Agricultural Drainage in Acid Sulfate Soil Backswamps in New South Wales, Australia - Technical, Regulatory and Policy Responses

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Abstract

Most of the acid sulfate problem in New South Wales is caused by historical overdrainage of former backswamp wetlands for agriculture. The majority of this land is now privately owned and managed for agricultural production. Government, industry and the community have therefore generally sought solutions within a framework of generally maintaining current forms of land use and levels of productivity. The paper outlines a range of approaches that have been used for managing drained areas within this framework, and assesses the success of these solutions. The paper also outlines the range of regulatory powers available to governments for managing drained areas, examines their use, and assesses the success of these approaches. It is concluded that environmental outcomes have been marginal, incremental and subject to reversal. The paper explores opportunities for environmentally sustainable models of land management in backswamps in the context of the most recent research, and outlines a range of policy mechanisms which may be utilised. It is argued that governments need to make greater use of non-regulatory, voluntary, property right- and incentive-based mechanisms to achieve the necessary changes.

Keywords: Acid sulfate soils, backswamps, drainage, regulation, policy, incentives

Introduction

Most of the contaminants from acid sulfate soil areas that cause chronic and acute pollution of coastal rivers on the north coast of New South Wales flow from overdrained backswamps on alluvial floodplains. Poor water quality emanating from these areas is largely a result of acid sulfate soil oxidation products including acid leachate, high iron and aluminium, and low dissolved oxygen. Priority Areas, or acid sulfate 'hot spots' have now been documented and mapped (Tulau 1999a,b,c,d,e,f, Tulau and Naylor 1999). It was confirmed that the bulk of the acid sulfate problem in

New South Wales is caused by historical drainage of former backswamp wetlands. Most backswamps are now artificially drained for agriculture.

The management of backswamps is therefore a key issue in floodplain and acid sulfate soil management. The greatest challenges in remediating these areas are to remove the existing drains, floodgates and related structures in previously drained areas or to manage them in a more environmentally beneficial way.

However, the vast majority of this land is now privately owned and managed for agricultural production including sugar cane, tea-tree, and dairy and beef cattle grazing. Government, industry and the community have generally sought solutions within a framework of generally maintaining current forms of land use and levels of productivity. Governments have generally supported existing agricultural practices by investing heavily in research and the extension of results. In rare cases, regulatory responses could be triggered reactively when generally accepted water quality discharge criteria or other standards were not met.

However, it has often been found that environmental outcomes have been marginal, incremental and subject to reversal. The opportunity therefore exists for governments to recognise where a wider range of policy mechanisms may be utilised in relation to the sustainable management of backswamps. It is argued that in order to do this, governments need to make greater use of non-regulatory, voluntary, property right- and incentive-based mechanisms (Young *et al.* 1996).

This chapter therefore:

- provides a brief history of agricultural drainage in backswamps, outlines the resultant changes in agricultural land management in these areas, and places these changes in the context of government and community policy;

- outlines a range of approaches that have been used for managing drained areas within a framework of generally maintaining current forms of land use and levels of productivity, and assesses the success of these solutions; and

- outlines the range of regulatory powers available to governments for managing drained areas, examines their use, and assesses the success of these approaches.

In concluding that these approaches have not succeeded to the degree required, the chapter then

- explores opportunities for environmentally sustainable models of land management in backswamps and lower floodplain areas in the context of the most recent research; and

- examines non-regulatory, voluntary, property right- and incentive-based mechanisms, and in particular, frameworks for agreements, by which government and landholders can achieve the necessary changes.

Brief history of drainage

Extensive flooding occurred on the north coast of NSW in the latter half of the nineteenth century, resulting in large agricultural losses and fuelling a climate of community expectation for the draining of private freehold land on coastal floodplains. The government obliged. The colonial *Drainage Promotion Act 1865* and later, the *Drainage Promotion Act 1901*, were enacted to provide for the "better drainage of lands" and the establishment of drainage unions. The NSW Public Works Department also facilitated drainage by making investigations and surveys and designed swamp drainage schemes from the early 1900s under the provisions of the *Water and Drainage Act 1902* (PWD 1902). Although frequently justified on flood mitigation grounds, an additional, and often primary motive was the “reclamation” of dry land, often by the drainage of backswamps and the exclusion of tidal waters. The Public Works Department Annual Report of 1906 noted for example that

“On the ... coastal rivers, there are thousands of acres of swamp lands of the richest character which only need proper drainage to make them very valuable”,

and concluded that

“the drainage of these lands appears to be one of the surest and most profitable investments on which money can be employed. It will undoubtedly be the means of inducing closer settlement of the coastal districts of the State.”

By 1907, steps had been taken to drain a number of areas including Cudgen (Tweed coast), Belongil (Byron), Newrybar - North Creek and Bungawalbyn (Richmond), Everlasting Swamp and Shark Creek (Clarence), Kinchela, Frogmore and Seven Oaks (Macleay) and Pipeclay (Manning).

Following major flooding in 1949 and the early 1950s, county councils were formed on the Richmond, Clarence and Macleay Rivers and a number of large flood mitigation and drainage schemes commenced, which often extended and augmented the early drainage networks.

Although the dangers of draining acid sulfate soils, or ‘cat clays’ had been understood by scientists by the 1960s (Walker 1960, 1961, 1963), this decade appears to have been the most energetic period for the construction of drainage and flood mitigation works generally. Much of this work was supported and/or undertaken by successive local and State governments that facilitated the construction of extensive drainage systems by drainage unions and private landholders.

The floodplains of rivers on the north coast of NSW have now been extensively drained, with large networks of floodgated drainage channels owned and operated by local councils, drainage unions and private landholders. From the Manning to the

Tweed, there are 5 039 km of drains >0.5 m deep on acid sulfate soils (DLWC 2000). Clarence River County Council alone owns 190 drainage systems, each with a headworks structure containing at least one flood or tide gate. Drain inverts are typically -0.5 to -1.0 m AHD but can be as low as -1.8 m AHD[1], resulting in the removal of near-surface groundwater as well.

