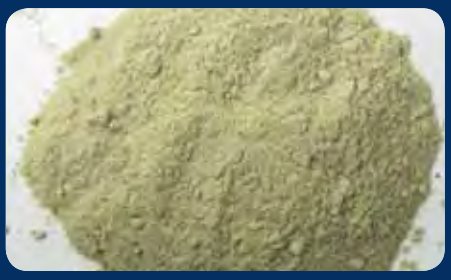
Issue 9 2012

Remediation Australasia

REMEDIATION PROCESSES:
The importance of community consultation



BIOREACTIVE ORGANOCLAYS
A new technology for environmental remediation

USING LIDAR TO POWER A NATION
Using lidar and wind power for Kenya's energy needs

MINE DUMPS AND LANDFILLS
Remediation using the giant reed *Arundo donax*

CRCCARE

Cooperative Research Centre for Contamination
Assessment and Remediation of the Environment

A safer, cleaner environmental future

CRC CARE is Australia's leading science-based partnership in assessing, preventing and remediating contamination of soil, water and air. With a unique mix of industry, university and government agency partners, CRC CARE's research program focuses on a range of environmental challenges, including contamination in water and soil through the use of fire-fighting foams.

Aqueous fire-fighting foams (AFFF), widely used in fire suppression systems, contain perfluorochemicals (PFCs) including PFOS and PFOA. CRC CARE technologies effectively clean up PFC contamination.

MatCARE™, our DIISR STAR Award-winning remediation product, has successfully demonstrated complete removal of PFOS and PFOA from wastewater and soil in field trials.

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Once assessment is complete, remediation decisions need to include the right clean-up approach. Recommending an appropriate remediation method is a big part of our work at CRC CARE.

How can we help you?

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editor's note

Welcome to Issue 9 of *Remediation Australasia*.

I have to tell you, I'm getting excited about publishing our tenth issue in the coming months.

We've locked in several feature articles for inclusion, but would still love to hear from you if you've got some research or discussion articles to share with us.

The articles in this issue – which offer insights into lidar technology, phytocapping, bio-reactive organoclays, emerging contaminants and community consultation – demonstrate the increasing importance of environmental remediation research and the demand from industry for current, informative resources.

I must extend a very warm thanks to all article contributors and advertisers who have helped us craft this publication into what it is today. It has come a long way from its original format as an online-only publication back in 2009.

Without our contributors, there would be no *Remediation Australasia* – which is where you come in. If you have something important to share with industry, something to say about research, consultation or policy, or are keen to raise national or international issues, we want to hear from you. Drop us a line at aric@crccare.com if you think you've got something for us.

I'm proud to announce that as a result of the popularity of our print publication, we've decided to migrate our suite of online issues (1–6) to our new format. While we won't be printing them for distribution, they will be much easier to browse, download and print.

We're currently putting the final touches on these migrated editions, so keep an eye on our website for these 'new' issues to make an appearance when we re-release them simultaneously with Issue 10.

Although the 'current' issue of *Remediation Australasia* is always unlocked and accessible to the public, until now only members with usernames and passwords have been able to browse through back issues. We've decided to make these new versions publicly available, so you won't need a member username and login to access them. This means that all LinkedIn forum members will now be able to browse old editions. Please pass the word on to any colleagues who might like to tap into our perspective on the science, technology and regulation of remediation.

Again, thanks to all who have offered support for our publication since its inception. Your contribution has been invaluable and we hope to continue working with you to build *Remediation Australasia* into a truly industry-leading publication.

Prof Ravi Naidu

Managing Director, CRC CARE

Editor, *Remediation Australasia*

Remediation Australasia **is a quarterly industry magazine produced by the Australian Remediation Industry Cluster (ARIC) for the Australian remediation industry.**

Circulation
The publication is currently distributed to more than 2,000 recipients throughout Australasia, free of charge.

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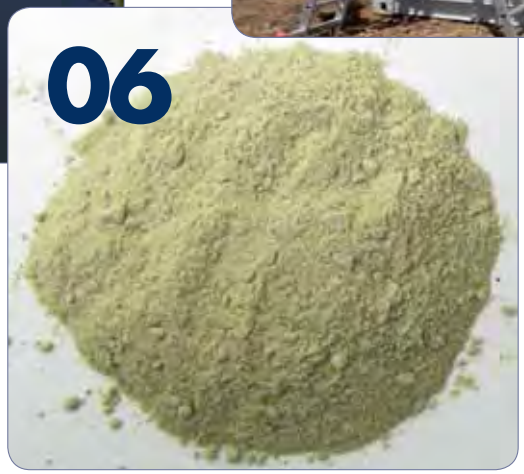
Front cover image: Aerial view of the Rhodes remediation project, Rhodes Peninsula, Sydney. Supplied by Kate Hughes.
Visit **www.rhodesremediation.com.au** for more information.



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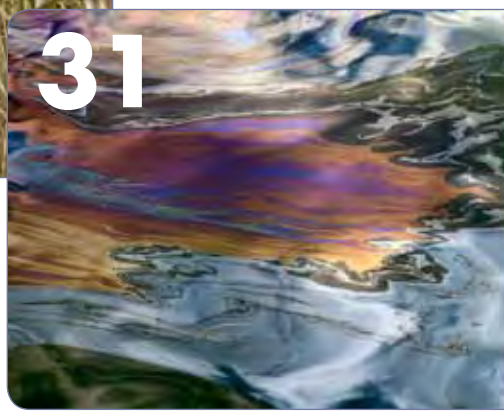


every issue

Bioreactive organoclays:

A new technology for environmental remediation

Binoy Sarkar, University of South Australia

Clay minerals are naturally abundant, inexpensive, stable, and have excellent adsorptive and ion-exchange properties – characteristics that make them ripe for use in environmental remediation.

Most natural clay minerals are hydrophilic, and consequently show very low affinity for hydrophobic organic contaminants. This can be overcome by modifying clay minerals with organic surfactants. Such modified clays, known as organoclays, have been used for a range of purposes including environmental remediation, environmentally friendly pesticide formulation, slow-release fertiliser, drug delivery, nanotechnology and animal feed. However, the full potential of organoclay use in remediating pollutants has yet to be realised. Until now, several factors have stifled development. These include a limited fundamental understanding of the way that organoclays interact with target pollutant compounds, a lack of knowledge of their regeneration or recycling scope, and limited applicability under flow conditions.

The guiding principle for contaminant remediation by organoclays is adsorption. However, a remediation technology or material singly based on the principle of adsorption has some basic disadvantages in long-term use. For example, after reaching its maximum adsorption capacity, an adsorbent should be either regenerated or replaced. Total replacement of a lot of spent adsorbent may require additional infrastructure, which will consume additional time, labour and money. There is also the chance of redispersal of contaminants from spent organoclay, depending upon environmental conditions such as pH, redox condition (Eh), temperature, ionic strength and dissolved organic matter.

To this end, an economically viable and environmentally sustainable solution might include adsorption followed by degradation of the contaminants. The degradation can be achieved by imparting either chemical or biological activity to the organoclays. Chemical reactivity, which so far has grabbed most of the research attention, can be imparted through grafting catalysts into the organoclays. Biologically reactive (bio-reactive) organoclays, however, remain largely unexplored.

If microorganisms thrive on the organoclay, they can help in the degradation or transformation of adsorbed contaminants. Such materials, which can both adsorb contaminants and subsequently degrade those contaminants biologically, have the capacity to regenerate themselves once all hydrocarbon contaminants are exhausted or degraded.

However, to synthesise such dual-property organoclay, we need innovative biochemical techniques that allow appropriate microorganisms to be mounted on clays. While bio-reactive clays would be capable of mineralising organic contaminants to carbon dioxide and water, inorganic pollutants (which exist as multiple species with variable toxicity levels – for example, chromium and arsenic) can be bio-transformed into nontoxic forms.

Application of bio-reactive clay technology to soil and groundwater remediation requires a multidisciplinary approach. For example, construction of permeable reactive barriers (PRB) for groundwater remediation requires both civil and chemical engineering support as it involves construction of permanent, semi-permanent or replaceable units across the flow path of a dissolved phase contaminant plume. As the contaminated groundwater moves passively through the treatment wall, contaminants are removed by physical, chemical or biological processes, which may include

precipitation, adsorption, oxidation/reduction, fixation or degradation.

Most PRBs contain materials that can immobilise contaminants by one or a combination of these processes. The PRB becomes bio-reactive when it concurrently degrades or transforms the adsorbed contaminants through deliberately introduced microbial agents. Organoclays are ideal as adsorbent materials in a PRB because of their fast and reversible adsorption properties.

The adsorption of contaminants by organoclays under flow conditions decreases for two key reasons. First, partially saturating organoclays with a contaminant decreases their relative permeability, and the presence of residual water limits the pore space available to the contaminant and resists its flow through the media. Second, the clay mineral in the adsorption media swells during the process, thus further reducing permeability due to the reduction in pore space.

"The full potential of organoclay use in remediating pollutants has yet to be realised. Until now, several factors have stifled development."

Fast and efficient adsorption is a precondition for contaminant immobilisation; subsequently, reversibility of adsorption might be required for the degradation or transformation. Encouragingly, organoclays can meet both these conditions. However, the biggest constraint for organoclay use in PRBs is their limited applicability under flow conditions. The direct use of organoclays under flow conditions appears to be restricted because of their low wettability and permeability.

