SD050.2/11/10

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E-MAILED
10-11-10
@ 1.48pm

SHIRE OF
SERPENTINE JARRAHDALE
11 NOV 2010

10 November 2010

Your Ref: P036804/01
Enquiries: Tony Wilkie

Shire of Serpentine-Jarrahdale
6 Paterson Street
MUNDIJONG WA 6123

Attention: Peter Veralis

Dear Sir,

RE: DAM INSPECTION NOT PREVIOUSLY APPROVED
LOT 29 HN 177 MEDULLA ROAD, JARRAHDALE FOR WAYNE STEWART

I wish to advise that I have inspected the dam at the above property and report as follows:

1. The dam was constructed in 2008 and has been filled by natural runoff for the past three winters and shows no sign of distress or deterioration since its construction.

2. The purpose of the dam is for firefighting and reticulation purposes as the Lot is not serviced with reticulated water.

3. The dam has been well constructed and thoroughly compacted in accordance with comprehensive Land Care Notes (copies attached)
   i) How to avoid dam construction failures
   ii) Small earth dams
   iii) Natural Resources Queensland farm dam construction.

4. The dam is 15.25m wide, 56.25m long and 4m deep. Due to my enquiries, I am convinced that it was constructed of thoroughly compacted clay (see attached plan and cross section) in a thoroughly workmanlike manner.

5. The batters are approximately on the downstream side 1 vertical to 3.7 horizontal and on the upstream or internal side 1 vertical to 4.9 horizontal.

6. The crest of the dam is some 3.5 metres wide and the embankment is well grassed and established, exhibiting no signs of erosion in the past three winters.

7. The spillway is located on the northern side of the dam with more than adequate dimensions some 1 sq m per cross section to allow for the adequate overflow of water. It is well protected with rock 'rip rap' from the top of the spillway to the culvert crossing over the adjacent access road and is well constructed.

My Client has stated that he was unfortunately unaware that planning approval was required for the dam and as consequence we seek retrospective approval.

In conclusion, please find attached certified sketches and my assurance that the dam has been constructed in a structurally adequate manner.

Should you wish to discuss any aspect of this matter further, please do not hesitate to contact our office.

Yours faithfully,

A.A. Wilkie
Consulting Engineer

Farm dam construction

The storage of water is crucial to many farming operations. To build a dam then have it fail because of poor construction, can be disastrous to the economy of a farm.

Your dam will serve you well if you build it right the first time.

Construction of a dam should begin only after proper planning has been done.

Contractor

Building a farm dam is not simply a matter of pushing up an embankment. You should start by engaging a contractor who is experienced and uses proper techniques in farm dam construction.

Machinery

Using proper construction techniques requires the use of the right machinery. The basic machinery for dam building is:

- bulldozer with blade and ripper
- bulldozer with hydraulic scraper
- sheepsfoot roller
- water truck.

The contractor may use a self-loading scraper instead of a bulldozer with hydraulic scraper. Other specialised equipment includes excavators and rock breaking tools.

Materials and compaction

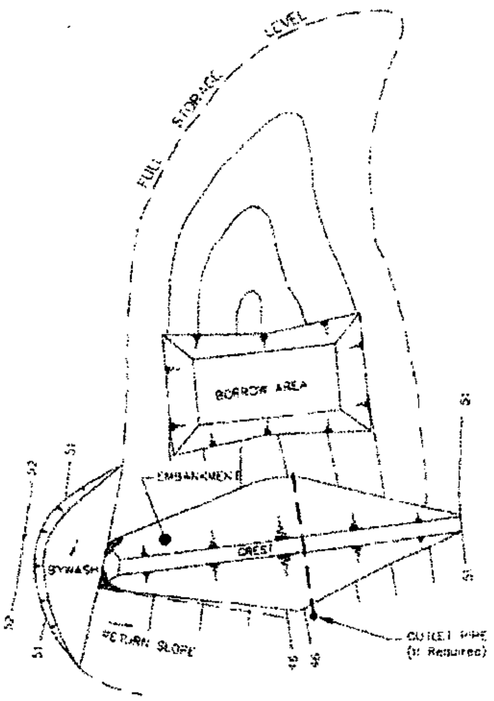
The embankment must be constructed using good clay materials and the correct compaction techniques. Fill material excavated from the borrow and bywash areas is built up in layers of not more than 200 mm thick. With each layer, close attention must be given to the moisture content and compaction of the material.

As a guide, the material has enough moisture if it is as wet as can be handled by a sheepsfoot roller. If you take a piece of the material in hand, it should roll out to the thickness of a pencil without it breaking up.

Construction

The sequence of construction work is:

- prepare the site
- excavate and backfill cutoff
- install pipework (if necessary)
- construct embankment
- excavate the bywash
- protect vulnerable areas from erosion.



Plan of dam site

Site preparation

Clear the embankment, borrow and bywash areas of trees and stumps. The area is then stripped of topsoil to a depth of 75 mm and the topsoil stockpiled near the site.

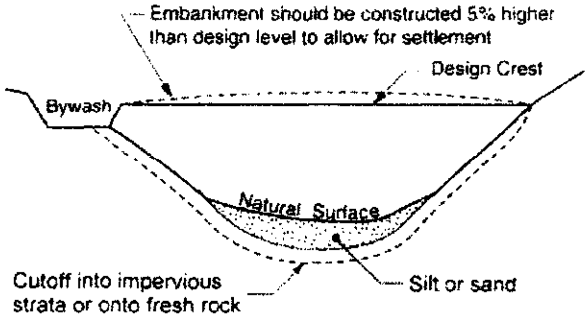
The bywash return slope must be left undisturbed. If trees need to be removed from the slope, it must be done carefully with minimal disturbance to the slope.