Important changes in patterns of land ownership on the floodplains resulted from the drainage schemes. Landowners were able to farm backswamps, and, assisted by relatively high prices for agricultural commodities in the post-war period, were able to subdivide properties into smaller holdings that often comprised lower floodplain land only. These landholders now rely on an effective drainage and flood mitigation system for current agricultural production systems to continue. In most cases the expected economic benefits of drainage were not realised, and these days, backswamp grazing of beef cattle in particular is often sub-economic, even without taking 'externalities' into account.

The main period of major drain construction has passed, although more recent changes to drainage patterns have accompanied economic changes, mainly in the tea tree and dairy industries. In both cases, new works have generally been confined to shallow, wide drains, and the main focus now in agricultural areas is on the redesign of existing works and alternative ways of operating control structures.

Despite the publication of a number of scientific works (Walker 1960, 1961, 1963, 1972), it was not until 1987 that the link between acid sulfate soils and a history of water quality problems and fish kills was generally recognised. In March of that year, following drought breaking rains, a 23 km stretch of the Tweed River turned clear revealing a large kill of aquatic organisms (Easton 1989).

Approaches to managing drained areas without significant changes in land use

The first *National Conference on Acid Sulphate Soils* was held in 1993 in order to scope the problem, to hear industry viewpoints, to summarise research findings to that point, and to encourage discussion on management options (Bush 1993). As a result, the NSW Department of Conservation and Land Management (CaLM) commenced a Statewide program of risk mapping acid sulfate soils in 1994, and 128 1:25 000 Risk Maps and explanatory notes were published the following year (Naylor et al. 1995, 1998). Planning maps, to be used as the basis for local environmental planning, were published in 1997. A *2nd National Conference on Acid Sulfate Soils* was held in 1996 (Smith and Smith 1996), which examined strategies for farmland management and wetland rehabilitation including ponding, floodgate control and lime neutralisation.

Existing knowledge and understanding was brought together in the *Acid Sulfate Soils Manual,* published in 1998. The Manual was a key document which outlined then best practice guidelines on aspects of acid sulfate soil, including assessment, management,

[1] The invert is the level to which a floodgate can drain. -1.8 m AHD is therefore well below low tide.

laboratory methods, and drainage guidelines. Management strategies considered relevant to drained agricultural areas at that time included the use of agricultural lime and active floodgate management.

Partly as a result of the risk mapping, it was realised that a strategic approach to the remediation of degraded areas was required. In 1999 the NSW Department of Land and Water Conservation (DLWC) documented and mapped the worst affected areas (Tulau 1999a,b,c,d,e,f, Tulau and Naylor 1999). The focus of management and government funding now relates to the remediation of these degraded areas.

In 1999, a *Workshop on the Remediation of Broadacre Acid Sulfate Soils* was held (Slavich 1999). New information was presented on the behaviour and implications of drain sludge, the benefits of installing weirs to reverse hydraulic gradients, and the importance of dissolved Fe^{2+}. Due to the range of management and remediation techniques advocated, a framework for assessing the technical efficacy of options was required. Containment and neutralisation of acid were recognised as key strategies for remediation of acid sulfate soils hot spots (Atkinson and Tulau 1999) and it is within this framework that options for remediation and their limitations are discussed below.

Neutralisation

Neutralisation with lime

Agricultural lime has been widely used to raise surface soil pH. However, the use of lime has significant limitations for the purposes of remediating acid sulfate impacts. Neutralisation with lime is a high cost option and is generally not cost-effective for broad-acre agricultural remediation of acidity from acid sulfate soil, where actual, and particularly potential, acidity is often substantial. Furthermore, lime is quite insoluble except at very low pH, and therefore is only effective to the depth of incorporation. Rather, lime is generally used only on a strategic basis, such as neutralising excavated soil. Even here, there may be practical difficulties of effectively mixing lime into the spoil, requiring ‘safety factors’ of 1.5 - 2.0.

Lime is generally used to treat drain waters. However, as a result of the low solubility of lime in moderately to slightly acid water, it can be difficult for discharged water quality standards that apply to most industries, pH 6.5, to be achieved (ANZECC 1992). It has also been found that lime tends to become coated with oxide compounds and other reaction products such as gypsum. Methods of maintaining neutralising efficiency, such as agitation, are being trialed, but are difficult to generally apply in agricultural situations.

Neutralisation by bicarbonates

Seawater neutralises acid with bicarbonates, and provides a supply of labile organic matter that is needed to reduce sulfate. It has been estimated that seawater can neutralise 2 - 2.4 moles H^+ per m^3 (Dent and Bowman (1995). Neutralisation with seawater can be achieved in drain waters or receiving waters, or by reflooding affected sites with seawater.

Neutralisation with seawater in drains - floodgate opening

Neutralisation in drains or receiving waters with bicarbonates in seawater has been encouraged in cases where dry land agriculture, such as sugar cane cultivation, is practised. Generally this involves the manual opening of floodgates with lifting devices. Clearly, this strategy can only be effective when the adjacent waters contain sufficient bicarbonate, which is generally the lower reaches of estuaries. Most acid sulfate 'hot spots' do not occupy a lower estuary position, and therefore have limited supplies of bicarbonates available for neutralisation. Therefore, whilst improvements in other water quality parameters may accrue from manual floodgate opening, neutralisation of acid is frequently not one of them.

Concerns have been raised that in neutralising acid water, the aquatic ecosystem (particularly crustacea) is deprived of calcium, an essential component of its nutrient environment. As a result, there may be significant environmental costs, particularly in closed or partly closed estuarine systems. The cumulative impacts from a number of proposals relying on the inherent neutralising capacity in an estuary system could be significant, even though the contribution of acid from individual works may be minor. Until research is undertaken on the availability and consumption of bicarbonate and ecosystem tolerances, this method should be considered experimental.

