

ASSAY

A NEWSLETTER ABOUT ACID SULFATE SOILS

No 19. September 1998

Agriculture Minister launches ASS Manual

Agriculture Minister and Minister for Land and Water Conservation, Richard Amery recently released the NSW Acid Sulfate Soils Manual following a regional State Cabinet meeting at Grafton.

The manual contains guidelines on assessment, planning, management, drainage, and laboratory analysis.

Mr Amery paid tribute to the work of the NSW Acid Sulfate Soils Advisory Committee (ASSMAC) and its Technical Committee members for compiling the manual. ASSMAC comprises representatives of environmental groups, fishing and

farming industries, academia and local government plus key state agencies.

ASSMAC Technical Committee Chairperson, Ian White said the manual has the latest technology and best practice methods for dealing with ASS and continues to place NSW at the forefront of acid sulfate soils management nationally.

The manual was coordinated by Yolande Stone, Dept of Urban Affairs and Planning along with Bruce Blunden (EPA & Wollongong University) and Col Ahern from the Queensland Department of Natural Resources.

The NSW Government has provided NSW Agriculture with a budget enhancement of \$2.1 million over three years for acid sulfate soils initiatives under the Acid Soil Action program which contributed towards the cost of printing the manual. Each coastal council in NSW will receive a copy of the manual.

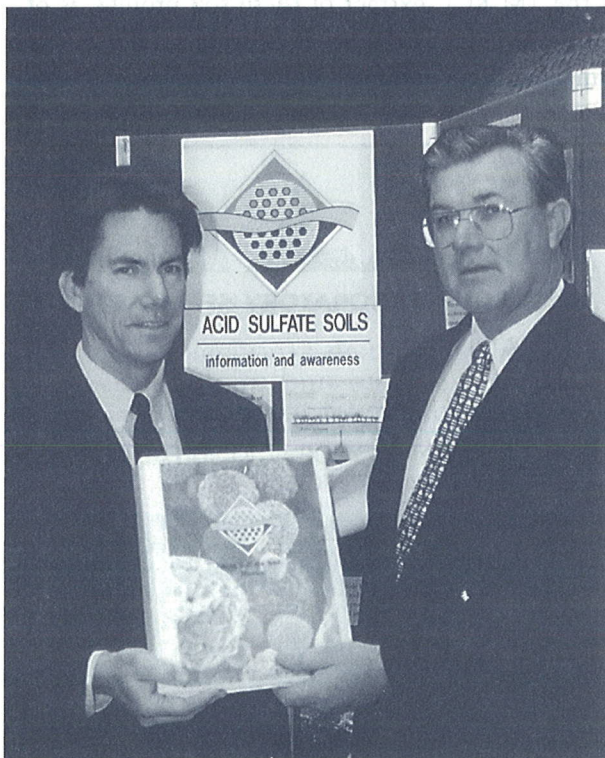
HOW TO ORDER YOUR COPY OF THE ASS MANUAL

The manual costs \$50 plus \$5 postage and is available from the Department of Urban Affairs and Planning, Governor Macquarie Tower, Sydney 2001; telephone credit card payments are available on 02 9391 2222.

Draft National Strategy launched

The National Working Party on ASS has released for public comment a Draft National Strategy for the Management of Acid Sulfate Soils. The Strategy provides a framework for governments, industry and the community to manage development on these soils. It seeks an integrated approach to management and provides general background about the impacts of acid drainage water.

Chairperson of the working party, John Williams says that the National Strategy introduces the problems, identifies the nature of impacts past and future and outlines the benefits of a national strat-



Mr Amery presents the first copy of the manual to Peter Ham General Manager of Clarence River County Council (Grafton) which has received a \$6,600 grant under the Acid Soil Action program to develop a local protocol for mechanical drain clearing in ASS.

egy. "It adopts a flexible, broad-based approach and a hierarchy of national aims and objectives that should help increase understanding of the problem, prevent it getting worse and improve rehabilitation strategies" John said. For details on the terms of reference, as given by the Federal Government's Standing Committee on Agriculture and Resource Management, please view the Draft Strategy on the internet at: www.dpie.gov.au/dpie/armcanz/pubinfo/ass/ass.html. The deadline for public comment is November 30, 1998. Written comments should be forwarded to the National ASS Working Party Chairman, John Williams, c/o Wollongbar Agricultural Institute, Bruxner Highway, Wollongbar NSW 2477. telephone (02) 6626 1340. Copies of the draft can be obtained from Jennifer Grant on 02 66261 346.

