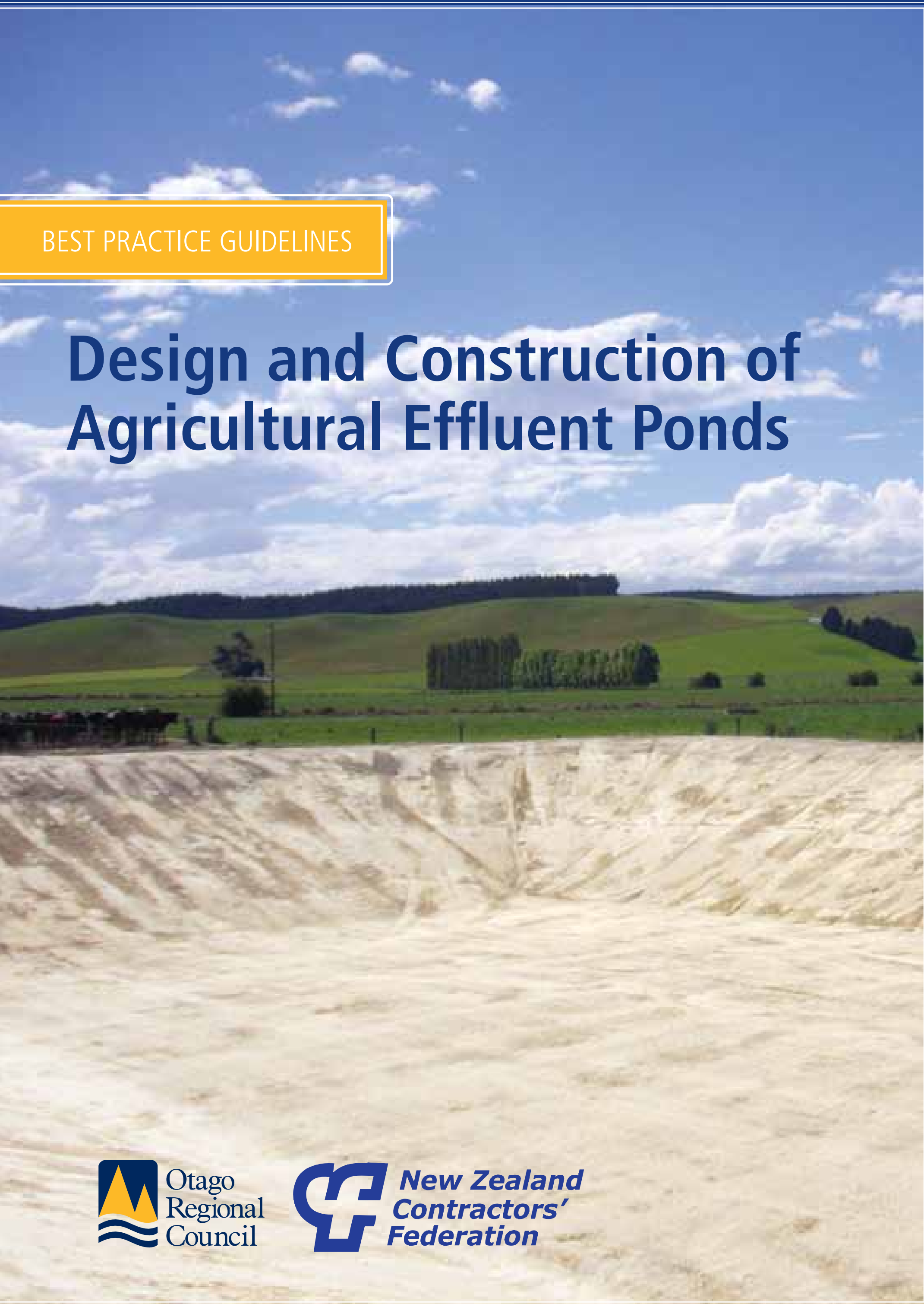
BEST PRACTICE GUIDELINES

Design and Construction of Agricultural Effluent Ponds



Otago Regional Council

New Zealand Contractors' Federation

Design and construction of agricultural effluent ponds

This booklet is intended as a set of guidelines for contractors and design consultants to follow to ensure high quality construction of agricultural effluent storage ponds in Otago.

CONTENTS

1 Introduction

Under the *Regional Plan: Water*, agricultural effluent ponds are a permitted activity, provided ponds are sealed and there is no leakage.