We need to be quite clear why proposals to open floodgates are being advanced. A potential environmental benefit accruing from floodgate opening is the provision of fish habitat and passage. However, artificial drains were never fish habitat originally, and the reversibility of floodgate opening and creation of fish habitat is of concern to many landholders. Manual floodgate operation can lead to improvements in a number of water quality parameters due to dilution, but will not generally reduce the rate of production of oxidation products, or the total export of those products. In fact, manual floodgate opening by landholders is often practised after floods or local rains in order to facilitate the rapid drainage of land. Consequently, rapid export of monosulfidic black oozes (MBOs), other acid sulfate oxidation products and other contaminants may occur. These contaminants should be biologically processed in backswamps. As such, the environmental benefits of floodgate opening may be negated in many circumstances.

In other cases, and despite a great deal of political investment in floodgate opening schemes, many have remained closed due to concerns, possibly held by a single landholder only, that opening could cause land salinisation or undesired water table regimes.

Neutralisation by reflooding land with sea water

Neutralisation by reflooding land with seawater involves manually opening floodgates (by lifting devices), or by removing levees which have excluded the adjacent seawater from the site. This strategy will necessarily lead to the introduction or expansion of salt-tolerant vegetation to the site, and may be most appropriate when an additional objective is the rehabilitation of saltwater wetland, as soil salinity will render the land semi-permanently unproductive for most agricultural uses. The likely uptake of this strategy within current ownership is therefore limited.

Containment of acid in the soil profile

As with neutralisation with lime, and neutralisation with seawater in drains by floodgate opening, containment of acid in the soil profile is also designed to reduce the export of acid sulfate products whilst preserving existing land uses. Containment of the acid within the soil profile operates on the principle that the means of transporting the acid from the site, being near-surface ground water, is excluded. The aim is to minimise the displacement of acidic ground waters to waterways by reducing the near-surface soil moisture, and therefore maximising the soil moisture storage for local rainfall, whilst maintaining water tables above the potential acid sulfate soil layer in order to minimise further acid generation. Infiltration of local rainfall into the soil is commonly minimised by laser levelling and drainage redesign or infilling. It has been shown at a site in south-east Queensland that whilst most of the water leaves a site as surface water, most of the acidity leaves via drains (Cook *et al*. 2000). Infilling of drains therefore assists in reducing acid export. This containment strategy therefore can only be applied where:

- responsive watertable control is practised (possibly involving irrigation and pumps);
- soils with suitable hydraulic properties, being low saturated hydraulic conductivity, are present (requiring detailed soil and ground water investigations);
- laser levelling and drainage redesign is carried out (requiring substantial investment); and
- the crop grown is sufficiently deep-rooted to extract water from below the water table (since the strategy involves minimising infiltration).

This remediation strategy has been implemented with apparent success in sugar cane land at McLeods Creek, on the Tweed River floodplain.

However, lack of precision in watertable control may lead to the generation of further soil acid store. This is of particular concern where this model is extrapolated to silvicultural systems, where it is not possible to achieve similar control of watertable level regimes

Conclusions

Neutralisation with lime, floodgate opening, seawater reflooding and containment in the soil each have potential economic, technical and/or practical impediments. Nevertheless, where significant changes in agricultural practices are not contemplated, often for economic reasons, most attempts to address the impacts of acid sulfate soils in agricultural areas have revolved around floodgate management and modifications, neutralisation of drain waters with lime, and containment in the soil profile.

Regulatory responses to the management of drained areas[2]

Precautionary standards, enforced by regulation, are a necessary underpinning of any policy mix (Young *et al*. 1996). This section outlines the powers available to regulatory authorities to discourage inappropriate management of overdrained areas. The actual use made of some of these powers is also examined.

Regulatory powers

Relevant environmental law can be summarised as relating to development control of new works, and to the management of activities relating to existing works. The *National Strategy* (NWPASS 2000), the NSW Acid Sulfate Soils Management Advisory Committees's *Strategic Plan*, and the *Acid Sulfate Soils Manual*, emphasise the control of new works, thereby placing the NSW *Environmental Planning and Assessment Act 1979* at the centre of regulation of acid sulfate soil management in NSW. Possible triggers for government interest and involvement in the management of existing drains and other structures will generally occur when further work is undertaken in relation to those structures. However, in some cases the distinction between new works requiring development consent, and the management of activities not requiring consent but possibly requiring some other approval, such as drain deepening and widening versus legitimate drain maintenance, is not always easy to determine. More importantly, it has been argued that many day-to-day agricultural works should not trigger consent requirements.[3]

Reliance on development control therefore fails to address many aspects of agricultural management which affect acid sulfate soils. In some cases, the law can actually impede remediation, since it does not distinguish between development and remediation projects. For example, at Yarrahapinni on the Macleay River floodplain, a project to open a floodgate to return saline waters to an area affected by tide exclusion works required an Environmental Impact Statement, as the replacement of the mapped *State Environmental Planning Policy No. 14* freshwater wetland with saltwater wetland was deemed to involve ‘clearing’.

Certain works may not require development consent, but will require another form of approval from a public authority[4] In most cases however, these regulatory tools are not designed to deal specifically with acid sulfate soils, therefore generally limiting the extent to which acid sulfate impacts may be specifically or explicitly addressed.

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[2] For an expanded treatment of this issue, see Tulau (1999g).

[3] Following the example of the *Tweed LEP 1987*, a facility is being included in LEPs for an exemption for the sugar industry from the need to require development consent for certain works, provided that the works are carried out pursuant to an Acid Sulfate Soils Plan of Management agreed to by agencies and local government.

[4] In many cases works will require both development consent, and another approval listed in s 91 of the *Environmental Planning and Assessment Act 1979* (NSW), in which cases the proposal will be considered to be Integrated Development and subject to a coordinated assessment and approval process.