Hinchinbrook Inquiry

The Senate Inquiry into Queensland's Hinchinbrook Channel has received hundreds of submissions at hearings in Cardwell, Brisbane and Canberra.

The Inquiry's terms of reference deal with all ecological impacts on Hinchinbrook Channel, including a resort development project near the World Heritage listed Hinchinbrook Island.

Some of the researchers who presented information about ASS issues to the inquiry include Ian White (ANU); Jes Sammut (UNS); Mike Melville (UNSW); Bernie Powell (QASSIT); and Queensland consultant Neil Sutherland.

A recreational fishing group, Sunfish, submitted a summary of reported impacts of sugar industry activities adjacent to Hinchinbrook Channel.

The Inquiry was called for by Senator Woodley. His office says that one more hearing will be held in Canberra soon and a final report should be delivered sometime after the Federal Elections.

For further information, telephone Senator Woodley's Brisbane office on 07 32529129.

Acidified wetland still producing acid underwater


Mike Melville and C. Lin recently presented a paper 'Is ASS reflooding a panacea for drained wetlands' to an Institute of Australian Geographers conference in Perth.

ASS in parts of Asia are managed with wet sea-

son paddy rice and dry season shrimp farming. Ponds are drained to flush salt and acid from the paddy/pond at the end of the dry season. Residual soil acidity is converted by reflooding before rice planting because there is adequate labile organic matter in the paddy soil system.

In Australia there is currently interest in ameliorating acidified ASS wetlands by reflooding. However, we contend that this is not a panacea. In fact, the practice is most likely to increase acid water discharge because of Australia's different soil chemistry; the large store of wetland acidity; the greater pyrite content in the ASS profile; the flushing capacity/acid neutralising capacity is probably much less; and different overall hydrology.

At Rossglen, on the Camden Haven River, an ASS wetland was drained for agriculture in the 1920s. The increase in rainfall and flooding after 1948 made drainage increasingly difficult and the main part of the wetland has remained re-inundated since the early 1960s. The standing water (<1 m) is pH 3 to 4, and to more than 2 m below the soil surface, the porewater pH < 3.5. The sum of soluble and exchangeable acidity, as measured by 'TAA' on the 1M KCl extract of these soil profiles, is of order 200 t H₂SO₄ / ha. If existing acidity in the form of soil/salt-retained sulfate complexes is also



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included, this value is increased several-fold. Reflooding for 30 years has not reverted, or flushed, a large store of acid from the landscape. The water draining from the wetland after recent rains was pH < 3.5. The amount of such acid discharge is likely to increase in the future as urbanisation of the adjacent catchment increases.

Preliminary studies show much of the pyrite oxidation and acidification occurred naturally before installation of drainage works. Very severe and prolonged droughts are likely to have occurred during the past 6,500 years since the present sea-level was reached. Markedly warmer periods, such as "the Medieval Warm Period" (about AD 1100 to 1300), with average temperatures 1 to 2 degrees Celsius above today, would have been associated with increased evapotranspiration and drying of the Rossglen backswamp wetland which was isolated from the tidal Camden Haven River by its natural levee. The drainage works enable acidity to be easily exported to the river.

The closure of drainage works and greater re-flooding would exacerbate the acid export problem while lime treatment is impracticable. For further information please telephone Mike Melville on 02 9385 4391 or Fax 02 9313 7878.

Review of Partridge Creek plan of management

Australian National University Professor Ian White has developed a model for assessing the likely impacts of remediation works in ASS areas.

Ian developed the model while reviewing a plan of management for Partridge Creek at Port Macquarie. He has suggested the automatic dispensing of lime as one short term management option for raising pH levels in Partridge Creek.

