3.8 POND SYSTEM MAINTENANCE

3.8.1 Desludging

Research has shown that management of sludge levels in the anaerobic pond is a key factor affecting aerobic pond performance.

If an analysis has been taken of the pond outflow and the quality is termed poor, this may indicate that the pond requires desludging. However, farmers should not wait until such a situation exists before desludging a pond.

Effluent flow will be reduced in ponds that are not regularly desludged. The outlet baffle (i.e. subsurface pipe, T-piece or timber baffle) may clog up and fall into disrepair due to sludge build-up or excessive crusting.

3.8.1.1 When to desludge

Regional Councils have different rules and consent conditions regarding desludging. It is recommended that as a minimum, **anaerobic ponds should be desludged at least once every four years but best practice is to desludge every two years or even annually.**

Desludging is less of a concern to Regional Councils if the pond is used for storage before land application, rather than discharging to a waterway.

Undersized ponds, those in colder climates and those that discharge into sensitive environments need more frequent desludging. In-flows to ponds will also influence the need for desludging e.g. if a stand-off area or feed pad is connected to the effluent system.

A useful indicator of when individual ponds may need desludging is when the sludge level is over half the normal effluent depth. This can be checked by probing with a long pole.

The aerobic pond will need desludging less frequently, depending on the rate of sediment build up. However, it may be more convenient to desludge all ponds in the system at the same time.

The consumption of poorer quality pasture by the herd (e.g. pastures high in kikuyu, paspalum and fescue) may result in excessive crusting and require more frequent desludging.

If operating barrier ditches the system, especially the first ditch sections, will need regular desludging. If they are not desludged regularly, the system will become inefficient and ineffective at treating the effluent. Effluent flow will be reduced and the outlet baffles may clog up and fall into disrepair due to sludge build-up or excessive crusting. **As a general rule, barrier ditches should be desludged annually.**

3.8.1.2 Methods of desludging

Sludge and crusts are usually removed with excavation machinery. Alternatively, a drag line can be used. Contractors in most regions have appropriate equipment and experience in desludging ponds.

If possible, **the surface liquid effluent should be removed before desludging** by suction drawing it into a vehicle spreader (refer to 2.10 Vehicle spreading).

Removal of the liquid effluent makes the sludge easier for excavators to contain and handle. The liquid can be pumped out using a vehicle spreader, where a tanker is backed close to the pond and effluent is drawn into it by a PTO-driven pump.

Pond stirring, to mix the various layers of the pond during tanker filling, can remove the need for excavators to desludge ponds (refer to Figure 3.8-1).

Effluent from the aerobic pond can also be pumped into the first pond to make it easier to dilute and remove effluent solids prior to land application.

FIGURE 3.8-1

SIMULTANEOUS POND STIRRING AND TANKER FILLING

Ponds should never be emptied out completely. A third of the sludge should be left behind as it will contain bacterial populations necessary for the continuation of anaerobic processes.

3.8.1.3 Applying pond sludge to land

Considerations when applying pond sludge to land include:

- **regional council regulations** regarding land application of effluent, and in particular the higher concentration of nutrients in sludge
- **buffer distances** from waterways and public areas
- **correct application rates** and **area requirements**
- **suitable weather and ground conditions.**

For information on the application of pond sludge to land refer to 2. Land application and 2.8 Land application of sludge.

3.8.1.4 Chemical and biological treatments

Several kinds of additives are available and are claimed to dissolve and disperse solids build-up, particularly crusting. These additives vary in their effectiveness. Current evidence shows that they are not a long-term solution to reducing sludge and crusting problems.

3.8.2 Weed control

Crusts on ponds may begin to support vegetative growth (refer to Figure 3.8-2). This can give the appearance of solid ground, creating a potential safety hazard for people and stock. Furthermore, the roots of weeds will entangle pond stirrers and interfere with desludging machinery. **Do not let weeds build up on the crust layer of ponds.**

However, **maximise weed growth in receiving drains.** The weeds will act as a filter, taking up effluent nutrients and sifting out suspended solids. Clean out only a third of the receiving drains at a time so that there is always weed present to assist with effluent filtering.

Do not spray the drains.

FIGURE 3.8-2

UNACCEPTABLE WEED GROWTH ON PONDS

3.8.3 Daily

- Before and after every milking, **check that the stormwater or washwater diversion is in the correct position.**

3.8.4 Regularly

- **Clean and clear the effluent stone trap and gratings.**
- **Check that the pipes running in and out of the ponds are not blocked.**
- **Check the effect of the discharge on the receiving waterway.**
- **Check that the pond walls are stable, and that there is no seepage.** Visible wetness or pasture that is growing exceptionally well are indicators of seepage problems.
- **Control weed growth in and around ponds** by spraying with a herbicide.
- **Check that the fencing remains stock-proof.**

3.8.5 Six monthly to annually

- **When the area around the ponds is dry, graze them.**
- **Clean out only a third of the receiving drains at a time** so that there is always weed present to assist with effluent filtering.
- **Check that there is not excessive build-up of solids in the anaerobic pond.**
- **Desludge ponds regularly, preferably annually or every two years but at least once every four years.** Dispose of sludge on to land according to recommendations in 3.8.1.3 Applying pond sludge to land.
- **Check that the pond is not becoming shaded by vegetation** as this will decrease treatment efficiency.

3.9 POND SYSTEM REGULATIONS

Pond systems are designed and constructed relative to the volume and quality of farm dairy effluent they are expected to handle, and the region in New Zealand in which they are sited. However, **Regional Councils** (and District Councils) and the **NZ Food Safety Authority in conjunction with the Dairy Industry** also have regulations governing the design of pond systems.

3.9.1 Food safety and dairy industry requirements

The health and hygiene practices on the farm, and within the farm dairy, are closely monitored by overseas markets and have a considerable effect on the saleability of New Zealand's dairy products. Hence, the Dairy Industry has worked with the NZ Food Safety Authority to put hygiene regulations in place that must be followed to help promote the industry to overseas consumers.

These regulations are focused on **human and animal health** as effluent may contain transmissible animal diseases, including bacteria, viruses, cysts, and eggs and larvae of parasites (e.g. hookworm, roundworm and tapeworm).

Disease-causing micro-organisms present in effluent originate mainly from stock and so **the levels of disease-causing microorganisms reflect the current state of health of the herd.** Therefore, with good husbandry practices, effluent originating from dairy cows should be free of major diseases.

If effluent is retained within the pond system for long enough pathogenic micro-organisms will be destroyed.

The survival of various disease-causing micro-organisms during effluent storage and treatment is summarised in 2.13.1 Food safety and dairy industry requirements.

3.9.1.1 Food safety, dairy industry and health regulations

Food Safety regulations for the dairy industry (i.e. the Farm Dairy Code of Practice NZCP1) require that **storage sumps** (where the effluent is **not** immediately pumped or gravity fed into ponds) **must not be located within 10 m of the milking area, milk receiving area or milk storage area. Sumps greater than 22500 L must not be within 45 m of the above areas.**

Effluent **may not be disposed of within 45 m of the farm dairy** (i.e. milking area, milk receiving area and milk storage area). This includes pond systems, barrier ditches, constructed wetlands and places where effluent is applied to land.

Occupational Safety and Health regulations require stock to be vaccinated against harmful animal and human diseases (e.g. leptospirosis).

Care should be taken with personal hygiene after handling effluent in any form, and when working with treated soil.

3.9.2 Regional Council requirements

Regional Council concern is primarily focused on:

- **siting, design and construction of pond and barrier ditch systems**
- the quality and quantity of the discharge
- environmental **effects that the discharged effluent may have on waterways.**

3.9.2.1 Pond siting, design, construction and operation

In light of the Resource Management Act (1991), Regional Councils have policies and rules in their Regional Plans that describe what **effluent and receiving water quality standards must be met, rather than outlining the physical design of the system itself.**

Regional Councils may also insert conditions in resource consents regarding the design of pond systems. The following is a list of those components of the system that must be taken into account in design to avoid or minimise adverse effects. Some of these aspects may also be standards for design and specified in Council rules or resource consents.