Nevertheless, a range of powers may be available under the *Crown Lands Act 1989*[5], the *Fisheries Management Act 1994*[6], the *Local Government Act 1993*[7], the *Rivers and Foreshores Improvement Act 1948*[8], the *Native Vegetation Conservation Act 1997*[9], the *Roads Act 1993*[10], the *Soil Conservation Act 1938*[11] and more recently, the *Water Management Act 2000*[12]. Many of these provisions have not been exercised in relation to degradation due to acid sulfate soils.

In terms of regulating discharges from acid sulfate areas, the power of the Environment Protection Authority and local councils to issue notices and take legal action under the *Protection of the Environment Operations Act 1997* is a key component of the regulatory regime in relation to acid sulfate soil management.[13] Chapter 4 of the Act provides a range of environment protection notices, including "clean-up notices",[14] "prevention notices",[15] and "prohibition notices".[16] Clean-up notices direct an occupier of premises and/or a person responsible to take clean-up action when a "pollution incident" has occurred or is occurring.[17] Prevention notices can be issued when it is suspected that that an activity has been or is being carried on in an "environmentally unsatisfactory manner", including if it is not carried on in accordance with 'good environmental practice'.[18]

Use of regulatory tools

Although a moderately large body of case law has accumulated in relation to acid sulfate soil management, the cases below illustrate various difficulties which authorities have encountered in exercising their regulatory functions.

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[5] *Crown Lands Act 1989* ss 153–158.
[6] s 201(1), s 204, 179(1)(a).
[7] s 68
[8] Part 3A.
[9] s 22, s 14.
[10] *Roads Act 1993* s 138(1)(a), s 138(1)(b).
[11] s 15A.
[12] e.g. ss 89-91, ss 326-327, s 329, ss 343, 344.
[13] Local councils are normally the "appropriate regulatory authority"(s 6) in respect of pollution from 'non-scheduled premises', unless the activity is conducted by a public authority (s 6(2)(c).
[14] s 91 or s 92.
[15] s 96.
[16] s 101. It is intended that prohibition notices be issued by the Minister in extraordinary circumstances only.
[17] s 91(1).
[18] s 95(d). 'Good environmental practice' will include accordance with the ASSMAC Guidelines. Examples of action required may include: carrying on an activity in a particular manner s 96(3)(e), monitoring, sampling or analysing any pollution s 96(3)(g), or preparing a plan of action to minimise pollution s 96(3)(i).

Early cases largely concerned the adequacy of assessment in the context of mining, subdivision, and proposals for resort development, and commonly accepted proponents' assessment and proposed management of acid sulfate soils. This litigation has included *Citizens Against Sand Mining (Inc) v Australmin Holdings Pty Ltd & Anor*,[19] *Hancock Byatt & Associates Pty Ltd v Wyong Shire Council,*[20] *Byron Businesses for the Future Inc v Byron Council and Holiday Villages (Byron Bay) Pty Ltd ("Club Med case")*,[21] and *Cameron v Nambucca Shire Council & Anor.*[22] Acid sulfate soil issues have also been successfully prosecuted under the Class 4 jurisdiction of the Land and Environment Court where consent had not been obtained but was required: see e.g. *Hastings Council v Macmillan* (1993)[23], *Ballina Shire Council v Leeson and Wall* (1996)[24] and *Hastings Council v Maria River Tea-tree Plantation Co*[25]. A more complex exploration of the exercise of development control and approval functions under a range of instruments arose in *Fishwatch Inc v Sawtell & Ors*.[26]

However, for the purposes of refining policy and practice relating to the regulation of works affecting acid sulfate soils, it may be more illuminating to focus on those instance where action taken by the relevant authority(s) failed to deliver the desired environmental outcomes, and to examine the reasons why.

Two of the main reasons appear to be difficulties in relation to evidentiary issues and instruments of insufficient scope.

A perceived difficulty in exercising regulatory functions in relation to water pollution in agricultural situations has been that of clearly attributing the pollution to a particular person, although clearly, in many situations, this will not apply. However, other evidentiary issues have precluded use of such instruments. In many circumstances, regulatory authorities have been reluctant to prosecute where it may have been difficult to demonstrate sufficient evidence of pollution of waters. See for example *Hastings*

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[19] *Citizens Against Sand Mining (Inc) v Australmin Holdings Pty Ltd and Ballina Shire Council* (Unreported, Land and Environment Court of NSW, No 10328 of 1989, 3 November 1989).

[20] *Hancock Byatt & Associates Pty Ltd v Wyong Shire Council* (Unreported, Land and Environment Court of NSW, No 10429 of 1992, 15 April 1993).

[21] *Byron Businesses for the Future Inc v Byron Council and Holiday Villages (Byron Bay) Pty Ltd* (1994) 84 LGERA 434.

[22] *Torquil Cameron v Nambucca Shire Council and Resource Design and Management Pty Ltd* (1997) 95 LGERA 268.

[23] *Hastings Council v Macmillan* (Unreported, Land and Environment Court of NSW, No 40191 of 1993, 9 February 1994).

[24] *Ballina Shire Council v Leeson and Wall* (Unreported, Land and Environment Court of NSW, No 40193 of 1996, 24 March 1997).

[25] *Hastings Council v Maria River Tea-tree Plantation Co* (Unreported, Land and Environment Court of NSW, No 50018 of 1998, 23 March 1998).

[26] *Fishwatch Inc v Sawtell, Sawtell, Gray, Stark, Lismore City Council, Richmond River City Council, the Minister administering the Crown Lands Act, and the Minister for Planning* (Unreported, Land and Environment Court of NSW, No 40241 of 1994, 11 March 1996).

Council v Maria River Tea-tree Plantation Co[27], where the company took immediate action to ameliorate the disturbed acid sulfate soils, including blocking the drain. Again, major works on Micalo Island in 1999 could not be prosecuted because spoil had been removed from beside the drains before soil or water samples could be collected.

