NSW DEPARTMENT OF
PRIMARY INDUSTRIES

Hunter and Central Coast Sustainable Aquaculture Strategy

Readers' Note

This document is part of a larger publication. The remaining parts and full version of the publication can be found at:

http://www.dpi.nsw.gov.au/fisheries/aquaculture/publications/general-management-and-policy/hunter-and-central-coast-sustainable-aquaculture-strategy

Updated versions of this document can also be found at the above web address.

Planning and Design

Hunter and Central Coast Sustainable
Aquaculture Strategy
Land Based Aquaculture

A NSW Government Initiative

Hunter and Central Coast Sustainable Aquaculture Strategy

A NSW Government initiative of Department of Primary Industries, Department of State and Regional Development, Department of Environment and Conservation, Department of Lands, Department of Infrastructure, Planning and Natural Resources and NSW Premiers Department to encourage sustainable aquaculture in New South Wales.

Planning and Design

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1. Good planning and design are *Key* elements

Land-based aquaculture accounts for over 95% of world aquaculture fish production. Earth ponds are used for the production of fish in many regions of the world. They provide a practical, reliable and viable means of producing fish on a large scale provided attention is paid to selection of site and design. In addition to growing interest in pond culture, there is also increasing interest in the use of super-intensive tank recirculation systems. Evolving technology continues to improve reliability, performance and viability of these systems in certain production applications. Design and to a lesser extent selection of site are also important considerations in these tank systems.

Careful consideration of these issues can ensure sustainable economic production and environmentally friendly methods of producing a product that is a valuable commodity in the market place in Australia and abroad. The area of land selected for a fish farm should be large enough to include:

- the maximum number of ponds/tanks required plus holding ponds/tanks,
- reconditioning ponds/tanks (possibly 20+% of the total pond area),
- laboratory complex (and hatchery, if appropriate),
- packing and handling sheds, and
- administration, maintenance, storage, waste management facilities.

For freshwater complexes, on-site use of the reconditioned water may also need to be accommodated. In addition, it is preferable if there is sufficient capacity for future expansion.

There is no doubt that new and exciting advances in the design and operation of facilities will occur in the aquaculture industry during the next few decades. This reflects the dynamic and evolving nature of aquaculture in Australia. However, caution needs to prevail and the experience and knowledge already gained both in Australia and abroad should be utilised to best advantage. Too often effort and opportunities are wasted because of the lack of reference to available and relevant scientific and engineering information.

It cannot be over-emphasised that site planning and design are critical steps to the successful culture of farmed species. Sound planning and design will minimise the costs associated with the construction and management of ponds and associated environmental protection measures. These principles can equally be applied when building a new facility or expanding an existing aquaculture farm.

It should be noted that the construction of the pond/recirculation/ reconditioning system constitutes one of the major capital investments in pond fish culture and is also an important factor in the depreciation (most frequently over 10% of the operating costs). As a result, careful consideration should be given to design and layout options, as these factors will significantly affect the cost of fish production and environmental viability of the farm.

Once a site has been selected, a comprehensive feasibility study should be conducted on various layout, systems and management options to assess their strengths and weakness in terms of reliability of economic and environmental performance prior to finalising the design for the facility.

2. General site layout and design issues

Once a suitable site and species to be grown have been identified, the next important step is the physical site planning and design. Topography, site conditions and water availability are not the only factors influencing the design and layout of ponds. Available capital, costing, management factors such as stocking rates and the intended function of the pond (e.g. broodstock, nursery, wintering, grow-out) must also be taken into consideration.

The design and construction of an aquaculture facility must be carefully planned. Advice and assistance from professionals such as aquaculturists, water and soil chemists, engineers, irrigation and agricultural scientists, accountants and relevant Government Departments should be sought and used. Consideration should be given to whether a qualified consultant is needed to help in planning and also designing the enterprise taking into consideration environmental and other technical operational factors. In addition, the consultant may assist in preparing the documentation for the necessary approvals.

A detailed survey of the site should be undertaken so that facilities can be most efficiently located, to minimise construction costs and provide for the most efficient running of the operation. A plan detailing the farm layout, water supply, circulation and drainage lines, electricity lines, buildings, visual barriers etc. should be drawn up and pond specifications documented. Make a checklist and consult with Department of Primary Industries as to available information sources and what approvals may be required given the risk profile (see *Site Selection* and *Project Profile Analysis* Sections of this Manual).

2.1 Setback from any natural waterbody

As a general principle, all ponds, dams and internal drains should be set back at least 50 metres from a natural waterbody or wetlands.

There should be sufficient buffer so that if any pond water should overtop or be released, it will not drain directly into the natural waterbody. This separation distance also provides protection for the riparian vegetation and allows for natural hydrological processes such as bank erosion without putting the ponds at risk. The buffer areas should be vegetated so as to prevent erosion and minimise flow into the waterbody.

Preferred design:	Pond/dam setback of at least 50 metres from the bank of a natural waterbody or wetlands.

In addition, a vegetated buffer zone of not less than 20-40 metres should be maintained between any irrigated areas and the high bank of any adjoining watercourse. This vegetated buffer should be maintained so as to protect any existing native plant species.

It should be noted that a setback of more than 40 metres would avoid the need for a permit from DIPNR under the *Rivers and Foreshore Improvement Act 1948*. In addition, as Aboriginal sites commonly occur in the vicinity of waterways, a set back may reduce the likelihood of disturbance to Aboriginal sites.

2.2 Native vegetation

(a) Disturbance of native vegetation

Areas of significant vegetation on the site should be retained wherever possible.

The site layout for the ponds, dams, water intake, outlet and circulation system and operational facilities should be designed so as to minimise the destruction or disturbance of native terrestrial as well as aquatic vegetation or the habitat of native fauna.

Preferred design:	No native vegetation/habitat should be disturbed

The clearing of more than 2 hectares of native trees, shrubs or grasses will usually require an approval under the *Native Vegetation Conservation Act.* Reference should be made to any Regional Vegetation Plan prepared for the catchment. If the vegetation is within 40 metres of the bank of a waterway or wetland, an approval could also be required under the *Rivers and Foreshore Improvement Act (or new Water Act)*.

The water inlets and outlets should not be in the immediate vicinity of important seagrass beds or other aquatic vegetation communities. Any channels, drains, pipes or pumping equipment should be installed in such a manner so as to minimise disturbance of foreshore or aquatic vegetation communities (in particular mangrove communities).

If mangroves, seagrass or foreshore vegetation is to be disturbed by the inlet and outlet pipes or drains, an approval may be required under the *Fisheries Management Act* and *Rivers and Foreshore Improvement Act*.

Preferred design:	No disturbance of riparian vegetation, mangroves or aquatic habitat

(b) Threatened species issues

If terrestrial or aquatic threatened species, populations or ecological communities or their habitats occur on the site or in the area of impact, an 8 Part Test (S5A of the EP&A Act) must be undertaken. The 8 Part Test sets out the factors to be considered in determining whether there is likely to be a significant impact on threatened species, populations or ecological communities, or their habitats. If there is likely to be a significant impact on threatened terrestrial species or marine mammal or reptile species, populations or ecological communities, or their habitats, a species impact statement (SIS) must be prepared in accordance with the requirements of the *Threatened Species Conservation Act 1995*. The proponent must contact the DEC to obtain these requirements. The DEC maintains a register of critical habitat. If there is likely to be a significant impact on any threatened aquatic species, populations or communities or their habitats, a species impact statement will be required under the *Fisheries Management Act.*

The 8 Part Test should be referred to the consent authority prior to lodging the Development Application (DA) for it to decide if a SIS is required. For a more efficient process, the 8 Part Test (if necessary) could be referred to the consent authority at the same time as the Project Profile Analysis is referred, to determine the appropriate level of assessment for the proposal.

Preferred design:	No impact on threatened species, populations or ecological communities or their habitats

2.3 Landscaping issues

Where vegetation is to be cleared or lopped, the material should be mulched and used on the site to minimise erosion and to encourage revegetation of disturbed areas. Where areas are to be disturbed during the pond construction or other site works, the disturbed area should be revegetated as soon as possible using native species including grasses and herbaceous covers. Propagation material should be collected and available in a suitable form for use in the revegetation of disturbed areas, prior to disturbance occurring.

If none exist, native vegetation endemic to the area should be established as visual buffers especially for tank culture or sheds. Species should be carefully selected so that the trees are not likely to become habitat for predator species.

Preferred design:	3 metre wide vegetated buffer on the street alignment or around sheds

2.4 Heritage considerations

At the site selection stage, Aboriginal and non-Aboriginal heritage should have been considered. This preliminary assessment should have identified the more obvious heritage items such as heritage buildings, landforms, scar trees or middens and established their significance. At the planning and design stage, more detail survey work may need to be undertaken, especially in areas where minimal disturbance by agriculture or other previous land uses have occurred. As with site selection, information may need to be sourced from the DEC and the local Aboriginal community. In some cases, a detail archaeological survey (on land and/or under water) will be necessary.

If heritage items are present on the site, the project should be designed, whenever possible to ensure that there is no disturbance or impact on their significance, curtilage or setting. In areas where there has been minimal disturbance, heritage items may not be noticed or evident until appropriate assessments have been undertaken. With non-Aboriginal heritage, studies and archaeological zoning plans may provide guidance and information. With Aboriginal heritage, the DEC Aboriginal Heritage Information Management Systems and the local Aboriginal community may provide information. If items are discovered during construction or operation, works should cease immediately and the DEC contacted if Aboriginal sites are discovered, or the Heritage Office for other items. Prior to further disturbance occurring to Aboriginal sites, an approval is required from the DEC. Under s.140 of the Heritage Act, works involving the disturbance of other archaeological relics (land or under water) require a Heritage Council approval.

Preferred design:	If heritage items are present on the site, no disturbance or impact on their significance.

2.5 Noise issues

In the design and layout, every opportunity should be taken to minimise the impacts of the operation of the aquaculture facility on the neighbours and the broader community. Reference should be made to the DEC's Industrial Noise Policy (replaces the Environmental Noise Control Manual). Wherever possible noisy activities eg. truck loading areas or plant/equipment (pumps) should be located remote from neighbouring houses or in a location where there is an existing barrier between the noisy activity and the receiver. Where there is the potential for noise to become a nuisance, options to reduce noise impacts should be considered including

- quieter, insulated plant/equipment,
- enclosing the noisy activities in a building, or
- building of noise barriers.

