ENGINEERING REPORT

on

DAIRY EFFLUENT PONDS

for

BENEFIT/COST ANALYSIS

CLIENT : Taranaki Regional Council

PROJECT TITLE : DEP Assessment
Taranaki Region
New Zealand

DOCUMENT NUMBER : RPT-1208-1-0

Issue	Description	Date	Prepared By	Checked By	Approved
A	Issued for Review	Signature	A Fraser	A Jordan	
		Date	Sept 2013	Sept 2013	
0	Issued for Use	Signature	A Fraser	A Jordan	
		Date	Oct 2013	Oct 2013	
		Signature			
		Date			
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1.0 INTRODUCTION

This report covers an assessment of the benefit/cost of three different pond types in Taranaki that are used for the storage of dairy effluent. The information set out within this report will be considered as part of the review of the Regional Fresh Water Plan (RFWP) for Taranaki.

The benefit/cost is assessed for both the capital expenditure (CAPEX) and operational costs (OPEX).

2.0 BACKGROUND

A *Dairy Effluent Pond Guidelines Update (2013)* report was presented to the Council in July. The report had been prepared by Tonkin & Taylor consultants, with input from Red Jacket Ltd, at the request of the Council. A copy is attached in Appendix I.

The executive summary of the agenda item to the Council for the report noted that:

- there is no such thing as a fully leak-proof pond
- Taranaki volcanic ash is a suitable raw material for a compacted-soil liner that will perform to an acceptable level
- existing pond systems constructed according to good practice perform adequately
- quantitative statements about an acceptable level of permeability are now being provided by several parties
- there is scope for the Council to modify the guidance offered to farmers in the current RFWP, when it is reviewed.

The study proposed a permeability standard of 1x 10^{-9} m/s as the default standard. This level of performance should be readily achievable for ponds in Taranaki- that is, it is an effective, efficient, and cost-efficient requirement, should the Council and community choose to adopt it as an outcome of the RFWP review. The study outlined the site engineering requirements that would be expected to achieve this standard.

3.0 TYPES OF PONDS

The three distinctive pond types under consideration are described below.
There are other pond types that may have features in common with these ponds but are not common use at this time.

3.1 IN-SITU CLAY LINER

The clay lined pond is the most common form of pond that has been in use for several decades. Such ponds utilise the proven sealing properties of local volcanic ash.
The clay lined pond is traditionally used for conventional set ups utilising both anaerobic and aerobic ponds and the same method of construction can be used for new storage ponds.
The pond is rectangular in plan with 2H: 1V internal slopes.

The pond is typically formed by partial excavation into the original ground with the balance of the required pond depth achieved by compacting the cut material around the perimeter to complete the bund wall.

If the in-situ soil is unsuitable for the liner material then suitable clay imported from elsewhere within the farm, or close by, will be used to complete the pond.

3.2 GEO-MEMBRANE LINER

The geo-membrane lined pond is uncommon compared to the clay lined pond.

The use of geo-membrane lined ponds in Taranaki extends mostly over the past 10 years where ponds have been constructed in the more sandy ground conditions around the western coastal area where suitable soil for lining and constructing a pond is not readily available.

The liner is typically put together in a factory outside of Taranaki based on the required pond volume and batter shapes.

The lined pond requires accurate excavation to match the liner shape to avoid overstressing of the liner and possible tearing that could lead to unwanted leaks.

3.3 CONCRETE POND

The concrete pond is a more recent addition to Taranaki.

The concrete pond is generally made up of pre-cast wall panels laid out in a circular arrangement and tied together with in-situ concrete piers or ring beams with an in-situ concrete floor.

The concrete pond is typically set partly into the ground which allows good securing against seismic actions and gravity falls from the dairy shed.

4.0 BASIS OF DESIGN

This assessment between the three pond types is based on a 250 cow farm operation.

The effluent per cow (50 litres per cow per day) is the dominant variable in the pond size design.

There is no allowance for stormwater run-off from yards or roofs into the pond.

The average rainfall and evaporation rate for the pond surface area is 4mm per day.

The pond has a 500mm freeboard to cover wind wave action and sloshing.

The above design parameters have been taken from Appendix VIIB of the RFWP and are attached as Appendix II.

5.0 RISK ASSESSMENT

The best practice liners currently used for the design and construction of effluent ponds in Taranaki are summarised in Table 1. Most of the data is taken from the 2013 study.

The relative risks of the design and construction associated with the three pond liners are qualitatively assessed as 'high', 'medium' and 'low' using experience and knowledge of these type of liners under Taranaki conditions.

The benefit/costs associated with the CAPEX and OPEX of each pond liner are also given.
The following key points are drawn from the assessment.

5.1 DESIGN RISK

The design requirements vary between the three ponds.

The clay lined pond typically follows the design in the TRC Guidelines in the current RFWP which have proven track record. Hence there is a low design risk subject to good material selection and appropriate construction.

The geo-membrane lined pond using HDPE material has the thickness matched to the required soil permeability as given in Table 1. The design then relies on 100% sealing of the double seam welds between the liner strips which are usually hydrostatically tested in the manufacturing plant.

The concrete pond design is invariably by specific structural design by an engineer experienced in this field. The design differs from the two non-structural ponds as it requires good design and detailing to the loadings code and concrete code.

5.2 LEAKAGE DETECTION

Leakage in clay lined ponds can be detected after monitoring of water levels during dry periods meaning any leakage could go undetected for some time.

Leakage in geo-membrane lined ponds should be comparatively more immediately detected by monitoring water level changes.
Leakage in concrete ponds should be similarly detected.

5.3 LINER INTEGRITY, DAMAGE & REPAIR

The ponds rely on complete integrity of the liners to prevent unwanted significant leakage.

The clay lined pond relies on good quality control during construction to provide a uniform seal against leakage.

The clay lined pond is possibly the most easily repaired once the leak is detected and typically the pond is drained and a new clay liner added which effectively provides a new pond.

The unprotected geo-membrane lined pond is exposed to damage on the upper surface by mechanical means and will eventually break down by long term UV exposure. Both of these are readily seen and repaired. The liner could be damaged from fluctuations in groundwater levels within the depth of the pond that disturb the liner and cause folding and tearing leading to leakage. It would also be vulnerable to puncturing during installation and filling, or while in use, from material within the underlying formed excavation. Damage to the liner may also occur during pond de-sludging. The liner would most often be repaired by draining the pond and carrying out local “bicycle patch” repairs in-situ. Manufacturing plant repair would not be cost effective or practical.

