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DAM SITE SELECTION IN THE NORTH-EASTERN WHEATBELT

By J. L. Frith, Adviser, Irrigation and Water Resources Branch

Western Australia's wheatbelt farm dams are dug three to eight metres deep and are generally sited in soils which either are inherently impermeable or can be made so during construction.

In the eastern and north-eastern wheatbelt, however, only a small proportion of the soils meets these criteria. Dam site selection in these areas therefore depends on a good knowledge of which soils are suitable and on our being able to locate them efficiently by using surface indications such as surface soil, natural vegetation or topographic features.

Site experience

Experience or the 'conventional wisdom' of dam building in the central and south-eastern wheatbelt shows that dams sunk in:
- plastic soils of sandy clay and sandy clay loam texture hold water;
- lighter textured soils such as sandplain tend to leak;
- soils with numerous large stones at the surface, which indicates shallow soil above rock, tend to leak; and
- dams sunk on a 'break' in the country—that is, a lateral change in surface soil—tend to leak regardless of the underlying soil texture.

The use of indicators for sites has generally given successful dams in the older settled districts and in the south-eastern wheatbelt, but they do not fit well with experience in the eastern and north-eastern wheatbelt.

Dam surveys

Surveys of farm water supplies near Beacon and Kalannie in 1976 and 1977 showed that three-quarters of the dams failed. About 30 per cent of the failures were due to leaking and the rest to lack of depth, inadequate catchment, or both. Nearly all these failures were on heavy textured red soils. These soils overlie the pallid zone, a deep zone of greyish-white material in which the fine fraction has been only partially weathered from the granite. Pallid zone material is usually permeable in these districts. Excavation to a depth which would minimise excessive evaporation loss could expose the suspect pallid zone.

Since the surveys it has been found that, at some considerable cost, dams sunk into the leaky pallid zone can be made to hold water by lining them with clay from the upper soil horizons. Some pallid zone dams which leaked...
Granite rock dams

Shallow soils varying from a veneer to two metres deep and, in small pockets, six metres deep are found close to and within the outcrops. Soil properties vary greatly over short distances. Dam sites are the deeper pockets of mainly tough sandy or gritty clay traversed by quartz veins and containing numerous granite boulders. These usually support only small, sometimes irregularly shaped dams. See Figure 1, dam site A.

Granite clay dams

Large areas of up to 100 hectares of deeper soil derived directly from granite often surround the outcrops. These soils are more uniform and less likely to contain quartz veins and granite boulders. They are typically yellowish to greenish-brown sandy clays extending more than six metres deep. Granite clay dams typically have hard setting batters which are stable in water. The sites are deep and can support large dams. See Figure 1, dam site B.

Heavy textured red soils—'red country'

Areas of heavy textured red soil alternate with areas of sandplain over most of the intermediate levels of the terrain—on top of lower level hills, mid slope and in all but the lowest valleys.

The main features include:
- an uppermost layer of red, red-brown or red and grey mottled sandy clay from one to five metres thick;
- an underlying white or off-white pallid zone extending between the red soil and bed-rock and ranging from a few metres to more than 20m thick.

The red and mottled clays are often suitable for building dams.

Although the clay content of the pallid zone is usually well above the lower limit judged as suitable for dam building, in the northern wheatbelt it is permeable and unsuitable for dams.
The Department has used the mottled clay to line pallid zone material in seven dams on red country. In four dams a bulldozer was effectively used to compact the moistened lining material. In two dams this procedure did not provide enough compaction and subsequent replacement of the lining and compaction with a vibrating sheepsfoot roller was necessary. In the remaining dam the lining was too thin to prevent seepage, at times exceeding 40 millimetres a day. This rate has decreased over a three-year period to 10 mm a day.

A site for a clay-lined dam on red country is shown in Figure 1 by dam D.

Sandplain
Sandplain is underlain by a pallid zone, but often this is deeper and sometimes not as permeable as with red country. There are three broad categories of sandplain:

- yellow sandplain;
- gravelly sandplain; and
- deep yellow sands.

Yellow sandplain
The soil surface is grey or yellowish-grey sand. Where native vegetation is present it is dominated by thin-leaved Acacias collectively known as wodgil.

Typically the soil profile consists of two metres of yellow loamy sand with loose gravel in the lower half. This overlies half a metre of very hard, coarsely laminated, dark brown and grey hardpan which forms a cap over an underlying softer, grey, light brown and orange mottled hardpan. The thickness of the hardpan under
the cap varies from one to seven metres. It is usually highly impermeable and where it is a thick enough layer close to the surface, it provides good dam sites.

Although the overlying loamy sands are permeable, they are covered and blended with the crushed hardpan during dam construction. Seepage through the above-ground batters has not been observed.

