Fish Habitat Guideline FHG 005

Fisheries Guidelines
for

MANAGING PONDED PASTURES

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FHG 002:
Hopkins, E., White, M. and Clarke, A. (1998) *Restoration of Fish Habitats: Fisheries Guidelines for Marine Areas*, Department of Primary Industries, Queensland, Fish Habitat Guideline FHG 002, 44 pp.

FHG 003:
Bavins, M., Couchman, D. and Beumer, J. (2000) *Fisheries Guidelines for Fish Habitat Buffer Zones*, Department of Primary Industries, Queensland, Fish Habitat Guideline FHG 003, 39 pp.

FHG 004:
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- innovative science and commercial uptake of new technology by food and fibre industries
- sustainable use of natural resources
- food safety and protection against imported pests and diseases
- market-driven and ethical food and fibre production.

These Guidelines identify the potential and actual impacts that ponded pasture has on native fish movement and survival and recommends ways in which these impacts can be mitigated.

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1.0 Introduction

These fisheries guidelines identify the potential and actual impacts that ponded pasture has on native fish movement and survival and recommend ways in which these impacts can be mitigated. Those property owners maintaining ponded pasture in coastal areas should consider this information to ensure impacts on the movement and survival of native fish are avoided or minimised.

> Ponded pasture is a permanent pasture system where water is impounded by banks and adapted grasses are grown in the water for green high quality fodder when the water dries off (Miles & Wildin 1996).

Why are Ponded Pastures a Concern to Fisheries?

Wetlands perform an essential ecological role in maintaining natural resources by providing access to and from freshwater, estuarine and marine habitats for refuge, reproduction, feeding, recruitment, nursery and growth for many coastal fishes (Garrett 1991). Fisheries production levels in inshore waters appear directly related to the quality of adjacent coastal wetlands. Rural developments involving wetland areas such as ponded pasture, can diminish their ecological function and adversely impact fisheries by disrupting fish movement and survival.

Ponded pasture has been established in riverine and coastal habitats by building banks across and adjacent to coastal waterways to limit tidal intrusion and encourage pasture development (Hyland 2002). The development of the ponded pasture usually relies on 3 exotic grasses: hymenachne (*Hymenachne amplexicaulis*), para grass (*Brachiaria mutica*), and aleman grass (*Echinochloa polystachya*).

Fish movement and survival between freshwater, estuarine and marine habitats, may be disrupted by:

- inappropriately designed and located ponded pastures; and/or
- the escape and invasion of hymenachne, para grass and aleman grass into natural wetland systems.

2.0 Background

Ponded pastures in Queensland extend from the coastal areas of Central Queensland to the Dawson and Callide Valleys, the Mackenzie-Isaac Rivers, along the Fitzroy River, to Capella, Clermont, Jericho, and north of Aramac. Other locations include Charters Towers, around the Burdekin, Mt Garnet and the Gulf Country in north Queensland (Wildin 1991).

The reported benefits of ponded pastures to cattle producers include the capacity for higher stocking rates (0.3-0.6 animal/ha), provision of high quality feed, provision of "out of season" forage, and realisation of good dry matter yields (>30 t/ha/yr) (Middleton *et al.* 1996). The availability of high quality fodder from ponded pastures during the dry season allows producers to maintain and/or improve the condition of cattle and provides greater marketing flexibility. Ponded pastures have also been promoted as a means of "drought proofing" certain grazing properties, particularly in regions where rainfall is low or unreliable. Murphy and Wildin (1996) also report that ponded pastures have the potential to reduce the need for dry season supplement for cattle.

The development of pondage systems continues to rely on the introduction of 3 exotic grasses:

- Hymenachne (*Hymenachne amplexicaulis*)
- Para grass (*Brachiaria mutica*), and
- Aleman grass (*Echinochloa polystachya*).

Hymenachne and aleman grass are native to South America and were introduced into Queensland in the 1970s. Para grass is native to South Africa and possibly South America (Cameron and Kelly 1970), and was released in 1880. All species are highly water tolerant and capable of growing in greater water depths than those for native water tolerant pasture species (Hyland 2002). Para grass is capable of growing in water up to 60 cm deep while hymenachne and aleman grass may grow in water 2 m deep (Humpries *et al.* 1994). These grasses are now regarded as invasive weeds in freshwater wetlands systems and other waterways of Queensland.

Legislation

Concerns over the effect of ponded pastures on coastal wetlands and on coastal fishing and fisheries were expressed by the Capricorn Coast Fisheries Area Advisory Committee and the Queensland Commercial Fishermen's Organisation (Luck 1991). In a response the Queensland Government established an Interdepartmental Ponded Pasture Steering Committee (industry groups, community groups and government agencies, supported by public submissions) to develop policy options that would control the location, design and management of ponded pastures. In 1991, the then Queensland Minister for Environment and Heritage announced a moratorium on new ponded pasture banks being constructed below highest astronomical tide (HAT), with repair and maintenance works to be allowable on existing banks.

In June 2001, the Queensland Government adopted the *Ponded Pastures Policy* to replace the moratorium. Three (3) government agencies and a number of key stakeholders were involved in the development of the Policy – Department of Natural Resources, Mines and Energy (NRM&E), Environmental Protection Agency (EPA) and Department of Primary Industry & Fisheries (DPI&F) – with NRM&E having primary responsibility for its implementation. For the purposes of the Policy, ponded pastures are defined as:

> "*the practice developed by pastoralists to create an environment by either the construction of banks or the modification of naturally wet areas, in which fresh water is impounded or used primarily to grow suitably adapted plant species and produce fodder for grazing*".

The Policy position statement indicated that ponded pastures should only be located in areas that are **not**:

- tidal areas below Highest Astronomical Tide (HAT); or
- in or adjacent to natural wetlands; or
- of high conservation or fish habitat values.

