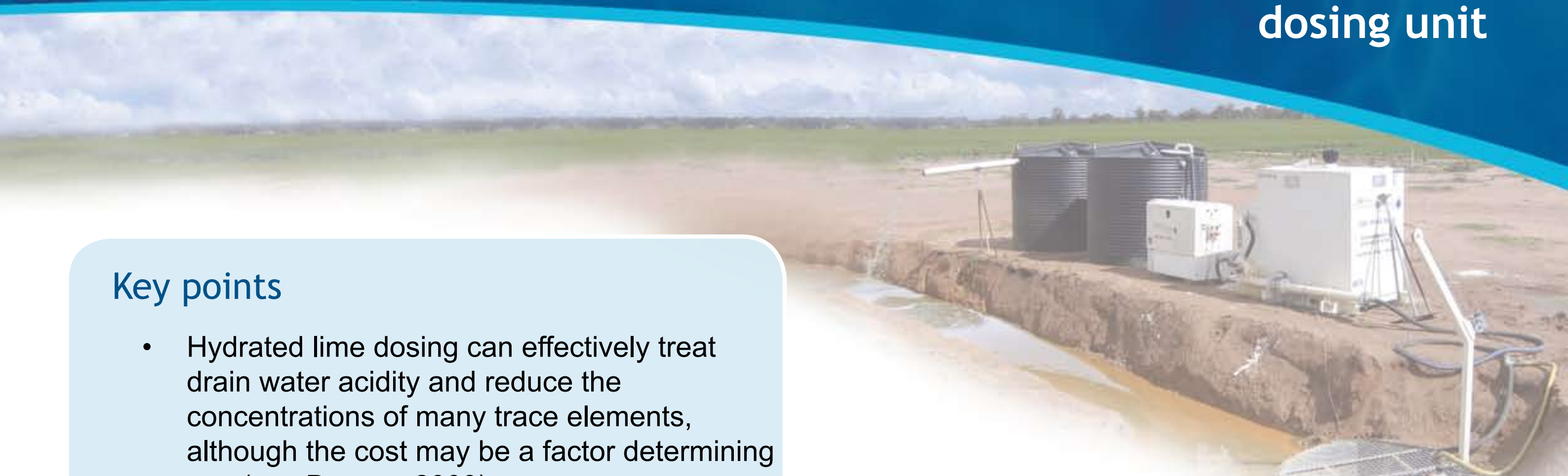
Government of Western Australia
Department of Water

Treating acidity in saline water and sediments in the Wallatin Creek catchment using a hydrated lime dosing unit



Key points

- Hydrated lime dosing can effectively treat drain water acidity and reduce the concentrations of many trace elements, although the cost may be a factor determining use (see Degens 2009).
- Neutralising drain water can improve the quality of water released into creeks and slowly neutralise the effects of previous acidification by drain water.
- Acidity can be stored in creek beds and take some time to be neutralised.

Background

Deep drains used to manage shallow groundwater in Wheatbelt valley floors can intercept acidic saline groundwater that may need treatment before discharge or reuse (Shand & Degens 2008).

Neutralising agents are one of several treatment approaches trialled by the Department of Water under a project funded by the Avon Catchment Council. Although lime-sand is widely available and easy to handle, it can be unreliable in neutralising saline acidic drain water unless used in pulsed up-flow reactors with pumps and holding ponds (Degens 2009). Industrial neutralising agents such as hydrated lime (calcium hydroxide) are more reactive and reliable, but require automated dosing units to prevent overdosing.

This brochure outlines some aspects of treating acidic drain water with hydrated lime using an automated dosing unit and how much and how far downstream the dosing unit treated acidity in a creek that had been receiving acidic water.

