ASSAY

A NEWSLETTER ABOUT ACID SULFATE SOILS

Issue # 51 March 2010

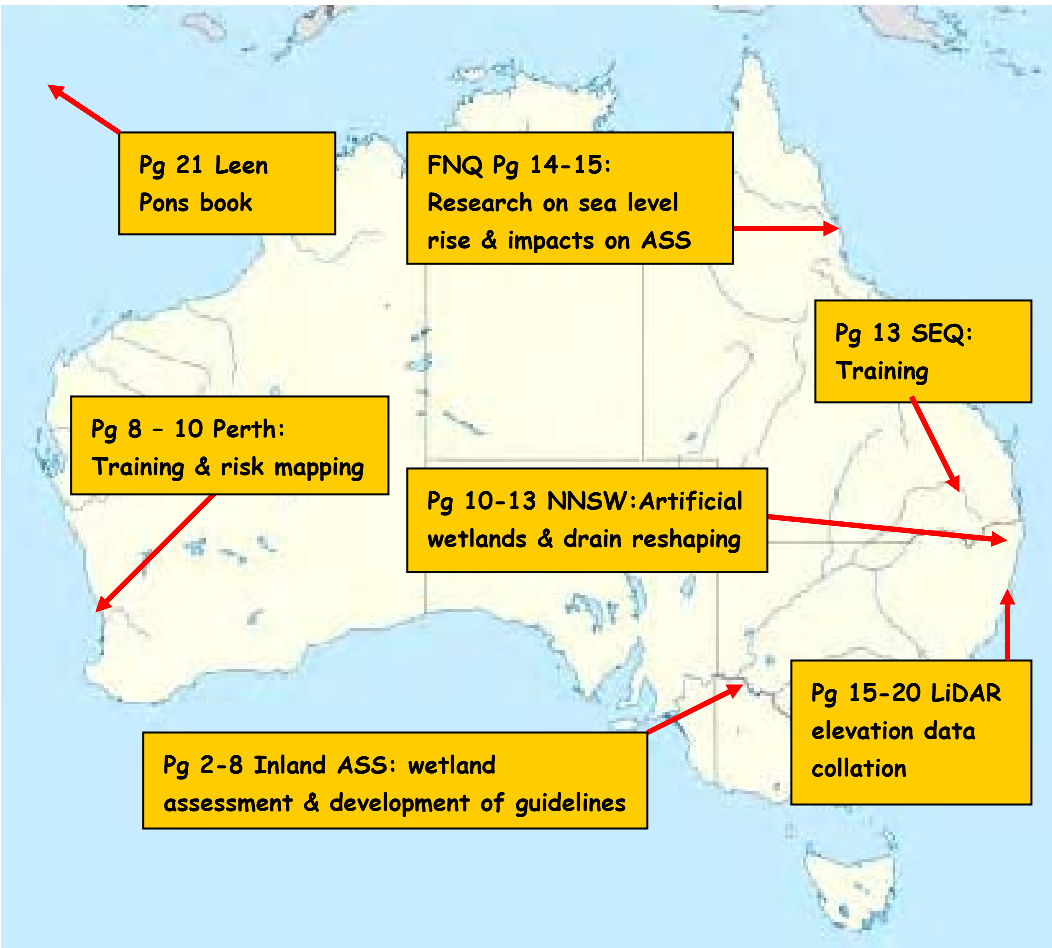
# ASSAY goes electronic !

Welcome to the latest issue of ASSAY – the national acid sulfate soils newsletter. As mentioned in the last edition, we are now completely electronic to both reduce production costs and improve ASSAY's ability to deliver all the latest information to YOU – readers keen to stay abreast of emerging research findings and current best management practices for acid sulfate soils across Australia.

This is a bumper edition thanks to the diversity, quality and quantity of articles you have sent me! There is now significant interest in inland ASS, which is very encouraging and reflected in the diverse range of articles in this issue.

*Happy reading...Simon*

## Places and stories in this issue.....



## National guidance for inland acid sulfate soils

**Emma Warren, Department of Environment, Water, Heritage and the Arts (DEWHA)**

Inland acid sulfate soils (ASS) are an emerging issue of national significance. The effects of drought and climate change are compounding the effects that changes to land use, hydrological regimes and high demand for water have already had on wetlands, rivers and other aquatic ecosystems. The cumulative impact of these factors includes increasingly limited water availability. This in turn is resulting in the exposure and oxidation of acid sulfate soils in these aquatic ecosystems.

The development of the guidance has been informed by an understanding of the on-ground issues of inland ASS assessment and management. *Photo: Ebony Coote, DEWHA 2010*

The consequences of this exposure as acid sulfate soils dry and may then be re-wet include acidification of water and soil, increased metal availability and rapid oxygen depletion of the water column. The potential risks resulting from this process are varied and may include effects on water quality, biodiversity, human health, fisheries, agricultural productivity, buildings and infrastructure, recreation and amenity, real estate values and tourism.

While none of these issues will be new to those with experience of coastal acid sulfate soils, applying management principles like "avoid disturbing ASS" that are relevant to coastal ASS management may not be possible as avoidance may not be under our control. Another important difference is that human activity has made a significant contribution to the production and accumulation of inland ASS. Sulfate is one of the "raw ingredients" of acid sulfate soils and the salts already present in the landscape are a good source of sulfate. These salts are mobilised in the landscape through surface and ground water flows. Human induced changes to land and hydrology have greatly facilitated this mobilisation. In the right conditions (i.e. under water, without oxygen and with bacterial activity), when this sulfate mixes with metal ions and organic matter, ASS are produced. In highly regulated systems, ASS may accumulate and thus may present a far more serious potential risk than in aquatic ecosystems with little or no regulation.

While the impact due to the exposure or disturbance of inland ASS is an increasingly serious issue in certain areas of the Murray Darling Basin and Western Australia for example, there is little assessment and management guidance available, which is of concern. Addressing this gap has been seen as an urgent need and the Environment Protection and Heritage Council (EPHC) agreed last year to the development of suitable guidance.

A Joint Steering Committee for Acid Sulfate Soils with jurisdictional representation and incorporating policy and technical expertise was set up in 2009 to oversee this work. It is anticipated that the *National guidance for the management of acid sulfate soils in inland aquatic ecosystems* will be available mid year subject to endorsement by the Council (EPHC). The guidance will provide an authoritative guide on inland acid sulfate soils to assist natural resource managers, planners, policy makers and other practitioners in their work.

For more information, please contact Kim Forbes: (02) 6274 2334 or Kim.Forbes@environment.gov.au

# The Murray-Darling Basin acid sulfate soil risk assessment project

**Rob Kingham and Lucy Paterson, MDBA**

The Murray-Darling Basin Authority (MDBA) is conducting the first Basin-wide assessment of acid sulfate soils, revealing key hot spots for these soils.

The Murray-Darling Basin acid sulfate soils risk assessment project is assessing the spatial extent of, and risk posed by, acid sulfate soils at priority wetlands in the Murray River system, Ramsar wetlands and other key environmental sites in the Murray-Darling Basin (MDB). The project will also identify and assess management and mitigation options for these priority wetlands.

As a result of the comprehensive assessment, seven priority regions requiring further investigation were identified.

## The process

The project involved the selection of wetlands of environmental significance, as well as sites that may pose a risk to surrounding waters. These were then subjected to a tiered assessment program, whereby wetlands were initially screened by (1) a desktop assessment stage, followed by (2) a rapid on-ground appraisal and then (3) detailed on-ground assessment, if warranted. The level of risk will then be assessed at those wetlands where acid sulfate soils are determined to be a priority concern at the wetland scale, and broad management and remediation options identified. This approach will concentrate scientific effort and expertise on sites where acid sulfate soils are present and pose the greatest risk to the environment.