Unsatisfactory outcomes also occur due to the insufficient scope of retrospective instruments. For example, drainage works in 1998 could not be reversed in Everlasting Swamp, despite the significance of the relevant land being recognised by listing in the *Directory of Important Wetlands in Australia* and the *Register of the National Estate*.[28] Action under the *Clean Waters Act 1970* was also not pursued. In the Micalo Island matter, despite the magnitude of the works, apart from a notice under the *Protection of the Environment Operations Act 1997*, the only action that was taken was the seizure by NSW Fisheries of floodgates that were restricting tidal movement and commencement of proceedings for restriction of fish passage under the *Fisheries Management Act 1994*.

Regulatory tools in relation to works not requiring development consent are frequently fragmentary and issue based, are rarely applied, and only on an opportunistic basis. These difficulties are compounded by the fact that regulatory responsibilities are spread across a number of government agencies, which tends to produce an uncoordinated and inconsistent approach to the exercise of statutory powers, which therefore diminishes the deterrent effect of those regulations.

Nevertheless, despite a paucity of prosecutions that are progressed to adjudication, regulatory tools are often used to lubricate negotiations towards an agreed outcome. See for example *Hastings Municipal Council v Quildan Pty Ltd*[29] and *Fishwatch Inc v Sawtell & Ors*.[30]

A major reason for preferring consented over adjudicated outcomes is illustrated by cases where there has been a lack of correlation between legal and actual outcomes. In *Kempsey Shire Council v Berne*[31] for example, despite a conviction in 1997 for the construction of a 1.6 km drain through part of SEPP 14 Coastal Wetland No 484 on the Maria River, a tributary of the Hastings River, remediation was not forthcoming. Doubts were expressed as to the ability of the respondent to carry out the orders, which included that a Plan of Management be prepared, that certain other works be carried out, and that the respondent intensively monitor water quality and manage a remediation

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[27] *Hastings Council v Maria River Tea-tree Plantation Co* (Unreported, Land and Environment Court of NSW, No 50018 of 1998, 23 March 1998).

[28] Under the *Australian Heritage Commission Act 1975*

[29] *Hastings Municipal Council v Quildan Pty Ltd* (Unreported, Land and Environment Court of NSW, No 40129 of 1997, 25 September 1998).

[30] *Fishwatch Inc v Sawtell, Sawtell, Gray, Stark, Lismore City Council, Richmond River City Council, the Minister administering the Crown Lands Act, and the Minister for Planning* (Unreported, Land and Environment Court of NSW, No 40241 of 1994, 11 March 1996).

[31] *Kempsey Shire Council v Berne* (Unreported, Land and Environment Court of NSW, No 40195 of 1996, 13 June 1997).

structure accordingly. These concerns may also apply in other cases.[32] *Berne* points to the deficiencies of orders made in the absence of financial arrangements to give effect to those orders. State and local government spent more on these proceedings and the associated actions, than it would have cost to hire plant do the remediation work, pursuant to an agreement or an appropriate court order. If relevant authorities could agree on a suitable scheme for cases such as *Berne*, cost-effective and environmentally-effective outcomes could be achieved whilst preserving precedent and deterrence, yet minimising adverse political outcomes for State and local authorities and the Government generally.

Conclusions

Despite a firm policy commitment by government to address the acid sulfate soil issue, and a range of regulatory instruments with which to effect these intentions, the use of regulatory powers for the purposes of controlling the disturbance of acid sulfate soils has so far delivered mixed results in NSW.

So far, most of the regulatory emphasis has been directed towards ensuring that acid sulfate soils are addressed at the development control stage through Part 4 of the *Environmental Planning and Assessment Act 1979*. Unfortunately, many day-to-day agricultural land management practices do not trigger consent and approval requirements. Of those that do, the consent process is often poorly tailored for agricultural management practices due to the costs and delays associated, therefore risking significant levels of non-compliance.

Major problems in addressing the issue by reactive regulatory means have included a lack of suitable regulatory tools of sufficient scope or specificity, uncertainty concerning the appropriateness and effectiveness of the use of regulatory powers relating to acid sulfate management, and uncertainty concerning the roles and obligations of agencies and statutory authorities. Another major impediment to the exercise of statutory powers generally appears to be the costs associated with prosecutions, and a lack of resources available to the prosecuting authority, both financial and technical, especially for smaller organisations such as local authorities. Even where a matter is successfully prosecuted, this may only be the beginning of a new phase of attempting to have orders enforced. As a result, greater use is likely to be made of more cost-effective tools such as notices under the *Protection of the Environment Operations Act 1997,* and similar provisions under other Acts.

Furthermore, it was indicated above that the current problems associated with the overdrainage of acid sulfate areas for agricultural uses have been largely caused by historical drainage. As a consequence, and for legal, political and practical reasons, governments have generally been unable or reluctant to utilise regulatory tools to address the impacts of past drainage works which were constructed in a manner

[32] In *Fishwatch Inc v Sawtell & Ors* (1996) landholders were required to prepare a Strategic Plan such that waters discharged from the offending drain have pH<5 with monitoring to be carried out by the primary respondent.

consistent with then prevailing community standards.[33] It appears that the infrequent use by governments of regulatory tools to address existing land uses suggests that as far as governments and the community are concerned, the best environmental standards that may practically be expected of agriculture are in fact generally being met.

More importantly, the sanction is by nature reactive, and does nothing to encourage environmentally positive changes in land management. Although 'traditional' regulatory tools will always be required as a necessary underpinning of any incentive mix, to protect against the recalcitrant few, governments now need to explore ways in which the law can be used in a proactive manner. However, in designing tools that can provide for the ecologically sustainable management of backswamps effectively, it is necessary to ensure that the policy and regulatory mix recognises some fundamental aspects of backswamp hydrology, and from that basis, to explore opportunities for sustainable land management in backswamps.

Hydrology of backswamps

In order to reassess the efficacy of options for the remediation of acid sulfate discharges from backswamps, an understanding the hydrology of backswamps is fundamental. Backswamps occupy the lowest land on the floodplain, generally below 0.5 m AHD[34], and prior to drainage, would have been seasonal to semi-permanent wetlands dominated by reeds in the wettest areas. Most backswamps formerly had extended periods of inundation, often ponding to 0.5 m for many months. Under natural conditions, little contamination flowed into rivers, mainly because there were few natural drains. Acid water and other contaminants were contained and neutralised by the breakdown of organic matter.