The use of scare devices to manage predator birds can have significant noise nuisance implications. If there are residences within a kilometre, their use should not be considered to be the first line of defence in a suite of predator management options. When there are near-by neighbours, it is preferable that noisy devices only be used as a back-up. Prior to serious consideration of noise predator options, it is recommended that discussions be held with neighbours and the council to determine if acceptable protocols can be developed with neighbours regarding the use of noisy scar devices. It is critical that neighbours understand at the outset the likely frequency of use of the devices, the times of the day and year of their use, the loudness and likely affect on the birds. If neighbours do not understand what is happening, they are more likely to complain, especially if they think that birds are being killed.

2.6 Drainage and flooding controls

It is preferable for freshwater aquaculture ponds to be constructed above the probable maximum flood (PMF) level and estuarine ponds above the 1:100 year flood level. However a case by case evaluation can be considered for estuarine aquaculture farms with species that are indigenous to NSW.

Preferred design: so ponds/tanks not flood liable – Freshwater above PMF
– Estuarine above 1:100

The construction of banks, levees or above ground ponds which are likely to affect flood flows and levels can pose an increased risk to neighbours and possibly the catchment flood mitigation controls. Prior to the design of a flood prone site, an analysis of the flooding implications should be undertaken and discussed with Local Council. All flood works are to be constructed and installed so as not to obstruct the reasonable passage of floodwaters flowing in, to or from a river. These should be designed in consultation with DIPNR. The plans for levees or other floodworks should:

- specify the location and nature of the works,
- specify the level of the crest of the works, and
- analysis to indicate that flooding will not be increased on nearby land.

Preferred design so flood management will not effect passage of flood waters

In addition to considering the impacts of the project on flooding, the affect of the proposed layout and on-site drainage management on local stormwater management should be considered. The blockage of stormwater drainage passage across the site by ponds, drains, roads or other structures can result in problems for management and maintenance of the facilities as well as local flooding problems for neighbouring properties. It is preferable that there is no catchment stormwater drainage across to the site and if present, measures to manage the flows are available so as not to affect neighbouring properties or the environment.

Preferred design:	so as not to affect stormwater drainage

2.7 Waste management

The aquaculture farm should be designed from the outset so as to minimise waste and reuse and recycle materials at every opportunity. This includes:

- pond water,
- processing water,
- pond sludge and filter materials,
- processing wastes and dead fish, and
- packaging material.

The section *Operating the Farm* outlines classification of material which are not to be reused/recycled and are classified as wastes. Adequate facilities should be included in the design for the safe and efficient management of all wastes, especially organic material. The short-term storage of waste on site or its permanent disposal can lead to odour and vermin issues which can become evolve into amenity and health issues. The site should be laid out so as to not locate any short-term organic waste storage or composting facilities adjacent neighbouring houses or public areas.

Preferred design:	so that there can be daily disposal of organic wastes or the material held so that it does not generate odour or other issues.

Any proposal which includes the on-site disposal of waste, in particular organic waste must give consideration to the potential to generate impacts on any nearby residences or for contamination of surface or ground water.

Preferred design:	so that waste can be disposed of off-site or on-site so as not to affect groundwater or the neighbour’s amenity.

The major issue for aquaculture is water management that is covered in section 4 and 5 of this guideline. The location of any irrigation scheme should take into consideration factors such as soil characteristics, slope, drainage as well as proximity to neighbours (*See Site Selection).*

Preferred design:	slope should be < 5% for irrigation areas.

2.8 Energy

The access to a power supply to the site is an issue in the design and layout of the facility as well as in the site selection. Early discussion should be held with the appropriate power transmission authority with regard to capacity and access issues.

The consideration of energy efficiency in the layout and design of the facility is critical in relation to the ongoing management costs. The facility should be designed to minimise energy use and maximise opportunities for the use of alternative energy sources.

Water pumping costs can put a significant burden on operational budgets. Where possible gravity should be used in the water recirculation system. Buildings should be well designed to minimise lighting and heating/cooling costs. Options could also exist for the use of solar or wind power in heating of tanks or in the powering of remote facilities. The NSW Sustainable Energy Development Authority and the Australian Greenhouse Office (in Canberra) should be contacted about energy saving approaches in the design and management of a business.

2.9 Accommodating operational facilities

The buildings are essential components of an aquaculture facility and their design and location should be planned so that space, labour and equipment are used efficiently and economically. The layout should meet the relevant local council's Development Control Plan or the development controls below.

Preferred design:	Buildings should be set back > 5 metres from the boundary Buildings should be < 7.2 metres high Buildings should have a floor space ratio of <1:1 Buildings should comply with the Building Code of Australia

2.10 Road access

The road access to the site should provide for safe entry to and exit from the site. The entry and exit from the site should provide for adequate traffic sight lines in both directions. The design standard should take into consideration the traffic flow in the road adjacent to the site and the likely level of vehicle movements particularly during peak flows. If the public road has high flows, Council or RTA (as the responsible authority under the s138 of the Roads Act) may require turning and acceleration lanes in accordance with the RTA Road Design Guide. Adequate off-street parking spaces should be provided for trucks and cars (particularly if tourist or fishout facilities are part of the aquaculture enterprise). Carparking layout should take into consideration the provisions of AS 2890.1-1993.

Preferred design:	Complies with the approval requirements of the Local Government Act.

2.11 Crown lands and road reserves

Any structure that is built on Crown land or crosses it or is attached to the estuary bottom, will need a licence under the Crown Lands Act 1989. The bed of all estuaries (the bottom) below the high tide mark are considered to be Crown Lands. The estuary extent varies depending on the river system. Some river beds are also Crown land but they may also be private property. The status of estuary and riverbanks will vary and a title search will be needed. Title searches should be undertaken to determine the exact land status of the proposed development site.

There are numerous unconstructed “unopened” council controlled (and dealt with by council) or Crown roads (and dealt with by Department of Lands) roads for which a reserve has been created under the Roads Act. Some of these roads have been incorporated into the management of abutting freehold properties for a number of years. Before any aquaculture works are built on these roads they should be formally closed if not required for access. If access is required, alternative access should be arranged or the road opened. Opening and closure can take months as advertising has to occur and neighbours concurrence obtained. Sometimes alternative access may be provided, but it is preferable if aquaculture ponds or other structures are not located on road reserves.

3. General water supply issues

The most critical constraint for the successful management of an aquaculture business is the water supply – both in terms of reliable quantities and quality. As a general rule a reliable supply of 40ML/ha/annum of good quality water is recommended as a minimum water budget for non salmonoid intensive aquaculture culture, intensive salmonoid aquaculture culture may require up to 40ML/day. The Stressed Rivers Reports published by DIPNR covers all sub-catchment on the Hunter and Central Coast and provides preliminary data on water availability, numbers of licences, and water quality indicators. Also, water management plans have or are being prepared for the Hunter and Central Coast river systems outlining water access and environmental flow requirements. Water sharing plans detail yearly and daily extraction limits that apply to a given water source. Assessment of the available water (based on eg. embargo provisions, flow rules etc.) should be undertaken to determine if adequate water is accessible for development. Consideration of transfer rules will also be required. These documents and DIPNR should be consulted to ascertain current and future management regimes for river systems.

Table 18. River stress categories for the Hunter catchment (does not include estuarine areas)

Subcatchment	Hydrological stress	Environmental stress
Allyn	High	Medium
Baerami	High	Medium
Black	High	High
Bow	Low	Medium
Bylong	High	High
Dart	High	High
Glenbawn	Low	Medium
Glennies residual	Low	High
Goulburn and residual	High	High
Halls	High	High
Hunter estuary	Low	High
Hunter residual	High	High
Karuah	High	Low
Krui	High	Medium
Lake St Clair	Low	Low
Lostock	Low	Low
Martindale	High	Medium
Merriwa	High	Medium
Munmurra	Low	Medium
Myall	High	Medium
Pages (includes Isis)	High	High
Rouchel	Medium	Low
Wallis Lake	High	Medium
Williams	High	Medium
Widden	Medium	Medium
Wollar	Low	Medium
Wollombi	High	High
Wybong	High	High

Table 19. River stress categories for the Central Coast catchment

Subcatchment	Hydrological stress	Environmental stress
Brisbane Water	Low	Medium
Jilliby Jilliby	High	High
Lake Macquarie	High	Medium
Lower Wyong	High	Low
Ourimbah	High	Medium
Tuggerah	Low	Low
Upper Wyong	Medium	Low

DIPNR Classification for hydrological or environmental stress
Hydrological stress was derived for each catchment by proportioning estimated water extraction to the estimated streamflow. The classifications being, low (0 to 30% extraction of flow), medium (40 to 60% extraction of flow) and high (70 to 100% extraction of flow). For those catchments that fell between these parameters additional local information was used to classify into which stress level they were placed. Environmental stress was determined utilising the following eight indicators, riparian vegetation, bank condition, bed condition, barriers to fish, turbidity, electrical conductivity, phosphorus and pH. If two thirds of the indicators scored high a high stress rating was assigned, however, if two thirds were scored low the a low stress rating was assigned and all other catchments were assigned a medium stress rating.

Trading of water on the Hunter and Central Coast is developing. With the new Water Act, there are likely to be changes in water transfer patterns with water rights being separated from the land and being transferable within catchments. Water sharing plans detail specific transfer rules for each water source. Water users will also be able to buy futures in water. The other changes are likely to result from the deregulation of the dairy industry. Organisations such as stock and station agents (eg Elders), NSW Farmers or water trading sites on the Internet (*www.waterexchange.com*) can provide information on how to access water rights.

A key issue in planning and design is the consideration of risks associated with the water supply and planning to ensure the farm can deal with various contingencies. For example for fresh water aquaculture enterprises, on-farm water storage or supplementary groundwater supplies should be considered, to provide a back up supply during droughts or when there is poor water quality in the river (eg. during low or high flows).

Another critical issue is the use of water resource. It is important that the aquaculture farm is planned and designed in such a manner to prevent wastage of water. This includes minimisation of seepage or leakage from channels, dams and ponds, the treatment and recycling of water and (for freshwater) the use as a substitute for raw water in agriculture or other purposes. All water related works should be constructed, maintained and operated so as to ensure public safety and prevent possible damage to any private or public property.