## Wetland categories

The initial stage of the project identified wetlands for consideration in the assessments. A steering committee of state representatives and a scientific reference panel identified the following 'categories' of wetlands for inclusion based on environmental significance, risk profile and potential impacts on surrounding waters should acid sulfate soils risks materialise.

- wetlands in the Murray River system affected by regulated flow
- Ramsar wetlands
- wetlands listed on the *Directory of Important Wetlands in Australia*
- managed wetlands
- wetlands and creek systems receiving irrigation return water
- wetlands located adjacent to domestic water supply off-takes and
- other wetlands identified by the Steering Committee as high priority.

## Desktop assessment

A desktop assessment identified wetlands possessing the typical precursors for the development of acid sulfate soils, namely input of sulfate-rich water such as saline groundwater, waste water and irrigation-return water. The scientific reference panel developed the following criteria.

- Does/did the wetland receive saline water?
- Does/did the wetland receive waste water?
- Is/was the wetland used as irrigation storage?
- Does/did the wetland receive irrigation return water?
- Where salinity levels are regularly measured (at least 6-monthly intervals), do average EC measurements exceed 1,500 EC units?

Wetlands meeting any of these criteria proceeded to the next stage of assessment. Where information was not available to assess a wetland against these criteria, the wetland also proceeded to the next stage. Information was collected to assist in prioritisation of wetlands requiring additional assessment. This included information on the hydrological regime of each wetland, specifically whether the wetland undergoes complete drying at least annually, and whether it is above the height of regulated flows.

### Rapid assessment

A rapid on-ground assessment of field observations and measurements of basic surface water and sediment chemistry identified sites with a high likelihood of acid sulfate soils.

A standardised rapid assessment method was developed to determine the risk of acid sulfate soils at priority wetlands in the MDB. This method was based on a decision support tool developed by the Murray Darling Freshwater Research Centre (MDFRC) (Baldwin *et al.* 2007). The MDFRC protocol was modified to suit the purpose of this study and was deliberately kept simple to ensure that implementation did not require specialised scientific expertise or equipment. The method is based around recording a series of observations at the wetland, describing soil features and measuring soil pH and EC at defined points along a selected topo-sequence. Soil and/or water samples for laboratory analysis were collected from each wetland. A series of photographs were also captured for each wetland sampled to assist with the analysis.

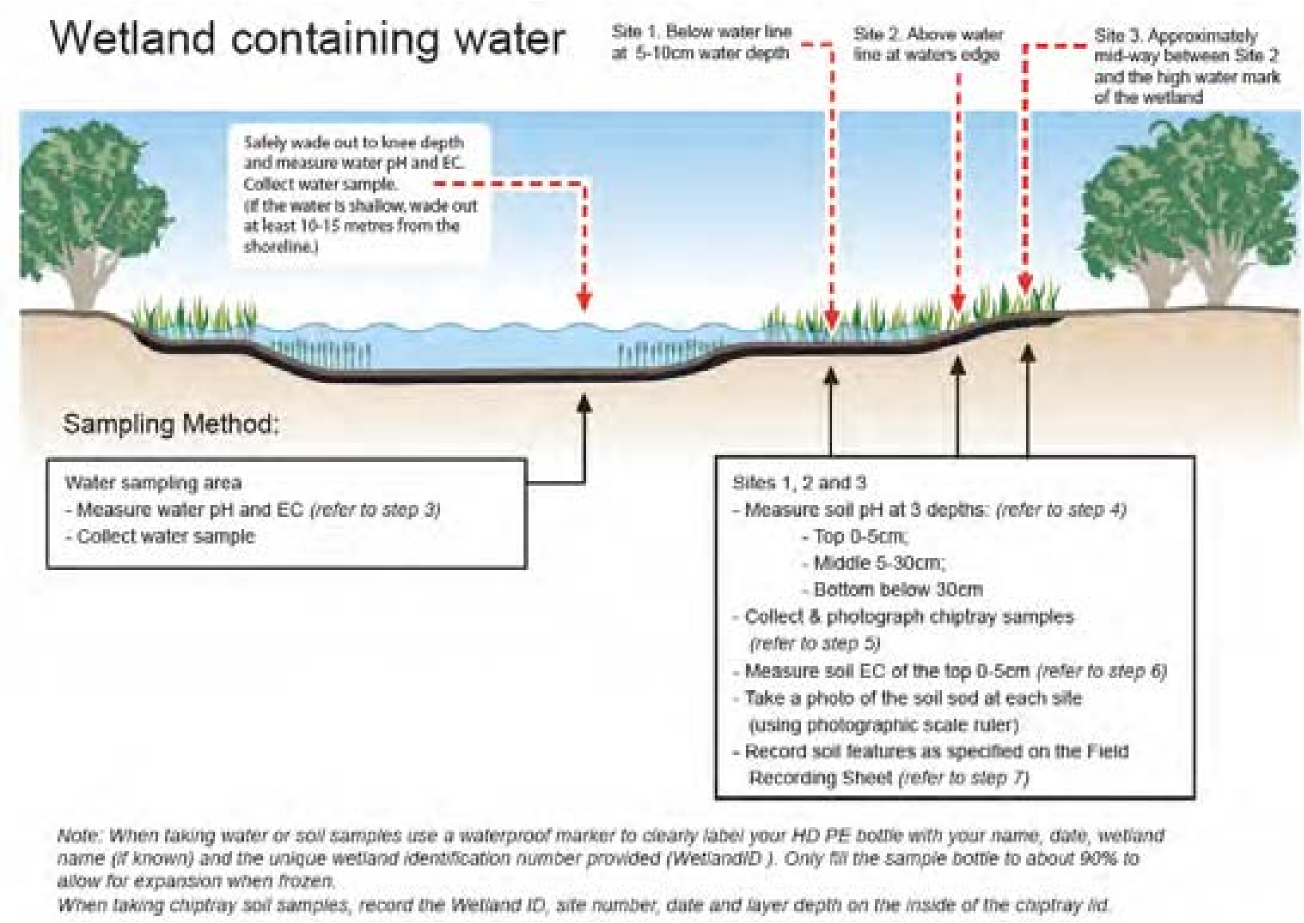



***Figure 1. Example of the sampling toposequence for a wetland from the Rapid Assessment field guide.***

The Rapid Assessment field guide provides clear instructions for the implementation of the rapid assessment method. The field guide was prepared for use by regional agency staff and land managers and outlines each step required to complete the Rapid Assessment method. Toposequence diagrams were also produced to clearly illustrate sampling locations for both wet and dry wetlands (see Figure 1), and highlighted the samples to be collected and measurements to be recorded at each sampling location. A field recording sheet was also developed for capturing the required observations and measurements at each wetland undergoing the Rapid Assessment method.


Baldwin DS, Hall KC, Rees GN, Richardson AJ 2007 *Development of a protocol for recognising sulfidic sediments (potential acid sulfate soils) in freshwater wetlands*. Ecological Management and Restoration, **8**, 56-60.

### Training

Limited staff resources were identified as a key risk to completion of the project. As such, development of a standardised training module and delivery of training courses was identified as the best method to mitigate this risk, and promote consistency in the assessment of wetlands within the project.

Training courses were delivered at Murray Bridge and Banrock Station in South Australia, Albury and Dubbo in New South Wales, and Mildura and Melbourne in Victoria. The six courses trained over 75 State agency staff and regional natural resource managers, which enabled the implementation of the rapid field assessment component of the project. This was a substantial capacity building exercise that not only supported the rapid assessment process, but also strengthened the capacity of regional stakeholders to identify acid sulfate soils and their associated issues.


