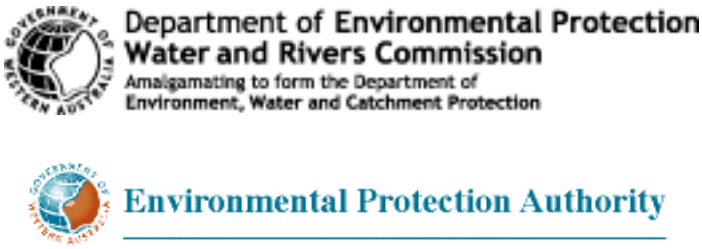
Draft DEWCP and EPA guidance on managing acid sulfate soils



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Comments invited on draft guidance

Comments on this draft would be appreciated. Please direct your submission to:

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Abbreviations

The abbreviations used in this guidance are as follows:

DEWCP	The Department of Environmental Protection and the Water and Rivers Commission amalgamating to form the Department of Environment, Water and Catchment Protection
EPA	Environmental Protection Authority
WAPC	Western Australian Planning Commission
DPI	Department of Planning and Infrastructure

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Appendices

1 Overview of acid sulfate soils in Western Australia

1.1 The purpose of this guidance

This guidance has been prepared to assist agencies, including local government authorities, to manage development in areas where acid sulfate soils may potentially exist. The advice will also assist individuals and organisations that carry out works that may disturb acid sulfate soils.

The purpose of the document is to provide:

- An overview on how, where, when and why acid sulfate soil problems may arise; and
- Guidance on managing acid sulfate soils and activities that may disturb acid sulfate soils.

A summary of the management advice is the flow-chart in Appendix 1.

The information in this guidance should be read in conjunction with the Western Australian Planning Commission's Planning Bulletin No. X: Acid Sulfate Soils.

This guidance is not intended to address the management of acid sulfate soils or acid drainage associated with mining proposals[1], as mining can raise complex issues that require site specific management techniques. Soil acidity problems other than caused by acid sulfate soils are not addressed in this guidance.

1.2 Introduction – What are acid sulfate soils?

Acid sulfate soil is the common name for soil containing iron sulfides or their oxidation products.

When acid sulfate soils are exposed to air, the iron sulfides (commonly iron pyrite) oxidise and produce sulphuric acid, iron precipitates, and concentrations of dissolved metals such as aluminium, iron and arsenic. This leachate has been responsible for environmental damage, damage to infrastructure and buildings, and human health problems.

While the eastern coastline of Australia has had to deal with acid sulfate soils problems for some time, Western Australia has, until recently, only infrequently encountered the issue. While, it is thought that acid sulfate soils problems in Western Australia are on a more localised and less severe scale, there is still much to be learnt about the issue.

For the purposes of this guidance, acid sulfate soils include both actual acid sulfate soils and potential acid sulfate soils.

[1] It should be noted, however, that the removal of peat and other materials may be subject to the provisions of the *Mining Act 1978.* It is advisable to check with the Department of Mineral and Petroleum Resources.

Actual acid sulfate soils are soils or sediments that contain iron sulfides and/or other sulfidic material that have been exposed to the air and have oxidised, producing highly acidic soil horizons or layers. Queensland and New South Wales guidelines recognise a pH criterion of 4 or less for actual acid sulfate soils.

Upon exposure of acid sulfate soils to air, acidity problems may persist for a long time. In some areas of Australia, acid sulfate soils drained 100 years ago are still releasing acid (Sammut 2000).

Potential acid sulfate soils (PASS) are soils or sediments which contain iron sulfides and/or other sulfidic material that have not oxidised by exposure to air. Based on criteria in the Queensland and New South Wales guidelines for PASS, the field pH of these soils in their undisturbed state is pH 4 or more and may be neutral or slightly alkaline. These soils or sediments are invariably saturated with water in their natural state. This waterlogged layer may be peat, clay, loam or sand and is usually dark grey and soft.

PASS are not associated with environmental problems unless they are exposed to air. While the natural exposure of these soils or sediments to air (eg during severe droughts), is associated with the generation of acid, the acidity tends to occur in low frequency, low magnitude, short duration events after drought breaking rains (NHT 2001).

1.3 Where are acid sulfate soils found?

In Western Australia, acid sulfate soils are known to have formed in the following general locations:

- In estuarine areas and coastal lowland areas such as mangroves, tidal flats, salt marshes and swamps, in deposits laid down within the past 10,000 years;
- In many wetland areas, particularly in the coastal region;
- In saline inland areas; and
- Near some mining operations.

Particular areas of concern in Western Australia include (though are not limited to):

- The south west of the State between Perth and Busselton, in estuarine, floodplain and wetland areas eg Peel-Harvey estuarine system and the Vasse River area;
- The northern parts of the State's coastline including the Pilbara and Kimberly coastlines;
- The Scott River Plain on the South Coast; and
- Some parts of the Wheatbelt where land salinisation has occurred.

In the Perth area, specific examples of disturbances of acid sulfate soils include sediments disturbed during bridge construction at the Garrett Road and Guildford bridges on the Swan River; disturbances in Stirling, Bassendean, Guildford and Bayswater; and exposure of acid sulfate soils in wetlands eg Lake Gnangara.

The identification of areas in Western Australia where there may be a risk of disturbing acid sulfate soils is further addressed in Section 2.3 and Appendix 2.

1.4 What types of development may cause acid sulfate soil problems?

Developments that involve excavation works or the lowering of the water table in acid sulfate soil risk areas may result in soil, groundwater and/or surface water acidity and the release of metals and precipitates.