The concrete pond has good integrity of the concrete walls and floor slab and the potential weaknesses are at the various construction joints and pre-cast to in-situ joints.

6.0 ENVIRONMENTAL EFFECTS

An important consideration in the selection of the type of pond system is the associated environmental effects. Ponds can discharge odour to the atmosphere as part of the waste storage and treatment process and can also leak wastes to land and potentially impact ground and surface water resources. The 2013 study (section 2) noted no pond was totally impermeable, so there will always be leakage. It is important to assess the environmental significance of the leakage.

At a permeability of 1x 10^{-9} m/s, that can be achieved with properly managed Taranaki ash/clay material, the estimated leakage represented 2-3 % of the influent volume. This would be attenuated in the groundwater system and was unlikely to impact surface water, if the pond was located away from waterways. State of the environment ground water monitoring undertaken by the Council has not shown the impacts of pond leakage.

The Council intend to introduce policy in the reviewed RFWP that requires farm dairy effluent to be discharged to land whenever and wherever possible. So instead of discharging treated effluent to surface water, the Council is effectively reducing the overall discharge by around 97-98%. As noted above only 2-3% of the pond influent would find its way via leakage to groundwater and thence eventually to surface water. Also there would be a lower rate of discharge through the liner, because of the sealing properties of the effluent sludge on the base of the pond.

7.0 CONSTRUCTION AND OPERATING COSTS

The construction costs of the three ponds were obtained from contractors familiar with pond construction, from the experiences of the writer, and from the actual costs of ponds surveyed during the survey associated with the 2013 report.

The CAPEX's vary considerably ($15,000 to $120,000) and with the increasing level of technology and complexity.

The OPEX's are comparatively very low ($0 to $1,000) and are also low relative to the CAPEX's, as shown in Table 1.

All ponds will require de-sludging at some time during their life, typically every ten years, and these costs are not factored into the OPEX costs in Table 1.

The in-situ soil liner is the best value, in terms of CAPEX and OPEX, and when balanced against the design and construction risks, as demonstrated by existing overall pond performance in the region.

Refer to the comments in Table 1 for further detail and comments.

8.0 CONCLUSION

We have assessed that a pond constructed with an in-situ soil liner continues to be the most cost effective option compared to the geo-membrane or a concrete pond. The environmental effects of leakage from such ponds are considered minor.

9.0 LIMITATION

This report has been prepared for the use of the TRC for the purpose of reviewing and updating their Guidelines for the design and construction of new effluent ponds.
Accordingly this report cannot be used for any other purpose or by others unless authority is given by Red Jacket Ltd.

Table 1. Best Practice Pond Liners for the Majority of Locations in the Taranaki Region

Best Practice Liner	Minimum Liner Requirements	Potential for Liner Damage	Expected Pond Life	Design Risks	Construction Risks	Construction Cost CAPEX	Operating Cost OPEX	Benefit/Cost CAPEX	Benefit/Cost OPEX	Comments
<u>In-situ soil liner</u> typically Taranaki volcanic ash or clay	Minimum 1m thickness of soil with permeability $<1x10^{-9}$ m/s; or Minimum 2m thickness of soil with permeability $<5x10^{-9}$ m/s	Medium Risk typically when sides can dry out, and soil liner being repaired or renewed	10 years to first maintenance	Minimal design usually carried out Correct choice of site location very important	Correct choice of in-situ lining materials is fundamental	$15,000 based on numerous ponds by competent contractors in Taranaki	$500 pa minor repairs around edges of the earth bund	High least cost option	Medium Operational cost of the pond only is relatively low compared to installed cost	Best value when balanced against risk as demonstrated by existing pond performance overall in Taranaki Installation typically agreed between the farm owner and the civil contractor generally with proven success to date
<u>Synthetic Liner</u> also known as a geo-membrane	Geo-membrane laid over: Minimum 450mm thickness of compacted soil with permeability $<5x10^{-6}$ m/s; or Minimum 1m thickness of in-situ soil with permeability $<5x10^{-6}$ m/s	High Risk during installation from puncturing liner, and from poor fitting into the excavated pond shape High risk in service from high groundwater causing uplift and possible tearing of liner when unsettled High Risk from potential damage from backhoe equipment during de-sludging	10 - 20 years to replacement of liner		Seals in laps in membrane tested in factory to minimise risk with this part Possible damage to liner during installation and filling	$30,000 based on the recent cost of a few ponds in Taranaki	$1,000 pa minor repairs to liner and anchorages	Medium	Med/High Similar to above	Not a widely used method in Taranaki, but is used where in-situ material not suitable for liner, for example in the coastal area around Okato and from Rahotu to Pihama – refer to Geological map in Tonkin & Taylor report of 2013 (Appendix 1) Earthworks cost similar to in-situ pond with added cost of synthetic liner
<u>Concrete Ponds</u> comprising typically both In-situ concrete and pre-cast components	Minimum 100mm thickness of in-situ reinforced concrete over; Minimum 450mm thickness of compacted soil with permeability $<5x10^{-6}$ m/s; or Minimum 1m thickness of in-situ soil with permeability $<5x10^{-6}$ m/s	Low Risk because of the high durability of the concrete surface Low/Medium Risk of leakage through construction and shrinkage joints where poorly made, or through excessive ground settlement leading to unwanted cracking	50 years minimum	Requires specific engineering design for the concrete structure and for the foundations to avoid settlements	Interruption of concrete supply to site leads to unwanted construction joints and repairs	$120,000 based on a number of ponds completed by two different contractors recently in Taranaki	$0 maintenance repairs to concrete not expected	Medium	High Operational costs of pond only almost nil	More recent type of construction method used in Taranaki Specific engineering design costs are typically provided by the pond supply contractor High cost balanced against high pond integrity

APPENDIX I

Dairy Effluent Pond Guidelines Update (2013) report by Tonkin and Taylor

REPORT

Taranaki Regional Council

Dairy Effluent Pond Guidelines

Report prepared for:

TARANAKI REGIONAL COUNCIL

Report prepared by:

Tonkin & Taylor Ltd

Distribution:

TARANAKI REGIONAL COUNCIL	1 copy
Red Jacket Ltd	1 copy
Tonkin & Taylor Ltd (FILE)	1 copy

June 2013

T&T Ref: 85537

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1 Purpose and objective

There are a number of considerations when putting in a dairy effluent storage pond. Choosing a suitable pond for your property is important to minimise leakage from the pond, protect water quality and meet resource consent conditions.