The estuarine area has a high ecological value and is used for recreational and commercial fishing as well as oyster growing. Ian estimates that the catchment produces about 400 tonnes of acid annually, some of which could be neutralised by 'leakage' of saltwater through floodgates. He says that the original plan provides useful data but needs more detailed topographic and water balance studies, and community consultation, before floodgate opening can be trialed.

"As well as lime, controlled floodgate opening is one of the few simple short term strategies available to improve water quality. Floodgate opening would

require a moratorium on all drainage works, a topographical survey of drain bases, and an estimation of the amount of acid stored behind floodgates.

"I am suggesting an initial trial opening of one floodgate with monitoring of creek, drain and outlet water quality."

Ian's review of the plan, drafted by ERM Mitchell McCotter last year, was commissioned by the NSW Environmental Restoration and Rehabilitation Trust which will fund the Partridge Creek works with Hastings Council. His review covers issues such as hydrology, social and ecologic impacts, topographic surveys, acid discharge rates, ASS distribution, modifications to floodgates. He hopes it will be useful as a model for further ASS management plans in NSW.

Ian says the ERM study has documented the existence of potential ASS above mean sea level up to (AHD .5 m) and adds to the store of existing knowledge about ASS. For an email copy of the checklist model please contact ASSAY editor, Jon Woodworth.

For further information please contact Ian White on ian.white@cres.anu.edu.au.

ASS drain mapping project

The NSW Department of Land and Water Conservation's (DLWC) Glen Atkinson has used sophisticated analysis tools to identify drain density in ASS areas from aerial photographs.

Using a stereoscope and 1:25 000 scale coloured air photographs, drains as small as 0.5 m deep and 1 m wide were defined. Drains of less than 0.5m depth were resolved if they occurred in high densities as a system of field furrows.

Glen has mapped the Macleay River floodplain. ASS consultant Bob Smith has commissioned student Thor Aaso to map drains in Hastings River and Everlasting Swamp, using the same technique, with funds from the NSW Acid Soil Action program.

Glen says that in ASS backswamps drainage volume determines the rainfall detention time and therefore the rate of transport of acid. Understanding drainage enables ASS impact assessment and will help develop management strategies.

Drains within the moderate to high ASS risk areas identified by the DLWC ASS Risk maps (1995) are classified according to depth, width and

type. It takes about 10 hours to assess a 1:25 000 topographic map sheet (Aaso, 1996).

The process involves a small area being coded and then ground tested to allow calibration. The whole study area is mapped and coded with additional drains to those shown on the topographic maps added in dark pencil. The final map includes associated structures such as floodgates, weirs, and bridges.

For further information please telephone Glen Atkinson on 02 6563 1212.

ASS presentation to Queensland Sugar Industry Forum

Members of the Queensland Acid Sulfate Soil Investigation Team (QASSIT) ran an ASS workshop as part of the Mackay Sugar Environment Forum earlier this year.

More than 400 participants discussed environmental issues affecting the sugar industry at the two day forum. ASS are recognised as an issue potentially affecting the sugar industry in Mackay and surrounding regions as well as throughout most coastal areas in Queensland. Many of these coastal areas are suitable for cane growing.

The Sugar Industry has recognised that acid sulfate soils are a significant issue for the industry.

Over 40 forum participants discussed identification, sampling and analysis, and management issues related to ASS.

Bernie Powell (Team Leader), Col Ahern, Kylie Hey, Dennis Baker, and Ted Gardner, as well as George Rayment made presentations. A copy of the workshop proceedings *Understanding and managing acid sulfate soils in canelands, 1998* is available from Kylie Hey on 02 3896 9819.

Major Cudgen Lake fish kill was predicted

Don Buckley from Tweed Shire Council says that a major fish kill at Cudgen Lake was predicted as heavy rain in mid-August forced acidic drains water into the lake.

Leachate is coming from a tea tree plantation, cane growing areas, a large discontinued development site and grazing land. The lake has only a small tidal exchange and previous kills occurred in 1991 and 1992. Australian National University's Professor Ian White and Mike Melville from the University of NSW propose a staged approach to managing the problem. The first stage involves trials of lime and mulch to treat agricultural areas funded through a \$30,000 grant from the NSW Acid Soil Action program.

