

Identifying acid sulfate soils

Acid sulfate soils (ASS) are marine or estuarine sediments that contain iron sulfide minerals, commonly pyrite. When these soils are exposed to air by excavation or drainage, they produce large amounts of sulfuric acid (battery acid). The acid causes damage by itself, and can also release toxic quantities of iron, aluminium, and heavy metals from the soil. These pollutants can seep into waterways, killing fish, other aquatic organisms and vegetation. Concrete and steel structures in ASS areas are vulnerable to acid attack and may degrade rapidly, needing replacement before their planned lifespan is over.

Accurate identification of ASS is important to avoid causing damage to the environment and to structures. Acid sulfate soils occur in particular locations and have a distinctive appearance. The information in this science note is intended to help identify areas that are likely to contain acid sulfate soils and recognise the soils themselves.

Location in the landscape

Acid sulfate soils occur along the Queensland coast and near-coastal plains. Locations where they are found have the following characteristics:

- **Elevation:** less than 5 metres AHD (Australian Height Datum). Note that this includes some areas with greater elevation (generally up to 20 metres AHD), where ASS are buried underneath non-ASS soils.
- **Geological origin:** Water-borne, marine-influenced sedimentary deposits, usually of recent geological age (Holocene and occasionally upper Pleistocene)
- **Landscape features:** Low-lying coastal wetlands or back swamp areas e.g. mangrove forests, salt flats; waterlogged or scalded areas; stranded beach ridges and adjacent swales, interdune swales or coastal sand dunes, coastal alluvial valleys.

While ASS occur predominantly in low-lying coastal areas, they can also occur some distance from the existing coastline in situations where historic low-lying coastal areas have been covered by younger alluvial sediment deposits of terrestrial origin.

The Queensland Government has been mapping high-priority ASS hazard areas since 1995. Published maps and reports are available in PDF format from the Library Catalogue

<<http://qldgov.softlinkhosting.com.au/liberty/libraryHome.do>>. Spatial data can also be downloaded from the Queensland Open Data Portal <<https://data.qld.gov.au/>>.

Where acid sulfate soils maps do not exist, other data can be used to make an assessment of ASS encounter risk. Useful data sources include:

- LiDAR elevation-based hazard dataset for acid sulfate soils produced by the Queensland Government (this contains 0 metre, 5 metre and 20 metre contours)
- other elevation data with a contour interval of 1 metre or better
- surface geology and regolith mapping
- satellite imagery and aerial photography, including historical imagery
- vegetation mapping

- field investigations carried out by suitably qualified persons

Map scale for data sources listed above should be 1:100 000 or better (1:50 000 or better for imagery). For more information on interpreting these data sources, please refer to Queensland Government (2013b).

Soil physical appearance

Undisturbed ASS layers (Potential ASS or PASS) are water-saturated, and their texture is commonly sandy or muddy. Some peats can also contain iron sulfides, and gravel deposits have been observed to contain a ‘soup’ of fine sulfidic sediments around the larger rocks. Potential ASS are also strongly chemically reduced, and this gives the soils a steely blue-grey colour which can range from pale to dark and is commonly referred to as ‘gley’. Sediments of marine origin will often contain shell fragments. Microscopic carbonate sources such as *Foraminifera* skeletons may be present, but will not be visible to the naked eye.

Zones of permanent or temporary ASS oxidation will often contain yellow and orange mottling. The yellow mottle is the mineral jarosite, and the orange shades will be various other iron oxide minerals. PASS may underlie disturbed ASS (Actual ASS or AASS), or the top of the PASS layer may simply be seasonally oxidised due to water table fluctuations. The thickness of the mottled layer, its degree of development, the soil moisture, and field test results will help to distinguish AASS.

AASS are generally less saturated than PASS, with strong blocky structure. The ‘gley’ matrix colours may disappear, replaced by dark to pale browns. Mottling may be extensive, and the soil surface can be almost entirely orange in cases where AASS are not buried.

Jarosite

Jarosite is a yellow mineral and is the most conclusive field indicator that iron sulfides in acid sulfate soils are oxidising and forming sulfuric acid (Figure 1). Jarosite requires very acidic conditions (pH <3.7) to form.



Figure 1. Jarosite in a soil core from far north Queensland. The yellow mineral is soft to touch.

Monosulfidic Black Ooze (MBO)

Monosulfides are unstable iron sulfides (FeS and related compounds) that can form at the bottom of slow-moving or still waters in acid sulfate soil prone areas, for instance in the bottom of paddock drains and residential canals (Figure 2).