- **Stormwater control.** Stormwater originating from the farm dairy roof or yards, or from runoff from the land surrounding the pond system, will add loading and flush the pond system. This has the effect of decreasing effluent retention time and, subsequently, treatment time, effluent quality and efficiency.
- **Solid waste entry prevention.** Offal, pesticides, fertiliser and rubbish can block the treatment system as well as reduce the system's ability to treat the effluent.
- **Receiving water restrictions.** Certain surface waterways are too sensitive to receive treated effluent at any time (e.g. fresh water lakes and natural wetlands). The concentration of ammonia in receiving waters may be measured, following reasonable mixing, to determine the potential for waterway pollution.
- **Siting.** Buffer distances between ponds and surface waterways and groundwater are necessary so that the risk of contaminating water is minimised. Locations such as swampy ground and sloping ground may be subject to instability and stormwater or groundwater intrusion into the system.
- **Pond sizing.** The size of both the anaerobic pond and the aerobic pond is usually based on the BOD loading from maximum herd numbers. The depth of the ponds is important as system efficiency is largely determined by the pond depth.
- **Freeboard.** The minimum freeboard is given as insurance against flash loading and to reduce the erosion effects of wave motion.
- **Embankment construction.** The slope of batters, presence of key trenches, and the methodology in laying and compacting soil all affect the stability of the pond structure and its ability to withstand erosion and seepage.
- **Sealing.** Ponds need to be sealed so that no effluent seeps to groundwater, or through the embankment to surface water. Most Councils specify that ponds must be impermeable.
- **Inlet and outlet structures.** The design and position of the inlets and outlets can determine the efficiency of the system. Incorrect installation may result in seepage, embankment erosion, short-circuiting of the ponds and system blockages.
- **Fencing.** Fences are essential for the protection of stock and farm labour, and the protection of embankments from animal damage.
- **Desludging.** Over-accumulation of sludge or crusting decreases the treatment efficiency of effluent and increases the risk of solids passing into the system. However, the complete removal of the sludge layer can halt the operation of the pond system because of the absence of beneficial anaerobic bacteria populations living in the sludge.
- **Weed control.** Weed growth adversely affects the operation of the pond system as well as causing a physical nuisance with pipe blockages.
- **Shading.** The ponds (most importantly the second and any subsequent ponds) should not be shaded by trees or structures that can reduce the treatment of the effluent.

3.9.2.2 Measurable effects of effluent discharged into waterways

Regional Councils are responsible for the monitoring and upkeep of water quality standards. Table 3.9-1 shows a list of those factors which may be measured and used as standards for discharges to waterways and some typical critical levels for water quality (refer to 1.4 Why control the discharge of effluent? and 5.2 Resource management act (1991)).

TABLE 3.9-1

FACTORS IN MEASURING WATER QUALITY	
Clarity (Hue/Horizontal Visibility)	**Significance:** clarity is important for the enjoyment of swimming, fishing, and passive recreation, and for the wellbeing of many aquatic ecosystems **Measurement:** either the concentration of suspended solids (i.e. SS), measured in grams per cubic metre of water, or as turbidity where light is scattered by undissolved particles, measured in Nephelometric Turbidity Units (i.e. NTU), or the depth at which a black disk becomes invisible, measured in metres **Indicator Concentration:** contact and passive recreation: SS = 4 g/m^3, Turbidity = 2 NTU, Black disk = 1.6 m.
Dissolved oxygen levels	**Significance:** declining dissolved oxygen levels damage aquatic ecosystems **Measurement:** dissolved oxygen measured as the percentage of saturation concentration or as grams per cubic metre of water **Indicator Concentration:** aquatic ecosystems: 80% saturation or 5 to 6 g/m^3. Water supply: 5 g/m^3
Organic matter content	**Significance:** high organic matter is associated with the growth of fungi and with fish respiratory distress and death **Measurement:** biochemical oxygen demand, measured as the amount of oxygen consumed by organisms as they degrade the organic matter, at 20°C, over 5 days (i.e. BOD_5) **Indicator Concentration:** contact and passive recreation: BOD_5 = 3 to 5 g/m^3
Acidity levels	**Significance:** extremes of acidity (i.e. high acidity or alkalinity) and rapid changes in acidity are damaging to aquatic ecosystems and are undesirable for public water supplies **Measurement:** measured as pH **Indicator Concentration:** human consumption: pH = 7.4 to 8.5. Aquatic ecosystems. pH = 6.0 to 9.0
Dissolved nutrient status	**Significance:** high levels of reactive phosphate and inorganic nitrogen are associated with water weed proliferation and algal blooms. High levels of nitrate are implicated with a form of cyanosis or poisoning in bottle-fed infants during the first six months of life (known as 'blue baby syndrome'). High levels of ammonia-N are toxic to aquatic fauna **Measurement:** levels of Dissolved Reactive Phosphate (i.e. DRP), and levels of Dissolved Inorganic Nitrogen (i.e. DIN), and levels of nitrate nitrogen, and levels of ammonia-N. All measured in grams per cubic metre of water **Indicator Concentration:** contact and passive recreation: DRP = 0.01 g/m^3, DIN = 0.10 g/m^3. Human consumption: Nitrate-N = 10 g/m^3. Stock water: Nitrate-N = 30 g/m^3. Aquatic ecosystems: Ammonia-N = varies with temperature and pH. Can be toxic at < 1 g/m^3 with high pH
Pathogenic micro-organism levels	**Significance:** pathogenic micro-organisms occur in water primarily as a result of faecal contamination, and are a public and stock health risk **Measurement:** the number of faecal coliforms or the number of enterococci or the number of E. coli, per 100 ml of water **Indicator Concentration:** contact recreation: 200 faecal coliforms or 33 enterococci or 126 E. coli per 100 ml. Stock water: 1000 faecal coliforms per 100 ml with no more than 20% over 5000 per 100 ml. Human consumption: Nil faecal coliforms per 100 ml. Irrigation: 1000 faecal coliforms per 100 ml

Ministry of Health, 1995; Department of Health, 1984; Department of Health, 1992; Ministry of Agriculture and Fisheries, 1993; Parminter, 1995.

3.9.2.3 Regional Council regulations regarding effluent discharge to surface water

Each Regional Council has different rules for the discharge of effluent to surface water. Regional Councils may also have different rules between catchments within the same region (check with the Regional Council for the relevant rules). Table 3.9-2 outlines how the activity is classified in each region. A permitted activity has certain conditions that must be met but does not require a resource consent, whereas a controlled, discretionary, restricted discretionary or non-complying activity all require a consent before the activity can commence. A prohibited activity means that it will not be possible to get a consent for the discharge of effluent to surface water. For more information on the different classifications of activities refer to section 5.3.1 What is a regional plan? If the conditions of the activity cannot be met then the classification is likely to be more restrictive. For example if the conditions of a controlled activity rule cannot be met then it is likely to be classified as a discretionary or non-complying activity.

Table 3.9-2 is a summary and should not be used for legal purposes. To obtain the information in full, request the **Regional Plan(s)** pertaining to soils, water and air quality from the Regional Council. The classifications of these activities are current (January, 2006) and may be subject to change by the Regional Councils.

TABLE 3.9-2

ACTIVITY CLASSIFICATIONS FOR THE DISCHARGE OF FARM DAIRY EFFLUENT TO SURFACE WATER

Regional Council or Unitary Authority	Type of activity
Northland Regional Council	Discretionary
Auckland Regional Council	Controlled
Environment Waikato	Discretionary
Environment BOP	Discretionary
Gisborne District Council	Non-complying
Hawke's Bay Regional Council	Discretionary
Taranaki Regional Council	Controlled
Horizons	Discretionary
Greater Wellington	Discretionary
Marlborough District Council	Discretionary
Nelson City Council	Discretionary
Tasman District Council	Unrestricted discretionary
Canterbury Regional Council	Prohibited
West Coast Regional Council	Discretionary
Otago Regional Council	Discretionary
Environment Southland	For up to 50 cows - Permitted For up to 51 - 600 cows - Controlled For 601+ cows - Discretionary

3.10 CONSTRUCTED WETLANDS

Wetlands are areas which support the growth of a variety of plant species adapted to flooded conditions for part of, or the entire, year. The plants are densely spaced and, together with the shallow water, provide good wildlife habitat as well as water purification.

Constructed wetland systems are designed to simulate and optimise the filtering and organic matter breakdown processes that occur in natural wetlands. **They are a possible solution to improve the performance of pond systems, as they can 'polish' farm dairy effluent before discharge to a waterway.**

During summer months, such a system may even result in zero discharge to waterways, due to evapotranspiration of water from the wetland.

