Ecological impacts of flood mitigation and drainage in coastal lowlands

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There are increasing development pressures on the south-eastern Australian coastal lowlands. The climate of these coastal floodplains provides favourable conditions for crop and pasture growth but it also causes frequent flooding and propagates the effects of land use changes into streams rapidly. Government-encouraged drainage and flood mitigation schemes have altered the hydrologic response time of coastal catchments, increasing the volume of water and the speed with which it is delivered from floodplains into streams. These, in turn, have increased sediment, nutrients and pollutant loads into coastal streams and embayments.

Almost all of Australia's coastal embayment and estuarine floodplains are underlain by brackish water sediments, called acid sulfate soils, containing naturally-occurring iron sulfide minerals. These sediments oxidise when exposed to air producing sulfuric acid. Drainage and flood mitigation schemes have promoted the partial acidification of most NSW coastal floodplains and export of acidic drainage waters into coastal streams. Thousands of tonnes of sulfuric acid are exported annually into coastal streams. The ecological consequences of soil acidification and export can be severe. Introduced crops and pastures which are not acid-tolerant die or are stunted leaving exposed, bare, acid scalds which are strongly acidified, right to the surface. Acidic waters exported into streams cause massive fish deaths, fish diseases and dramatic changes in aquatic communities. Estuarine reaches can be rendered sterile for months at a time. Aquaculture and estuarine fishing are adversely affected and aquaculture, particularly oysters can be severely impacted. Lasting impacts on biodiversity have yet to be documented. These constitute persistent, recurring ecological emergencies, driven by climate, but whose causes may be buried in time. They are difficult to treat once initiated. Emergency procedures such as drainage or breaching of levees could have long-lasting ecological impacts.

Government responses have varied. Conflicts between farmers and fishers in NSW led to the formation of the multi-agency Acid Sulfate Soil Management Advisory Committee, ASSMAC. The effectiveness of the plethora of existing legislation in protecting coastal ecosystems in acid sulfate soil areas is questioned and an urgent review of the Drainage Act of 1903 is suggested. Institutional impediments to better floodplain management are identified. Recent trends in environmental management and planning towards self-regulation, 'marketisation', regionalisation and agency downsizing may have adverse impacts on coastal areas and should be examined. Finally, changes in attitudes and approaches of governments, agencies and landholders, which are producing environmental benefits, offer considerable promise in rectifying the ecological impacts of flood mitigation and drainage.

Coastal lowland development, drainage and flood mitigation in eastern Australia

Coastal lowlands throughout the world are under increasing development pressures as evidenced by continued clearing of mangroves and draining of wetlands. In Australia, eastern coastal floodplains were the first areas to be developed for agriculture use because of their generally favourable soil, water and temperature regimes (King 1948). These favourable factors and few environmental constraints to production (Nix 1994) have led governments of all persuasions to actively encourage coastal floodplain development and protection through drainage acts and flood mitigation schemes.

There is also continuing urban expansion in coastal catchments. About 80% percent of Australians live in the coastal zone, and about 66% of these are concentrated around large urban centres on estuaries and inlets. In the period 1971 to 1991 the population of the non-metropolitan coastal zone grew by 95%, from 2.1 to 4.1 million people, compared with a 32% growth for all of Australia. About 25% to 30 % of the coast is subject to increasing development, most of this concentrated in the south eastern section of the country (State of the Environment, Australia 1996). Rapid coastal growth is expected to continue over the next five decades (National Population Council 1992).

Coastal lowlands are subject to frequent flooding and governments have sought to mitigate flood impacts through drainage, stream redesign, levies and floodgates. These activities have been extremely effective in controlling excess water and promoting productivity and development, but have produced unexpectedly severe water quality and ecological problems.

Almost all of Australia's coastal embayment and estuarine floodplains are underlain by brackish water sediments containing naturally-occurring iron sulfide minerals. These sulfides pose no problems provided the sediments remain beneath the watertable. When the watertable falls below the sulfide layer, either naturally through evapotranspiration or by drainage works augmented by levies and floodgates, sulfides oxidise producing sulfuric acid. Because of this, these sediments, which occur throughout the world, are known as acid sulfate soils (Dent 1986). Acid produced in the soil water attacks soil minerals dissolving aluminium, iron, silica, manganese and other species and forming a toxic brew harmful to both terrestrial and aquatic species. Rain causes the export of acidic groundwater into streams. Both the generation and export of acid water is altered by drainage and flood mitigation. Major ecological impacts result from this export (Brown *et al.* 1983, Easton 1989, Callinan *et al.* 1993, Sammut *et al.* 1995, Sammut *et al.* 1996). Their cause is buried in the past, yet episodic ecological emergencies can continue for decades or centuries. Once started they are difficult to treat because of the large costs and complex social, institutional, legal and political factors.

