UR1979_50

1979/50. Report on pre-feasibility geological site investigation: Carlton River Project

A.T. Moon

Abstract

The proposed Carlton River Project involves a 15 m high dam on Carlton River about 30 km east of Hobart. Pre-feasibility geological studies have been carried out during 1979.

The project area is underlain by sandstone and shale of Triassic age and by dolerite of Jurassic age. The rocks have been subjected to faulting, uplift, weathering and erosion. Residual soils have developed on valley sides and alluvium covers valley floors.

Slightly or highly weathered dolerite crops out on the left bank of the dam site. The surface soil on the valley sides consists of clay and sandy clay. The valley floor contains 3 to 4 m of alluvium. Three main joint sets occur. The weathering profile below the surface is not known but it is indicated by interpretation of seismic refraction results.

The storage area is underlain by sandstone, dolerite and alluvium. The reservoir is expected to be watertight.

Possible rock-fill quarry sites within the storage area have been indicated but not mapped in detail. Core and filter material may be available locally.

The south-east of Tasmania has a low level of seismic activity and felt earthquakes are rare.

Although investigations have not revealed any major geological problem, a thorough subsurface investigation is required before the feasibility of the project can be confirmed from the geotechnical point of view. Recommendations for feasibility investigations are given in the final section of the report.

INTRODUCTION

The Carlton River Project involves the construction of a dam about 15 m high on Carlton River [EN580543] about 7 km upstream from its mouth. Carlton River flows into Frederick Henry Bay about 30 km east of Hobart. The dam will impound about 3500 *Ml* of water in a storage area extending about 4 km upstream. It is not known which type of dam is proposed for the site, but it is assumed that the choice will depend on foundation conditions and the availability of suitable construction materials.

In late 1978, Scott and Furphy Engineers Pty Ltd requested the Department of Mines to undertake geological investigations for the project. This report details the results of the investigations carried out during 1979 and recommends a programme of subsurface investigation considered necessary to assess project feasibility from the geotechnical viewpoint.

The investigation has involved geological mapping on scales of 1 to 5000 and 1 to 500 and seismic refraction traverses. The writer was assisted in the field by geologists D.J. Sloane and R.C. Donaldson. Information on regional geology was provided by A.B. Gulline.

REGIONAL SETTING AND GEOLOGY OF PROJECT AREA

Part of the project area is underlain by sandstone and shale of Triassic age (fig. 1). Sandstone, believed to have been deposited in freshwater, crops out in the upper part of the storage area (fig. 2). The massively bedded rock is a medium- to coarse-grained quartz sandstone. Thinly bedded shale occurs in a cutting overlooking the storage area about one kilometre north-east of the dam site (fig. 2). Hornfels fragments found on the surface in parts of the storage area probably represent shale that has been thermally metamorphosed.

The dam site and lower part of the storage area is underlain by dolerite, which intruded the Triassic rocks during the Jurassic period. The dolerite varies in grain size. The outcrops and rock fragments near the dam site consist of coarse-grained dolerite, while in other areas fine- to medium-grained dolerite occurs.

During the Tertiary period, sediment and basalt were deposited in basins between outcrops of older rocks. A cap of basalt occurs on the ridge about 200 m north-west of the dam site (fig. 2). Since the basalt eruptions, erosion and weathering have been the dominant geological processes in the area. Most of the rocks exposed on the surface are highly weathered. Residual soils have developed, high plasticity clay (CH)* overlying dolerite, and silty sandy soils (ML and SM) overlying the sandstone. Sandy silt (ML) topsoil, which may be windblown in origin, overlies the dolerite in places. Talus, consisting of rock fragments in soil, has developed at the base of the steeper slopes. Alluvium consisting of organic clay (OH) overlying sandy silt (ML) and clay (CH) has been deposited in valley floors.

The whole of south-eastern Tasmania is divided into blocks by north and north-westerly trending faults. Most of the faults initially developed during the Jurassic, but many were also active during the Tertiary. Many of the blocks are gently tilted towards the west. The Triassic sandstone in the project area appears to be near horizontal.

DAM SITE

Rock and soil types and their distribution

Rocks

Dolerite is the only rock type exposed in the dam site area (fig. 3). Several outcrops occur on the left bank but no outcrops were observed on the right bank. The distribution of the outcrops is shown in plan on Figure 3.

The rock exposed at the surface is slightly or highly weathered. The dolerite is coarse-grained, grey or grey-brown, and generally of very high to extremely high strength (see Appendix 1 for strength and weathering classifications).

Dolerite usually occurs in sills (flat sheet intrusions), with coarse-grained material in the centre and finer grained material close to the margins where cooling occurred more quickly. The fact that the dolerite

---

* Unified Soil Classification System, S.A.A. Site Investigation Code AS 1726-1975 Addendum 1, Appendices A-D (1978)

is coarse-grained at the dam site suggests that the material comes from the centre of a sill and implies that dolerite will occur for some depth below the site (possibly greater than 50 m).

Soils overlying the valley sides

Most of the valley sides are covered by soil and scattered rock fragments up to 500 mm in diameter. The surface soil generally consists of yellow-brown or red-brown clay or sandy clay (CH) of high plasticity with angular, slightly to highly weathered fragments of dolerite. The proportion of rock fragments increases with depth. The seismic refraction results (fig. 4, Appendix 2) indicate that soils (V = 200 - 350 m/s) occur to depths of up to two metres and that rock fragments with soil or loosened weathered rock (V = 900 - 2000 m/s) occur to depths of up to nine metres. Locally, angular dolerite fragments are more abundant on the surface (fig. 3).

Two ridges of fill occur at the dam site, one on each bank. The ridges are up to one metre high and consist of logs, soil and dolerite fragments.