Redesigning the catchment's extensive drainage network is another possible management tool. The Federal Natural Heritage Trust has provided Council with funding to do further hydrology and soil mapping study and to develop a management plan.

Craig Copeland from NSW Fisheries estimates that all the fish and invertebrates were killed by acidification of the lake ($> \text{pH}3$). He says that management solutions may take a number of years to reduce the extent of acidification process. The NSW Government has committed a further \$29,000 to measure water pH increases which may result from the lime and mulch trials, and to pinpoint acid leachate sources.

Protocol for opening of floodgates

Clarence River County Council (CRCC) recently adopted a protocol for managing floodgates during non-flood periods.

The CRCC controls 300 major floodgate structures many of which drain ASS areas. Landowners are interested in operating floodgates to maintain

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fresh water levels for irrigation and stock, for flood irrigation of paddocks, to reduce acid slugs washing into the main river, and to improve drain water quality. Allowing salt water into drains is one method of neutralising acidified water. However, floodgates need to be opened correctly or else they can damage the floodgate or water can threaten cropping areas.

The CRCC is currently negotiating individual floodgate management plans with local farmer groups.

For more information please telephone Alan Cibilic on: 02 6642 3277 (email: crcc@nor.com.au).

ASS and shrimp farm research

The Australian Centre for International Research (ACIAR) has granted the University of New South Wales School of Geography, and collaborating agencies, \$674,000 to develop low-cost technologies to rehabilitate shrimp farms degraded by ASS, soil erosion and siltation in Indonesia and Australia.

ASS and other soil-related problems have led to widespread pond abandonment and poor pond productivity throughout the world. The ASS studies will be based mainly in South Sulawesi, Indonesia, but the technology will be adopted at sites in Darwin, Cairns and the Clarence River. The technology will also be useful for other applications in Australia. The project is led by Jes Sammut (UNSW) and involves the expertise of Dr Paul Smith (UWSM), Associate Professor Mike Melville (UNSW), Professor Ian White and a team of Indonesian researchers. For further information please contact Jes Sammut on 02 9385 6211 or by email at j.sammut@unsw.edu.au.

No known link from ASS to Oyster parasite

There is no scientific evidence to back claims by some oyster growers that most of the oyster production destroyed in the Tweed River recently from the so called QX disease is linked to ASS leachate.

The claims were reported in the Sydney Morning Herald as well as on local radio and television.

Fisheries researcher Dick Callinan says that two studies proved that QX disease can develop in waters which have a normal pH and which are not affected by ASS leachate.

The QX disease (Queensland Unknown) is

caused by a parasite and the host species is not known.

For further information telephone Dick Callinan on 0266 261 294.

Clarification on ASS dumping at sea

An article in the June Assay entitled, 'Ban on off-shore ASS sediment dumping', reported that the Federal Government may plan to stop dumping of dredge spoil at sea.

However, Michael Hansford from Environment Australia says dredge spoil is specifically listed as an item which may be dumped at sea under the 1996 Protocol to the London Convention, of which Australia is a signatory.

The Australia's Environmental Protection (Sea Dumping) Act 1981 requires ports to apply for a Commonwealth permit to dump dredge spoil (in waters other than 'waters internal to a State').

The applications are individually assessed by Environment Australia against strict environmental, human health and other criteria. Only material that has been assessed and passed as suitable for disposal at an agreed ocean dump site can be dumped. The amount of heavy metals in dredge material is one of the assessment criteria.

For further information, please contact Michael Hansford at the Marine Section,

Environment Protection Group, Environment Australia, PO Box E305, Kingston ACT 2604. Tel. (02) 6274 1602.

Electricity from ASS

A Tuckean electrician, Garry Owers, is neutralising acid water by separating the chemical elements of dilute sulfuric acid (H₂SO₄) using carbon - zinc cells.

His experiment also generates electricity and allows sulphur to dry and be removed as a powder. The amount of water neutralised, electricity generated and sulfur produced are all a function of scale, efficiency and pH level. Water of pH 2.65 has been converted to pH 7.4 by the action of the cell.