This paper explores the interactions between hydrology, drainage and flood mitigation, acid sulfate soils and their ecological impacts in south-eastern Australia, and examines government response to the ecological emergencies generated and the institutional impediments to addressing them.

Hydrology of coastal catchments

Harries (1997) has recently reviewed acid drainage from mines in Australia. He used a climatically-based regional classification scheme similar to that developed by Nix (1994), to identify areas that have the highest potential risk for exporting materials into surface streams. Essentially this is determined by the trade off between rainfall, P (mm) and evapotranspiration, E (mm). Over sufficiently long time periods, of order a year, the runoff, R (in mm), from any given area is just the difference between rainfall and evapotranspiration;

$$R = P - E \qquad (1)$$

There are two characteristics of rainfall that influence the overall export of materials into estuaries. The first is the ratio of runoff to precipitation, the runoff coefficient, $C = R / P$. *Figure 1* shows the average runoff coefficient for NSW coastal rivers. The catchment average runoff coefficients in *Figure 1* indicates where landuse changes may have, potentially, most impact. The smaller catchments such as the Brunswick, Bellinger, Bega, Hastings and Tweed have relatively high runoff coefficients and we expect that landuse changes in those catchments will have proportionally more impact on estuarine water quality and ecology than in streams where the coefficient is less than the approximately 27% average for NSW coastal catchments. The mean annual runoff coefficient for Australia as a whole is only about 8% (Smith 1998).

The second important characteristic of rainfall is its variability in time. As a consequence of their high rainfall variability, Australia and South Africa share the highest variability of annual stream-

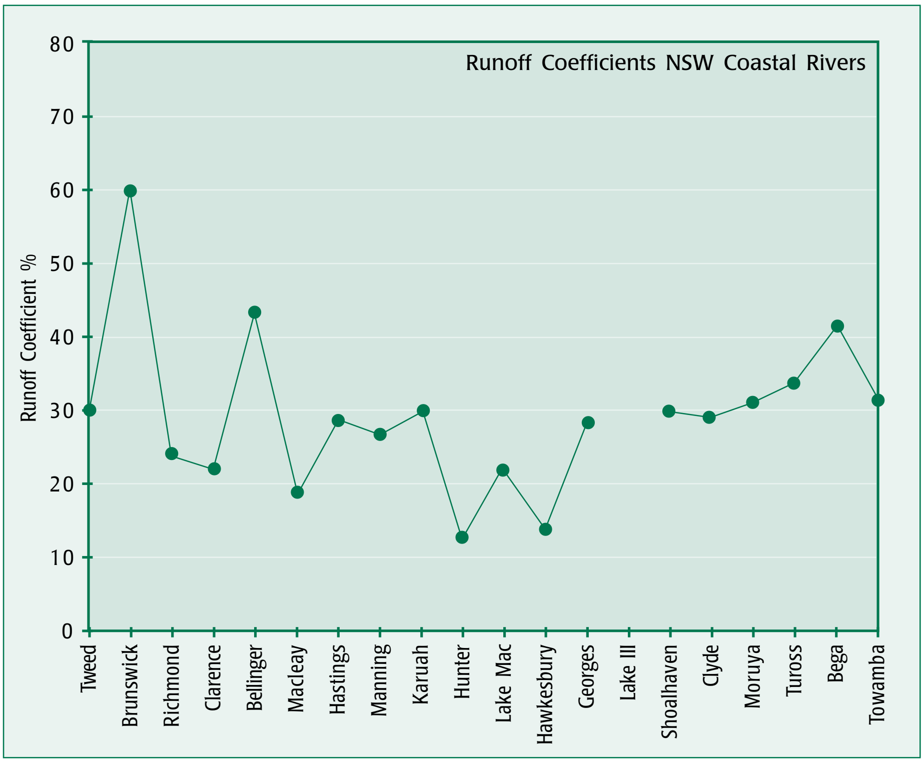

Figure 1: *Annual runoff coefficients for NSW coastal catchments (Source: NSW DLWC)*

flow, with a coefficient of variability of around 75% (McMahon, *et al.* 1992). Both the long term average runoff coefficients and the extreme rainfall events, as well as length of dry season, critically determine exports of water and pollutants into coastal streams.