The New Zealand Contractor's Federation (Otago Branch) in association with the Otago Regional Council, has prepared these best practice guidelines to ensure that effluent ponds are appropriately located, designed and constructed of suitable materials, and in such a manner, that for all practical purposes they function, do not leak and are structurally sound.

2 Personnel required

2.1 Design and supervise – Design consultant

A suitably qualified person should be used to design and supervise the construction of an agricultural effluent pond. A suitably qualified person shall be a person with an agricultural or civil engineering qualification, and/or experienced in working with soils and earthworks. They will analyse the specific site and produce a *site specific specification* that will guide the construction process.

2.2 Construction – Experienced operator

An experienced operator should be used to construct the pond and follow the *site specific specification*.

2.3 Compliance – ORC

To ensure ponds are built to standards set out in these best practice guidelines, pond assessments will be undertaken to ensure leakage rates are meeting a suitable standard.

3 Design outcomes

Key design outcomes are:

1. A pond leakage rate that avoids adverse environmental effects
2. A pond floor level at a safe height above the water table or flood level
3. The use of appropriate artificial liners that ensure no leakage to groundwater or vice versa
4. A pond that provides for ongoing maintenance and
5. A pond that meets ORC rules

The leakage rate through a pond lining is a function of the hydraulic conductivity of the lining material and the lining thickness. A pond lining will need to achieve a leakage rate of 3.8×10^{-8} m/s or less to prevent the leakage of contaminants to the environment.

The design process should determine the properties of the lining material so the appropriate thickness and construction processes can be specified. It should also determine the structural stability of the lining material and bank material.

If the on-site soil material is not deemed suitable as determined by soil tests (see pg 20) then alternative measures need to be considered, such as importing better quality clay or artificial liners.

The pond design and dimensions should be shown on a site plan and take into account batter requirements. On-site pegging out should also be in place prior to construction.

Section 6.2 of this document contains information on water table considerations to aid with determining a safe height for a pond floor level above the water table.

Another key design outcome is allowance for pond maintenance; specifically, designers should provide for ease of maintenance, drying and resilience to agitation or activities of heavy machinery that may occur during the maintenance process.

* Further design outcomes are discussed in Chapter 3.5 of the *Managing Farm Dairy Effluent Manual 2006*.

4 Regulatory requirements

4.1 ORC rules

- Ponds must be sealed with no leakage.
- Any odours are not noxious, dangerous, offensive or objectionable at or beyond the boundary of the property.
- A storage pond must be at least 150m from the property boundary.
- There is no overflow of material that runs off onto any other person's property, or into water.

4.2 Consents

If your pond meets all the ORC rules, then pond construction is a permitted activity, and you will not require a resource consent.

The Building Act 2004 specifies that a building consent is required if the pond is more than 3m deep and holds more than 20,000m^3. However, this size is unlikely to be reached in most standard farming operations. If you are still unsure please contact a Land Resource Officer at the ORC.

4.3 Other regulatory requirements

Under the Food safety standards, administered by the New Zealand Food Safety Authority, ponds must be at least 45m away from the milking area, milk receiving area, milk storage room/area and milk collection point of the dairy shed.

4.4 Recommended positioning in relation to water

The placement and orientation of ponds should also take into consideration nearby waterways in regard to potential slope instability, erosion of the pond wall and inundation from flooding.

In a flood prone area ponds must be sited and built to avoid inundation. Diversion of stormwater also needs to be considered. In areas subject to actual or potential inundation, the crest of the pond embankments should be at least 300mm above the highest known flood level. It is also preferable that long ponds be orientated along the floodplain rather than across it.

Pond banks must be higher than surrounding land to prevent in-flows of stormwater and scarification of the pond liner.

5 Pond size

Refer to ORC Dairy effluent storage and application fact sheet for guidance on the minimum recommended weeks of storage for the district, which is based on regional soil types, climate and irrigation systems.

For actual site specific pond size calculations, factors that should be considered and included into the *site specific specification* by the design consultant are:

- current and future number of cows
- irrigation system
- manner of wash down (litres/cow/day)
- the presence or absence of rainwater diversions for roof water, the presence or absence of yard water diversion for the non-milking part of the year
- the type of shed, water management and the catchment area of the pond (some dairy sheds have additional concreted areas, e.g. races, feed pads, underpasses, silage bunkers etc; also the surface area of the pond itself)
- the length of time cows are on concrete. Additional effluent can be generated if cows are fed supplement at the dairy shed for example
- seepage from groundwater at underpasses or lower areas at the dairy shed, e.g. pit
- local rainfall and variation in climatic conditions and the effect that unusually wet years can have on storage requirements and the volume of stormwater that runs off from the catchment.