3.1 River and estuary extraction

Preferably the site chosen for extraction of water from the river or an estuary should provide sufficient depth for the pumping head during low flows without the need to excavate the bed to deepen the pumping hole. In addition, the water extraction site should offer a bank location so that the pump can be located so that it is not likely to be damaged during high or flood flows.

The existing profile of the channel or bank must not be disturbed any more than is necessary to install the pumping facility. Any disturbance should be restored as soon as possible to prevent erosion. If the bank or the bed of the river requires substantial disturbance (especially of aquatic or bank vegetation) a permit will be required under the *Rivers and Foreshores Improvement Act*. If mangroves are likely to be disturbed, a permit may also be required under the *Fisheries Management Act.*

Where water is extracted from a river or estuary, a suitable device should be installed to accurately measure the quantity of water extracted. Provisions should be made for this equipment to be adequately maintained. For freshwater extraction (and possibly estuarine under the new Water Act), DIPNR will require the quantity of water to be recorded and reported under the water licence provisions. The annual return of information to DIPNR (or more regularly if required) should include hours pumped, monthly extraction rate and use of water. DIPNR may limit the extraction from a river from time to time to ensure an adequate flow remains for other water users and the environment.

3.2 Dams

The implications of the Dams Policy should be considered with the option to "capture" and use 10% of the average yearly regional runoff from the property without needing a licence. If an aquaculture enterprise is located on a large property, this quantity could be significant and could provide a primary or supplementary source of quality water. The guideline *Rural Production and Water Sharing* (DLWC 1999) covers dams policy and how to calculate harvestable rights. The farm dams and stressed rivers policy is on the DIPNR web site. Reference to relevant water sharing plans in regard to provisions for dams and storages should also be undertaken.

In areas where the river or estuary water quality is poor during low and high river flows, the feasibility of off-river storage should be discussed with DIPNR so that water reserves can be extracted from the river when the water quality is good and held for later use. This form of off-river water storage dam could if feasible, increase the reliability of supply in some areas.

Dam safety can be a major issue depending on the stability of the geology/soils, the size of the dam and the size and characteristics of the dam's catchment. Any guidance on the location, design and construction of the dams provided by DIPNR and DL should be followed. Factors to be considered include:

- the location of the dam in relation to local water flows,
- the dam construction – wall design, heights, method of construction, etc
- volume of water and extent of the land inundated when the dam is at capacity,
- the relative height and dimensions of the by-wash to control the dam's capacity or the provisions to ensure that inundation of land does not

exceed the specified extent,
- provision to provide for passing flows.

Once approved, the dam design or location should not be altered without the agreement of DIPNR and DL. The Dam Safety Committee should be contacted for technical advice on the safety of large-scale water storage dams.

3.3 Groundwater

All piezometers or bores must be licensed by DIPNR.

A bores must be at least
- 40 metres from the nearest bank of any river or creek,
- 500 metres from any town water supply bore,
- 400 metres from any irrigation bore on an adjoining property,
- 100 metres from a property boundary, and
- 400 metres from a DIPNR observation bores. Note that distance criteria may change dependent on the relevant water sharing plan.

DIPNR must be notified within 2 months of sinking a bore if a useable water supply has been obtained, the location, pumping tests, depth, water analysis and other relevant details. The bore must be of an approved diameter, lined and capped to the standards required by DIPNR.

CURRENT WATER POLICY WHICH APPLIES TO AQUACULTURE

Works that need a license

All naturally occurring water (both surface and sub-surface) in the State of NSW that is capable of being used for irrigation or for watering stock is regulated by the provisions of the Water Act. Any “work” (which includes any dam, pump, weir, regulator, race, channel, cutting, well, excavation etc) which affects the quantity of water flowing in, to or from, or contained in a river, stream or lake comes within the provisions of the Water Act. Licenses are issued to authorise (construct/install and use) such works. In relation to groundwater, the construction of any bore (which includes any bore, spear point or excavation) requires authorisation under the Water Act.

Embargoes

Throughout the Hunter, the demand for water for commercial purposes exceeds the available supply (on a sustainable basis). This situation has led to the imposition of embargoes, which effectively place a limit on the volume of water which may be extracted from rivers, and on the construction of dams to intercept flows in streams. A water management plan, showing all sources of water to a development, must be developed to determine if a water licence will be required. Prior to making any application for a water licence, a determination of licensing requirements, and the possible direction to purchase and transfer existing active water entitlements may be required.

Restricted groundwater areas in the Hunter Region include the Tomago-Tomaree-Stockton sandbeds and coastal sandbeds on the coastal lakes systems of the Myall and Wallis catchments, and further entitlements may not be available.

Transfers

A water transfer scheme (for surface water) is in place for all catchments. This permits (subject to certain statutory licensing requirements) the transfer of water use entitlements from one property to another within a sub-catchment. The scheme operates as a market, subject to supply and demand and other relevant market forces. The DIPNR is not involved in brokering these arrangements (see stock agents or waterexchange.com). All applications for transfers are subject to interim guidelines that include:

- no movement upstream
- no transfer into stressed sub catchments
- no transfer of sleeper licenses

Transfer rules may be amended as part of the water management committee planning process.

Stressed Rivers Assessment

The level of stress in the State's rivers and streams has been assessed on a sub-catchment basis using criteria related to hydrologic stress (water extraction) and environmental stress (general river health including water quality and status of the riparian zone). A special category of high conservation value also applies to a restricted number of sub catchments. These assessments will be used to determine further water management planning relating to current embargoes, transfers, prioritising of the preparation of river management plans and volumes available for extraction. Any application for licenses for aquaculture purposes would be assessed in light of the classification determined under the stressed stream determination.

Access rules

All current and any new licenses will be subject to conditions requiring the maintenance of low flows in the streams from which water is extracted. To ensure security of supply in periods of low flow (when extraction will not be permitted), users will need to construct off-stream water storage facilities. A license classification system is soon to be introduced which will specify the flow regime from which water may be extracted. The system will be based upon "A", "B" and "C" class licenses. "A" class license will have access to the low flow regime, "B" to medium flows and "C" to high flows only. In the case of aquaculture, it is anticipated that most licenses will be issued as category "C" due to current commitments in the low flow regime in most streams.

Water Management Committees (WMC)

WMC's have been established for all catchments throughout the State. Each committee has an independent chair with members representing relevant water user groups, conservation groups, local government, aboriginal representatives, special interest groups as required and government agencies with involvement in natural resource management. Each committee is required (amongst other things) to produce management plans to advise government on what actions are needed to achieve environmental objectives relevant to their area. There may be a need for the aquaculture industry to make representation to the WMC's for appropriate consideration.

Volumetric allocation

All licences for industrial (aquaculture) purposes will be allocated an annual entitlement. Unless proponents obtain additional water entitlements through the transfer market, no new licences in a high stressed river system or embargoed catchment will be given an allocation. The system of volumetric allocation requires both regulators and users to manage the available water resource in a sustainable manner. It will be necessary for metering of water supply to any regulated water use.

Harvestable rights

On 1st January 1999 the NSW Government introduced a new policy which allows all landholders to harvest a basic volume of water (10% of run-off) and store and use that water for any purpose without the need to obtain a license under the Water Act. The policy has a number of exceptions, exemptions and location variations and reference to the full policy document is recommended.

Charges

Fees are payable for licenses for most purposes and are currently issued for a period of 5 years. In addition an annual management charge applies to these licenses. Charges are fixed by the Independent Pricing and Regulatory Tribunal of NSW

(IPART).

COAG

The above initiatives are all part of the NSW Government's Water Reform Package which demonstrate its commitment to the water policy framework announced by The Council of Australian Governments (COAG) in 1994. That framework aims to achieve an efficient and sustainable resource management. It covers the five broad areas of cost recovery and pricing, institutional reform, allocation and trading of water entitlements, environment and water quality and public consultation and education.

4. Ponds and related facilities

Ponds are structures that are constructed by excavating earth and reshaping it to create a structure that has the capacity to hold water and may be earthen or lined.

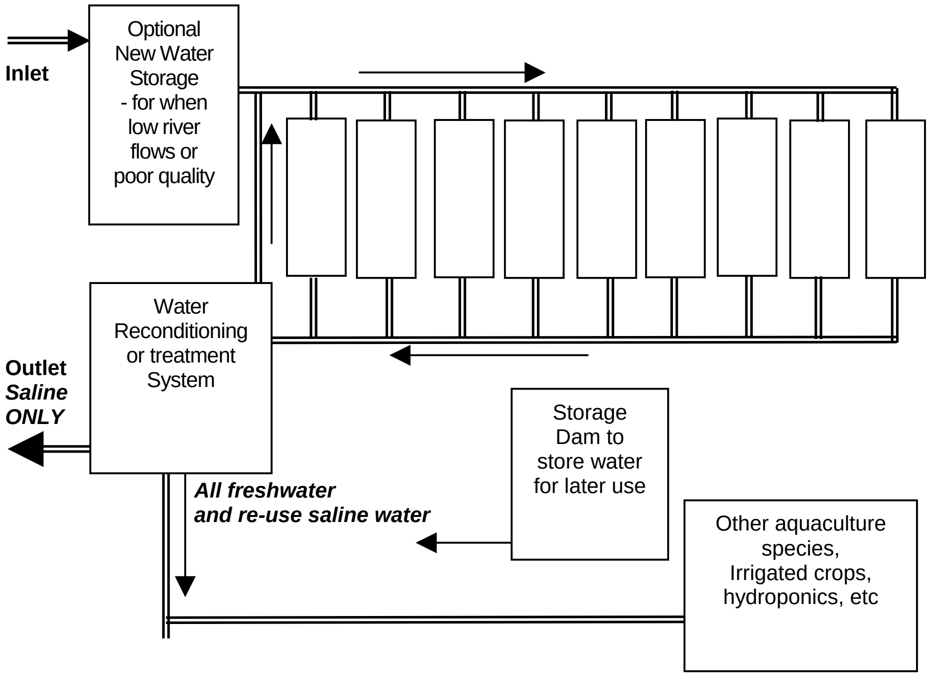
4.1 Layout

(a) Efficient circulation and drainage system

Ponds should be orientated so as to allow for an efficient water circulation through water supply access facilities, storage dams, growing ponds, reconditioning ponds and drainage lines.

Reticulation systems should be designed so that pond discharge water can be retained in reconditioning ponds (for an appropriate time to reduce suspended solids and to allow for appropriate treatment if necessary) and have the capacity to recirculate the water on the farm or release/reuse the water in an appropriate manner.

