Down to *Earth* Solutions

Welcome to the Spring 2001 edition of our newsletter. We're keeping you up-to-date on what's happening in our firm, contamination issues, new processes and technologies and the latest legislation.

Tidal considerations . . .

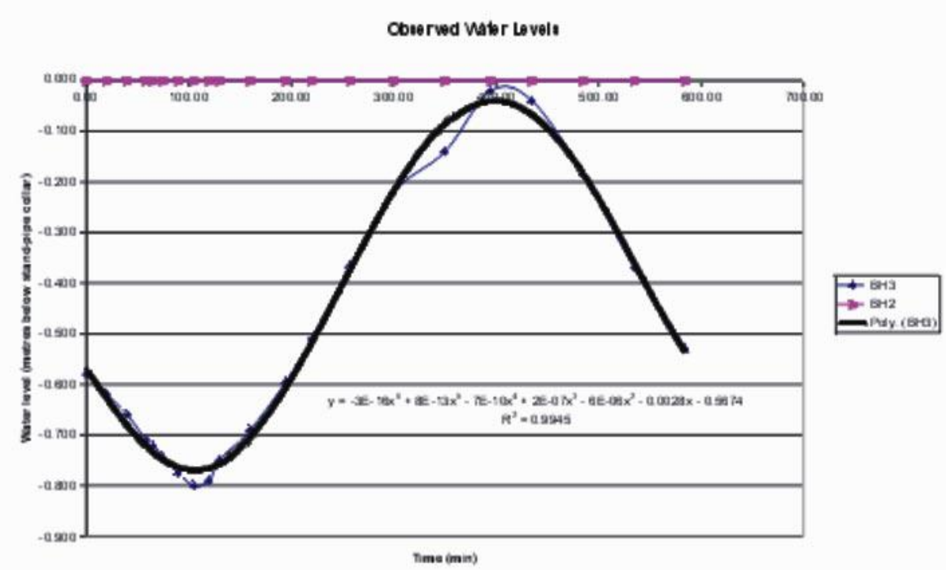

Figure 1: Groundwater level fluctuation over time in a borehole adjacent to a tidal river (BH3), and in a background borehole (BH2).

New Zealand is comprised of two relatively large islands and a number of much smaller ones. The two main islands are elongated, cover an area of 270 500 km^2 and have a coastline with a total length of approximately 7 000 km. The average width of the South Island, which is a fairly regular rectangle, is 160 km, while the North Island, which is more varied, ranges from approximately 250 km to 10 km wide.

Because of its topography and the fact that it is surrounded by large expanses of ocean, coastal rivers are abundant in New Zealand. Some river mouths form large, spectacular delta systems while harbours in the North Island can stretch far inland. Because of this closeness to the ocean all geohydrological investigations need to take into consideration the tidal effect.

Environmental & Earth Sciences has recently been involved in two separate studies in which the tidal effect in boreholes was so dominant that normal data accumulation procedures had to be modified to compensate for the large rise and fall of the groundwater levels in the area.

During a hydrological investigation of an aquifer in Northland, the water level in an observation borehole near the banks of the Wairoa River showed a 0.8 metre fluctuation over a twelve-hour monitoring period (Figure 1). A second observation borehole positioned 500 metres from the river showed a 0.075 metre fluctuation over the same period (Figure 2).

The R^2 values for the curve fit of groundwater levels in the two boreholes shown in Figures 1 and 2 clearly describes a polynomial tidal influence.

In another investigation of the groundwater level below a landfill approximately 15 km from the coastline but adjacent to the Waikato River, the variation (over two hours) in water levels varied from nearly two centimetres near the bank

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Profile – Lucy Wildman

Recently married, Lucy Wildman (nee Vincent) is the new Southern NSW Manager, with an office recently established in Canberra, which services the southern areas of NSW as well as the ACT.

Lucy has been with Environmental & Earth Sciences for three years and has previously worked in the Sydney and Auckland offices. Previously, Lucy worked part time as a technical officer at the CSIRO in Canberra.

As well as expertise in soil characterisation and chemistry with particular reference to soil contamination and degradation issues. Lucy has extensive experience in landfill management and environ-mental work to meet licensing requirements.