5.1 Determining final pond capacity

There is a difference between storage capacity and total capacity. Once you have calculated storage capacity, you then need to determine your total capacity which will be greater as it needs to allow for approximately 500mm of free board.

* Further information on pond size is contained in Chapter 3.5 of the *Managing Farm Dairy Effluent Manual 2006*.

6 Site investigation

A site investigation must initially be carried out to assess variance of soil properties throughout the site and down the profile; groundwater levels; and reference to ORC rules (see 4.1 ORC rules).

The investigation should also allow for the detection of drains, pipes and tree roots that may be present. During construction the site investigation should be continued to pick up any changes that may become apparent.

6.1 Soil properties

When assessing a site for its suitability for pond construction and the availability of materials, the following factors should be considered:

- What materials are available for bank construction?
- What materials are available for lining the inside of the pond?
- How does the soil texture vary down the profile and are there inherent potential problems due to layering of the materials present?
- Is there likely to be a variation in the soil profile across the pond site?
- Is the base of the pond well above the maximum predicted level of groundwater? Or if not, can the pond be built above ground or alternative materials considered?

Test holes should be excavated. It should be expected the soil profile will vary. Samples of the subsoil can be taken and their physical properties checked. The test holes should be deeper than the proposed pond floor level.

Further investigation and sampling should be undertaken where textural change is observed during construction. Further information on soil tests can be found in section eight of this document.

6.2 Water table levels and fluctuations

The test holes are also necessary to assess the level of the water table along with seasonal fluctuations. These fluctuations can be significant and must be determined if the floor level of the pond is to be set at a safe height.

Some sites may have a temporary perched water table in winter, due to an impervious subsoil which overlies the main water table.
Test holes in late winter will normally show where the highest water table is, but test holes at other times of the year will require more careful interpretation and a period of monitoring may be required to obtain reliable data. There will usually be indications down the soil profile of fluctuations in the water table.

Much of South and West Otago has been artificially drained. Artificial drains can comprise either of open ditches or mole and tile drains.

The presence or otherwise of drainage may also influence water table height. If water table levels are too high, then artificial liners and or ponds constructed entirely above ground may need to be considered.

7 Construction considerations

7.1 Pond construction

Chapter 3.6 of the *Managing Farm Dairy Effluent Manual 2006* outlines construction steps that are included when constructing a pond. A list of these ' best practice construction steps' is outlined in the appendix.

In addition, the following recommendations are made:

- Pond banks are best formed by over-constructing and trimming back later to the required dimensions. The finished top bank width should be twice the roller width. For safety, the bank should be made over-dimension so that the roller does not need to work right to the outer edges of the bank, since these will be trimmed back later. The bank top should also be slightly sloped back to prevent precipitation falling onto the top of the bank and flowing into the pond.

- Fill surfaces and materials must be protected from becoming wetter than optimum. If materials become wet, continuing with compaction becomes counterproductive and the required soil densities will not be achieved. Valuable time will be lost in waiting for excessive built up pore pressures, (as evidenced by surface heaving and rutting) to dissipate. The moisture content to achieve optimum compaction needs to be continually monitored during construction;

- It is good practice to seal off and slope surfaces away from the work at the end of the day or at the onset of rain. Wet material can be dried, either by mixing in drier material or rotary hoeing up the surface on a warm or windy day.

7.2 Contractual arrangements between design consultant and contractor

PRIOR TO POND CONSTRUCTION

The *site specific specification* outlines exactly what is expected by both parties to achieve a sealed, well built pond. The suggested criteria for the *site specific specification* are included in the appendix. A contractual document should be signed by the design consultant and the contractor that they are both satisfied with the proposed plan before construction begins, with a copy given to the farmer.

DISCUSSION DURING CONSTRUCTION

The consultant will maintain a liaison with the operator during construction, as specified in the agreement. The operator must make contact with the consultant if any matters arise that differ from the original plan - such as the soil material changing unexpectedly as the contractor digs down.

COMPLETION OF POND

The design consultant and contractor sign the 'producer statement'. An example can be found in the appendix.
The agreement states that:

- The contractor has followed the *site specific specification.*
- To the best of the design consultant's knowledge the pond has been constructed in accordance with the *site specific specification*, certifying that everything in the best practice guidelines and application has been done correctly.
- The design consultant will carry out a completion inspection during the months following the commission of the pond to ensure the pond has remained sealed.
- Copies of all documents must be given to the land owner.