Alluvium

Alluvium occurs in the valley floor. It consists of grey, sandy silt (ML) or grey-brown, high plasticity silty clay (MH) overlying mottled grey and yellow-brown, high plasticity fissured clay and sandy clay (CH). In most places the alluvium is overlain by a top soil of dark grey, high plasticity organic clay (OH). The seismic refraction results (fig. 4, Appendix 2) indicate that the alluvium (V = 600 - 700 m/s) occurs to a depth of 3 to 4 m and overlies weathered dolerite (V = 3000 - 3500 m/s).

Depressions up to one metre deep occur in the valley floor (fig. 4). These depressions are elongate parallel to the river. Most are remnants of old river channels but some may be caused by erosion. Some of these depressions are floored with dolerite boulders.

A section of valley floor at the base of the left bank is not covered by alluvium; there are outcrops of dolerite, many dolerite fragments and only thin soils. It may be an erosional feature and is described as such in Figure 3.

Defects in the rock mass

The only defects observed in the rock mass at or near the dam site are joints (see Table 5, Appendix 1). The rose diagram (fig. 3) shows the main joint directions for the steeply dipping joints, and the poles to all the joint planes measured at the dam site are plotted on a sterographic projection in Figure 6 (Appendix 1). Although five or six joint sets occur, most joints can be grouped together into three main sets and these are described in Table 1.

Table 1. MAIN DEFECTS AT DAM SITE

Set No.	*Attitude*	*Description*
1	Near horizontal (0 to 20°), strike varies but many joints dip gently east or north.	Joints, extent greater than 2 m, spacing not known, irregular, surfaces rough.

Set No.	Attitude	Description
2	Strike 075° to 110°, near vertical	Joints, extent greater than 2 m, spacing 0.3 to 1 m, usually irregular but sometimes planar, surfaces rough.
3	Strike 150° to 010°, near vertical	Joints, extent greater than 4 m, spacing generally 0.3 to 1 m irregular or planar, surfaces rough.

In outcrop, many joints are open or filled with soil.

The highest velocities obtained in the seismic refraction traverses were 4000 - 5000 m/s and this probably represents a compact rock mass consisting of fresh and slightly weathered rock with tightly closed joints. Velocities lower than this may be partly due to the more weathered condition of the rock and partly due to the presence of open or infilled joints in a slightly loosened rock mass. The interpreted material for the different seismic velocities is given in Table 6 (Appendix 2).

Depth and degree of weathering

The dolerite exposed in outcrop is slightly or highly weathered. The weathering profile below the surface is not known, but it is indicated by interpretation of the seismic refraction results. It is likely that fresh rock will be closer to the surface below the valley floor than under the valley sides.

STORAGE AREA

Assuming a 15 m high dam, the storage area extends for about 4 km up Carlton River (fig. 2). Geological mapping has shown that the storage area is underlain by dolerite, Triassic sandstone and shale (or hornfels) and by river alluvium.

There is potential for minor leakage of the reservoir through either bank of the river close to the dam site. The remainder of the reservoir is likely to be watertight.

Most of the margins of the storage area have been examined. Side slopes are generally less than 10° and seldom exceed 30°. There are unlikely to be any stability problems around the margin of the storage area. Three main soil types occur in the storage area. Residual red-brown and yellow-brown, high plasticity, clay soils (CH) overlie the dolerite. Silty sand and sandy silt (SM and ML) soils overlie the sandstone in the upper part of the storage area, and grey silty sand (ML) topsoil, possibly wind blown in origin, overlies the dolerite residual soils in places. It is not known whether the soils are dispersive.

CONSTRUCTION MATERIALS

Assuming a 15 m high dam in the position shown in Figure 3, with 1.5 to 1 slopes, the total volume of the dam will be about 40 000 m^3. It is not known what type of dam is preferred for the site, but it is assumed that it will be rock fill with either a clay core or an upstream impermeable face.

It is also assumed that, if possible, the construction material should come from within the storage area.

The most suitable material available locally is dolerite. It occurs close to the dam site and is of very high to extremely high strength, even when slightly weathered. The other main rock type in the area is sandstone of Triassic age. The nearest observed outcrops are about 3 km from the dam site and consist of low to medium strength, highly weathered rock which was slightly friable.

Two possible quarry sites have been indicated on Figure 2. Both occur upstream of the dam site on the right bank of Carlton River. Neither site has been examined in detail. Although no outcrops were observed, the abundant fragments at the surface indicate that dolerite is likely to occur at shallow depth.

Geological mapping of the dolerite in the storage area indicates that the main defects are similar in orientation to those at the dam site. The rose diagram (fig. 2) shows the main joint directions for the steeply dipping joints, while the poles to all the joint planes measured in the storage area are plotted on a stereographic projection in Figure 5 (Appendix 1). Joint spacing is generally 0.3 - 1 m but locally closer (100 - 300 mm).

The dolerite exposed in outcrop and the fragments at the surface are slightly or highly weathered. The weathering profile below the surface is not known.

If a clay core dam is preferred it would be necessary to prove reserves of about 10 000 m^3 (25% of the volume of the dam) of suitable core material. This high percentage allows for rejected material and wastage during working. No suitable reserves of core material were proven during the surface investigations. Residual soils developed over dolerite (high plasticity clay with rock fragments) may prove suitable, although in most cases they are probably too thin to be workable and could also be prone to contamination by the overlying sandy silt. Thicker deposits may occur locally and weathered talus deposits at the base of slopes may provide thicker accumulations of suitable material.

A core dam would also require filter material and two local sources may provide suitable material. Firstly the rockfill quarry may provide suitable material as a by-product of its main operation and secondly there is an existing gravel pit on Sugarloaf Road, about 2 km east of the dam site (fig. 1). This pit is owned by the Sorell Council and reserves are estimated to be about 400 000 m^3 (Threader, 1977). The material is extremely weathered dolerite. Grainsize analyses indicate it is a sandy gravel (GW) with less than 10% fines. No petrological examination of the material has been made and its long term susceptibility to chemical weathering and mechanical breakdown would have to be checked before use in the dam.

