DEVELOPMENT OF QUEENSLAND ACID SULFATE SOIL MANAGEMENT GUIDELINES

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Abstract
Management of acid sulfate soils is an issue that needs to be addressed by a range of stakeholders during the development application process. Approved management strategies for a site must satisfy local and state government, community, conservation groups, developers, consultants and industry.

In 2002, a project was initiated to develop acid sulfate soil management guidelines for Queensland, as prior to that, clear guidance on appropriate management strategies was limited. The *Soil Management Guidelines* were developed using extensive consultation with industry, community, government and interstate representatives. This has resulted in widespread acceptance of the Guidelines by acid sulfate soil stakeholders.

The negotiated outcome has led to the formulation of Guidelines that are acceptable to both industry and government—there is technical robustness to the Guidelines, while at the same time practical solutions for industry are provided. The *Soil Management Guidelines* is a professionally produced publication, providing clear guidance on acid sulfate soil management strategies that are considered best practice. The consultative approach employed here serves as a successful model for other similar projects.

Additional Keywords: management principles, consultation, neutralisation, avoidance

Introduction
The *Soil Management Guidelines* constitute one chapter of the *Queensland Acid Sulfate Soil Technical Manual*. The Guidelines were developed in order to provide clear guidance on management of acid sulfate soils (ASS). Prior to their development, advice on management strategies was somewhat limited, and tended to be focused on broadacre agricultural management. It was evident in Queensland that advice on ASS management that could be used by consultants, earthmoving contractors, developers, agricultural producers, sand and gravel extraction operators, community groups, and administering authorities from state and local government was needed.

The Guidelines were formulated with the assistance of funding from the Natural Heritage Trust (NHT), the Queensland Government and the Queensland Acid Sulfate Soils Management Advisory Committee (QASSMAC) and its member organisations. The Guidelines built on the earlier work of Ahern *et al*. (1998) with a much greater emphasis on practical management outcomes for the urban development industry.

In order to ensure the *Soil Management Guidelines* were going to be widely accepted and used by industry, it was decided early on that a thorough consultative process would be employed to develop the Guidelines. This process was very effective at producing a widely recognised publication that documents best practice environmental management of acid sulfate soils.

Consultative process
In producing and preparing the *Soil Management Guidelines*, great efforts were made to undertake extensive consultation with industry, community, government and interstate stakeholder representatives.

The first stage in the process was to establish an editorial committee in January 2002 and a larger technical committee in March 2002. The editorial committee was made up of five technical people with expertise and experience in ASS management, representing the Department of Natural Resources, Mines and Energy (NRM&E), Environmental Protection Agency (EPA) and industry. The technical committee consisted of 51 people, representing state and local government, environmental consultants, industry, community, academia and other experts with an interest or experience in acid sulfate soils.

The editorial committee met on average every three weeks for a 10-month period in 2002 to write, discuss and develop the Guidelines. During this time, a number of draft versions of the Guidelines were produced by the editorial committee and distributed to the 51-member technical committee for review and comment. The first draft

was sent out in June 2002. This iterative process worked very well and all comments received were discussed and debated to produce new drafts. In September 2002 the third draft was forwarded to QASSMAC to obtain approval to distribute the Guidelines to a wider group via a series of 2-day workshops. During September–October 2002, five 2-day workshops attended by 196 people involved in acid sulfate soil management were held along the Queensland coastline. The workshops were basically a means to further disseminate the information contained in the *Soil Management Guidelines* and to seek additional comment. Following the workshops, a final draft was produced in November 2002 and distributed to the technical committee and QASSMAC.

The *Soil Management Guidelines* were endorsed by QASSMAC on 15 November 2002 and officially launched by the Honourable Stephen Robertson MP, Minister for Natural Resources and Minister for Mines in February 2003.