Following on from recent natural resource field days, Lucy is also involved in expanding work into the agricultural industry. With a special interest in environmental investigation and policy, Lucy is working to attain CPSS accreditation and is due to start a Masters in Environmental Law in the next semester.

For further information on environmental issues in southern NSW, please contact Lucy on (02) 6260 3302 or 0407 399 950 or visit her at the office at 30 Longford Street, Lyons, ACT 2606.

Acid sulfate soil risk may vary unexpectedly

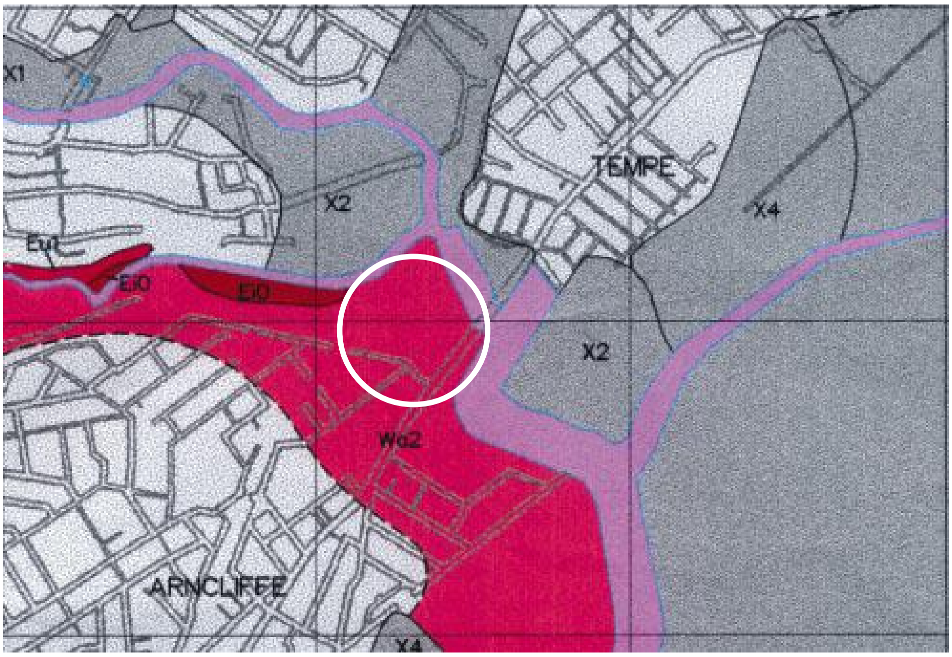


Figure 1: excerpt from *Department of Land & Water Conservation (1997) — Acid sulfate soil risk map, Botany Bay (913053)*—investigation area circled.

Geological evolution of the western edge of the Botany Basin – a site specific assessment at the Cooks River/Wolli Creek confluence, Sydney, NSW

The Botany Basin is an erosional feature formed within the Triassic aged (200 million years old) Hawkesbury Sandstone (Griffin, 1963). Wianamatta Group shales overlie the sandstone to the west of the Basin, and these rocks experienced uplift during the Tertiary Era, between three and 70 million years ago. The Botany Sands were deposited alluvially, as aeolian dune sands, and fluvially along watercourses and low-lying areas, over the last three million years.

The first depositional stage commenced three million years before present (bp) when ocean surfaces were elevated above the current level (approximately at the level of Princes Highway). Subsequent progressive sea-level lowering over the early Pleistocene (or Glacial) geologic period, due to the cooling of Earth's climate and the expansion of polar ice caps, resulted in estuarine deposition over the Triassic aged rocks. Sea-level stabilisation allowed further deposition of marine and dune sands throughout the remainder of the Pleistocene period.

At the conclusion of the last Glacial age (and commencement of the Holocene epoch), approximately 9 to 10 000 years bp, sea-levels on the east coast of Australia were about 20 metres below the current level (Roy and Crawford, 1979).

Gradual sea-level increase over the next 5 to 6 000 years resulted in the deposition of estuarine sediments in river valleys incised in the Pleistocene sand swamp (such as the Cooks River Valley). These deposits were subsequently overlain by marine and dune sands as sea-levels stabilised, allowing formation of the unconfined Botany Sands Aquifer.