Recent research suggests that remediation strategies that do not entail major changes to, or the removal of, drains, will not significantly impact on the pollution of receiving waters. It has been found that during post flood drainage, the majority of oxygen depleting contaminants are exported from backswamps via drains when drainage water levels fall below local mean high water (Johnston 2001). The solution is to retain water in backswamps to this level and to increase the residence time of the waters in the backswamps. This has significant implications for the agricultural management of these areas.

Further research examining the properties and behaviour of MBOs, an acid sulfate oxidation product which accumulate in drains, suggests that these may oxidise rapidly when disturbed, depressing dissolved oxygen to lethal levels (Sullivan and Bush 2001). The best way to avoid the production of MBOs is to infill the drains to at least the top of the acid sulfate layer. Both these mechanisms were implicated in the pollution of north

[33] The first standards specifically relevant to acid sulfate soil management are the EPA *Guidelines* 1993.
[34] Australian Height Datum, approximates mean sea level. In mesotidal NSW, 0.5 AHD is therefore ~0.5 m below spring high tide level.

coast rivers and resultant fish kills in 2001. The common theme in both cases is the hydrologic functions performed by the drains.

An understanding of the hydrology of ground water is also critical. It was originally thought that deep drains would facilitate sub-surface drainage, whereas it is now known that rainfall/evapotranspiration ratios are critical in determining inter-drain sub-surface watertable levels. Drain water levels do not determine the watertable level in those parts of the floodplain between drains. Often, the water level may be higher in the drain where the level is maintained by the waterways into which the drain flows. For example, it has been shown (White *et a*l. 1997) that rainfall/evapotranspiration ratios over long periods may be critical in determining inter-drain watertable levels. However, this does not mean that drought is more important than drainage in lowering watertables, rather the two factors operate in combination - drainage works determine the watertable depth/elevation ranges over which such climatically induced fluctuations can occur. Formerly, drying out of any sulfidic layers below backswamps would have begun later in a drought cycle, if at all, and lasted for shorter periods of time. Whilst oxidation of acid sulfate soils may have occurred naturally from time to time in hydrologically isolated backswamps in extreme drought, it is likely that the degree and depth of oxidation and rate of production of acid was a fraction of that produced by artificial drainage, and the discharge of any acid to receiving waterbodies even less.

The implications of understanding the hydrology of backswamps, and especially the role of evapotranspiration, is that further oxidation products will be generated unless watertable management mimics natural cycles at critical times of the year and in critical parts of the landscape.

Opportunities for sustainable land management in backswamps

The type of land use, and particularly the economics of land use, commonly constrain the choice of a remediation strategy. Industries that generate high returns are unlikely to prefer strategies that preclude or reduce current returns in the absence of appropriate offsets (Mullen and Kaur 1999). In areas where less economically profitable and viable agriculture is practised, landholders may be more open to changing those practices, often to the benefit of both the environment and the profitability of agriculture. One of the key changes that is encouraged in grazed systems, is containment by freshwater ponding in backswamps.

Containment of acid by freshwater ponding

Containment of acid by ponding involves closing or modifying floodgates, constructing levees and/or installing dropboards in drains, resulting in generally higher watertables behind the structures and intermittent to permanent wetlands. Water is lost from the system primarily by evaporation.

This backswamp management model may generate environmental benefits whilst retaining agricultural production. Many graziers are now installing and actively managing structures to retain water on their backswamp paddocks to improve pastures at beneficial times of the year. For example, some graziers on the Macleay floodplain are reducing or excluding stock from backswamps and retaining water on paddocks by drop weirs and penstocks. Graziers on the floodplain of the Coldstream River, a backswamp distributary of the Clarence River, harvest water from the river to retain water on a 1,400 ha backswamp.

Options for managing site water

Watertables can be manipulated by a range of options outlined below. The depth and duration of retained water will depend on factors including: the size, precipitation and runoff regime of the catchment, especially in relation to the size of the backswamp; evaporation rates; and the nature of the drainage system including floodgate specifications. In backswamps with smaller catchments, depth fluctuations due to catchment input are less important, and the evaporation component of the water balance assumes greater importance. Depths generally vary due to local, rather than catchment, rainfall on a seasonal basis.

Ponding of the whole of a backswamp may be effected where a single headworks controls the hydrology of the basin, such as at Clybucca on the Macleay, Rocky Mouth Creek and Tuckean Swamp on the Richmond. However, it will be difficult to secure agreement from all landholders in a backswamp for significant alteration to headworks design or operation. Containment on a part-backswamp avoids the need to secure agreement from all landholders in a backswamp. For example, at Pipeclay Canal on the Manning River floodplain, an intensive floodgated drainage system connects at a number of points along the length of the canal.

A range of structures can be actively managed to pond seasonal flows within backswamps, allow fresh river water to enter backswamps, avoid over-drainage and acidification, and control storm surges.

Dropboards are commonly installed in-drain or in floodgates to raise upstream water levels. Sluicegates are generally engineer-designed, guillotine-action, steel constructions which can be fully or partially lowered to allow flows in either direction by either overtopping or bottom flows (Paterson and Smith 2000).

Vegetation and stock management

Vegetation management and productivity is a key issue in relation to backswamp management. A number of valuable native wet pasture species may be encouraged in ponded backswamp systems. Water couch (*Paspalum distichum*) in particular is regarded as a valuable grazing species which can cope with water up to ~0.5 m deep. In moderately saline areas salt water couch (*Paspalum vaginatum*) may be encouraged. However, water level control is essential - the margin between insufficient and excessive water is considered to be fine, and fresh meadow species will die if suddenly inundated. Weeds can also be treated by water table management as dry land weeds do not normally colonise undrained backswamps (Paterson and Smith 2000).