Hydrated lime dosing of acidic drain water

A hydrated lime dosing unit was installed to treat acidity in water flowing from a deep drain in the Wallatin Creek catchment for a six-month period during winter and spring 2008 (Fig. 1). The leveed drains were constructed to demonstrate valley floor groundwater drainage as part of the Wallatin-O'Brien Catchment Demonstration Initiative (see box below). The water was treated by a commercial hydrated lime slurry dosing unit controlled by a continuous pH monitoring system. The hydrated lime was delivered from a 1000 L tank containing 40% hydrated lime slurry (mostly calcium hydroxide) (Fig. 1). All the drain water was pumped from a sump, dosed to pH 7 and passed through two 4500 L tanks before being returned to the drain and discharged into Wallatin Creek. The tanks were designed to trap the sludges formed after neutralisation.

Wallatin-O'Brien Catchment Demonstration Initiative

This project demonstrated the planning, integration and implementation of salinity management options in farming systems to tackle salinity at catchment scales in the Wallatin-O'Brien catchments north-east of Kellerberrin. The techniques used in this initiative included plant-based measures, engineering options such as deep drains, groundwater pumping and surface water management as well as productive uses of saline land.

Australian Government
AVON Catchment Council
Wallatin Wildlife and Landcare Inc.

Brad Degens, Department of Water, Perth, 2009
www.water.wa.gov.au

Looking after all our water needs

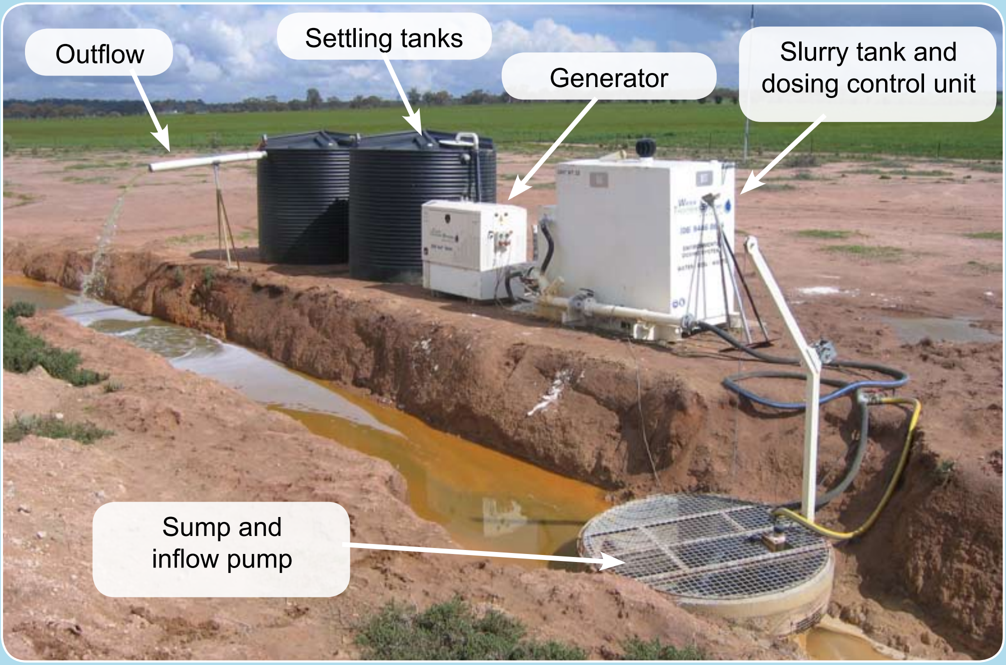


Figure 1 Hydrated lime dosing plant treating water at the end of the deep drains in the Wallatin Creek catchment

The effects on acidity were evaluated by monitoring water and sediments in the drain, creek and at various points in the catchment (Fig. 2).

During the trial, the pH of creek sediments was monitored using a spear point pH probe and several months after the trial ended sediments were taken for laboratory analysis.