The chemical action of the cell is as follows - the electrolyte (H₂SO₄) contains a large number of freely moving negatively and positively charged ions. With the addition of carbon and zinc electrodes and the closing of the external circuit, ion flow occurs within the electrolyte giving a potential

circuit from the negative zinc electrode to the positive carbon electrode. Hydrogen gas forms on the carbon electrode which combines with oxygen to form water, reducing the specific gravity and therefore increasing the pH of the electrolyte. Acid water and sulphur are heavier and sink while water of lower specific gravity and higher pH rises to the top of the cell where it can be returned to the water system as neutral water.

"It should be possible to neutralise large volumes of acid water and separate large amounts of sulphur by generating large quantities of electricity." Garry is working with Southern Cross University to determine what byproducts are created during the process.

For further information please telephone Garry Owers on 02 6683 4065.

Bruce Blunden, also tinkering with ASS and electricity, has managed to generate enough DC current to light up a torch bulb by connecting wires from two small sheets of galvanised iron pushed into a wet ASS scald at Berry.

Progress report on geophysical test method

Keeva Vozoff of HarbourDom Pty Ltd, Sydney, says that PASSfinder - a 'non-invasive' geophysical

method for detecting potential ASS conditions in situ - may provide a quicker, cheaper assessment method.

Recent measurements by the PASSfinder method at two estuarine sites in Sydney found a direct correlation between system response and sulfide percent. A third site near Berry, NSW, was tested with help from Bruce Blunden (Wollongong University and Environment Protection Agency) who is doing a PhD on ASS. "From all of this work it is clear that lithology, as well as sulfide content, contributes to the results, and we are learning how to recognise and use this behaviour. The main difficulty has been to get consistent estimates of metallic sulfide content from the different locations, since methods vary at different laboratories."

"We hope to reduce the amount of wet chemical analysis, thereby cutting the cost of mapping and assessing potential ASS. However, we will still rely on conventional analysis for site calibration and validation. The method will suit large areas that need to be assessed quickly. Additional trials are to be carried out soon and a major consultancy may make the service available commercially," He said.

For further information contact Keeva Vozoff at HarbourDom P/L, ph/fx 02 9922 1383; email: harbour@ozemail.com.au.

Kylie "Indiana Jones" Hey digs some prehistoric ASS

Queensland's popular ASS information Officer, Kylie Hey, has just returned from a USA "holiday" and says the highlight was seeing actual ASS deposits from the Cretaceous period (up to 90 million years ago).

Professor Del Fanning from Maryland University, Washington State, showed Kylie an upland actual ASS site which exhibited bright yellow jarosite to a depth of about 3.5 m and at 120 m above sea level.

"It was some of the best jarosite deposits I have ever seen and was exposed in glauconite (sandy loam) material exposed in a road cutting."

Instead of forming in root channels, the jarosite had a lateral formation through faults in the rock. Kylie spent three weeks in US and gave a lecture on ASS and mosquito control at Maryland's University.

For further information, please contact Kylie Hey on telephone 07 389 69819.



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AGSO report available soon

A coastal geomorphologist from the Australian Geological Survey Organisation (AGSO), Dr Trevor Graham has left the agency to establish a Brisbane consultancy, GeoCoastal (Australia).

While at AGSO, Trevor developed techniques for remote sensing satellite and geo physical techniques to identify iron precipitates in oxidised ASS over parts of the Richmond and Clarence Rivers in NSW.

Trevor believes that understanding how our coastlines formed will give soil scientists greater tools in mapping and assessing ASS. He has worked with the Qld Department of Natural Resources on ASS studies of the Gold Coast hinterland and did a three year study on the Stratigraphic relationships in ASS investigation. Trevor has also documented the pyrite enrichment process in coastal sediments reworked by the ocean.

The AGSO survey report will soon be available on the internet.

For further information please contact Trevor Graham on telephone 07 3348 5691 or Email GEOCOASTAL@bigpond.com

Draft Internet site

ASSAY editor, Jon Woodworth has developed a draft NSW ASS internet site which you can now view for comment.

The address is at: <http://www.scu.edu.au/services/tl/graham/ass/acid.html>.