Figure 2. MBOs in a coastal waterway.

MBOs look like a black gel and are very easy to disturb. When they are disturbed (by human activity or by flooding) they react within minutes, consuming dissolved oxygen and producing acid as they break down in the water.

Soil chemical characteristics

While appearance is important, conducting field pH tests is the most effective way to distinguish PASS and AASS from other soils, and also from each other. Two kinds of pH test are required: pH in water, and pH in strong hydrogen peroxide. The results of those tests and most importantly the difference between the two results are the key pieces of information.

pH in water measures the current acidity or alkalinity of the soil. Actual ASS will have a pH of less than 4, often as low as 2. 'Normal' soils and PASS can have a range of pHs but are usually limited to between 5.5 and 8. This means that the pH in water test can identify AASS, but can't tell PASS from normal soil.

Hydrogen peroxide is a strong oxidising agent. When it comes into contact with iron sulfides, it breaks down the minerals very quickly, releasing the iron and acid that they contain. When the pH of a normal soil is tested after hydrogen peroxide has been applied, the pH will be very similar to pH in water. When the pH of a PASS is tested however, it will be much lower than the pH in water. The reaction between peroxide and iron sulfides can be violent, with frothing and steam. To sum up:

- 'non-ASS' soil—pH in water and peroxide similar and rarely lower than 5
- PASS soil—pH in water near neutral, pH in peroxide very acidic (<4)
- AASS soil—pH in water and peroxide similar and very acidic (<4)

For more information on how to properly conduct these tests, please refer to the:

- Queensland acid sulfate soils technical manual: laboratory methods guidelines (section H)
- Guidelines for sampling and analysis of lowland acid sulfate soils.

To access these documents, search for them in the library catalogue:

<<http://qldgov.softlinkhosting.com.au/liberty/libraryHome.do>>

Signs of disturbance

Water quality

When sulfuric acid reaches a water body, the water can become highly acidic (pH <4). Clear blue-green water indicates the presence of soluble aluminium and iron (Figure 3). When aluminium from the soil moves into the water, it can cause suspended particles to clump together and drop to the bottom of the water body. This results in water with a deceptively healthy-looking appearance.



Figure 3 - Clear blue-green water with acid conditions and high aluminium content in a coastal farm dam.

Fish kills

Fish kills may be associated with acid sulfate soil or monosulfide exposure. Sudden changes in acid, aluminium, iron or oxygen levels in the aquatic environment can kill fish and may also kill less obvious aquatic organisms, including crustaceans and oysters. Diseases such as red spot may also be triggered.

Infrastructure damage

Sulfuric acid attacks concrete, weakening bridge pylons, canal walls, pipes, culverts and foundations. The acid 'eats' away the alkaline material in the concrete and exposes the aggregate, causing instability, cracking, pitting, and ultimate failure.

Iron staining

A by-product of the oxidation of acid sulfate soils is the production of rust-coloured iron stains and oily-looking bacterial scums. When acid water mixes with water of a higher pH, the dissolved iron in the water precipitates as a rust-red scum, which can smother and kill vegetation and aquatic organisms (Figure 4). During iron scum formation, oxygen is removed from the water, resulting in low dissolved oxygen levels. This can be a potential cause of fish kills.



Figure 4 – Iron-contaminated water from ASS-affected land meeting incoming tidal waters in an impounded treatment area, East Trinity, far north Queensland.

References

Queensland Government (2013a) Guideline: Planning and Development Assessment Guide for Acid Sulfate Soils. Queensland Government, Department of State Development, Infrastructure and Planning, Brisbane.
Queensland Government (2013b). Queensland Acid Sulfate Soils Technical Manual: Field Assessment and Sampling Guideline. Queensland Government, Department of Science, Information Technology, Innovation, and the Arts, Brisbane.

Further information

This and other science notes are available from the Queensland Government website www.qld.gov.au – search ‘science notes’ or for further information about this science notes series phone **13 QGOV** (13 74 68) – Ask for science notes – L61. Other science notes related to this topic include:

- L60: Acid sulfate soils in Queensland
- L62: Managing acid sulfate soils
- L64: Using acid sulfate soils maps

For more information on acid sulfate soils, visit <http://www.qld.gov.au/environment/land/soil/acid-sulfate/> or email soils@qld.gov.au.

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