The permeability of an organoclay barrier can be improved by mixing the organoclays with other inert materials such as sand, quartz, soils and aquifer materials at a given ratio. Aquifer material is the better option, because it can retard the transport of organoclays from the barrier and improve the water flow. The dispersivity of the barrier material, which is a mixture of organoclays and other inert materials, may increase with increased organoclay content. This increase in dispersivity is attributed to increased microscopic pore water velocities within the barrier, which also increase with organoclay content.

The breakthrough capacity of an organoclay barrier increases when the dynamic adsorption is carried out using finer particles of the organoclay and a slower feed rate of contaminated water. The flow behaviour is also expected to improve when organoclays are used in granulated form in the barriers. If organoclays are used along with microorganisms in a bio-reactive barrier, formation of exopolysaccharides and mucilaginous compounds may also limit the flow of liquid through the barrier.

Without doubt, further research is required to develop an organoclay-based bio-reactive barrier that is compatible for use under flow conditions. It is a new approach that requires multidisciplinary approach, including soil science, clay mineralogy, material science, microbiology, ecotoxicology and environmental engineering. Although a commercially available product remains some time away, the technology offers a great potential boost for environmental remediation. ■

Using laser radar and wind energy to power a nation

Julian Cribb, Cribb & Associates and John Sutton, CRC CARE

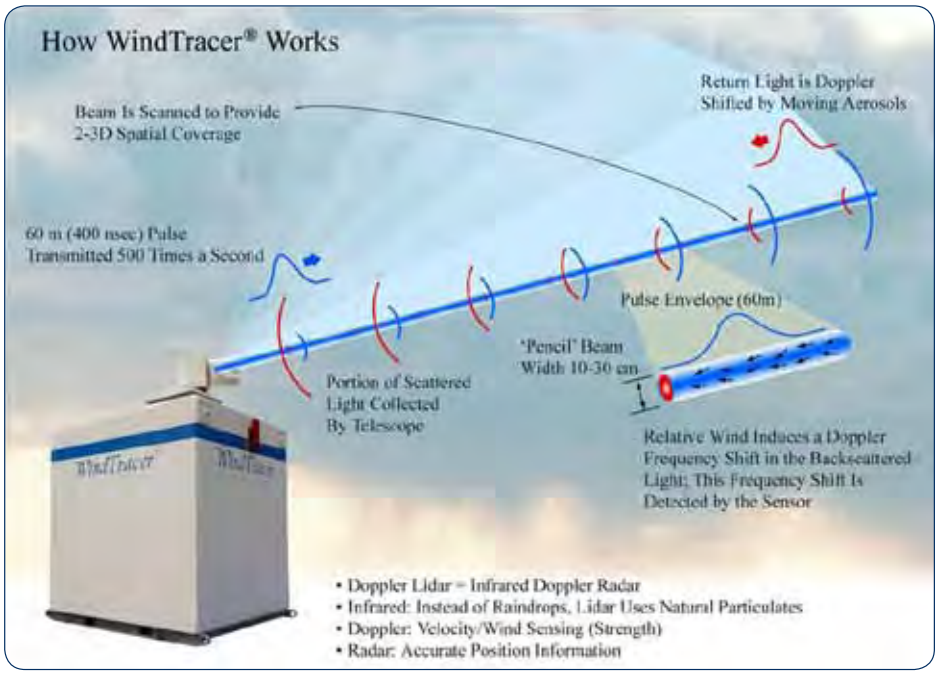
Smart Australian laser technology is poised to bring a huge improvement to the lives of tens of millions of East Africans by helping to ignite industrial, economic and jobs growth.

A state-of-art lidar (laser radar) system is being used to perfect the design of what could become the world's largest wind farm, at Lake Turkana in northern Kenya. The system will supply 20–30% of the entire power needs for Kenya, and potentially also for neighbouring East African countries.

The $775-million Lake Turkana Wind Power Project, which is being carried out by an international consortium led by Dutch firm KP&P Africa, is the largest single development in Kenya's history.

"It's an absolutely massive project – in renewable energy terms it's the equivalent of discovering a major oil field," says John Sutton, (CRC CARE/Curtin University), who developed the sophisticated lidar analytical technology and has collaborated with scientists at Arizona State University to extend the laser radar technology to wind energy applications.

Setting up a Coherent Doppler lidar system onsite in Turkana.



ABOVE Schematic of a Coherent Doppler lidar system illustrating scanning capability and retrieval of Doppler frequency shifts. Picture: Lockheed Martin Coherent Technologies.

CRC CARE researchers have developed algorithms that enable the 1.6 µm pulsed coherent Doppler lidar instrument to analyse pollution plumes in the atmosphere. These are currently being used to help industry in reducing dust and other forms of air contamination in Australia.

The first stage of the vast project will have 365 turbines producing 300 megawatts of power, possibly growing to as much as 2000 megawatts in future. The first stage alone will make it the largest wind-farm in sub-Saharan Africa. Construction is due to begin in June, and energy generation in 2014.

"In renewable energy terms, it's the equivalent of discovering a major oil field."

The technology enables the study of atmospheric processes – whether for the purpose of preventing industrial pollution, detecting windshear at airports, or for generating energy more efficiently. It can also help mining companies dramatically reduce the cost of monitoring and controlling dust pollution from mining, stockpiling and ship-loading activities. The new lidar has significant potential advantages over existing technologies, including the capability to measure wind fields to a distance in excess of 10 km.

The radial wind speed output from the lidar was processed using advanced data-retrieval techniques to retrieve wind vectors. The data are being used to verify the accuracy of wind modelling and to optimise the placement of wind turbines in the complex landscape.

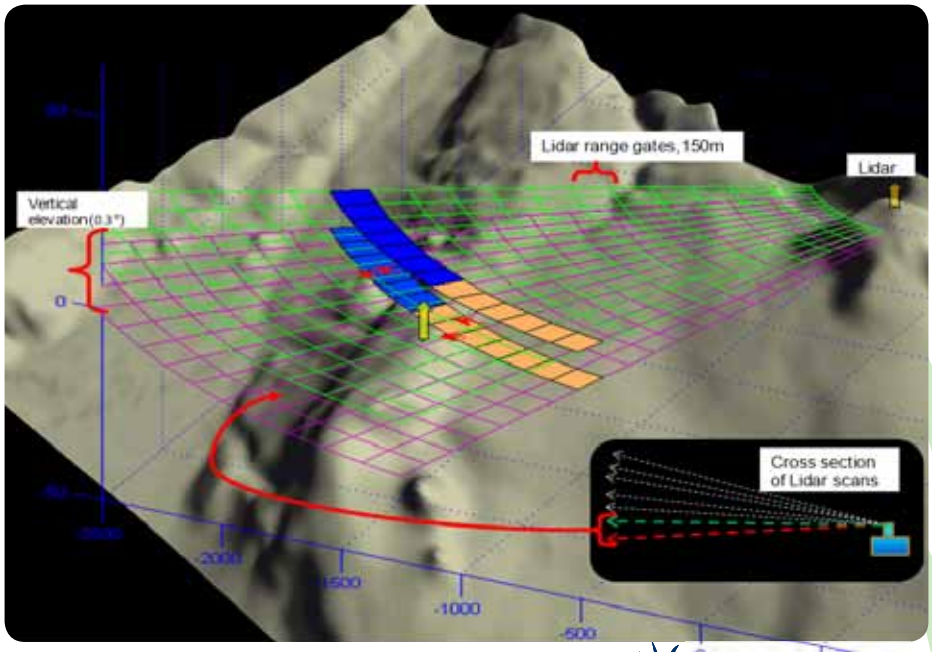
The team used a lidar 'wind tracer', which uses a laser beam to scan and measure wind vectors by bouncing light off wind-borne dust particles. The fast scanning and data-processing capability enables measurement of the three-dimensional boundary layer over an area of 400 km2 in less than 10 minutes.

At Lake Turkana, the technology precisely measured the wind field at points every 100 m across the entire landscape, and results were used to validate the models being used to design the wind farm. The jet stream is channelled between two mountain ranges and blows at a steady average of 11 m/sec, day and night.

The project requires detailed models and maps of the wind flow over the complex terrain to design the farm and place the turbines in the best locations. Key outputs from the 6-week field study included detailed information on the horizontal and vertical structure of the boundary layer, and terrain-following wind maps.

This novel application of the lidar demonstrates how clean Australian technology can make a major difference to the lives of millions around the world. It will enable several developing countries to achieve much faster growth, while sidestepping the traditional polluting phase of industrial development.

BELOW Figure 1: Lidar scanning pattern in the southwest sector of the study site.



Uncertainty analysis

A detailed uncertainty analysis was undertaken to identify challenges arising from comparing lidar and mast measurements, instrument pointing accuracy, and velocity retrieval accuracy in the far field. Further investigations are underway to address these challenges and to further improve the accuracy of the lidar vector retrievals.

Objectives

The objectives of the study were to:

- quantify the 2-dimensional wind flow across the complex landscape at Lake Turkana
- transform the retrieved data into a form(s) suitable for comparison with modelling results, and
- validate the lidar wind speed measurements against available mast and ground based anemometers.