This short guide provides information to assist with choosing a suitable pond. It includes information on the key steps and considerations for putting in a pond, including:

- Choosing pond location.
- Leakage and permeability.
- Taranaki soils.
- Dairy effluent pond types and features.
- Construction.

This guide has been specifically developed for Taranaki and addresses storage ponds only. This reflects changes in effluent management from traditional treatment ponds (with discharge to water) to effluent holding ponds (with irrigation to land).

For information on treatment ponds and leak rates from existing ponds see *Managing Dairy Farm Effluent* (Dairying and Environment Committee Manual), Chapter 3, prepared by Taranaki Regional Council.

Links to more detailed guidance on design and construction of dairy effluent ponds are provided in Section 8.

Please note: advice on Resource Management Act (RMA) requirements is not provided in this guide, and should be sought from Taranaki Regional Council prior to construction.

Tonkin & Taylor has prepared this guideline in accordance with our engagement dated 6 June 2012 and letter dated 24 May 2013.

2 Choosing the pond location

Pond location should be chosen to minimise the risk and impact of leakage, and the impact of smell from the pond. Choosing a pond location that meets the following criteria will help to minimise these impacts. If these criteria cannot be met then special design may be needed.

Pond location criteria:

- The pond base must be at least 1 m above the groundwater table. If this is not possible special design must be used (refer IPENZ Practice Note 21 (2012) Part 1, Section 5.10.1).
- Choose a location that allows you to minimise stormwater catchment. Use stormwater diversion methods if necessary.
- Pond must be more than:
  - 150 m from a dwelling.
  - 45 m from the farm dairy.
  - 20 m from the boundary.
  - 20 m from trees, or two-thirds the expected height of the mature tree.
  - 50 m from water courses (streams, rivers, ponds, lakes).
  - 90 m from a drinking water well, if on the ring plain. Elsewhere, site specific assessment if well is within 200 m of pond.

- Avoid:
  - Areas prone to flooding or freezing.
  - Steep slopes running toward a waterway.
  - Springs and boreholes.
  - Areas that are pipe-drained, mole ploughed, or have been recently disturbed.
  - Free draining soils such as sands and gravels.
  - Areas of instability and areas prone to settlement.

3 Leakage and permeability

Leakage from a pond depends on the permeability of the material that lines the pond. The permeability of soil present at the pond site (in-situ soil) is important in determining the type of pond liner that is required, particularly as it might be able to be used to line the pond.

Permeability of soil varies depending on what the soil is made up of, for example sandy soils are more permeable than clay soils. The permeability is measured by how quickly water is able to pass through the soil: the faster water passes through soil, the more permeable the soil is. For example, a soil with a permeability of one-millionth of a metre per second ($1x10^{-6}$ m/s) is more permeable than a soil with a permeability of one-billionth of a metre per second ($1x10^{-9}$ m/s) so water (or effluent) will pass through the soil more quickly.

Indicative permeability information for Taranaki soils is included in Section 7.

4 Dairy effluent pond types and features

Described below are the six broad types of dairy effluent ponds. The description of each pond type lists the design features required to meet a common performance standard (so the leakage is restricted to a specified value). Because detecting leaks is difficult after installation, the performance standard relies on good construction methods to ensure pond performance. For example, a poorly installed geomembrane liner will leak more effluent into the ground than a well-constructed unlined pond.

If the pond location does not meet all the criteria listed in Section 2, a site specific assessment of environmental impact to determine the standard of pond lining is required.

4.1 Soil lined ponds

Compacted soil

450 mm soil with permeability $\leq 1 \times 10^{-9}$ m/s.

Soil can be either in-situ soil dug up and reworked, or imported from elsewhere on the farm or region.

Cover layer of soil required to prevent surface drying out when pond is empty.

In-situ soil

Either 1 m thick soil below base of pond if permeability $\leq 1 \times 10^{-9}$ m/s; or 2 m thick soil below base if permeability $\leq 5 \times 10^{-9}$ m/s.

Scarify (make cuts) and compact top 150 mm.

Scour protection may be required.

Bentonite-enhanced soil liners

Same as for compacted soil liner (450 mm thick with permeability of $\leq 1 \times 10^{-9}$ m/s).

Bentonite is mixed with soil to achieve desired permeability at a rate of 10% of the dry weight of soil.

Should work well with sandy soils.

The use of bentonite slurry from drilling would require:

- specific trials to confirm the required permeability can be achieved, and
- contamination testing to assess effects on the environment or liner (if used under a geomembrane).

4.2 Geomembranes

Geomembrane (synthetic) liners

HDPE or butyl rubber liner.

Needs a layer of soil beneath it with a permeability $\leq 5 \times 10^{-6}$ m/s.

The soil layer can be 300 mm thick if compacted soil, or 1 m thick if in-situ, with top 150 mm scarified and compacted.

Avoid a 'cushion' or sand blinding layer, use silt if blinding layer necessary to protect geomembrane.

If a soil gas or groundwater drainage layer is needed, it must be placed below the soil layer.

4.3 Concrete liners

Concrete liners

Site specific design required.

Minimum 100 mm concrete liner with a layer of soil beneath it.

If a soil gas or groundwater drainage layer is needed, this should be placed below the soil layer.

Not recommended if ground settlement is expected.

Concrete tanks (in photo)

Commonly have pre-cast walls and poured in place floor. Underlying soils must be strong enough to take the weight. Soft clay or peaty soils are unlikely to be suitable without special design

5 Choosing a pond type

Below is a decision path to determine which type of pond is right in a given location. Note that concrete lined ponds and pre-cast concrete ponds are not recommended if ground settlement is expected. Permeability testing is only required if soil layers are used in the pond design, either as the main lining or as a secondary layer below a concrete or geomembrane liner.