Estuarine deposition in this period caused the reaction of iron-rich sediments with sulfate in sea-water under anaerobic (oxygen depleted or swampy) conditions. This process resulted in the formation of pyrite (FeS_2) or sulfidic sediments.

Figure 1 (DLWC, 1997) shows the occurrence of potentially sulfidic sediments on the western edge of the Botany Basin. Landform codes on Figure 1 show Holocene aeolian (Wa) and estuarine (E), and Pleistocene alluvial (Ap) deposition dominates this region. Note that landform code 'x' denotes disturbance by man.

Recent investigation of a site immediately south of the Cooks River and Wolli Creek confluence showed localised variations not shown on Figure 1. Pleistocene and Holocene sediments deposited on the site were able to be differentiated physically through field texture differences, and chemically through analysis of soil sulfide and carbonate content.

Consequently, the potential for development constraints on this site associated with acid sulfate soil were less than the map indicated. This project provides an example of how an understanding of soil chemical and physical characteristics and behaviour as a result of geological evolution can, through scientific study, ensure the environment is not degraded through urbanisation, and allows appropriate management practises to be implemented. Environmental & Earth Sciences provides the skills in understanding the unique environment of individual sites, often resulting in a reduction in development costs for our clients.

For further information contact Phil Mulvey or Mark Stuckey at our Sydney office: 9922 1777.

'Risk based' approach to clean-up standards

In the last edition of *Solutions*, Tracey promised she would explore the pros and cons of 'risk based' approaches to setting clean-up standards for petroleum contaminated sites. Unfortunately time and work constraints have not permitted the completion of this article, which will feature in the next edition of *Solutions*.

If you are in urgent need of further information please call Tracey at Environmental & Earth Sciences

Sydney office: (02) 9922 1777
or email: eesi@zeta.org.au

TCE slow to breakdown

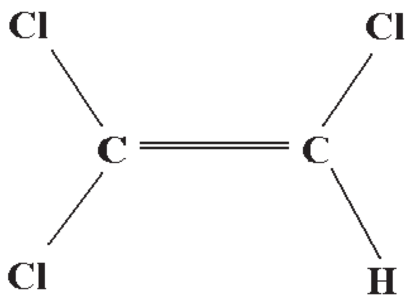
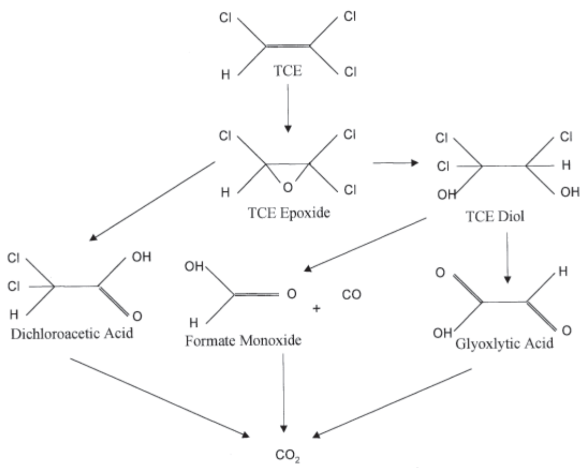


Figure 1: Chemical diagram of TCE

Trichloroethylene or TCE is a chlorinated organic compound with a wide variety of applications to a number of industries. A few common uses include degreasing and drying metals and electronic parts, extraction solvent for oils, waxes and fats, as a solvent in decaffination of coffee, a refrigerant and heat exchange liquid, fumigant, diluent in paints and adhesives and as a dry cleaning fluid.



Possible aerobic breakdown pathway

High soil water sorption and octanol water coefficients (Koc and Kow) indicate that the compound bonds to the soil surfaces and is not readily miscible in water. In addition TCE is also considered a DNAPL compound (Dense Non Aqueous Phase Liquid) as its density is greater than that of water.

From a health point of view, breathing high concentrations of TCE vapours may cause nervous system effects, liver and lung damage, abnormal heartbeat and possibly death. In addition, it is considered a potential occupational carcinogen.

Within the soil TCE can exist in five states; sequestered within the soil matrix, adhered to the soil surface, solubilised in groundwater, as free phase liquid and as a vapour. Movement of TCE within groundwater is governed by the concentration being released from soil surfaces and partitioning in the water or free phase, and the groundwater velocity.