If you have any comments please email Jon at jon.woodworth@agric.nsw.gov.au.

The final version of the ASS page will be located at NSW Agriculture's internet home site.

The draft site was compiled with assistance from Graham Broadbent of Southern Cross University.

NSW Agriculture working group

NSW Agriculture has established an Acid Sulfate Working Group to enhance coordination and review the departments various ASS projects. The Working group, which includes all NSW Agriculture staff who have significant project activities in ASS management, held its first meeting recently in Coffs Harbour.

NSW Agriculture has a range of activities aimed at increasing awareness of ASS management through information and educational projects. Staff working in this area include Jon Woodworth (ASS Information Officer, Wollongbar), Scott Henderson (ASS Rehabilitation Officer, Kempsey) and Alice Woodhead (Biometrics, Wollongbar). Current project activities include publication of ASSAY newsletter, directing enquires on ASS, developing and distributing publications, raising the profile of ASS with councils, industry groups, community groups, and benchmarking of current awareness and management practices in agricultural industries.

NSW Agriculture staff, Roy Lawrie (Soil Survey, Richmond), David McCoy (ASS Officer, Taree) and Graeme Robertson (Irrigation Officer, Wollongbar) also conduct a range of field experimental, demonstration and monitoring trials. These include pasture evaluation trials on ASS, chemical weed control in ASS drains, evaluation of scald revegetation, and drain management demonstrations. Michael Wood (Tuckean Landcare Coordinator) also located at Wollongbar is working closely with many of these projects. Mitch Tuala, DLWC Kempsey, also gave a presentation on identifying ASS hotspots on the NSW North Coast.

Peter Slavich (Director, Wollongbar Agricultural Institute) and Mike Hughes (Research Agronomist, Grafton) presented a new research project proposal on managed opening of flood gates to allow greater tidal exchange in farm drains.

Working party representatives from other organ-

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isations include Leigh Sullivan (Southern Cross University); Sarah Fairfull (NSW Fisheries); Graeme Budd (EPA); Glenn Atkinson (Dept of Land and Water Conservation) and ASS consultant Bob Smith. For further information, contact Peter Slavich, on 0266 261 352.

Telstra takes a call on ASS

NSW Agriculture's ASS Project Officer, Scott Henderson, has recently conducted workshops for Great Lakes Council officials as well as gangers and works staff. Scott has also been busy training local Telstra staff about the need to keep ASS from oxidising when laying telephone cables in ASS.

Scott recently conducted a training workshop for excavator operators at Kempsey and has been invited to join estuary management committees for the Hastings River, Lake Cathie, Camden Haven and Great Lakes. He is also helping dairy farmers develop a best management code of practice for farming on ASS.

Cane seeks Local Environment Plan exemption

The sugar cane industry has asked the NSW Government for an industry exemption from council local environment plans covering ASS management issues.

The sugar cane industry is currently negotiating with both Tweed and Richmond Shire Councils and the Department of Urban Affairs and Planning over details of how an exemption would work.

Under the proposed system, sugar cane mills would require ASS best management practices; as a

condition of their cane quota. Farm plans would contain in details equivalent to a development application.

The Tweed draft LEP is expected to go on public display for comment within a month. Richmond River Shire Councils ASS LEP was recently exhibited. Maclean Shire Council, on the Clarence River, will soon draft an LEP for ASS.

ASS management plans for farms would be developed by mills and would cover issues such as drain weed clearing, landforming, lime use and drain infilling.

For further information telephone Peter Nielsen on 02 6620 8257.

Evan Heads water quality concerns

Dr David McConchie from Southern Cross University (SCU) believes that ground water affected by ASS may be corroding residential water pipes and causing elevated copper and lead levels.

A group of householders upset with the problem of "green tap water" commissioned the SCU study. Part of the Evans Head water supply was previously taken from bores in ASS areas. McConchie believes that although the water had relatively high pH, hydrogen sulfide gas was forming on the inside of new pipes (which hadn't formed an oxidised coating) and was dissolving copper and lead into water.