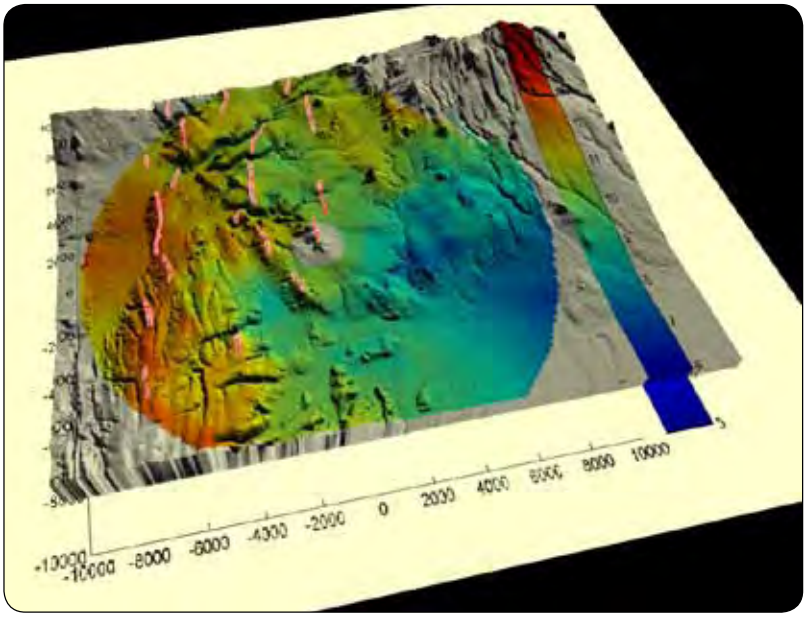
The principal output from the measurement is a terrain-following wind speed map which illustrates the relative velocity differences across the study domain over the 6-week measurement period. The map comprises of 10 minute average wind speed estimates at a height of 45 m above the ground.

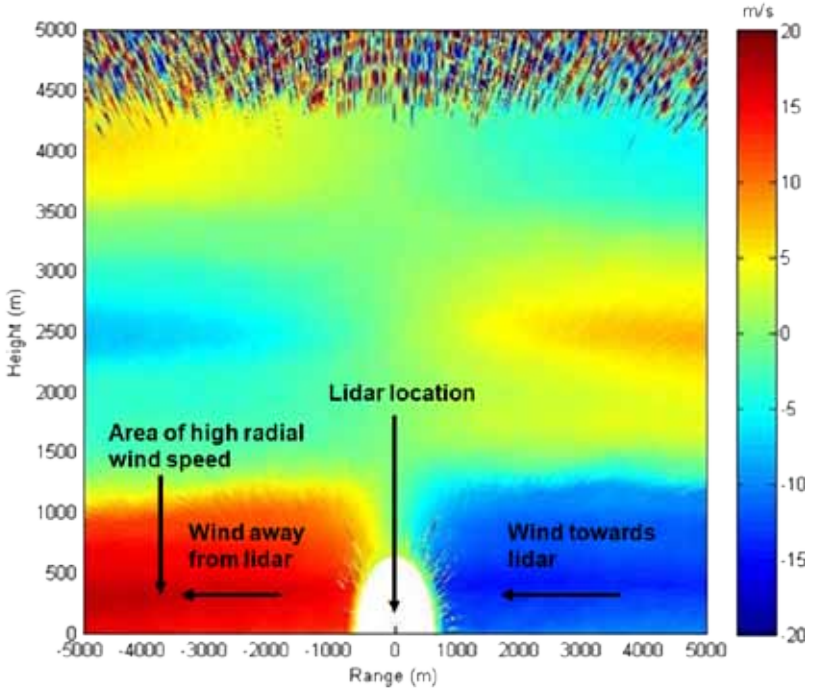
Results

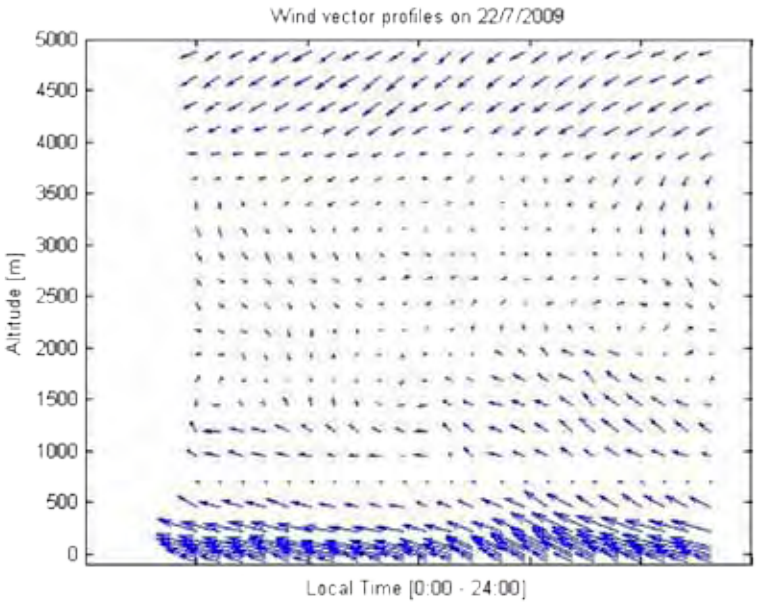
The 10 minute average wind speed estimates at a height of 45 m above the landscape for October 2009 are presented in Figure 2. Figure 3 is an example of a vertical cross sectional scan showing the structure of the atmosphere to the top of the mixing layer. Details of vertical flow structures are further obtained through the vector processing algorithms (Figure 4).

Data validation

The retrieved wind speed estimates were validated using direct comparisons of the available masts and sonic anemometry. A time series plot comparing the lidar retrieved wind speeds to the corresponding mast measurements at the Sirima site is shown in Figure 5. The comparison of the averages over the experimental period (not shown) have a strong correlation and thus provide confidence in the lidar retrieved wind speed estimates at the site.



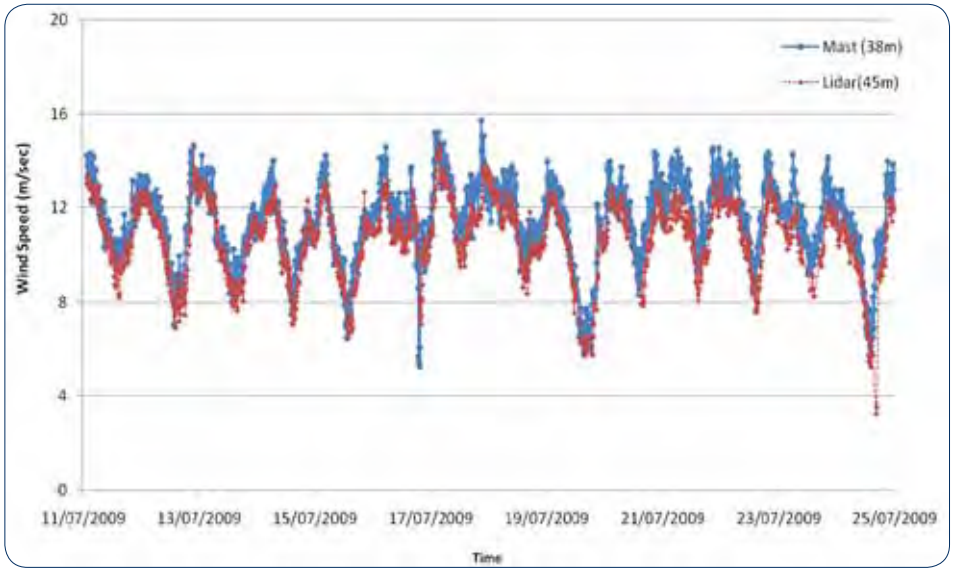




Conclusions

The study demonstrated the utility of the 1.6 µm lidar in wind energy applications to provide:

- detailed quantitative information on the horizontal and vertical structure of the wind field in topographically complex landscapes
- accurate estimates of wind speed, as validated by the lidar/mast measurement comparisons
- valuable insights into changes in the structures and behaviour of the surface flow field over time and space
- quantitative data for validation of computer modelling, and
- the potential to reduce wind resource assessment costs, project lead time, and project risk through the use of a single instrument. ■



TOP LEFT Figure 2: The plot shows that the average wind speed ranges from approximately 7 m/sec on the eastern edge of the measurement domain rising to 13 m/sec along the right ridges to the east.

CENTRE Figure 3: Vertical cross sectional scan (5 minute-averaged radial wind speed at 11:15pm on 22 July 2009).

BOTTOM LEFT Figure 4: Vertical flow structure (1-hour-averaged wind vector profiles for 22 July 2009).

ABOVE Figure 5: Lidar scanning pattern in the south western sector of the study site.

Contaminants of emerging concern:

Identifying emerging and priority contaminants

Kerry Scott, CRC CARE

Does the term 'chemicals of emerging concern' mean anything to you? It's a phrase that's being used increasingly often, and for good reason. These chemicals are receiving attention because of the risk they pose to human health and the environment associated with their presence, frequency of occurrence, or concerns due to the limited toxicity data and effects. Chemicals of emerging concern encompass both those (existing) chemicals for which concerns are emerging, as well as chemicals that are new to the Australian market.

As part of its consultative process with regulators and industry participants, CRC CARE noted that a number of contaminants were being repeatedly highlighted as a priority for further research (see box).

Priority contaminants

- MTBE
- 1,4-dioxane
- PFOS/PFOA
- nitrate
- chlorinated solvents
- perchlorate
- cyanide
- nanoparticles
- sulfates
- antimony
- pathogens
- benzo(a)pyrene
- weathered hydrocarbons
- Polybrominated diphenyl ethers (PBDE)
- phosphate-ester fire retardants
- all POPs (updated Stockholm Convention on persistent organic pollutants)
- the chemicals associated with clandestine laboratories
- endocrine disrupting compounds

forum held in February 2012 may be considered as an important first step for the Australian contaminated land industry in identifying and prioritising research on these contaminants.