SEISMICITY

The south-east of Tasmania has a low level of seismic activity and felt earthquakes are rare. There have been no reports of damage to buildings in recorded history. The two most significant events close to the site recorded in the last 20 years were:

Date	*Magnitude*	*Location*	*Distance from site*
September 1975	1.5	Storm Bay	30 km south-west of site
20 October 1978	2.7	15 km south of Orford	20 km north-east of site

The second event was the largest of a swarm of at least 6 events. Some of these were felt, but there were no reports of any damage. The maximum acceleration at the site caused by these events is likely to have been less than 0.01g. Further information on seismic risk, if required, can be provided by R. Underwood of the Hydro-Electric Commission.

CONCLUSIONS

The pre-feasibility geological investigations have not revealed any major problem that could throw doubt on the feasibility of the project. However, the work to date has been based on surface investigations only and a thorough sub-surface investigation is required before the feasibility of the project from a geotechnical point of view can be confirmed. Recommendations for feasibility investigations are given below.

RECOMMENDATIONS FOR FEASIBILITY INVESTIGATIONS

The overall objective of the investigation would be to confirm the feasibility of the project from a geotechnical point of view and to gather sufficient information to allow preliminary design. Regular progress reports would be provided throughout the investigation and a formal report would be prepared on completion of the work.

For convenience, the objectives of each of the major aspects of the work are set out at the beginning of the section describing the proposed activities.

Regional setting and geology of the project area

Studies of the regional and project area geology are aimed at:

- providing an understanding of the geological history of the region;
- assessing whether any geological processes are still active to the extent that they could affect the project;
- locating the main geological features of significance to the dam and storage;
- checking that the area containing the dam site fits into the regional geological picture.

This work has already started and would continue during the feasibility studies. The work has included a review of published geological work in the region, interpretation of aerial photographs, and geological mapping on a scale of 1 to 5000 (produced at 1 to 5000 and 1 to 10 000).

Dam site

Studies in the dam site area should provide a model of the sub-surface geological conditions in sufficient detail to allow:

- adoption of the best dam and spillway design and location (geologically);
- confirmation of the suitability of the site;
- estimation of the requirements for excavation and foundation treatment for the type and size of dam proposed.

The following field activities are proposed to achieve the above objectives:

(a) geological mapping on a scale of 1 to 500 (produced at 1 to 500 and 1 to 1000). This has already been started;

(b) excavation of about 300 m of trenches. The positions shown on Figure 3 are for a dam with an upstream impermeable face. For a core dam, the layout of the trenches (and boreholes) would be modified. Trenches 1 and 3 should be excavated with a Caterpillar D7 and ripper and cleaned up by a backhoe and sluicing. These trenches can also serve as access tracks for the drill. Trench 2 should be excavated with a backhoe. Trenching should also be carried out at the site chosen for the spillway;

(c) geological logging of the trenches on scales of 1 to 100 and 1 to 500;

(d) drilling of 4 diamond cored boreholes totalling about 120 m in length. The positions of proposed holes suitable for investigation of a faced dam are shown on Figures 3 and 4. If a cored dam is preferred, boreholes 2, 3 and 4 should be relocated close to the central axis of the dam. The details of the proposed holes are given in Table 2. The positions are tentative and final siting would depend on the results of the previous activities;

(e) logging of the cores on a scale of 1 to 50 and the production of coloured photographs of the cores;

(f) testing of the rock mass permeability by water pressure (Lugeon) tests in the boreholes;

(g) seismic refraction traverses where appropriate.

Table 2. PROPOSED BOREHOLES AT DAM SITE

Borehole No.	*Bearing*	*Inclination*	*Length (m)*	*Approximate RL (m)*	
				Top	*Bottom*
1	325°	60°	35	20	- 10
2	315°	60°	27	8	- 15
3	210°	60°	27	8	- 15
4	130°	60°	31	17	- 10

Storage area

The storage area should be studied to confirm its water-tightness, to assess the nature of any soil erosion problems, and to check for any areas of potential slope instability.

The study will involve:

(a) stereoscopic examination of aerial photographs of the storage area (already started);

(b) geological mapping on a scale of 1 to 5000 (produced at 1 to 5000 and 1 to 10 000) and at more detailed scales where necessary (already started);

(c) dispersion tests on soils;

(d) seismic refraction traverses where appropriate.

Construction materials

Studies of construction materials should be aimed at:

- locating a rockfill quarry site within the storage area;
- assessing the quantity and quality of material;
- confirming its suitability as a construction material for the dam;

- confirming that the selected quarry will provide material cheaper than can be obtained from existing quarries.

If a cored dam is proposed it will also be necessary to:

- locate sufficient reserves of material suitable for use in the core;
- locate sufficient reserves of material suitable for use in filter zones;

The investigation of the rockfill would involve:

(a) geological mapping of selected sites on a scale of 1:500;

(b) excavation of about 200 m of trenches at the preferred rockfill site with a Caterpillar D7 and ripper. The trenches should be cleaned up with a backhoe;

(c) geological logging on scales of 1 to 100 and 1 to 500;

(d) drilling of one diamond drill hole to a depth of about 30 m. The position of the borehole would be selected after the trenching;

(e) logging of the core on a scale of 1 to 50 and the production of coloured photographs of the core;

(f) seismic refraction traverse where appropriate;

(g) testing of the material. Point load tests (induced tensile) and petrological examination could be carried out by the Department of Mines. Other testing can be carried out by the Hydro-Electric Commission. The HEC usually carry out modulus tests on their construction materials. This involves load/deformation tests on graded samples in a 200 mm high, 200 mm diameter cylinder. Such tests are useful for comparative purposes and the results can be correlated with the field performance of material in many dams in operation in Tasmania.

The investigation for the core material would involve mapping, backhoe trenching, logging, seismic refraction traverses and testing. The investigation of the filter material would mainly involve material testing.

Seismicity

If further information is required on the seismic risk at the site it is recommended that the advice be sought of R. Underwood of the HEC.