***Some ASS training courses held in the MDBA*** ***Photos: Rob Kingham, MDBA***

### Detailed assessment

The purpose of the detailed assessment stage is to determine the presence and extent of acid sulfate soils and associated risks, including potential for acidification, metal mobilisation and deoxygenation. The detailed assessment will involve more comprehensive sampling and analysis and thus requires significant scientific expertise. This stage represents the first point at which the presence of acid sulfate soils can be confirmed and the level of risk described. A protocol for the field sampling, field characterisation, laboratory analysis, data interpretation and reporting, was developed by members of the Scientific Reference Panel and it describes the full method for this stage. This protocol document is currently being published and will be available on the MDBA website http://www.mdba.gov.au/ in April 2010.

The detailed assessment stage is separated into two phases in order to concentrate scientific effort at those sites where acid sulfate soils are confirmed. Phase 1 investigations determine whether or not acid sulfate soil materials are present for the study area and provide characterisation of the types and properties of acid sulfate soil materials. Phase 2 investigations will only be conducted if the acid sulfate soil materials identified during Phase 1 are determined to be a priority concern at a wetland-scale.

### Results

The desktop and rapid on-ground assessment stages of the project are now complete. Of the approximately 19,000 wetlands included in the project, desktop assessment identified about 1,500 wetlands that required rapid on-ground assessment. Rapid assessment was completed at 338 wetlands in SA, 417 wetlands in NSW, 372 wetlands in Vic, 200 wetlands in Qld and 4 wetlands in the ACT.

***A wetland in SA (left) and a channel in NSW (right), both affected by acid sulfate soils***

***Photos: (left) SA MDB NRM Board & (right) NSW DECCW***

Following the rapid assessment phase it was recommended that a large number of wetlands be considered for the detailed assessment phase. To help refine the list of wetlands for detailed assessment, a prioritisation process was established to enable individual States to prioritise wetlands based on both the results of the rapid assessment and the risk associated with a wetland if it were to become affected by acid sulfate soils.

The results of the State prioritisation highlighted seven regions of greatest priority. Within these regions, State representatives and Scientific Reference Panel members identified 95 wetlands for the detailed assessment process (16 in NSW, 26 in Vic, 52 in SA and 1 in Qld). These wetlands were identified by taking into consideration the risk profile, ecological value, regional knowledge and representativeness of each wetland.

Detailed assessments commenced in mid-March 2010, and are largely due for completion in mid-2010.

Phase 1 of detailed assessments have also been carried out at high priority wetlands identified at the start of the project, including 14 Ramsar wetlands within the MDB, nearly all wetlands below Lock 1 on the Murray River in South Australia, sites on the Loddon River in Victoria and Currency Creek and Finniss River in SA. Phase 2 detailed assessments are currently underway at Banrock, Chowilla, Fivebough and Tuckerbil wetlands and the Kerang Ramsar wetlands.

With a large number of priority wetlands assessed, key regions identified and the detailed assessment currently underway, the entire project will be completed by the end of 2010 and will result in the first Basin-wide assessment of acid sulfate soils.

For more information contact Rob Kingham, A/Director Wetlands Unit, Murray-Darling Basin Authority
rob.kingham@mdba.gov.au

## Minimising environmental damage from the recovery of inland wetlands

**Anthea Brecknell, National Water Commission**

***Pegs define experimental plots at Bottle Bend Lagoon***
***Photo: Anthea Brecknell, National Water Commission***

The National Water Commission is funding a research project *Minimising environmental damage from the recovery of inland wetlands* through its Raising National Water Standards Program. This work, commenced in 2007, is being undertaken by the NSW Murray Wetlands Working Group (MWWG) and the Murray-Darling Freshwater Research Centre (MDFRC).

The project will determine appropriate wetting and drying strategies in inland wetlands to minimise the formation of acid sulfate soils and prevent the further buildup of these soils. The outcomes will also provide guidance on best practice remediation methods for affected systems. Testing is currently underway across different inland wetland regions of Australia that are affected or potentially affected by this problem.

MDFRC commenced plot-scale experiments in August 2009 at Bottle Bend Lagoon, south east of Mildura, to scientifically determine practical, low cost and sustainable remediation methods for wetlands already affected by sulfidic sediments due to drought and climate change. The results of these trials will be finalised in mid-year with the project work due to conclude in December 2010.

***Dr Darren Baldwin, MDFRC, testing water quality at Bottle Bend***
***Photo: Anthea Brecknell, National Water Commission***

The scientific knowledge gained through this project has contributed significantly to the drafting of the *National guidance for the management of acid sulfate soils in inland aquatic ecosystems*, currently under development by the multi-jurisdictional Joint Steering Committee for Acid Sulfate Soils.

This project will advance the National Water Initiative objectives towards improved adaptive management practices to meet environmental and other public benefit outcomes. Evidence-based decision-support tools developed through this research will help environmental water managers reduce the build-up of acid sulfate soils in inland wetlands, including high conservation value aquatic ecosystems. The products will be widely disseminated through relevant research networks.

For more information contact Anthea Brecknell at the National Water Commission: 02 6102 6038

Anthea.Brecknell@nwc.gov.au

or go to the NWC website

http://www.nwc.gov.au/www/html/2435-minimising-environmental-damage-from-wetland-recovery-from-inland-wetlands.asp?intSiteID=1

## Understanding soils workshop - WA

**Clare Nixon, DEC**

***Photos: Matylda Thomas (UWA)***

An "Understanding Soils Workshop" was run in Perth recently by the University of Western Australia's (UWA) Centre for Land Rehabilitation and the Department of Environment and Conservation's (DEC) Contaminated Sites Branch.

UWA's Professor Bob Gilkes said the focus of the workshop was to promote a better understanding of the physical and geochemical properties of soil, their mineralogy and pedology, and the potential for acidification associated with soil and groundwater management.

He said the three-day workshop, which combined classroom lectures with laboratory work and site visits, gave participants the opportunity to apply their newly acquired knowledge both out in the field and in the laboratory.

Professor Gilkes hoped the Workshop would be run on a regular basis to help improve awareness of land management issues in an urban context.

"This type of workshop and training should enhance co-operation between academics, regulatory agencies, landholders and industry," he said.

For any further information on this project, please contact clare.nixon@dec.wa.gov.au

***A landscape with extensive soil excavation and de-watering using a series of spears to lower the groundwater. Note the upper soil horizons consisting mainly of white, bleached, sandy soils.***

***A cross-section of a typical Bassendean Sands unit profile at Ellenbrook showing white, bleached, sandy soils with deeper dark brown organic horizons (coffee rock) which are highly susceptible to oxidation and acidification***

## ASS risk mapping on the Swan Coastal Plain, Perth metropolitan region, WA.

**Clare Nixon, DEC**

***Photos: DEC***

The Department of Environment and Conservation (DEC) has completed its acid sulfate soil (ASS) mapping program within the Perth metropolitan area. The completed maps are freely available via https://www.landgate.wa.gov.au/bmvf/app/waatlas/ and are compatible with most topographic maps at scale 1:50,000.

Potential acid sulfate soil (PASS) materials occur widely across Perth, most commonly in swamplands near wetlands and lakes, and along the Swan and Canning River systems. These materials can also be found in more elevated topographic landscapes.

***Sonic drilling rig used in the DEC Swan Coastal Plain ASS mapping program***

However, a large proportion of the Perth metropolitan area is also underlain by the Bassendean Sands unit which typically exhibits poor neutralising capacity.

In the topographic low elevations, humus podsol soils with a strongly cemented, dark brown, organic B horizon (coffee rock) are common. Iron-humus podsol and iron podsol soils are found in the topographic mid-slopes and crests respectively.

DEC's Acid Sulfate Soils Section Manager, Stephen Wong, said that all these soils were sandy, highly leached and consequently, poorly buffered. "Depth and intensity of coffee rock material varies due to the changeable groundwater table level," he said.

"Current laboratory techniques commonly adopt the 0.02% S level as a detection limit to satisfy regulatory agency requirements for the need to manage acid sulfate soils that are below the action criteria at 0.03% S content."

"This has led to the underestimation of the net acidity of a number of sites where the recorded pH values following the addition of hydrogen peroxide were typically less than 3."