Constructed wetlands are designed to ensure greater reliability, a low risk of environmental impact and increased control over the treatment process. The advantages of constructed wetlands are that they:

- **have the ability to treat a wide range of contaminants**
- **have the ability to handle shock loadings of effluent**
- **do not normally rely on electricity or machinery**
- **have aesthetic value and provide wildlife habitat**
- **are more acceptable to Maori than direct discharge to surface waterways**
- **require minimal ongoing capital expenditure and maintenance once established**
- **operate successfully over a wide range of climate regimes** (as long as cold temperatures do not affect the functioning of the pre-treatment ponds).

Constructed wetlands are not 'stand alone' treatment systems. They are designed to polish effluent flowing from a pond system before it reaches a surface waterway.

For constructed wetlands to operate successfully the pond system must be working to expectations and effluent flowing from the pond system must be treated to a high standard.

3.10.1 Planning for a constructed wetland system

Figure 3.10-1 gives the steps to follow when considering installing a constructed wetland as an additional treatment system.

FIGURE 3.10-1

PROCEDURE FOR PLANNING A CONSTRUCTED WETLAND SYSTEM

Peak volumes and loading
Identify the volume, BOD and pollutant loading
(refer to 3.2.4 Pond system effluent characteristics)

Topography, landscape, waterways and soils
Consider land suitability and potential to link to other landscape features
(refer to 3.10.6 Siting of constructed wetlands)

Wetland system regulations
Meet Regional Council and food safety requirements
(refer to 3.10.10 Constructed wetland regulations)

Wetland site selection
Select a suitable site for the wetland system
(refer to 3.10.6 Siting of constructed wetlands)

Wetland design
Calculate the area required and estimated average depth.
Consider retention times and pre-treatment standards
(refer to 3.10.7 Wetland design and construction)

Wetland construction
Pay attention to effluent flow control, stormwater control, wetland sealing and fencing
(refer to 3.10.7 Wetland design and construction)

Select and establish suitable plants
Consider adaptability, persistence and growth habits.
Favour native sedges and plants. Avoid invasive weeds
(refer to 3.10.7 Wetland design and construction)

Wetland management
Correctly carry out system management and maintenance.
(refer to 3.10.8 Constructed wetland maintenance)

3.10.2 Constructed wetland management

To ensure the best treatment of effluent, **both the initial pond treatment system and the constructed wetland should be designed, constructed and planted correctly from the beginning.** Constructed wetlands should not be considered as a 'patch up' system for ponds or barrier ditches that are not working properly. Wetlands are designed to function effectively only if used together with an initial treatment system that is operating adequately.

Establishing and maintaining constructed wetland plants is the critical and most difficult challenge. To achieve ongoing plant growth, the constructed wetland must be maintained regularly and properly from the time of installation.

Control of effluent levels within the wetland is also important during plant establishment. **After planting keep effluent levels to a minimum (i.e. 50 mm to 100 mm) then gradually raise them as the plants develop** (refer to Figure 3.10-2 and Figure 3.10-3).

FIGURE 3.10-2

PLANT ESTABLISHMENT

FIGURE 3.10-3

PLANT DEVELOPMENT

Waterfowl (e.g. pukeko and canada geese) can pull out and destroy young plants. Electric fencing or other deterrents may be required during the establishment phase if these birds are present.

If contractors are involved in establishing the wetland plants, make it their contractual responsibility to have a set percentage of successful and active growth by a certain time.

Maintenance involves monitoring, controlling pests and weeds, managing the plant species and repairing and maintaining pipes and embankments.

3.10.3 Costs of a constructed wetland

A basic cost for installing a 400 m^2 constructed wetland (surface flow) suitable for basic treatment of oxidation pond effluent from 200 cows will be around $12 000 - $15 000 including earthworks, a clay liner, inlet and outlet structures, gravel and plants. Additional establishment costs (site survey, design and resource consent processes) may be up to $2500. Other costs depend on:

- **the site.** Obstacles such as rocks, the soil type and accessibility largely influence the time and effort required to excavate soil and seal the wetland base
- **whether any pumping facilities to and from the wetland are required**
- **the need for artificial liners.**

The expense is governed by the complexity of the system.

3.10.4 Constructed wetlands as an economic and practical option

The financial costs associated with capital outlay, ongoing maintenance and labour requirements for a constructed wetland are moderate. Furthermore, effluent discharged to waterways from an effective wetland is of a higher quality. Together, this makes incorporating a wetland into the existing/planned pond system an attractive option, especially if habitat and aesthetic improvements are valued.

For both existing and planned pond systems a constructed wetland can be introduced in an effort to obtain both the economic advantages of employing a pond system, and effluent quality standards that will satisfy Regional Councils and be of benefit to the environment.

3.10.5 How constructed wetlands work

Wetland processes treat waste in a number of ways:

- **solid particles settle out in shallow, slow-flowing waters with dense vegetation.** Algae production is also inhibited due to shading of the wetland plants. This is advantageous as algae growing within the effluent add to its BOD
- **pathogenic micro-organisms are reduced through enhanced sedimentation (settling out with the solids), natural die-off and grazing by protozoa**
- **micro-organisms break down the wastes.** Bacteria, fungi, protozoa and algae break down the organic matter. In particular, microbial slimes (biofilms) which form on the surface areas provided by plants, settled solids, soils, and gravel rapidly break down organic materials and take up nutrients. Wetlands provide a mosaic of oxygenated (aerobic) and oxygen-free (anaerobic) 'micro-environments' where different bacteria can work to break down matter and transform nutrients such as nitrogen and sulphur to gases that are released back to the atmosphere. This is assisted by the snorkel-like action of wetland plants, which transport oxygen down to the root zone
- **plants take up nutrients for their own growth** and return them back to the wetland as organic matter when they die. This is largely a recycling system and will not account for much nutrient removal. In general, nutrient uptake and storage by plants generally accounts for a small proportion of nutrient removal from the wetland (5-15% on an annual basis).

The effective 'polishing' of effluent in a wetland system depends on the design employed for maximising retention, the quality of the in-flowing effluent, the climate and season, and the plants used.

An established wetland can be expected to behave differently than a recently constructed wetland.

The two principal types of constructed wetland systems are **surface-flow wetlands** and **subsurface-flow wetlands.**

Surface-flow wetlands have effluent flowing through the stems and lower foliage of the wetland plants that are rooted in soil. Subsurface-flow wetlands have effluent percolating horizontally through the root zone of the wetland plants growing in a gravel bed.

A combination of both surface-flow and subsurface-flow systems can also be employed. This combination, when correctly loaded and designed, can significantly improve on pond systems. The figures for wetland effectiveness vary depending on whether a single wetland is used (lower range figures below) vs a combination of surface and subsurface (higher range figures below). The higher range nitrogen removal will only be achieved if mechanical aeration is part of the pre-treatment pond system.

Above and beyond pond treatment, wetlands can achieve a:

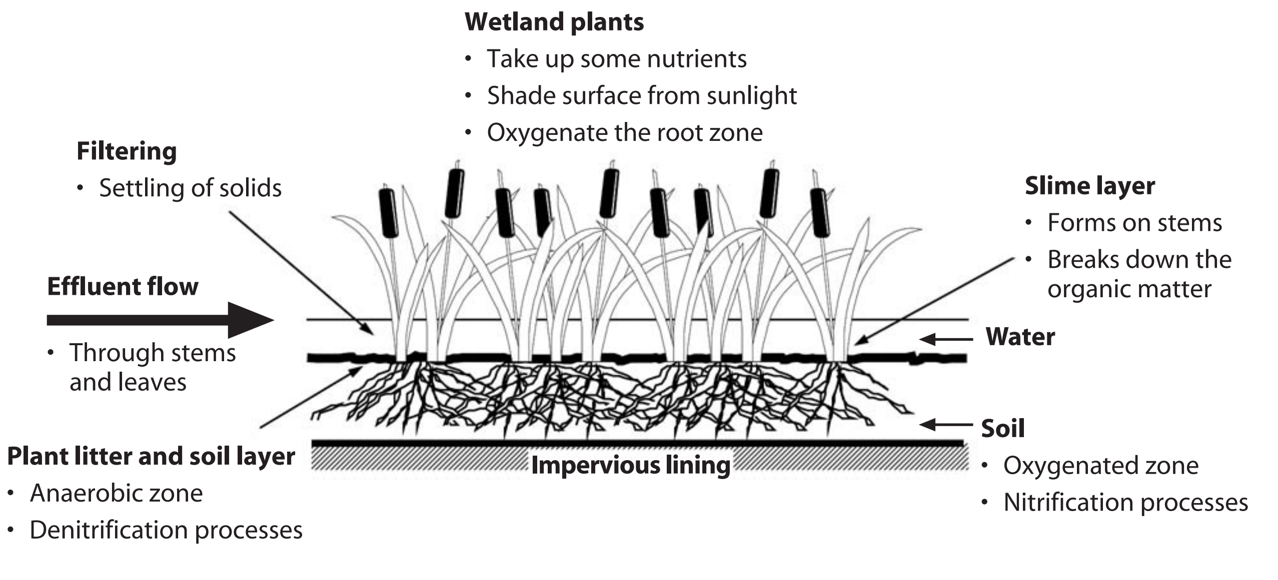
- **reduction of 35% to 75% BOD and suspended solids**
- **reduction of 15% to 80% total nitrogen** through nitrification and denitrification processes and some ammonia volatilisation. The higher rates of nitrogen removal can only be achieved with mechanical aeration in the pond or intermittient - dose vertical flow wetlands
- **reduction of 70 to 95% of pathogenic bacteria populations** by filtration, biological breakdown and plant toxin effects. However, even at the high end of microbial treatment, the outflow will still usually contain microbial contamination that exceeds 500 faecal coliforms/100 ml and therefore is not suitable for contact recreation
- **possible reduction of small and variable quantities of phosphorus and sulphur.** Initial removal may be highest (i.e. up to 75%) with continuing removal depending on the use of special substrates to absorb phosphorus and management steps such as plant harvesting and wetland dredging. Ongoing phosphorus removal could be higher if specifically absorbent soils or sediments are used (e.g. iron oxides, steel wool, bauxite clays, allophane clays, natural loam soils, bauxite, red mud, red sand, smelter slag). However, the use of these materials has not yet been sufficiently researched to make recommendations.

3.10.5.1 Surface-flow wetlands

In surface-flow wetlands (refer to Figure 3.10-4) a slime layer or bio-film develops on the plant stems and in the litter. This layer provides a habitat for bacteria that biologically break down effluent. Plants also filter out suspended solids from the effluent stream.

FIGURE 3.10-4

SURFACE-FLOW



Surface-flow wetlands are simpler to design, and less costly to construct than subsurface-flow wetlands. They can also tolerate higher suspended solids loadings and are more easily desludged and re-established.

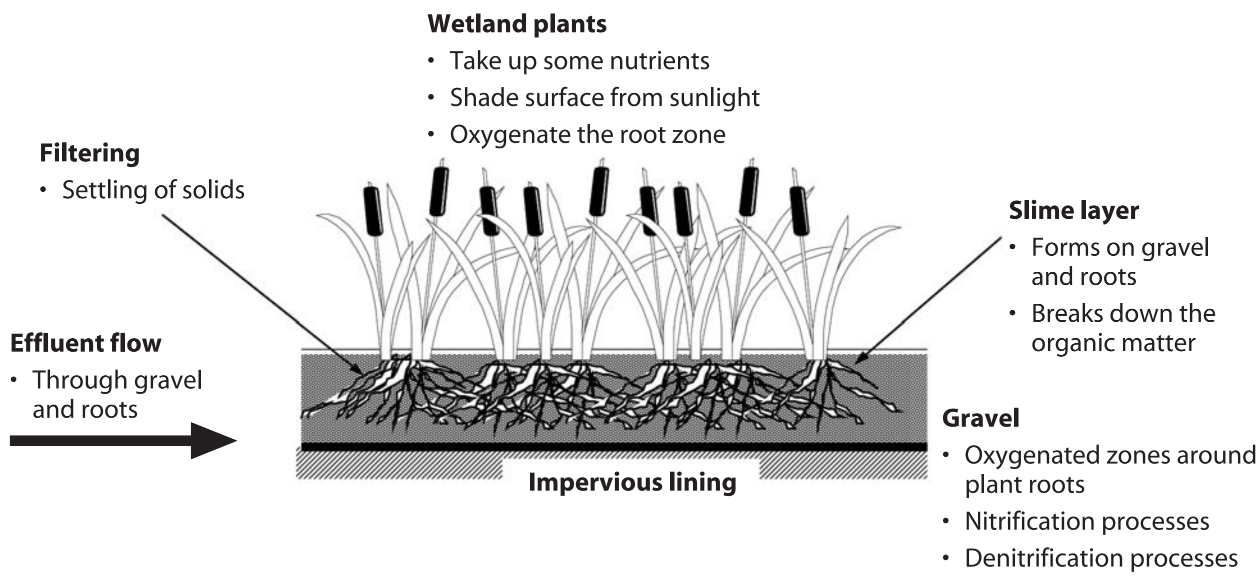
Surface-flow wetlands are readily adapted to provide a habitat for wildlife. Open, unvegetated zones can be created by providing additional deep zones within the wetland. However, effluent from the open area should pass through a densely vegetated shallow zone before discharge to a waterway.

3.10.5.2 Subsurface-flow wetlands

A subsurface-flow constructed wetland (i.e. 'root-zone' system) works similarly to 'hydroponics'. The wetland bed is excavated and lined with an impermeable layer. It is then backfilled with the gravel in which the plants root and there is no free water above the gravel surface (refer to Figure 3.10-5).

FIGURE 3.10-5

SUBSURFACE-FLOW



A slime layer develops on the gravel and plant root rhizomes, providing a habitat for bacteria and other microbes that break down effluent.

Subsurface-flow wetlands require more accurate and detailed engineering design than surface-flow wetland systems to ensure correct gradient and flow. They are more costly because suitable gravels have to be brought onto the site.

However, **subsurface-flow wetlands can treat effluent to a much higher and consistent quality.** Subsurface-flow wetlands have a high potential for suspended solid and nitrogen removal. They also have less potential for causing nuisance with insects and odours since there is no exposed water surface.

3.10.5.3 Combined systems

To reduce the potential for clogging by suspended solids, surface-flow and subsurface-flow constructed wetlands can be used in combination.

Subsurface-flow wetlands are vulnerable to clogging if loaded with high rates of suspended solids, or subject to sediment inputs from stormwater or the erosion of embankments. **Since effluent flowing from a pond system has variable and often high levels of suspended solids, subsurface-flow wetlands are best preceded by a surface-flow system.**

The surface-flow wetland can reduce levels of suspended solids that may otherwise clog up the subsurface-flow system, and can provide initial BOD reduction and a reduction of other contaminants. It can be desludged when accumulation occurs.

3.10.6 Siting of constructed wetlands

The availability of land in an appropriate location often proves to be the limiting factor when considering the installation of a constructed wetland facility. (Refer to 3.4 Siting of ponds, as this section discusses considerations when siting effluent treatment systems.)

Wherever possible, wetlands should be constructed below the initial treatment system so that gravity can be used to convey the effluent.

The contour of the land needs to be selected on the basis of the most cost-effective wetland cell arrangement. Such an arrangement should **minimise earthworks and loss of grazing area** while achieving the treatment requirement and best fit with the existing landscape. Consider surface and subsurface drainage, the location of springs and potential for flooding. Avoid springs and steep slopes, as stormwater runoff will add loading to the system, and retention of water in the wetland may be too short. Consider the outflow point and where the discharge will go.

The availability of suitable soil for the construction and sealing of the wetland is important (i.e. soil with significant day content). Suitable soil is also required for the growth of plants.

Constructed wetlands rarely cause odour and insect nuisances. However, when planning the location of wetlands it is still wise to consider the risk of such issues (refer to 3.4.3 Wind direction and proximity to residential housing). As an effluent treatment system, food safety regulations apply so the wetland should not be within 45 m of a farm dairy (refer to 2.13.1 Food safety and dairy industry requirements).

3.10.7 Wetland design and construction

Constructed wetland design does not lend itself to conventional design criteria. This is because there are site-specific details such as the standard of farm dairy effluent pre-treatment, the desired standard of wetland treatment and suitable local wetland plant species.

This chapter addresses the general design of constructed wetland systems.