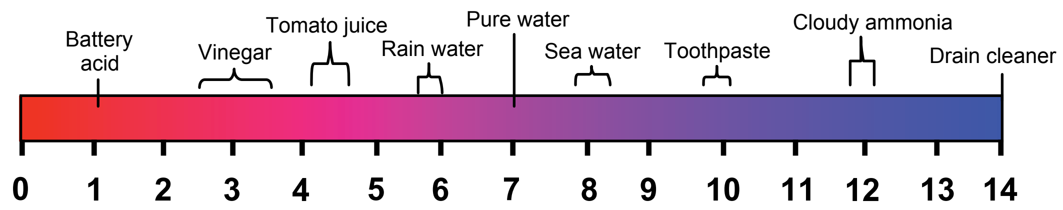
Table 1 The median and range of pH of water at various sites before, during and after the hydrated lime dosing trial

	Before treatment[a]		During treatment[b]		After treatment[c]	
	pH	Flow	pH	Flow	pH	Flow
Upstream creek	6.5 (6.8–7.3)	Occasional	N/A	None	N/A	None
Drain	3.6 (3.3–5.1)	Continuous	4.5 (4.2–6.2)	Continuous	4.2 (3.9–4.9)	Continuous
Downstream sites						
0.6 km	Not sampled	Not sampled	6.4 (4.5–7.0)	Continuous	3.4 (3.2–4.5)	Continuous
3 km	3.6 (3.3–5.1)	Intermittent	6.2 (5.6–7.7)	Intermittent	N/A	None
7 km	5.5 (5.6–6.0)	Occasional	7.1[d]	Very occasional	N/A	None
8.3 km	6.9[d]	Very occasional	N/A	None	N/A	None

[a] During the 4 months before treatment
[b] During the 6 months of treatment
[c] During the 4 months after treatment
[d] Single value reported since flows were very occasional
N/A - no flows during the monitoring period

pH and why it is important to water

pH is a measure of the acid or alkaline property of water commonly ranging from 0 to 14, where a pH<7 is acidic, pH 7 is neutral and pH>7 is alkaline. pH reflects the balance of hydrogen ions (acid) and hydroxide ions (alkaline) which make up part of the acidity or alkalinity of water that is often due to other things dissolved in the water such as metals, bicarbonate or carbon dioxide gas.



Low pH or acidic water is corrosive and harmful to aquatic life and can contain metals that can also affect aquatic life.

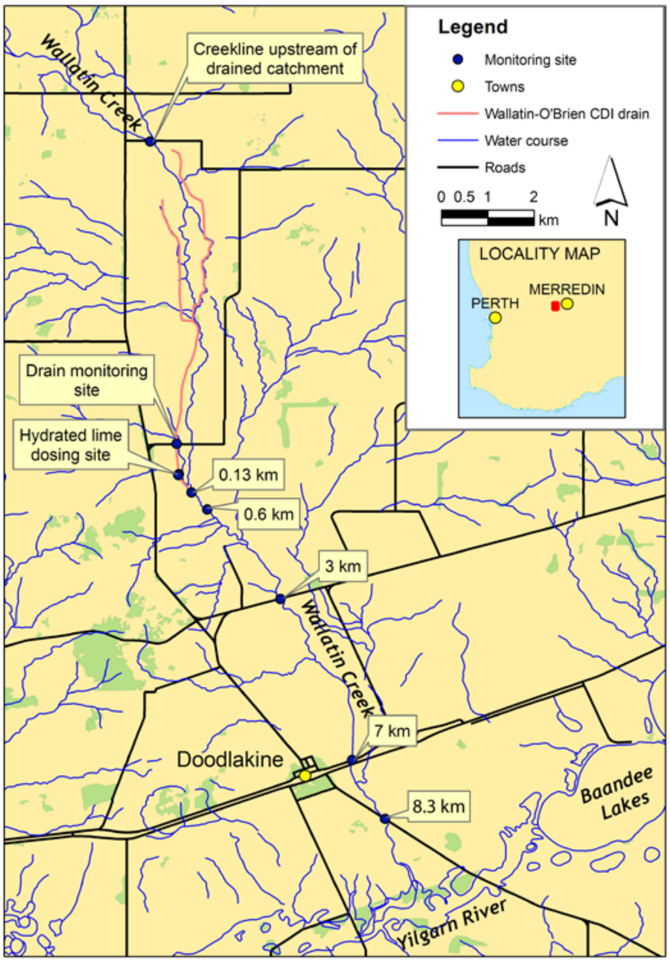


Figure 2 Location of the hydrated lime dosing trial and monitoring sites in the Wallatin Creek catchment

Before treating the drain water, the creek water during winter was occasionally acidic up to 3 km downstream of the drain–creek confluence (Table 1). Occasional flow in the creek even further downstream was of marginal pH (Table 1) and had very little capacity to buffer further falls in pH by way of dissolved alkalinity (mostly bicarbonate). Low flows in Wallatin Creek unaffected by the drain were around pH 6.5 (Table 1), but similarly had little buffering capacity (see box *Acidity and alkalinity in water*).