The Policy deemed that existing banks that impound freshwater or prevent seawater incursion should remain. The development of ponded pastures in other areas should proceed only where proponents can demonstrate that there will be minimal and acceptable environmental impacts. However, proponents will need to demonstrate that proposals to develop ponded pastures meet ecological sustainable development principles. This is strongly reinforced in the *Curtis Coast Regional Coastal Management Plan 2003.*

Controls dealing with the development and approval of ponded pastures in tidal habitats do exist under the *Fisheries Act 1994*. A Waterway Barrier Works Approval is required for the building of new works, or raising of an existing structure, across a waterway (freshwater or tidal) (Peterken 2001). The *Fisheries Act 1994* also protects all intertidal vegetation (i.e. saltcouch, mangroves, and seagrasses) (Couchman and Beumer 2002). Prior to any works on intertidal areas proceeding advice should be sought on whether a permit to remove or otherwise damage a marine plant is required.

Other legislation that affects ponded pastures includes the *Coastal Protection and Management Act 1995* which restricts the construction of works in, on, over, through or across land which is affected by tidal waters. Local government Planning Schemes, prepared under the *Integrated Planning Act 1997,* may make ponded pastures an assessable development

Within in the Fitzroy Basin, there is currently a moratorium on control of overland flow water. The State Government introduced this moratorium while the Basin's Water Resource Plan (formerly known as the Water Allocation and Management Plan) is amended to include the management of these flows. This means that the construction of banks for ponded pastures cannot commence because the banks take and interfere with overland flow (NR&M 2001). However, maintenance and repair works to existing banks for ponded pastures within the original specifications are not affected by the moratorium (NR&M 2001).

3.0 Fisheries Considerations

A number of fisheries management issues were identified by Hyland (2002) following an investigation of the impacts of ponded pastures on barramundi and other finfish populations in tropical coastal wetlands of Queensland. These formed the basis for developing these Guidelines for the better management of the impacts of ponded pastures on fisheries resources. Including the following:

- the management of water flows for fish movement,
- the management of water quality for fish survival, and
- the management of coastal modifications.

Assessing the impacts of ponded pastures on different ecosystems is reflected in the level of management required.

Fisheries Approach to the Classification of Ponded Pastures

Ponded pastures may be classified in terms of the ecosystems in which they are located. Using this approach ponded pastures may be classified into 2 categories (refer to Figure 1).

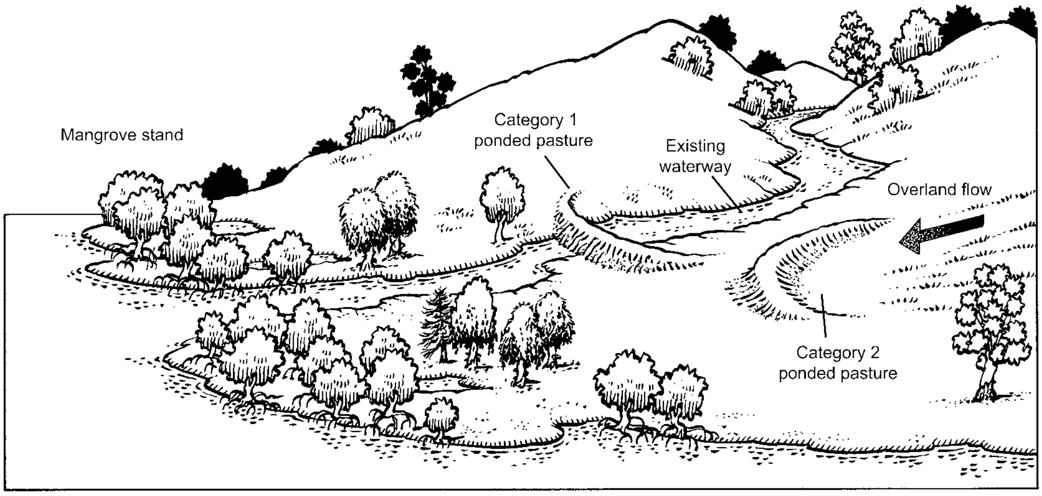

Figure 1. Ponded pastures, Category 1 - considerable impacts on marine or estuarine ecosystems. Category 2 - minimal interference with natural downstream processes in marine or estuarine ecosystems.

Category 1 Ponded Pastures

Ponded pastures, with banks located across a waterway, in tidal areas or in or adjacent to natural wetlands, that interfere with the normal tidal flows and have considerable impacts on marine or estuarine ecosystems.

This category includes ponded pastures where banks are located across a waterway in freshwater, estuarine or marine ecosystems and where ponded pastures are located in tidal areas or in or adjacent to natural wetlands.

In particular, this category considers the impacts on fish habitats and fish movements from ponded pastures situated in tidal areas below Highest Astronomical Tide (HAT) or in or adjacent to natural wetlands including:

- restrictions to fish movement and survival between marine, estuarine and freshwater habitats; and
- the potential to impact on saltcouch, mangroves and other coastal wetlands.

As a result of these and related impacts, the *Ponded Pastures Policy 2001* no longer permits the construction of 'new' banks in these estuarine and marine ecosystems. However the Policy deems that 'existing' banks should remain.

For this category, these Guidelines will address the impacts within the maintenance of existing ponded pastures to enhance water flows and water quality for fish survival and movements and the restoration of fish habitats in coastal wetlands.

Category 2 Ponded Pastures

Ponded pastures, with banks located parallel or adjacent to waterways in predominantly freshwater habitats, that generally have minimal interference with natural downstream processes in marine or estuarine ecosystems.