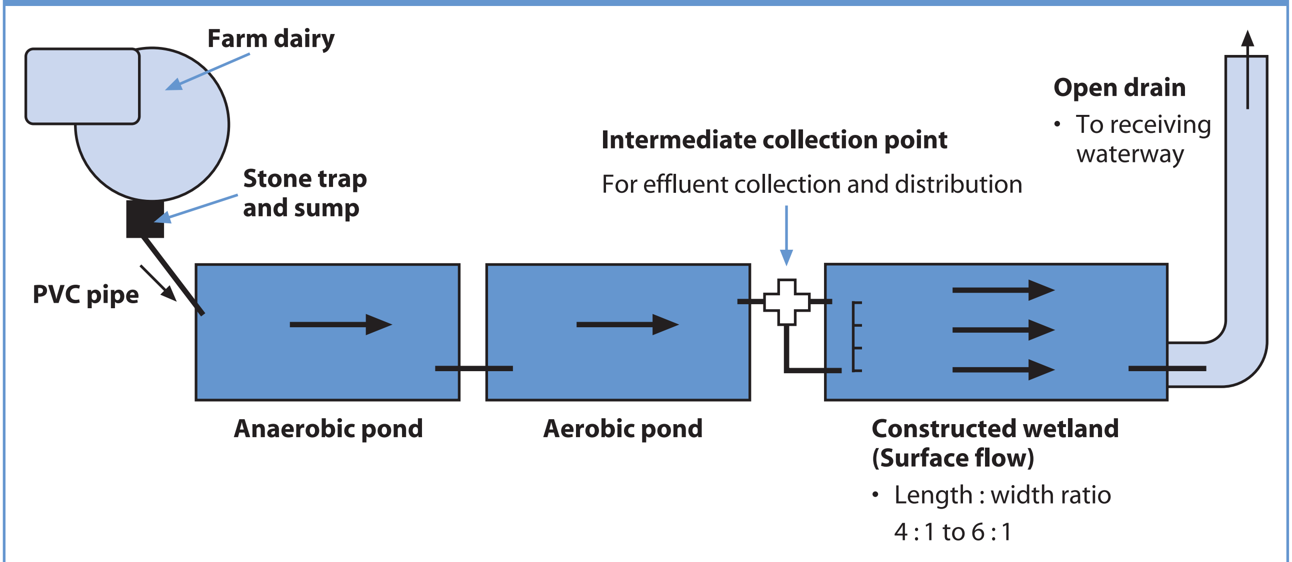
Comprehensive constructed wetland design guidelines were released by NIWA in 1997 (see the NIWA website www.niwa.cri.nz). These guidelines should be followed, along with appropriate advice from expert designers.

In constructed wetland design, the key variables on which to focus are the:

- **effluent volume and loading**
- **retention time**
- **size and configuration**
- **vegetation.**

FIGURE 3.10-6

CONSTRUCTED WETLAND SYSTEM LAYOUT



3.10.7.1 Effluent loading

The first step in constructed wetland design is to identify the treatment objectives. This is done by identifying:

- **the required quality standards of the discharged effluent.** Regional Councils have rules regulating the discharge of effluent into waterways (check with your Regional Council for requirements)
- **the original volume and characteristics of the effluent and degree of pre-treatment that the effluent has already undergone** in the pond system (refer to 1.6.1 Effluent characteristics and volumes)

The required standards at outflow and percentage decrease in key contaminants of the pond effluent will determine the wetland size and whether a combination of wetlands is required.

Table 3.10-1 shows the approximate percentage of removal for key effluent contaminants for a single wetland treatment option and a combination option of a surface-flow followed by subsurface-flow wetland.

TABLE 3.10-1

EXPECTED CONTAMINANT REMOVAL BY CONSTRUCTED WETLANDS		
Contaminant	**Mean annual percentage removal (refer to Table 3.10-2 for wetland size according to herd size)**	
	Surface flow wetland	Combination wetlands
BOD	35-50	60-75
Suspended solids	40-65	70-75
Total nitrogen	15-35	40-50
Ammonia	10-30	35-50
Faecal coliforms	70-85	85-95

Note: Assumes both pre-treatment and wetland systems are functioning well and normal effluent volumes apply.
Adapted from Tanner and Kloosterman, 1997.

To improve pre-treatment:

- **correctly carry out pond system maintenance** (refer to 3.8 Pond system maintenance)
- **ensure the outflow pipe and baffle system from the aerobic pond is allowing only liquid effluent through.** Take effluent from below the pond surface where algae are concentrated, but above any sludge layer on the pond floor
- **provide pre-filtration of effluent** through rock filters
- **provide mechanical aeration** in the pond. This will greatly reduce total nitrogen and ammonia content in the wetland discharge.

The outflow from the wetland will be low in dissolved oxygen. Oxygenation can be enhanced by cascading the effluent over land or rocks before discharge to a waterway.

Having considered the effluent loading in and out of the system, the remaining design process revolves around obtaining **maximum retention time, simple operation and minimal maintenance.**

3.10.7.2 Retention time

Treatment efficiency of constructed wetlands is generally related to retention time.

Effluent should be maintained within the constructed wetland system for 7 to 14 days. Shorter times than this will result in poor performance.

For surface-flow wetlands, an acceptable retention time is 7-10 days.

Where a combined surface-flow and subsurface-flow system is employed to provide higher levels of treatment, the effluent should remain in the initial section for 7 - 12 days and the subsurface-flow section for 2-3 days.

3.10.7.3 Size and configuration

The size of the constructed wetland is determined by the herd size contributing to the volume of effluent flow, the average depth of the wetland and the retention time.

The depth of the wetland is largely dependent on the plants chosen and controlled by the use of adjustable swivel pipe outlets. However, it is usually between 300 mm and 400 mm deep.

Table 3.10-2 gives recommended bed surface areas for dairy farm wetlands to achieve the treatment levels given in Table 3.10-1. These surface areas do not include the area required for the embankments. For larger herds, these dimensions may be divided among multiple cells.

TABLE 3.10-2

RECOMMENDED BED AREA FOR CONSTRUCTED WETLANDS

Herd size	Area of surface flow wetland (basic treatment)[1,2]	Combined wetland (higher level of treatment)[3,4]	
		Surface-flow	Subsurface-flow[5]
100	210 m^2	250 m^2	105 m^2
150	310 m^2	375 m^2	160 m^2
200	415 m^2	500 m^2	215 m^2
250	520 m^2	625 m^2	270 m^2
300	625 m^2	750 m^2*	320 m^2
350	730 m^2	875 m^2*	375 m^2
400	835 m^2*	1000 m^2*	430 m^2*
450	940 m^2*	1125 m^2*	480 m^2*
500	1045 m^2*	1250 m^2*	535 m^2*

Note 1: Effluent volumes based on 50 l/cow/day (refer to 1.6.1 Effluent volumes and characteristics).
Note 2: Assuming the surface-flow wetland has an average depth of 300 mm and a 10-day retention time.
Note 3: Assuming a combined wetland with the surface-flow section of 300 mm average depth and a 12-day retention time, and the subsurface-flow section of 400 mm average depth and a 3-day retention time.
Note 4: Assuming the mature vegetation, litter and sludge takes up 20% of the wetland volume.
Note 5: Assuming the gravel in the subsurface-flow system takes up 65% of the wetland volume.
* For these larger sizes, division into two parallel cells is recommended.

3.10.7.4 Multiple cells

The use of multiple channels or cells, rather than a single large wetland, is recommended on properties with herds of more than 200 cows to obtain maximum flexibility and facilitate maintenance. Two or three cells are adequate.

In such designs, cells can be isolated and closed down for maintenance, or rested when flows are low, without affecting the overall system. The number of cells will depend on the total size of the wetland system and site constraints. Addition of further cells can accommodate herd size increases.

3.10.7.5 Length to width ratios and shape

Appropriate length to width ratios will maximise treatment efficiency. **Ratios of between 4 : 1 and 6 : 1** (i.e. 4 m to 6 m length to every 1 m width) **are recommended for surface-flow systems and 2 : 1 for subsurface-flow systems.** Such ratios will avoid excessive loading at the inlet end while still promoting uniform flow of effluent across the width of the wetland rather than 'short-circuiting' of the system.

For subsurface-flow systems, the saturated cross-section of the bed must be sufficient to contain the design flow. Problems can occur if the beds are very long and narrow, or media with a low hydraulic permeability are used (e.g. soil or sand).