Landuse changes and flood mitigation works can effect runoff and stream flow dramatically. Urbanisation dramatically increases the runoff coefficient to as high as high as 95%. Cropping, forestry, clearing and grazing in areas adjacent to coastal streams have the potential to change the volume, quality and rate of water entering streams through changes to cover, surface soil and stream bank conditions and evapotranspiration regimes.

The predicted impact of climate change on flooding and streamflow in coastal floodplains is widely and hotly debated. In Australia, these predictions are starting to converge, with quite different expected impacts across the country. Sea levels are now predicted to rise by about 0.25 m in the next 50 years and in the east, the climate may be drier but with more intense rains. The implications for coastal floodplains, ecosystems and their management remain to be elucidated but increased coastal flooding would appear to be a major issue (Smith 1998).

The hydrology of coastal floodplains provides favourable conditions for crop and pasture growth, but its variability also generates prolonged dry periods and frequent flooding. This flooding propagates the effects of land use changes into streams rapidly. This export of water can lead to episodic ecological emergencies.

Flood mitigation and drainage of coastal floodplains

Before European settlement coastal floods resulted in many natural back-swamp areas remaining inundated for sometimes half the year. During early settlement, these back-swamps were valued for grazing as drought refuges. The government-encouraged development of coastal floodplains for agriculture resulted in the major re-engineering of back-swamps and coastal streams through flood mitigation and drainage works. Crops, generally, require floodwaters to be removed within five days, so that natural floodplains have quite different hydrological characteristics when drained.

Floodplain re-engineering has occurred at two scales. Flood mitigation works have been carried out at the floodplain scale and have been designed to divert upland flows rapidly through the floodplain. These systems have been designed and built by state and local government authorities and have been financed partly through federal and state flood mitigation schemes. Critical factors here are the ratio of the floodplain area to the upland area and the distribution of rainfall and runoff across the catchment. Coastal catchments with smaller floodplain to upland ratios require higher drainage densities to cope with upland flows. *Figure 2* shows these ratios

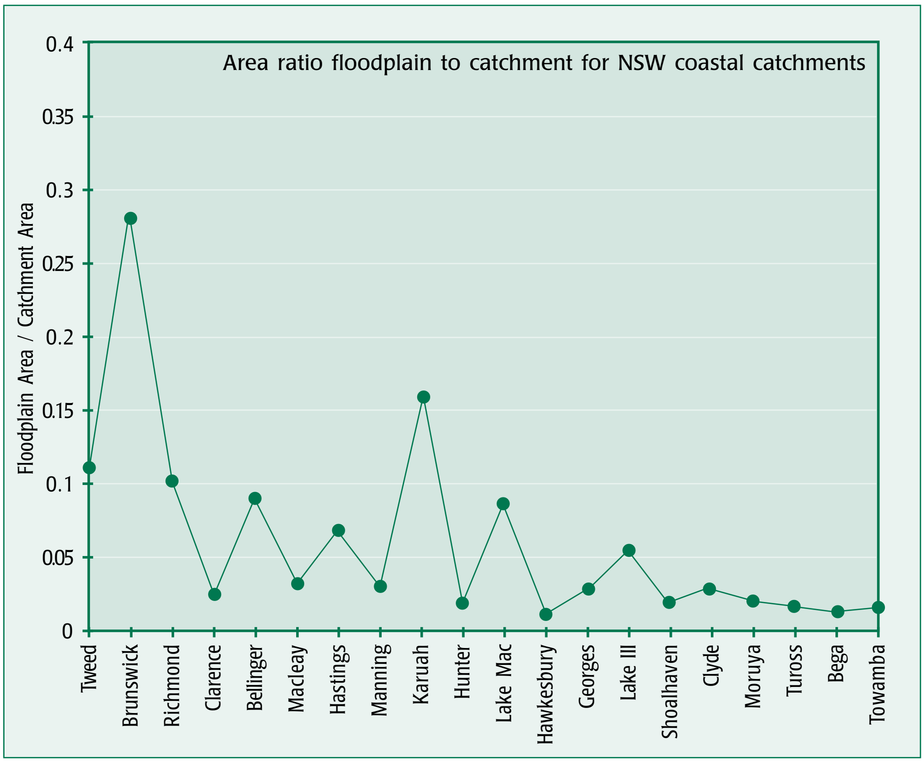

***Figure 2:** Ratio of floodplain area to total catchment area for coastal catchments in NSW (Source: NSW DWLC)*

for New South Wales. Rivers such as the Clarence, Hunter, Hawkesbury and Manning have substantial upstream areas which contribute both water and exported materials to the lower floodplains and estuaries.