DEC is now working closely with researchers to further investigate the soil geochemical properties and processes needed to refine a set of realistic management action criteria when assessing the acidity risk in poorly buffered sandy soils in ASS landscapes.

***Soil profile from a bore in the Perth suburb of Bedford -- white to grey, bleached sand of Bassendean Sands unit***

"It is hoped that the current research incorporating column leaching, incubation studies and revised laboratory techniques will better characterise the acidity risk associated with the Bassendean Sands unit," said Mr Wong.

For further information, please contact clare.nixon@dec.wa.gov.au

## Professional acid sulfate soil training course builds momentum in 2010

**Chrisy Clay – GeoScience Communications officer**

Southern Cross GeoScience's professional short course on acid sulfate soils is rapidly building upon its initial success in New South Wales and Queensland. The latest course - specifically designed for those involved with either the development or assessment of Acid Sulfate Soil Management Plans in Western Australia - was held at Mandurah, Western Australia in March 2010.

"The course was very successful" says Stephen Wong, Manager of the Acid Sulfate Soil Section of WA's Department of Environment and Conservation. "As predicted we had a full house and overall the feedback we've received from participants has been extremely encouraging".

The course, which is being delivered with the assistance of the national Caring for our Country program, aims to provide a common knowledge base to those who write and implement Acid Sulfate Soil Management Plans and those who assess and approve them. Developed in conjunction with the relevant regulatory authorities in each jurisdiction, the state-specific course provides a unique opportunity for both proponents and assessors to discuss different aspects of managing acid sulfate soils.

***Photo: Chrisy Clay***

"During the course there was plenty of discussion between the different stakeholders" says Stephen Wong. "Many of the participants stated that the interaction they had with the speakers and other participants was particularly valuable".

For the participants of the Mandurah short course, all felt that they have significantly increased their knowledge, skills and confidence in managing acid sulfate soils as a result of the course. "The course was very good and very informative" said one of the participants, "the knowledge transfer of ideas and theories was absolutely great".

Building upon its success, the course will be delivered in a number of locations throughout 2010, including:

| | |
|---|---|
| Maroochydore, Qld | 26th and 27th of May |
| Launceston, Tas | 22nd and 23rd of June. |

The course will also be run in Victoria, Northern Territory and again in Western Australia later in 2010.

For further information or to register for upcoming courses visit www.scu.edu.au/geoscience and follow the links. To express interest in any future courses contact the short course project officer Chrisy Clay on 02 6620 3095 or chrisy.clay@scu.edu.au

## Using artificial wetlands to treat acidic discharge waters, North-Eastern NSW

**Mike Melville (University of New South Wales), with Andrew Kinsela, Ben Macdonald, Ian White and Robert Quirk**

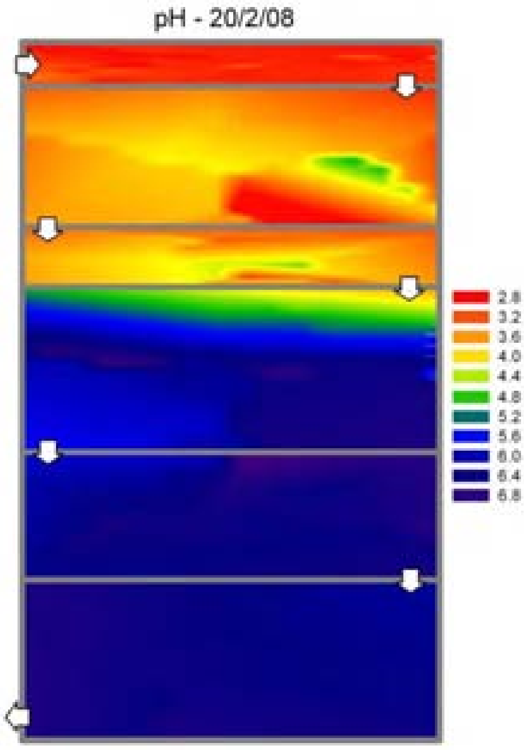
A trial examining the remediation of acidic discharge using a constructed wetland has been completed on the Tweed River. Monitoring showed the wetland significantly increased the pH of agricultural discharge waters.

***Upper four bays of the trial wetland (April 2009)***

The McLeods Creek study site in north eastern NSW, is a 100 ha intensively cultivated sugarcane farm, underlain by Holocene acid sulfate soils (ASS). Collaborative ASS research over the last two decades with owner Robert Quirk, has resulted in numerous positive environmental outcomes as well as increases to the overall farm productivity. In an effort to mitigate the remaining acidity and metal exports from the property, the Sugar Research and Development Corporation provided funds for the construction of a 1.6 ha, six-level, terraced, freshwater wetland alongside the farm's drainage discharge point.

Wetland vegetation was established by natural recruitment and was dominated by couch grass (*Cynodon dactylon*) and common spike rush (*Eleocharis palustris*). Both of these perennial, strongly rhizomatous species are native to Australia, and are widespread elsewhere in the tropics and sub-tropics. The primary aim of the study was to examine whether artificial wetlands might be a viable option for the treatment of acidic, metal-rich drainage from ASS, in much the same way as they have been applied to acid mine drainage discharges.

Despite the high average annual rainfall in eastern Australia, significant dry periods can occur. These make it difficult to maintain flooding of the freshwater wetland. In dry times, the available volume of water in the main (brackish) drain is insufficient to fill the wetland and is also too saline (EC >8 mS/cm) to be applied. Consequently the wetland dries out allowing deposited iron sulfides to oxidise.




***Spatial variation of pH throughout the wetland (Feb 2008). The water was gravity fed from the highest terrace at the top of the image and gradually made its way to the lowest bay at the base of the image.***

Measurements at the site in 2009 showed that, having limited the entry of salt to the wetland, the inputs of acidity from the farm's drain water have not permanently damaged the soil and the land can easily be rehabilitated for cane production after adequate lime application, removal of terrace and perimeter banks, and re-establishment of the laser-graded drainage regime.

The amount of acidity accumulated in the wetland over the 3 to 4 year period of its intermittent operation would appear to have had a significantly smaller impact than that of works on the land adjacent to cane field drains when they are cleaned and the drain sediments limed, spread, and incorporated into the cane field, in line with the NSW sugar industry's Code of Best Management Practice (CBMP).

The trial wetland occupied some 2% of the farm's total land area and only treated about 10% of the acid water discharge. On this basis, it would require a constructed wetland, occupying some 20% of a cane farm, to treat all of the acid discharge. Such a management tool is impracticable due to the take-out level of potentially productive land. However, there are still useful lessons that can be gained from this experiment. While these would require some shift in understanding and operational practices by cane farmers, it is clear that acid water passing

through the wetland is significantly reduced in metal ion content and has become less acid.
Most drains in NSW cane lands support diverse vegetation, often including the principal species (couch and rush) used in this wetland. It is not uncommon for farmers to regard the presence of any in-drain plant growth as deleterious to the passage of drainage water. Nevertheless, the drains are mostly required to remove water quickly under fairly high flow conditions. At these times, the useful plant species identified in the trial will be drowned-out and would cause little obstruction to flow.

In the waning phase of a flood hydrograph, the flow rates are less and it is then that acidity level is greatest and the wetland treatment processes become effective in reducing acidity and dissolved metal ions. Any metal-sourced acidity precipitates would periodically be neutralised by liming during drain cleaning in accordance with the sugar industry's CBMP.