Cutoff works

The cutoff provides a water seal beneath the embankment and therefore must extend the full embankment length. The cutoff trench must be excavated at least 300 mm into impermeable material or on to fresh rock.

Excavated material may be placed in the downstream outer zone.

Backfill the trench with selected clay, compacted at the correct moisture content.



Typical section through gully

Installation of pipework

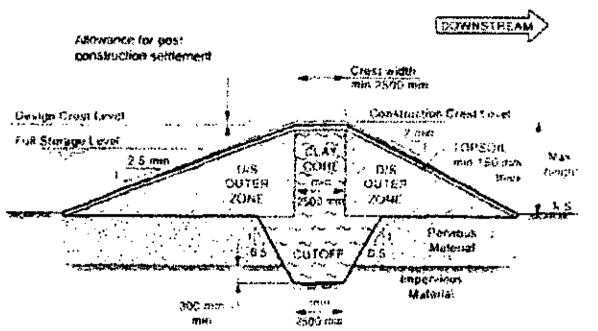
Install any outlet pipework where required and hand pack good moist clay around pipes. Anti-seepage baffles should be placed around the pipe where it passes through the core/blanket zone. The baffles can be concrete or steel construction.

Embankment construction

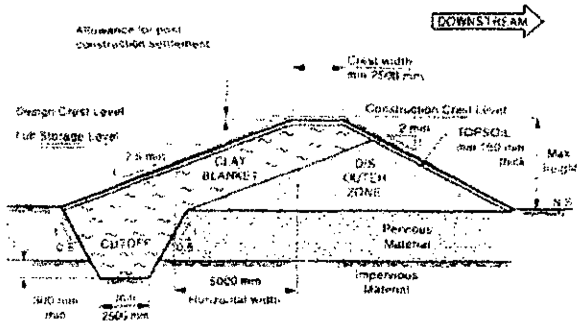
The embankment is built up in horizontal layers. The clay core or blanket zone must consist of impervious clays compacted at the correct moisture content.

The outer zones are usually compacted with a roller, however attention to moisture content of this material is not as critical as with the core/blanket zone.

Silt, sand or gravelly material can be placed in the downstream outer zone.



Cross section - clay core



Cross section—clay blanket

Bywash evacuation

Bywashes must be cut level. This ensures a uniform flow of water across the bywash to the return slope. The bywash level should be at least 1 metre below the crest level of the dam.

Material excavated from the bywash may, if suitable be used in the embankment.

Erosion protection

Spread topsoil over the bank and bywash, and plant with a good holding grass. Make sure the bywash return slope is fully grassed. Promote growth of the grass with water and fertiliser.

Protect the ends of the embankment where they meet with the bywash and the outfall from any pipework with rock pitching or concrete.

Further information

Fact sheets on water and other topics are available from Natural Resources and Water (NRW) service centres or the NRW website <www.nrw.qld.gov.au>.

March 2006
W10
For further information phone 13 13 04

48. Small earth dams

This Technical Brief is concerned with the typical small dam (up to about three metres high) which is built across a stream to form a reservoir. It provides guidance on planning, design and construction, but professional help should always be sought before building any dam whose failure could endanger lives, property or the environment. Care must also be taken to avoid the health hazards of reservoirs, including schistosomiasis and polluted water; and the rights of existing users of the water and land must be protected.

A reservoir is useful where the available flow in the stream is sometimes less than the flow required for water supply or irrigation, and water can be stored from a time when there is surplus, for example, from a wet season to a dry season. In addition to the simple earth dam, alternatives to consider are using the sub-surface (groundwater) dam (see *The Worth of Water,* pages 97-100) or using wells. These may be preferable for environmental and water-quality reasons.

Simple earth dams can be built where there is an impervious foundation, such as unfissured rock, or a clay subsoil. The channel upstream should preferably have a gentle slope, to give a large reservoir for a given height of dam. An ideal dam site is where the valley narrows, to reduce the width of the dam.