Figure 5. Water Recirculation and Reconditioning System



Site planning should include drainage layout

- to protect the farm and ponds from excessive run-on drainage from surrounding land during storms or flooding, and
- to protect surrounding areas from run-off water from the farm.

For estuarine and marine water farms, the site layout should ensure that the discharge points are located so as to maximise the dispersion of the discharge water and minimise disturbance on marine vegetation or any oyster leases in an estuary.

For freshwater farms, site planning for efficient use of reconditioned water resources following pond use is essential. In some areas, relationships may be able to be established with nearby irrigated agriculture, hydroponic or other water users. In these cases, the piping and pumping of water will need to be considered including the costs, capacities and storages. If the pipes are to cross public road, permission will be required from RTA, Local Council or Department of Lands. If on-site irrigation is proposed, the layout of irrigated land should consider slope, soils type, distance from natural creeks or drainage lines, location of pumping systems, irrigation reticulation systems and catch drains (if relevant). See Section 4.2 in the Site Selection Chapter for further information on site and soil assessment for proposed irrigation areas.

(b) Designing for climatic effects

An open site is advantageous because it allows wind to aerate water in the ponds. In wind exposed areas, consideration may need to be given to the direction of the prevailing of wind to reduce wave setup and associated bank erosion. In areas where there are likely to be temperature inversions, it is critical that any noisy or odour generating activities are not located near residents or in areas where still area or air flows are likely to amplify impacts on neighbours.

(c) Acid sulfate soils

For estuarine ponds in areas where there is a risk of acid sulfate soils (ASS) being present, the layout of the ponds and drains should be designed so as to minimise the disturbance of ASS. As ASS is not necessarily evenly distributed across a site, some soil survey work will be required to identify the depth to the ASS and any likely “hot spot” areas. Reference should be made to the ASS Manual for sampling and assessment regimes.

Preferred design:	Where there is no acid sulfate soils, or ASS Landform Class A with Landform Element class b, l, t, p, y or w

In addition to issues with regard to the potential to generate acid in the ponds and the drains, issues relating to the structural characteristics of ASS in subsoil layers may need to be considered. As some potential acid sulfate soil clays have the consistency of a gel with up to 70% water content, they have low load bearing capacity resulting in lateral movement or considerable subsidence under load. For dams and ponds on these types of soils, geotechnical data should be analysed to consider the extent of possible movement of the sulfidic material under load and appropriate management strategies developed.

Preloading of the site may need to be considered. If preloading of the site is to be undertaken, hydrological analysis should also be undertaken to consider the effects of compaction on groundwater levels and the potential for discharge of acid. The material used for preload should be non-ASS and if it is to be removed in the future, it should be separated by some geotech fabric to allow final removal without ASS contamination.

(d) Fencing ponds and/or the farm

In addition to screening of water outlets to prevent accidental release of aquaculture stock, ponds that are used in the culture of crayfish, yabbies and eels should be laid out so that they can be fenced (an unbroken fence 60 cm in height) to prevent escape and/or entry of wild stocks. In addition fencing of ponds can prevent loss from water rats, predation by eels and people wandering onto the farm.

4.2 Pond design

Ponds commonly refer to those structures that are purpose built constructed earthen dams where fish are intensively farmed and are usually situated either wholly or partly below ground level.

(a) Pond shape

Intensive aquaculture ponds must be purpose-designed earthen dams for efficient filling, cleaning, draining and water circulation and for efficient stocking, feeding and harvesting of fish. The shape of a pond affects:

- the cost of construction,
- the inlet and outlet options and water circulation in the pond (with subsequent effects on management of plankton, sediments and reconditioned water),
- the harvesting and feeding methods, and
- pond banks and bottom maintenance including erosion risks.

The topography and site characteristics will affect the pond size and shape. Square and rectangle ponds make the most efficient use of available land. Rectangular ponds tend to be easier to manage than square ponds and offer good water circulation provided they are not too narrow. This shape is relatively cheap to build and offers practical advantages in feeding and harvesting.

Excessive water depth may result in stratification of the pond waterbody (e.g. of oxygen, temperature, organic load and sulfides) and unintentional destratification (eg. sudden winds or rains) can have disastrous effects. On the other hand, very shallow water promotes excessively low or high temperatures and weed growth. Preferably each pond should be designed to have a deep section (at least 2 metres) and a shallow section (about 1 metre). The actual depths will vary with the species and the locality but generally having a deep section provides a buffer against extremes of temperature, reduces evaporation during summer, facilitates harvesting, reduces the growth of macrophytes and increases production.

(b) Pond size

There is a large variation in the optimum size of ponds for aquaculture. Freshwater fingerling and grow-out ponds for silver perch may be 0.2 ha up to 1.0 ha in surface area to provide a balance between management and economies of scale.

A number of factors affect what is the most efficient pond size for each farm including species, management techniques and stocking densities, cost of land, topography, capital and equipment available for construction and proposed production capacity. While larger ponds tend to be lower in cost per unit to construct and maintain than smaller ponds, larger ponds present a number of disadvantages such as size of harvest - handling and marketing; water quality management problems; disease monitoring and control difficulties; algal bloom control. Harvest management in larger ponds is often more difficult to manage so as to not stress the catch. While overseas large ponds from 10 – 40 ha are known, it is generally considered that ponds less than 2 ha represent the optimum pond size for intensive aquaculture on the Hunter and Central Coast with the current methods.

(c) Pond banks

Pond banks if earthen should be constructed of suitable material and designed with optimal batter angles to prevent slump or erosion. Banks should be wide enough to ensure strength, stability and vehicular access. This is extremely important, and enables efficient management of ponds.

In general, the dimensions of pond embankments should:

- crest approximately at 3m; with batter minimum
  - 2.5:1 on the inside and 2:1 on the outside for embankments less than 3m high,
  - 2.5:1 for embankments greater than 3m but less than 6m,
  - 3:1 for embankments greater than 6m (rare); and
- have freeboard minimum of 0.5m (where wave action fetch is less than 100m); and
- have cut-off trench minimum 300mm into good clay.

Ponds constructed of manufactured products such as plastic/rubber liners and reinforced embankments utilising concrete/tyres etc., may have steeper gradients however care must be taken so that the steepness does not create access and maintenance issues.

Walkways to the drainage outlet structures enable efficient control of the boards, screens and valves, as well as being ideal sites for observing and sampling water and observing, sampling and feeding of fish.

If there is no other alternative, the ASS Manual must be consulted to ensure acid sulfate soils are managed so that the long-term use of the ponds is not jeopardised. It should be noted that the use of acid sulfate soils in the construction would constitute a “high risk” option, requiring a high level of assessment and approval. It is preferable that acid sulfate soils are not used for backfill or in pond bank construction

The earthen pond banks and batters backfill should be lined with topsoil and planted with endemic grasses to ensure stability and prevent erosion. In some circumstances (highly erodable soils, or with some water circulation/aeration systems), a pond bank liner should be used to cut down on bank erosion and reduce the sediment in the water (and hence improve the water quality). Any embankment at the water inlet should be fortified to protect from erosion. It is preferable that the grass is mowed when necessary and animals are not used to keep the grass down. Animals (such as cattle and to a lesser extent sheep and goats) can lead to bank degradation and may enter the water and increase turbidity and nutrients.

(d) Pond water inlet

Water inlets from the natural environment should be screened prior to entering the circulation system to prevent the entry of trash fish and other undesirable aquatic fauna. Where there is likely to be poor water quality or restricted access to water supply because of seasonal variations in flows, it is good practice for the farm to include a “new water supply” reservoir to ensure that there is good quality water available to supplement the pond water recirculation system when required.

Each pond should have separate water inlets and outlets. Water supply and drainage pipes should be at least 15 cm in diameter. Water supply pumps may include axial pumps used in areas of low pumping head through to deepwater bore pumps typically used in the Coleambally irrigation area of the Riverina (NOFARIC, 1995c). The water in the supply reservoirs should be aerated and subsequently piped by gravity or circulation pumps to the individual ponds and buildings.

Preferred design: so largest pond can be filled in 24 hours or less

(e) Pond water outlets

Ponds should be designed so that they can be drained individually, completely and rapidly. This will enable the removal of all stock during harvesting and facilitate efficient management, particularly when water quality and disease problems occur. Complete drainage can be achieved by a raceway or well in the deepest section of the pond. The bottom of the pond should be level and slope gradually towards this area.

Preferred design: no pumping required to drain pond completely

The water outlet (also called a monk, tower, penstock, gate or standpipe) is the most important feature used in regulating the water levels and in draining the pond. The outlet should be designed so that water can be withdrawn from the surface and excess water can overflow through a screen and escape. The water outlet should also be structured so that water can be drained from the bottom so that "dead" water (low or deficient in oxygen) can be removed. Water outlets should be screened to prevent the inadvertent loss of stock from ponds.

The width of a pond monk is typically between 300 and 500 mm. There must be adequate space between the rear board and back wall of the monk to avoid restricting the drainage capacity of the pipeline. If the fish are to be channelled through the outlet pipe for harvesting, the pipes must have a minimum diameter of 300 mm.

It is essential that the bottom of the monk must be the deepest point of the pond and designed so that the last 10 cm of pond water can be drained in less than 1 hour. The drainage pipeline (made usually of concrete, HDPE pipe or PVC) traverses the embankment and discharges in the main drainage line. The incline of the pipeline should be between 0.5 and 1.5%.

PVC standpipes of 150-200 mm can also be used in smaller ponds as outlets but are less robust, more prone to mishaps and blockage of screens and are relatively difficult to operate efficiently.

The pond bottom should slope evenly towards a centre drain system or sump, standpipe or monk gate and be designed so that the pond is completely drainable. Ditches in the pond bottom inclining towards the outlet may be dug to improve the water drainage from the pond and enable complete drying out of the pond following harvest. It is extremely important in earthen ponds that suitable soil material is used in the installation of the water control outlet for ponds with careful attention to compaction to prevent pond levee failure.