This category includes ponded pastures with banks located parallel or adjacent to a waterway in predominantly freshwater or terrestrial ecosystems which are not directly connected to marine or permanent freshwater ecosystems.

Ponded pastures in this category generally have relatively minimal interference with natural downstream processes in marine or estuarine ecosystems. The main impacts associated with these ponded pastures include:

- the escape and invasion of introduced grasses such as hymenachne, para grass and aleman grass, into natural waterways.

For this category, these Guidelines will address the maintenance of existing ponded pastures for fish survival and movements in wetlands adjacent to these pastures.

4.0 Fisheries Requirements

Restrictions on the Construction of Ponded Pastures

As already mentioned in section 3, there are currently 2 management measures that regulate the construction of ponded pastures in Queensland.

1. The ***Ponded Pastures Policy 2001*** no longer permits the construction of ponded pastures in tidal areas below HAT, in or adjacent to natural wetlands or in areas of high conservation or fish habitat value. Furthermore, the Policy deems that the development of ponded pastures in other areas should only occur if the proponents can demonstrate that there will be minimal and acceptable environmental impacts.

2. The **Moratorium on Overland Flow Water** prohibits the construction of ponded pastures in the Fitzroy Basin. The Moratorium remains in place while the Basin's Water Resource Plan is amended to include the management of overland flows. The Moratorium also limits the maintenance of existing structures to within the original specifications.

Copies of these documents may be obtained by:
- Phoning NRM&E on 07 3896 3111;
- Visiting a NRM&E regional office; or
- Downloading a copy from the NRM&E website.

For a copy of the *Ponded Pastures Policy 2001*on line please go to:
http://www.nrme.qld.gov.au/land/management/pdf/ponded_pasture.pdf

For a copy of the Overland Flow Moratorium on line please go to:
http://www.nrme.qld.gov.au/wrp/pdf/general/m_ofw.pdf

Management of Category 1 Ponded Pastures

Category 1 ponded pastures are those with banks located across a waterway, in tidal areas or in or adjacent to natural coastal wetlands (refer to figure 1).

The management of Category 1 ponded pastures focuses on:

- managing fish movement around ponded pasture banks;
- managing ponded pastures for fish survival; and
- managing the impacts on coastal wetlands.

Managing Fish Movement Around Ponded Pasture Banks

Ponded pastures located in marine and estuarine ecosystems have the potential to disrupt the movement of fish between instream and offstream aquatic habitats (Hyland 2002). Fish such as barramundi, spawn near the mouths of estuaries and young juveniles utilise coastal swamps, supralittoral saltpans and marine plains as nursery areas (Coates and Unwin 1991). The role of coastal wetlands as fish nursery areas relates to the provision of shelter and food for juvenile stages of a variety of fish species (Hyland 2002). Older juveniles, although they may enter these areas, use the more permanent tidal creeks and the freshwater reaches of coastal rivers. Ponded pastures which prevent access to and from these areas will have an adverse effect on fish populations.

Recommendations for managing water flows to facilitate fish movement to and from ponded pastures, including the use of nature-like fishways, are addressed below.

Nature-like Fishways

Fishways are structures that allow fish to move freely past the banks to access previously isolated habitats up or down stream. In particular, nature-like fishways are informal structures designed to imitate naturally occurring riverine structures that provide fish passage past barriers (Thorncraft and Marsden 2000). Nature-like fishways are used to provide fish passage over low barriers where formal fishways designs are inappropriate or not cost effective. Nature-like fishway technology and construction techniques required for low barriers are relatively simple, with limited engineering expertise required (Marsden, Thorncraft and Woods 2003). In addition, because of the informal nature of their design, these structures are often cheaper to construct than technical fishways (Thorncraft and Marsden 2000). Nature-like fishways fall generally into two categories:

1. Bywash or bypass channels
2. Rock ramp fishways.

Bywash or Bypass Channels

Bywash or bypass channels divert excess flow out of the pondage area back to the adjacent waterway. These channels play an important role in directing fish back to the main natural waterway channel, and in minimizing the risk of the main bank breaching.

Bywash or bypass channels consist of long low gradient (1:50 to 1:200) channels built on or above the bank to pass around a barrier (Thorncraft and Marsden 2000). Aspects of the design of a bywash include a minimum height to deal with storm runoff. If the bypass or bywash channel is inappropriately located or inadequate to cope with storm run-off, water will flow over the lowest parts of the bank causing it to fail (Wildin and Chapman 1988). A level bywash or bypass channel area is a necessity so that banks are not breached and that these channels are not eroded.

Importantly, fish must be attracted and guided to the bywash or bypass channel. This occurs when the bywash diverts excess water in the direction of main channel (Parasiewicz *et al*. 1998). This requires an adequate flow of water to facilitate fish movement at critical migration times.

Rock Ramp Fishways

Rock ramp fishways (1:20) are generally steeper than bypass channels (Thorncraft and Marsden 2000) (refer Figure 2). The rock ramp fishway uses large rocks in transverse ridges, creating pools and small falls, to mimic stream riffles (Harris *et al.* 1998). They are usually constructed from easily sourced materials such as rock and timber. Initially, the rock ramp fishway was used as erosion control structures as well as providing fish passage (Thorncraft and Marsden 2000). The rock ramp is one of the most versatile fishway designs. As long as certain design principles are satisfied, these structures have the ability to operate on a range of flows (Thorncraft and Marsden 2000).