REFERENCE

THREADER, V.M. 1977. Reserves of dolerite gravel at Sugarloaf Road gravel pit, Carlton. *Unpubl.Rep.Dep.Mines Tasm.* 1977/42.

[23 November, 1979]

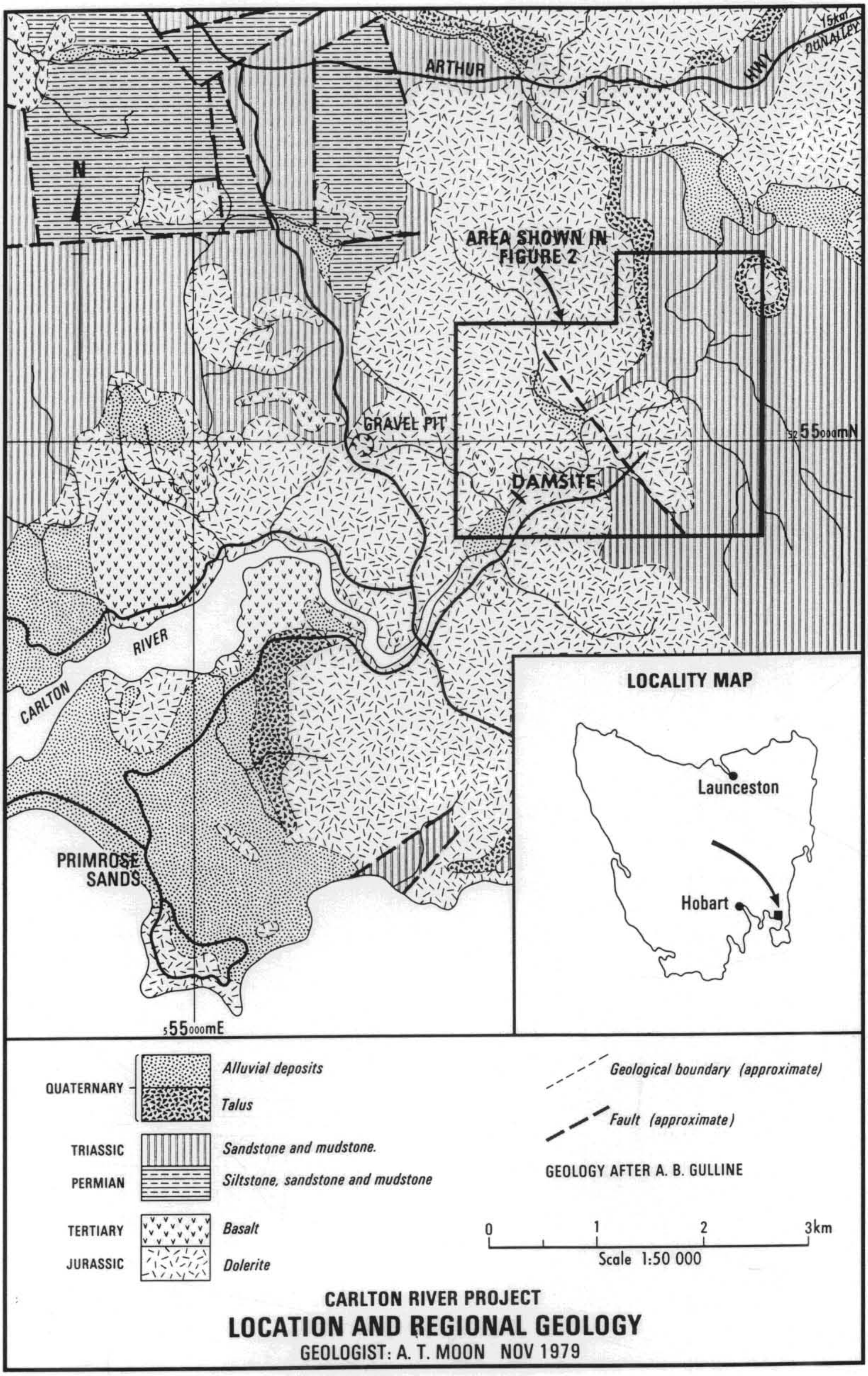

ARTHUR
HWY
15km DUNALLEY
N
AREA SHOWN IN FIGURE 2
GRAVEL PIT
52 55000mN
DAMSITE
CARLTON RIVER
PRIMROSE SANDS
555000mE
LOCALITY MAP
Launceston
Hobart
QUATERNARY
Alluvial deposits
Talus
TRIASSIC
Sandstone and mudstone.
PERMIAN
Siltstone, sandstone and mudstone
TERTIARY
Basalt
JURASSIC
Dolerite
Geological boundary (approximate)
Fault (approximate)
GEOLOGY AFTER A. B. GULLINE
0
1
2
3km
Scale 1:50 000
CARLTON RIVER PROJECT
LOCATION AND REGIONAL GEOLOGY
GEOLOGIST: A. T. MOON NOV 1979

Figure 1.