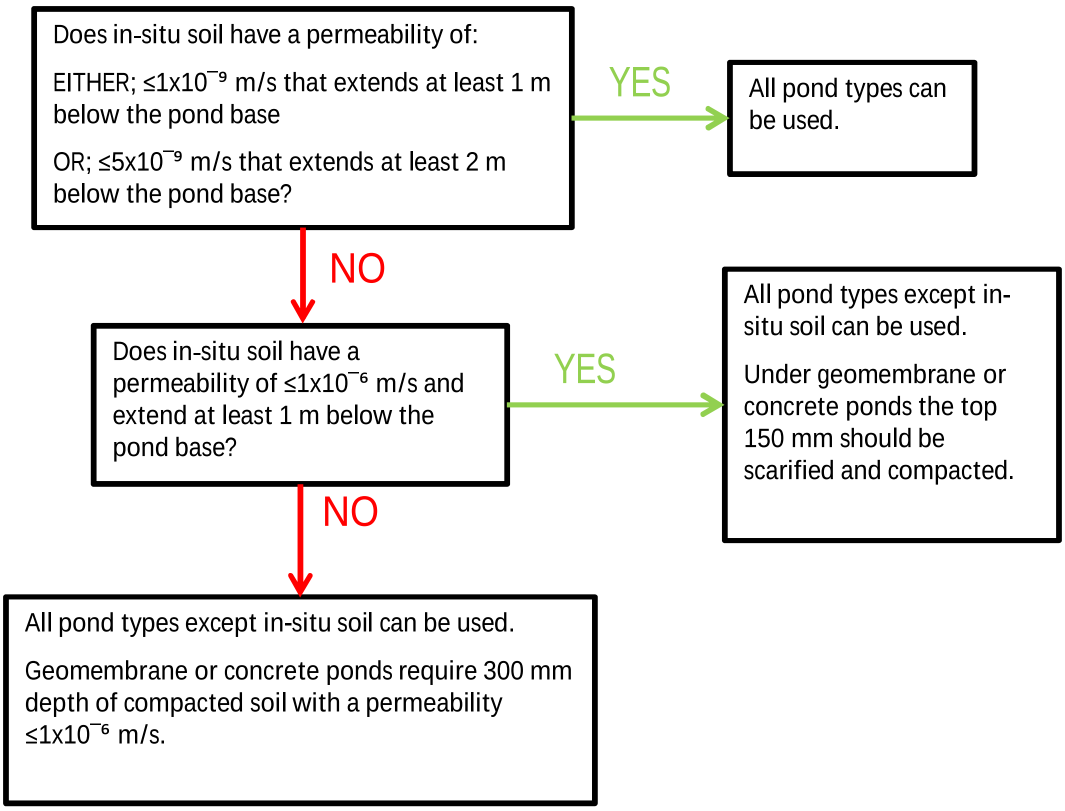

Figure 2: Flow chart for selection of suitable pond liner (normal environmental sensitivity).

6 Construction

Good construction practices and quality control are essential to ensure a new pond performs well. This section outlines the fundamental aspects of construction for all ponds, and some of the considerations for constructing different types of dairy effluent ponds. Construction requirements also differ from site to site, and this should be accounted for during site-specific design.

6.1 Fundamental aspects of pond construction

Use a contractor with the right equipment and expertise to install the type of pond you have decided on.

Soil used in construction should be tested for permeability.

Any soil layers required during the construction of the pond should be laid down and compacted in 150 mm layers to ensure they are adequately compacted and achieve the necessary permeability, including on the sides of the pond.

Keep good documentation, including:

- A specification and drawings.
- An agreed method for construction, to:
    - Comply with the requirements of the specification.
    - Achieve the required quality of materials and construction
- Quality control procedures, including records of construction and testing results, to:
    - Ensure the agreed method is followed.
    - Ensure the requirements of the specification are achieved.

NOTE: This documentation forms the basis for execution and control of construction, and if required, can be provided to Taranaki Regional Council to demonstrate compliance with the performance standard. Without this documentation the pond may not meet the pond performance criteria, and even if it does, it may not be possible for you to verify compliance.

6.2 Pond type specific construction requirements

Some additional points for construction of different pond types are:

- Geomembrane and concrete lined ponds
    - To avoid damaging the lining, prepare a smooth surface for the liner to rest on.
    - To minimise leaks, a high standard of workmanship is required on the joints. Joints should be tested for leaks.
- Concrete lined ponds
    - To minimise leaks, a high standard of workmanship is required on the joints.
- Bentonite-enhanced soil liners
    - Trials and testing to check suitability of mixing soil and required bentonite content.
    - Essential to control bentonite application rate and thorough mixing.
- Concrete tanks
    - Tanks to be designed to appropriate standards, with site investigation and design of foundations by a geotechnical specialist.

Further detail on design and construction of dairy effluent ponds, including testing requirements is available in IPENZ Practice Note 21.

7 Taranaki soils

The following map (Figure 1) shows the geological terrain zones for the Taranaki Region. Table 1 provides a description of each zone and indicative permeabilities of soils within that zone. Each zone has a number of different soil types and each soil type can have a range of permeabilities. The values in Table 1 are a general guide. Permeability testing may be required for site specific design. See IPENZ Practice Note 21 for testing information.