Acidity and alkalinity in water

Acidity and alkalinity are chemical properties of water that are opposing properties and can cancel each other if mixed. Acidity refers to the dissolved metals in water and low pH that gives water the capacity to consume alkaline materials to reach a neutral state. In contrast, alkalinity refers to high pH and concentration of alkaline materials, most often bicarbonate, dissolved in water that will consume any acidity and have the effect of stopping pH from falling. pH in this context is a measure of the acidic or alkaline property of water, where pH<7 is acidic, pH 7 is neutral and pH>7 is alkaline.

Twenty-one tonnes of hydrated lime were used to treat water from the drain over the 6-month trial, raising the pH from a median 4.5 to 7 at the outlet of the settling tanks (Degens 2009). Hydrated lime dosing removed most of the aluminium and iron as well as the majority of trace elements including arsenic, cadmium, cerium, copper, lanthanum, lead, nickel, silica and uranium. Some constituents of the drain water like manganese and nutrients were not removed (Degens 2009) and, as expected, there was no measurable change in the salinity.

Neutralising the water produced an iron and aluminium rich sludge (Fig. 3) that needed to be trapped and removed. The sludge contained concentrations of some trace elements that might pose environmental risks. For drain water with higher dissolved trace metal concentrations than at Wallatin, treatment may generate sludges that need careful disposal (see Degens 2009 for details of when this may apply). For further information on disposal of sludges with high trace metal concentrations contact the Waste Management Branch of the Department of Environment and Conservation.

Although complete treatment of acidity can be achieved by dosing drain water with hydrated lime, the effects were not immediately evident in the creek receiving the treated water. The pH of creek flows (dominated by drain flow) downstream of the drain–creek confluence was raised after treatment but did not reach pH 7 (see box *pH and why it is important to water*) and could vary widely (Table 1). This fluctuation was attributed to the neutralised creek water being re-acidified by creek bed acidity accumulated during pre-trial drain flow.

It took some time for acidity in the creek bed to show signs of being neutralised despite surface water pH higher than 6 most of the time during the trial (Fig. 4). The pH in shallow sand in the creek bed 130 m downstream of where the drain discharged into the creek (Fig. 5) remained less than 4 for about 1½ months after treatment started (Fig. 4). Full treatment was not apparent even after 5½ months, probably because of slow redistribution of acidity in the sands.

Figure 3 Iron and aluminium rich sludge precipitated from drain water after neutralisation with hydrated lime