8 The liner material

Liners can be formed from compacted clay or specially manufactured materials, such as polyethylene, polypropylene, synthetic rubber or concrete-based products.

To prevent potential adverse environmental effects, a liner material must meet a leakage rate of 3.8×10^{-8}m/s or less. The leakage per square metre through a liner will depend on:

- the depth (head) of water above the pond floor
- the thickness of the material used
- the permeability of the material used.

The permeability of a material is usually expressed in terms of a parameter called the saturated hydraulic conductivity (Ksat). Ksat is the rate that water will move through a square metre of material for a 1m head and 1m thickness of the material.

8.1 Clay liners

In preparing clay liners, designers must consider soil properties, the method and timing of compaction, and machinery requirements. The overall design of the pond must also be such that the clay liner does not deteriorate over time, either from wave erosion, excessive drying, agitator use or activities carried out during pond maintenance.

SOIL TESTS

In their natural state, the permeability of soils varies from being highly permeable to 1 x 10^{-11} m/s, with the majority of subsoils being moderately permeable. As a minimum, the following soil tests are recommended in the preparation of clay liners:

Soil texture

This is the single most important test to consider. To reliably achieve a hydraulic conductivity of 3.8 x 10^{-8} m/s or less, there needs to be a suitable mix of textures. A minimum of 20% clay and 50% silt content is suggested. Textural analysis or particle size analysis (hydrometer test) can be used to determine the sand, silt and clay percentage contents.

Slaking

The stability of the soil in water must be checked. Soils may meet the textural requirement to achieve satisfactory impermeability but may weather badly, leading to excessive erosion and thus be unsuitable for use in a clay lining. In some cases, slaking may be managed by decreasing the batter slope.

Dispersion

Soils where the clay colloids do not readily bind to each other when in suspension are dispersive. Some dispersion is required to help sealing, but excessive dispersion leads to leakage through tunnelling. When soils are checked for stability in water their dispersivity can also be observed.

Shrinkage

Soils that shrink and swell excessively with drying and wetting can develop lines of weakness. Measuring linear shrinkage on a soil that has been finely worked into a fairly wet state and then allowed to air dry will indicate the potential for problems. Less than 10% shrinkage is considered satisfactory and is unlikely to be significant, assuming proper compaction has occurred at the appropriate moisture content.

Plastic limit

Soils need to be just plastic when they are consolidated. The plastic limit is the moisture content at which soils go from being semi-friable to a plastic state. As a guide, if a finely worked soil with adequate clay content can be kneaded and rolled into a stable thread of approximately 3mm in diameter and not crumble the moisture content is likely to be close to the plastic limit. Being able to roll a finer worm than this indicates excess moisture for optimum consolidation.

COMPACTION

The *site specific specification* should confirm and specify the minimum construction requirements, such as the number and depth of the loose soil layers, the target percentage of maximum density, the moisture content required to achieve the necessary soil compaction and the minimum depth of the completed impervious zone.

To pack the soil particles as closely as possible to each other, the soil must be at the optimum moisture content. There has to be sufficient moisture for particles to move but not so much that the moisture occupies excessive pore spaces. Usually, the optimum soil moisture content is close to the soils plastic limit.

MACHINERY REQUIREMENTS

Construction machinery needs adequate room to work and this should be considered in site selection. Compaction equipment should be matched to the materials to be compacted. The two most commonly used rollers for pond compaction are:

- Tamping (or pad) foot rollers - protruding plates on the roller combine the advantages of both the steel wheeled and sheeps-foot rollers. Like the sheeps-foot roller, it compacts from the bottom to the top of the lift for uniform density, and like the steel wheel, it compacts from the top of the lift. The tamping-foot roller is capable of high rolling speeds without throwing material

- Sheeps-foot rollers – protruding studs on the roller drum provide a kneading action. For compaction of plastic soils like clay or silt they are very effective.

8.2 Artificial liners

The installation of artificial liners and geotextural underliners is a specialist area and should be undertaken by a suitably qualified person experienced in the installation and use of the type of liner concerned.

A variety of manufactured materials are suitable for use as pond liners including geomembranes, geosynthetic clay liners and concrete-sheet based products. For good results, the liner must be fit for the intended application and able to resist any hydraulic head that exists at the base of the pond.

Factors that should be considered:

THICKNESS AND LIFESPAN

Consider the liners resistance to ultraviolet light and punctures. A geotextile underliner can be installed under the lining membrane to increase puncture resistance.