As a result of devastating floods in the 1950s, New South Wales became a world leader in both floodplain risk mapping and flood mitigation works (Smith 1998). In the past, flood mitigation works and indeed most estuarine engineering works have overlooked the ecological consequences of drainage, installation of floodgates and levee construction. In NSW, the focus of engineering works is broadening with State Government projects such as 'Returning the Tide'.

At the more local scale, coastal floodplains in New South Wales have been drained by smaller drainage union drains. Drainage unions were set up under the Drainage Act of 1903 to empower local groups of farmers to drain floodplains cooperatively. Drainage unions are financed through rates from local beneficiaries of drainage. Currently, resources available to drainage unions have dwindled and many drainage unions have lapsed or their functions have been taken over by county councils or local governments. There is an urgent need for a review of the NSW Drainage Act.

Many local drains have been constructed by straightening, widening, deepening, desnagging and floodgating existing meandering, floodplain streams. Drainage union drains are usually connected to a network of smaller individual farm drains. Drainage is a technical endeavour, however, most local and farm drains have not been designed, rather they have evolved. The existing drainage network in some areas appears excessive (White *et al.* 1997).

There has been confusion on the function of farm drains, with many believing that they are necessary to lower water tables. Since many of the coastal crops use groundwater during dry times, excessive lowering of watertables may be counterproductive. In most cases, the proper function of drains is to remove surface water from fields as quickly as possible (White *et al.* 1997, Wilson *et al.* 1999). The dense network of drains in some floodplains was necessary because of the small undulations of floodplains. Laser levelling of floodplain areas now being practised in the sugarcane and tea tree industries permits better control of surface water, and enables a decrease in drainage density through the infilling of drains.

Floodgates on drains prevent tidal and partial flood ingress into drained areas and permit the drainage of land to mean low tide level. Floodgates also limit fish passage to creeks and back-swamp areas which were natural feeding and breeding areas in high water periods. Environmental audits and mapping of floodgates have been carried out by NSW Fisheries and others on the Clarence and Hastings Rivers, with other river audits planned for the near future. These audits have shown an amazing number of structures in varying degrees of repair.

Some floodgates protect land which is below mean sea level. The wisdom of protecting such low-lying areas from what seems to be inevitable inundation seems questionable. Apart from these low-lying regions, floodgates are only needed during flood events and could otherwise remain open. Farmer groups have naturally been wary of such proposals, fearing inundation of land and salinisation of adjoining areas. The inadequacy of floodplain elevation data is an impediment to determining risks of inundation. Current elevation data gives 1 m elevation contours whereas contour intervals of at least 0.1 m are required. Cane farmers on the Tweed River, with the assistance of local government, have opened floodgates to allow tidal flushing and fish passage.

The impact of a predicted 0.25 m rise in sea level due to climate change within the next 50 years will be significant on all low-lying areas of coastal floodplains. A policy response to this expected rise has yet to be developed.

Drainage and flood mitigation impose changes. One way of determining how rapidly land use changes may be expected to propagate into surface streams is to consider the residence times, t *(days)*, of materials in the near stream environment. This is estimated by dividing the storage volume of the particular environmental compartment , V (m^3), by the flux of material, Q (m^3/day):

$$t = V / Q \qquad (2)$$

For groundwater in coastal floodplains, a key factor is the storage of material in the unsaturated zone in the soil. Here V is typically 20 mm and recharge into this zone, Q, can be 800 mm/year. *Equation (2)* therefore gives a residence time of only 9 days. In contrast, for arid inland areas, V can be about 1000 mm and Q approximately 10 mm/year giving a residence time of 100 years. Land use changes in coastal floodplains are transmitted much more rapidly to streams than in arid areas. The residence time for water in the floodplain with its back-swamp areas has been changed from of order 100 days under natural conditions to around 5 days under drained and flood mitigated conditions. In the past, much of that water in the undrained back-swamp areas evaporated, now it is exported into streams.

Drainage and flood mitigation schemes have shortened the residence time of coastal floodplains, increasing the volume of water and the speed with which it is delivered from floodplains into streams. These, in turn, have increased sediment, nutrients and pollutant loads into coastal streams and embayments.

