Water conservation on rural properties

David Cummings, Melbourne

December, 1999
LC0065
ISSN 1329-833X

A primary need of any rural property is to collect, store and distribute water. Meeting this need is an integral part of property development and will influence the sustainablity of all land use activity.

Water is required for:

- Stock needs;
- Domestic supplies;
- Garden supplies;
- Fire fighting reserves; and,
- Environmental benefits.

Properly developed water conservation systems can strongly contribute to good land management.

Benefits include:

- protection of rivers and streams;
- employment of more controlled grazing techniques;
- better animal health;
- less damage to soil and vegetation by trafficking stock;
- increasing environmental biodiversity; and,
- aesthetic improvement.

Property water conservation is based on water collection, storage and distribution systems. Nelson (1985) give useful information on both design and construction. This article outlines the steps needed to develop useful water conservation systems and presents them in a check list format.

Types of storages

Gully dam

This is an earthen embankment built across the valley of a drainage line. The embankment intercepts and retains water travelling down the drainage line. The dam generally incorporates an earthen spillway at one or either sides of the embankment to pass surplus water.

The earthen spillway is sometimes supplemented by a small piped spillway (trickle pipe) to give protection from long term base flows.

Water is distributed through direct stock access, outlet pipes through the embankment, siphons or pumping.

Hillside dam

This is an earthen dam located on a hillside or slope and not in a depression or watercourse. It is either 3 sided or curved to effectively retain the water. It directly collects water from sheet flow, although diversion banks are frequently used to increase the collection area.

Ring tanks

These utilize a continuous circular or square embankment built of material won from within the storage.

Pumping is required to both fill and remove water from this storage.

Turkeys nest

Similar to a ring tank but embankment is obtained from outside the storage. This means that while it can only be filled by pumping, it can supply water via gravity.

Excavated tank

Storages confined below natural surface and restricted to flat sites.

Weirs

Not used to store water but to raise stream water level to allow either

- diversion to an off stream storage; or,
- to create a sump to pump from.

Water quantity requirements

Stock Water

Annual stock water requirements	
Type of Stock	Annual KL/head
Ewes on dry feed	3.6
Mature sheep - dry feed	2.7
Mature sheep - irrigated	1.35
Fattening lambs - dry feed	0.9
Fattening lambs - irrigated	0.45
Dairy cows in milk	22.5
Dairy cows dry	17
Beef cattle	17
Calves	8.2
Horses - working	20
Horses - grazing	13.5
Pigs - brood sows	8.2

Department of Natural Resources and Environment

Annual stock water requirements (continued)	
Type of Stock	Annual KL/head
Pigs - mature	4.1
Poultry - laying hens	12 per 100 birds
Poultry - pullets	6.3 per 100 birds
Poultry - turkeys	20 per 100 birds

(See Landcare Note LC0066: *How much water do I need*?)

Fire fighting

Buildings 1200 litres/10 m^2
Grass 725 litres/10 m^2

Domestic

Domestic Water Consumption (litres/day)						
No of people	1	2	3	4	5	6
With septic	180	270	320	340	360	380
Without septic	140	200	250	270	300	320

Wash down

Piggeries & Dairies 50 000 litres/10 m^2

Sheep dips

Spray 4500 litres/1000 sheep
Plunge 6750 litres/1000 sheep

Insecticide spraying

Citrus 80 litres/tree
Other 70 - 150 litres/tree

Garden

The water required for domestic gardens varies widely with the climate and type of garden.

Water use is generally in the range of 1 - 5 ML/ha.

- 1 ML/ha for a native garden (no lawn).
- 3 ML/ha would be for an average garden (lawn and plants).
- 5ML/ha would be for a garden in the northern part of the State with lawn, exotic plants and/or vegetables.

Water quality requirements

The three aspects for consideration are:

Physical composition

That is suspended solids resulting from erosion in the catchment, or perhaps dispersion from the dam construction materials. Water of high turbidity will be undesirable for domestic use and some irrigation uses (see Landcare Note LC0067: *Dealing with turbid waters*)

Chemical composition

Electrolyte levels in water will influence:

- saltiness
- hardness
- acidity/alkalinity

Suggested upper limits of total saline content for stock water supplies		
Livestock	Desirable maximum Ppm	Upper limit for drought ppm
Sheep on green feed	5000	15000
Sheep on dry feed	4000	12000
Grazing cattle	4000	10000
Dairy cattle	3000	6000
Working horses	4000	7000
Pigs	2000	4000
Poultry	2000	4000

Note: these limits apply for sodium chloride.

Biological composition

The presence of organisms in water can affect aesthetics, taste, odour and healthiness.