4.3 Pond water reticulation system

(a) Water management as a resource

Reconditioning and recycling of pond water should be part of standard environmental management practice for all aquaculture farms. Any new or expanding existing aquaculture farms should incorporate, as standard practice, a suitably designed reconditioning pond and/or treatment systems as part of the water circulation system so that water is reused within the aquaculture farm

- For estuarine farms, the water circulation system should include pre-treatment ponds and appropriate reconditioning ponds before reticulation and eventual discharge to the estuary.
- For freshwater aquaculture farms, the water circulation system should include appropriate reconditioning ponds before recirculation or re-use so that there is no discharge of water from the fish farm to the natural waterway. Re-use options may include agriculture or other purposes on the farm or by arrangement with other water users as a substitute for raw water.
- The use of water on freshwater aquaculture enterprises is conditioned on "no discharge" into public or Crown roads, Crown land, neighbouring land, rivers, creeks or natural wetlands, groundwater aquifers or native vegetation.

(b) Reconditioning system

The capacity to recirculate water within a farm system relies on the capacity to recondition water from the aquaculture ponds. The technology for doing this is under intensive research both in Australia and abroad and is currently being reported in a range of journals and industry forums. Undoubtedly, there will be significant developments in this area over the next decade.

However, for the purposes of this AIDP, provisions must be made in the farm reticulation system (both for fresh and estuarine water) for reconditioning of pond water. This must include reconditioning ponds equivalent to at least twice (x 2) the volume of the largest rearing pond for non salmonoid production.

In addition, in estuarine pond systems where discharge is permitted under license, the reconditioning system must be a minimum of 10% of the total net-growing area of the farm and discharge water must be retained for a minimum of 1 day prior to discharge. However it is considered good low risk practice for the reconditioning ponds to be 20% of the total net-growing area of the farm and for the water to be retained 6 days prior to discharge or strategies which produce an equivalent to better outcome.

Preferred design:	reconditioning storage capacity of > 2 times the size of the largest growing pond.

The following design guidelines must be considered:

- The sediment condition (dispersive/prone to erosion) must be an important consideration in the design features of the reconditioning system; Minimisation of sediment entrainment (eg through use of levee liners) in the reticulation/pond system should be a design priority.
- The design criteria for the reconditioning unit must consider allowable benthic shear maxima in the settlement process to maximise the potential for settlement of solids prior to exit from the reconditioning unit.
- The farm design must include the capacity to manage complete drain down of aquaculture ponds at the end of the season without discharging sediments to estuary or waterway system. Depending on the management approach, reconditioning pond and overall

reticulation system may also be completely drained down or maintained to encourage the natural ecosystem in the reconditioning ponds to maintain the biofilter systems.

- The reticulation system should include provisions for the management of accumulated sediment that may be removed after a production run or when maintenance is undertaken on the reconditioning pond.
- Provisions should be made for the management of sediments so that there are no adverse environmental impacts (for example drying, storage and/or composting areas prior to its use on the farm or by another landowners or removal to a landfill).

Preferred design:	For estuarine pond systems, retention of longer than 6 days prior to reuse or discharge or surface of reconditions ponds of > 20% of total water surface of growing ponds.

(c) Use of reconditioned freshwater

There is an obligation on all water licence holders to use water efficiently. This includes the use of water that is no longer to be recycled in the pond or raceway system, eg. as a result of a constant daily exchange with fresh water or at the end of a growing season when the ponds are to be cleaned out.

Consideration should be given to establishing an integrated aquaculture/ agriculture system. Reconditioned water could be used by hydroponics or agricultural crops in the system to utilise any existing nutrients in the system. Preferably the reconditioned water should be a substitute for raw water for productive use rather than a disposal scheme. In many cases, a relationship may be able to be formed with a neighbouring water user so that any reconditioned water can be passed on – or on sold to them. The high volumes associated with salmonoid production may limit the opportunity to pass on or on sell water utilised on the salmonoid farm.

With any irrigation scheme, there should be adequate provisions for the storage of water during wet weather until there are opportunities for irrigation. Depending on where the water is to be used (on farm or by a near-by water user) adequate provisions must be made in the wet weather storage dam for extended wet periods.

(d) Use of reconditioned saline water

In some saline water aquaculture systems overseas, the water may be used by a number of species such as fish, then filter-feeding organisms, and then seaweed prior to the water passing through mangroves or wetlands into the natural system. While this approach is in its infancy in Australia, there may be opportunities for the multiple use of the reconditioned water in the future.

4.4 Pre-Market conditioning facilities

For some species, to enhance the quality of taste, it is essential to place fish in pre-market conditioning (purging) facilities prior to marketing (for 2 days to possibly 2 weeks). It is preferable if the conditioning tanks are fibreglass or plastic and are self-cleaning with a water supply free of algae and off flavour compounds (eg. underground (bore or spring), rainwater or domestic (dechlorinated aeration system). Preferably the conditioning tanks should be in an enclosed sheds.

4.5 Predator management

(a) Bird predators

Predator birds can be a serious problem in many areas leading to significant losses. In many cases, the exact extent of losses is circumstantial and more research is needed to better understand the threats particular species pose and the best methods of control.

SUMMARY OF POTENTIAL THREATS

Based on Llewellyn Report *Cormorants and their Control at Fish Farms in NSW 1999*

Great Cormorant

The Great Cormorant (*Phalacrocorax carbo)* occurs in most areas of NSW, breeding along rivers and lakes in the Murray Darling and some coastal rivers including in the Hunter and Central Coast. They congregate in considerable numbers at breeding locations but at the end of the breeding season, will disperse moving considerable distances in search of suitable feeding habitats. The estuaries can support numbers of cormorants year round. These numbers can be boosted significantly during droughts when inland birds are forced to more permanent coast waters. Breeding is usually in colonies but occasionally in dispersed pairs, in autumn and spring.

Cormorants are sociable feeding birds, usually take 1 or 2 trips to the feeding ground per day, diving several metres deep to take fish. Their diet is mainly freshwater fish supplemented by crustacean, salt-water fish, frogs and insects. Though they principally feed in daylight hours they have been observed feeding at night. They are capable of taking fish up to 1kg with a daily intake of a breeding bird of around 750 gm. They have been recorded with as many as 63 small fish (2-4.3 cm in size) in their stomach at one time. The extent to which they impinge on native fish stocks is not known, but once they detected the presence of aquaculture ponds, they can make significant impacts on the stock in a fairly short period if unchecked.

Threat: Most serious because of their gregarious nature and ability to take large numbers of large fish from grow out ponds both during the day and night.

Little Black Cormorant

The Little Black Cormorant (*Phalacrocorax sulcirostris)* has a distribution similar to the Great Cormorant. They are abundant in most ares in NSW where there is available water including the Hunter and Central Coast. During summer and autumn they tend to congregate in colonies of up to 100 birds in breeding localities such as swamps, lakes and along rivers but tend to disperse during other times. Drought will increase the numbers in coastal areas and the potential problem for aquaculture farms. The Little Black Cormorant feeds socially taking fresh and salt water fish, crustacean and insects. They have been known to herd schools of fish. They tend to take smaller slow swimming fish but because of their abundance on the Hunter and Central Coast have the potential to have significant impacts on aquaculture farms.

Threats: Most frequent visitor to fish farms. If fingerling ponds are not netted they can have a devastating effect. If they build up in numbers greater than 6 they can become a concern. Research is needed to determine what actual effect they have on grow-out ponds.

Pied Cormorant

The Pied Cormorant (*Phalacrocorax varius*) occurs sporadically in most areas of NSW, occasionally in reasonable numbers on the Hunter and Central Coast of NSW. They tend to breed in colonies during the autumn and winter in estuarine areas often on islands or in mangrove swamps producing substantial stick nests. Only immature birds tend to disperse from the breeding colony. They feed principally on fish but also take crustacea and molluscs. Because of their size, they are capable of taking quite large fish but are less of a problem to aquaculture farms compared with the Great Cormorants as their numbers visiting tend not to reach the large numbers of the Great Cormorants.

Threat: Though they are also capable of taking significant numbers of large fish pose less of a threat because of their lower numbers

Little Pied Cormorant

The Little Pied Cormorant (*Phalacrocorax melanoleucos)* is widespread and the commonest of the cormorants breeding in colonies or pairs along most of the rivers, lagoons and swamps of the Hunter and Central Coast region. Colonies may include as many as 4000 birds. The breeding season is irregular but tends to be in spring and autumn. Birds may disperse between breeding seasons but tend to return to their breeding localities.

Little Pied Cormorants tend to be solitary feeders mainly on freshwater crustacea, invertebrates or small slow moving fish up to about 90mm in size. However, large numbers may accumulate in suitable feeding areas. Generally they are not considered to be a problem for fish farms but can be a major problems for yabby farms. They mainly take slower moving trash fish. Their solitary feeding habit and preference for crustacea contrasts them with the more gregarious fish-loving Little Black Cormorant.

Threats: While they are regular visitors they tend not to be a problem for fish farms provided the fingerling ponds are netted. However they can become a major problem for crustacea farms especially if the numbers build up.

Darter

The Darter (*Anhinga melanogaster*) distribution is similar to other cormorants but is never seen in large numbers. They can be nomadic evidenced by their sudden appearance and disappearance at water bodies. They are known to breed on the Hunter and Central Coast areas, frequently as single pairs but may form colonies of up to 100 birds. The breeding season is irregular and extended.

The main source of food is fish and small crustacea, molluscs and aquatic insects. They catch fish by stalking and spearing them. As a result large and fast moving fish are rarely caught. However, because their size is similar to the Great Cormorant, it can be expected that they will consume similar quantities of fish. However, because they are solitary feeders, they are thought to pose less of a problem than the Great Cormorant.

Threats: If the numbers build up, they can become a problem for smaller fish and crustacea.

Other potential problem birds

Sacred and Straw-neck Ibis, Spoonbills (usually night visits), Nankeen Night Heron (usually at night) and White Faced Herons can be problems especially for crustacea, fry and even larger fish.

Other birds not seen to be a problem

Brahminy Kites, White Breasted Sea Eagles and Ospreys are often frequent visitors to ponds but are not considered to be a problem. Large Egrets tend to take trash fish. Little Egrets can be frequent visitors and tend not to be a problem.

(b) Management approaches

Consideration should be given at the outset as to how the pond systems can be designed so that losses to predator birds can be minimised. Protection in both the daylight and night hours may be necessary. Vigilance is needed as pond may be clear one day but become invaded by a large number of birds during the following day or night. Methods could include

- deterring the birds from gathering around the farm,

- deterring the birds from entering the water,
- providing protection for the fish.