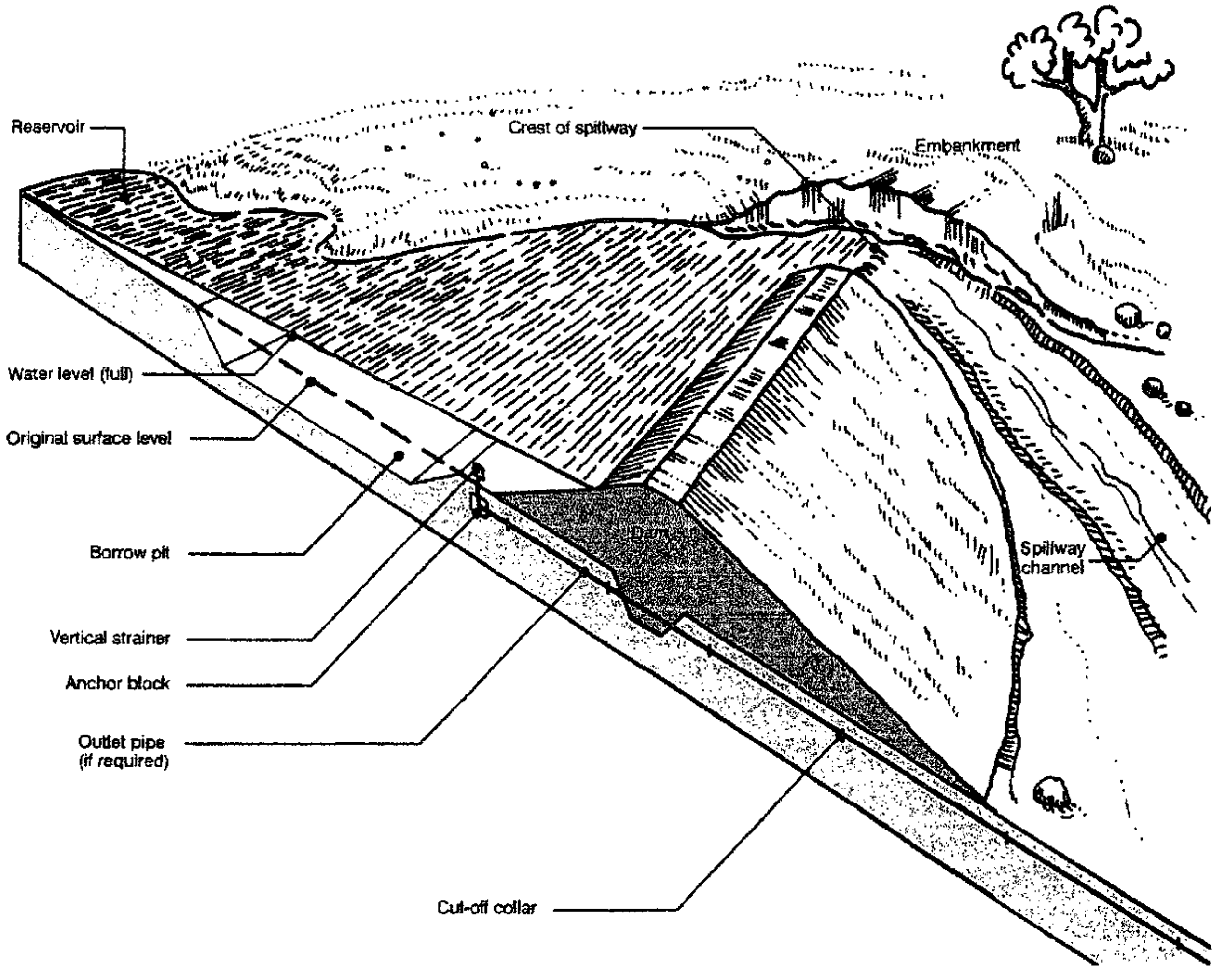


Figure 1. Section through a small earth dam and reservoir

Small earth dams

Design

The design below is suitable for dams up to 3m high. It is a uniform embankment of inorganic, clay loam soil, such as sandy clay loam, clay loam, silty clay loam, or soil with a higher clay content (sandy clay, clay, or silty clay). Any of these can be used provided cracks do not form. The dam must have a 'cut-off' which locks it into the subsoil foundation, ensuring that the dam is stable.

A 3m high dam would typically have a 2m maximum depth of water when full, increasing to 2.5m under flood conditions, with a 0.5m depth of flow over the spillway. The top 0.5m (minimum) is required to provide a safety margin (freeboard) which allows for water rising on the dam due to wind and waves, and wear and tear on the dam crest. The total design height of the dam must be increased for construction by at least 10 per cent, to take account of settlement.

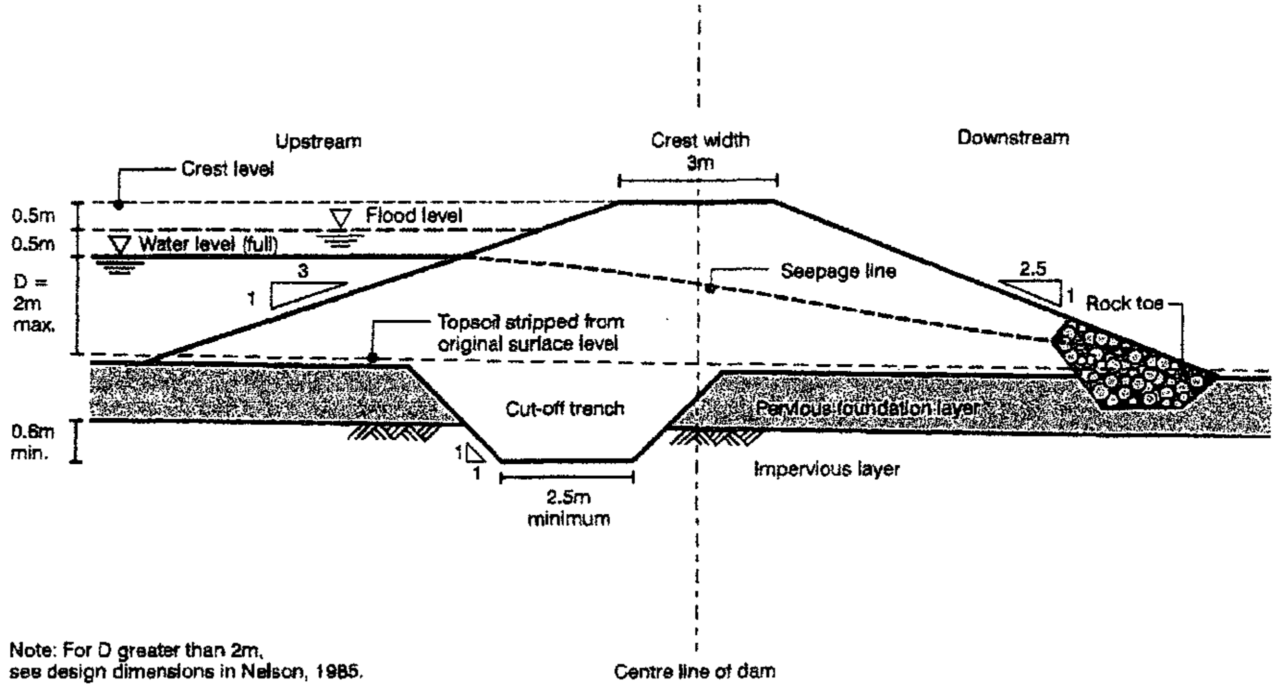


Figure 2. Section through a small earth dam (Source: Nelson, 1985)