5 cm

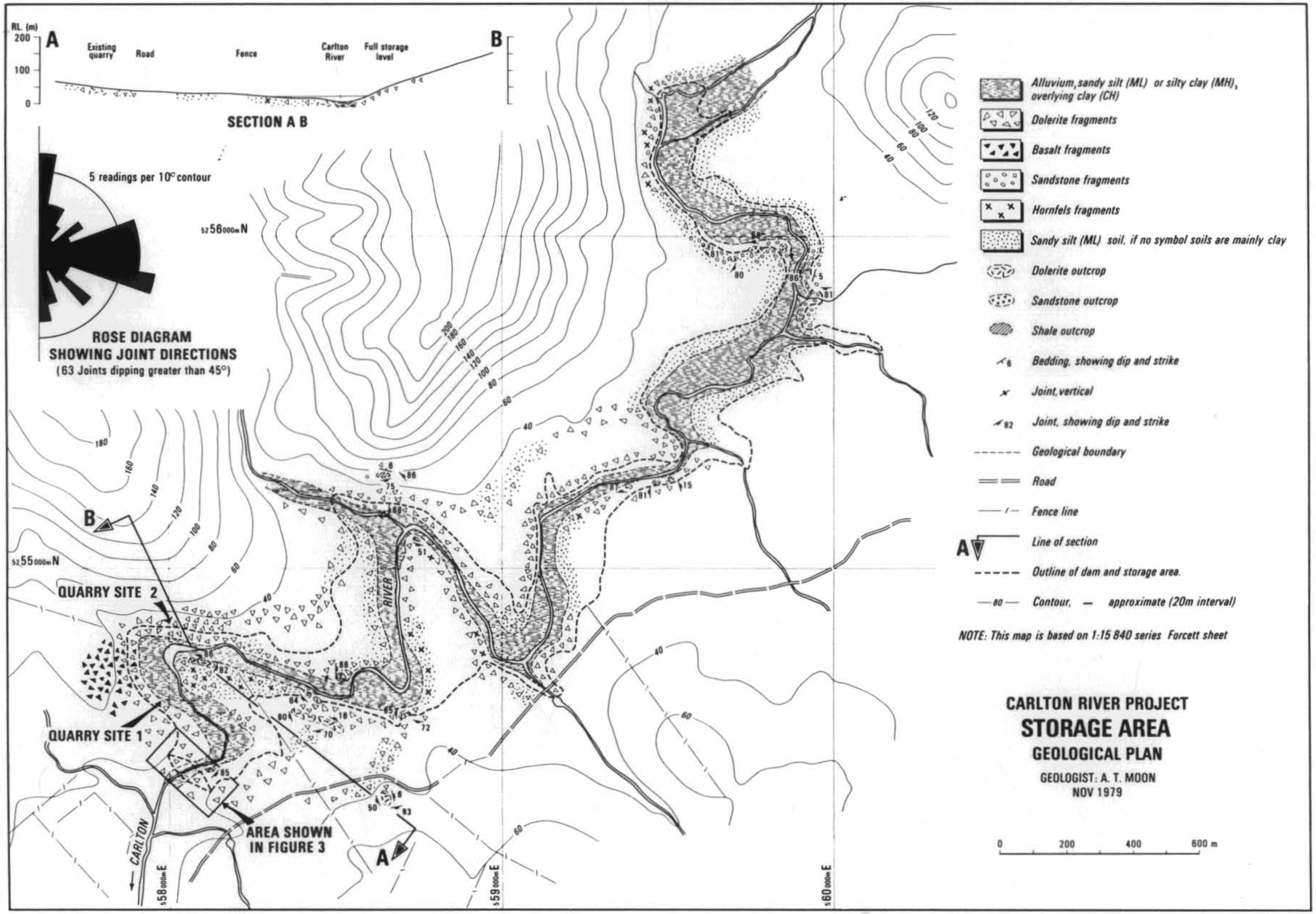
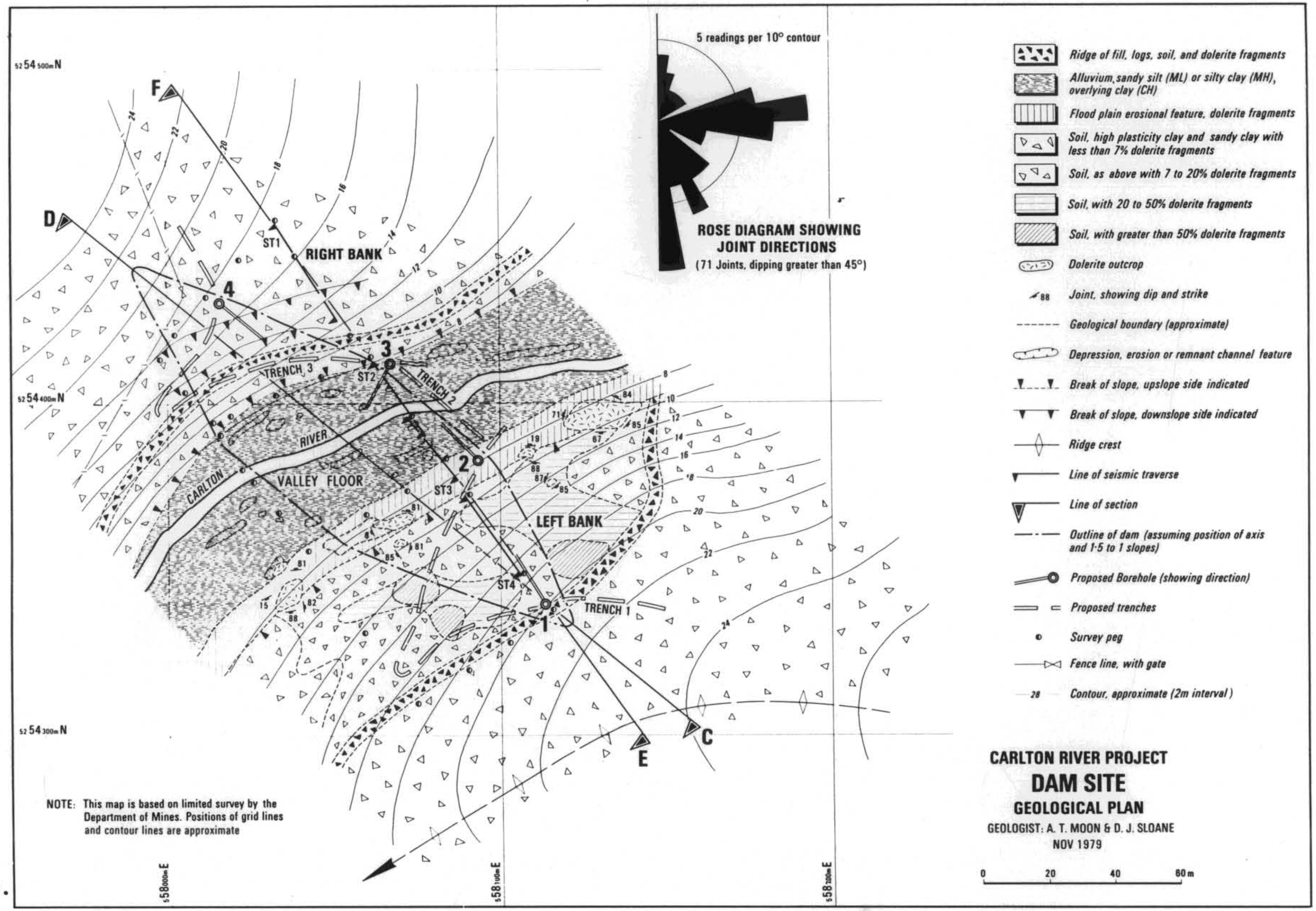