For further information on this project, please contact Andrew Kinsela at: a.kinsela@unsw.edu.au

## Research to remediation at Blacks Drain, Tweed, NSW (2005 - 2010)

**Sebastien Garcia-Cuenca & Richard Collins**

In a partnership with Tweed Shire Council (TSC) and the NSW Cane Growers Association, researchers from the University of New South Wales (UNSW), Australian National University (ANU) and Southern Cross University (SCU) were awarded an Australian Research Council Linkage grant in 2005 to undertake a project aimed at developing innovative, scientifically-sound, practicable, floodplain management techniques to reduce the impacts on estuary and coastal water quality from acid sulfate soil (ASS) drainage products. Most of the research was undertaken at the infamous Blacks Drain (South Murwillumbah) which displayed all signs of chronic ASS-related issues with drain-water pH values < 3.5 and discharges of more than 10 t of aluminium and /or iron to the Tweed River during single rainfall events.

**Before**: Blacks drain 1500mm x1500mm (average) showing chronic signs of acidity such as scalded pastures and drain water pH < 3.5


**After**: The drain has been limed, filled and remodelled to a 1km 600mm x 3500mm (average) channel displaying drain water pH 6.5 & good pastures growing

Among the most significant conclusions resulting from the 3-year study, researchers from UNSW found that the greatest source of acidity and heavy metals produced through oxidation of ASS was located in the upper catchment of Blacks Drain (i.e. lower elevation back swamp) and, then only from the drains of this part of the catchment. Tidal flushing appeared to be very effective at mitigating acidic discharge from the lower catchment (nearest to the Tweed River) which is dominated by ASS and used for sugarcane production. These findings indicated that maximum benefit from remedial works would be obtained by shallowing and remodelling the main western drain in the upper catchment, thus reducing export of acidity and metals to the downstream catchment and ultimately the Tweed River and its estuary.

In October 2008, Tweed Shire Council was awarded $300,000 by the NSW Environmental Trust's Urban Sustainability Program to undertake a number of projects including one involving remediation of acid sulfate soil issues at Blacks Drain.

In late 2009, a 1 km section of Blacks Drain was reshaped from a narrow deep drain to a shallow, wide channel transferring drainage capacity horizontally (see photos above). The aim of raising the invert of the drain above the ASS front is to minimise further oxidation of ASS and drainage of acid groundwater, The project also included substantial liming (112 t in total) of the drain and scalded areas, levelling, liming and seeding of the new channel and pasture, as well as fencing off the 12 ha catchment and installation of four off stream watering points for cattle. The stock can now access good water and productive pasture while the drain is removing only surface water instead of acid ground water.

This project is a good example of the benefits that can be obtained through collaboration between council, universities and growers to foster sustainable agriculture that supports productivity and environmental services simultaneously.

UNSW is currently developing another Australian Research Council Linkage research project for 2010 with NSW Cane Growers Association and TSC to determine how this remedial work has modified the landscape processes that control acidity and heavy metal export and then to further assess whether this can be generically applied across other problematic ASS catchments within the Tweed catchment (i.e. Christies Ck, Clothiers and Reserve Ck), some of which haven't responded to previous remediation efforts.

Special credit should be given to the landholders Jim and Les Dickinson for their substantial financial and technical contribution to the remediation project.

For more information please contact Sebastien Garcia-Cuenca (TSC Sustainable Agriculture Program Leader, (02) 6670 2629, sgarciacuenca@tweed.nsw.gov.au) or Richard Collins (Senior Research Associate, UNSW Water Research Centre, 0401 847 653, richard.collins@unsw.edu.au).

## ASS Technicians' workshop

**Dr Angus McElnea**

On the 12th and 13th April 2010, the Australasian Soil and Plant Analysis Council (ASPAC) in collaboration with the Qld Department of Environment and Resource management (DERM) are conducting a two day workshop in SE Queensland, especially for laboratories and soil technicians who carry out acid sulfate soil analysis.

The aim of this 'hands-on' workshop is to help improve the quality and consistency of results coming out of ASS laboratories. Recent sample exchange programs by Standards Australia and ASPAC showed that there was plenty of room for improvement judging by the spread of results.

Presenters are considered leaders in the field, have published methodologies associated with ASS testing, and have long histories of involvement in such testing. Topics will include: overviews of methods, reasons for low recoveries, performance in proficiency programs, practical examples, case studies, feedback sessions, and a laboratory tour.

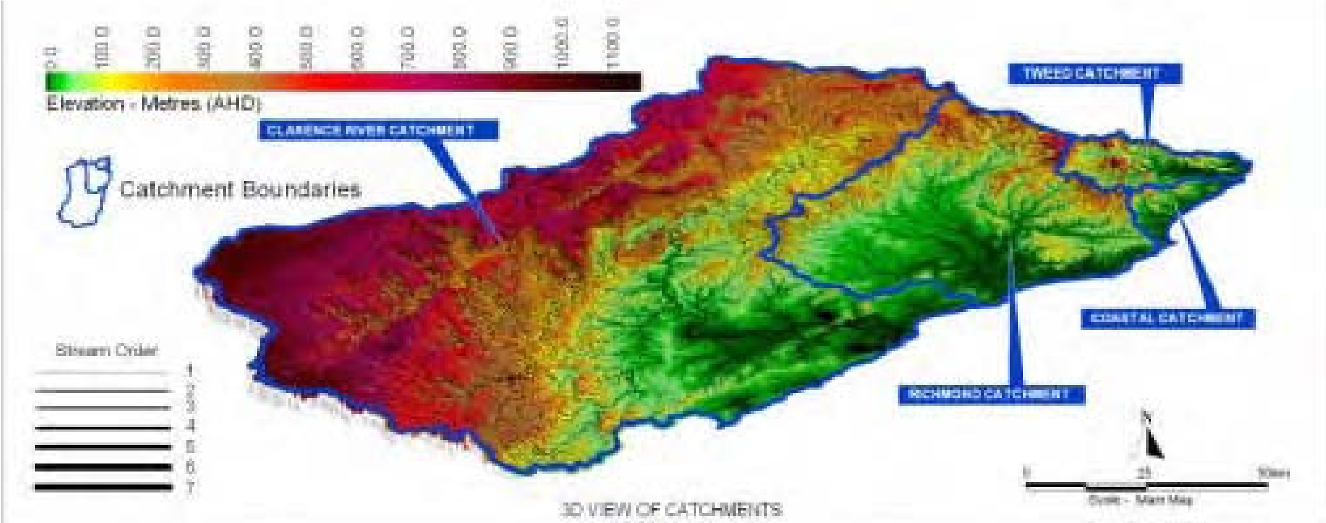
Speakers will be happy to reveal the 'tricks of the trade', including the parts of the methods where things commonly can go wrong and what to do about it. Also, representatives from various labs will talk about their experiences with the methods and what they have learned and the traps to avoid.

The workshop will be held at the Qld Government Laboratories at Meiers Rd Indooroopilly and will cost $150 per head (and will be free for ASPAC members). Please contact Dave Lyons (e-mail: dave.lyons@derm.qld.gov.au, Ph: 07 3896 9477) for more details or a registration form. Numbers are limited, with preference given to ASPAC members.

# A window into the future...revealing the multi-faceted effects of rising sea-levels on coastal acid sulfate soils

**Dr Scott Johnston**

It is no secret that large areas of coastal acid sulfate soils around the world are extremely low lying. As such, they are highly vulnerable to seawater inundation due to predicted future sea-level rise. Research teams at Southern Cross GeoScience have shed some light on the likely consequences of seawater inundation of acid sulfate soils.




***Elevations of three coastal catchments in NE NSW*** ***Image: DECCW***

The picture emerging is one of two distinct, sequential geochemical processes which operate over different time-frames and both of these processes influence acidity and trace element behaviour in contrasting ways.

Investigations led by Dr Vanessa Wong have shown that initial inundation by seawater triggers cation exchange processes that lead to rapid desorption of acidity and acidic metal cations. "Even relatively dilute seawater (~20%) can cause a very rapid (hrs), pulse-release of acidity from inundated acid sulfate soils. Aluminium appears to be a major component of this acidity, which is obviously very important for water quality" said Dr Wong.