Certain characteristics of the hardpan denote its suitability as a dam building material. When drilled dry with a powered auger the hardpan crumbles to a fine grey or yellow powder with a characteristic soft fluffy feel similar to dry Portland cement. However when this powdered hardpan is moistened and moulded by hand it has a texture similar to loamy sand or sandy loam.

Within areas of yellow sandplain the surface indications of the presence of hardpan of a suitable type, thickness and proximity to the surface are:

- the presence of a particular wodgil known as sugar-brother (Acacia coolgardensis) and isolated York gums (Eucalyptus loxophloeba);
- a local subtle ‘greying’ of surface soil;
- usually a slight surface depression;
- sometimes a ‘break’ in the country such as a change from sandplain to red country.

In Figure 1 dam sites in yellow sandplain hardpan are shown by dam E in a slight surface depression and dam C on the transition from yellow sandplain to red country.

**Gravelly sandplain**

Gravelly sandplain has much dark brown ironstone gravel lying on an otherwise sandy surface. Where natural vegetation remains it is usually dominated by tamar (Casuarina spp.). The profile is a very gravelly loamy sand over a hardpan at a depth of three to four metres. The hardpan is extremely hard, brown or yellowish-brown and coarsely crystalline. Beneath it there is either a softer hardpan or a pallid zone.

This profile shows high seepage rates from test holes and is not suitable for building dams.

**Deep yellow sands**

Deep yellow sands consist of about three metres or more of yellow loamy sand with an increase in texture to weak sandy clay loam with depth. At three metres or more there is often a yellow hardpan of variable hardness and thickness.

Deep yellow sands seldom contain useful dam sites because the hardpan, if it is a suitable material, is usually too deep for all but the biggest dams.
Heavy textured soils in major valley floors

The broad floors of the major trunk valleys in the north-eastern wheatbelt have slopes of 1 per cent or less. The lowest parts are usually occupied by salt-pans or lakes a metre or two below the general level. Beyond the lakes there is a saline watertable often within four metres of the soil surface.

Soil types in the valleys are complex. Several contain clays suitable for dams but their use is sometimes limited by saline watertables or by restricted catchments.

Valley soils which should be avoided for dams or at least treated with caution include:

• powdery-surfaced red and brown soils originally carrying morrel (Eucalyptus longicornis);
• extensions of red country into valleys where the pallid zone is usually a saline aquifer;
• heavy ‘gilgai’ or ‘crabhole’ relief types. These soils usually have highly dispersive clay which is difficult to stabilise and can cause ‘piping’ and ‘slumping’ failures in dams.

Techniques of construction and selection criteria

In engineering practice, materials for dam building are judged on laboratory measurements which indicate the strength, stability and impermeability of the disturbed and recompacted material. Construction methods are specified to ensure that the tested material is placed in a sufficient thickness all over the dam and compacted to a minimum density which will give a required performance. The results of engineering methods—prior testing of material and measured control of construction—are predictable and successful. Unfortunately these methods are too expensive for small projects such as farm dams.

When selecting sites and constructing farm dams, the Department, some contractors and farmers apply what was earlier termed experience or the ‘conventional wisdom’ of site selection. These criteria pre-suppose the following construction procedures.

• The removal of overburden (permeable topsoil) beyond a critical proximity to the inside wall of the dam and its replacement with compacted clay from the excavation.
• The over-excavation and repacking with clay of any light textured seams or pockets of soil encountered during excavation.
• In some cases an initial excavation of the whole batter and successive over-layering so that dam batters are reconstituted with material which has been disturbed and re-compacted. In other cases the exposed cut face of undisturbed clay in the batters is acceptable.
• Compaction by the bulldozer of the above-ground wall to render it impermeable and to give it the mechanical strength to hold water above ground.

Mr Pavlinovich believes that certain construction procedures should be implicit in the selection of the three unconventional types of dam sites: granite rock, granite clay and sandplain hardpan dams.

• Permeable topsoil should be removed from under the inside of the above-ground wall. Topsoil of loamy sand or heavier textures is sometimes returned to the batters and blended with underlying materials which might be unsuitable alone to hold water. These would include any dark, reddish-brown, ochrey sandy clay loams or weak clays sometimes encountered above or within the hardpan. Good water-holding clay can sometimes be extended in quantity and coverage by blending with yellow sandy loam or with the crushed hardpan.

• The hardpan is ripped and worked over by the bulldozer more than is required simply to remove it. The object is to reduce it to a tilth fine enough to be formed into the batter.

• The batters are undercut as each floor of the excavation is ripped and pushed out. Ripped material is pushed across the floor by the bulldozer and pushed hard into the vertical, undercut face of the previous floor. The blade is then slowly raised to allow the bulldozer gradually to move up the batter. In this way a degree of lateral compaction is achieved which Mr Pavlinovich believes is important to seal pre-existing horizontal cleavages.