Examples include:

- Coastal developments eg canal estates, marinas, golf courses and general urban development;
- Dewatering and drainage works associated with urban development, including permanent or temporary drainage or pumping of groundwater;
- Developments involving disturbance of wetlands and waterways eg artificially deepened lakes in public open space, and removal of peat;
- Infrastructure projects eg bridges, roads, dredging, port facilities and flood mitigation works;
- Rural drainage which lowers the water table;
- Mining and quarrying operations;
- Aquaculture eg prawn farms in mangrove communities; and
- Filling (filling has been identified as a problem in Queensland, since, in places, filling can compact saturated soils or sediments and/or laterally displace previously saturated sediments, resulting in groundwater extrusion and aeration of acid sulfate soils).

1.5 What are the potential impacts from disturbing acid sulfate soils?

When acid sulfate soils oxidise there may be considerable generation of acid and iron precipitates, and the release of metals such as aluminium, manganese, arsenic and cadmium. Problems from this leachate may persist over a long time, or peak seasonally after dry periods with the first drought breaking rains. Environmental, economic and social impacts may be short term and long term.

The potential environmental, social and economic impacts that may be experienced in Western Australia include:

- Adverse changes to the water quality of the soil, groundwater (including shallow aquifers), wetlands, watercourses and estuaries;
- The deterioration of ecosystems and the ecosystem services associated with soils, groundwater, wetlands, watercourses and estuarine environments;
- Local and regional loss of biodiversity;
- The deterioration of significant conservation areas eg Ramsar wetlands;
- Increased risk of algal blooms and larger algal blooms (Weber);
- Land subsidence due to soil shrinkage when acid sulfate soils are drained (this can make farmland for example more prone to flooding and waterlogging);

- Conflict with activities that depend on healthy surface or ground water regimes, including commercial fishing, recreation and tourism activities;
- Loss of quality of groundwater and surface water sources used for irrigation and other purposes;
- Reduction in opportunities for agriculture and aquaculture;
- Human health concerns particularly from arsenic contamination of groundwater in areas affected by acid sulfate soils;
- Corrosion of concrete structures (concrete cancer) such as bridges, piles, pylons, floodgates, drainage pipes and sewerage lines;
- Corrosion of iron, steel and certain aluminium structures;
- Blockage of perforated plastic pipe drainage systems by iron precipitates;
- Loss of visual amenity from rust coloured stains, scums and slimes from iron precipitates, plant deaths, weed growth and increase in algae; and
- Costs to the community, in terms of financial outlays and the community's and government's time and effort in minimising impacts and repairing disturbed areas.

In the Perth region, acid sulfate soils problem have been triggered by the disturbance of wetlands, peat and the lower parts of waterways. The main concerns identified to date in the Perth region are as follows:

- Degradation of wetlands;
- Localised reduction in habitat, biodiversity and surface water quality of estuarine waterways;
- Reduction in the usability of groundwater for irrigation;
- Human health risks associated with arsenic, aluminium and other heavy metals contamination in surface and groundwater, and acid dust;
- Risk of long term infrastructure damage through the corrosion of sub-surface pipes and foundations by acidic water; and
- Invasion by acid tolerant water plants and dominance of acid tolerant plankton species.

1.6 National Strategy for the Management of Coastal Acid Sulfate Soils

In recognition that a nation-wide co-ordinated approach to managing the acid sulfate soil issue was needed, the National Working Party on Acid Sulfate Soils was set up. The Working Party has developed a National Strategy for the Management of Coastal Acid Sulfate Soils (NWPASS 2000).

The National Strategy identifies four principle objectives:

- **Identify and define coastal acid sulfate soils in Australia.** To assist landowners, coastal resources managers and planners to identify the areas of risk, an accurate environmental hazard assessment process at a catchment level and a reliable property assessment method are needed to help establish whether particular properties are at risk, and if so, the extent and severity of acid sulfate soils;

- **Avoid disturbance of coastal acid sulfate soils.** Undisturbed acid sulfate soils pose little problem for the environment. Avoidance of exposure of acid sulfate soils to air prevents environmental damage and obviates the need for expensive remedial works. Avoidance of problems is most likely to be achieved through a combination of education programs, well considered development and planning controls and promotion of best management practices;
- **Mitigate (and manage) impacts when acid sulfate soils disturbance is unavoidable.** If development has to occur on these soils it should be undertaken in a manner which ensures that there is no resultant acid water discharge into streams and waterways. Management presents difficulties and some risk. However expensive treatment technologies have enabled some major developments to occur; and
- **Rehabilitate disturbed acid sulfate soils and acid drainage.** Where past land use practices such as excavation and drainage have disturbed areas of acid sulfate soils, works to rehabilitate areas will be necessary to improve water quality and mitigate on-going adverse effects.

1.7 Statutory controls, and agencies that may provide advice

The legislation processes and agencies most relevant to acid sulfate soils issues in Western Australia are outlined in this section.

The land use planning process is arguably best positioned to ensure that new developments in areas prone to acid sulfate soils are appropriately managed to meet the community's planning objectives. The WAPC has prepared Planing Bulletin No. X: Acid Sulfate Soils to provide advice and guidance on matters that should be taken into account in the rezoning, subdivision and development of land that contains acid sulfate soils.

Proposed developments that may disturb acid sulfate soils may also be subject to the provisions of the *Environmental Protection Act 1986* – the licensing provisions, the environmental impact assessment process, and/or the provisions of various environmental protection policies. Where pollution arising from the disturbance of acid sulfate soils has occurred, the general pollution prevention provisions of the Act may, depending on the circumstances, be applicable.