The shape of wetlands can be curved slightly to provide a more natural fit with the landscape. To ensure efficient treatment, only gentle curves should be used to avoid creating stagnant backwaters. Widths should not vary more than 20% for surface-flow wetlands and 10% for subsurface-flow wetlands.

3.10.7.6 Excavation and embankment construction

Wetland cells are best formed and separated by earthen embankments. These serve to contain flows and control the effluent level. Timber dams should not be used for dairy farm wetland systems.

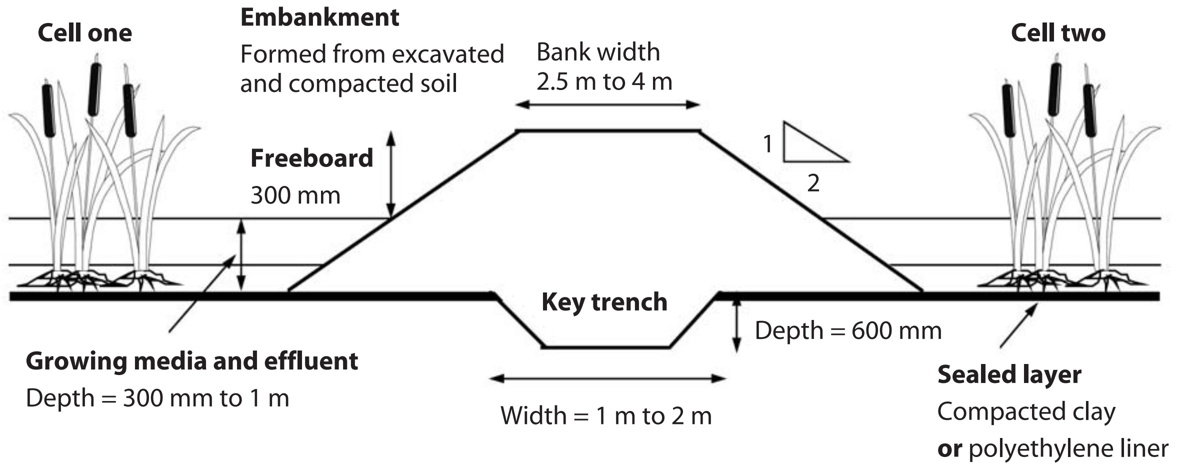
Recommended equipment for construction of embankments are a hydraulic excavator for earth moving and placement, and a rubber-tyred tractor towing a sheepsfoot roller for compaction. Embankment materials should be spread and compacted in layers of no more than 200 mm thickness.

For cell embankment construction refer to Figure 3.10-7 and Figure 3.10-8. The following design guidelines are recommended:

- **a freeboard of 300 mm**
- **the top on the embankment separating the wetland cells should be at least 2.5 m wide.** Widths can be increased to aid construction and also allow for maintenance machinery access if side access is a problem. Where soil is porous or the wetland is to be built above ground, key trenches are required (refer to 3.6 Construction of ponds)
- **the batter slope on the embankments should be 3 horizontal to 1 vertical.** This will ensure stability and allow machinery access to the wetland's edge (refer to 3.6.2 Batters). Inner embankments can have a gradient of 2:1.

FIGURE 3.10-7

DESIGN SPECIFICATIONS FOR WETLAND CONSTRUCTION



3.10.7.7 Stormwater control

In some situations wetlands may be useful for the treatment of water runoff from land. Since such water may contain large quantities of nutrients from the farm system, the wetland will provide a buffer between the land and waterways.

However, during high volume stormwater runoff from surrounding land, where the capacity of the wetland is exceeded, large increases of pollutant loading can occur. This is due to:

- **additional pollutants within the stormwater** such as soil, nutrients and pesticides
- **the incoming water disturbing already settled solids.** The solids, containing nutrients, are re-suspended within the effluent.

Therefore, there should be a diversion channel, or cut-away ditch, around the top of the wetlands to divert surface runoff (refer to 3.6.3.2 Diversion channels around the ponds).

3.10.7.8 Inlet and outlet design

The inlet and outlet structures should allow for water level control and complete draining of the cells for maintenance (refer to Figure 3.10-8). Flow velocities within the wetland system must be low to promote the sedimentation and accumulation of solids. Levels will need to rise as vegetation is established and as sediment builds up in the mature wetland system.

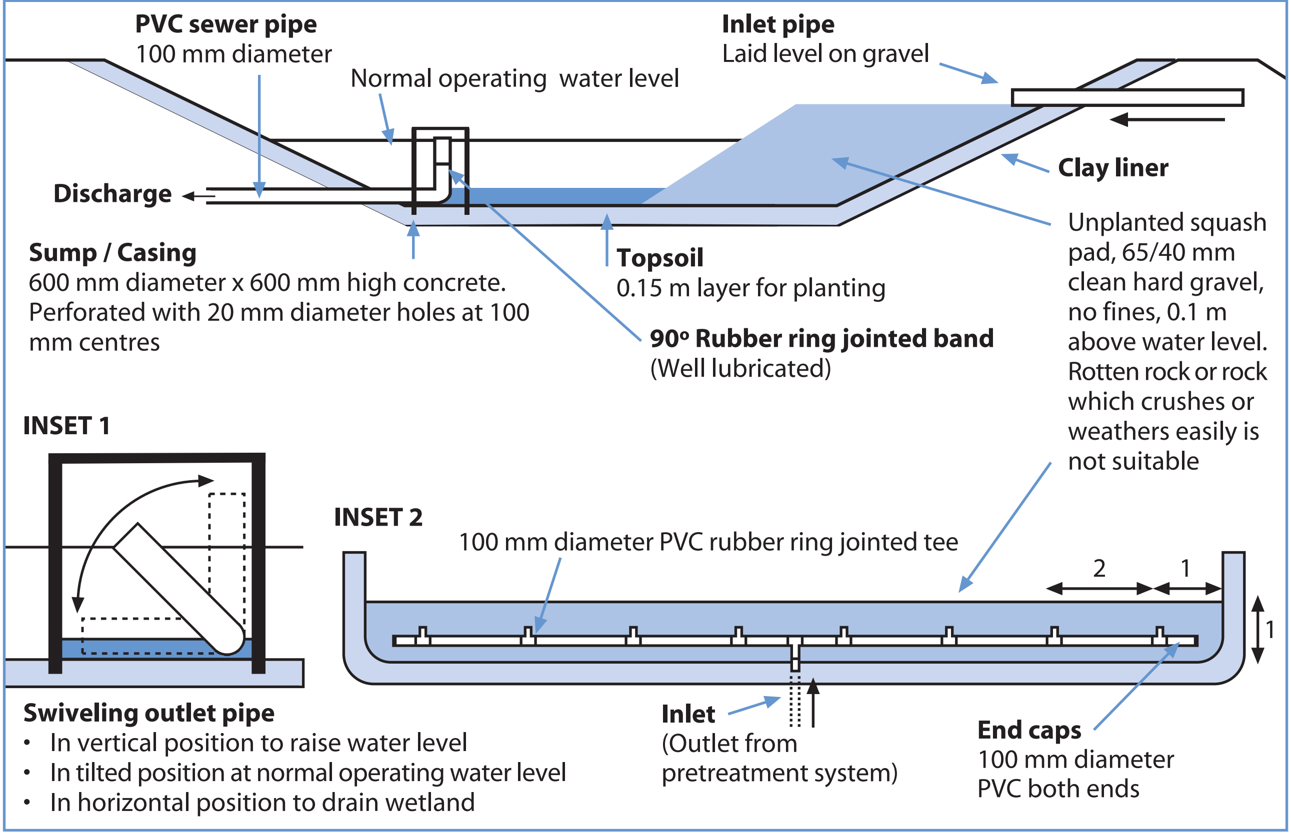
Baffled outlet structures from the initial pond treatment system should take in effluent from well below the pond surface to reduce the proliferation of algae in the wetland system. The effluent may be collected at an intermediary collection point before distribution to the wetland cells (refer to Figure 3.10-6).

The inlet system is designed to achieve even distribution of the flow across the entire wetland width. It is important that the inlet pipe is laid level so that inflows are dispersed evenly across the bed using adjustable T-pipes for final distribution of flows (refer to Figure 3.10-8).

The outlet structure can use a swivelling outlet pipe system to allow simple water level adjustment with low clogging potential. The swivel pipe should be contained within an enclosed perforated concrete sump unit or treated timber box, set in a coarse gravel zone (refer to Figure 3.10-8).