Purpose of the Guidelines

The *Soil Management Guidelines* provide technical and procedural advice to avoid environmental harm and to assist in achieving best practice environmental management when disturbing acid sulfate soils. The Guidelines are risk-based and describe a number of 'preferred' and 'higher risk' strategies that can be used to manage acid sulfate soils. For each strategy, the Guidelines document environmental risk, performance criteria, verification testing, and management issues that need to be considered. The environmental risks associated with 'generally unacceptable' strategies are also documented.

The *Soil Management Guidelines* are a guideline document for all stakeholders on ASS management; they should not be followed blindly; they may not be applicable to every site; and the professional environmental manager for each project must make decisions regarding the way that, and the extent to which, guidance provided in the Guidelines is applied for a particular site. Various legislation will apply to each individual project, and the Guidelines must be applied and interpreted within the relevant legal framework. These Guidelines are a chapter of the *Queensland Acid Sulfate Soil Technical Manual*, and should be read and implemented in conjunction with other chapters. The Manual is being developed over a number of years, chapter by chapter.

Management principles

The management of ASS is dealt with by eight management principles (see Figure 1). The preferred management strategy is avoidance. Where disturbance is unavoidable, preferred management strategies are minimisation of disturbance, neutralisation, hydraulic separation of sulfides either on its own or in conjunction with dredging and strategic reburial (reinterment). Other management measures may be considered but must not pose unacceptably high risks to the environment.

Acid Sulfate Soil Management Principles

1. The disturbance of ASS should be avoided wherever possible.
2. Where disturbance is unavoidable, preferred management strategies are minimisation of disturbance, neutralisation, hydraulic separation and strategic reburial.
3. Works should be performed in accordance with best practice environmental management.
4. The material being disturbed, the *in situ* soils and any contaminated waters must be considered and managed.
5. Receiving waters are not to be used as a primary means of treatment of ASS or contaminated waters.
6. If the ASS texture-based action criteria is reached or exceeded, management of the soil will be required.
7. Storage of ASS above the watertable with (or without) containment is not an acceptable long-term management strategy.
8. The receiving environment, groundwater, surface water, management and planning strategies and the heterogeneity, geochemical and textural properties of the soils should be considered when formulating ASS management strategies.

Figure 1. Summary of the eight management principles outlined in the *Soil Management Guidelines*

Preferred management strategies

The information provided below gives a summary of the preferred management strategies contained in the *Soil Management Guidelines*. Further advice should be sought from the actual Guidelines.

Avoidance
Avoidance is the most preferred management strategy, and it should be considered at all sites. This management strategy carries the least risk, as ASS are inert while they remain in anoxic, preferably anaerobic (reducing) conditions. Avoidance is often the cheapest option, given the risks and costs associated with long-term discharge of leachate, long-term management and monitoring requirements, the potential for degradation of aquatic ecosystems, delays in development approvals and potential remediation costs. The Guidelines state that 'Documented evidence should be provided that avoiding the disturbance of ASS has been seriously considered at all sites and sound reasons identified for choosing to disturb ASS'.

The *Soil Management Guidelines* discuss two strategies for avoidance. Firstly, planning to avoid ASS can be achieved during the formulation and implementation of local government planning schemes. In areas with a high probability of containing ASS, preferences can be given to land uses that avoid the disturbance of ASS, while land uses that disturb ASS (eg. extractive industries, golf courses, marinas, canal estates, agricultural uses requiring drainage systems, basement carparks and underground storage) can be discouraged. Secondly, in situations where groundwater levels are not affected by the earthworks on or off-site, undisturbed *in situ* ASS can be covered with clean fill. The fill must be of adequate depth to ensure that the ASS under the fill are not disturbed during excavations associated with building foundations, infrastructure trenches or other incidental excavations eg. swimming pools.