Aerobic breakdown

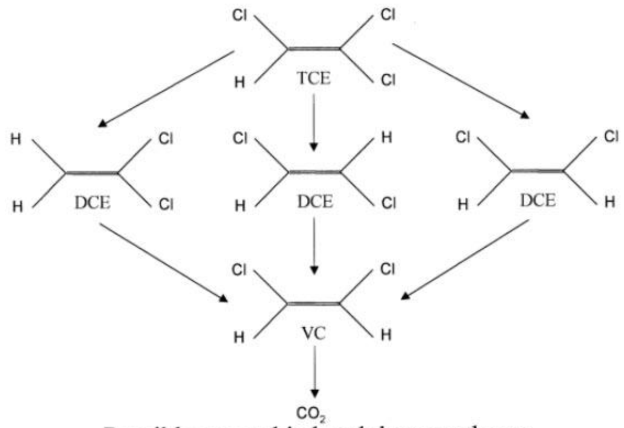
Natural oxidated conditions rarely occur in groundwater unless there is rapid and recent recharge and a lack of oxygen consuming reactions occurring in the environment. TCE is a naturally oxidated compound and hence microbial breakdown of the compound under oxygenated conditions is somewhat limited.

Breakdown of TCE under aerobic conditions typically begins with the conversion of TCE to TCE epoxide and is catalysed by methane monooxygenase which is present in methanotrophic bacteria. TCE epoxide is an unstable compound, which then transforms to various organic acids including dichloroacetic acid and glycoxytic acid. Other breakdown products may include formate monoxide and carbon monoxide. These breakdown products undergo mineralisation the produce carbon dioxide and water.

Anaerobic conditions

Anaerobic breakdown of TCE is more common than aerobic degradation and involves a process of progressive reductive dechlorination.

The first breakdown product is



Possible anaerobic breakdown pathway

dichloroethylene (DCE). The breakdown of DCE involves the stripping of another chlorine from the structure, which results in vinyl chloride (VC). Both DCE and VC are considered more toxic in the environment than TCE. The VC may eventually be converted to ethylene under anaerobic conditions but this process is slow and the right environmental conditions must exist such as the presence of a suitable source of carbon for microbial growth.

Currently Environmental & Earth Sciences Pty Ltd are managing two projects involving TCE as a major contaminant of interest within contaminated groundwater.

For further information contact Colin McKay at our Sydney office on 9922 1777.

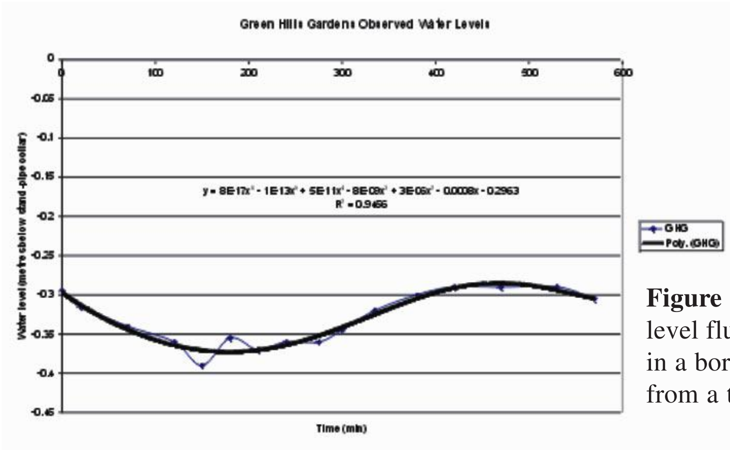


Figure 2: Groundwater level fluctuation over time in a borehole 500 metres from a tidal river