The purpose of the forum was to prioritise contaminants previously identified by regulators and end users as requiring further work to improve CRC CARE's understanding of the contaminants in regard to the risk they pose and their fate and behaviour in the environment. The forum was attended by, and received input from, regulators, environmental consultants, an environmental community group and industry representatives. The outcomes of discussions at the forum, together with information gathered from other consultative processes, are encapsulated in the table (right), which summarises the contaminants that appear to have the highest priority for the Australian contaminated land industry.

Future work on chemicals of emerging concern is expected to include

- a review and report on international literature and new data on toxicity of these contaminants,
- identification of new remediation technologies,
- the development of laboratory based analytical techniques for their measurement and reporting,
- and appropriate policies and guidance on their assessment, management and remediation.

Contaminant	Nature of concern	Research requirement
MTBE	While mostly an historical contamination issue its prevalence and impact on groundwater remains a concern	Extent of prevalence Risk threshold/criteria Remediation options
PFOS and PFOA dispersants	Extreme persistence of perfluorinated compounds	Risk threshold Analytical techniques Ability to treat and dispose
Weathered hydrocarbons	Widespread presence Uncertainty re: composition, toxicity and significance	Characterisation Risk assessment Treatment
Benzo(a)pyrene	Widespread in urban area at level exceeding HILs	Measurement of bioavailability/toxicity
PBDE	Prevalence Gaps in regulation and assessment	Measurement Risk assessment

ABOVE Among the contaminants of emerging concern are PFOS and PFOA, which can enter the environment through the use of fire-fighting foam.

LEFT Contaminants that appear to have the highest priority for the Australian contaminated land industry.

Some observations on

The community consultation process

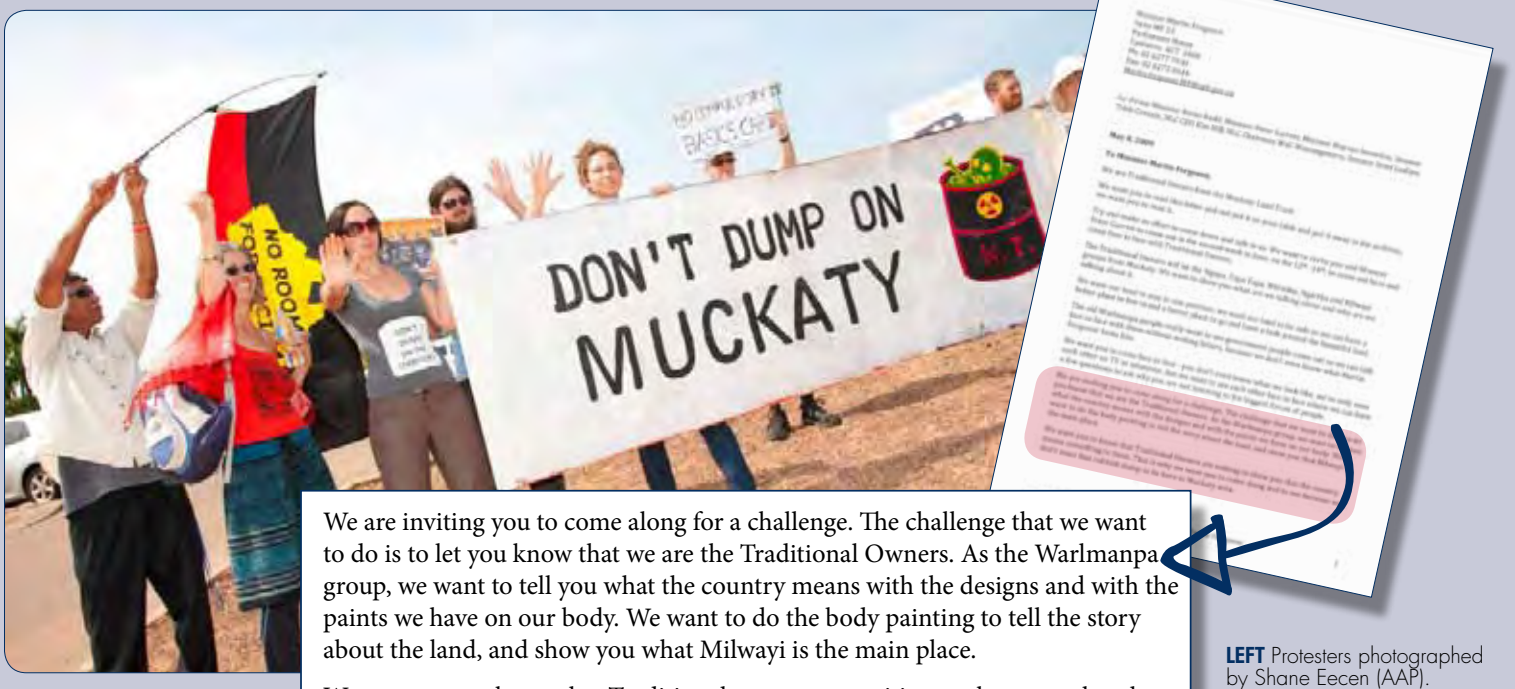
Kate Hughes, Chair: Earth Foundation Australia

In March 2012, a proposed nuclear waste 'dump' at Muckaty Station in the Northern Territory ignited major community and media scrutiny. Critics of the proposal called for those pushing the project to come out of the trenches and engage in proper consultation, particularly with Aboriginal elders. They wanted real transparency of process to allow the development of a broad community understanding about the nature of any nuclear waste facility.

The difficulties in situating such a facility anywhere in Australia highlight the challenge of community consultation in the face of land pollution issues: the mixed bag of styles and approaches range from abysmal to highly effective. Guidance on professional performance standards can be found in the 2011 National Environment Protection Measure (Schedule B8) for contaminated site assessment, which covers both community consultation and risk communication. An outsider could be excused for assuming that combining these two areas into a single policy document presupposes an acceptance that all risks are manageable provided that they are properly communicated to the general public. It's not a view that all would agree with. Suffice to say that mistrust of anything to do with pollution and pollution clean up is the default position held by many Australians.

Despite the current difficulties, it must be acknowledged that community consultation has come a long way in 30 years. In the early 1980s, when public concern about pollution issues was growing, we saw the beginning of 'engagement' with communities affected by pesticide spray drift, landfill run-off and industrial air pollution.

Contamination of surface waters was one area of intense discussion in rural communities, where the spraying of crops and road-side verges was linked to birth defects, cancers and other unexplained



We are inviting you to come along for a challenge. The challenge that we want to do is to let you know that we are the Traditional Owners. As the Warlmanpa group, we want to tell you what the country means with the designs and with the paints we have on our body. We want to do the body painting to tell the story about the land, and show you what Milwayi is the main place.

We want you to know that Traditional owners are waiting to show you that the country means something to them. That is why we want you to come along and to see because we don't want that rubbish dump to be here in Muckaty area.

LEFT Protesters photographed by Shane Eecen (AAP).

ABOVE + INSET A letter from Aboriginal elders to Minister Martin Ferguson regarding the proposed Muckaty dump.

Aerial view of the Rhodes remediation project, Rhodes Peninsula, Sydney. Photo: Kate Hughes.

health problems. In the cities, urban pest controllers were using the persistent organic pollutant (POP) insecticides dieldrin and chlordane inside people's homes for the control of nuisance pests and underneath and around them for termite control.

These were standard industry practices of the times and were done with or without the necessary permit, despite the fact that they were banned in the US and most Organisation for Economic Co-operation and Development (OECD) countries. A few environmental organisations campaigned for reforms to pesticide law, but there were no accessible pathways to negotiation with government or industry. Affected rural communities in particular had nowhere to go.

In the mid to late 1980s, things changed when the mass media began paying attention to stories of poison use, particularly where birth defects or child cancer were involved. Hundreds of front-page, radio and television stories about very sad, personal events were bolstered by some in-depth journalism about the science and politics of pollution. As government attention increased, communities began to be heard. Sure enough, media coverage became a central part of campaigns for law reform on hazardous chemicals.

> "Media coverage became a necessary part of campaigns for law reform on hazardous chemicals… it helped put contaminated sites on the environmental agenda."

In many ways, it drove a new agenda, forcing governments to initiate dialogue or face political consequences. It also helped put contaminated sites on the environmental agenda.

In hindsight, some of those early attempts at consultation were truly appalling. Dysfunctional meetings were called by embattled officials to discuss such emotive issues as cancer clusters and possible links with crop spraying, hazardous waste landfills or municipal incinerators. Experts were called in, people's concerns dismissed and, if necessary, meetings were shut down by turning off the lights.

From the community viewpoint, it was all very unsatisfactory. Participation could be restricted to one or two 'complainants', essential information was unavailable, and follow-up was usually slow and incomplete.

It was not unusual for parallel meetings to be held with polluters

to assure them that the community outrage was being managed. Sometimes government itself was responsible for the pollution, as was the case with local government road-side weed spraying with 2,4,D and 2,4,5-T in northern NSW.

During the late 1980s and early 1990s, consultation became more formalised and, at least in some policy areas, started to improve. One significant example was the process established for the NSW Government-owned industrial waste facility at Castlereagh in far western Sydney. Nearby residents had become vocal about emissions from the site and then Minister for the Environment Pam Allen agreed to set up a consultation process. It continued for about 6 years and achieved some success but suffered from relentless community outrage and a lack of structure.