Groundwater extraction and dewatering in declared public drinking water source areas including underground water pollution control areas, water reserves and public water supply catchment areas declared under *the Metropolitan Water Supply, Sewerage and Drainage Act 1909* and the *Country Areas Water Supply Act 1947* are subject to licensing by DEWCP.

Development within and abutting the Swan River Trust management area generally requires the approval of the Swan River Trust. Similarly, other catchment management authorities eg the authorities for the Peel Inlet, Leschenault Inlet, Wilson Inlet and Albany Harbour areas determine some approvals in their area of jurisdiction.

At this stage, the Western Australian government department leading action on the issue is DEWCP. Advice on technical aspects of acid sulfate soils issues is available from DEWCP's Land and Water Quality Branch.

Other agencies that may be able to provide advice in relation to specific categories of developments include:

- Department of Agriculture Western Australia – for advice on agricultural land developments;
- Department of Fisheries – for advice on aquaculture projects; and
- Department of Mineral and Petroleum Resources – for advice on mining projects and the statutory controls applying to the removal of peat and other materials that are subject to the *Mining Act 1978.*
- Department of Conservation and Land Management – for areas that affect on conservation areas including wetlands.

2 DEWCP and EPA position and guidelines

2.1 Management objective for acid sulfate soils

The DEWCP and EPA management objective for acid sulfate soils is that development that may potentially disturb acid sulfate soils is planned and managed to avoid adverse effects on the natural and built environment and human health and activities.

2.2 Key management principles

The DEWCP and EPA position is consistent with the aims of the National Strategy for the Management of Coastal Acid Sulfate Soils (NWPASS 2000). In broad terms the principles supported by DEWCP and the EPA are as follows:

- The preferred approach is to avoid disturbing soils and sediments exhibiting acid sulfate soil characteristics where possible.
- All projects should consider acid sulphate soils if they involve earth works, excavation works; lowering of the groundwater table by dewatering or drainage works; and, in some cases, filling (see Section 1.4);
- All decision-making authorities, agencies, infrastructure providers and individuals involved with earthworks that may disturb acid sulfate soils, are aware of the risks associated with such disturbances, and will have set procedures to complement the broader State-wide guidelines (as recommended in this guidance).
- No impacts on key elements of the biophysical environment eg conservation areas and public drinking water supplies, are acceptable;
- Where a project or proposal that has the potential to disturb acid sulfate soils, a preliminary site assessment such as using onsite indicators, field pH tests and chemical analysis, will need to be carried out. This process will ensure that acid sulfate soils issues are considered at the early planning phase of the project; (see Section 2.3 and Appendix 2).
- Where the disturbance of acid sulfate soils is unavoidable after the preliminary investigation and soil sampling have been conducted, it is expected that the general procedures outlined in the flowchart in Appendix 1 will be followed. Key steps include;
  * Consideration of a range of mitigation and management strategies, and demonstration that every reasonable step has been taken to minimise and avoid the disturbance of acid sulfate soils and adverse environmental and community impacts;
  * Demonstration that there will be no unacceptable risks to the natural or the built environment or human health;
  * Preparation of an appropriately detailed Acid Sulfate Soil Management Plan (see Section 2.4 and Appendices 3 and 4); and
  * Implementation of the Acid Sulfate Soil Management Plan;
- Where there are development pressures in acid sulfate soil risk areas, the local authority is urged to ensure that the community are aware of the acid sulfate soil

issue, to complement any actions being taken at other government levels e.g. DEWCP and Department of Planning and Infrastructure (DPI);

- Where damage to the environment has occurred as a result of previous inappropriate disturbance of acid sulfate soils, works to rehabilitate the environment and to mitigate any on-going adverse affects should be implemented as soon as practicable; and
- At this stage the extent and the variability of acid sulfate soils in Western Australia are not well documented, a precautionary approach is urged.

DEWCP is currently developing a series of guidelines to assist with the management of acid sulfate soils. In the absence of local acid sulphate soils guidelines, the investigation, assessment and management procedures developed by other States, particularly Queensland and New South Wales, may be used as an interim guide (see sources of information in Section 4). However, it should be noted that some procedures and management techniques are not applicable for Western Australian conditions. It is therefore recommended that methodologies for detailed site assessments and management plans are developed in consultation with DEWCP and other relevant authorities.

Should a proposal need to be referred to the EPA (see Section 3), the EPA may have additional specific requirements either at the referral stage, or during any formal assessment.

2.3 Site investigations for acid sulfate soils

Adequate information on the extent and nature of acid sulfate soils is clearly crucial to ensuring that development does not result in adverse impacts on the environment and on human health and amenity. Investigations may be carried out in a hierarchical way to establish whether particular land contains or is near acid sulfate soils, and if so, the extent and severity of acid sulfate soils.

The first step is to establish whether or not a proposed development site is in an area where there could be a risk of disturbing acid sulfate soils. It involves a desktop assessment and a site visit to identify indicators of acid sulfate soils, followed by soil sampling. The desktop assessment includes copies of site maps, aerial photos, and description of the site works. Groundwater issues should be considered at this early stage.

The desktop assessment should check the location of the proposed development against suitable ASS maps. In the absence of a comprehensive acid sulfate soils map in Western Australia, DEWCP with assistance from the DPI has developed a draft ASS map for the Swan Coastal plain areas. The categories include high to moderate risk, moderate to low risk and low to nil risk of acid sulfate soils presence. The map units have been classified on the basis of the geomorphological and hydrological properties of the relevance formation, including depth to groundwater and height above sea level in AHD.