FIGURE 3.10-8

WETLAND CELL INLET AND OUTLET DESIGN



Final discharge from a wetland can be via simple overland flow, seepage fields, vegetated drains or natural wetlands. These are preferable to direct discharge to streams (refer to 3.6.5.5 Outlet pumping, drains or wetlands).

Pristine, low nutrient bogs or wetlands with high conservation values should not be used to receive a constructed wetland discharge, but most wetlands dominated by raupo on farmland will readily assimilate this type of wastewater. Check the policies of your Regional Council before proceeding with this option.

If the discharge is to a natural waterway, flowing the water over simple rock cascades or waterfalls can help aerate it, addressing the low dissolved oxygen levels that can occur in constructed wetland discharges.

Effluent can be dispersed through a perforated pipe laid along the contour of a gentle slope (2-10% gradient), allowing water to flow for at least 5-10 m before reaching a waterway. A pipe 20 m in length with 20 mm holes drilled at 200 mm spacings would be required for an average 200 cow herd. Removable end-caps can be used to allow periodic flushing of the dispersal pipe.

It is best if small intermittent doses are applied rather than continuous flows (e.g. 1 hours application followed by 3-4 hours rest). It is also good to have two or more disposal areas (e.g. 1 year's application followed by 1 year's rest period).

The dispersal area should be fenced from stock to avoid pugging.

3.10.7.9 Sealing and lining

Sealing and lining is necessary for wetlands. Sealing ensures the effluent is not lost from the wetland system through seepage.

Clay can be used to line the wetland and should be kept moist to avoid splitting. Test that the wetland is watertight before adding topsoil and planting.

Heavy-duty polyethylene lining (greater than 1 mm) is necessary where clay soils are not available for compacting and sealing. Such a liner will be subject to at least 200 mm of soil or gravel being placed upon it for plant rooting purposes.

Since some polyethylene liners are not manufactured to sustain such loadings, a geotextile or butyl rubber liner can be used as its strength will protect it from soil and gravel damage. These liners are also useful on the wetland edges where sunlight may otherwise degrade polyethylene.

The liner should be placed over a layer of sand for cushioning and protection from stones. For further sealing and lining techniques and costings refer to 3.6.4 Sealing and lining.

3.10.7.10 Wetland media

In a surface-flow wetland, topsoil is spread to a depth of 200 mm and lime incorporated to reduce toxicity to plants after flooding. The soil should be carefully levelled and lightly compacted to avoid problems with patchy plant establishment.

Uncompacted gravel is used in subsurface-flow wetlands, to a depth of 0.5 m. The top 150 mm of this should be a levelled layer of 20/12 mm gravel for plant growth with the lower layer being 65/40 coarser gravel, with no fines.

Both surface-flow and subsurface-flow wetlands need a gravel zone around the inlet and outlet structures of coarse 65/40 mm clean, hard gravel with no fines.

Gravel size and hardness are critical, as the media can be easily clogged. Avoid any soil entering the gravel as this can also cause clogging.

3.10.7.11 Vegetation

Constructed wetland vegetation:

- **assists in flow regulation and promotes settling of solids**
- **provides surfaces for bacterial films which carry out effluent treatment**
- **provides oxygen to the aerobic bacteria by releasing it to the root zone**
- **takes up nutrients**
- **shades the wetland from sunlight,** reducing algae growth
- **reduces the stirring effect of wind on the effluent surface.** This may otherwise stir up settled solids and associated nutrients.

Plant selection and establishment is important. However, **vegetation alone cannot ensure the success of a wetland system without the right quality of in-flowing effluent, system size and configuration.**

Plant establishment problems can multiply if:

- planting occurs too late in the season
- there is insufficient or excessive water
- inappropriate soils or gravels are used
- plants are damaged by livestock or pukeko
- there is weed invasion and suppression of desirable plants.

FIGURE 3.10-9

EMERGENT VEGETATION

Plants in a constructed wetland system may be floating, submerged or emergent. **Systems using emergent plants are recommended in New Zealand.**

Emergent plants are rooted in the bottom soil or gravel and have their stems and leaves extending up, through the flow, to above the effluent surface (refer to Figure 3.10-9). The stems and roots filter out suspended solids and provide sites for bacterial breakdown of the effluent.

Floating plants can be used in surface-flow wetlands. They float on the effluent surface with their roots extending down into the flow. The use of some floating plants in wetlands may be helpful.

Submerged vegetation is not widely used in constructed wetlands because it is shaded out by algae and is generally sensitive to anaerobic conditions.

Wherever possible, use native species and locally sourced plants. These are likely to do better in the local climate. Choose a selection of plants that are compatible (i.e. no single species is likely to out-compete and dominate.)

Do not grow trees on the wetland embankments as the roots will provide seepage lanes, weakening the embankment wall. However, plantings of flax and native toetoe on the embankments will provide habitat enhancement, bank stabilisation and weed exclusion.

Some guidelines for sourcing and planting wetland vegetation include:

- **for best establishment, plant vegetation from spring through to early summer (i.e. between October and Christmas), provided appropriate water conditions can be maintained.** Early spring planting will allow good growth and coverage before the following winter. It is essential that water (fresh water or effluent from the aerobic pond) is available during plant establishment. Some plants will die back during winter or in a brief period of drought but will then re-grow from underground rhizomes. Additional attention to weed control is required in this case
- **it is important to check plant availability well before the planting contract is let.** Some plants may be out of stock due to their popularity during the spring season
- wetland species can be obtained as either small plants established from seed (e.g. 1-yr-old root trainer grade) or as bare-root rhizome cuttings with shoots trimmed to 200-300 mm. Both will establish well in the right conditions. Do not bring plants in too far in advance. They must be maintained up until the time of planting in cool, semi-shaded conditions and kept watered
- **emergent wetland vegetation should initially be planted at a density of 4 plants per m^2**
- plants should be planted at 40-60 mm depth in the growth medium and be well firmed so that they are less prone to uprooting and do not float out when water levels are raised
- immediately after planting, water levels in surface-flow wetlands should be raised to 50-100 mm above the soil surface to optimise conditions for the wetland plants and suppress weed growth. Avoid flooding above the height of the plant shoots. In subsurface wetlands, water levels should be maintained within 20 mm of the gravel surface during plant establishment. Use the pond water if there is a reliable flow at this time, or supplement from another water supply
- when plants are well established, water levels can be raised in stages e.g. to 200-250 mm after one season's growth and to a final depth of 300-400 mm after the second growing season. After this time, surface-flow wetland plants can be subjected to short periods of drought, but subsurface-flow plants are more dependent on water levels being maintained due to the poor water storage capacity of gravel.

Plant establishment may be a problem where birds, small animals and stock have access to the constructed wetland. Pukeko are a particular problem as they will uproot young plants and graze the growing tips.

To exclude pukeko, install a fence with 3 horizontal trip wires approximately 100 mm above the ground and 200 mm apart. Gas bangers are sometimes effectively used to deter pukeko.

Stock need to be prevented from entering the wetland area. For these reasons **it is recommended that the constructed wetland be permanently fenced off.**

Table 3.10-3 gives recommended wetland plants commonly used in New Zealand.

TABLE 3.10-3

POPULAR CONSTRUCTED WETLAND PLANTS

Plant	Notes
Bulrush / Clubrush *(Schoenoplectus tabernaemontani)*	Occurs naturally from Northland to Canterbury. High ability to oxygenate its root zone and has high treatment efficiency. Foliage dies off over winter, except in northern coastal areas, so best combined with other species for winter cover.
Flax *(Phormium tenax.)*	Most suitable for wetland embankments but not permanently wet areas. Also attracts birds e.g. tui.
Kuta (tall spike rush) (*Eleocharis sphacelata)*	Found throughout NZ but less common in southern regions. Preferred species for surface-flow wetlands. Not suited to sub-surface flow wetlands. Excellent filtering capabilities.
Jointed Twig Rush *(Baumea articulata)*	Found from Northland to Manawatu. Can be slow to establish and spread. Forms dense, persistent growth that has little winter die-back – good in combination with Schoenoplectus bulrush.
Raupo *(Typha orientalis)*	Generally the dominant species in wetlands on NZ farms. Not recommended for subsurface-flow wetlands due to its thick rhizomes. High tolerance for effluent, and high ability to filter out solids. Excessive litter generation may clog and overload the system and this plant may out-compete others so not a favoured species for constructed wetlands.
Rushes *(Juncus spp.)*	Useful on the edge of wetlands as they have a low tolerance to long-term flooding. Do not die back in winter. Choose local species.
Duckweed *(Lemna spp.)*	Floating native plant, widely distributed and often introduced by waterfowl. Can provide surface cover in bare patches in surface-flow wetlands to reduce algal growth by shading the water.
Sedges *(Carex spp)*	Native sedges and tussocks that can be used around wetland margins and embankments for diversity, habitat value and landscape appeal. Classic plants of NZ streamsides and wetlands. Choose local species.
Toetoe *(Cortaderia richardii, C. fulvida, C. toetoe)*	Useful, hardy plants for bank stabilisation and landscape appeal. Do not confuse native toetoe with invasive introduced pampas grass – get expert help to identify.