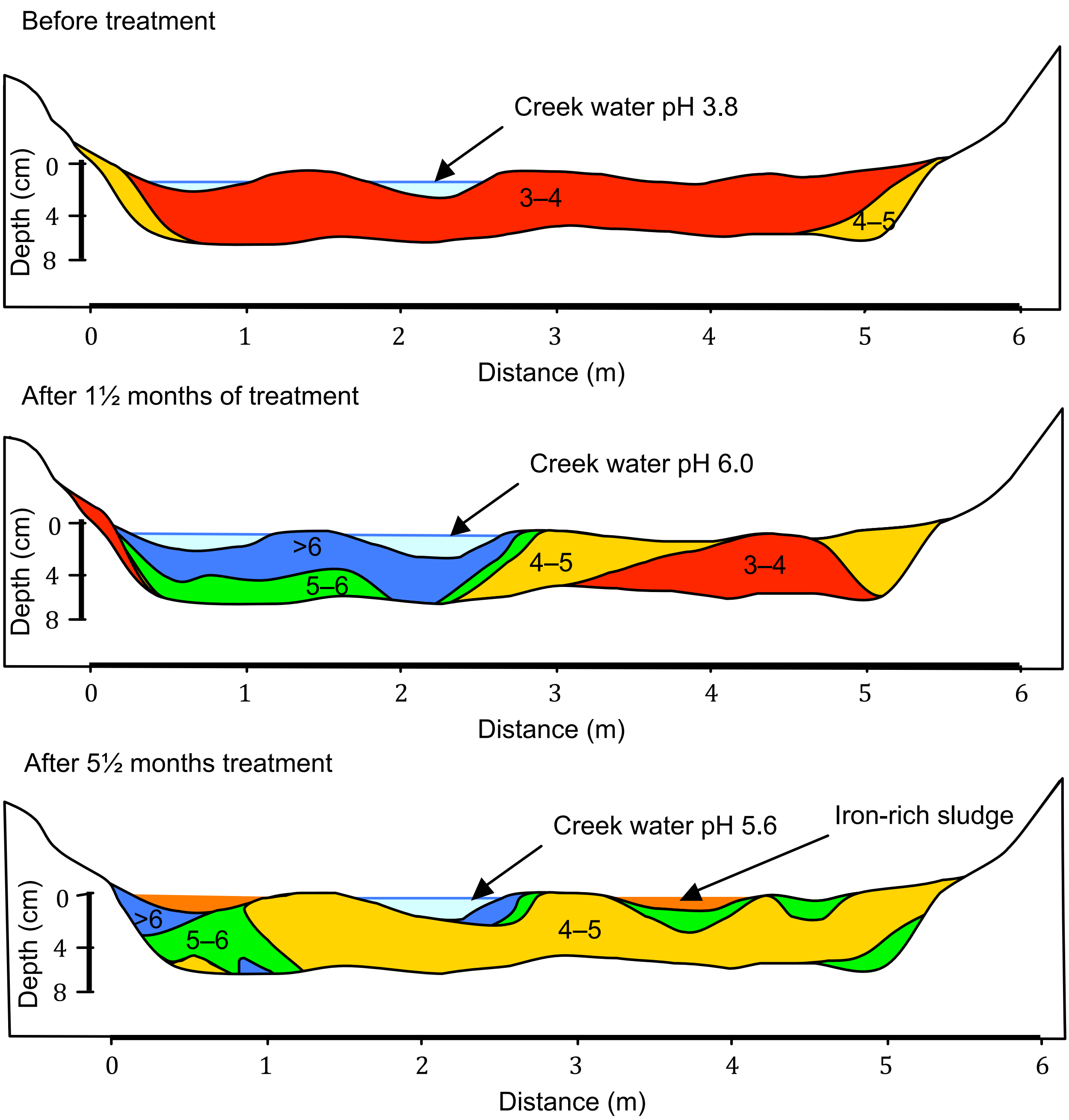


Figure 4 Cross section showing pH changes in shallow sand in the creek bed 130 m downstream of the drain-creek confluence in Wallatin Creek

Acidity was stored in the creek bed mostly as acid adsorbed onto clays and silts as acidified creek water seeped into the creek bed before the treatment trial began. After the trial finished, sampling of the creek bed downstream of the drain discharge showed sediments were still acidified down to 30 cm below the surface (Table 2). This penetration of acidity probably occurred in the months before the trial, but showed that acidity was mostly contained within the central part of the creek bed and had not spread laterally at any of the sampling sites (Table 2). The creek was acidified along about 0.6–3 km downstream of the drain discharge (Table 2) with the main impact probably within 1 km.

The acidity remaining in the creek bed was equivalent to a maximum of 2 kg of sulfuric acid being held in the bed every metre of creek line, which is the same as spreading 4.5 L of battery acid (36% sulfuric acid) per metre. Acidity in the creek bed was commonly more than 100 times higher than acidity in the water flowing down the creek at any time.

Where the creek bed was acidified, the acidity was mostly stored in the underlying clays rather than the creek bed's shallow sands (Table 2). Clays often have a greater capacity than sand to initially neutralise and then adsorb the acidity from the moving water and so often become larger stores of acidity that can be more difficult to neutralise. The penetration of acidity up to 10 cm into the clays was surprising because the clays had low permeability and seepage would have been slow.