ASS maps are broad scale assessment (1:25,000) of the presence of acid sulfate soils to assist for planning purposes. The reliability of the ASS map is dependent on the

correspondence between the properties of the map units and the occurrence of acid sulfate soils on-ground. Local variance in soil conditions will greatly influence the onground validation of key map units. Rapid field appraisal of these units will verify the classification scheme based on "best-guessed" of the chances of acid sulfate soils occurring in different surface geological units.

Where a preliminary site assessment has established that acid sulfate soils are likely to be disturbed by a proposed development, further investigations and analyses should be carried out at an appropriate time, to determine the extent of potential impacts, and how manageable these are.

A more detailed site assessment may be carried out in a hierarchical way. The level of detail of site survey work and analyses may reflect the stage of planning, the extent of ground disturbance proposed, the potential impacts on the environment and human health and amenity, and the severity of the acid sulfate soil.

Until comprehensive site assessment procedures are developed for Western Australia, the investigative and assessment procedures adopted by the Queensland or the New South Wales Governments may be useful as a guide (see Ahern 1998, Stone 1998, and the websites for the Queensland Department of Natural Resources and the NSW Department of Agriculture).

2.4 Management

Management of acid sulfate soils presents difficulties and some risk. If development has to occur on acid sulfate soils, it should be carried out in a manner that ensures that there is no resultant acid water discharge that may adversely affect the biophysical environment and human health and amenity.

In each case, it is recommended that alternatives are considered with a view to favouring an alternative that minimises disturbance of acid sulfate soils.

In the event that disturbance is considered acceptable in particular circumstances, it is generally expected that an Acid Sulfate Soil Management Plan will be prepared and implemented. The detail will be dependent on the scale and characteristics of the particular development, the potential on-site and off-site environmental impacts and sensitivity of the environment likely to be affected, and the level of certainty associated with the proposed mitigation strategy.

Guidelines for the preparation of an Acid Sulfate Soil Management Plan area in Appendix 3.

Techniques for the management of acid sulfate soils are referred to in the references in Section 4. However, these are for other States and may not in all instances be directly applicable to Western Australian circumstances, or meet the objectives of the EPA.

2.5 Consideration of acid sulfate soils during the land use planning process

The WAPC is currently developing a policy response to deal with the issue of acid sulfate soils. That response, however, will require completion of acid sulfate soil risk mapping. In the meantime, the WAPC has published Planning Bulleting No. X: Acid Sulfate Soils which contains a set of general guidelines that should be sued in the assessment of town planning scheme amendments, subdivision and strata applications and applications for planning approval where there is evidence of a significant risk of disturbing acid sulfate soils.

A copy of the Bulletin is available at http://www.planning.wa.gov.au.

2.6 Works that do not require planning or external approval

A range of excavation, drainage and dewatering works currently may not always be subject to an external assessment and approval process. It is nonetheless very important that these works are well managed to avoid inadvertent disturbance of acid sulfate soils in areas at risk.

Works in this category may, depending on the circumstances, include:

- Local authority road and drainage works, and works in public open space;
- Works by public authorities in regional reserves;
- Works for main roads and railways;
- Works for sub-surface infrastructure eg for gas, water, effluent disposal, oil, power and telecommunication services;
- Agricultural works eg drainage works;
- Bore water extraction in areas that do not require a licence; and
- Ground disturbing works associated with any other land use or development.

To avoid unanticipated impacts on the environment, human health, infrastructure, buildings and a range of water uses, it is strongly urged that:

- Authorities, infrastructure providers and individual operators that carry out sub-surface works:
    - Check with the draft acid sulfate soils risk map where applicable and home in on likely areas of acid sulfate soils in the localities in which they work; and
    - Take on board the following general procedures and considerations:
        - Check whether a site is in an area where there is a risk of disturbance of acid sulfate soils (see Section 2.3 and Appendix 1);
        - If the works are to be carried out in an area of risk, engage qualified people to carry out investigations and analyses using an acceptable methodology, generally as recommended in Section 2.3 and Appendix 2;
        - If disturbance of acid sulfate soils is proposed, the authority, infrastructure provider or operator, should generally follow the steps in the flowchart in

Appendix 1, and, as appropriate prepare and implement an acid sulfate soil management plan following consultation with relevant agencies such as DEWCP;

- Local authorities and other responsible agencies with advisory and regulatory functions become aware of likely areas of acid sulfate soils in development areas and ensure that the community are aware of the issue, and complement any actions by authorities such as DEWCP and DPI.

3 Referral to the EPA

3.1 Referral of a proposal to the EPA under Part IV of the *Environmental Protection Act 1986*

With respect to the issue of acid sulfate soils, a proposal associated with only minor potential environmental impacts that may be readily managed in the opinion of DEWCP by conditions that will be imposed by the decision-making authority is not likely to require referral to the EPA under Section 38 of the *Environmental Protection Act 1986*. Of course, if the proposal is associated with other potential impacts that may adversely affect the environment in a significant way, referral of the proposal to the EPA may be appropriate. The issue of environmental significance is discussed in the *Environmental Impact Assessment Administrative Procedures 2002.* (All planning schemes and their amendments are required to be referred to the EPA.)

The EPA considers that proposals or schemes should not proceed if they are associated with the potential for a significant impact on the environment that cannot be mitigated satisfactorily. However, should a decision-making authority not wish to refuse the application, referral to the EPA should be considered.

Proposals that are likely to require referral to the EPA include those where leachate from acid sulfate soils may directly or indirectly affect:

- Native bushland areas of high conservation significance;
- Significant wetlands;
- Waterways;
- Groundwater regimes that support the above and/or are used for public drinking water supply or other significant use;
- Any other environments with high conservation values; and
- Human health, activities and amenity - if the impacts may be significant.