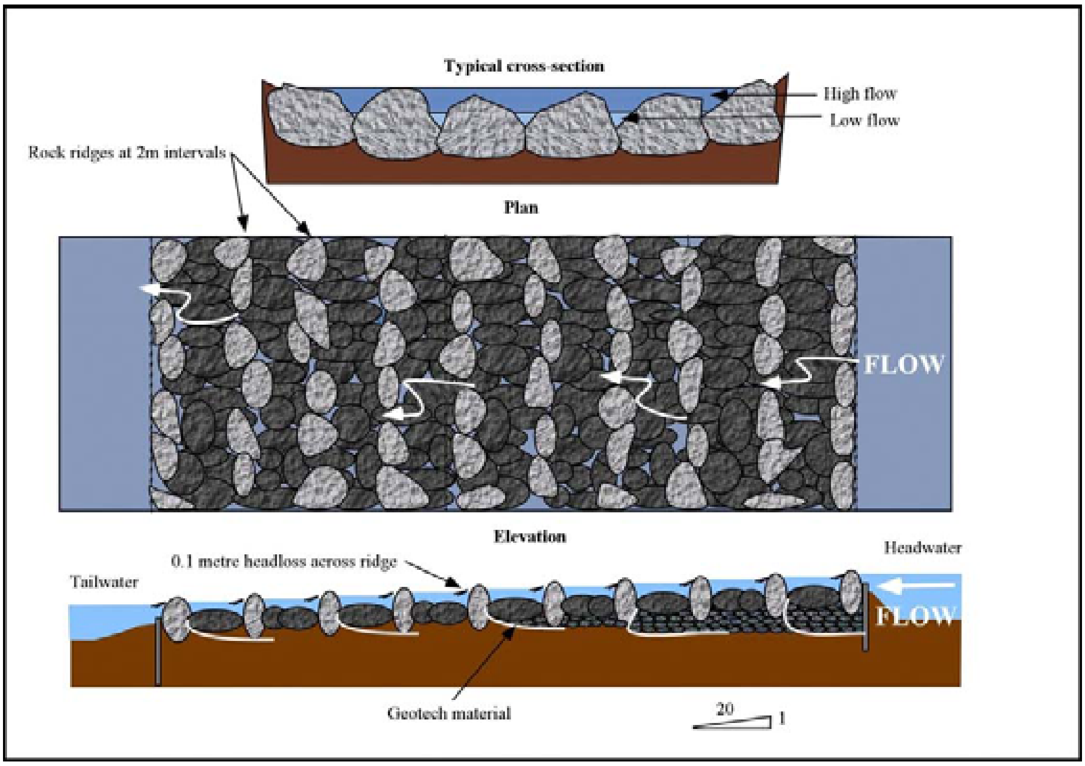

Figure 2. General layout of a Rock-ramp fishway.

Source: Timothy Marsden (Fisheries Biologist), Department of Primary Industries and Fisheries.

For each situation, the viability of the fishway's design should be carefully assessed.

Construction Material For The Rock Ramp

Rock and/or timber are used to form the bulk of the fishway, with small amounts of concrete or steel used to ensure the stability of the structure (Thorncraft and Marsden 2000). Rock is generally more suited to larger ramp fishways and timber is more appropriate to smaller ramps. However, depending on availability and cost, a mixture of materials may be used (Thorncraft and Marsden 2000).

Elevation Features Of A Rock Ramp

The slope of the fishway needs to be as close as possible to a consistent 1:20 grade. Any sudden dips or rises in the ramp may create pressure drops that create high water velocities and turbulence that prevent fish passage (Thorncraft and Marsden 2000). When using natural material, a general aim of achieving an average vertical fall of 0.1m per every 2 horizontal metres should form the basis of construction methods (Thorncraft and Marsden 2000).

Surface Of The Rock Ramp

The surface of the ramp needs to be formed-up into a series of transverse ridges at two metre intervals. The ridges control the flow and randomly placed rocks ensure the velocity of the flow is reduced to a level within the swimming capabilities of most species of fish. As no two rocks are the same shape, the ridges and pools will not line up in neat rows, which thereby creates a diversity of water flows and depths throughout the ramp (Thorncraft and Marsden 2000).

Cross Section Of The Rock Ramp

As shown in Figure 2, the ramp should have a generally v-shaped cross section. This concentrates water into the low flow channel during reduced flows and maximises the depth of water in this section of the fishway. During high flows, the low flow channel will carry a greater mid-depth of water, reducing the effect of roughness of the ramp surface, resulting in generally higher water velocities (Thorncraft and Marsden 2000). In higher flows the sides of the ramp will become inundated and it is these areas that will increasingly provide fish passage until the whole structure overflows (Thorncraft and Marsden 2000).

Maintenance of Fishways

Maintenance inspections of the fishway after high flow periods and at least after the last of each summer flow period ensure that the fishway is effective in transferring fish. This would identify (and rectify) any shift in the rocks and any debris that needs to be removed from the fishway (McGill and Marsden 2001).

Where can I get More Information and Assistance on Installing Fishways?

For a copy of the Fisheries Guidelines for Fish Passage in Streams FHG 001 on line please go to:
http://www.dpi.qld.gov.au/fishweb/2887.html

Please contact the DPI Call Center on 13 25 23 for additional information.

Managing Ponded Pastures for Fish Survival

As already mentioned, the migration of fish between freshwater, estuarine and marine environments is associated with flow conditions. Despite the property owner's best efforts to manage water flows between these environments, fish can get trapped behind ponded pasture bank and fish kills may occur. However, if the ponded pastures do not dry out completely, these artificial wetlands have the capacity to provide a fish habitat in the dry season (Hyland 2002).

The mortality of fish trapped in ponded pastures can be attributed to a number of characteristics. Ponded pasture systems are generally shallow and unshaded and exhibit characteristics indicative of poor water quality. Hyland (2002) reported that water quality in ponded pastures was periodically poor, especially during the dry season (June – October) with high pH, low dissolved oxygen and high temperatures. In addition, ponded pastures can be subject to increased loads of sediment and nutrients from overland flow as these are retained behind the ponded pasture bank.