Acid sulfate soils in NSW

Australia has over 34,000 km^2 of iron sulfide-rich coastal acid sulfate soils under a variety of land uses (White *et al.* 1997). In Australia, recognition of their importance has lagged behind the rest of the world. The first Australian maps, showing their widespread distribution, were only published in 1995 (Naylor *et al.* 1995) together with guidelines for their management and use (Blunden and Naylor 1995). Acid sulfate soil maps in NSW are risk maps showing the probability of occurrence of acid sulfate soils. The highest risk category is where the iron sulfide layer is within 0.5 m of the soil surface (Naylor *at al.* 1995). *Figure 3* shows the areas of high risk and the estimated total acid sulfate soils in coastal NSW.

The area of acid sulfate soils in *Figure 3* is larger in the northern part of NSW than in the south, reflecting the change in river morphology between coastal embayments in the north and flooded river valleys in the south. The largest concentration of high risk soils occurs on the Clarence River. Research on the Tweed (Wilson 1999) and Richmond Rivers (Sammut *et al.* 1996) has found acid production rates of order 0.1 to 0.3 tonnes sulfuric acid/ hectare/year together with similar amounts of dissolved iron and aluminium. Some coastal floodplains are capable of discharging 1,000 tonnes of sulfuric acid following a single storm event. Once oxidised, floodplains can continue to discharge acid water for centuries (White *et al.* 1997). Floodgates promote the formation of acid reservoirs which leak acidic waters into the downstream environment for months (Sammut *et al.* 1996). Any emergency management procedure which requires the rapid drainage of a lowland area or the breaching of a levy bank should be handled with great care since it could cause a persistent acid discharge through watertable lowering.

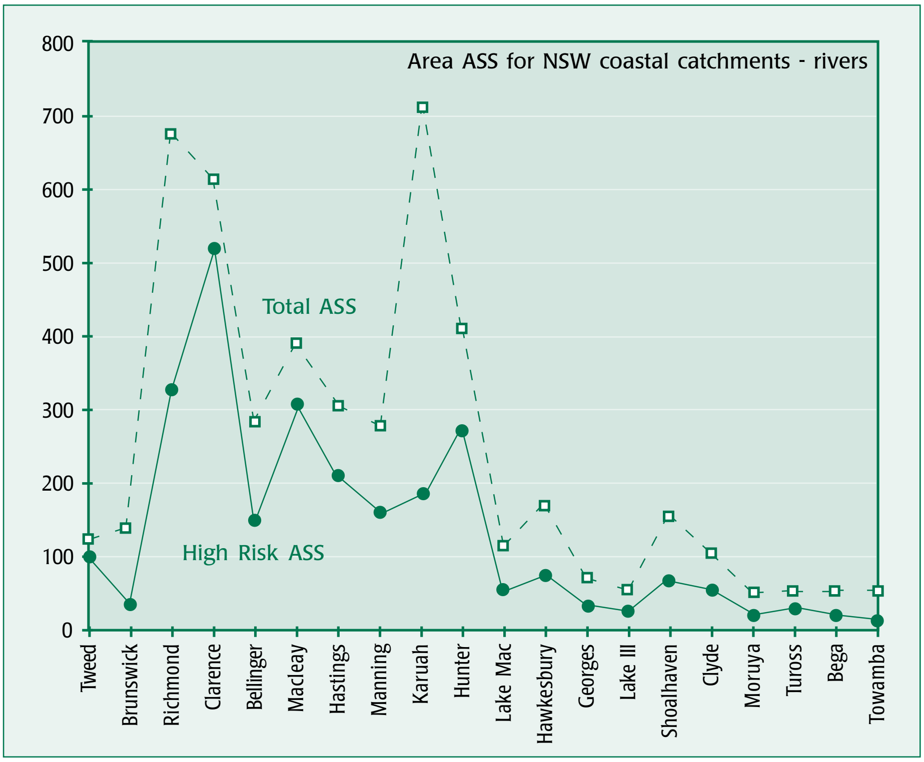

***Figure 3:** Area of high risk and total area of acid sulfate soils in coastal NSW*

Ecological consequences

The ecological consequences of soil acidification and export are well documented. Introduced crops and pastures which are not acid-tolerant can show severe affects. Under extreme conditions, most plants die leaving exposed, bare, acid scalds which are strongly acidified right to the soil surface. In less extreme cases, plant productivity is greatly reduced (Dent 1986). In streams the acidic waters can have dramatic impacts including: massive fish deaths (Brown *et al.* 1983, Easton 1989), fish diseases (Callinan *et al.* 1993, Sammut *et al.* 1995) and dramatic changes in aquatic communities (Sammut *et al.* 1996). Estuarine reaches can be rendered sterile for months at a time. Lasting impacts on biodiversity have yet to be documented. These in-stream events constitute persistent, episodic ecological emergencies.