3.2 Triggers for formal assessment of a scheme or proposal

The EPA may decide to set a formal level of assessment on a scheme or proposal that may lead to the disturbance of acid sulfate soils, where a significant impact on the environment is likely as outlined in Section 3.1.

3.3 Information required at the time of referral

Where a scheme or proposal referred to the EPA may be associated with the disturbance of acid sulfate soils, information that may assist the EPA to set an appropriate level of assessment on the referral, includes:

- The results of any desktop and onsite field tests, or laboratory tests that indicate the likelihood of acid sulfate soils;
- Any further proposed investigations that the proponent expects to carry out;

- The potential impacts on the physical environment and biota, and human health and activities;
- The proposed management of any acid sulfate soil, and actions to avoid or minimise adverse impacts on the environment and human interests;
- Advice on any consultation carried out with stakeholders, government agencies and experts; and
- The statutory approvals required before the referral may be implemented.

4 Sources of information

4.1 Information on acid sulfate soils

Australia (general) and overseas references

Dent, D and Dawson, B *The acid test: an expert system for acid sulfate soils* manual on the internet, Loughborough University, England
Available on: *http://www-staff.lboro.ac.uk/~cobrd/identman.pdf*
(A relatively easy to use methodology for identifying the likelihood of acid sulfate soil by using site evidence)

Sammut, Jesmond 2000 *An introduction to acid sulfate soils* National Heritage Trust, Australia, available on the web at:
http://www.ea.gov.au/coasts/programs/cassp/booklet.html
(Introductory information on how acid sulfate soils formed naturally in Australia, and their serious impacts)

National Working Party on Acid Sulfate Soils on behalf of the Agriculture and Resource Management Council of Australia and New Zealand, the Australia and New Zealand Environment and Conservation Council, & the Ministerial Council Forestry Fisheries and Aquaculture 2000 *National Strategy for the Management of Coastal Acid Sulfate Soils* NSW Agriculture, Wollongbar, NSW
Also available at:
http://www.affa.gov.au/docs/operating_environment/armcanz/pubsinfo/ass/ass.html
(The National Strategy includes a recommended reading list)

http://www.ea.gov.au/coasts/programs/cassp (This is Environment Australia's acid sulfate soils website and has links to other websites)

Fitzpatrick, RW, Merry, RH, Williams, J, White, I and Taylor, G 1998 *Acid Sulfate Soil Assessment: Coastal, Inland and Minespoil Conditions* Natural Land and Water Resources Audit Methods paper

Queensland

http://www.dnr.qld.gov.au/resourcenet/fact_sheets
(Useful information on the issue in Queensland)

Ahern, CR, Ahern, MR and Powell, B. 1998 G*uidelines for Sampling and Analysis of Lowland Acid Sulfate Soils (ASS) in Queensland 1998* Queensland Acid Sulfate Soils Investigation Team, Department of Natural Resources, Resource Sciences Centre, Indooroopilly, Queensland

available at the following web site:
http://www.nrm.qld.gov.au/resourcenet/land/landplan/lp-ass/ass-guidelines.pdf
The sampling and chemical analysis methods set out in the above guidelines as established by the Queensland Department of Natural Resources are the de facto national standards

Queensland Government 2002 *State Planning Policy 2/02 planning and managing development involving acid sulfate soils* Department of Communication and Information, Local Government, Planning and Sport, Department of Natural Resources, Queensland.

Hey KM and Ahern CR 2000 *Preliminary methods for recognition of acid sulfate soils: desktop assessment and use of onsite indicators* Department of Natural Resources, QASSIT Queensland

Hey KM, Ahern CR, Watling KM 2000 *Using chemical field tests to identify acid sulfate soils likelihood* Department of Natural Resources, QASSIT Queensland

Ahern CR, Eldershaw VJ, Hey KM and Watling KM 2000 *Quality and intensities of sampling for site assessment of acid sulfate soils* Department of Natural Resources, QASSIT Queensland

NSW

Stone Y, Ahern CR and Blunden B 1998 *Acid Sulfate Soil Manual 1998* Acid Sulfate Soil Management Advisory Committee, Wollongbar NSW
(The above is a comprehensive manual with guidelines for planning, management, laboratory methods, drainage, groundwater, management plans and industry.)

Woodhead, A, Jenkins, A Wood, M 2000 *Acid sulfate soils: keys to success* Acid Sulfate Soil Management Advisory Committee and NSW Agriculture, NSW
(This is a user friendly book for people who want to identify acid sulfate soils in NSW.)

http://www.agric.nsw.gov.au (search on acid sulfate soils)

Victoria

EPA August 1999 *Acid Sulfate Soil and Rock* EPA Information Bulletin Publication 655, Victoria

4.2 Information on acid sulfate soils in Western Australia

Weber Paul *Acid Sulfate Soils in Western Australia – An Introduction* research paper, Ian Wark Research Institute, University of South Australia, Adelaide

Water and Rivers Commission, Department of Environmental Protection and Agriculture Western Australia December 1999 *Acid sulfate soils in coastal Western Australia* unpublished brochure, Perth

Maps that may assist to identify risk areas are listed in Section 2.3.1

Western Australian Government 2002 *Environmental Impact Assessment (Part IV Division 1) Administrative Procedures 2002* procedures pursuant to the *Environmental Protection Act 1986* published in the Western Australian Government Gazette No. 26, 8 February 2002, Government Printer, Perth

OTHER

State Sustainability Strategy

4.3 Example of EPA Bulletin that has considered the issue of acid sulfate soils

Environmental Protection Authority June 1999 *Derby Tidal Power Project: Derby Hydro Power Pty Ltd: Report and Recommendations of the Environmental Protection Authority* Bulletin 942 Environmental Protection Authority Perth

4.4 Agencies in Western Australia regulating or advising on projects that may impact on, or be affected by acid sulfate soils

Department of Planning and Infrastructure

DEWCP - Division of Environmental Regulation (lead agency proving advice on acid sulfate soils issues)

Department of Agriculture

Department of Mineral and Petroleum Resources

Department of Fisheries

Glossary of terms

Australian Height Datum (AHD): The datum used for the determination of elevations in Australia. The determination uses a national network of bench marks and tide gauges, and sets mean sea level as zero elevation.