Minimisation of disturbance
Minimising the disturbance of ASS is a preferred management strategy in situations where the disturbance of ASS is unavoidable. Four strategies to minimise the disturbance of ASS are discussed in the Guidelines, all of which require an in depth understanding of the ASS stratigraphy on site. The first option entails the redesign of the earthworks layout for sites with a variable distribution of ASS (eg. a large site that contains areas of relatively low or negligible levels of ASS and other areas with higher levels of sulfides). In this situation, the areas with high levels of sulfides are avoided, and the disturbance is focused in the areas that contain low or negligible levels of sulfides. A second measure to minimise the disturbance of ASS entails limiting disturbance on site so that only shallow disturbances are undertaken and the ASS remain undisturbed. The third option for minimising the disturbance of ASS discusses the redesign of existing drains so that they are shallower and wider and do not penetrate the sulfidic layers. The final option for minimising disturbance focuses on minimising groundwater fluctuations by avoiding activities such as the construction of deep drains and the installation of new groundwater extraction bores in ASS areas if they will expose ASS to oxidising conditions.

Neutralisation of acid sulfate soils
Neutralisation of ASS entails the physical incorporation of neutralising/alkaline materials into the soil. There must be sufficient capacity to neutralise all existing acidity present, as well as all potential acidity that could be generated from complete oxidation of the sulfides. This management strategy is a preferred management strategy if the disturbance and minimisation of disturbance is unavoidable and if the risks to the environment have been adequately characterised and are considered to be acceptable. The risks associated with neutralisation can be significant in poorly supervised sites, sandy sites with high levels of sulfides, sites with marine clays that are difficult to work, sites that require dewatering for significant periods to allow excavation in the dry, or sites in or adjacent to the habitat of pH-sensitive wildlife (eg. acid frogs and fish).

Performance criteria and verification testing requirements for neutralisation are documented in the Guidelines. These equate to there being no net acidity in the soil following neutralisation. If post-neutralisation, the soil fails to satisfy the criteria during the verification testing regime, the soil must be re-treated until the performance criteria are met.

The Guidelines discuss a variety of management issues that must be considered for effective neutralisation without risk to the environment. There is a reliance on the completion of a detailed ASS investigation and an understanding of the stratigraphy at the site. Sampling of the soils for laboratory analysis during the excavation phase, and sampling treated material after the earthworks are completed are also required. Post neutralisation, the pH of the soil must be above 5.5; with an upper limit of 8.5, unless pH-sensitive wildlife are present and have dictated a reduced upper pH limit. This can generally be achieved by incorporating the calculated amount of neutralising agent at 1.5 to 2 times the theoretical acid production potential. A variety of neutralising agents are available for

this management strategy, with the most common being finely ground agricultural lime ($CaCO_3$). There are several factors that need to be considered when choosing the appropriate neutralising agent. Neutralisation of the ASS must be carried out in an appropriately designed treatment pad. The Guidelines discuss several issues that must be considered in the treatment pad design.

Hydraulic separation
Hydraulic separation as discussed in the Guidelines entails hydro(sluicing) or hydrocycloning, where the sulfidic fines are hydraulically separated from the coarser textured materials. The fines produced via the process then require neutralisation or strategic reburial. This is an effective form of ASS management in areas when the sediments contain less than 10–20% clay and silt, and have a low organic matter content. However, there can be considerable risks to the environment given the significant reliance on technology and site management, the potential for exposure of the sulfides to oxygen during the different stages of the process, and risks associated with inefficient separation. The process water can become enriched with non-settling fines and can become acidic, requiring neutralisation.

Performance criteria and verification testing requirements for hydraulic separation equate to a target of 0.03 % sulfur in the soils following separation. If the soil fails to satisfy the criteria during the verification testing regime, the soil must be re-processed or neutralised until the performance criteria are met.

The Guidelines discuss a variety of management issues that must be considered for effective hydraulic separation without risk to the environment. Again, there is a reliance on the completion of a detailed ASS investigation and an understanding of the stratigraphy. All sites need to be hydraulically isolated using bunding and diversion drains. Guard layers (ie. the spreading of a neutralising agent on the soil surface prior to the placement of any washed sand) can be used to reduce the level of risk at a site. If appropriately designed and placed, these layers should intercept and neutralise any significant acidity that may be produced within the washed sand stockpiles, and will assist in protecting groundwater quality. The 'in-line' application of neutralising agents is a technique that can be used during hydraulic separation processes to neutralise acidic process waters, provide additional neutralising capacity to the sulfidic fines, and to provide additional neutralising capacity to the fill or sand product.