Preferred design: all ponds screened (or equivalent) or as a minimum screening of fingerling ponds and deterrent system for other ponds

Table 20. Summary of Some Fright Methods

Birdscare, Bird eter or recorded calls	Various commercial machines have been developed which generate distress calls of target species, which are turned on and off at random or in response to the presence of birds. Devices that emit more random noises, or respond to movement are likely to be more effective. However used alone the birds can become acclimatised to the device. It is likely to irritate any nearby neighbours
Birdfrite	Cartridges are fired from shotguns or pistols that explode in the air. When fired at random and aimed at the flock it is likely to be more effective. It is labour intensive and is likely to irritate any nearby neighbours
Water bird effigies,	Life size models of birds with the wings open strung up from the head on a string that can be jiggled can simulate a bird in distress. In combination with birdscare calls it can be effective for a time.
Hawk kites & silhouettes	When the wind is favourable, the flying of simulated birds of prey Balinese kites can be effective. The kites can also be suspended from a helium balloon. The approach is labour intensive and effective for a short time but may be useful in scaring a recent "invasion"
Helium balloons	Helium balloons can be strung on a line above the ponds. While the methods has proved effective in some circumstances in the US it has been less successful in Australia
Remote control Model aeroplane	The noise and physical presence of the plane may be effective. It is labour intensive but may be effective for a short time to scare a flock. It could have dual usefulness during school holidays.
Chemicals	The use of Avitrol a chemical hallucinogen that causes tremors, erratic flight, distress calls and ultimately death is not recommended. In theory, the baiting of members of the flock with sub-lethal doses is supposed to scared away the rest of the flock by the distress calls of affected birds. However the effectiveness of the approach with cormorants has not been proven. In addition, the effectiveness of repellents such as Naphthalene, Thiram and Mesurol with waterbirds has not been tested. A permit is required from DEC to use the material. The use of chemicals around the ponds is not recommended.
Scare crow	To be at all effective scarecrows need to be moved around the site from time to time. Otherwise the birds become acclimatised to them.
Dogs	Dogs can be trained to chase birds. The success of the approach will depend on the dog and its training. However dogs which will also swim can be quite effective. Barking dogs however can annoy the nearby neighbours.
Motor bikes	A rider doing the rounds of the ponds from time to time can be very effective. It is labour intensive but can be a useful management tool in the short term when a flock of cormorants is around.

Exclusion netting

Total exclusion netting can be a costly option but may need to be considered in areas where predator birds are prevalent. All fish farms should net fingerling ponds with total exclusion netting. In many circumstances, the existing exclusion netting systems may not be practical for ponds larger than 2 ha. In addition to the capital cost, the existing net systems can be costly to clean and maintain. However new systems are being developed which are likely to be cheaper to install and easier to maintain.

Partial exclusion netting

Where there are likely to be significant management problems, ponds should be constructed as small as practicable so that some form of partial exclusion can be erected if necessary such as parallel nylon lines or lines on a 1 metre grid. The design of long narrow ponds may be possible to make this method more practical. While further research needs to be undertaken to refine these types of system, the approach appears to offer a cost effective partial exclusion option.

Fright methods

For grow out ponds a number of mechanisms may need to be used depending on the bird species and the numbers involved. (Llewellyn 1999) "Fright" approaches such as gas scare guns, birdfrite, birdscare and sonic emitters used alone tend to have limited or short term success and often cause long term problems with the neighbours. Birds also soon get used to scarecrows and helium balloons. Well-trained dogs are likely to have more success. Human presence around the ponds can be most effective. Effective human surveillance (often a person on a motor bike doing "rounds") coupled with a number of fright mechanisms seems to offer the best current option. It is important to understand that the success of these devices are dependent on the vigilance of the operator and their understanding of the behaviour of the bird species. It is preferable that a number of devices are used alternatively. The more methods used, the more effective is likely the control.

Killing of birds

Killing of birds by shooting or trapping is an ineffective method of reducing numbers particularly when dealing with common species (Llewellyn). The random removal of individuals tends to create a vacuum for another bird. For shooting to be an effective component of a management strategy, a knowledge of bird behaviour is required. The shooting of scout birds may be an effective control in certain "social" species, but it should been seen as a last resort. (see *Operating the Farm* section for more information on this matter). Depending on the species it may require an approval not only from the DEC but also from the Commonwealth Government under the EPBC Act requirements.

(c) Other predators

Human predators

Poaching could be an issue in some areas. Controlled access after hours (gates and fencing) can prevent most instances. In other cases, strategically placed movement detection lights may be an effective deterrent.

Fish predators

Poor screening of inlet water can allow the entry of "feral" fish into the system including eels. As well as providing competition for feed, certain feral fish will prey on the fingerlings. Better screening can partly eliminate this problem along with the use of lines or traps.

Water rat predators

Water rats can be a nuisance in some area especially raiding fingerling ponds. Fencing of fingerling ponds should manage the problem.

4.6 Construction of ponds and related facilities

Professional supervision of pond construction is strongly recommended, as correctly constructed ponds will result in long-term savings by avoiding costly maintenance later from pond wall erosion, slump, leakages or failures.
Leaking ponds cost money and pose a risk to the environment.

The most common type of pond is the "excavated" pond in which earth is removed and used for building the banks. This type of pond can be constructed on flat or undulating land. "Levee" ponds are constructed on very flat land typically with imported material and are similar in structure to rice bays except that the banks must be high enough to contain the necessary depth of water.

(a) Soil material

The pond walls and floor should be constructed and/or lined with material capable of retaining water with a hydraulic conductivity (eg <10^{-9}metres/sec). Clay or clay/loam are preferable. In loamy soils, heavy compaction using rollers or bulldozers will result in sealed walls though they may leak for a period. However, prior to construction, the proposed site should be surveyed for rock stratas, gravel or sand layers or other soil characteristics that may interfere with the water holding capacities. Ponds constructed in sandy or other porous soils can be made watertight by lining the bottom and sides with clay, bentonite seals or liners, but it can be expensive.

(b) Groundwater

The construction of structurally sound, sealed ponds in areas of high groundwater can be extremely problematic. It is also difficult to build ponds that can be completely drained and dried, in these areas - steps that are necessary for efficient pond management. Saline water ponds leaking to groundwater pose an environmental risk from contamination from nutrient rich saline water.

(c) Climatic conditions

Seasonal conditions can affect construction and must be taken into consideration in the scheduling of the contracts. Wet weather can create difficulties with plant and equipment and add significantly to costs. Dry conditions will necessitate the application of water to maintain soil moisture. The two main factors that contribute to embankment failure are insufficient soil moisture content, lack of compaction and the use of structurally inappropriate material.

(d) Erosion and sediment controls

To minimise erosion and dust, the area to be disturbed at any one time should be kept to a minimum. Appropriate methods should be used to reduce erosion during construction activities including from soil stockpiles, rehabilitation works and truck movements in accordance with the "Urban Erosion and Sediment Control Handbook" 1992.

Measures to be used to reduce erosion occurring and to intercept and retain mobile sediment during construction should include silt fences, sediment traps or straw bales. In some cases, it may be necessary to bund the construction site and stockpile areas to prevent overland flows from entering the construction area.
Measures should include:

- Integrate clearing and grading with layout design; limit grading to those areas involved in current construction activities; limit the time during which unprotected graded areas are exposed to the wind and rain; subdivide drainage catchments into smaller units, at a size appropriate to the type of sediment control measure to be used
- trap sediment as close to the source as possible; locate sediment traps or filters below all disturbed areas to intercept and detain sediment laden runoff; locate sediment filters above environmental sensitive areas such as streams or steep slopes; use sediment traps or basins as

the most effective structures to control concentrated runoff flows; locate multiple sediment basins or major sediment traps so that they drain in parallel not in series to reduce the risk of total failure

- minimise the length and steepness of the slopes; reduce runoff velocity by minimising the length of flow paths, constructing channels with gentle gradients and by providing rough linings to the steeper channels
- intercept, divert and safely dispose of clean runoff flowing onto all disturbed or critical areas, including soil stockpiles; use sediment filters as the most appropriate means of controlling sheet runoff flows; identify areas of existing vegetation which have the potential to filter sediment laden sheet runoff flows
- install permanent stormwater drainage works as soon as possible
- apply temporary vegetation or mulch to all disturbed areas, including soil stockpiles, where construction is only partially completed and which will remain exposed for a period of 14 days or more; progressively stabilise all disturbed areas either with permanent vegetation as each stage is completed.

(e) Rehabilitation of the dam walls and disturbed areas

Topsoil should be stripped off and stored for use on the pond walls, batters or in the rehabilitation of other disturbed areas. As soon as possible, dam walls, pond walls, batters, backfilling and disturbed areas should be rehabilitated preferably with suitable local native vegetation. All cleared vegetation should be mulched or used to help establish disturbed areas. This material should not be placed so as it is likely to be swept back into streams during a flood.

Any disturbance on the riparian zone including the bed or banks of rivers, estuaries or drainage lines should be stabilised and restored as soon a possible with local native vegetation. No species other than local native plant species should be planted in this zone (with the exception of sterile cover crops). Any revegetated areas should be appropriately maintained and weeded to ensure effective rehabilitation.

(f) Contaminated soils

If the site was previously used for agriculture that employed chemicals (pesticide, herbicides, cattle dips), the soils should be tested for chemical residues. If present, it may be necessary to remove all the topsoil and not to use it in the rehabilitation of the pond and batter walls.

(g) Acid sulfate soils

The excavation or disturbance of acid sulfate soils in the construction of the ponds, access roads or circulation drains should be avoided when ever possible. ASS could be a particular issue in the construction of water return drains on estuarine sites. If the disturbance of acid sulfate soils is unavoidable, then the construction must be undertaken in accordance with an approved environmental management plan that is consistent with the ASS Manual. The management plan should relate to any excavated ASS material as well as the drain walls. All excavated ASS material should be treated in accordance with the ASS Manual prior to use on the site or being taken off the site.

(h) Aboriginal heritage

Care should be taken to ensure that accidental disturbance does not occur to any Aboriginal sites (relics) or Aboriginal places protected under the National Parks and Wildlife Act. Any identified Aboriginal sites or places near the construction area, for which there is no permit authorising disturbance, should be clearly marked or temporarily fenced off.

If during construction, a previously unrecorded Aboriginal site (eg midden or tools) is uncovered, work in the area should cease immediately and the Regional Office of the Department of Environment and Conservation (DEC) should be contacted along with the Local Aboriginal Land Council.