Figure 2.

50-10

5 cm

10/17



5 readings per 10° contour
ROSE DIAGRAM SHOWING JOINT DIRECTIONS
(71 Joints, dipping greater than 45°)
Ridge of fill, logs, soil, and dolerite fragments
Alluvium, sandy silt (ML) or silty clay (MH), overlying clay (CH)
Flood plain erosional feature, dolerite fragments
Soil, high plasticity clay and sandy clay with less than 7% dolerite fragments
Soil, as above with 7 to 20% dolerite fragments
Soil, with 20 to 50% dolerite fragments
Soil, with greater than 50% dolerite fragments
Dolerite outcrop
Joint, showing dip and strike
Geological boundary (approximate)
Depression, erosion or remnant channel feature
Break of slope, upslope side indicated
Break of slope, downslope side indicated
Ridge crest
Line of seismic traverse
Line of section
Outline of dam (assuming position of axis and 1·5 to 1 slopes)
Proposed Borehole (showing direction)
Proposed trenches
Survey peg
Fence line, with gate
Contour, approximate (2m interval)
RIGHT BANK
LEFT BANK
VALLEY FLOOR
CARLTON RIVER
TRENCH 1
TRENCH 2
TRENCH 3
ST1
ST2
ST3
ST4
5254500mN
5254400mN
5254300mN
558000mE
558100mE
558200mE
NOTE: This map is based on limited survey by the Department of Mines. Positions of grid lines and contour lines are approximate
CARLTON RIVER PROJECT
DAM SITE
GEOLOGICAL PLAN
GEOLOGIST: A. T. MOON & D. J. SLOANE
NOV 1979
0 20 40 80 m

Figure 3.

5 cm

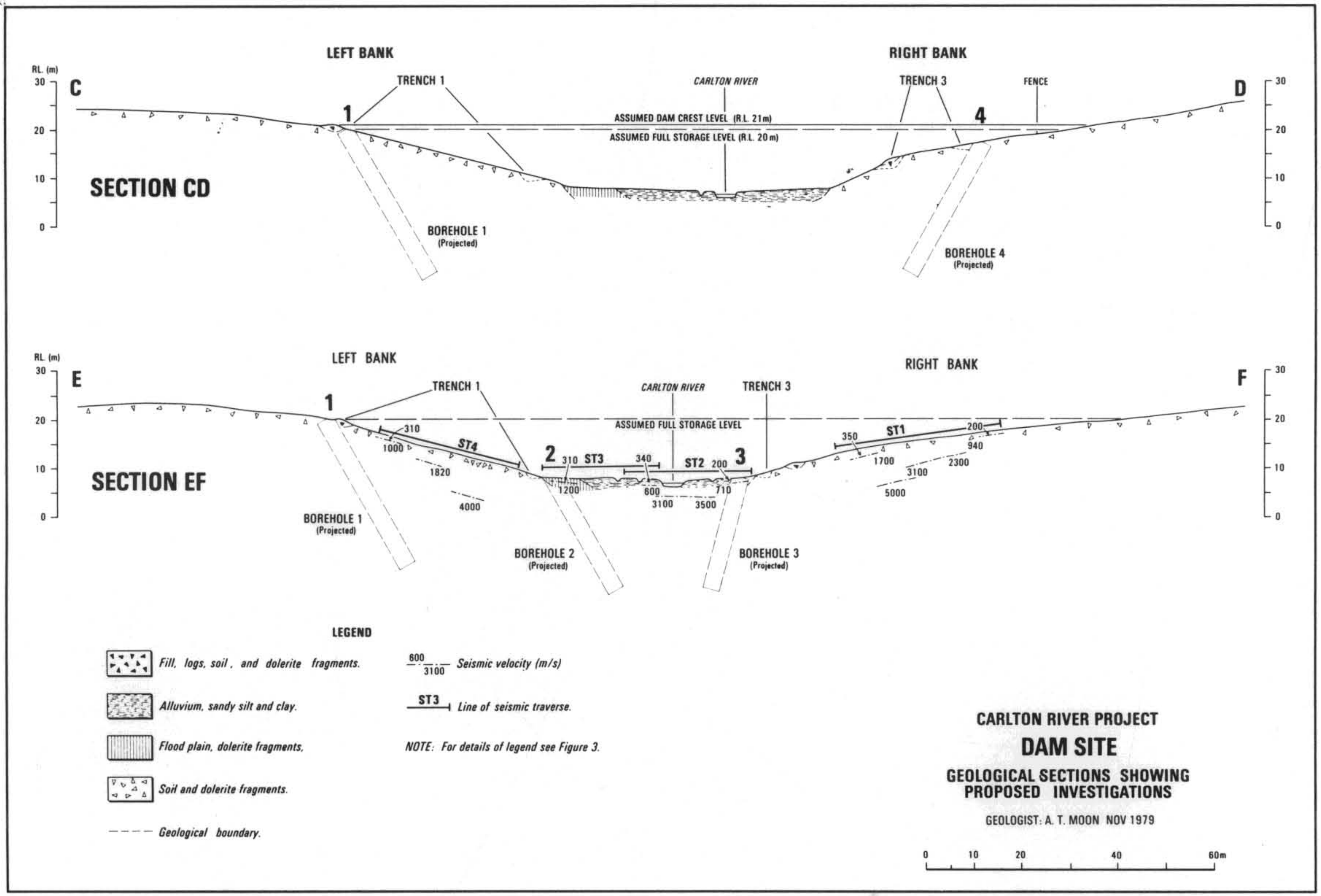


Figure 4.