The process was not, at least in the beginning, sufficiently resourced to satisfy people's need for detailed dialogue. Nor were government workers and their technical and scientific experts trained to respond helpfully. Leadership was lacking and the agenda would often wander around key issues without getting to the nub of the matter: community health and site clean-up. Meetings sometimes lasted well into the night, with high levels of emotion from people who felt that they were being poisoned. Key features of this early period of community consultation included lack of awareness about process, lack of access to data, unsuitable location, impossible meeting schedules and poor resourcing. It all added up to an adversarial approach which was time-consuming and very frustrating for everyone concerned.

By the early to mid 1990s, community consultation came of age, becoming recognised as a civil process that was a legitimate part of solving pollution issues. People became more informed and were better able to present their concerns to governments who in turn began to appreciate the benefit of more inclusive dialogue. Effective community consultation now included a broad spectrum of stakeholders: community members, local government, environmental organisations, doctors, scientists, public servants and forward-thinking industry professionals. It also focused on the absolute need for 'good process'. This was very much the case for the consultative process set up for POP waste issues. Although at times cumbersome and long-winded, the National Advisory Body on Scheduled Waste established new consultation ground rules and eventually delivered national plans for dealing with Australia's various hazardous waste streams.

Another consultation pioneer process that ran during the 1990s was that established for Sydney's 2000 Olympic Games. This started with pre-bid consultation in 1992 and, driven on by the promise of a 'green Games', evolved into a full-blown community consultation process called the Homebush Bay Environment Reference Group (HBERG). During this period, new computer technology was becoming widely adopted and began to change everything. Rapid communication became a reality through the internet and information became available to anyone who had a computer or a library membership card.

The HBERG process set a new benchmark for community consultation. After some painful teething troubles, it evolved into a truly inquisitorial and inclusive process, characterised by a high level of cooperation and information delivery. Its role was to monitor the implementation of the Olympic Coordination Authority's enhanced remediation strategy, which involved a massive brownfields site remediation as well as POPs waste destruction project. HBERG had an independent chair, a dedicated project officer, a standing agenda, terms of reference and a consultation protocol.

From July 1998 to June 2001 HBERG met every 6 weeks for 3 years, with membership drawn from community and local government sectors, the district historical society, environmental non-governmental organisations and university specialists. NSW government staff participated as observers. There was little turnover of membership and the process was well resourced, both intellectually and financially. Although it was not without its problems, most members were satisfied with the process, and proud to have helped create a practical legacy from the green Games – one

that was soon applied to another major site clean up across the bay on the Rhodes Peninsula, where Australia's biggest POPs pollution clean ups were scheduled.

The Rhodes remediation projects could well have been highly adversarial, involving as they did the dioxin legacy of the Union Carbide chemical company, thermal treatment technologies, changing standards of risk, urban development and the Sydney property market. Fortunately it was a logical follow-on from HBERG, with its community members joining up for yet another lengthy consultation process. This one took nearly a decade, starting in 2002 with two inquiries and the environmental impact statement process, and ending with site handover in May 2011.

The Rhodes Community Consultative Committee was a mandated consultation process. There was an independent chair selected by the community and, for the first time, two independent advisers to assist understanding of both on-site and off-site issues, particularly POPs destruction technology and air pollution. Members developed their own charter to provide a framework for discussion and there were accepted rules of engagement that were generally respected. Community members were picky and pokey when they needed to be, asked lots of questions and offered some good advice to the remediator. But, as with all things, there was still room for improvement. Government workers did not attend enough meetings, and developers hardly bothered except when they really had to. Long-term Rhodes residents attended virtually all meetings but very few new residents were interested.

On the plus side, NSW Health and the Environment Protection Authority went beyond what would normally be expected of government and the City of Canada Bay continued to champion the community engagement process after site handover in May 2011. That council is currently supporting a web publishing project that explains the peninsula's history of pollution and how the brownfields sites were transformed from a liability to an asset.

The lessons learnt from this and previous consultation processes are important ones. In the future, everyone who wishes to can benefit from a better understanding of pollution and remediation processes. New media including social networking could well be part of a matured remediation industry, where a social license to operate is as relevant to site remediation as an environmental license and a legally compliant corporate governance structure. ■

Enhance your career with a research degree in environmental remediation.

CRC CARE is offering three PhD scholarships, valued up to $28,500 p.a. (tax free) for three years, for potential candidates to undertake projects focussed on light non-aqueous phase liquids (LNAPLs).

Australian petroleum industry and regulatory agencies wish to support improved understanding of the sustainable remediation of LNAPLs, such as petroleum fuels in groundwater environments. Such improved understanding will be developed through better field-scale quantification of the effectiveness of remediation strategies in removing LNAPLs from aquifers, thereby reducing exposures and risks. There are currently 3 research projects available:

- Field evaluation of the inter-comparison of petroleum (LNAPL) remediation technology efficiencies in complex fractured and/or porous media
- Multiphase modelling of petroleum (LNAPL) remediation options in aquifers with complex geologies
- Quantifying the transient risk due to petroleum (LNAPL) removal from impacted sites

The PhD students will work closely with project investigators, consultants and other specialist staff on this well funded, industry linked project. The projects will be conducted at CSIRO Land and Water, Floreat Western Australia in partnership with the University of Technology Sydney (UTS), and jointly with industry partners where field investigations are undertaken and applications tested.

For further project related information, please contact:

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Visit **www.crccare.com** for more information on these and other scholarship opportunities.

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CRCCARE

Green cap for contaminated land:

Transforming landfills and mine dumps into usable land

Nanthi Bolan, UniSA

There isn't a city in the world that doesn't have health and environmental risks caused by old waste dumps. This is why a new green technique developed by CRC CARE, offering the potential to transform old urban landfill sites and mine dumps, has the potential to form the basis of a highly profitable export industry worth millions. Known as 'phytocapping' or 'green capping', the technique uses green plants to reduce rainwater flow into old dumps that could release pollution into nearby groundwater and streams, or greenhouse gases into the atmosphere. The plants can later be harvested to produce clean energy.

CRC CARE, along with technology firm FibreCell Pty Ltd, recently announced the successful demonstration of the technique using a combination of a clay cap and the plant *Arundo donax* (giant reed) to seal an old landfill at Salisbury, South Australia. The successful Salisbury trial and other similar trials have given Australian an international edge in phytocapping with major export potential. Dealing not just with historical contamination, but also preventing greenhouse emissions and generating green power, illustrates the creativity that is making Australia a world leader in clean-up science and technology.

Australia has an estimated 160,000 contaminated sites, some being old urban refuse dumps and landfills, which our expanding cities have grown over and around.

LEFT Professor Nanthi Bolan leads a research group through the Salisbury demonstration site where the Giant Reed has been cultivated.

BELOW The Giant Reed, *Arundo donax*, in its early stages of planting.

PREVIOUS PAGE The same site, after the plantation has reached its ideal growth stage.

Municipal authorities face a major challenge in keeping decades-old toxic chemicals contained within these sites so they do not affect surrounding communities or wetlands. Nationally, there are literally tens of thousands of old landfills, dumps and factory sites that are too contaminated to use in their present condition, but which can be cleansed and rejuvenated into high-value real estate by low-cost techniques such as green caps.

The giant reed used at Salisbury reduces the amount of water that enters the old landfill. This in turn reduces the organic decomposition that emits greenhouse gases from the landfill, and also prevents toxic chemicals and heavy metals from leaching out. The giant reeds grow so rapidly that they can be harvested for use in producing electricity, methanol (for use as a fuel), or biochar for use for sequestering carbon and improving soil in agriculture. This makes the process of cleaning up an old toxic dump useful and potentially quite profitable.

The growing characteristics of giant reed are well known and understood by FibreCell Australia following 7 years of extensive research and trials. This knowledge has led to the development of effective management protocols that optimise the beneficial uses of giant reed without threatening the ecosystem.

In separate research, the green cap of reeds has also helped prevent dust containing toxic minerals from blowing out of old mine and mineral processing tailings across inhabited areas. CRC CARE has also tested a range of native Australian grasses and plants to see which are most effective at extracting toxic minerals for safe disposal – a form of clean up known as phytoremediation.

A unique feature of the Salisbury project was the use of biosolids (the solid residue left over from sewage treatment) as a nutrient source for the green cap crops, the use of wastewater to irrigate them, and the innovative use of industrial wasteland to grow a product with real market value for energy generation.

Over time, it is expected that the degraded land will be gradually cleaned up and made safe for other uses, such as urban development. By freeing up more land in urban areas in a very affordable way, this emerging technology can ultimately add billions of dollars to Australia's economy. ■

Developing a national remediation framework

Kerry Scott, CRC CARE

Does Australia need a consistent national approach to contaminated site remediation and management?

When CRC CARE developed its re-bid proposal for the Department of Industry, Innovation, Science and Research (DIISR) back in 2010, the response from national feedback was a resounding yes. Representatives of environmental regulatory bodies across the country, as well as major corporate entities involved in cleaning up sites across multiple Australian jurisdictions, indicated to CRC CARE that this was an issue of concern that needed to be addressed.

Although current general guidance for remediation and managing contaminated sites offer some high-quality national documents, these are dated. Likewise, the guidance issued by some jurisdictions is also of high quality, but not harmonised across states and territories.