Calculating the height of the dam

The height of the dam will depend on the storage required in the reservoir. To calculate this:

- determine the water requirement per day (R litres per day);
- estimate the area of the reservoir (A m^2), the evaporation and seepage losses per day (Emm per day) and, hence, the volume of losses per day (A x E litres per day);
- estimate the length of the critical period (T days), during which the stream flow is less than the water requirement and losses, when requirements would be met using the storage in the reservoir;
- estimate the average stream flow during the critical period (Q litres per day);
- the effective storage required (S litres) = (water requirement per day plus evaporation and seepage losses per day minus average inflow per day) multiplied by the length of critical period:

S = (R + AxE – Q) x T

The dam must be high enough to store this quantity of water. The storage capacity of the reservoir (C litres) is best determined from cross-section surveys across the valley, but can be estimated from the area of the reservoir (Am^2) and the maximum depth of water at the dam (Dm) when full:

C = 330 A x D

The site should then be surveyed to estimate the area (A) of the reservoir for different values of D, and a trial-and-error method will then give the reservoir capacity (C) which meets the storage required (S) and provides a safety margin. The resulting value of A should then be used in the calculation of S to obtain a consistent result. Height of dam = D + 1m.

Construction

The materials should preferably be taken from the reservoir area; different parts of the side of the valley should be examined so that the most suitable soils are located (soil textures will vary according to position in the valley). The following materials should be avoided: organic material — including topsoil — decomposing material, material with high mica content, calcitic clays, fine silts, schists and shales, cracking clays, and sodic soils. Avoid material with roots or stones.

Other construction points to consider:

- Construct during the dry season.
- Divert the stream; block it with a temporary low dam, or divert it through a culvert (which could become part of the outlet works or spillway later).
- Strip topsoil because it contains organic matter (such as roots) which prevents proper compaction and may provide seepage routes (piping) once the organic matter has decayed.
- Pay attention to people's safety — avoid hazardous practices and dangerous equipment.
- Place material in the dam:

  i) in layers 100 to 200mm deep;

  ii) at the optimum moisture content — when material can be rolled to pencil thickness without breaking, and is as wet as possible without clogging the roller; then

  iii) compact with a heavy roller, or by driving across vehicles or animals.
- Cover the whole dam with topsoil:

  i) plant strong grass (such as Kikuyu grass, star grass or Bermuda grass) to protect against erosion;

  ii) maintain the grass (water in the dry season if necessary), but prevent trees taking root, and keep out animals such as rats and termites.
- Protect the upstream slope:

  i) lay a stone or brush mattress (for example bundles of saplings between 25 and 50mm long) on the slope, and tie it down with wire anchored to posts:

  ii) secure a floating timber beam 2 m from the dam — these need replacing every 10 years or so.

Settlement

Even with compaction, earth dams settle as the weight forces air and water from voids (consolidation) — allow for this settlement in the design.

For small dams, well-compacted settlement should be between 5 to 10 per cent of the height of the dam.

Seepage/filter

Some water will seep through the dam, even if it is constructed of good materials, and well-compacted. This seepage reduces the strength of the dam. Nelson recommends the crest width and slopes shown in Figure 2 to provide a stable, 3m-high embankment making extra seepage protection unnecessary. A safer, but technically difficult, solution is to include a rock toe drain (as shown), to collect seepage water. This should extend up to a third of the height of the dam, and a graded sand and gravel filter must be placed between the dam fill material and the drain to prevent fine clay particles being washed out. The filter must be designed according to the particle size of the dam material and the drain, following, for example, recommendations in Schwab *et al.* p488-490.

Extraction of water from the reservoir

A gravity outlet can be constructed, as shown in Figure 1, using a screened inlet on the bed of the reservoir, and a pipe in a trench below the dam. Problems can arise with seepage through poorly compacted material beside the pipe (reduced by placing seepage collars along the pipe to increase the perimeter by at least 25 per cent), and difficulty repairing a damaged pipe. Alternatively, water can be extracted by lifting or pumping, using some of the methods described in Technical Briefs Nos. 22 and 47, for example:

- a sump (well reservoir) in natural ground at the side of the reservoir, supplied by gravity from a screened inlet and pipe through the bed and side of the reservoir;
- a bank-mounted motorized or human-powered pump; or
- a floating intake.

Safety and management

National and local regulations on small dams must be checked and followed in design, construction, and maintenance.

A technically competent person (an engineer or technician) should be responsible for designing and supervising the construction of the dam. The level of expertise required will depend on the potential for failure. Particular technical attention should be paid to the selection of materials and the design of the filter and spillway.

The sizeing of the spillway is important for protecting the dam during floods, but it is difficult to design. It depends on the rainfall intensity and the size and characteristics of the catchment area, and technical advice should be sought on local standards and practice.

A system needs to be set up for checking the condition of the dam and spillway, and for arranging any necessary repair work. This will usually involve training a local caretaker, who has access to a technician who inspects the dam at an appropriate interval (e.g. before each rainy season).

The dam should be regularly inspected for signs of deterioration, such as cracks, gullies, damage by rodents or insects, seepage, and damage to structures, especially the spillway.