In contrast, longer-term (years) seawater inundation of acid sulfate soils initiates strongly reducing conditions in the soil, which raises pH, generates internal alkalinity, decreases groundwater acidity and begins the process of reforming pyrite. "Our work at East Trinity has been like working in an 800 ha natural laboratory which is simulating the long-term effects of sea-water inundation", said Dr Scott Johnston.

"While this long-term seawater inundation greatly decreases the acidity hazard, there are complex interactions occurring between soil geochemistry and tidal forcing of the shallow groundwater. This is creating a very dynamic environment which is quite different to the original wetland before it was drained. We are seeing a huge enrichment of Fe(III) oxides near the soil surface, mobilisation of arsenic in shallow groundwater and a geochemical environment which favours the formation of acid volatile sulfides (AVS) and elemental sulfur near the soil surface" Dr Johnston said.

Some recent papers which document some of these and other findings include;


Johnston S.G., Keene A.F., Burton E.D., Bush R.T., Sullivan L.A., McElnea A.E., Ahern C.R., Smith C.D., Powell B. (2010) *Arsenic mobilisation in a seawater inundated acid sulfate soil.* Environmental Science and Technology **44** (6), 1968–1973.

Keene A.F., Johnston S.G., Bush R.T., Burton E.D., Sullivan L.A. (2010) *Reactive trace element enrichment in a highly modified, tidally inundated acid sulfate soil wetland: East Trinity, Australia.* Marine Pollution Bulletin (in press) doi: 10.1016/j.marpolbul.2010.02.006

Johnston S.G., Burton E.D., Bush R.T., Keene A.F., Sullivan L.A., Smith D., McElnea A.E., Ahern C.R., Powell B. (2010) *Abundance and fractionation of Al, Fe and trace metals following tidal inundation of a tropical acid sulfate soil*. Applied Geochemistry **25**, 323–335.

Copies of these papers are available from the GeoScience website:
http://www.scu.edu.au/geoscience/index.php/18/

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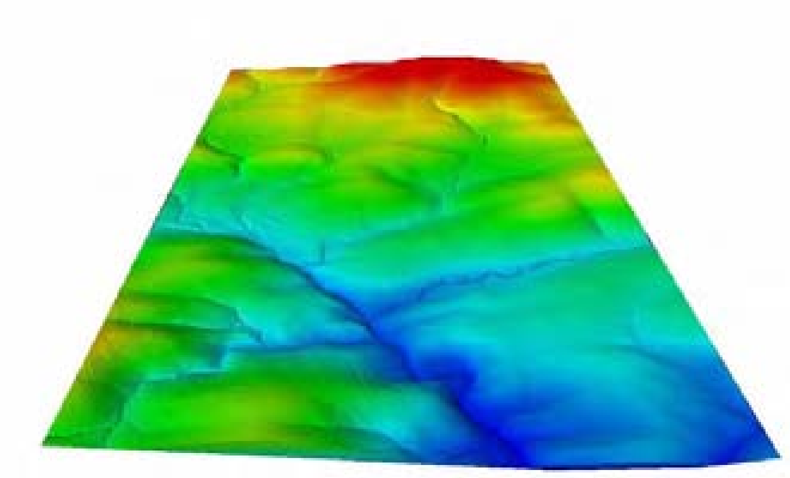
## LPMA and LiDAR

**Glenn Jones - Project Manager Elevation Data and Imagery Management** ***Images: LPMA***

The Land and Property Management Authority (LPMA) has an improved capacity to capture high resolution elevation data, though its acquisition of Light Detection And Ranging (LiDAR) hardware. This article outlines the technical capabilities and deployment of that system. Knowledge of surface elevations is crucial in acid sulfate soil risk mapping and in providing predictions of sea level rise impact zones, amongst a wealth of other applications.

LPMA is responsible for providing and maintaining the fundamental spatial information layers for NSW. This includes the capture and delivery of the State's survey, cadastral, topographic, addresses, imagery and surface or Digital Elevation Model (DEM) data.

A DEM is a digital cartographic representation of terrain elevation, usually devoid of vegetation and man-made features. It is comprised of uniformly spaced (grid) height values and may include both topographic and bathymetric data.



LPMA's current DEM is based primarily upon contours derived from stereo analysis of aerial photographs taken as part of the State's topographic mapping program. This elevation data is up to 30 years old and, depending on contour intervals, may yield a relatively low vertical accuracy.

In recent years, environmental monitoring and reporting requirements have demanded a higher terrain modelling accuracy necessary for critical analysis functions such as coastal vulnerability assessment, flood inundation mapping, assessment of the impact of rising sea-levels and hydrological modelling for water resources management. Practitioners are now dependent upon and require access to timely, high quality, high resolution DEM data. This includes LPMA's own airborne imagery sensors. Light Detection And Ranging (LiDAR) has evolved over the last decade into the clear 'technology of choice' for the generation of high-resolution DEMs characterised by vertical accuracies of 10-30 cm (1 sigma).

The Surface Model Improvement Project (SMIP) is a major initiative of LPMA (previously the Department of Lands) to improve the elevation surface model for NSW. The project will deliver wide-ranging benefits to government agencies and commercial organisations that have a need for this high accuracy elevation data in their planning, decision making and operations.

The project also provided funding for procurement of LiDAR hardware, technical support and staff training.

On 15th July 2008, LiDAR technology became the latest addition to LPMA's airborne remote sensing capability.

LiDAR Equipment:

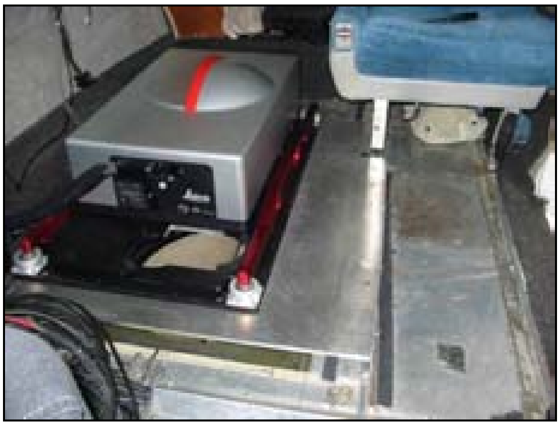
- Leica ALS50-II and
- Leica RCD105 digital camera (inset)

The ALS50-II features up to a 150,000 Hz pulse rate, MPIA (Multi Pulse in Air), multiple (4) returns, a 75° field of view with an operating altitude between 200 m and 6000 m above GL. The RCD105 is a 39 mega pixel digital frame camera.

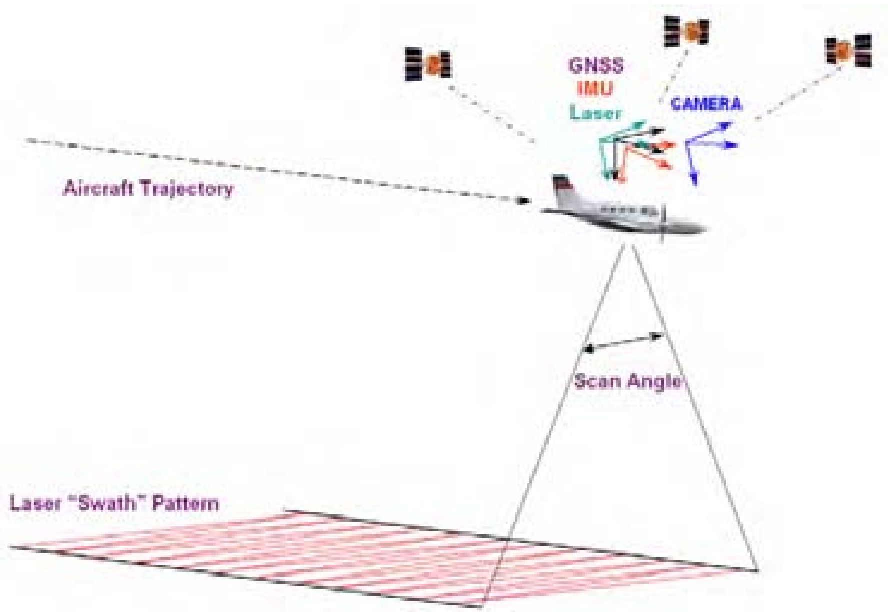
***Photo: Leica Geosystems***

### Airborne Platform

As shown below, the LiDAR system is installed into a Piper Navajo on a 'sled' which houses the laser, inertial measurement unit (IMU) and digital camera bolted to the floor with appropriate shock protection.