Table 3.10-4 gives plant species that should be avoided and eradicated if identified. They are either unsuitable as wetland species or classed as noxious weeds.

TABLE 3.10-4

CONSTRUCTED WETLAND PLANTS TO AVOID		
Plant	**Growth**	**Notes**
Pampas Grass *(Cortaderia selloana, C. jubata)*	Emergent	Forms large, dense basal clumps that restrict effluent flow and do not provide adequate surface area for bacterial slime growth. Highly invasive.
Alligator Weed *(Alternanthera philoxeroides)*	Floating	Serious weed species found from Northland to Waikato. Floats like a mat and can spread to pasture and crops. Has oval shaped leaves and white clover-like flowers. Slightly poisonous to young stock.
Manchurian Wild Rice *(Zizania latifolia)*	Emergent	Serious weed species capable of invading pasture, drains and lake margins. Dull grey/green leaves and grows to 4 m high.
Common Reed *(Phragmites australis)*	Emergent	Found in Hawkes Bay and Murchison. Serious weed species in New Zealand, although commonly used for wetland treatment overseas. Large and erect, with bamboo-like leaves and semi-woody stems.
Reed Sweet Grass *(Glyceria maxima* but previously known as *Poa aquatica*)	Emergent	Can form floating mats over open water. Quick to establish and common in drains. Very persistent non-native species, may out-compete others and will continue growing over winter. Do not introduce into new catchments. Readily eaten by stock, but can poison them with cyanide.
Yellow Flag Iris *(Iris pseudacorus)*	Emergent	Tall, yellow-flowered iris that can spread in the wild. Banned from sale and distribution.
Water Hyacinth *(Eichhornia crassipes)*	Floating	Glossy green leaves with thick runners. Delicate, mauve/blue flowers with yellow centre spot. National Surveillance Plant Pest under the Biosecurity Act (1993).
Water Fern *(Salvinia sp.)*	Floating	A water fern capable of forming thick, floating mats that choke waterways. Notifiable plant under the National Pest Management Strategy. Green to bronze coloured, spongy -leaved fern.
Water Net *(Hydrodicton reticulatum)*	Net-forming algae	Found in northern half of North Island. Can form dense filamentous nets that choke waterways. Can be spread by waterfowl or with plant material from infected areas.

3.10.8 Constructed wetland maintenance

A major goal in constructed wetland design is to minimise and simplify the maintenance needed. Once plants have been established, wetlands require minimal ongoing maintenance. With wetlands, early identification of problems is the key. Maintenance relates to:

- **care of the pre-treatment system** to ensure the pond system is discharging high quality effluent (refer to 3.8 Pond system maintenance). Maintaining high quality effluent into the wetland will greatly prolong its life as excessive solids will clog the wetland and raise the bed level, requiring overhaul and desludging
- **inlet and outlet structures.** Check that flows are evenly distributed across the wetland, adjusting T-pipes up and down until the flow is visually uniform (refer to Figure 3.10-8). Pipes should be inspected for blockages or damage. End caps of both inlet and outlet pipes should be removed annually to flush the pipes. Outlet pipes should be adjusted up or down to keep water levels at 300 mm for surface wetlands and just below the gravel surface for subsurface wetlands. Water level adjustments may be required as sludge gradually accumulates

- **embankments and fencing.** Check for weed spread from the embankments and signs of erosion or damage. Graze outer embankments very lightly (with sheep if possible) but otherwise maintain stock exclusion
- **ensure the wetland plants are growing well over the majority of the bed and check they are healthy. Plants will die off naturally in winter but stress at other times needs to be rectified.** The most likely cause is drying out at times when cows are not milking or when ponds have been drained for desludging. Replant bare areas with new plants or those carefully thinned from dense areas to fill gaps
- **ensure nuisance plants do not invade and dominate the wetland system.** Such plants will need to be removed either by hand weeding or for more extensive invasions by draining cells and physically removing the plants or applying a suitable selective herbicide. It may otherwise be possible to adjust effluent flow to drown out unwanted plants.

The following is a schedule of periodic maintenance tasks that need to be planned for.

Regularly

- **Visually inspect vegetation** for any signs of stress or invasion of unwanted species.
- **Monitor the wetland area for pests.** Pukeko may invade the wetland system, uprooting and eating wetland plants. Areas can be fenced to keep out larger wildlife, but it is more effective to ensure sufficient plant species unattractive to foraging animals are established in the wetland. Control of animal pests such as possums, rats and weasels, stoats or ferrets will also enhance bird life.
- **Monitor the wetland area for odour problems.** Standing, swampy water will cause odour problems. By ensuring good circulation and flow of effluent, dead zones will be reduced and odours should be minimised.
- **Check the effect of the discharge on the receiving waterway.**
- **Check that the pipes running in and out of the ponds are not blocked and that in-flow is uniform across the wetland.**
- **Adjust effluent levels** to maintain them at the correct depth.
- **Check that the fencing remains stock proof.**

Six monthly to annually

- **Repair and maintain inlet and outlet structures.** Clean and remove plants around outlet pipe to provide access and guard against blockages.
- **The wetland area may require desludging after ten years or move to remove accumulated sediments and associated nutrients.** This should be carried out in stages, not removing all the vegetation at a single time. Replanting should follow desludging.

3.10.9 Constructed wetlands – top tips to avoid trouble

- **Does the existing initial treatment system operate correctly? If not, the constructed wetland cannot be expected to work to its potential.**
- **Before installation, determine the likely expansions to herd and property size or intensification over the next 10 years. Ensure sufficient wetland area is part of the design.**
- **Design the wetland to be of appropriate shape and depth to minimise short-circuiting and maximise retention time.**
- **Ensure the wetland is adequately sealed to prevent water loss or groundwater intrusion.**
- **Assess the pollution risks associated with the failure of the wetland, should it be flushed during storms or not operate to expectations.**
- **Install a drainage channel around the wetland to prevent water runoff from the land entering the system. Stormwater may carry pesticides, herbicides and create excessive loading.**
- **Do not let prohibited chemical materials enter the wetland. Many chemicals can affect the breakdown of effluent and the growth of wetland plants.**

- **Check availability of planting material early on in the planning process.**
- **Establish wetland plants in shallow water before gradually introducing higher effluent volume. Maintain adequate effluent flow to ensure year-round survival of wetland plants.**
- **Waterfowl can be deterred from destroying young plants by using temporary electric fencing, trip wires and gas bangers. Fence to exclude stock.**
- **Regularly check the wetland plants and carry out maintenance on in-flow and out-flow structures.**

3.10.10 Constructed wetland regulations

Food Safety and Dairy Industry Requirements

The survival of various disease-causing micro-organisms during effluent storage and treatment is summarised in 2.13.1 Food safety and dairy industry requirements. This section also outlines their requirements surrounding effluent treatment and storage facilities. A constructed wetland system can be defined as such a facility and must not be sited within 45 m of the farm dairy facility.

Regional Council requirements

Regional Council concern is focused on the quality of effluent discharged into waterways following wetland treatment. Poorly treated and discharged effluent can cause elevated nutrient levels, suffocation and poisoning of aquatic life, increased water turbidity and increased pathogenic micro-organism levels.

While some Regional Councils do not recommend this method, others view constructed wetlands as a useful addition to the traditional pond system, especially when required dilution in the receiving water is not available.

It should be noted that although constructed wetlands offer a possible additional treatment alternative, where they discharge to a waterway a Resource Consent will still be required.

For region-specific regulations regarding the discharge of effluent to waterways check with your Regional Council.