Aquaculture is also severely affected. Oyster production losses in NSW of up to $12 million have been claimed. In addition, concrete and steel infrastructure corrosion has resulted in costs of over $4 million (White *et al.* 1997). Economic losses of fish are more difficult to estimate because of the mobility of fish and the contributions of extraneous factors such as by-catch, over-fishing and habitat destruction. Crop and grazing losses and impacts on human health are yet to be determined.

The Sydney rock oyster has been farmed for over 130 years in NSW and middens indicate they have been eaten for over 8,000 years. The NSW oyster industry is the state's most valuable fishery and one of Australia's major aquacultural producers with production worth around $30 million. It is a significant regional employer and contributor to coastal economies. Oysters are filter-feeders who extract food from particulate and dissolved materials in water. They take between two and a half to three and a half years to reach market size. During that time the average oysters will filter about 1ml of estuarine and river water. Oysters are mobile for only a brief period in their early life, after which they are sedentary. Their feeding habits and life-style therefore make oysters valuable indicators of water quality in our coastal zone. *Figure 4* shows the 50% decline in production of Sydney rock oysters over the last twenty years (data from NSW Fisheries).

There are many factors that have caused the production decline in *Figure 4*. Some are demand-side driven, some are supply-side driven. Of the supply-side factors, one of the most important is the degradation of water quality in coastal rivers and estuaries. Significant problems occur after runoff-producing rains especially in acid sulfate soil areas. Direct impacts through shell dissolution in acid waters has been demonstrated. It has also been proposed that devastating oyster diseases, such as QX and winter mortality, may be linked to runoff from acid sulfate soils (J. Sammut, personal communication 1998). Oysters are a valuable indicator of the sustainability of coastal development.

Government responses

Conflicts between fishers and farmers became so intense that the NSW Minister for Agriculture and Fisheries set up the Acid Sulfate Soils Management Advisory Committee in 1994 to provide government with advice on the management of acid sulfate soils. Because acid sulfate soils cut across the jurisdiction of many government departments, ASSMAC has attempted

***Figure 4:** The decline in production of Sydney Rock Oysters in NSW since 1975. Each Bag is 100 dozen oysters (NSW Fisheries)*

to provide a whole of government approach to the problem; providing information, a forum, training, guidelines and maps on acid sulfate soils. ASSMAC have used an approach based on awareness, education, research, and legislation (as a last resort). Until recently, however, this effort was under-resourced. In 1997 the NSW Government set up the ASSPRO funding program, with $2.1 million over 3 years, to provide resources for education and training, research and remediation projects.

Harries (1997) has estimated that the cost of remediating already acidified mine dumps could be as high as $110,000/ ha. If this applies to already acidified coastal floodplains, then the cost of remediation could be tens of millions. There are no quick fixes for already acidified floodplains. In China, rice paddies are still affected by acidity from acid sulfate soils at least two hundred years after they were first developed.

ASSMAC's approach to prevent the further disturbance of acid sulfate soils and to correct existing problems has been to raise awareness of the consequences of disturbance, to provide training and education, to promote research particularly on management and rehabilitation strategies and to explore regulations. ASSMAC has encouraged the adoption by coastal councils of Local Environment Plans, LEPs, specifically for acid sulfate soils. Hastings Shire Council was the first to approve such a strategy. Compliance with these LEPs is a significant issue. While regulation is but one management option, it would appear to be a missing option in acid sulfate soil management. The reliance on LEPs without overarching regulation would seem to be a deficiency in the range of options for mitigating the impacts of acid sulfate soils.

ASSMAC has been criticised by both land-holders and fishers and aquaculturalists as being too bureaucratic, too timid, too slow to act and ineffective. Yet in the 4 years ASSMAC has been established an array of information materials have been produced and projects have been completed. ASSMAC's tasks are politically and institutionally complex, reflecting the complexity of acid sulfate soil management, institutional arrangements and conflicting stakeholder demands. ASSMAC's output has been quickly transferred to other states, and a National Working Party on Acid Sulfate Soils (1998) has recently released a Draft National Strategy for the Management of Acid Sulfate Soils.