The survival of fish, particularly juveniles, in ponded pastures during periods of low flow is dependent upon an adequate volume of water of a high quality. Management considerations for water volume, dissolved oxygen, temperature, sedimentation and nutrients are outlined in this section (refer to Table 1).

Table 1. Impacts and concerns effecting the survival of fish in ponded pastures.

Water Volume	Survival of fish trapped in ponded pastures will requires maintenance of an adequate volume of water. Many ponded pastures are in low rainfall areas, are generally shallow (<1m) and have a relatively large surface area. The critical issue to maintaining fish survival in these systems is firstly to ensure adequate water volumes throughout the year.
Dissolved Oxygen (DO) Levels	Low-dissolved oxygen levels can potentially cause fish kills. Low levels are associated with high water temperatures, inadequate volumes of water, crowded conditions and outbreaks of blue green algae. Algae contribute oxygen into the water during the day, but remove it at night, so oxygen levels are at their lowest at sunrise. This is when fish may be stressed and fish kills are more likely to occur. Para grass and hymenachne can break through the water surface reducing wind velocities and preventing adequate oxygen exchange.
Temperature	After dissolved oxygen, water temperature may be the single most important factor affecting the condition of fish. Fish body temperature varies with that of their surroundings. The temperature of the water affects the activity, behaviour,

	feeding, growth, and reproduction of all fish species. Temperature also determines the amount of dissolved oxygen in the water, with DO decreasing rapidly as temperatures rise. Low water levels in ponded pastures contribute to higher temperatures and reduced DO.
Sedimentation	Sedimentation of ponded pastures can have a pronounced effect on water quality and fish health. Sediment can clog and abrade fish gills, suffocate fish eggs and aquatic insect larvae, and cause fish to modify their feeding and reproductive behaviour. It also reduces the depth and storage capacity of the ponded pasture.
Nutrients	Probably the most significant impact of nutrients on ponded pastures is eutrophication: the excessive growth of algae and other aquatic plants in response to high levels of available nutrients. When plant growth becomes excessive, the ponds may become depleted of oxygen, largely due to decomposition of plant material. This can affect the ongoing ability of a water body to support plant and animal life. Management of stock watering can be critical during blue-green algae outbreaks. Hyland (2002) reported blooms of blue green algae at one of the study locations which appeared to be associated with fish deaths.

Deep-water reservoirs and buffer zones are considered appropriate strategies, managing issues associated with water volume, dissolved oxygen levels, temperature, sedimentation and nutrients.

Deep Water Reservoirs

Deep water reservoirs are deeper sections or borrow pits within ponded pastures (refer to Figures 3 and 4). These play an important role in supporting fish that are trapped behind banks, by providing a fish refuge that has adequate water depth and water volume of high quality. This is particularly important during periods of low rainfall.

Deep water reservoirs should be located in areas that reflect the natural depressions of the land (i.e. the last place for water to dry up). They can be constructed by utilising borrow pits. Borrow pits result from fill excavated for the construction of the ponded pasture bank. Borrow pits should be excavated about 6 m away from the bank to discourage scouring.

The minimum water depth in the reservoir needs to be 3.0 - 3.5 m during the dry season. This is more than the maximum depth that hymenachne or any other ponded pasture grass, for example, para grass and aleman grass, will root in. This depth will also allow an adequate water temperature to be maintained. Maintenance of this depth throughout dry periods will give fish temporary habitat till the next ‘wet season’.

Features that will reduce evaporation from ponded pastures assist in the maintenance of water levels and volumes. Planting trees along the northern bank will provide adequate shade to reduce evaporation and maintain cooler, more even temperatures in the summer months. In addition, trees play an important role in filtering sediments and nutrients from land runoff (refer to next section on ‘Buffer Zones’).

The minimum length of the deep water reservoir needs to be 20 m. This will create a surface area extensive enough to prevent para grass completely covering the water's surface, and provide enough clear surface area for sufficient oxygen exchange. To further encourage oxygen exchange, the deep water reservoirs should be aligned along the path of the prevailing wind (usually south east to north west). Ripples created on the top of the reservoirs help raise the oxygen levels in the water.