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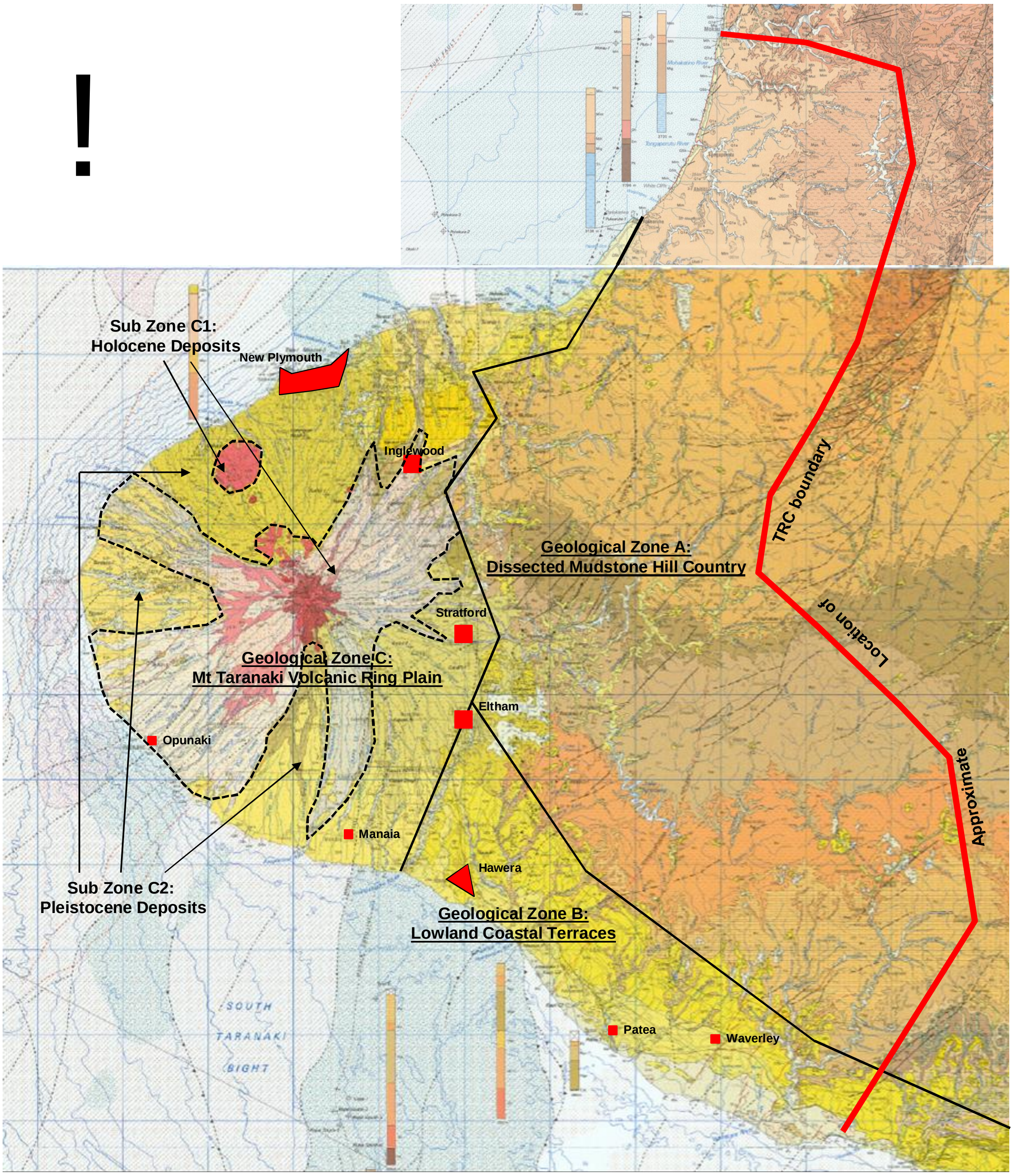

Sources:
Townsend et al., 2008. Geology of Taranaki Area. Institute if Geological and Nuclear Sciences 1: 250,000 Geological Map 7.

Edbrooke, S. W (compiler). 2005. Geology of the Waikato area. Institute of Geological and Nuclear Sciences 1: 250,000 Geological Map 4.

Approx Re-sized Scale (Original scale 1:250,000)
0 10 20 30 40 50 (km)

Figure 1: Taranaki geological terrain zones

Table 1: Description of Taranaki soil zones, associated soil types and permeabilities

Geological terrain zone	Soil types and general description	Range of permeability (m/s)
A: Dissected hill country Inland hill country. Relatively low hill topography and flat benches dissected by streams and rivers.	Mudstone/siltstone derived: very fine grained, with no grains visible to the naked eye. Brown or grey.	$1x10^{-6}$ to $1x10^{-9}$
	Sandstone derived. Fine grained with some grains visible. Brown or grey.	$1x10^{-4}$ to $1x10^{-6}$
	Volcanic Ash. Fine grained. Orange-brown to dark brown.	$1x10^{-5}$ to $1x10^{-9}$
B: Coastal lowlands Sets of uplifted marine terraces that stretch from south Taranaki Bight inland for approximately 20km.	Marine terrace deposits: - Fine grained with some grains visible to naked eye. Light brown to grey. - Coarse grained with sand and gravel. Light brown to grey.	 $1x10^{-5}$ to $1x10^{-7}$ $1x10^{-2}$ to $1x10^{-5}$
	Dune sand. Fine grained, gritty, with uniform sized sand grains. Crumbles in fingers.	$1x10^{-2}$ to $1x10^{-4}$
	Loess. Fine grained with some grains visible to naked eye. Orange-brown to dark brown. Sticky when wet, but cannot be rolled into thin threads in fingers.	$1x10^{-6}$ to $1x10^{-8}$
	Volcanic Ash. See description above.	$1x10^{-5}$ to $1x10^{-9}$
C: Mt Taranaki ring plain Circular area of undulating terrain around Mt Taranaki, radius approx. 30km. C1: gravels and sand covered by thin or no silt and clay ash. C2: relatively thick layers of silt and clay ash deposits.	Laharic deposits. Ranges from clay to large gravels. Red-brown to light brown. Clay is sticky when wet and can be rolled into thin threads with fingers.	$1x10^{-1}$ to $1x10^{-8}$
	Volcaniclastic deposits. Fine grained with most grains visible to the naked eye. Grey. Crumbles when rolled in fingers.	$1x10^{-4}$ to $1x10^{-8}$
	Volcanic Ash. See description above.	$1x10^{-5}$ to $1x10^{-9}$

Note: permeabilities sourced from IPENZ Practice Note 21, Part 2 Clay Liners for Ponds.

8 Further information

This guide draws on the following sources, which contain further information on designing and constructing dairy effluent ponds:

- IPENZ Practice Note 21: IPENZ: Farm Dairy Effluent Pond Design and Construction, available at: http://www.dairynz.co.nz/page/pageid/2145869375?resourceId=686
- Managing Dairy Farm Effluent (Dairying and Environment Committee Manual), Chapter 3, prepared by Taranaki Regional Council can be found here: http://www.trc.govt.nz/assets/taranaki/environment/land/dairying-environment/effluent/3.pdf
- DairyNZ has a number of online resources about effluent systems, available at: http://www.dairynz.co.nz/page/pageid/2145866686/Effluent_Systems

9 Applicability

This report has been prepared for the benefit of the Taranaki Regional Council with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose without our prior review and agreement.