(i) Native vegetation

The level of disturbance of native vegetation (terrestrial or aquatic communities) should be kept to a minimum and should be in accordance with any relevant approvals (eg under the Threatened Species Conservation Act, Native Vegetation Conservation Act, Fisheries Management Act). Generally all areas of native vegetation located near construction activities (which are not to be disturbed) should be marked or temporarily fenced (or equivalent) to ensure that accidental damage does not occur. In particular threatened or protect species for which disturbance has not been approved, should be marked, to avoid accidental disturbance. Where ever possible, native vegetation including grasses should be used in the rehabilitation or stabilisation of disturbed areas.

(j) Construction noise

During construction, the DEC noise guidelines should be adhered to. Recommended maximum noise levels for construction periods measured at nearest residences are:

<4 weeks	background noise levels + 20 dBA
4-26 weeks	background noise levels + 10 dBA
<26 weeks	background noise levels + 5 dBA.

Where these levels are not possible discussions should be held with neighbours and the Council on how noisy activities can be managed to minimise impacts on the neighbours. Reference should be made to the DEC's Industrial Noise Policy. This policy replaces the EPA's Environmental Noise Control Manual after July 2000. Generally a Construction Noise Management Protocol will be required with the level of detail matching the level of noise nuisance. Protocol should include:

- Compliance standards,
- Community consultation,
- Complaints handling monitoring / system and site contact person to follow up complaints; Contingency measures where noise complaints are received,
- Mitigation measures; Design and orientation of the proposed mitigation method demonstrating best practice,
- Construction times,
- Monitoring methods and program.

5. Tanks, Raceways and related facilities

Tanks and raceways commonly refer to those structures that are constructed from materials such as fibreglass, plastics, concrete, glass and metals and are usually situated either wholly or partly above ground.

5.1 General provisions

The interest in tank recirculating systems in Australia has increased significantly, with increasingly reliable recirculation treatment systems. Advantages include control over the stock, conservation of water, flexibility in site selection, smaller labour component, reduced impacts on the environment and extended growing season to year round if temperature controls are incorporated in the design. However, the system often has higher capital and operational costs and the success of the system depends on the successful operation of the recirculation system to avoid losses.

Intensive tank culture systems can be classified as:

- flow-through systems where water passes through the production system once and then is discharged or used for another purpose eg. in raceways. These forms of systems are generally <u>not acceptable</u> under this Strategy unless a demonstrated requirement can be justified such as in salmonoid, marine hatchery or abalone production. However, with such a system, very stringent discharge conditions would be applied. (See Section 5.4 in the Operating the Farm Chapter for further information on discharge considerations and requirements).
- recirculation systems where the water is reconditioned and recycled. The percentage of water recycled depends on the system design. High rates of recycling, together with high stocking levels require sophisticated equipment to polish the reconditioned water. These types of systems have been used successfully with species such as Murray Cod, Barramundi and eels.

If recirculation systems can be built in sheds, the conditions can be controlled to provide for optimum growing conditions. The following buildings, rooms and equipment are essential components of a tank aquaculture facility and their design and location should be planned so that space, labour and equipment are used efficiently and economically. These are:

- Structurally sound sheds or buildings;
- Stock culture tanks;
- Water pumps and drainage system;
- Recirculation system with mechanical filters to remove solids, biological filter system to remove metabolic by-products and a means of dissolved gas and possibly temperature management;
- Laboratory and general workroom with tanks for holding, sorting, quarantining and treating fish - with vehicular access;
- Handling/ packaging room for preparing stock for packaging and dispatch;
- Plant room(s) with backup generators if necessary;
- Store rooms for chemicals, feed, equipment;
- Office(s) and staff meeting room, toilet and washroom;
- Solid waste management facilities (filters, dead fish, packaging, solid waste);
- Reconditioned water-holding tanks and disposal provisions if no trade waste agreement with council.

5.2 The buildings

The recent expansion of aquaculture recirculation systems has resulted in a range of options and alternatives regarding building design and function. However fundamental requirements for a suitable building are:

1) It must be structurally sound and meet the functional needs of the proposal
2) It must be cost effective to construct/convert and maintain
3) It must have sufficient room on the site surrounding the building(s) for all necessary activities.

Relevant building codes and necessary permits must be obtained/complied with. In some circumstances it may be most efficient to construct a purpose built facility. In other cases it may be possible to convert an existing factory/shed complex. A number of intensive recirculation ventures have recently begun operations in disused freezer storage facilities where modifications were only required to provide for adequate drainage systems.

To optimize productivity and efficiency, the functional aspects of the building need thorough consideration. The structure should have sufficient room to accommodate nursery and grow-out tanks as well as isolated quarantine facilities.

The floor and wall materials should be conducive to effective and efficient temperature and humidity management and should be water-resistant. There should be the capacity to design into or retrofit sufficient drainage to avoid standing water on the floors. It is unwise to enclose all drainage lines in the concrete slab as routine cleaning and airing of drainage lines is important. It also allows easy access to all plumbing fixtures and allows for later modifications to the lines if necessary as a result of changing needs or capacity.

There should be sufficient floor space and elevation to accommodate mechanical operations such as biofiltration, mechanical filtration, CO^2 stripping, oxygenation, foam fractionator, sterilisers, temperature regulators, back-up generator (these are usually placed outside) in the recirculation system. Structure layout can serve as a mechanism to preserve biosecurity (minimise introduction of disease and infectious agents and facilitate pest management strategies).

Management of humidity in the building can become an issue. There should be a low humidity area for office and feed storage. Electrical service to the site should be sufficient to accommodate immediate and future needs. The site should be able to be secured.

5.3 The tanks

Generally, the best rearing tanks in a recirculating facility are circular as they allow for efficient recirculation and solids removal. The tanks should be designed to be self-cleaning but this will be dependent on the correct dimensioning of the tanks and water inlet and outlet design. Fibreglass tanks are generally considered better than concrete because of reduced fin wear and friction loss. Drains are of two basic types; single or double with the latter usually being superior in getting solids out of the tank as soon as possible. There are many designs and patented commercial drains available.

5.4 Tank water treatment

Recirculation systems require a high degree of management and knowledge of pumps and filtration systems, fish and organism physiology and water chemistry. The risk of loss in these systems increases proportionally with intensification due to the inherent dependence on life support technology. The basic factors to be considered in selecting a recirculation system include

- the fish to be produced,
- markets being served (weekly niche vs. monthly wholesale sales),
- available water supply and land;
- local, state and federal effluent regulations.

(a) Filters to remove solids

The basic elements of the recirculation system include processes to remove solids, remove ammonia and nitrite-nitrogen, oxygen addition and carbon dioxide removal, and in some cases disinfection.

Recirculation systems must first remove settleable and suspended solids prior to treatment by biological filter systems to convert ammonia and nitrite-nitrogen to less toxic nitrate-nitrogen. Faeces and uneaten food should be removed as fast as possible to minimise solids degradation. This can be achieved with settling tanks, and mechanical filters such as screen filters, disk filters, granular media filters. In most systems, the filtration process targets the removal of waste particles of greater than 30 microns in diameter. If necessary, fines solids and dissolved organic waste can be removed by using a foam fractionator, where these solids attach to the bubbles that float the waste out of the system.

(b) Biofilters to remove dissolved toxic wastes

Recirculation tank systems can be prone to water quality problems associated with the rapid buildup of toxic levels of ammonia and nitrite-nitrogen. Biofilters have an essential function in converting ammonia and nitrite-nitrogen in the water to a less toxic nitrate-nitrogen. This is achieved by use of nitrifying bacteria (eg. *Nitrobacter* sp and Nitrosomonas sp.) in purpose built biofilter systems. These must be adequately sized, operated in optimal temperature range, be designed to accept increasing flow rates up to a maximum load and assure constant shearing of the biofilm. The biofilters should have the right bacterial populations. Pre-activation of the biofilter is essential before stocking.

(c) Post filtration treatment

Additional treatment may be necessary to maintain a healthy environment in the fish culture tanks.

- Ultra -Violet or ozone filters may need to be incorporated into recirculation systems to control pathogens and limit disease occurrences.
- Intensive tanks will require supplemental aeration. In these circumstances the tanks should be fitted with an oxygen/air generator with back up blowers and electrical generators in the case of failures.
- Some form of water temperature control may be required for some species particularly in colder locations.
- Treatment may be necessary to control the pH.
- In intensive systems, gas stripping may be necessary to control the accumulation of carbon dioxide.

(d) Discharged water management

For recirculation tank systems, the volume of discharge water tends to be relatively small (5 - 10% of culture tank volume / day). In industrial estates, the potential exists for wastes and facility wash down water to be disposed of through a sewage system under a Trade Waste Agreement with the local council. In rural areas, freshwater to be discharged will need to be collected in a water storage unit (tank or pond) prior to irrigating to agriculture. (See *Section 4.3 Pond Water Reticulation System*).

5.5 Raceways

Raceway systems are generally utilised for species such as salmonoid, abalone and other species that have a requirement for high water flows. Raceway systems require a high degree of management and knowledge of pumps and filtration systems, fish and organism physiology and water chemistry. The risk of loss in these systems increases proportionally with intensification due to the inherent dependence on life support technology. Raceways are commonly constructed of concrete, plastics, fibreglass or other materials that can withstand the pressures of high water flows. The basic factors to be considered in selecting a raceway system include

- the fish to be produced,
- markets being served (weekly niche vs. monthly wholesale sales),
- available water supply and land
- local, state and federal effluent regulations.

(a) Construction issues

Raceways systems should be constructed to where possible include recirculation systems

Preferred design:	Raceway farms that utilise recirculation systems.

It is preferable that acid sulfate soils are not used for concrete raceway backfill or bank construction. Acid sulfate soils may react with concrete and jeopardise the integrity of the structure.

Groundwater can also cause constructed raceways to be undermined resulting in structural failure.

(b) Inlets

In flow through systems the inlet and discharge points, because of the large volumes of freshwater required, should be placed in close proximity to prevent dramatic modification to stream levels and flows between points. The diversion of water for flow through systems will require extensive consideration by DIPNR in terms of water extraction, embargoes and water quality impacts on the river system. Also embargoes in the Hunter and Central Coast area may prevent the reuse of any water from flow through systems. (See Section 5.4 in the Operating the Farm Chapter for further information on discharge considerations and requirements).