Successful prosecution under the Clean Waters Act of any recent, deliberate discharge of acidity from acid sulfate soil areas through drainage would send a strong signal to the community The NSW EPA is, at present, bringing to settlement the first successful case on discharge from drains in acid sulfate soils. Previously, the EPA had regarded acid discharge from drains in acid sulfate soil areas as diffuse, rather than point discharge and therefore outside the ambit of the Clean Waters Act.

Prosecution is seen as a last resort. Tweed Shire Council, in northern NSW, has led the way in facilitating cooperative approaches to estuarine management. It brought together land-holder, fisher, aquacultural and other representatives to agree on common goals and has provided them with expert advice. As a result, canefarmers have been using their own resources in attempts to improve water quality by re-engineering the floodplain using laser levelling to remove low spots which pond water and improve surface shedding of water. In this technique, fewer drains are needed resulting in lower acid discharges. This has resulted in a win-win situation as cane production has been improved by up to 10%. In addition, farmers are applying lime to further decrease acid production and have also opened floodgates in order to increase fish passage and tidal neutralisation of acid water. This cooperative model involving land and water users and the facilitation of local and state governments, may be appropriate for the management of all our estuaries.

Institutional impediments to floodplain management

There are a plethora of extant laws applicable to the protection of coastal estuaries, embayments and streams in NSW. The more important of these are the Rivers and Foreshores Hydraulic improvement Act of 1948, the Fisheries Act of 1994, the Clean Waters Act, the Local Government Act, the Native Vegetation Act and the Protection of the Environment Act. There are several specific State Environment Protection Plans, such as SEPP 14 Wetlands and SEPP 46, the Clearing of Native Vegetation. SEPPs are almost universally detested by broadacre land-holders, since they deprive them of freedom of decision-making over land use on their properties. Because of this ASSMAC has been loath to introduce an acid sulfate soil SEPP. A critical study of the use of these instruments and their effectiveness in protecting estuaries, and the need for overarching regulations could be of significant benefit. The general perception amongst fishers and aquaculturalists is that there is a great reluctance on the part of government agencies to use existing legislation.

There are several determining authorities in coastal floodplain and estuarine areas who are exempt from development approvals or the EIS process. These authorities have been major participants in the modification of estuaries and floodplains. A critical examination of the number and operation of determining authorities in relation to acid sulfate soil development could prove useful.

In its examination of the management of selected coastal rivers, the NSW Health Rivers Commission has concluded that there is no single authority with sole responsibility for the health of the river systems. Indeed it has identified that there are conflicting objectives amongst those agencies currently managing rivers and estuaries. Their suggested solution has been the appointment of a River Manager with sole responsibility for the health of the river. Victoria, with a similar but broader aim, has established Catchment Management Authorities with considerable responsibilities, power and resources. In NSW, both solutions appear unacceptable, at present, since they introduce, essentially, an additional level of government.

Rapid and profound changes are occurring in the way the Australian environment is managed. Some are the result of the national thrust for Ecologically Sustainable Development, some resulting from National Competition Policy and the COAG 1995 reform process. These changes include (Dovers and Guillett 1998):

- a move away from regulation towards self-regulation, codes of practice and agreements;
- 'marketisation' of government authorities and the reduction of government involvement through outsourcing, corporatisation and the application of market-based policy instruments;
- a large shift to community participation and involvement in environmental management and monitoring;
- increasing use of risk assessment and management approaches and policy and decision making in the face of uncertainty;
- a strong regional focus in planning, policy implementation and program delivery.

The efficacy of self regulation for acid sulfate soil development deserves critical examination. The 'marketisation' of government authorities has considerable implications for the management of estuarine environments. It has lead to the downsizing of management and regulation departments with associated loss of corporate memory, and the reliance on consultancies whose products are of variable quality. Monitoring, an expensive process, is often an early casualty, and there is a danger that the considerable store of data will either be more difficult to access or will be lost. Downsizing also means that the supply of advice to local government and community groups involved in environmental management inevitably decreases. Indeed, the very necessary supply of back-up advice and information to such community groups has not been adequately resourced in the transfer of responsibilities to these groups for acid sulfate soil management.