Tonkin & Taylor LTD

Environmental and Engineering Consultants

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Appendix II

Extract from Regional Fresh Water Plan (2001) Appendix VIIB Good Management Practices for Discharging Farm Dairy Effluent to Water

Appendix VIIB
Good management practices for discharging farm dairy effluent to water

In the Taranaki region the discharge of treated farm dairy effluent to water is a controlled activity requiring a resource consent. Where there is a failure to comply with conditions outlined in the regional rule regarding discharge of effluent to water then the activity becomes a discretionary activity.

The material presented in this appendix must not be considered as a set of rules that will be applied universally. Each individual situation will be considered by the Taranaki Regional Council on its particular merits and circumstances, with regard for the level of environmental protection that is appropriate in that situation.

This appendix contains information relating to the discharge of farm dairy effluent to surface water. The material is laid out so that information relating to treatment and the discharge system is addressed first, then information relating to site selection is presented.

1. Improving existing effluent treatment systems

The pond system will not work well:

- If it is too small.
- At temperatures below 20° C.
- When bottom sludge or surface crusting has built up sufficient to affect performance.
- If the retention time is less than 60 days.

For a poorly operating pond system to continue to be an acceptable and practicable option, the volume of effluent often needs to be reduced and be treated to a higher standard. Pond sizes may also need to be increased, see 1.4 for further detail.

1.1 Reducing clean water entering the system

Prevent clean water from entering the effluent system as it unnecessarily adds to the volume of effluent to be disposed of.

- Rainwater from roofs should not run into the sump. Install roof guttering and downpiping.
- Use a stormwater diversion to redirect the yard stormwater to a soak hole or waterway between milking. stormwater must be directed to the farm dairy effluent treatment system during milking and washdown of the yard. this will ensure that contaminated stormwater cannot discharge to local waterways. Make sure it is open during the day and night, and it is closed during milking and washdown.
- Clean water from plate coolers should be reused as washdown water.

1.2 Reducing manure

Manage the herd to reduce effluent. Consider the following:

- Reduce noise and herd stress - treat the stock gently before yarding and milking, be even tempered, do not use dogs in and near the farm dairy, and check for, and stop, stray electricity.
- Improve cow flow. Extra time spent on the yard and raceways will increase the total amount of manure. If using the farm dairy yards as a wintering pad or as a stand off pad remember - more effluent has to be treated.
- Split larger herds during milking.
- Do not feed the herd during milking.

1.3 Reducing washwater and waste

Speed up final cleaning and minimise the amount of washdown water by prewetting the yard before milking, and by using manual scrapers and squeegees, and shovelling off the manure pats.

Also prevent afterbirth, rubbish and waste products from entering the effluent treatment system. Have a trash drum outside the farm dairy to dispose of rubbish.

1.4 Additional Treatments

Attaching an additional treatment as part of the pond system can solve the problem of poor effluent quality. Different methods of providing additional treatment are listed below:

- Apply the effluent to land rather than discharging to a waterway. The pond system can provide an excellent first treatment and storage facility. Refer to Appendix VIIA 'Good management practices for discharging farm dairy effluent to land'.
- Add another pond to the system. This is an inexpensive and simple solution to a herd size increase. The additional pond should be at least half the surface area of the facultative pond (second pond). An alternative is to divide the second pond in two with a curtain wall.
- Increase the size of the pond system.
- Install constructed wetlands. They use water, plants, air, sunlight, and bacteria to further 'polish' pond effluent before it reaches the surface waterway. This is not always successful as the option requires high capital expense and management to work well.
- Consider mechanical aeration. Aerators introduce oxygen to the effluent so that facultative bacteria can more effectively break it down. There are significant operational costs when using mechanical aeration. Compare these to those lesser costs associated with land application systems.
- In an emergency use chemical and biological additives. These control odours and break down crusting and solids. Additives do not reduce the polluting properties of effluent but make it more manageable.
- Desludging of the ponds. Desludging is recommended on an 'as necessary' basis.

2. Pond systems

2.1 Pond system design

The pond system is an attractive option for treating effluent because it is:

- Low in cost.
- Simple to install, taking 2 to 3 days to construct.
- Low in maintenance requirements.

The key standard is that effluent from ponds must discharge into receiving waters capable of diluting the effluent by at least 100:1 at the discharge point.

Pond systems have two or more ponds in a series. Effluent is piped to the anaerobic pond (first pond) from the farm dairy sump. The anaerobic pond acts like a septic tank, collecting a sludge on the bottom and slowly breaking down the effluent.

Effluent then flows to the facultative pond (second pond) by a pipe and baffle. In the facultative pond further breakdown occurs. The effluent then passes through an additional treatment or is discharged directly into a waterway.

2.2 Site selection

When choosing a site to construct a pond system, select an area where the water table is deep and the soil is heavy and impermeable. Silt or clay soils are ideal for pond foundations and construction. Avoid building ponds over coarse sands, gravels, fractured rock or other materials that will allow effluent to seep out of the pond or allow groundwater to enter in.

An officer of the Taranaki Regional Council must be present at the time a site is chosen.

- Hygiene: not within 45m of the farm dairy as disease causing micro-organisms may live in the effluent and can pose a risk to both animal and human health. Separation distances for hygiene purposes are specified in the Dairy Industry Farm Dairy Code of Practice.
- Recommended proximity to dwellings: no part of the system to be within 150m of any dwelling house. If possible, site the ponds downwind from dwellings, roads and other public places. The greater the distance from a potential complainant the better.
- Recommended proximity to public roads: no part of the system to be within 20m of any road or farm boundary.
- Allow for a straight run of pipelines, tractors and desludging vehicles to the ponds.
- Site in an open area so as to take advantage of the sun and wind, which assist the efficient operation of the facultative pond and thus improve the quality of the discharge.
- Keep systems away from overhead or underground power lines.
- Avoid sites that are likely to flood, have steep slopes that run towards a waterway, spring or bore hole, are pipe drained or mole ploughed, are likely to freeze over, or have recently been cleared of trees or similarly disturbed.
- Construct the system below the farm dairy so that gravity can be used to carry the effluent.
- Orientate the longest side of the pond at right angles to the prevailing wind.