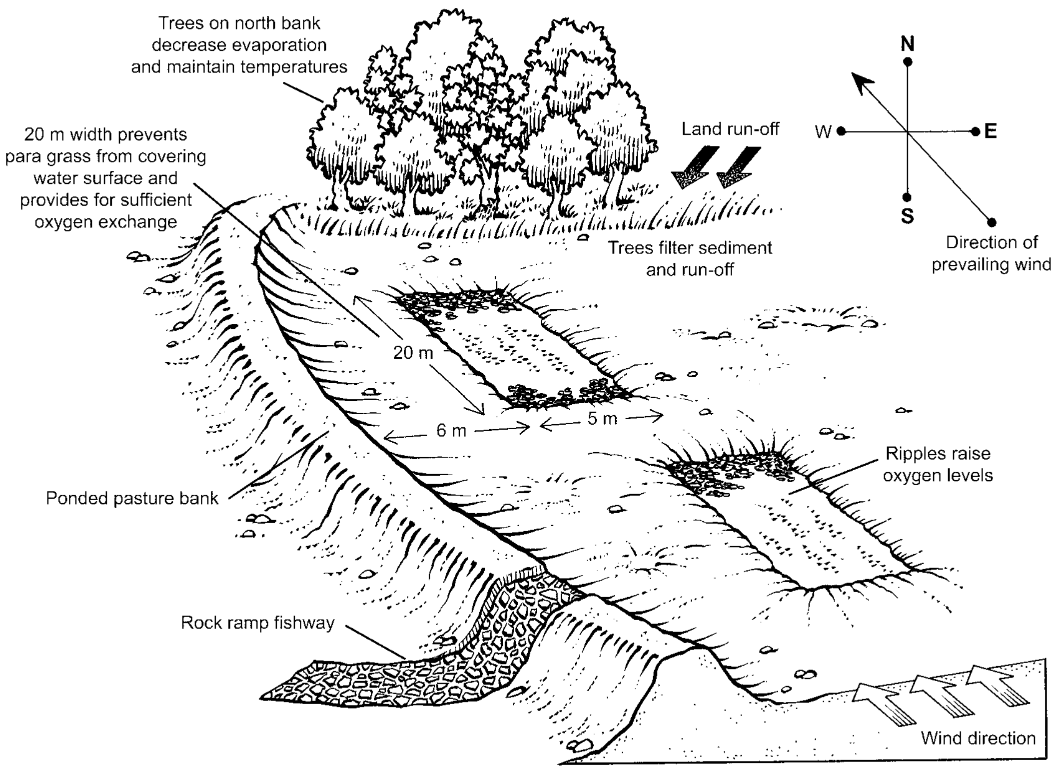

Figure 3. Optimal ponded pasture layout provides maximum fisheries benefits; note deep water reservoirs and buffer zones.

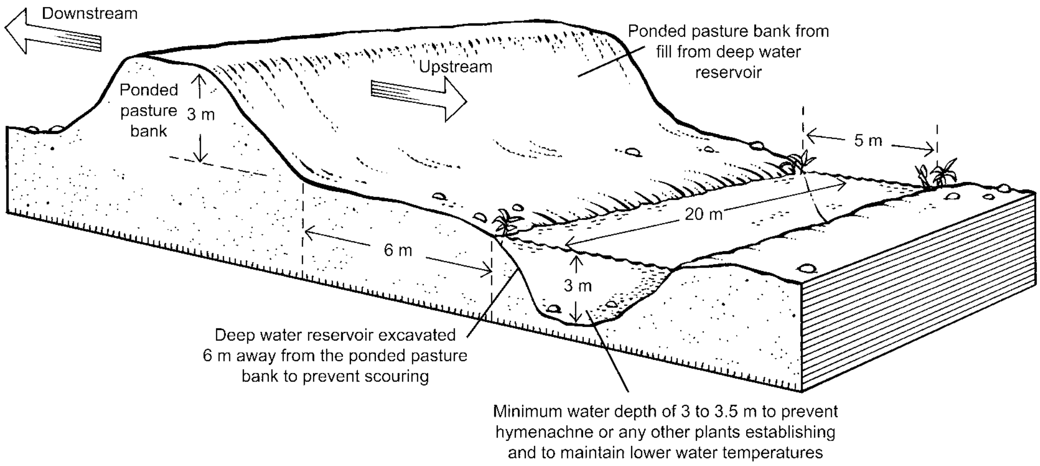

Figure 4. Cross section of a deep water reservoir; formed from excavated borrow pit with soil removed to provide maximum depth of 3 - 3.5 m during the dry season.

Buffer Zones

Buffer zones have been found to be effective filters for sediments and nutrients, including trapping nitrogen and phosphorous from land runoff. Many ponded pastures occurring on riverine plains or coastal plains have been designed to increase and maximise pasture and therefore usually contain few trees (Boyd 1990). The planting of trees around the pondage perimeter of the deep water reservoir (buffer zone) plays an important role in removing sediments and nutrients from land runoff before they reach the ponded pastures. This helps maintain the storage capacity of ponded pastures which can be reduced by increased sedimentation. In addition, trees planted along the northern side of the reservoir assist in maintaining even temperatures and reducing evaporation.

Buffer guidelines to reflect fisheries requirements have been prepared (Bavins *et al.* 2000) and are available on the DPI&F website at:
www.dpi.qld.gov.au/fishweb/4253.html

Hard copies can be obtained by contacting the DPI&F Call Centre on 13 25 23.

Managing the Impacts on Coastal Wetlands

Importance of Mangrove, Seagrass and Saltcouch Habitats

Coastal wetlands have a central role to play in the maintenance of many recreational and commercially important species of fish and crustaceans. Coastal wetlands are pivotal in providing shelter and food for a variety of fish species. In particular, saltcouch, mangroves and seagrasses provide key marine habitats for fish (refer to Figure 5).

Mangroves are not only important to commercial and recreational fisheries because of their role in providing feeding and shelter areas for many species of fish, they also play an active role in cycling nutrients. In addition, they help stabilise the coastline and reduce erosion from storm surges, currents, waves and tides.

Seagrass meadows are crucial habitat components for many species of marine fauna and provide a vital nursery and shelter for many commercially and recreationally utilized species (Byron 1991).

A permit under fisheries legislation is required if the construction of ponded pastures is to result in the removal of or damage to marine plants.

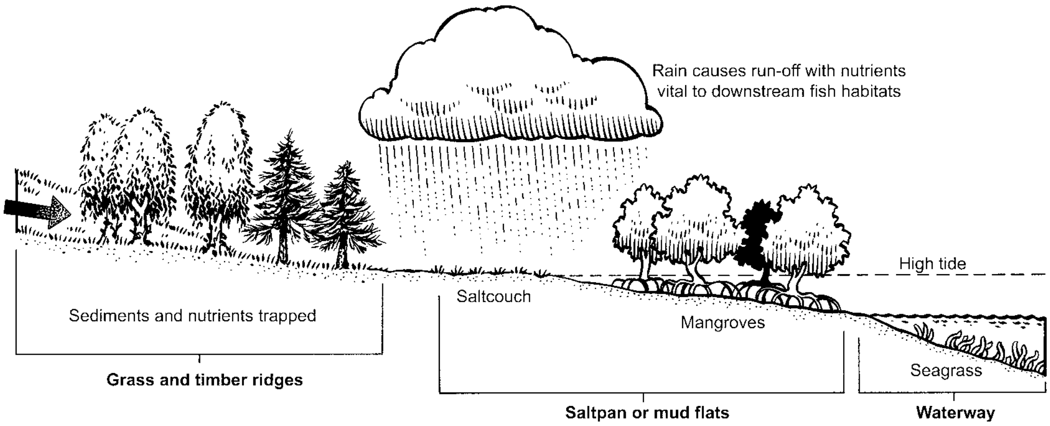

Figure 5. Coastal wetlands are pivotal in providing shelter and food for a variety of fish species. In particular, saltcouch, mangroves and seagrasses provide key intertidal habitats for fish.