The ALS50 emits pulses of laser by way of an oscillating mirror, resulting in a 'swath' of data with a zigzag pattern as shown below.

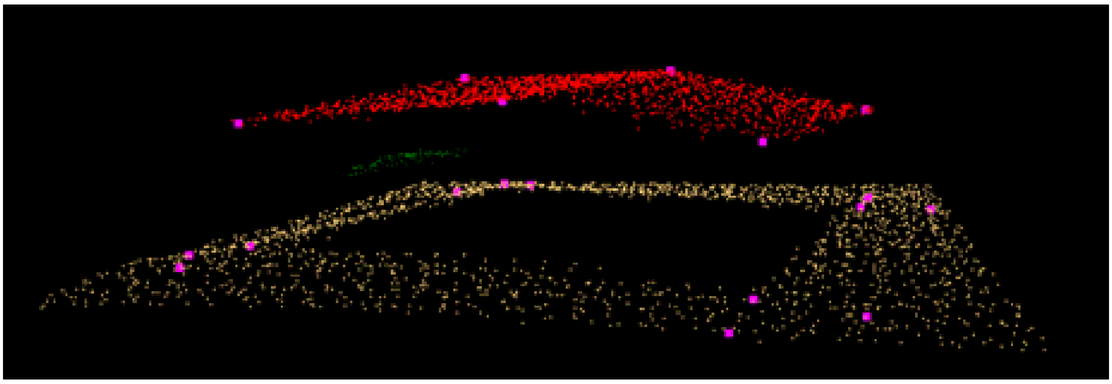



The airborne LiDAR system is a combination of three sensors, each with its own reference system:

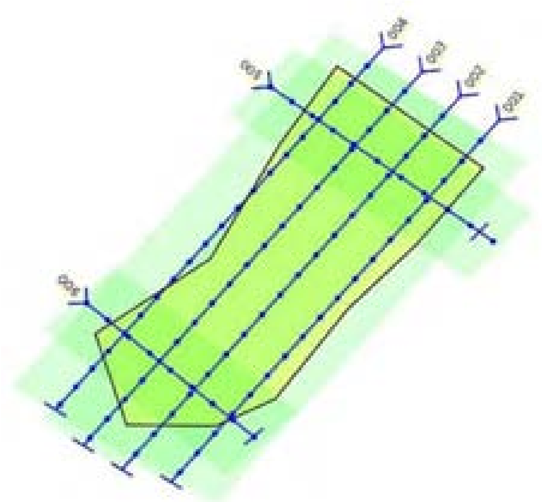
1. Global Navigation Satellite System (GNSS) receiver,
2. Inertial Measurement Unit (IMU),
3. Laser Controller.

The onboard digital camera further complicates the situation; however the coincident imagery is highly desirable for sorting out data anomalies and quality assurance, as well as a useful product in its own right.

In order to achieve the required accuracy, all sensors are aligned by way of a ‘boresight’ calibration. This uses accurate ground control, comparisons of flight runs and factory settings to provide the many parameters necessary for processing of the data into a spatially accurate ‘point cloud’. The results of a well-calibrated survey compared to ground control can be seen below.



With an airborne LiDAR survey, the starting point is usually - *how many points per square metre (ppm)?*



Ideally this would be derived from product specifications, for example the size of the DEM grid (1 m, 10 m etc) or which contour interval the water flow modelling software requires to produce meaningful results.

The flight plan, in other words the flying height, aircraft speed, laser pulse and scan rates, field of view and therefore swath width are all highly correlated to the ppm and each other. Once the various parameter values are settled on, it is a reasonably straightforward task to prepare a flight plan to cover the area of interest (AOI):

The picture above is a simple flight plan for a floodplain test site. The plan shows a 20% side overlap and two cross-runs to aid with quality assurance. The dots indicate where the RCD105 camera is ‘triggered’, in this case with a 60% forward overlap. This flight plan data is then uploaded to the in-flight computers.

**Ground Operations**

For LiDAR to produce ground data with accuracy of 15 cm, the computed aircraft trajectory must have accuracy in the order of 5 cm!

Operation of the ADS40 imagery sensor therefore also requires GNSS reference stations to be located on the ground within the project area for computation of precise differential corrections.

**Check Points**

A key component of quality assurance (QA) is to independently check the accuracy of the processed LiDAR data against the known height of ground check points. This is typically done at locations of bare open ground which is accurately surveyed. Some projects also require testing of the data amongst vegetation and sloping ground.

**LiDAR Processing**

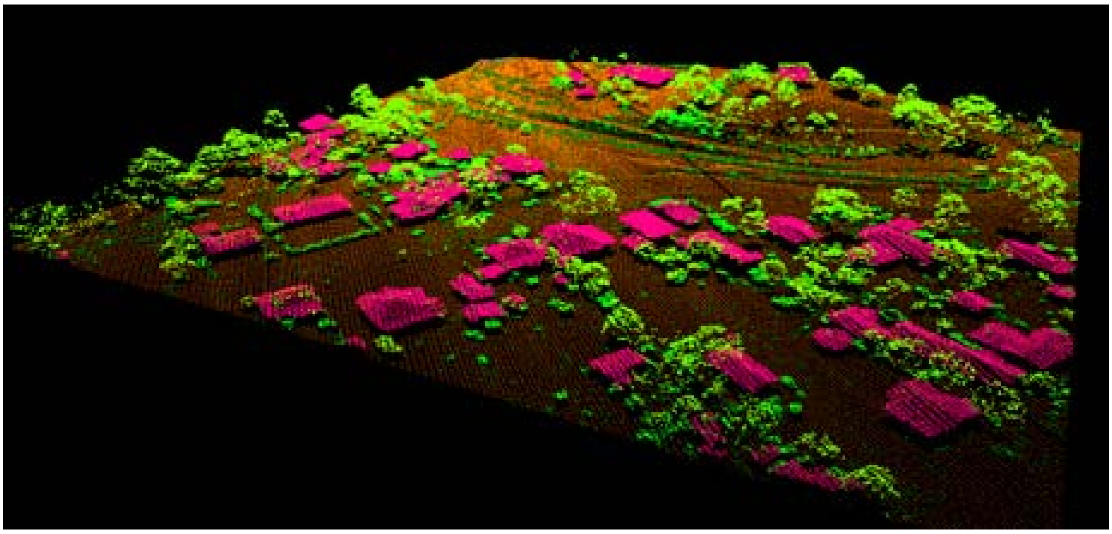
LiDAR data is processed by individual flight runs with other inputs being the calibration parameters, coordinate system information, geoid model and the all important final trajectory. Each flight run produces one LAS file. Although text ASCII outputs are common, LPMA strongly recommends working with the industry standard binary 'LAS' format.

For more information see www.asprs.org/society/committees/lidar

The result, particularly when combined with digital imagery, is nothing short of spectacular.

Depending on the capture parameters, millions of points per square kilometre are generated. Each point has an x, y and z position in the selected coordinate system along with an 'intensity' reading sourced from the reflectivity of the surface at that point. Due the sheer number of points, these intensity values can be viewed with an effect similar to monochrome photography as shown below.

An additional attribute is the ‘return’ value, which determines whether the sensor has received a pulse showing a single return from a hard surface such as the ground or a building or multiple returns as it passes through vegetation or catches the edge of a structure. This is important information to assist with classification of the data as described below.