What are we doing about this? A national remediation framework steering group has been established by CRC CARE and commenced discussions on the purpose, benefits and limitations of a new remediation framework for Australia. To date, the steering group, consisting of representatives from the petroleum industry, Department of Defence, contaminated land industry bodies (the Australian Contaminated Land Consultants Association and the Australasian Land and Groundwater Association), and contaminated land auditors and regulators, has completed a scoping exercise to shape a national framework that harmonises the approach to contaminated site management and remediation for all states and territories of Australia.

Defining the framework requirements

Following the identification by the steering group of important elements to consider in developing the approach, structure and content of the framework document, it was agreed that the framework should:

- enable a nationally consistent approach to remediation of contaminated sites
- be established under the umbrella of the Standing Council on Environment and Water
- NOT impinge on the policy and decision-making prerogatives of the states and territories
- NOT be legally binding
- distil and utilise existing documentation and experience, and
- provide practical guidance within an overall framework which establishes the context for remediation in Australia.

Initial project and outcomes

In 2011, the steering group identified existing international and Australian approaches and regulations for contaminated site management and remediation. Possible barriers and potential pathways to adopting a national contaminated site remediation framework in Australia were also determined. This information is expected to assist the steering group in further considering the potential structure and content of the framework in an Australian regulatory context.

The documents examined in this preliminary scoping exercise share substantial structure and content. Similarities were also noted in the way that remediation and management of sites is generally approached, in both Australian and international jurisdictions. In light of these similarities, the steering group identified the potential for adapting or adopting existing approaches for developing principles, policies and practice for an Australian management and remediation framework. Following completion of the scoping exercise, a draft framework structure and content was endorsed.

The draft framework structure features possible elements to be included and will be used as a tool to summarise the elements shared in management and remediation approaches in different jurisdictions and countries. It will also address the elements and issues required for national harmonisation.

The draft framework comprises two distinct parts:

Part 1: Philosophy

- *Context*
  - includes background and jurisdictional arrangements, as well as the purpose and intended audience for any framework documentation.
- *Policy and principles*
  - includes discussion of agreed principles and policy approaches that do or will guide activities related to remediation and management, e.g. precautionary principle, liability, risk management, green remediation.

Part 2: Practice

- *Guidance*
  - includes practical guidance for practitioners, provided either as specific advice or techniques outlined within the text of the framework document, or as references to tools and guidance available elsewhere. Guidance could relate to all steps of the remediation and management process from the setting of remediation objectives to post-remediation auditing and the use of institutional controls.

The next phase

The next phase in establishing the national remediation framework comprises work in developing the principles and policies section of the framework. This entails collating current regulatory practices across Australia, and identifying those that can be adapted to a national context without compromising jurisdictional independence.

In tandem with the principles and policy project will be another project to identify and collate existing practical remediation and management guidance material from international and Australian sources. Expected outcomes of the second project include a review of appropriateness of collected documents and recommendations for adoption or adaptation, and the identification of gaps in guidance material. It will involve the identification and collection of national and international guidance documents for contaminated site remediation and management, in accordance with the broad areas outlined in the draft framework.

Once this body of work is completed, the compilation and development of remediation or management guidance can begin, possibly including:

- *Development of remediation plan*
  - development of site-specific remediation objectives
  - identification and evaluation of remedial options
  - selection of remedial technologies
  - treatability studies
  - cost-benefit analysis
  - preparation of a remedial action plan/site management plan/risk management plan.
- *Implementation of remediation plan*
  - health and safety considerations – worker and public
  - community consultation and risk communication
  - reports, documentation and record-keeping.
- *Post-remediation considerations*
  - remediation validation
  - long-term monitoring
  - auditing/third-party review
  - institutional controls.

The work completed to date is the first of several steps required to deliver an accepted national remediation framework and guidance. As acknowledged by the National Remediation Framework Steering Group, the development of a national remediation and management framework is a long-term project that will be best managed by a staged approach. ■

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Sustainable Remediation Forum of Australia and New Zealand

Developing sustainable land and groundwater contaminant remediation practices

Garry Smith and Peter Nadebaum,
SuRF ANZ Forum Committee

'Sustainable remediation' (SR) has emerged as a topic of intense interest and debate in Australia and New Zealand. In the past, initiatives in the US and UK have resulted in the formation of sustainable remediation forums (SuRFs); similar bodies have now been formed in several countries, including a partnership between Australian and New Zealand remediation practitioners known as 'SuRF ANZ'.

Australian and New Zealand consulting companies, regulatory agencies and industry at large broadly support the consideration and application of sustainability principles for land and groundwater remediation projects. However, different groups have varied approaches toward the standards of evidence required, and the importance of sustainability in the hierarchy of remediation considerations. Where government jurisdictions overlap, the development of formal frameworks for SR in Australia and New Zealand requires tools and policies to unify practical SR outcomes.

The practicability of applying remediation concepts is being considered in Australia and New Zealand in the context of ecologically sustainable development. This requires the effective integration of economic, social and environmental considerations in decision-making processes, with the need to improve community wellbeing and the benefit of future generations. It is recognised that measures adopted should be cost-effective, and in proportion to the significance of the environmental problems being addressed. Papers and sessions on SR are increasingly being included in industry conferences.

Contributions from SuRF ANZ to such events enable opportunities for national discussion and international communication regarding the application of sustainable remediation in Australia.

Australia and New Zealand have established statutory systems using independent third party audits, delegated by government regulatory agencies, to assess remediation results and formally certify that land is suitable for use. This work is carried out in accordance with detailed guidelines issued by the respective regulatory agencies. The audit system is not inconsistent with the application of sustainability principles; it can, for example, allow a variety of solutions, including retention and the long-term management of site contamination using appropriate risk assessment-based processes.

Australia and New Zealand also have generally accepted 'clean-up to the extent practicable' (CUTEP) approaches that consider the technical feasibility, logistics and financial aspects of pursuing clean-up, particularly when cleaning up groundwater contamination. This

Objectives of SuRF ANZ

- Encourage and manage the activities of the various working groups
- Provide website-based SR guidance and tools
- Organise meetings and forums in which SR is discussed
- Facilitate member contact with international SR associations and SR developments
- Contribute to a National Remediation Framework being developed through CRC CARE.

has resulted, where appropriate, in regulatory acceptance of remedial solutions that cannot practically achieve complete clean up. Such an approach is compatible with consideration of the principles of sustainability during selection of remedial strategies.

on a way forward for SuRF in Australasia, leading to the legal establishment of SuRF ANZ in 2012. SuRF ANZ is now an independent group supported by ALGA, with more than 300 members. The early years of SuRF ANZ activity have been accompanied by:

- broad interest from the Australian and New Zealand remediation industry
- development in 2011 of a draft 'Framework for Assessing the Sustainability of Soil and Groundwater Remediation' by interested participants
- confirmation by members in 2012 of a work plan that establishes working groups on an ANZ-specific SR framework, on Planning SR, on identifying suitable ANZ SR metrics/ tools, and on highlighting illustrative SR case studies and conferencing opportunities, and
- a series of conferences, seminars and workshops organised by ALGA in 2011 and 2012 in which SuRF ANZ was a contributing organisation, with streams focusing on sustainable remediation.

"Applying remediation concepts (in the context of ecologically sustainable development)... requires the effective integration of economic, social and environmental considerations in decision-making processes, with the need to improve community wellbeing and the benefit of future generations."

The organisation and operation of SuRF ANZ activities was initially supported by CRC CARE, whose support contributed to significant advances; the Australasian Land and Groundwater Association Inc (ALGA) took on this role in 2011.

A meeting of involved persons from the contaminated sites industry in August 2011 included a discussion

This included a series of workshops on Green and Sustainable Remediation, including SR metrics, delivered in Australian and New Zealand capital cities.

Sustainable remediation is defined by SuRF ANZ in the draft framework as:

'a remediation solution selected through the use of a balanced decision making process that demonstrates, in terms of environmental, economic and social indicators, that the benefit of undertaking remediation is greater than any adverse effects'.

The draft captures suggestions from industry participants for incorporating sustainable development criteria in soil and groundwater remediation decisions that can be applied in Australia and New Zealand. The formulation of this framework drew heavily on an earlier document prepared by the Sustainable Remediation Forum (SuRF) UK and CL:AIRE (Contaminated Land: Applications in Real Environments **www.claire.co.uk**).

The draft framework recognises that there are two main stages where sustainable remediation decision-making is applied:

- at the project/plan design stage, when some of the most influential decisions about the remediation solution can be embedded into a sustainable project design, and
- at the point of remediation selection and implementation, when the decision is about selecting the optimum remedial strategy or technique.

Thus, SR decision-making can take place at various points within a project/property life-cycle.

Preferably, SR will be considered in the early stages, when basic remediation requirements for a particular site can include important considerations such as regional land-use planning and site-specific land-use considerations, and later, when more detailed remediation strategy

Want more information on SuRF ANZ?
Visit www.surfanz.com.au

and technology selection decision-making is taking place in the project design and delivery phases.

The principles of SR can be applied across a variety of remediation scenarios including, for example, brownfield redevelopment; in this scenario, sustainability issues associated with remediation are just one of a number of factors that influence whole project sustainability. The principles can also apply to remediation on operational land, where the remediation decisions define the sustainability of the ongoing operation of the facility.

In selecting remedial solutions, a decision-making process would

- identify key stakeholders and the mandatory requirements that must be satisfied (vs. those requirements that are desirable but not mandatory)
- systematically identify and select a remedial strategy (i.e. source treatment, pathway interception or receptor modification) to satisfy the essential requirements, and
- optimise the net benefits of the risk-management actions that make up the strategy.