Small earth dams

Spillways

A spillway is required to protect the dam from overtopping, for example during high flows. It passes surplus water downstream safely, preventing both the failure of the dam, and damage downstream.

Surplus water flows over a spillway crest at the top water level, and into an open channel around the side of the dam, discharging safely into the stream below the dam. It may be made from reinforced concrete, but a cheaper solution is a grassed spillway with a:

- vegetated earth channel
- protected crest at reservoir top-water level
- maximum velocity 2.5m/s

A grassed spillway requires regular inspection and maintenance, so that erosion can be repaired and a good grass cover is maintained. It is often used together with a trickle-pipe spillway so that small inflows into a full reservoir flow through the trickle pipe, and do not erode the grass spillway. Table 1 can be used to find the minimum inlet width for a given flood flow. These widths apply to well-grassed spillways. Poorly grassed spillways should be wider.

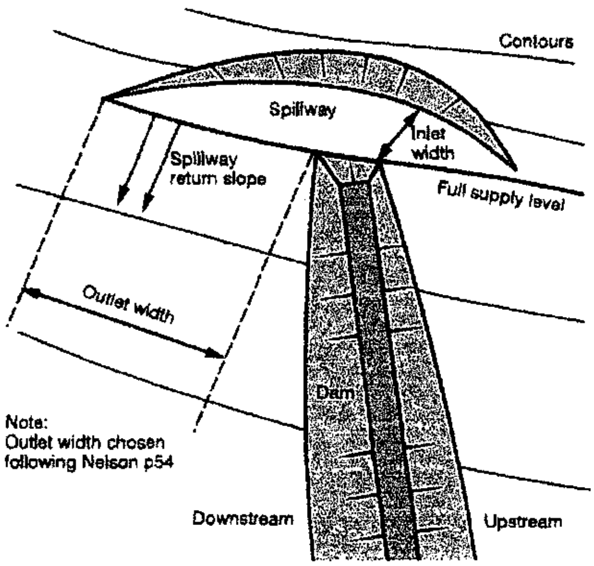


Figure 3. Plan of a spillway
(Source: Nelson, 1985)

Table 1. Minimum inlet width of the spillway

Flood flow (m^3/s)	Inlet width (m)
Up to 3	5.5
4	7.5
5	9.0
6	11.0
7	12.5
8	14.5
9	16.5
10	18.5
11	20.0
12	22.0
13	23.5
14	25.5
15	27.5

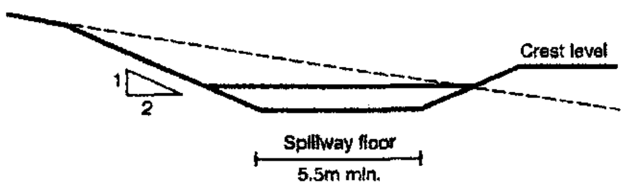


Figure 4. Cross-section of a spillway
(Source: Nelson, 1985)

Further reading

Fowler, John P., 'The design and construction of small earth dams', *Appropriate Technology*, Vol.3, No.4 (reprinted in *Community Water Development*, IT Publications, London, 1989).

Nelson, K. D., *Design and Construction of Small Earth Dams*, Inkata, Melbourne, 1985.

Pickford, John (ed.), *The Worth of Water: Technical Briefs on health, water and sanitation*, IT Publications, London, 1991.

Schwab, G.O., Fangmeier, D.D., Elliot, W.J. and Frevert, R.K., *Soil and Water Conservation Engineering*, Wiley, London, 1993.

Stephens, Tim, *Handbook on Small Earth Dams and Weirs*, Cranfield Press, Bedford, 1991.

Prepared by Ian Smout and Rod Shaw

WEDC Loughborough University Leicestershire LE11 3TU UK
www.lboro.ac.uk/departments/cv/wedc/ wedc@lboro.ac.uk

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Landcare Notes

How to avoid dam construction failures

July 1997
LC0085
ISSN 1329-833X

Emile Kyriacou, Box Hill

This Landcare Note gives information on how to minimise the risk of either design failure or operational failure of farm dams <u>not</u> located on waterways

Dams which are to be constructed on waterways must be referred to your local water authority

How to prevent failures

Usually, the causes of the failure can be easily found. The owner may have been over-confident in undertaking planning, and in doing so, failed to include soil testing in the investigatory program.

The other common cause of failure is in the use of inexperienced contractors. Nothing can take the place of a reliable and reputable contractor, and by using experienced machine operators you can reduce the risks of failure dramatically. Their previous jobs can be checked and a good outcome is considered the best recommendation

Soil assessment and testing

It cannot be stressed too heavily that the soil on the actual site should be examined before detailed planning starts. Many types of soil and subsoil do not "hold" water and it is necessary to confirm the existence of impervious clay to seal the excavation and to form the core of the bank. It is also highly desirable to determine the susceptibility of the soil to tunnel out and cause bank failure. Landcare Note LC0069: *Soil materials for dam construction* provides further information. Many potential failures can be prevented if the contractor is fully aware of any soil limitations on the site.

A further requirement is to investigate the materials along the centreline of the bank to ensure that the core trench reaches impervious material

Equipment

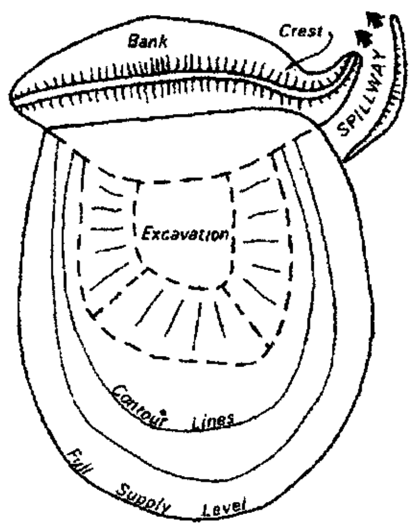
A bulldozer or a scraper is mainly used when constructing a farm dam, preferably in conjunction with a sheepsfoot roller on larger jobs. Scrapers generally give better bank compaction, but bulldozers are more manoeuvreable.