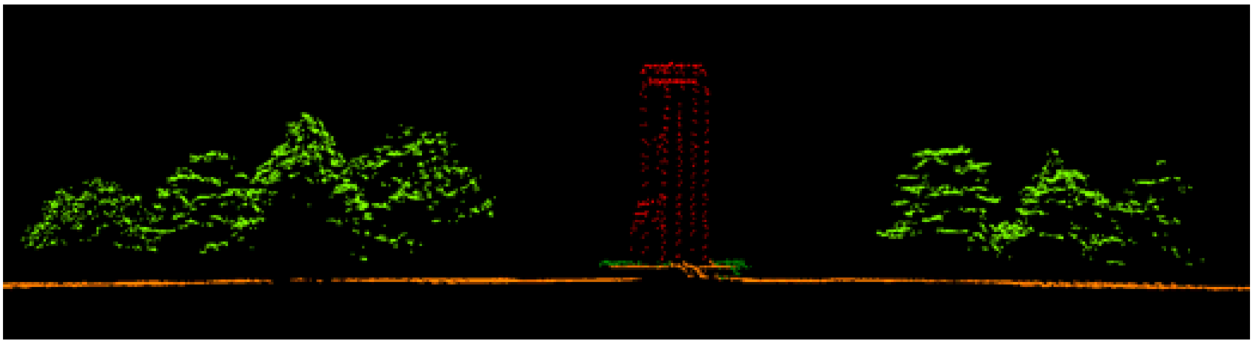
**Classification**

This is where the LiDAR-observed points are identified as ground, low and high vegetation, or buildings and other structures.

A series of program macros are run to automatically filter the data into classifications.

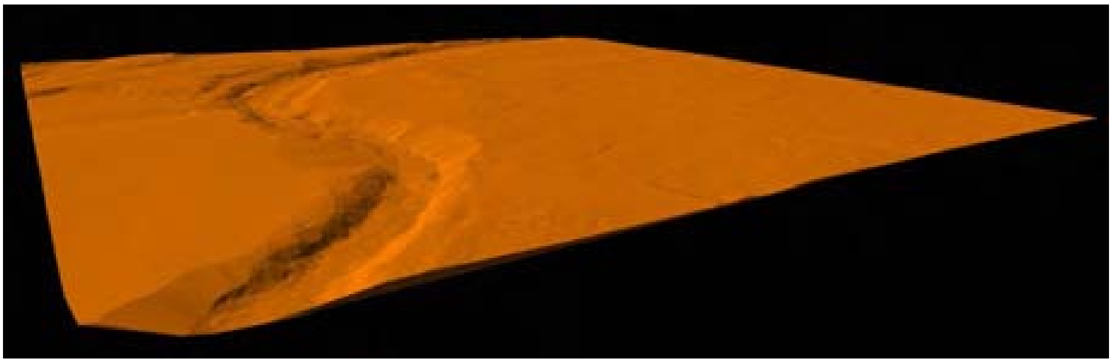
The algorithms start with ‘last return’ points and move through the data finding low and high points as a function of slope and distance analysis according to parameters which can be user defined to suit the terrain. Although this process is in excess of 95% accurate, further classification by manually inspecting the data is necessary to find anomalies. Depending on the location, many hours can be spent on this task and this is currently the ‘bottleneck’ with regard to the provision of data products.

An example of properly classified data can be seen below.

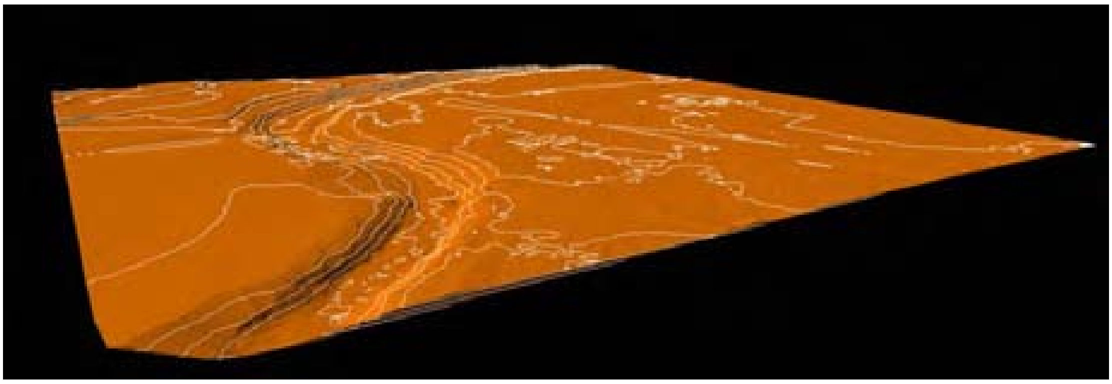


## Products

The most common product, and one that LPMA considers as core business, is the bare earth DEM which is devoid of any vegetation or man-made structures and is the elevation surface required for orthorectification of imagery and derivation of contours. This DEM is produced by filtering out classified ground data and usual practice is to average the point height values within a specified grid size. Typically, using an appropriate file format, this gridded elevation data is a fraction of the size of the original point files.



Interestingly, whereas contours were previously source data for computation of elevation models, they are now simply a product generated at the push of a button at whatever interval is required. As shown below, automated smoothing routines may be necessary to make them 'pretty'.



Following acquisition of its own LiDAR sensor, the knowledge base within LPMA has matured to a level where the Authority is playing a lead role in the ongoing development of national standards, specifications and quality assurance measures for elevation data. In conjunction with the Intergovernmental Committee on Survey and Mapping (ICSM) Elevation Special Interest Group (ESIG), LPMA is committed to 'exposing' all aspects of LiDAR capture and processing, thereby assisting industry to gain a better understanding of the technology. This in turn will lead to more realistic expectations for product deliverables and their inherent accuracy limitations rather than simply copying the specifications from one job or contract to the next. Of assistance is that software is now available to efficiently manage the raw or classified LAS format data, edit (re-classify) if necessary and output products in various formats.

## LPMA Capture Program

Currently the focus of LPMA's capture program is the NSW coastal plain which complements similar activity in other States whereby high resolution data is being acquired below the 10 m contour level.

The program is a 'whole-of-government' initiative and details of the forward program, data specifications and licensing are available on request from LPMA.

"Capture once, provide for many!"

## Leen Pons book – now available online

**Del (D. S.) Fanning**

*Leen, at left, examining a soil with an auger, apparently in a rice paddy, in Selangor, Malaysia in 1988.*

Leendert Japhet Pons, formerly of Arnhem, The Netherlands, and Emeritus Professor at Wageningen University, was an outstanding individual who left an indelible impression on all who came in contact with him.

Some of those impressions have now been brought together in book form as Leen Pons: Father of the international acid sulfate symposia/conferences. This work is now available in a searchable pdf format at: http://www.lad.wur.nl/NR/rdonlyres/B883CAC3-06FB-4680-9766-3FF302EA5508/88258/Ponsbook42.pdf .

I was pleased to have the opportunity to edit this volume and to contribute one of the ten chapters that contain vivid recollections and many images of Leen in various settings around the world where he did research and advised people and organisations on various aspects of acid sulfate soils and other issues.

This book, technically the second edition, also has an Appendix that lists Leen's publications, written in various languages, which began in the 1940s and continued until, and even beyond, his untimely death on June 16, 2008.

For more information, please contact dsf@umd.edu

## ASSAY contact details

**ASSAY is a quarterly newsletter about acid sulfate soils around Australia, and is available to all people interested in this issue.**

**It is produced by Industry & Investment NSW with funding from the Department of Environment, Water, Heritage and the Arts.**

**To subscribe, email the editor, Simon Walsh with "Subscribe ASSAY" in the subject line:**

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ACID SULFATE SOILS

information and awareness