Acid sulfate soils: Soil or sediment containing highly acidic horizons or layers by the oxidation of iron sulfides (actual acid sulfate soils) and/or soil or sediment containing iron sulfides or other sulfidic material that has not been exposed to air and oxidised (potential acid sulfate soils).
Note: The term acid sulfate soil generally includes actual and potential acid sulfate soils. Actual and potential acid sulfate soils are often found in the same soil profile, with actual acid sulfate soils generally overlying potential acid sulfate soil horizons.

Actual acid sulfate soils (AASS): soil or sediment containing highly acidic soil horizons or layers affected by the oxidation of soil materials that are rich in iron sulfides, primarily pyrite. This oxidation produces hydrogen ions in excess of the sediment's capacity to neutralise the acidity, resulting in soils of pH 4 or less. These soils can usually be identified by the presence of jarosite.

Potential acid sulfate soils (PASS): soil or sediment containing iron sulfides or sulfidic material that have not been exposed to air and oxidised. The field pH of these soils in their undisturbed state is pH 4 or more, and may be neutral or slightly alkaline.

Agricultural lime: a neutralising agent commonly used to treat acidic soils; by composition, it is commonly 95–98% pure calcium carbonate ($CaCO_3$); it is insoluble in pure water, with a pH of ~8.3; application rates will depend on the purity and fineness of the product.

Anaerobic conditions: conditions whereby air (oxygen) is excluded, usually by waterlogging.

Aquifer: rock or sediment in a formation, group of formations or part of a formation that is capable of storing and transmitting water (or another fluid) in significant quantities to bores, wells or springs.

Advice agency: for a development application, means an entity prescribed under a regulation as an advice agency for the application, or if the functions of the entity in relation to the application have been devolved or delegated to another entity, the other entity.

Anoxic: means in the absence of oxygen.

Borehole: the actual hole created when an auger or push-tube is inserted into the soil body; the portion removed (the core) will demonstrate the soil profile.

Drain water: water contained in a drain, which flows into a drain, or flows immediately from a drain.

Dewatering: means the deliberate pumping siphoning, draining or other diversion of waters to render a site or area dry.

Estuary (Estuarine): numerous definitions have been given for estuaries. The standard definition for an estuary only describes the interaction between river and marine currents ' …a widened mouth of a river valley where freshwater intermixes with seawater and where tidal effects occur' (Lapidus 1990).

Extracting groundwater: this includes drainage, pumping or otherwise removing groundwater.

Flocculation: the process whereby small particles clump together into particles of greater mass; commonly seen as iron flocs in streams.

Framboidal (pyrite): microscopic pyrite crystals aggregated in clusters resembling the shape of a raspberry. Common in ASS.

Groundwater: subsurface water in the zone of saturation, including water below the watertable and water occupying cavities, pores and openings in underlying soil and rock.

Groundwater flows: Water that moves laterally or vertically through the body of soil but is not confined as to direction of flow.

Holocene: a period of time from about 10 000 years ago to the present, an epoch of the Quaternary period.

Jarosite: an acidic pale yellow iron sulfate mineral: $KFe_3(SO_4)_2(OH)_6$. Jarosite is a by-product of the acid sulfate soil oxidation process, formed at pH less than 3.7; commonly found precipitated along root channels and other soil surfaces exposed to air.

Leachate: the soil constituent that is washed out from a mixture of soil solids.

Mobilise: situation where the naturally occurring metals in soil or sediment are changed from an insoluble to a soluble state.

Neutralising: the process whereby acid produced (by the oxidation of iron sulfides) is counteracted by the addition of an ameliorant such as lime ($CaCO_3$); there are formulae for calculating the amount of ameliorant needed.

Oxidised: process of chemical change involving the addition of oxygen following exposure to air.

pH: a measure of the acidity of alkalinity of a soil of water body on a logarithmic scale of 0 to 14; a pH <7 is acid, pH 7 is neutral, and pH >7 is alkaline. Note that one unit change in pH is a tenfold change in acidity.

Piezometer: a pipe of small diameter installed in a borehole that is used to measure the height (elevation) of the watertable (piezometric or potentiometric surface). The term can also refer to the instrumentation installed in the pipe. Nested piezometers are a group of piezometers established at different depths to measure the height of the watertable throughout an aquifer.

Pyrite: pale-bronze or brass-yellow, isometric mineral: FeS_2; the most widespread and abundant of the sulfide minerals.

Quaternary: a geological time period extending from 1.8 million years ago to present time; incorporates both the Pleistocene and Holocene epochs.

Recharge area: the portion of the landscape in which rainwater enters the soil body moving down the profile to the groundwater.

Scalded areas: areas which are bare of vegetation due to extremely adverse growing conditions, such as being too acid.