Where it was unaffected by acidity, the creek bed was alkaline and contained neutralising materials. The creek bed upstream of the drain discharge to 3 km downstream contained alkaline materials in the top 20 cm, equivalent to about 8 kg equivalent limestone per metre of creek line (Table 2).

Figure 5 Acidified creek bed sands before treatment, with a thin iron crust, 130 m downstream of the drain-creek confluence in Wallatin Creek

In some cases, neutralising materials remained in the soils on the banks of the creek which had acidic sediments in its bed. Creek sections acidified by drain water would have contained similar amounts of neutralising materials before drain water flowed in and some of the initial acidity seeping into the creek bed was probably slowly treated.

Table 2 Creek bed (and comparable drain) sediment descriptions and acidity or alkalinity content upstream and downstream of the drain discharge point

Site	Description (creek/drain bed)	Acidity per metre creek bed/drain[a]	Alkalinity per metre creek bed/drain[b]
0.2 km upstream	Light brown sandy clays (pH 7.9–8.1) with occasional beds of red sand (pH 8.4–8.6)	None present	Up to 8 kg equivalent limestone (top 20 cm)
Drain	Yellowish-red silt up to 6 cm thick (pH 3.2–3.5) overlying light silt with black lenses (pH 6.1–6.5) and deeper grey sandy silt (pH 7.5–8.1)	0.5 kg equivalent sulphuric acid (surface silts)	Up to 15 kg equivalent limestone in subsurface silts (possibly fine carbonates from drain walls)
0.13 km downstream	Red sands up to 10 cm depth (pH 4.2–5.7) overlying mostly grey sandy clays extending to more than 30 cm depth (pH 4.5–4.7) Margins of channel consist of mostly brown sands (pH 6.8–7.8) overlying brownish grey sandy clays (pH 7.8–7.9)	2 kg equivalent sulfuric acid (to 30 cm depth) = about 4.5 L of battery acid Over 75% residing in clays	Approximately 1 kg equivalent limestone (creek margins)
0.6 km downstream	Brown sands up to 9 cm depth (pH 4.8–5.5) overlying mostly grey-brown clays extending to more than 20 cm depth (pH 5.2–6.4) Margins of channel consist of mostly brown sands (pH 5.3–5.4) overlying grey-brown clays (pH 7.8–7.9)	0.9 kg equivalent sulfuric acid (to 20 cm depth) = about 1.9 L of battery acid. Over 80% residing in clays	At least 2.5 kg equivalent limestone (top 30 cm in creek margins)
3 km downstream	Brown sands up to 9 cm depth (pH 7.5–8.3) overlying mostly brownish-grey sandy clays extending to more than 20 cm depth (pH 7.5–7.8) Margins of channel consist of mostly brown sands (pH 8.1–8.5) overlying mottled grey-brown clays (pH 7.7–7.8)	No acidity present	At least 7.4 kg equivalent limestone (top 20 cm in creek bed and margins)

[a] Acidity expressed as equivalent amounts of sulfuric acid determined by sampling and analysis of titratable acidity (base titration to pH 6.5) for samples with pH <6.5.
[b] Alkalinity expressed as equivalent amounts of limestone ($CaCO_3$) determined by sampling and analysis of acid neutralising capacity (acid titration to pH 6.5) for samples with pH >6.5.

Acknowledgements

We acknowledge the cooperation of Water Treatment Systems Australia Pty. Ltd. in sharing data collected during the extended operation of the hydrated lime dosing unit.

We also acknowledge funding support from the Avon Catchment Council and the cooperation of Wallatin Wildlife and Landcare Inc. and the McNeil family at Doodlakine in conducting the pilot trials.

For further information on treating acidic saline drain water

Degens, B 2009, *Proposed guidelines for treating acidic drain water in the Avon catchment, Western Australia: adapting acid mine drainage treatment systems for saline acidic drains,* Salinity and land use impacts series, Report no. SLUI 54, Department of Water.