12/17

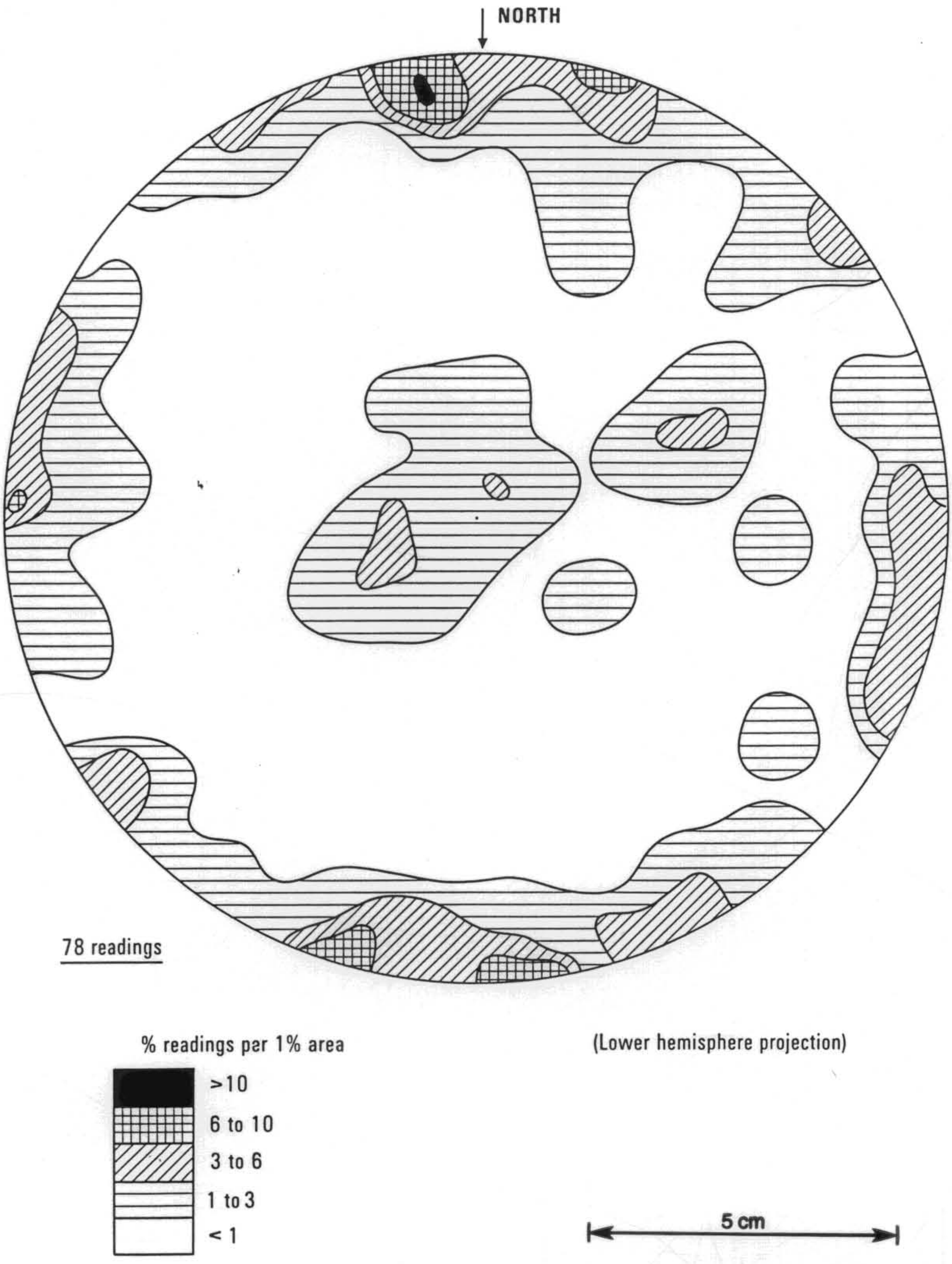


Figure 5. *Stereographic projection of poles to joint planes, Carlton River storage area*