Regionalisation does have the advantage of transferring assessment and decision making back to the affected area. This ought to move these responsibilities back to the community. Since regional bodies in NSW are appointed by state government, this possibility is weakened. Regionalisation also tends to duplicate functions and tends to diminish or even abandon activities where the centralisation of knowledge and skills is appropriate. The effect of all these changes on the management of coastal floodplains and downstream impacts is not described and would make an important and useful study.

Concluding comments

This paper has outlined the interaction of hydrology, flood mitigation and drainage of sulfidic coastal lowlands and their ecological impacts in NSW. On one hand, our attempts to control flooding have been successful in that they have allowed successful agriculture. On the other, this has promoted the oxidation of acid sulfate soils and down steam ecosystems have deteriorated. A cause buried in the past has resulted in persistent, episodic ecological emergencies due to periodic stream acidification. The decline of oyster production in NSW over the last 20 years is but one example that our estuaries and coastal catchments have problems. Any procedure which involves draining of flooded coastal lowlands or breaching of levees for emergency management, without proper treatment, runs the risk of producing a chronic acidic water discharge with serious ecological, economic and social consequences which are reversed only with difficulty.

There are a plethora of laws applicable to coastal lowland management. It would be valuable to review the role and efficacy of that body of legislation and its use in maintaining and improving estuarine health. In particular, an urgent review of the Drainage Act of 1903 is long overdue. There is also a pressing need to consider how coastal river systems might best be managed. The recent trends in environmental management in Australia to self regulation, marketisation, regionalisation and agency down sizing have very important implications for coastal floodplain management and ecology. These remain to be fully explored.

Acknowledgments

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Refereed

New Books

The day the sky fell down: the story of the Stockport air disaster

Morrin, Stephen
Stephen Morrin, Stockport, England, 1998, 145pp

10 am on Sunday 4 June 1967, a British Midland Airways, Canadair C-4 Argonaut airliner packed with returning holidaymakers from Palma, Majorca, turned onto the approach to Ringway Airport, Manchester. To Captain Harry Marlow and his First Officer Chris Pollard at the controls, it seemed a perfectly normal approach. The slight drizzle and low cloud presented no kind of hazard, yet nine minutes later the aircraft lay a tangled, twisted exploding wreck in the centre of Stockport. Of the 84 passengers and crew on board, only 12 survived. What went wrong?

Safe havens from bush fires: planning a response to external fire threats for schools, hospitals and other public buildings and the community

Bush Fire Service of Western Australia
Bush Fire Service of Western Australia, Perth, 1998, 16pp

Bush fires are annual events in Western Australia, threatening communities with the risk of death, injury, destruction or damage of property. The purpose of this document is to consider the threat of bush fires to communities, and the identification and development of public buildings as a community safe haven. Public buildings which may be considered for development as a safe haven include those with large populations or features that consider the welfare of a large cross section of the community, such as schools, halls and hospitals.

America's disastrous disaster system

Hunter, J. Robert
Consumer Federation of America, Washington, D.C., 1998, 14pp

This paper asserts that the U.S. has allowed its system of preparing for and responding to natural disasters grow in a haphazard way that inconsistently deals with these events and inadequately acts to save lives and property from loss.

It examines the risks due to flood, wind, and earthquake; how we cover the costs of these risks; current problems in covering these costs; and why the current system needs to be changed. It also suggests a system that ends taxpayer subsidy of anticipated levels of damage, moves the cost of high risk to those who live in high-risk areas, and minimises death and damage due to unwise construction.

Disasters and the media: managing crisis communications

Harrison, Shirley
Macmillan, Hampshire, England, 1999, 238pp

Covers issues on: Crisis, emergency and disaster — Television news — The national crisis — The local news — The local crisis — ommunicating in an international emergency — Civil emergencies and the media — The Hillsborough disaster — A newspaper at the heart of the Hillsborough tragedy — A tale of two cities: Liverpool — A tale of two cities: Sheffield — The management of an organisation in crisis — Learning the lessons — Training and rehearsal — Media liaison: lessons from the front — Postscript.

Cooperating with nature: confronting natural hazards with land-use planning for sustainable communities

Burby, Raymond J
Joseph Henry Press, Washington, D.C. c1998, 356pp.

Covers issues on natural hazards and land use: an introduction — Planning and land use adjustments in historical perspective — Governing land use in hazardous areas with a patchwork system — Integrating hazard mitigation and local land use planning – Hazard assessment: the factual basis for planning and mitigation — Managing land use to build resilience — The third sector: evolving partnerships in hazard mitigation — The vision of sustainable communities — Policies for sustainable land use.