Soil and sediment: the natural accumulation of unconsolidated mineral particles (derived from weathered rocks) and organic matter that covers much of the earth's surface. The chemical and physical composition varies greatly between soil and sediment types. Clays, silts, sands, gravels, peats, muds and indurated sands (e.g. 'coffee rock') are all examples of soil and sediment.

Soil permeability: a measure of the ease with which water can enter or move through a soil body.

Soil profile: this is an accurate representation of spatial proportions of the different vertical layers in a soil body; each layer has individual chemical and physical properties that govern its behaviour.

Subsoil: Commonly understood as that portion of the soil formed below the A horizon; the depth at which it commences varies enormously (e.g. from 5 cm to 5 metres); it has particular characteristics.

Acid sulfate soils map: risk map units have been classified on the basis of the geomorphological and hydrological properties of the relevence to the formation of acid sulfate soils, including the depth to groundwater and height above sea level in AHD.

Watertable: portion of the ground saturated with water; often used specifically to refer to the upper limit of the saturated ground.

Waters: includes river, stream, lake, lagoon, pond, swamp, wetland, unconfined surface water, unconfined water natural or artificial watercourse, bed and bank of any waters, dams, non-tidal or tidal waters (including the sea), stormwater channel, stormwater drain, roadside gutter, stormwater run-off, and any under groundwater, any part-thereof.

Appendix 1

Checklist for the identification of works that may disturb acid sulfate soils

and

Suggested procedures for works and development projects that may disturb acid sulfate soils

Checklist for the identification of works that may disturb acid sulfate soils (ASS)

It is recommended that works are considered as "works in an area where there is a risk of disturbing acid sulfate soils" if at least one "yes" is ticked in Part A, and at least one "yes" is ticked in Part B.

Suggested procedures for works and development projects in acid sulfate soil risk areas are summarised in the following flowchart.

PART A

Are the proposed works in any of the following areas? **(NB: the Environmental Geology series are considered to provide a useful indication of potential areas of acid sulfate soils in those areas where the series apply)**	**YES**	**NO**
Areas on Environmental Geology maps published by the Department of Mineral and Petroleum Resources, shown as Holocene swamp, tidal and estuarine deposits, marshes and floodplains		
Acid sulfate soils risk areas shown on government agency mapping (or mapping from a reputable source) specifically on acid sulfate soil risk areas. (As of March 2002, DEWCP is preparing maps for some regions at risk in Western Australia)		
Areas on Land System and Soil-Landscape system mapping by Agriculture WA, and soil, geology or geomorphology mapping, that indicate geologically recent shallow tidal, estuarine, marine, wetland, floodplain or waterlogged areas where deposition of fine sediments may have occurred or may be occurring; and vegetation mapping that shows mangroves or wetland dependant vegetation such as reeds and paperbarks		
Areas identified in geological descriptions or in maps as bearing sulfide minerals or former marine or estuarine shales and sediments, and mineral sand deposits		
Coastal areas where the following pre-disposing factors exist:: • Areas known to contain peat or a build up of organic material;		
• Areas near bores in which peat or other organic deposits have been recorded as part of the stratigraphy (some information on bore stratigraphy may be available from DEWCP, local Councils or the Department of Mineral and Petroleum Resources);		
• Permanently inundated wetlands;		
• Seasonally or occasionally saturated or inundated floodplains and sumplands;		
• Shallow estuarine areas receiving alluvium;		
• Mangrove areas;		
• Tidal swamps, wetlands and shallow estuarine areas receiving alluvium;		
• Artificial lakes excavated in peaty material;		
• Sites known or believed to contain carbonaceous or pyritic material, such as fill, and existing or former municipal waste disposal sites, industrial sites, food industry waste disposal areas, mining and metal waste disposal areas and animal based waste disposal areas;		
• Highest known water table within 3 metres of the surface; or		
• pH of soil or water less than 5		
Any areas in Western Australia where a combination of all the pre-disposing factors exist - organic matter, iron minerals, waterlogged conditions or a high water table, and sulphides or sulphates eg from rising saline groundwater originally brought inland in marine aerosols. For example, acid		

sulfate soils may develop in inland areas in association with wetlands and waterlogged areas with a salinity problem, and in association with some mining operations		
Any areas where field tests, visual signs and other methodologies indicate that there is a likelihood of acid sulfate soils. An easy to use international methodology for determining the likelihood of acid sulfate soils in coastal areas is reported in "The Acid Test: an expert system for acid sulphate soils" (Dent) and is available on the internet at http://www-staff.lboro.ac.uk/~cobrd/identman.pdf. Soil and water tests that may readily be carried out are also included in the NSW publication "Acid Sulfate Soils: Keys to Success (Woodhead 2000). Visual indicators of acid sulfate soils include;		
• Swamp / wetland vegetation, such as spike rush and melaleucas;		
• Surface waters that are crystal clear (indicates high aluminium at pH 3-4), blue-green (indicates aluminium floc at pH 4-5), milky-white (indicates high aluminium at pH 5-6), yellow-brown (indicates dissolved iron at pH below 3.8) or contain red/brown or brown/yellow floc (indicates iron at pH less than 4);		
• Soils that are gooey black, or grey to greeny/bluish grey (potential acid sulfate soils);		
• Silty black organic oozes (indicates iron monosulfides)		
• Soils that display red/orange mottling, straw yellow blotches or have a rotten egg gas odour (actual acid sulfate soils); or		
• Soil surfaces displaying salt crusts or scalds (bare patches).		
Areas within approximately 500 metres of any of the above AND THE PROPOSED WORKS INVOLVE THE LOWERING OF THE WATER TABLE		