2.3 Pond sizing

Pond size depends on the loading being applied to the system. Figures 1 and 2 in conjunction with Tables 1 and 2, give the major design recommendations for a pond system. Pond size is based on cow numbers and assumes all stormwater is prevented from entering the ponds (refer ‘Improving Existing Effluent Treatment Systems’, above).

- Have a length to width ratio of at least 2:1. This maximises the ‘flow path’ of the effluent, ensuring the effluent is kept within the system as long as possible.
- Keep pond width less than 24m because of the ‘reach’ limitations of excavator and desludging machinery.
- Orientate ponds with the long axis perpendicular to the prevailing wind. This will maximise the settlement of solids and help minimise intense odours.
- Provide for 500mm freeboard in the design.

2.3.1 The anaerobic pond

Anaerobic ponds are deep treatment ponds that exclude oxygen and encourage the growth of bacteria which break down the effluent. Construct:

- To a depth of 4m. Depths greater than 4m should be avoided due to limitations of desludging machinery.
- With a small surface area. A small surface area minimises the area in contact with oxygen at the pond surface, reduces heat loss, encourages mixing, promotes the formation of an undisturbed surface layer and minimises the surface area to catch rainfall.

2.3.2 The facultative pond

Facultative ponds are shallow and contain algae which produce oxygen that is used by bacteria to further break down the effluent. Odours are removed and most disease causing micro-organisms die-off. The larger the surface area of the facultative pond, the better its performance. Construct:

- To no deeper than 1.2m.
- As two smaller ponds rather than having one very large facultative pond when cow numbers in the herd are over 200, or when the pond is likely to be too large for effective desludging and stirring, or when the pond is too long for the site and interferes with existing structures such as fences.

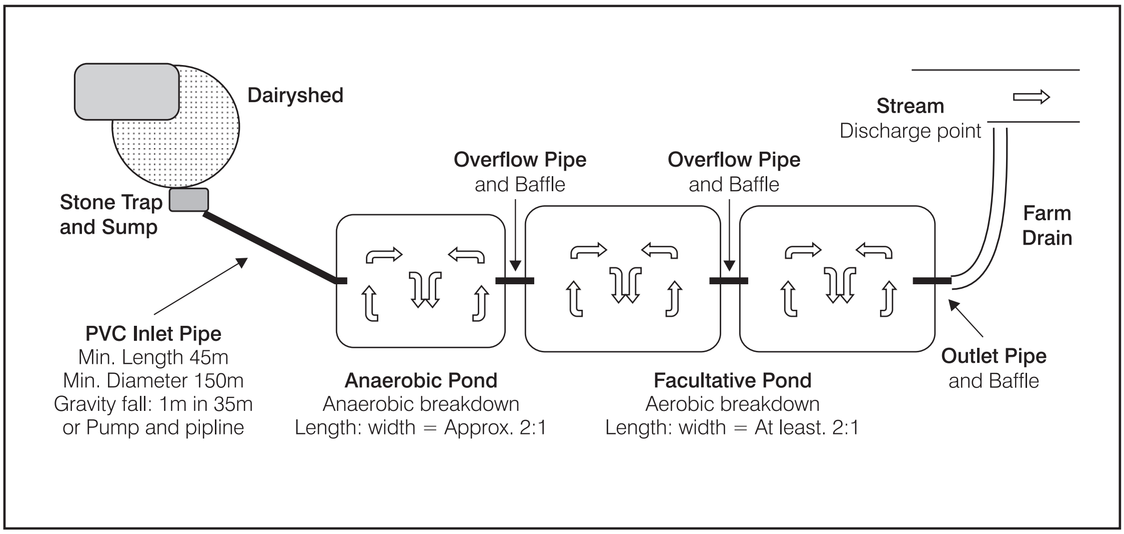

Figure 1 Layout of oxidation pond treatment system

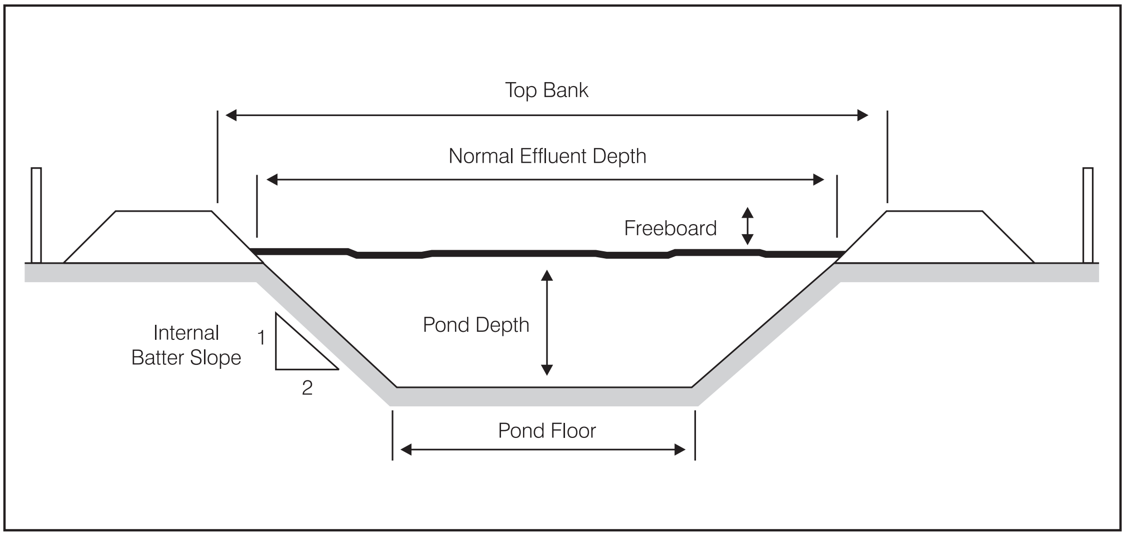

Figure 2 Construction parameters for oxidation ponds

Table 1 Recommended anaerobic pond sizing

Cow Nos	Required Volume	At Normal Effluent Depth Depth	Size	Surface Area	Top Bank Size	Pond Floor Size
100	525 m^3	4.0 m	16 m x 19 m	300 m^2	18 m x 21 m	0 m x 3 m
150	615 m^3	4.0 m	18 m x 21m	380 m^2	20 m x 23 m	2 m x 5 m
200	810 m^3	4.0 m	18 m x 26 m	470 m^2	20 m x 28 m	2 m x 10 m
250	1000 m^3	4.0 m	18 m x 31m	540 m^2	20 m x 33 m	2 m x 15 m
300	1200 m^3	4.0 m	18 m x 36 m	650 m^2	20 m x 38 m	2 m x 20 m
350	1390 m^3	4.0 m	18 m x 41 m	740 m^2	20 m x 43 m	2 m x 25 m
400	1580 m^3	4.0 m	22 m x 35 m	770 m^2	24 m x 37 m	6 m x 19 m
450	1770 m^3	4.0 m	22 m x 38 m	840 m^2	24 m x 40 m	6 m x 22 m
500	1970 m^3	4.0 m	22 m x 42 m	920 m^2	24 m x 44 m	6 m x 26 m