Ponded pastures impact on these marine habitats by altering sedimentation rates, relief, local tidal flows, nutrient fluxes and acid sulfate soils (refer to Figure 6). In addition, ponded pastures have had a direct impact on saltcouch when ponded pasture banks have been constructed on cleared saltcouch areas. The degree of impact on surrounding ecosystems is governed by the ability of these impacts to be managed.

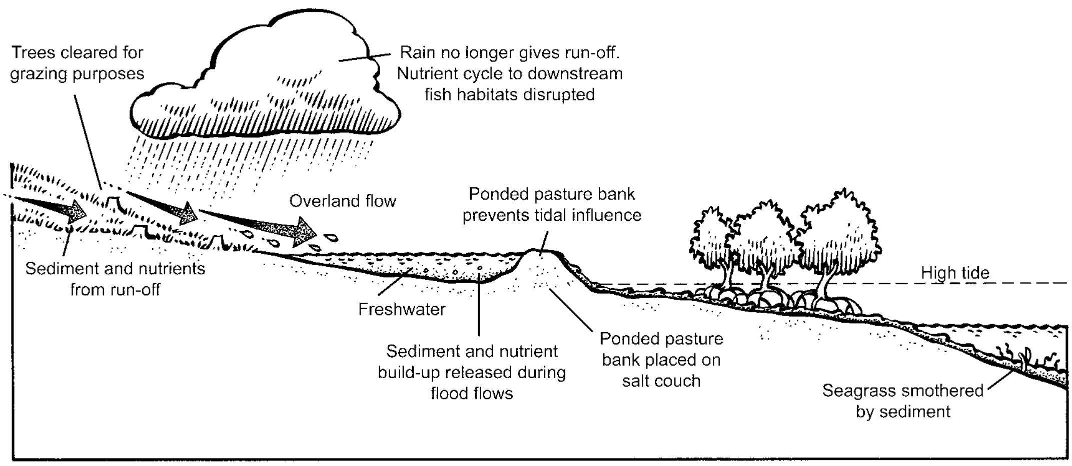

Figure 6. Category 1 ponded pastures have a significant effect on mangroves, saltcouch and seagrass meadows.

Sedimentation rates, nutrient levels, and acid sulfate soils are the effects of alterations in local tidal flows and relief and should be the focus of management actions.

Sedimentation and Nutrient Concentrations

Changes in sedimentation rates and nutrient concentrations are likely to occur in coastal wetlands adjacent to ponded pastures and will have a marked effect on both seagrass meadows and mangrove habitats (Byron 1991).

The Effects of Sedimentation on Mangroves

A balance between sedimentation and sediment resuspension is essential in maintaining mangrove stands. A certain level of sediment is required for optimum growth, with excess sediment causing reduced oxygen uptake by the roots (Byron 1991).

When pastures are ponded the sediment suspended in the water column settles out. This sediment accumulates behind the ponded pasture bank and is stabilised by pasture growth. Consequently the trapping of sediment behind the ponded pasture bank alters the level available for maintenance of mangroves (Byron 1991).

The sediment from the ponded pastures is generally only released during overtopping of the ponded pasture banks in a flood event. In such events, Bryon (1991) has reported that the velocity of the water is actively eroding sediment in existing mangrove stands and the silt flushed from the ponded pastures generally passes beyond the mangrove areas to the offshore sinks where it impacts on other habitats, including deep seagrass meadows.

The Effects of Sedimentation on Seagrass

Reduced sediment deposition in inshore areas will have a significant detrimental effect on the extent and diversity of seagrass meadows (Byron 1991). Conversely, during major flooding events if ponded pasture systems give way there is a real possibility that previously stored sediments will be released in bulk and may smother the seagrasses (Byron 1991).

In addition, deep water seagrasses could potentially be impacted by the temporary reduction in light caused by the increase in coastal runoff during the flood event (Coles *et al*. 2004).

The Effects of Nutrient Concentrations on Marine Habitats

Another concern is that during floods, nutrients are introduced into the coastal wetlands in larger than normal quantities, causing an overload of these elements (usually nitrogen and phosphorous) in the natural system.

The over-enrichment of coastal wetlands with nutrients can lead to excessive algal growth and algal blooms. In intertidal fish habitats, algal blooms can smother seagrass beds and mangrove roots and seedlings within coastal wetlands.

Management of Sediment and Nutrients

Management of sedimentation rates and nutrient concentrations on the land adjacent to coastal wetlands directly affects the level of impact of these factors on the wetlands themselves.

As already mentioned, buffer zones play an important role in filtering sediments and nutrients from overland flow before it reaches the ponded pastures. Refer to section on 'Buffer Zones'.

Acid Sulfate Soils (ASS)

There has been a marked increase in awareness of the impacts of disturbance of acid sulfate soils in coastal Queensland in recent years. As the majority of ASS is below five metres AHD (Australian Height Datum), there is possibility that the location and construction of ponded pastures and in coastal areas may involve ASS and their disturbance.