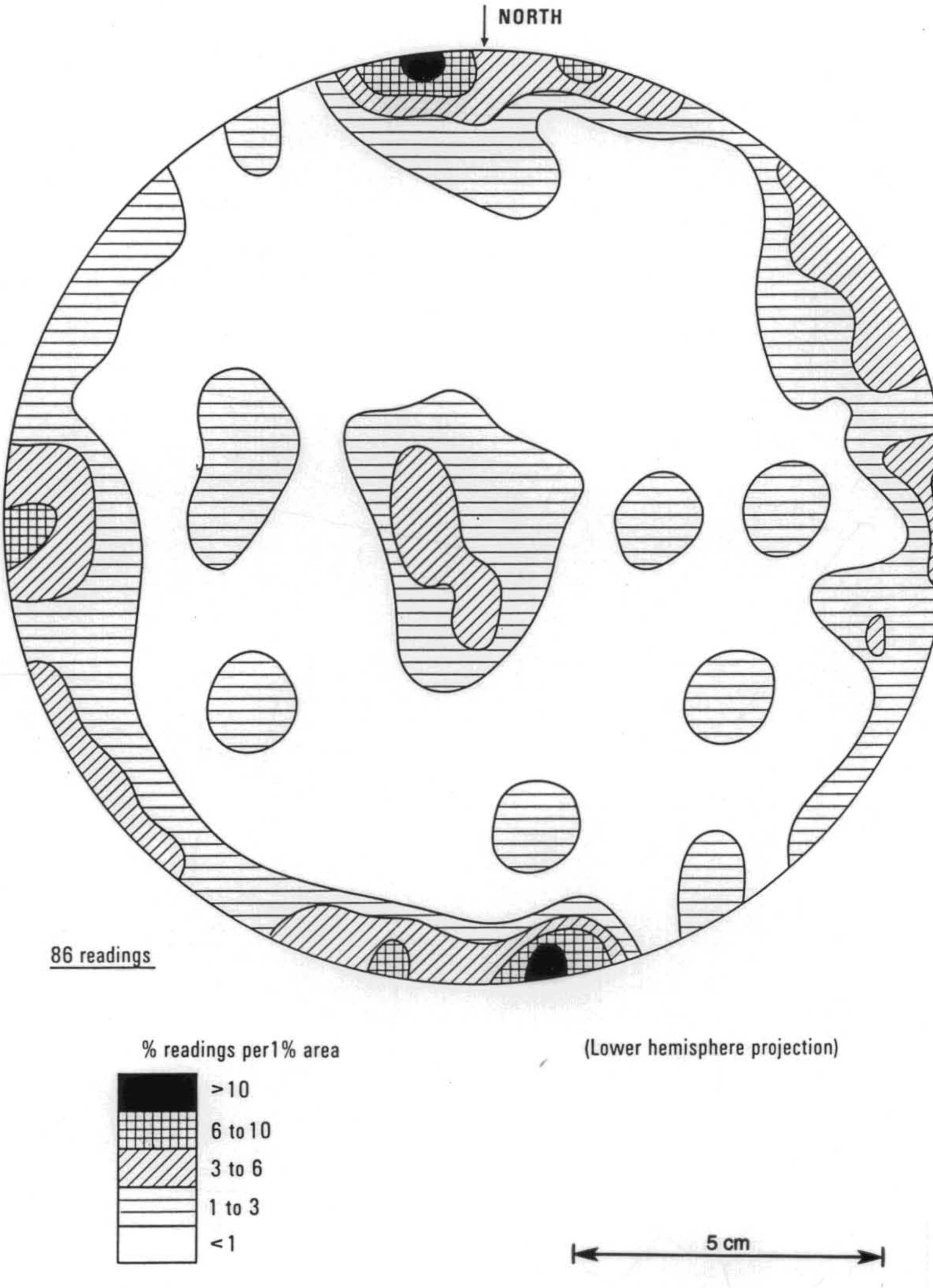


Figure 6. *Stereographic projection of poles to joint planes, Carlton River damsite*

APPENDIX 1

Rock mass classification and joint measurement

Table 3. WEATHERING PRODUCTS CLASSIFICATION

Term	*Abbreviation*	*Definition*
Fresh	Fr	Rock shows no sign of decomposition.
Slightly weathered	SW	Rock is slightly discoloured but generally shows little or no change of strength from fresh rock.
Highly weathered	HW	Rock strength changed by weathering. The rock may be highly discoloured, usually by iron staining. Porosity may be increased by leaching, or may be decreased due to deposition of weathering products in pores.
Extremely weathered	EW	Rock is weathered to such an extent that it has soil strength properties, *i.e.* it either disintegrates, or can be described according to the Unified Soils Classification system.

Table 4. ROCK STRENGTH CLASSIFICATION

Rock strength class	*Abbreviation*	*Point Load strength index, Is (50) (MPa)*	*Equivalent Unconfined strength, Qu (MPa)*
Extremely low	EL	< 0.03	< 0.7
Very low	VL	0.03 to 0.1	0.7 to 2.4
Low	L	0.1 to 0.3	2.4 to 7
Medium	M	0.3 to 1	7 to 24
High	H	1 to 3	24 to 70
Very high	VH	3 to 10	70 to 240
Extremely high	EH	> 10	> 240

Table 5. DEFINITIONS OF ROCK DEFECTS

Defect Name		*Description*
Bedding) Cleavage) (No cleavage at this site)		Layered or parallel arrangement of mineral grains microfractures, giving rise to planar anisotropy in the substance.
Joints		Almost planar surfaces or crack, across which the rock has little or no tensile strength. May be open or water or clay or soil filled. Joint surfaces may be rough, smooth or slickensided.
Sheared zone	These are faults in the geo-logical sense	Zones of rock substance, with roughly parallel almost planar boundaries, cut by closely spaced joints and/or cleavage planes. The joints are usually smooth or slickensided and curved, inter-secting to divide the mass into lenticular or wedge-shaped blocks.
Crushed seam		Seam with roughly parallel, almost planar bound-aries, composed of disoriented, usually angular fragments of host rock substance. The fragments may be of clay, silt, sand, or gravel sizes, or mixtures of these. Soil properties.
Infill seam		Seam of soil substance, usually with very distinct roughly parallel boundaries. Formed by migration of soil into open cavity or joint.
Extremely weathered seam		Seam of soil substance, usually with gradational boundaries. Formed by weathering of the rock substance in place.

If the geological origin of the seam is not apparent the term Clay Seam etc. has been used.

APPENDIX 2

Seismic refraction traverses

Seismic refraction traverses ST1, ST2, ST3, and ST4 were carried out with a Bison hammer seismograph. The positions of the traverses are shown on Figure 3. Depth interpretations were carried out by the critical distance method and the interpretations are plotted in profile on section EF on Figure 4. The seismic velocities and interpreted materials are given in Table 6.

Table 6. SEISMIC VELOCITY AND INTERPRETED MATERIAL

Velocity (m/s)	*Interpreted material*
200 to 350	Topsoil
600 to 700	Alluvium
900 to 2000	Dolerite fragments with soil or loosened rock mass of weathered dolerite.
2000 to 3500	Dolerite rock mass, weathered or slightly loosened or both.
3500 to 5000	Dolerite rock mass, compact, fresh or slightly weathered.