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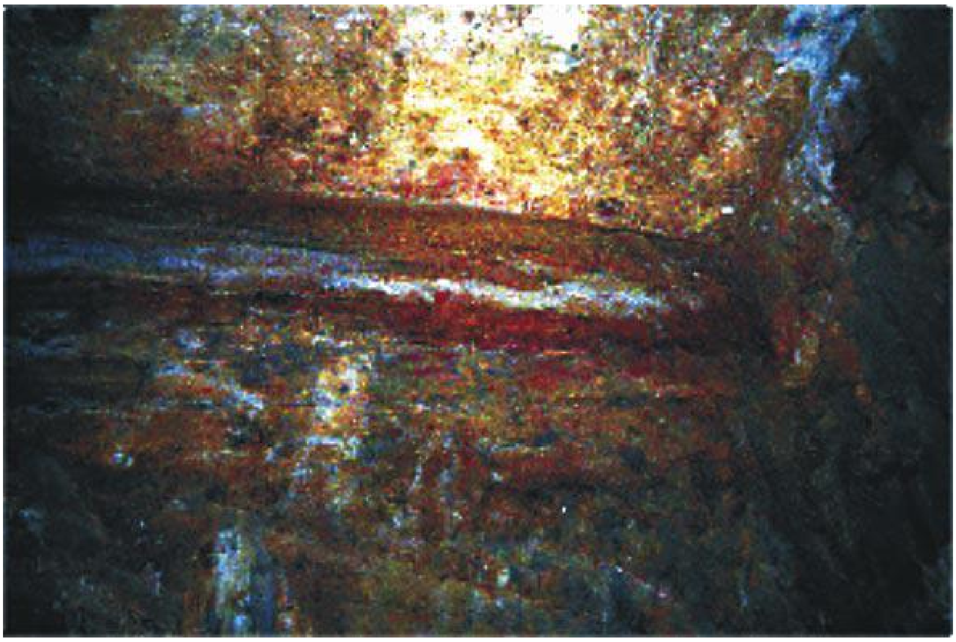
of the river to zero 250 metres from the river bank.

In both cases the results of the investigation would have been futile if the monitoring procedures were not altered to clearly establish the tidal effect and hence remove this effect from the observed data.

For more information contact New Zealand ofice on: 64 9 476 4483

Arsenic and fill material



Profile of geological formation showing iron oxides that potentially act as 'arsenic sinks' in natural material.

Recent environmental investigations conducted by our Melbourne office have provided several of the staff members and Environmental & Earth Sciences' clients with a valuable experience in dealing with 'natural' soils and heavy metals.

These investigations were commissioned primarily to classify the soil on-site as either 'fill material' or 'low level contaminated soil (LLCS)' for future off-site disposal as part of works on-site. In order to classify these soils, Environmental & Earth Sciences conducted analyses of the soil for several known contaminants, including heavy metals, and compared these results with the primary guideline used in Victoria for such circumstances; the Victorian EPA Publication 448 '*Classification of Wastes Criteria*.'

This guideline uses two criteria as mentioned above, 'fill material' and 'low level contaminated soil (LLCS).' The stricter criterion is 'fill material', with any concentrations exceeding the maximum levels outlined in this criterion to be classified as LLCS.

The application of this guideline to the recent investigations mentioned above highlight an important aspect to environmental investigations: the ability to differentiate between man-made contamination and the natural geological make-up.

Upon analyses of the soils at these sites, elevated concentrations of arsenic were encountered that exceeded the criteria to classify the soil as 'fill material', hence it was to be classified as LLCS. Arsenic is a potentially toxic heavy metal if present at significantly elevated levels in a soluble form such as to be available for uptake by plants, animals, humans or other components of the ecosystem.

Further research of the natural geology showed that limonite, a hydrated iron oxide mineral, occurs frequently in these areas. As iron oxides act as 'arsenic sinks', it is considered that the presence of elevated arsenic in the natural material may be associated with the iron oxides often found in geological formations.

In order to distinguish between the elevated concentrations of arsenic and their potential to impact on ecosystems, the soil samples are tested for potential leachability of the contaminant. Analyses from the aforementioned investigations indicated that arsenic was not available to relevant ecosystems by leaching into groundwater.

Depending on the extent of natural arsenic concentrations across such investigative areas, the zones of potentially contaminated 'hot spots' can be discriminated from the 'clean' material. These investigations showed the importance of understanding the geological nature of areas and making discrete judgments on the fate of material once destined for the landfill.

For more details, contact our Melbourne office on (03) 9593 8770

Apology
Lennox Head seminar

Unfortunately the seminar, **"Planning issues in relation to contaminated land"** had to be postponed due to the Ansett Airline collapse. It will now be held on Wednesday 21 November 2001. For information or to RSVP, please contact Hugh McCaffery on **02 6687 4650 or email: eesbb@nnsw.quik.com.au**

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soil is the foundation of life