It is important to note that the selected remedial solution must be acceptable to stakeholders, particularly in terms of complying with regulatory requirements, and with respect to the level of risk to each stakeholder. As such, SuRF ANZ believes it can be useful to refer to 'risk-based sustainable remediation', rather than simply 'sustainable remediation', to emphasise the critical role of risk in decision-making. As each stakeholder group will perceive risk differently, consultation to understand these different perspectives is an essential component of SR decision-making.

Finally, as is being practiced in Australia and New Zealand, SR is compatible with important established and emerging cross-disciplinary sustainable development practices including land-use planning ('brownfields'), urban design ('urban renewal') and transport ('transit-oriented development'). ■

Publications Update

This section contains publications that have been published in the last 3 months (since the last edition of *Remediation Australasia*). The publications may originate from research institutions, regulators or industry groups. Let us know if you have any appropriate publications (no promotional material) to be included by emailing **aric@crccare.com**.

Remediation Australasia to be re-released!

Remediation Australasia, until September 2011, was an online publication. The new print layout has sparked so much interest that ARIC is converting all back issues to the new format. Keep your eyes on the *Remediation Australasia* website for these 'new' issues in June, to coincide with the release of Issue 10.

CRC CARE Technical Report 20: *Guidance document for the revegetation of land contaminated by metal(loid)s*

The revegetation of sites contaminated by metals and metalloids is an important environmental challenge. This document provides a brief review of current knowledge, with a particular emphasis on Australian plants and landscapes.

Available for download at www.crccare.com

Technical Report 11: *Characterisation of sites impacted by petroleum hydrocarbons - national guideline document* available to buy online

National guidelines for the characterisation of petroleum hydrocarbon impacted sites, to unify current guidance and provide support for innovative technologies and approaches.

Available for purchase at www.crccare.com

Fact Sheet 13: Coal seam gas

Coal seam gas has rapidly become a major industry in Australia during the last decade. Environmental impacts from coal seam gas mining are an ongoing issue, and can be minimised and/or managed through environmental research.

Available for download at www.crccare.com ■

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Regulator RoundUp

South Australia

Roslyn Agate, EPA SA

The SA EPA has launched several major programs since the second half of last year.

Working together to bring back Adelaide's seagrass

The State Government, industry, local government and community groups have worked together to improve Adelaide's coastal water quality and bring back Adelaide's seagrass. This commitment is set out in the draft Adelaide Coastal Water Quality Improvement Plan (ACWQIP), which was released by the EPA for public comment in November 2011.

The plan recognises current and future work of the Adelaide NRM board, EPA licence holders along the coast and local councils in monitoring and on-ground works for improving water quality management. It is another step in a series of management actions designed to protect and restore Adelaide's coastal water quality and bring the seagrass meadows back closer to shore.

Public comments are currently being collated and a draft final report is due out soon.

State's rivers and creeks assessed

The Aquatic Ecosystem Condition reports on the health of South Australia's rivers and creeks, were released in November 2011, and represented a significant breakthrough in the way water quality is measured and reported in South Australia. The reports set out findings made by EPA scientists at sites including creeks and rivers in several NRM regions. In total 219 reports were released. These reports assessed the condition of waterways as ecosystems, including the water quality and the plants and animals that depend on it and provide a summary of information on each location; presenting the scientific findings as well as the key pressures and management responses. According to the EPA the reports confirmed what was expected in terms of overall trends and the ongoing impacts of land clearing and urban development. Further reports are due in 2012.

SmokeWatch program increases public awareness

The EPA SmokeWatch Mount Gambier program came to its conclusion at the end of 2011. The three-year program, launched in 2009 to look at the effects of wood heater usage, was a collaborative partnership between the EPA, City of Mount Gambier, Firewood Association of Australia, the Australian Home Heating Association and Department of Health. The campaign assisted in increasing community awareness of air quality issues. The program provided an understanding of the sources of particle pollution in Mount Gambier. The 2011 SmokeWatch winter air monitoring campaign report and any future activities to address wood smoke pollution in Mount Gambier will be available on the EPA website in coming months. For more information, visit **www.epa.sa.gov.au/smokewatch**.

Compliance program for vessel wastewater

In March 2012, the EPA launched a compliance and enforcement program to assist in the implementation and completion of the new vessel wastewater regulations as set out in the Code of Practice for Vessel and Facility Management (marine and inland waters). The new vessel wastewater regulations were introduced in 2008 and require owners of all commercial and private vessels operating on inland waters to either contain or treat greywater on board their vessel. The compliance and enforcement program will see Environment Protection Orders (EPOs) and court orders issued to vessel owners that do not comply. Letters have been sent to private vessel owners reminding them of their obligations under the Code of Practice, and random audits will be conducted throughout the year to monitor compliance progress of the houseboat industry.

Online public access to EPA licences

As part of the EPA's commitment to progressively providing more information on its public register and allowing easier access for interested parties licences have recently been published on the EPA website.

In September, around 2100 licences were made available for viewing online providing the public with a better understand of licensing conditions that are in place across the state to protect the environment and nearby communities. Environmental licensing is one of the tools used by the EPA to safeguard against potential public and environmental harm. The EPA reviews licences every five years in most instances, unless urgent circumstances exist that require a licence review earlier. Licence information refers to all types of environmental authorisations; licences, works approvals and exemptions and will be updated within the Public Register Directory section of the EPA's website on a quarterly basis. Other information now available through the Public Register Directory includes enforcement actions and notifications of actual and potential groundwater site contamination.

Further information will be placed on the register this year. ■

NSW

Jessica Dorricott, Elvin Wong & Niall Johnston, EPA NSW

The EPA became an independent statutory authority on 29 February 2012. The focus of the EPA is the protection of the community and environment from major sources of pollution and to reduce the impacts of emissions and contaminants into air, water and onto land. Members of the EPA Board have been appointed, along with Barry Buffier as the Chair and Chief Executive. The EPA Chair reports directly to the Minister for the Environment.

Recent changes have been made to the Protection of the Environment Operations Act 1997 to make provisions for:

- improving public access to pollution monitoring data in NSW;
- increasing maximum penalties for not notifying pollution incidents immediately; and
- specifying notification to certain agencies.

The reporting obligations came into effect on 31 March 2012 with a three-month compliance transition period for holders of environment protection licences (EPLs). From 1 July 2012, all holders of EPLs must provide public access to monitoring data recorded under each EPL that they hold. More information can be found on the EPA's website at **www.environment.nsw.gov.au**.

The EPA recently called for new applications for the NSW Accredited Site Auditor Scheme which closed on 23 April 2012. The accreditation process is anticipated to be finalised by the third quarter of 2012. In addition, the EPA is developing guidelines on hazardous ground gas and on landfarming and is currently consulting with site auditors prior to more general release. ■

Victoria

Barry Warwick, EPA Victoria

The HazWaste Fund is looking for innovative solutions to increase the remediation of contaminated soils. The HazWaste Fund is designed to support industry to accelerate reductions in the volume and hazard of hazardous waste (or prescribed industrial waste) generated in Victoria, and to increase remediation of contaminated soils. Almost $30 million dollars has been available over the course of the program with $21 million already committed.

Do you have a solution for removing metals in contaminated soil? Are you investigating new technology that can minimise or avoid hazardous waste? The fund is due to close in June 2012. Don't miss out on the chance to transform hazardous waste from a business cost into a resource opportunity. Contact EPA Victoria on **1300 EPA VIC** to discuss your project idea. For more information visit **www.epa.vic.gov.au/projects/piw_reduction/hazwaste.asp**. ■

Training and events calendar

May

2 **CPD Program 2012 Modules 1–3 Introduction to environmental site assessment**
ACLCA / Melbourne
www.aclca.org.au/cms-events/index.phps

9 **An update on clandestine laboratories and the development of state guidance and training**
ACLCA (WA) / Subiaco
www.aclca-wa.org.au/events

15 – 17 **Collaborate Innovate 2012**
CRCA / Adelaide
www.crca.asn.au/conference/index.html

23 **Confidence in analytical data**
(Peter McGowen, URS)
ACLCA (SA) / Adelaide
www.aclca-sa.org.au/events

June

13 **Presentation on practical treatment of ASS**
ACLCA (WA) / Perth
www.aclca-wa.org.au/events

13 **RemScan™: real-time analysis of TPH in soils**
ACLCA (WA) / Perth
www.aclca-wa.org.au/events

13 – 15 **Modelling with SMS and TUFLOW**
Sustainable Resources Industry Training (SRIT) / Brisbane
www.srit.com.au/course_details.php?id=27

18 – 21 **Floodplain modelling with WMS**
Sustainable Resources Industry Training (SRIT) / Brisbane
www.srit.com.au/course_details.php?id=40

25 – 29 **SRIT Advanced master class in Australian groundwater**
Sustainable Resource Industry Training (SRIT) / Perth
www.srit.com.au/course_details.php?id=9

July

4 **CPD Program 2012 Module 5 Introduction to environmental site assessment: Analytical chemistry**
ACLCA / Melbourne
www.aclca.org.au/cms-events/index.phps

9 – 13 **IWES Short course training**
University of Queensland & IWES / Gold Coast
www.iwes.com.au

17 **Workshop on combined exposures to multiple chemicals**
ACTRA / Canberra
www.actra.org.au

22 – 27 **4th International Congress on Arsenic in the Environment**
JKTech Pty Ltd / Cairns
www.as2012.com.au