Strategic reburial
Strategic reburial entails the reinterment (burial) of potential ASS into a void, where the potential ASS are maintained in anoxic, preferably anaerobic conditions at all times. The void can be deep (eg. within the base of a lake) and covered with standing or surface waters; or alternatively the void may be beneath the groundwater table, below compacted non-ASS or neutralised material. The material to be reburied can range from blocky non-dispersive clays to sulfidic fines created during hydraulic separation, and the risks associated with this technique depend in part on the nature of the material to be reinterred. The burial of sulfidic fines that are easy to resuspend pose much greater risk to the environment than blocky non-dispersive clays. There can also be risks to the environment if soils that have significant measurable existing acidity are reburied without first neutralising the existing acidity, or if the level of dissolved oxygen in the water is high enough to cause significant oxidation of the submerged sediments.

The performance criteria requirements for strategic reburial require that the soils be maintained in anoxic, preferably anaerobic (reducing) conditions at all times; and soils with significant untreated acidity are not to be interred. Failure to satisfy these criteria may necessitate the re-excavation of the soils and neutralisation of the existing acidity.

A variety of management considerations are discussed in the Guidelines. Again there is a reliance on adequate site investigations and understanding of the ASS stratigraphy of the soils on-site. The soils to be reinterred should be transported immediately from the excavation area to the burial pit and placed at the base of the void. Strategic reburial under surface waters also requires an appropriate water balance to be maintained to ensure the storage of the sulfidic material under permanent anoxic conditions. In addition, the material must remain in its intended location and not be moved by currents or floods, and oxygen transport to the interred sediments must be halted permanently. Limnological investigations as discussed in the Guidelines can be used to determine whether anaerobic conditions can be maintained at the depth at which the ASS are to be buried.

Higher risk management strategies

Management strategies with considerable risk to the environment, particularly where there is limited information on their successful implementation have been characterised as higher risk. The Guidelines specify that before any of these management strategies are to be permitted, the proponent will need to provide a risk assessment as well as documented scientific evidence that the process will not impact on the environmental values of the receiving environment. If such justification cannot be provided, some of these activities will not be allowed. The higher risk management strategies discussed in the Guidelines include stockpiling ASS, strategic reburial of soils with existing acidity, large-scale dewatering or drainage and vertical mixing.

Generally unacceptable management strategies

In terms of acid sulfate soil management, some strategies have been shown to carry an unacceptably high level of environmental risk; or to be generally ineffective; and/or lack scientific data to support their sustainability. Such strategies have been classified as generally unacceptable in the Guidelines. If there is low risk associated with these techniques the Guidelines do not preclude their use, however a risk assessment is necessary, and must demonstrate the low risk in sufficient detail. If risks cannot be reliably quantified, the Guidelines state that government policies and procedures are unlikely to approve such strategies. The generally unacceptable management strategies discussed in the Guidelines include above ground capping, hastened oxidation, seawater neutralisation and off-shore disposal of ASS.

Conclusions

During the consultation associated with the development of the *Soil Management Guidelines* there was extensive debate with industry as to the appropriate level of information contained within the Guidelines. The content of the Guidelines was greatly improved by the consultation process, and there has been improved communication between industry and government as a result of the project, specifically in relation to techniques that are currently being used to manage ASS. The management strategies outlined in the *Soil Management Guidelines* have been successfully implemented at a number of sites throughout Queensland. The *Soil Management Guidelines* have also been adopted by other Australian states to document best practice environmental management of acid sulfate soils.

The *Soil Management Guidelines* are an excellent example of the Queensland Government working well with industry, and coming up with practical approaches to management of acid sulfate soils in Queensland. There is now clear documentation of management techniques that have been shown to be effective at various sites in Queensland, and there is clear guidance on processes to be followed if alternative or higher risk management strategies are being proposed.

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References

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