Ponded pastures in Category 1 are located in or near coastal wetlands. In many regions of Queensland, these habitats are known to contain potential acid sulfate soils (PASS) (Sammut and Lines-Kelly 1996). When these soils are exposed to air, usually during the construction of ponded pastures and limited tidal flows, acid is produced by the oxidation of iron sulfides. Runoff over these exposed soils collects acid and this effects both soil and water fisheries resources which can be severely impacted with short-term impacts including:

- Fish kills;
- Fish disease (red spot);
- Mass mortalities of aquatic organisms;
- Increased light penetration due to water clarity;
- Loss of acid sensitive crustaceans;
- Destruction of fish eggs; and
- Oyster mortalities.

Long-term impacts include:

- Loss of habitat;
- Alteration of aquatic plant communities;
- Reduced spawning due to stress;
- Chemical migration barriers;
- Reduced food resources;
- Dominance of acid-tolerant plants;
- Reduced fish growth rates;
- Changes in food chain and web; and
- Reduced availability of nutrients.

(Environment Australia 2000; National Strategy for the Management of Coastal Acid Sulfate Soils 2000)

Management of Acid Sulfate Soils

Areas affected by acid sulfate soils (i.e. low lying areas below 5m Australian Height Datum (AHD)), can be restored in accordance with the Queensland Acid Sulfate Soils Technical Manual. These guidelines are produced by Department of Natural Resources, Mines & Energy and outline the best practice management of acid sulfate soils. These guidelines are available on the NRM&E website at:
www.nrme.qld.gov.au/land/ass/qassit/qass_tech_manual.html

A Fisheries Officer should be contacted to discuss the development of a restoration plan if intrusive acid sulfate soils are affecting the management of the ponded pasture. Contact details are available on line at:
www.dpi.qld.gov.au

Management of Category 2 ponded pastures

Category 2 ponded pastures are those with banks located parallel or adjacent to a waterway in predominantly freshwater or terrestrial ecosystems which are not directly connected to marine or permanent freshwater ecosystems.

Generally, ponded pastures in this category have limited potential to act as fish traps because they are not directly positioned in fish migration pathways. However, during flood events fish may access and disperse into these areas and subsequently become trapped behind the ponded banks. In these instances the guidelines pertaining to category 1 ponded pastures apply and should be considered to reduce any impacts.

Managing Pasture Species to Prevent their Escape and Invasion of Natural Waterways

The management of ponded pastures described for this category focuses on:

- managing exotic pasture species to prevent their escape and invasion of natural waterways.

Extent of Risk

Deepwater grasses used in ponded pastures such as hymenachne, para grass and aleman grass, have the potential to spread throughout catchments via their waterways to locations where their establishment is undesirable. These exotic grasses are highly invasive in freshwater wetlands and have the capacity to displace the native species of aquatic plants (Hyland 2002). Exotic ponded pasture species, especially hymenachne, have escaped and invaded natural wetlands utilized as nursery areas for juvenile fish species. Control and/or eradication of this species has become a critical management issue in a number of Queensland catchments.

Hymenachne can grow in water up to 2 m in depth, while para grass and aleman grass can grow in water 60 cm deep. The ability of these species to reproduce vegetatively greatly increases the risk of these species easily spreading downstream. Downstream displacement is facilitated by breaks in retaining walls, flooding after storm events and the inadvertent spread by machinery during the development of ponds (Lukacs 1993).

Hymenachne can also spread rapidly by seed, readily germinating, and producing a dense seedling cover (Anning and Kernot 1991). Seed dispersal methods of hymenachne can be associated with the action of grazing animals (Clarkson 1991), wind, water, waterfowl, for example, magpie geese (Lukacs 1993) and machinery (CRC Weed 2004).

Hymenachne, para grass and aleman grass affects the movement and survival of fish because of their ability to clog streams, channels, dams and drains. In northern Australia these weeds have been responsible for eliminating entire wetland ecosystems and the environmental costs has far outweighed any economic benefits (Weed CRC 2004).

Management of Pasture Species

A weed strategy for hymenachne has been produced by the Weeds of National Significance Committee (2001). The strategy aims to prevent the further spread of hymenachne and minimize its adverse impacts on the environment. The management of hymenachne should be incorporated into a Property Management Plan that will reflect the issues addressed in the Local Government's Pest Management Plan.

Property owners can control the spread of exotic ponded pasture grasses weeds by:

- not planting them in the first place;
- maintaining banks to withstand high flows; and
- pulling out small infestations of these grasses in natural waterways.

Reoccurring outbreaks of hymenachne outside of ponded pasture areas can be eliminated by repeatedly applying bioactive roundup (Peter James *pers com* 2004).

Only small sections of hymenachne should be treated in each application, as the dead and decaying plant material will release nutrients into the water body and result in depletion of dissolved oxygen. The application of bioactive roundup is relatively ineffective through water so application for control and eradication should be at the end of the wet season when the target weeds are no longer submerged in water. The use of any herbicide should in strict accordance with the label and material safety data sheet (MSDS).

This management strategy applies to Category 1 ponded pastures. In addition, the management of pasture species in category 1, through maintaining the depth of deeper water reservoirs beyond the pastures rooting depth (refer to figures 3 and 4), may also be appropriate for Category 2 ponded pastures.

For a copy of the Strategic Plan for Hymenachne on line go to:
www.nrme.qld.gov.au/pests/wons/pdf/hymenachne.pdf

5.0 Fish Kills

Despite the appropriate design, location and management of ponded pastures, fish kills may still occur. Early reporting may allow for remedial action, for example, the relocation of surviving fish, to be undertaken.

The Environmental Protection Agency is lead agency for reporting and investigation of fish kills. The Hotline number is 1300 130 372.

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