Backswamp areas are probably best suited to selective grazing rather than set stocking year round, as grazing backswamps can reduce organic peat cover and worsen or extend scald areas. Stocking rates in backswamps are low, ranging from 0.2 – 1 beast/ha, and due to the seasonal nature of wet backswamp productivity, it is necessary to alternate grazing in adjacent dry hill country (Paterson and Smith 2000).

Water quality in managed backswamps

Water quality in ponded fresh water backswamps depends on a number of factors including water depth, water temperature, degree of stratification, vegetation management, grazing management, the size of the acid store, and the amount of labile organic matter present. Where there are significant reserves of acid in the near-surface soil profile, especially over acid scalds, shallow surface water and ground water is often highly acid. Deeper fresh waters tend to be less acid (~pH 6.0).

Concerns have been raised that ponding may increase acid discharge by facilitating the mobilisation of stored acid, which would pose an extreme risk to the environment if released in the absence of significant dilution. It has also been suggested that inundation of acid affected lands with water will not necessarily halt the production of further acid (White *et al*. 1997). Unfortunately, research funds have tended to flow to more economic land uses, and the hypothesis has not been adequately tested in the field. Research should also be conducted into possible mechanisms and rates of sulfate reduction in these environments.

Nevertheless, at this stage, it appears that the benefits of ponding include:

- less additional acid is generated;
- the frequency of acid released through floodgates is reduced;
- the duration of acid release is minimised;
- the concentration of acid released is minimised;
- the volume of acid ground water released into drains is reduced;
- vegetation and organic matter cover of backswamps is increased;
- grazing production and habitat values of fresh meadow are enhanced; and
- vegetation survival following inundation is improved, therefore low dissolved oxygen problems in receiving waters are minimised.

Nevertheless, due to the uncertainties, a great deal of care should be exercised if a ponding option is being considered. Due to the limited research associated with this option, a high level of supervision and monitoring will be necessary. However, in some cases the approach could result in a viable long-term solution. Containment of acid by ponding may be the only possible acid sulfate soil management strategy at sites where other strategies are not viable.

Other policy frameworks to achieve the necessary changes

This section outlines other tools available to encourage appropriate management of overdrained areas. It has been previously argued that technical solutions pursued in the absence of significant hydrologic, and therefore, land management, changes, will produce outcomes that will be marginal, incremental and subject to reversal. At the same time, government use of regulatory tools to address the impacts of existing land management practices in agricultural acid sulfate soil areas uses has been ineffective for a variety of reasons.

However, governments have a role to play in finding solutions for a number of reasons. Firstly, the brief history of drainage outlined the historical involvement by governments in participating in earlier drainage schemes.

Secondly, it has been argued that biodiversity conservation is a public good, and as a consequence, those who benefit from non-market dimensions of biodiversity conservation, either directly or indirectly, should contribute to the costs of its maintenance (Young *et al*. 1996). The community as a whole should take financial responsibility for at least the non-marketable public goods produced, and that this portion should be borne by government when the costs of doing so cannot be recovered by market mechanisms. This argument may equally apply to the ecologically sustainable management of backswamps.

This section outlines actions that government can take to achieve significant hydrologic and land management changes in backswamps.

Land acquisition

The acquisition of private land is the most complete form of control over land, and in some cases may be the most economically viable means of implementing remediation strategies. In NSW, land acquisition may be effected through the *Land Acquisition (Just Terms Compensation) Act 1991*. Acquisition may be undertaken by public authorities, or by non-governmental organisations (NGOs). It may be preferable following purchase to sell or lease the land back to or through a non-governmental organisation with some form of covenant established under s 88E of the *Conveyancing Act 1919* or management agreement in place. In some cases, an easement, such as a drainage easement only, may be acquired. This may give access to and control of a controlling structure such as a floodgate. Note however, that complex questions of equity law may then arise relating to the management of the structure and the impacts of that management on land.

Precedents for State government involvement in the rehabilitation of wetlands and the remediation of acid sulfate soil backswamps have already occurred. At Yarrahapinni on the Macleay River, an area of former saltwater wetland was acquired by the Crown for the purposes of returning tidal waters to a drained area. At Hexham Swamp on the Hunter River, the acquisition of former wetland has been recommended, and a Memorandum of Understanding signed with a wide range of stakeholders (Evans 1999). Hastings Council has recently purchased most of the Partridge Creek backswamp with a view to implementing fresh water ponding remediation measures.

However, an unexpected consequence in relation to at least some of these purchases has been inflation of land prices in anticipation of further acquisition. In this context, there are a number of important policy considerations that must be assessed before acquisition is practiced on anything but a very selective and strategic basis. For example, should the government be in the business of purchasing degraded land, thereby running the risk of creating an incentive for inappropriate land management? Furthermore, concerns have been raised in relation to the capacity of governments to adequately manage acquired areas.

Rather, governments have an obligation to trial strategies that are less disruptive to local socio-economic conditions before resorting to those that are likely to be more intrusive. This appears to be the stage that government policy in relation to acid sulfate soil management finds itself in at present in NSW. Most backswamps are privately owned, and will remain so.

Agreements

One of the main ways that improved acid sulfate soil management may be effected is through management agreements between government and/or community groups and those who hold or have interests in land. Agreements may have statutory basis, or may accord to the laws of contract.

Statutory agreements

Statutory bases for such agreements may include the following. Some of these agreements may have a direct or ancillary relevance to acid sulfate soil management.

- Section 88E of the *Conveyancing Act 1919* allows public authorities to enter into voluntary agreements relating to land use with landholders and to attach covenants to particular pieces of land which can be enforced against subsequent landholders. Covenants are instruments that restrict a landholder's ability to use the land in a particular way. Note however that in NSW covenants are generally only enforceable by private suit in the Equity Division of the Supreme Court of NSW. Furthermore, s 28(2) of *the Environmental Planning and Assessment Act 1979* provides that a covenant specified in that planning instrument shall not apply, or shall be subject to modification (Code 2001).