Strip topsoil

Completely clear and strip at least 150mm of top soil from the excavation and the bank areas. Stockpile it in a convenient place, for later use.

Designing bank and excavation

Design the bank and excavation so that the upstream edge of the pit will be covered when the dam is full. This will help to prevent erosion of the edge of the pit.



<u>Figure 1: Plan view of dam</u>

Core trench

As a preliminary to the construction of the bank, a core trench at least 2.4 metres wide and at least 0.6 metres deep should be cut out along the full length of its centre line. It is essential to site the core trench in a foundation of impervious clay. In many cases the core will need to be deeper than 0.6 metres. It is essential that all soft, weak, coarse and organic materials are removed. The whole remaining foundation area of the bank site should be surfaced ripped. The core trench should then be backfilled and compacted with the most impervious material available, to provide a seepage seal.

Department of Natural Resources and Environment

Victoria The Place To Be

Building the bank

Probably the most important requirement of bank construction is to have effective compaction of soil material. The requirement for compaction cannot be overemphasized. Construction should be undertaken when the soil is moist. Autumn or early winter are usually the best times. Construction is often difficult in mid-winter because sites are too wet. It is not advisable to attempt construction in mid-summer, when the soil is too dry and difficult to compact. Even though the soil moisture content may be ideal in late spring, problems can occur when a newly built bank dries out over summer, and failure can result.

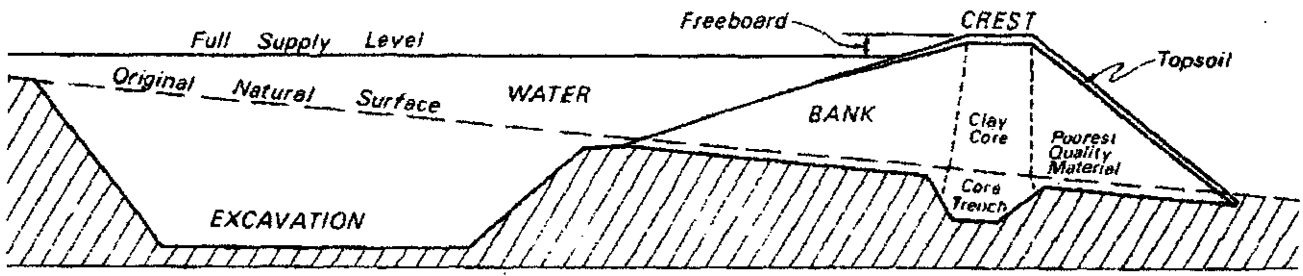


Figure 2: Cross section through dam

Start to build up the embankment by placing earth in regular and even layers no more than 100mm thick, with a scraper or bulldozer - 150mm layers can be used if compacted with a sheepsfoot roller.

If only a limited quantity of good quality clay is available, the best of it should be used to progressively build up the clay core. The least suitable materials should be kept for the downstream section of the bank. Do not incorporate any large rocks, logs or other debris into the bank.

Remember - to achieve adequate compaction, the soil must be moist, but not so excessively as to be muddy or slushy. In many cases a water cart should be used to moisten soil as it is spread on the bank.

The ideal way to compact the embankment is to use a sheepsfoot roller. This will minimise the risk of future failure. However, a bank up to 3 metres (10 feet) high may be satisfactorily compacted with the tracks of a loader scraper provided the soil is: moist; not dispersive; and it is built up in thin layers.

Freeboard

The correct amount of freeboard will vary with the size of the dam, area of catchment and likely wave action. Minimum freeboard should not be less than 1 metre. Even with good compaction some vertical settling of the bank should be expected. Make a 10% allowance for settlement.

Batters

For banks up to 3 metres (10 feet) high, the standard recommended slope of batters is 3:1 on the upstream side of the bank and 2:1 on the downstream side. Before building batters steeper than this, it is important to ensure that it is safe to do so.

Spillway

A correctly designed spillway is essential. Many dams fail due to faulty design or construction of the spillway. It must be large enough to handle flood flows without water overtopping the bank. Nor should the flows cause erosion of the spillway or disposal area below the dam. If the spillway has a newly formed earthen surface to take overflows from the dam, a heavy grass surface cover should be sown and established as quickly as possible. Do not allow construction equipment or vehicles to travel on the spillway discharge area, the vegetative cover is too important.

A rule of thumb for estimating the width of a spillway: it should equal (in metres) the square root of the catchment area (in hectares). For example, a catchment area of 9 hectares would require a spillway 3 metres wide.

If trickle flows of water are likely to be produced from the catchment during winter and spring, installation of a trickle flow pipe should be considered. See Landcare Note LC0090: *Trickle flow pipes for farm dams*.

Topsoil

When construction is completed, the stockpiled topsoil should be spread over the bank. Suitable grass species should then be sown to stabilise the bank and prevent it eroding. Trees should not be used on banks because their larger root system can disturb the compacted mass. Another important feature of placing topsoil back over the bank is that, when grassed, it helps prevent the clay bank from drying out and cracking.