For marine growout facilities and hatcheries the location of inlet systems is critical from an engineering perspective, particularly in areas with high wave energy. Pipelines traversing sandy beaches are very problematic. Existing infrastructure (eg piers) or utilisation of existing bedrock for anchoring the pipeline is recommended

Preferred design: existing infrastructure to carry inlet pipe at marine sites.

(c) Discharged water management

Raceway systems generally comprise of a flow through system of up to 100%. However, recirculation of part or all of the water should be investigated, such as utilising water for other fish farming enterprises.

Mechanical filtration and/or settlement ponds are required to remove settleable and suspended solids prior to further treatment or discharge. Faeces and uneaten food should be removed as fast as possible to minimise solids degradation. This can be achieved with settling ponds, and mechanical filters such as drum filters, screen filters (eg wedge wire), disk filters and granular media filters. Raceways may be shaped to maximise flow, removal of organic particle matter and to also aerate the water.

Flow through systems may be permitted to discharge under strict conditions, however, this will require extensive consideration by DIPNR in terms of water extraction, embargoes and water quality impacts on the river system. (See Section 5.4 in the Operating the Farm Chapter for further information on discharge considerations and requirements). In a flow through system (eg. salmonoid farm) utilising a flow of 30 ML/day, to obtain a reasonable particle removal from the water mechanical filtering systems down to 1000 microns or a settlement dam with a volume>10% of growout volume may achieve the desired objective.

Preferred design: Zero discharge.

In marine tank/raceway farms utilising saline water mechanical filters or a retention/recirculation pond capable of a retention time of at least 10 times the volume of the growout system would achieve reasonable solids removal. However, recirculation of part or all of the water should be investigated and zero discharge is the preferred design. Retention dam ecosystems may also result in some nutrient stripping however, the size of the retention dam required for a flow through abalone farm would be considerable and may result in other environmental impacts.

Preferred design: Zero discharge.

6. Hatcheries

6.1 General provisions

The development of the aquaculture industry in NSW will depend on the supply of reliable vigorous healthy seed stock. In addition to the demands from a growing aquaculture industry, there is an increasing focus on the development of marine and freshwater hatcheries that can produce fingerlings or shellfish spat for conservation purposes or for stock enhancement of waterways for recreational or commercial fishers. Increasingly, there is a need for modern breeding facilities that can deliver reliable quantities of genetically prescribed stock to meet a range of purposes (See *Section 3 Species Selection*)

In certain species, such as eels, industry still relies on the wild catch of juveniles from nature. In the farming of other species (such as oysters) the supply of juveniles is still mainly dependant on wild catch, though production through hatchery techniques is also undertaken on a commercial basis in New South Wales. For other aquaculture species, such as silver perch, the source of juveniles is solely dependent on the supply from hatcheries, operated under varying degrees of environmental manipulation.

Hatcheries may be stand-alone facilities or integrated with an aquaculture farm. Facilities specifically relating to the hatchery would normally include broodstock rearing facilities, spawning tanks, incubation facilities, nursery/larval rearing tanks (and in some cases ponds). The hatchery facilities must include a laboratory for quality control and management and high quality water treatment and management systems to meet the specific needs of each phase of the hatchery cycle.

The establishment and operation of a hatchery has serious potential hazards both from an environmental and economic perspective. Good hygiene must be practiced in relation to the tanks, transport containers, holding facilities, water reconditioning systems and operational equipment. Each rearing tank should have its own set of operational equipment including sampling and cleaning equipment. Worker transfer of disease on equipment, hands, clothes and shoes from one area of the hatchery to another is one of the common causes of disease spreading in hatcheries. All hatcheries should have the ability to quarantine the facility including storing all reconditioned water if there is a disease outbreak.

6.2 Water management systems

With an integrated hatchery/ aquaculture farm, it is recommended that the hatchery water treatment/ reconditioning system be kept separate from the farm's system. With hatcheries that import salt-water broodstock from interstate, the reconditioned water should be stored, quarantined and not released to any natural water system until disease-free certification of the progeny is approved. As with freshwater aquaculture farms, there should be no release of reconditioned water from freshwater hatcheries to natural waterways or wetlands. Salmonoid production may be considered as an exception however, it would be critically evaluated and strict discharge conditions would be applied. (See Section 5.4 in the Operating the Farm Chapter for further information on discharge considerations and requirements).

For marine hatcheries, the systems are usually designed for discharge but overall discharge and nutrient loading is low because of low biomass and feeding within the hatchery. Mechanical filtering such as drum filters can be employed to remove solids and prevent accidental discharge of larvae.

Preferred design: Zero discharge

6.3 Broodstock supply

Broodstock are the mature individuals of a species capable of naturally spawning or of being artificially induced to spawn in a hatchery environment. The initial source of broodstock in any aquaculture species is from the wild. For species where the broodstock need to be sourced from the wild a permit is required. The permit may stipulate that broodstock sourced from the wild must be returned to the site of capture and released at the end of the breeding program.

However, in some NSW species, particularly certain freshwater native fish, the availability of broodstock from nature is diminishing because of environmental degradation and other factors that have reduced natural populations in recent years. In some cases, such as the silver perch, the species is already considered threatened. To avoid undue environmental impact on these species and the negative image the aquaculture industry may derive from collecting precious broodstock from nature, Department of Primary Industries is encouraging the development of broodstock facilities in conjunction with hatchery projects in species that it considers necessary and feasible to have such a development program.

The long-term benefits of such a program include independence of industry from natural populations of the species and capacity for selective breeding/ domestication. In many species that are cultured here and abroad, broodstock programs are a very valuable part of an overall hatchery development.

Broodstock must be maintained in the hatchery under strict husbandry conditions to ensure that they are healthy and fit and capable of producing viable quantities of offspring or juveniles.

6.4 Genetics

The application of genetic principles in the production of stock is critical both for the reliable production in the aquaculture industry and in the stock enhancement program. Selective breeding programs for the aquaculture industry should be appropriately management and carefully monitored through the grow-out stages (See *Section 3 Species Selection)*.

6.5 Disease and pest transmission

Since the purpose of a hatchery is to provide juveniles for ongrowing in other areas, a hatchery has a potential for disease transmission, both to other aquaculture farms and into the natural environment. Common causes of disease in hatcheries include:

- poorly designed or inadequate facilities especially in relation to the water reticulation system,

- poor fish health management including overcrowding,
- lack of quarantine procedures or safeguards,
- lack of bio-security, eg in relation to bird or feed contamination sources,
- poor understanding of disease origins, prevention and remedy,
- lack of experience and /or poor training of staff in hatchery procedures,
- inadequate maintenance including routine total dry-out of facilities.

6.6 Accreditation and quality control

Well run aquaculture hatcheries providing quality stock to meet the conditions in NSW are fundamental to the future growth of the aquaculture industry in the State. Hatcheries need to be carefully regulated and monitored for the healthy development of the aquaculture industry as well as for the restocking of depleted natural stocks. Hatcheries are relatively complicated, requiring a high degree of technical expertise and experience, and significant capital investment. Hatcheries should not be considered a "do-it-yourself" business as significant environmental hazards to the industry and the environment can result from unprofessionally run facilities.

Hatcheries are a relatively risky venture with a potential for lucrative returns provided they are correctly established and operated with careful consideration of the market and the environment. Establishments which breed fish primarily for release to natural waterways have the potential to cause great environmental damage as well as economic damage to the commercial and recreational fishing industry, as well as tourism. Those breeding for commercial aquaculture farming have the potential for great economic damage on individual growers and the aquaculture industry.

Department of Primary Industries will require all hatcheries to be accredited and to comply with Audit Protocol requirements. Hatcheries will be assessed for risk that will be dependent upon the

- species of fish being cultured,
- the source of broodstock, and
- where the fish are destined.

Hatcheries breeding fish must be accountable for their day-to-day operations and have high levels of duty of care. There should be quality control programs where the hatchery provides an assurance as to the quality and viability of the stock being provided. A daily log should be kept of each rearing tank or pond recording water and fish details and other relevant information. This information should be available to Department of Primary Industries officers and prospective buyers of stock and attached to the Declaration of Origin.

Depending on the species, the log should contain information on the number of fry/larvae, feeding regimes, water quality parameters and any mortalities, abnormal appearances, behaviours or cessation of feeding.

- There should be an approved sampling program of stock to examine for health and vitality.
- All samples must be examined grossly and/or subgrossly with a dissecting microscope for the presence of abnormalities and parasites.
- If there is evidence of disease, the samples should be analysed to determine the causes.

7. Recreational facilities

7.1 Tourist destination

There is a high level of interest in many sectors of the community to visit commercial operating facilities and to buy produce directly from the growers. An aquaculture business can capitalise on this interest by providing visitor facilities and allowing visitors to look over the farm and purchase its products. From a public relations point of view, these types of visits provide an opportunity for the industry to show case the sustainability of the aquaculture industry and for the broader community to develop an increased understanding of fish, aquatic ecology and fish farming.

An aquaculture business can provide visitor facilities with displays explaining the fish growth phases with fish and fish products available for purchase. Tourism facilities would need to include adequate toilet facilities, possibly picnic tables, car parking and an appropriate level of public liability insurance. Local tourism authorities may also assist in providing information on the requirements of local tourists and how an aquaculture business can enhance a region's tourism experience.

If fish are to be maintained in an aquarium for public display, a permit must be issued by the Department of Primary Industries under the Exhibited Animals Protection Act.

7.2 Fishout facility

A fishout is a private dam or pond that is stocked with fish where anglers pay to catch the fish. A fishout sited in attractive landscaped surroundings stocked with trophy sized sport fish can become an attractive destination. A standard Class C commercial aquaculture permit needs to be expanded to include a Class F aquaculture permit for fishouts. The fishout ponds can be stocked from the aquaculture ponds or with fingerlings and allowed to grow. Feeding the ponds results in faster and more even growth. If fish are being grown in ponds, a number of fishout ponds may be required for stock rotation and so the fish do not become hook-shy. Fishing tackle should be provided for anglers as anglers using their own tackle could introduce disease to the farm.

Anglers visiting fishouts do not require licenses as long as the appropriate Class F Permit. Bag and size limits do not apply in fishouts but the operator must supply the angler with a "record" of the fish taken (date, number, size, combined weight by species and location of fishout) so as avoid confusion with wild fish. In some circumstances, fish are tagged or fin clipped to avoid confusion with wild stock.

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