- Part 5 of the *Native Vegetation Conservation Act 1997* refers to the making of property agreements between a landholder and DLWC concerning the management of native vegetation on the property.

- Section 69B of the *National Parks and Wildlife Act 1974* provides for conservation agreements between the Minister and the owner(s) of the land for purposes including the preservation or protection of fauna or native plants or the conservation of threatened species, populations or ecological communities, or their habitats.

- Section 11 of the *Soil Conservation Act 1938* concerns the making of agreements between the Crown and owners, occupiers or mortgagees of the lands proposed to be dealt with under a s.10 project. Agreements may include covenants, conditions and provisions relating to the methods and practices of land management to be adopted and assistance the Minister will provide towards the execution of any works or measures required to be undertaken.

- Chapter 2 of the *Water Management Act 2000* concerns water management planning. Water Management Plans may be used as a prerequisite for government assistance and the prime mechanism for reimbursing landholders for non-market benefits of management, or provide exceptions from regulatory requirements.

However, the above mechanisms are often highly specific for purposes other than acid sulfate soil management, and so far these and other statutory avenues for effecting improved management have been little explored by government authorities.

Non-statutory agreements

The greatest potential at present for governments or NGOs who wish to influence land management appears to reside in the common law of contract under which the land user agrees to manage land in a particular way in return for some form of incentive or reimbursement.

The basis of a contract between a government or NGO and those who control or have interests in affected land would be a management agreement. A range of forms of management agreements have been discussed by TPLUCC (1998). The management agreement would prescribe the terms and conditions under which the landholder agrees to manage her/his land. Matters addressed in a management plan may include stocking rates and seasonality, construction and operation of water control structures, and government support. Agreements may also be reached, not in respect of parcels of land, but in respect of the management of structures that determine or influence land management options, such as floodgates.

Non-statutory agreements may also take the form of contractual arrangements between purchasers and providers on a commercial, or industry basis. For example, the NSW Sugar Milling Cooperative requires that acid sulfate soil best practice guidelines will be followed as part of its contract with farmers.

The leasing of land may be another means of securing the necessary land management assurances for the required period short of acquisition. Land may be leased by the landholder to a statutory authority or a NGO. Leasing of land in NSW is conducted under Part 8 of the *Conveyancing Act 1919*. Leasing of land may be considered in cases where water table modifications are likely to affect the agricultural productivity of the land, for example, the rehabilitation of wetlands. An acid sulfate soils remediation plan may be included in the lease contract.

Incentives

In many cases, some form of motivational incentives will be necessary as a key component of any contractual arrangements underpinning a management plan. Incentives applicable to backswamp management may take the following forms.

Local government rating bonuses or rebates (Mobbs 1996) may be used to reward particular forms of management, such as the retention of higher watertables. Tradeable rights systems, such as emissions rights, are often a key component of market-based solutions advocated by economists. However, tradeable discharge rights need to be easily, quantifiably and auditably measured, which is not the case with discharges from acid sulfate soil areas. Another form of tradeable right is tradeable development rights, whereby planning restrictions may be modified. Modifications to taxation legislation, to allow for income tax deductions, or tax credits may also be used as policy instruments (ASSMAC 1999). However, each of these options will require legislative and/or institutional changes beyond the powers of the State government alone, and must therefore be regarded as longer term options.

The provision of incentive payments, for which landholders may agree to carry out land management practices in a way not expected of other landholders, is within the scope of existing mechanisms. Incentive payments can be used to reimburse landholders for the costs of biodiversity protection that cannot be recovered through normal market mechanisms (Young *et al*. 1996). A formula for the calculation of payments may be based on factors such as stocking rates, duration of stocking and gross margins (WCA 2001). DLWC recently announced an Environmental Services Scheme, whereby participating landholders will be paid for delivering the environmental services they produce. Eventually these will be converted into ‘environmental credits’ that can then be traded a market.

A further initiative that should be taken is the removal of perverse incentives that have caused unintended negative effects on backswamps, such as government subsidies for backswamp drainage schemes, including levee construction. Further, Rural Lands Protection Board ratings systems should be based on a realistic assessment of land capability.

Conclusions

In NSW, governments have a long history of involvement in the drainage of backswamps for agricultural uses. The drainage of backswamps could not have occurred on this scale without the resources of governments. This phase in the management of coastal floodplains lasted until the 1970s, and it was in the 1980s that the inherent limitations in the capability of lower floodplain lands and backswamps were generally realised. By that time significant changes in land tenure and land management had occurred and become entrenched in these areas.

In remedying the outcomes from past policies, governments, industry and the community have an obligation to act prudently and incrementally, to trial strategies that are less disruptive to local socio-economic conditions before resorting to those that are likely to be more intrusive to existing land uses.

However, it is apparent that minimalist technical approaches to resolving problems caused by the overdrainage of backswamps, such as lime application, active floodgate management and laser levelling, have significant limitations. These techniques have tended to produce environmental outcomes that are marginal, incremental and subject to reversal.

Similarly, the use of regulatory powers for the purposes of controlling the disturbance of acid sulfate soils has so far delivered unsatisfactory results in NSW for a range of legal and practical reasons. Although precautionary standards enforced by regulation are a necessary underpinning of any incentive mix, the infrequent use by governments of regulatory tools to address existing land uses suggests that the environmental standards expected of agriculture are generally being met. In these situations, if the community expects a higher environmental standard, the beneficiary pays principle may need to be adopted (Aretino *et al*. 2001).

Rather, a wider range of policy options must be therefore pursued in relation to the sustainable management of backswamps. The retention of the current drainage system will continue to cause pollution of waterways until aspects of the natural hydrology of backswamps is restored, and these areas are able to perform their original functions with respect to maintaining water quality in river systems.

In order to encourage land management systems, possibly including agricultural systems, that are compatible with the intrinsic capability of backswamps, governments need to develop a wider range of policy tools, including greater use of non-regulatory, consensual, incentive-based mechanisms, possibly including incentive payments.

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