Site selection

Earthern dams filled by runoff water are an important part of Australian farming operations. There is a level of risk associated with earthen storages and hence it is best to be well prepared. Many have been unsuccessful in operation because of things like:

- Inadequate quantity of runoff water available;
- Inadequate dam capacity;
- Excessive peak flows through or across the dam;
- Poor water quality in dam;
- Sediment accumulating in dam;
- Excessive seepage from dam;
- Bank failure;
- Excessive construction cost per unit of water stored.

It is well worth considering the following issues in some detail before finalizing site selection. Further information can be found in Landcare Notes:

LC0084: *Finding a dam site*
LC0091: *A gully dam or a hillside dam.*

Size of the storage required

Appropriate size is determined by the following factors:

- Storage time required ('drought-proofing'). The following is usually used as a guide

Annual Rainfall	Storage Period
> 800mm	12 months
500-800mm	18 Months
< 500mm	24 - 30 Months

- Water needed for the storage period for:
    - livestock
    - domestic
    - irrigation
    - other

- Evaporation.

  The rule-of-thumb method for calculating is:

  V_L = A/1000 x E

  where

  V_L =Annual water loss in mL

  A = Surface Area (in m²) at 0.6 of water depth

  E = Evap.(m) for Oct - Mar.

- Seepage likely.

- Minimum draw-down allowable. Guidelines have been put together for **minimum** depths of water dealing with the last 3 factors as a block and assuming "normal" seepage and evaporation losses and a minimum draw-down volume.

Guidelines for minimum storage depth	
Annual rainfall in mm	**depth***
> 1250	2.5
1000 - 1250	3.0
800 - 1000	3.5
550 - 800	4.0
300 - 500	4.5
< 300	5.0

*Minimum water depth (m) over 25% of the surface area.

Runoff available to the site

This is known as catchment yield. It is the volume of water that can be expected to run from the catchment area above the dam site. It depends on:

- Annual average rainfall;
- Catchment area;
- Soil type;
- Plant cover;
- Hard-surfaced areas; and,
- Slope.

Prediction is somewhat imprecise but a useful rule of thumb method is:

Runoff is calculated from the formula:

$$\text{Runoff (megalitres)} = \frac{\mathbf{A \times R \times Y}}{\mathbf{10\,000}}$$

A = Catchment area in Hectares
R = average rainfall in mm
Y = yield % from the table

Y can be estimated as follows:

Runoff (80% Reliability) from small catchments as a % of rainfall				
Average Annual Rainfall (mm)	Shallow sand and loam soils %	Sandy clays %	Well structured clays %	Clay pans, inelastic clays, shales %
> 1100	10-15	10-15	15 - 20	15 - 25
900-1100	10-12.5	10-15	12.5-20	15 - 20
500- 900	7.5-10	7.5-15	7.5 - 15	10 - 15
400- 500	2.5-5	5 - 10	2.5 - 5	7.5-12.5
250- 400	0-2.5	0 - 5	0 - 2.5	2.5 - 7.5

NB1: For 90% reliability, use about two thirds of the above %'s

NB2: Yields can be halved if a catchment is sown to improved permanent pasture or is timbered.

It is essential that a site can collect enough runoff water to reliably fill the required dam. Make sure the catchment is big enough and also remember that improved pastures can significantly reduce surface runoff.

Large catchments will however produce large peak flows and regular seasonal base-flows. Design and construction must take this into account.

If you chose a site on a "water course" remember that a permit is needed from the appropriate water authority

Likely flood flows

By-wash design and bank freeboard allowance are dependant on the likely size of flood flows arising from the catchment. Under-estimation or under-design will cause major damage to your dam.

The method to calculate peak flows is the same as that used by shire engineers to calculate the size of culverts needed for roads (It is given in the publication *Australian Rainfall and Runoff, 1987*)

Some catchments also produce small base flows (trickle flows) during the winter months and if a dam site is chosen where this occurs a "trickle pipe" will be a worthwhile investment to stop these low flows constantly running over the grassed by-wash (See Landcare Note LC0090: *Trickle pipes for farm dams)*

Land shape at the site

Storage to excavation ratio

Aim to get as high a ratio as possible which is determined by topography of the chosen site. Key factors are:

- Longitudinal slope of drainage line (aim for <5%)
- Occurrence of broad drainage line sections (eg confluences)
- Occurrence of constriction of sides of drainage line sides immediately below a wide section. Wall can be constructed between constricted sides.

Depth of storage

More important than area of storage.

Exposure to wind

Increases losses by evaporation

By-wash provision

Natural spurs and sundry depressions can greatly assist the provision of a safe disposal point for the by wash.