PART B

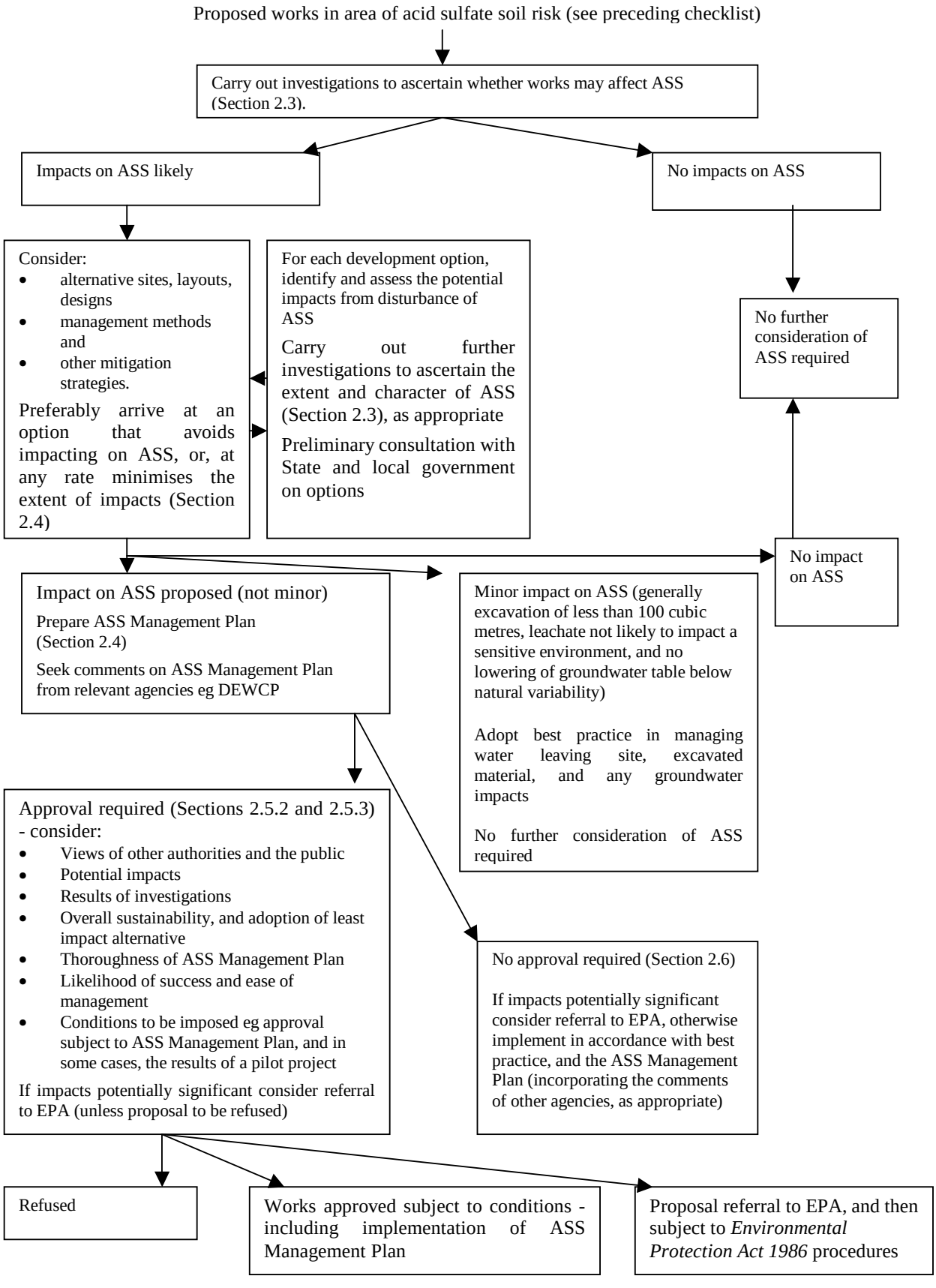
Do the proposed works involve any of the following disturbances?	**Yes**	**No**
Ground disturbing works in one of the above areas where the area is of high conservation significance (eg conservation category wetland), or drains into an area of high conservation significance (via surface water or groundwater)		
Excavation of more than 100 cubic metres of material		
Lowering of the groundwater table either temporarily or permanently eg dewatering, drainage works, or pumping		
Filling - where there is a potential for the fill to compact saturated soils or sediments and/or laterally displace previously saturated sediments, resulting in groundwater extrusion and aeration of acid sulfate soils		

Examples of works that may disturb acid sulfate soils:

- Coastal developments like canal estates, marinas, golf courses and urban projects;
- Excavation works associated with urban development;
- Dewatering and drainage works associated with urban development, including permanent or temporary drainage or pumping of groundwater;
- Disturbance of some wetlands and waterways eg artificially deepened lakes in public open space, and removal of peat;
- Infrastructure projects such as road cuttings and bridges;

- Urban or rural drainage which lowers the water table;
- Mining and quarrying operations;
- Agricultural activity;
- Aquaculture eg prawn farms in mangrove communities; and
- Filling (filling has been identified as a problem in Queensland, since, in places, filling can compact saturated soils or sediments and/or laterally displace previously saturated sediments, resulting in groundwater extrusion and aeration of acid sulfate soils).

Suggested procedures for works and development projects that may disturb acid sulfate soils (ASS) Draft



Appendix 2: Guidelines for preliminary site investigation and soil sampling

Appendix 3: Guidelines for the preparation of an acid sulfate soil management plan

Appendix 4: Guidelines for managing acid sulfate soils