APPROPRIATE SUBSTRATE SELECTION

This should provide contiguous and uniform support for the lining membrane. It needs to be free of loose rocks, stones and vegetation and well compacted prior to laying the liner.

SUFFICIENT GAS DRAINAGE

It is important to have the recommended fall on the base of the pond floor, for positive gas movement. This is essential if applying a liner to either an old existing earth effluent pond, or a new site.

SUFFICIENT WATER DRAINAGE

Situations where the groundwater level is likely to be higher than the base of the pond should be avoided. If, on occassion, the groundwater has potential to rise above the base of the pond, then water drainage should be installed under the liner to prevent a rising water table lifting the liner.

The use of the pond, including any maintenance activities, must be such that the integrity of the pond liner is maintained for its intended design life. If you add an agitator, a protective pad should be laid underneath the agitator to reduce the likelihood of tearing or lifting the liner.

Advantages of using artificial liner materials include manufacturer's service support and an assurance of high standards of installation and workmanship. An appropriately installed and fit-for-purpose artificial liner may be cheaper than a clay liner in some cases, particularly where there is a need to transport clay to the site of the pond.

9 Liability

The construction of an agricultural effluent pond system is a major project that requires competent planning, design and construction for the work to represent value for money, be effective, efficient and safe and not compromise the landowner's responsibilities under the Resource Management Act 1991.

- The pond needs to be properly designed by a consultant who has experience in the design and oversight of the construction of the particular type of pond.
- The construction of a pond is an operation requiring an experienced contractor using appropriate compaction equipment.
- Contractual documents should be signed by all parties before the work commences, agreeing that they are satisfied with the proposed plan.
- Photos should be taken during the construction process to corroborate the correct steps were undertaken. It is also recommended that soil test results and any other documentation be kept by the farmer for any future reference.
- Following construction, the 'producer statement' should be signed by all parties.

ORC will only be involved in the process through compliance with the 'no pond leakage' standard. However, to achieve this, it is strongly recommended that you base the design and construction process on this guide and seek the expertise of a qualified and experienced designer and contractor.

10 Appendix (site specific specification)

The *site specific specification* referred to in this booklet is comprised of:

- Cover sheet
- Construction criteria
- Best practice construction steps
- Producer statement

COVER SHEET

Specification for earthworks construction for effluent system

Client: Otago Area Dairy Ltd

Location: 123 Outback Road

Project No. 1185

CONSTRUCTION CRITERIA

- Scope
- Initial site meeting
- Construction progress and recording
- Pond set out
- Batter specifications
- Clearing
- Removal and stockpiling of topsoil
- Surface drainage
- Excavation
- Unforeseen irregularities
- Keyway construction
- Compaction methods and equipment
- Moisture conditions for compaction

- Layer thickness – depth of loose material layers prior to compaction
- Compaction zone – minimum depth of impervious layer
- Disturbance and working of cut surfaces
- Cut and fill balance of earthworks
- Top bank and vehicle access
- Finished surface slopes
- Trimming and rolling
- Topsoiling
- Pond filling post construction
- Fencing.

BEST PRACTICE CONSTRUCTION STEPS

- On-site pegging out
- Removal and stockpiling of top soil
- Excavation
- Keyway/key trench construction
- Batter specifications as per site plan
- Moisture conditions for compaction
- Compaction equipment and passes per layer
- Depth of loose material prior to compaction
- Compacted zone thickness
- Top bank and vehicle access
- Surface drainage
- Top soiling following construction
- Pond filling post construction
- Fencing the pond.

EXAMPLE OF A PRODUCER STATEMENT

ISSUED BY:	*Pond Designer Ltd, Otago Contracting Ltd*
TO:	*Otago Area Dairy Ltd*
IN RESPECT OF:	*Dairy Effluent Pond*
AT:	*123 Outback Road*

Design

Pond Designer Ltd

Director: *Jim Citizen*

I have designed the dairy effluent system to comply with the Otago best practice guidelines and appropriate standards and accepted engineering practice.

Signature ....Date

Construction

Otago Contracting Limited

Manager: *Pete Smith*

I have managed the construction of the dairy effluent pond. Appropriate construction methods and machinery have been employed to meet the requirements of the site specific specification.

Signature .... Date

Construction Review

Pond Designer Ltd

Director: *Jim Citizen*

I have monitored construction of the dairy effluent pond and consider that the contractor has exercised reasonable control over the construction process carried out in accordance with the site specific specification.

Signature ....Date

NOTES

For further information contact:

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