Property Boundary

The law requires water to be returned to the drainage line before crossing your boundary so ensure that site topography allows this to happen.

Material suitability

An adequate quantity of material of suitable quality is needed to build "water-tight" dam.

Assessment of this means looking at materials available at the site. Back-hoes or excavators can assist greatly. Augers are OK, but are slow and only give a limited view of the materials. It is necessary to look at both the material below the bank line, and material within the borrow pit; going just a bit beyond the proposed excavation depth.

The soil materials need to be adequate to build a stable and watertight bank, but also need to be capable of control seepage from the excavation area.

The following points need to be checked (see Landcare Note LC0069: *Soil materials for farm dam construction*):

- Is the material suitable for building watertight bank in terms of:
  - particle size distribution?
  - clay behaviour?
  - linear shrinkage?
- Is there an adequate quantity of suitable material? Bank batters should be determined from the type of material available, which will influence the amount of material needed.
- Are sand or gravel layers present?
- What is the depth of permeable topsoil?

There is always a risk of materials failure (excessive seepage or tunnelling) associated with dam construction but the more thorough the assessment, and the more care taken with the construction, the lower the risk.

Water quality to site

Check for salted ground in the catchment area, along the drainage line and around the site.

Other forms of contamination include sediment from an eroding catchment, or road, sheepyards, stock-camps etc.

Convenience of site

Consider:

- stock access to keep trafficking to a minimum,
- where the water is needed,
- reticulation (especially in terms of elevation) and
- relationship with subdivision.

Design

Once the dam site is chosen a survey should be made so that the dam, spillway and other features can be planned. The survey for embankment-type dams normally will consist of the centreline of the dam, a profile of the centre line of the earth spillway, and sufficient detail to estimate dam size and water capacity.

The profile along the centreline should extend up both sides of the valley above the expected elevation of the crest of the dam and beyond the probable location of the earth spillway. The results establish critical elevations for the structure, including the full supply level, crest of the emergency spillway and crest of the embankment.

The correct amount of freeboard will vary with:

- the size of the dam,
- expected peak flows, and
- likely wave action.

Minimum freeboard is about 1 metre.

Construction

Construction will usally be by bulldozer or self propelled scraper. Ideally they will be used in conjunction with a sheepsfoot roller on critical jobs. A scraper will generally give better compaction but a bulldozer allows greater manoeuvrability.

Where earth has to be moved more than 30 metres, a scraper has greater utility. For distances of less than 30 metres, a bulldozer is satisfactory, but supplementary compaction should be considered.

Further information can be obtained from Landcare Note LC0085: *How to avoid dam construction failures.*

Key points are:

- Strip topsoil to at least 150 mm and stockpile
- Keep excavation inside full supply level
- Ensure a core trench is used underneath the embankment
- Construct when soil is moist. It is a waste of time and effort to build dry. It is probably not possible to do so when the soil is wet.
- *Compaction.* (It cannot be overemphasised)
- Build the embankment in layers of no more that 100mm
- Get the spillway capacity and levels right and then densely vegetate as fast as possible.
- Respread topsoil over bank and sow with suitable grass species or perhaps low shrubs. Do not use trees.

Handy hints

- Watering points should be spaced so that stock do not have to travel more than 400m in rough broken country, nor more that 1500m in smooth relatively level areas.

- Gravity flow is considerably more economic and less time demanding than pumping.
- Do not locate a dam where any sudden release of water (ie failure) would result in death, injury, or damage to property or equipment.
- Watch out for powerlines. Power company permission is needed before construction is allowed beneath powerlines.
- Improving pasture in a catchment may reduce catchment yield
- All surveys made at the dam site should be tied to a stable bench mark.
- Watch out for buried pipelines and cables.
- Use experienced and reputable contractors.
- Don't make the dam wall or the sides of the excavation too steep (3:1 horizontal:vertical for batters in contact with water, 2:1 for others)
- Check for sand or gravel layers
- Trickle pipes are excellent for handling basal winter flows.
- Make adequate provisions for returning water back to its normal flow position.

References

Bourchier J (1998) *Liquid Assets: Water Management for Dryland Agriculture*. Kondinin Group

CNR (1988) *Farm Water Supply Manual*. Department of Conservation and Natural Resources.

Nelson K.D. (1985) *Design and Construction of Small Earth Dams*. Inkata Press Melbourne.

Further Information

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 1993 document *Your dam: an asset or a liability* is available from the DSE information centre

Contact consultants with local experience.

Many earth-moving contractors have a wide range of practical experience

Acknowledgements

This document based on the accumulated experience of many field officers over the past 20 years