The water supplier, Rous County Council, is disputing the theory. The NSW Department of Health is investigating the water quality concerns. For further information, please contact Graham Lancaster at SCU on 02 6620 3000.



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Belongil Swamp

Representatives from NSW Agriculture, Byron Shire Council, Belongil Drainage Union and a local ASS researcher are undertaking field samples to identify point sources of ASS acid leachate. The 1400 ha former wetland drains into a small, semi tidal inlet which suffers frequent fish kills due to low dissolved oxygen, low pH and high aluminium and iron levels.

Michael Wood from the Dept. of Land And Water Conservation, Alstonville, is coordinating the preliminary survey. One possible management strategy is the use of sewage effluent for reforestation of wetlands and treatment of ASS. The results to the study will provide Council and the Belongil Estuary Working Party with spatial ASS data. The pilot study precedes a possible comprehensive feasibility study.

For further information please contact Jon Rushforth at council on 02 6626 7000.

Study of iron monosulfide in drains

A Southern Cross University student, Michael Hallinan, is doing field and laboratory testing of iron monosulfide materials found in the base of drains in the Tuckean Swamp.

Michael says that the black, oily drain sediments were found to be rich in iron monosulfides, also known as acid volatile sulfur (AVS). Drains greater than two metres deep contained AVS but not wide shallow drains. Substantially lower AVS concentrations were detected in smaller subsidiary drains, increasing concentrations were recorded down the main drainage channel (Main Drain) with the highest concentration detected at the Bagotville Barrage.

For further information please telephone Michael on 02 6628 0365.

ASS Diary

ARBOvirus Conference - Gold Coast 25th September (papers ASS and mosquitoes).

Brisbane River Festival - QASSIT display - 3rd and 4th October

Kempsey Shire Council - 6th October One Day seminar on ASS management, floodgate, water table management etc (telephone 02 6562 7933)

NSW Save our Soils - Program launch Friday 16th October

Annual NSW Coastal Conference - Batemans Bay - 11th -13th November

Farming for Future - ASS and Tweed Cane farms, Friday 16th October

Recent ASS papers

Osaki M. Watanabe T. Ishizawa T. Nilnond C. Nuyim T. Sittibush C. Tadano T. Nutritional Characteristics In Leaves Of Native Plants Grown In Acid Sulfate, Peat, Sandy Podzolic, and Saline Soils Distributed In Peninsular Thailand

Source: Plant and Soil. 201(2):175-182, 1998
Reprint available from: Osaki M, Hokkaido Univ, Fac Agr, Lab Plant Nutr, Kita Ku, Kita 9, Nishi 9, Sapporo, Hokkaido 0608589 Japan

Astrom M. Partitioning Of Transition Metals In Oxidised And Reduced Zones Of Sulphide-Bearing Fine-Grained Sediments

Source: Applied Geochemistry. 13(5):607-617, 1998 Jul. Preprint available from Astrom M Abo Akad Univ, Dept Geol, Fin-20500 Turku, Finland

Astrom M. Mobility Of Al, P And Alkali And Alkaline Earth Metals In Acid Sulphate Soils In Finland

Source: Science of the Total Environment. 215(1-2):19-30, 1998 Apr 23.

Eyre B. Water Quality Changes In An Episodically Flushed Sub-Tropical Australian Estuary - A 50 Year Perspective

Source: Marine Chemistry. 59(1-2):177-187, 1997 Dec. Reprint available from: Eyre B, So Cross Uni, Ctr Coastal Management, PO Box 5125 E Lismore, Nsw 2480 Australia.

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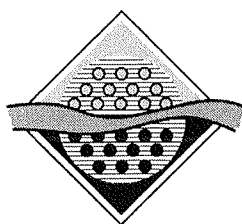
Editor: Jon Woodworth
ASS information officer

Address: C/o Assay Editor
NSW Agriculture
WOLLONGBAR NSW 2447

Phone: 02 66261 344

Fax: 02 66281 744

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ACID SULFATE SOILS MANUAL

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The ASS Manual has been compiled by the Technical Committee of the NSW Acid Sulfate Soil Management Advisory Committee, August 1998.

An initiative of the NSW Government's Acid Action Program.