For further reading on acidic water characteristics and risks

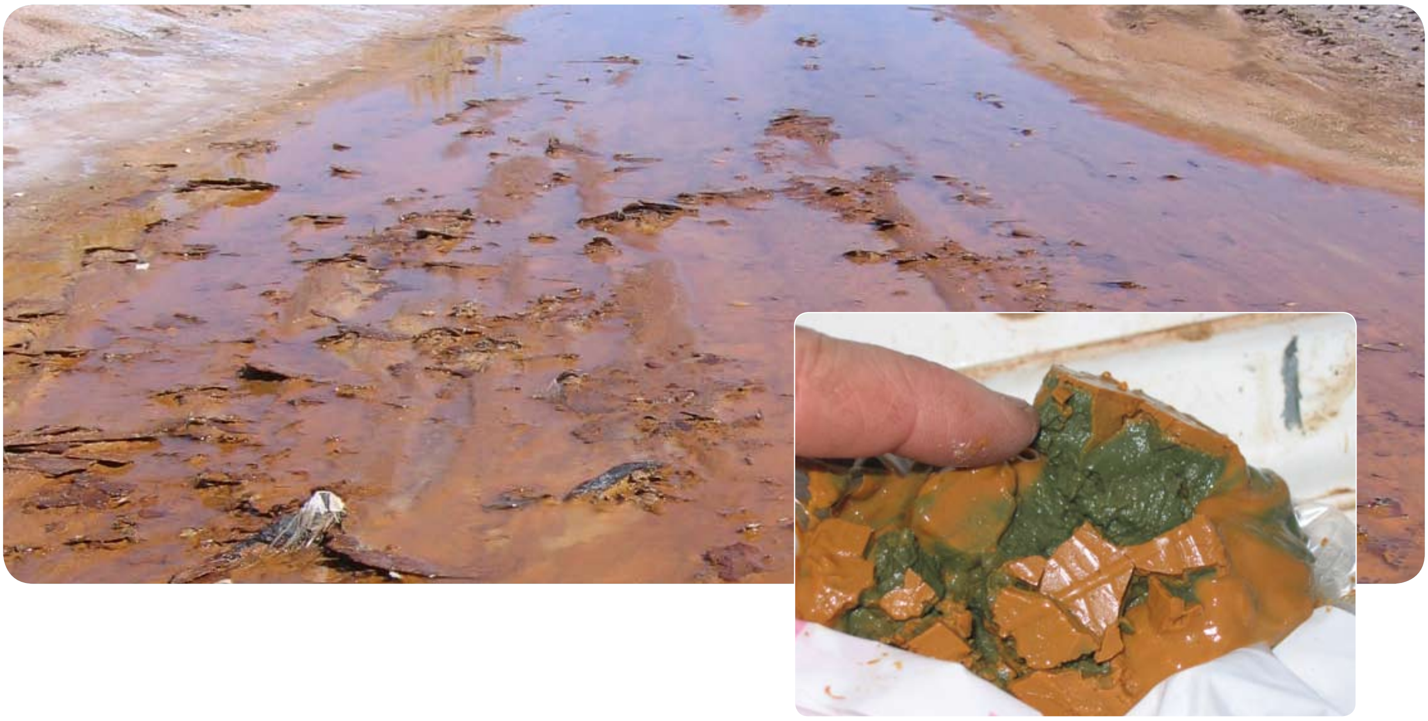
Shand, P & Degens, B 2008, *Avon catchment acid ground-water: geochemical risk assessment,* CRC-LEME Open File Report 191, CSIRO Exploration and Mining, Bentley, WA, accessible at http://crcleme.org.au/.

Related brochures — available from Publications at www.water.wa.gov.au

Degens, B & Shand, P 2009, *Introduction to acidic saline groundwater in the WA Wheatbelt – characteristics, distribution, risks and management,* Department of Water.

Degens, B 2009, *Using composting beds to treat acidity in saline drain water,* Department of Water.

Contact: Brad Degens (08) 6364 7800; brad.degens@water.wa.gov.au



December 2009