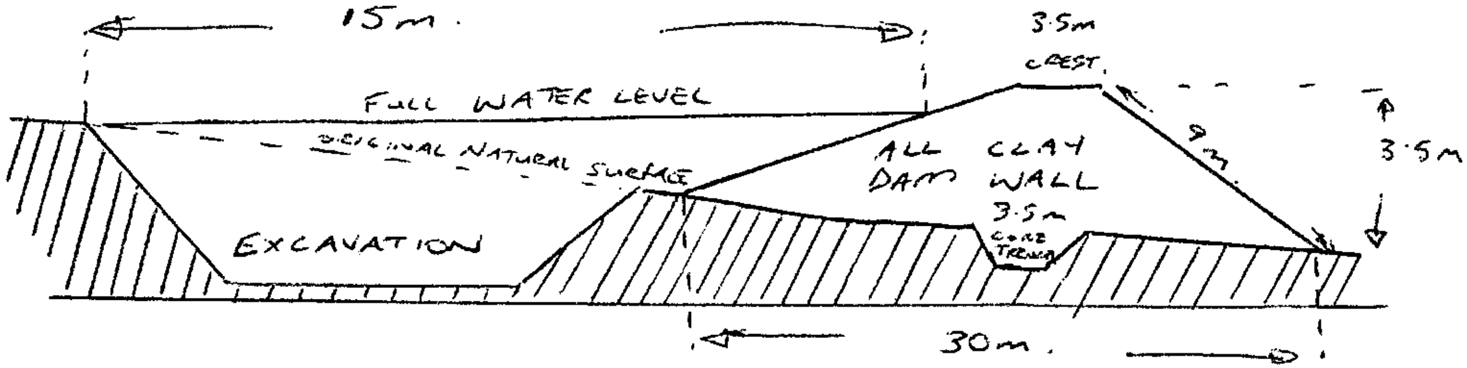
Further Information

- Widely varying circumstances apply on different properties and thus the information contained in this note should be used for general guidance only. It is advisable to seek expert assistance with detailed planning when a decision to construct is made.

- Your local water authority (ie either Southern Rural Water, Goulburn-Murray Water, Murray Sunrasia Water or Wimmera Mallee Water) is able to supply additional information.
- Southern Rural Water produce a set of Farm Dam Notes.
- The following 1993 publication is available from the NRE Information Centre
  Your dam: an asset or a liability.

NOT TO SCALE.

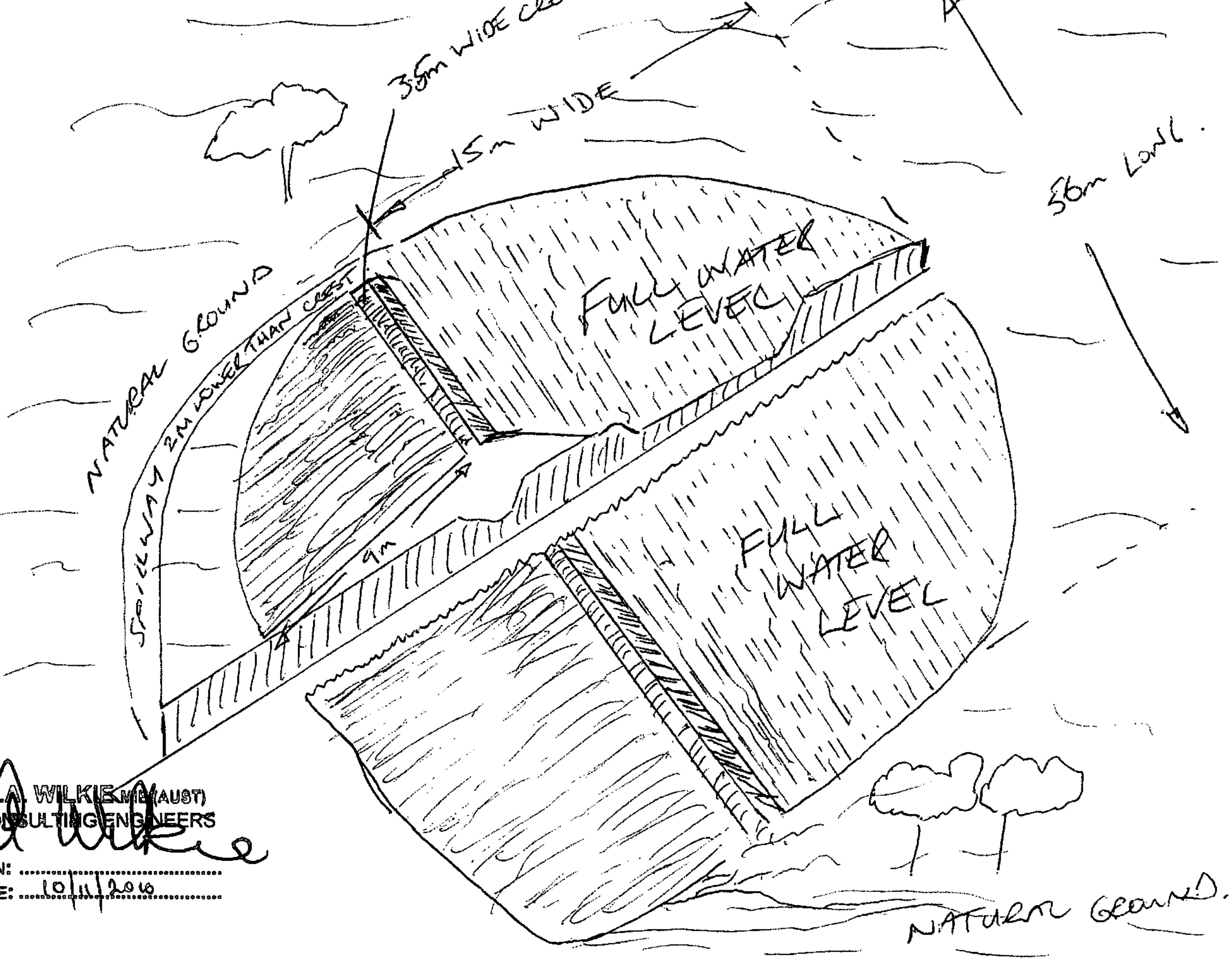
177 MEDULLA RD. JARRAHDALE.