Note 1: Batter slope on interior bank = 2 : 1.
Note 2: Freeboard = 500 mm.
Note 3: Based on 0.09kg BOD/cow/day

Table 2 Recommended facultative pond sizing

Cow Nos	Required Surface Area	At Normal Effluent Depth Depth	Size	Volume	Top Bank Size	Pond Floor Size
100	370 m^2	1.2 m	18 m x 21 m	340 m^3	20 m x 23 m	13 m x 16 m
150	560 m^2	1.2 m	18 m x 31 m	540 m^3	20 m x 33 m	13 m x 26 m
200	740 m^2	1.2 m	22 m x 33 m	720 m^3	24 m x 35 m	17 m x 28 m
250	*920 m^2	1.2 m				
300	*1100 m^2	1.2 m	Build an appropriate combination of			
350	*1280 m^2	1.2 m	the above ponds to make up			
400	*1570 m^2	1.2 m	the required surface area.			
450	*1660 m^2	1.2 m				
500	*1830 m^2	1.2 m				

Note *: Perhaps divide this dimension into two smaller facultative ponds.
Note 1: Batter slope on interior bank = 2 : 1.
Note 2: Freeboard = 500 mm for all herd sizes.
Note 3: Based on 0.09kg BOD/cow/day

2.4 Pond construction

A resource consent must be applied for from the Taranaki Regional Council prior to commencing any work on the ponds.

Preferably, build the ponds $^{2}/_{3}$ above and $^{1}/_{3}$ below the ground. Pond and embankment construction involves the following:

1. Stripping topsoil from the pond area and stockpiling it for replacement later.
2. Excavating. Ground conditions should be moist, but not wet, for excavation work.
3. Digging a key trench to a firm base, at least 1m deep and 3m wide, beneath the centre of the embankment. The key trench hinders flow of effluent through the ground by lengthening the seepage path, prevents erosion and offers structural stability to the embankment.
4. Banking up and compacting the soil, while excavating the pond, to form the pond walls, when ponds are built at least partly above the ground. Poor compaction will lead to effluent seepage and erosion of the embankment by wind and rain.
5. Placing layers of suitable graded soil on top of each other to a 200mm depth over the full width.
6. Packing the soil tight using suitable equipment. Fill should be compacted over the entire surface after each 200mm soil layer is added. Use water to aid compaction if the soils are too dry. Best compaction is obtained with heavy rubber-tyred vehicles and rollers. Track vehicles are unsuitable as their weight is spread over a large track surface area.
7. Building the banks with internal batters of 2:1 slope.
8. Building the banks high enough to allow for settling.
9. Building the top bank wide enough to allow for vehicle access for maintenance. Widths of between 3.0m and 4.0m are usual.
10. Building a loose metal platform to provide access and a firm platform for dredging machinery, pond stirrers and vehicle spreaders. This will prevent erosion of the banks and allow for easy access regardless of the prevailing soil conditions.
11. Grading the top bank away from the pond so that stormwater runoff into the pond is prevented.
12. Installing a plastic liner if the soil is less than 10% clay.
13. Sowing grass to cover the embankment to the water's edge to prevent erosion from sun, wind and rain. Phalaris, ryegrass and clover are suitable species.
14. Fencing. A secure perimeter fence is advisable for safety reasons.
15. Using buried PVC pipe, of at least 150mm diameter (preferably use 300mm diameter), for carrying effluent to, and between, ponds. Do not used perforated, ribbed drainage coil. Drains are not acceptable. Pipe the effluent towards the pond centre, 6m from the pond edge. Place the outlet at the opposite side of the pond, 1.5m from the far edge.
16. Including baffles on outlets. This is **very** important. Baffles prevent floating solids from moving between ponds. Make sure all pipes and baffles are fixed and do not float upon changing effluent levels.

3. Management and maintenance

Plan to first use the ponds at the beginning of the milking season to allow bacteria time to build up over the warm summer months.

- Encourage and maintain grass cover on the banks to prevent erosion, but keep Plants short.
- Do not allow trees or shrubs to grow on, or near to, embankments. Tree roots can pierce the embankment causing instability. If trees fall over, or roots die, the embankment will be breached.
- Examine embankments after heavy rain.
- Desludge ponds regularly, as necessary. Never empty out ponds completely or important bacteria will be lost.

3.1 Monitoring the system

The resource consent holder has primary responsibility for monitoring the functioning of the system.

A resource consent that has been issued to allow a discharge to a waterway will usually require that:

- A minimum dilution of 1 part effluent to 100 parts receiving water is maintained at all times.
- An ammonia-N concentration of not more than $0.025gm^{-3}$ is maintained at or beyond the downstream boundary of the mixing zone.
- The filtered carbonaceous BOD_5 concentration does not exceed $2gm^{-3}$.

Any readings above these figures indicate overloading and remedial measures will be necessary. The following visual guides will help identify such a poorly operating pond system:

- Sludge build-up or excessive crusting.
- Bubbling has stopped in the anaerobic pond.
- Discolouration of the receiving waterway.

Where it is suspected that the pond system is operating poorly or the necessary 1:100 dilution cannot be met, consider the options in 'Improving existing effluent treatment systems', above. Also, contact the Taranaki Regional Council.

References

Heatley, P.R., 1996. "Dairying and the Environment Manual: Managing Farm Dairy Effluent". Dairying and the Environment Committee, New Zealand Dairy Research Institute, New Zealand.

Vanderholm, D.H., 1984. "Agricultural Waste Manual". New Zealand Agricultural Engineering Institute Project Report No. 32. NZAEI, Lincoln College, New Zealand.