24 **Industry views on concentrations in the workplace**
ACLCA (SA) / Adelaide
www.aclca-sa.org.au/events

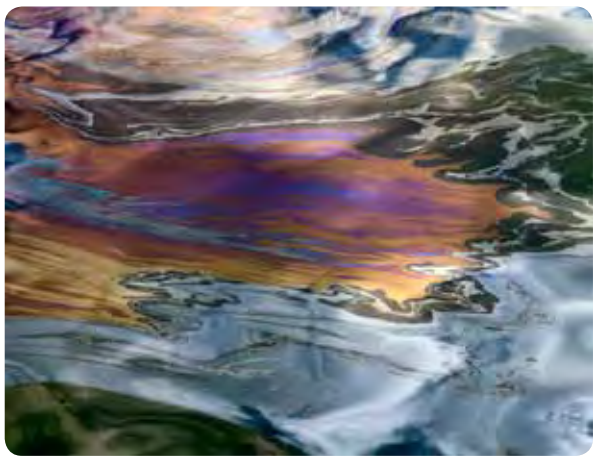
24 – 26 **Introduction to Australian groundwater**
Sustainable Resources Industry Training (SRIT) / Perth
www.srit.com.au/course_details.php?id=37

Research RoundUp

Research Roundup aims to keep you up-to-date with current research on environmental contamination assessment and remediation in Australia. By keeping content succinct and focusing on particular projects, *Remediation Australasia* makes it easier for you to find the time to read about areas which are relevant to you. In this issue, the focus is on CRC CARE funded projects.

CRC CARE's second term of operation commenced in July 2011, and the research programs have an increased focus on helping to develop uniform national standards for assessing and remediating contamination. The outputs from the research programs will fill knowledge gaps and allow adoption of remediation that balances health and environmental protection with economic and social considerations. With this focus in mind, the CRC has funded the following projects.

Integrating advanced oxidation processes (AOPs) and nano-technologies for persistent organic pollutants (POPs) removal from contaminated water and soil



Persistent organic pollutants (POPs) produced and used in industrialised nations are a cause of great concern globally due to their persistent, bioaccumulative and toxic nature and their propensity to travel long distances to affect even remote, uninhabited parts of the globe. POPs have diverse physico-chemical properties and are released in the environment from varied sources. Soil has been identified as one of the most important repositories for fluxes of POPs between soil and air. POPs are also released from industrial and household into water. In Australia, POPs pollution in water and soil remains an important issue for pollution control and remediation.

In this project, researchers from Curtin University will develop new technology incorporating nanomaterials and chemical oxidation to completely remove POPs present in water and soil. This technology will provide a solution for decontamination which can be widely used in water and soil remediation, bringing in significant benefits to industry and communities. ■

Novel solar-driven fibreoptic photocatalysis hybrid system for groundwater treatment

The program aims to design an integrated photocatalytic/fibreoptic system for in situ environmental remediation of chlorinated hydrocarbons. It combines fundamental science and engineering for the manufacturing of a hybrid system which can treat groundwater in situ by solar radiation. At night, the system can be modified to work on batteries, which are recharged at day time using solar light energy. The significance of this project lies in the use of the free solar energy for groundwater treatment.

In contrast to the current chemical oxidation practices that use nanoparticles such as nano zero-valent iron (nZVI), this process offers the innovation of treating groundwater without injecting nanoparticles emulsion to the groundwater. The disinfection is achieved by simple contact between the photocatalytic optical fibre coated with photocatalysts and the contaminants, which are eventually decomposed or mineralised to harmless by-products. ■

PAH bioremediation screening tool

Bioremediation is a readily available and relatively low cost (in relation to other treatment options) remediation technique. However, its current use is limited by the lack of understanding of bioremediation and the time required to reach acceptable endpoints, coupled with the extended treatment times that may be required to achieve cleanup targets and the associated actual or perceived 'delay' costs.

While bioremediation technologies are well established, the technique may be considered to be 'infeasible' on a time or budget basis due to lack of end point accountability. In addition, if bioremediation is implemented, it may fail to achieve cleanup targets even under optimal conditions due to limitations in contaminant bioavailability. This may result in significant expenditure, utilisation of resources and time without achieving the desired result. Alternative treatment technologies may subsequently need to be implemented, or additional financial resources expended for disposal of soil to higher containment landfills.

There is currently no rapid screening tool available in Australia to evaluate bioremediation success. The aim of this project, which is being undertaken at the University of South Australia, is to validate an inexpensive, rapid screening tool for determining the suitability of bioremediation for the treatment of soil contaminated by polyaromatic hydrocarbons. ■

Phytoremediation of red mud residues by giant hybrid napier grass

Phytoremediation of red mud residues by giant hybrid Napier grass for biomass production is a CRC CARE China program demonstration project.

CRC CARE projects on Napier grass and red mud remediation have demonstrated significant potential for the expansion of this technology to red mud contaminated sites in China containing over 200 million tons of red mud residues. These contaminated sites usually have a pH ranging from 11 to 13 and are generally nutrient deficient. Australian alumina producers are also facing the similar problems for safety disposal of red mud from Bayer process. In this project work, it is intended to transfer Napier grass technology to red mud dumping sites in China for phytoremediation. ■

Underground river bioreactor for piggery waste remediation

In China the main source of meat protein is pork that is produced in 1,850,000 piggeries scattered across China. The growing demand for pork has led to significant contamination of soil, surface and ground water due to inadequate disposal of solid and liquid wastes generated at the farms. While large farms have developed plants to convert solid and liquid wastes into biofuels, the majority of pig farms dispose wastes onto land and into water bodies.

During the last three years, CRC CARE has supported a pilot scale project on biofuel generation from piggery wastes. This work led to the development and implementation of an underground reactor system which is economical and prevents odour contamination of the air. The project was successful under both laboratory and field conditions. In this study, it is expeted that the biofuel underground reactor will be scaled up to enable the large-scale conversion of solid wastes to energy. ■

Green synthesis of iron nanoparticles and their application as a Fenton-like catalyst for the degradation of TPHs in ground water and oil sludge

Oil in groundwater and sludge is a complex mixture of petroleum hydrocarbons and non-petroleum solid and liquid contaminants, where some chemicals contained in the oil sludge are considered potent carcinogens and may pose a detrimental effect on human, ecological health and environmental resources. Iron nanoparticles containing iron oxides and zero-valent iron can be used as a Fenton-like catalyst for the degradation of organic contaminants.

Iron nanoparticles are recently gaining great interest in environmental remediation. Iron nanoparticles can be readily synthesised using sodium borohydride ($NaBH_4$) with aggregation. However, there is a high cost associated with this process, and iron nanoparticles also are not environmental friendly. To address these issues, as part of this CRC CARE project, iron nanoparticles will be synthesised using green methods based on the extracts from Australian native plant such as Eucalyptus, which contain polyphenols that act both as a reducing agent and a capping agent to act as a nanocatalyst for Fenton oxidation of total petroleum hydrocarbons in groundwater and sludge. The knowledge gained from the proposed project will provide the basis for the development of an innovative green nanoremediation technology. ■

Road-deposited sediment pollutants: measurement of mobility and bioavailability; remediation

Rapid urbanisation and associated ever-increasing motor-traffic density have led to escalating amounts of pollution along road-ways in the form of aerosols and road-deposited sediments (RDS) in many parts of the world. RDS can have a major impact upon terrestrial and aquatic ecosystems, both through the volume of sediments transported from these environments and the potential for high levels of pollutants associated with the sediments. It is, therefore, a key element of urban pollution management that levels and potential mobility of the pollutants in RDS are both monitored and actively managed to minimise their impacts.

In this project, to be undertaken by the University of Technology, Sydney, modified lab-based techniques will be developed to determine potential mobility and bioavailability of pollutants and tested in commercial laboratories.

Conventional remediation measures used to reduce the pollutant load in RDS have not been very successful for the remediation of all pollutants. One new option for remediation is the use of zeolites, which exist in a large amount in Australia and many other countries. Natural zeolites and their surface modifications by coating with iron and manganese oxides can be used as low cost materials for treatment of pollutants. Considering the environmental compatibility and media characteristics, a remediation technology based on zeolite has significant potential to reduce the impact of RDS. In this project, these materials will be tested for their effectiveness in pollutant removal. ■

ARIC Update

Since moving the ARIC member discussion board/forum from our *Remediation Australasia* website to LinkedIn, our online member network has grown to 250 members! A special welcome to our LinkedIn Forum must go to Karen Hager of Douglas Partners Pty Ltd, who was our 250th LinkedIn group member to join. And of course, welcome to all other members who have requested to join our forum.

Although only a few members have used the discussion board to post upcoming events (which you are all more than welcome to do), it's great to see so many industry participants letting us know they'd like information and updates from us by joining.

Already an ARIC member?

Head to http://linkd.in/nsO2TN and send us a request to join the online ARIC forum.

We've noted in particular, as is often seen on social networking sites, that a lot of interest in our forum appears to have been generated through shared connections. Much of the literature we see from science communication organisations recognises the importance of utilising social media to share accurate scientific information, so we're pleased to see a lot of our members are embracing social media and utilising the recommendations supplied by LinkedIn.

We must alert you, however, to the importance of supplying us with your postal address if you'd like to receive a hard copy of this publication.

If you're on our LinkedIn forum but you've had to pinch this publication from a colleague because you don't have one, send us an email. We'd love to send you a copy, but we need to know where you are to get it to you.

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