A.A. WILKIE MIE (AUST)
CONSULTING ENGINEERS
SIGN:
DATE: 10/11/2010

SD050.2/11/10

NOT TO SCALE.



A.A. WILKIE MIE (AUST)
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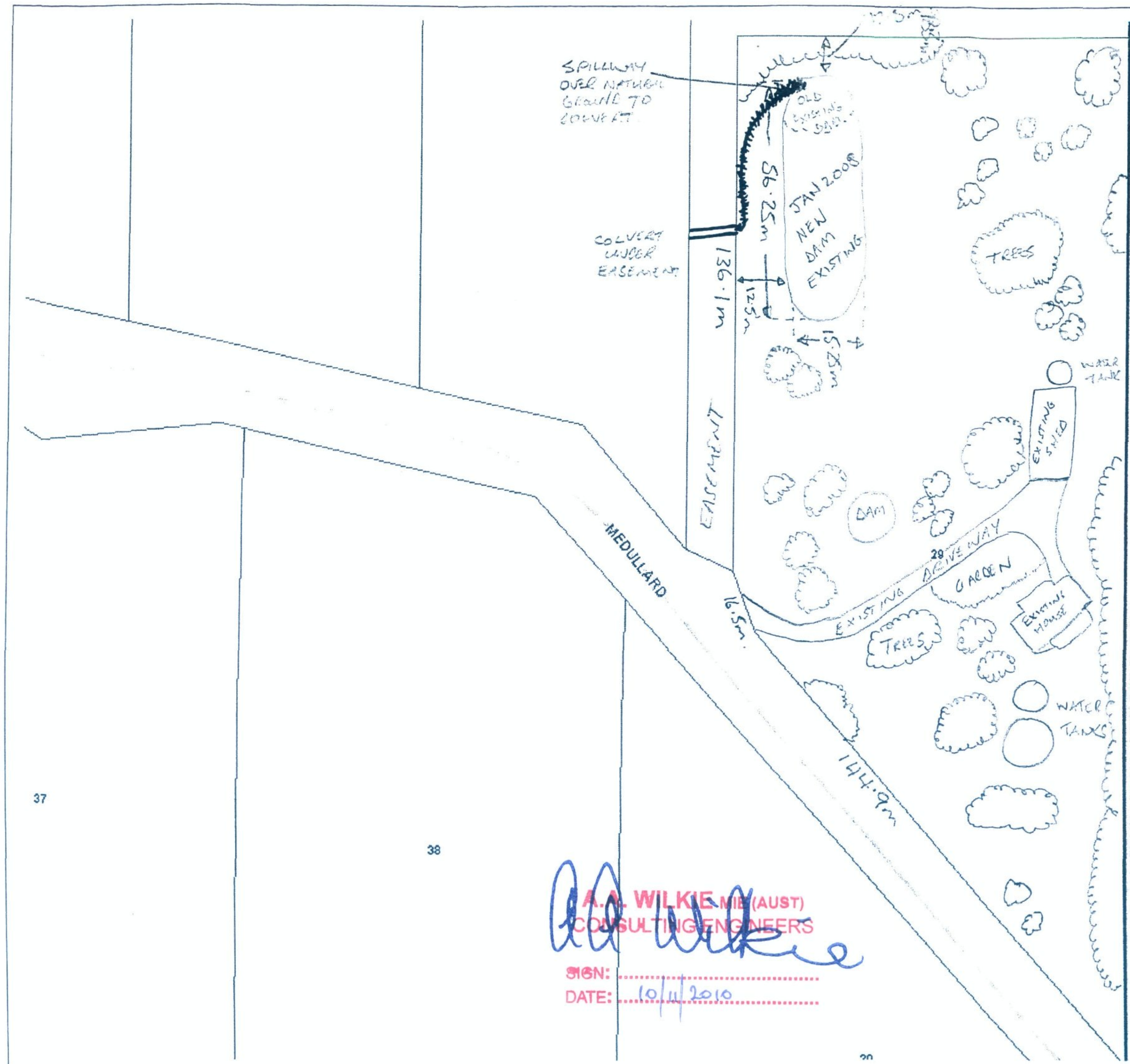

DAM WAS CONSTRUCTED IN JAN 2008.
DAM IS FILLED BY NATURAL RUN OFF.
DAM HAS A SPILLWAY CUT DOWN 2M AND SPILLS OVER NATURAL GROUND AROUND THE BACK OF DAM INTO THE EXISTING CULVERT ACROSS EASEMENT.
DAM WALL WAS RE-DRESSED & LEVELLED IN JAN 2009 DUE TO DAM SETTLING.
DAM WAS CONSTRUCTED WITH NATURAL CLAY FROM THE PROPERTY AND DOES NOT LEAK.

WAYNE STEWART
0413565169
7/1/10.

DAM IS SEASONAL.
DAM IS 15.25m WIDE
56.25m LONG
4 m DEEP.

DAM WALL IS CONSTRUCTED WITH CLAY THROUGH OUT.
THE PURPOSE OF THE DAM IS FOR FIRE FIGHTING AND RETICULATION.

0 50 100
meters

LOT 29
177 MEDULLA RD
JARRADALE.

6 January 2010

1:1250

N