43/100

Hydrology

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DEPARTMENT OF MINES
SOUTH AUSTRALIA

GEOLOGICAL INVESTIGATIONS

OF A DAM SITE

on

SMITH CREEK, HUNDRED OF MENZIES
KANGAROO ISLAND.

Hyd. 273.

by

W. JOHNSON, B.Sc. (Hons.)., and C. BLEYS, B.Sc.
HYDROLOGY SECTION

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December, 1956.

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Table of Contents. Page.

LIST OF PLATES, TEXT FIGURES AND TABLES TO ACCOMPANY REPORT.

P L A T E S

T E X T F I G U R E S.

T A B L E S.

- - - - - o O o - - - - -

GEOLOGICAL INVESTIGATIONS OF A DAM SITE ON SMITH CREEK, KANGAROO ISLAND.

W. JOHNSON, GEOLOGIST AND C. BLEYS, GEOLOGIST

ABSTRACT.

Detailed examination of the proposed dam site on Smith Creek has shown it to be suitable for either a concrete or earthern dam of the height proposed. The rocks in the main foundation area and both abutments are hard tough siltstones and sandstones. They have been affected by weathering to only a shallow depth, necessitating some excavation for the foundations. No faults were observed but the rocks are cut by numerous joints which require treatment by grouting, chiefly in the main foundation area, to minimise leakage. A suitable site for a side spillway is available or the excess flow could be spilled over the top of a concrete dam if such is built. Some of the materials of construction are available close to the site.

INTRODUCTION.

HISTORY.

The existing water supply for the town of Kingscote, Kangaroo Island, consists of water pumped from the Cygnet River to 4 x 1 million gallon elevated storage reservoirs. As the Cygnet goes saline after a prolonged dry spell pumping is confined, when possible, to the winter months. However, consumption has already reached 8 million gallons a year and on a number of occasions water has had to be pumped in summer time when the salinity of the water reached 300 grains per gallon or more.

The necessity for augmentation of the water supply to Kingscote has long been recognised by the Engineering & Water Supply Department and a number of schemes have been investigated. That finally recommended for detailed investigation consists of the building of a storage dam on Smith Creek and the laying of a pipe line to Kingscote.

Following this recommendation the Department of Mines was requested in August, 1955, to make a geological examination of the proposed site to report on its suitability for a concrete or earthern dam and also to examine and report on the general suitability of the catchment area.

LOCATION:

Smith Creek flows into the waters of Investigator Strait at the western side of Smith Bay and approximately 12 miles W.N.W. from Kingscote in a direct line. The road from Kingscote to Stokes Bay crosses the creek on a bridge about 1 mile upstream from its mouth and distance about 17 miles from Kingscote. The proposed dam site is immediately downstream from the bridge on the south-western corner of Section 325, Hundred of Menzies.

The Smith Creek catchment area comprises approximately 12 square miles on the western side of the Hundred of Menzies and extending into the Hundred of Cassini.

FIELD WORK & RESPONSIBILITY:

Geological mapping in the vicinity of the site and in the catchment area was done by C. Bleys during a number of visits to the area in the months August to November, 1955. The regional map, Fig. 1, was prepared using aerial photographs as a base. Some detailed mapping with plane table and telescopic alidade was done at the dam site and some levels were taken with the plane table on the thick massive quartzite about ½ mile downstream of the bridge. These levels were to enable an estimate of quantities available for construction purposes.

Inspections of the dam site and catchment area were made by E.P. O'Driscoll and C. Bleys in October, 1955, and by W. Johnson and C. Bleys in November, 1955. The leakage tests were supervised in the field by W. Johnson in August, 1955. This report has been written by W. Johnson who accepts responsibility for the opinions expressed and recommendations made. It was completed following the completion of the percussion drilling programme in early December, 1956.

GEOMORPHOLOGY

That part of Kangaroo Island in which Smith Creek is situated consists principally of a plateau elevated to a maximum height of 984 feet above sea level two miles to the west of the western boundary of the catchment area. Within the catchment area the plateau surface slopes gently to the north and east, terminating in cliffs at the sea coast and extending many miles to the east of the eastern boundary of the catchment area.

In the central portion of the plateau the creeks flow in low broad valleys radially away from Mount MacDonnell, as the highest point is known. These which flow to the northern coast enter narrow and comparatively deep and rugged gorges in their lower portions. Entrenched meanders are common and the bed gradient is rather steep, indicating fairly recent uplift of the plateau. It is believed that the larger creeks are antecedent.

Smith Creek drainage system consists of three principal tributaries which unite above the road bridge to form one stream. The Western Branch flows mainly east to join the Central Branch about 20 chains upstream from the bridge. The Central Branch, or Smith Creek proper, flows generally north-east and is the longest of the three branches. The Eastern Branch flows east in its upper reaches and then turns and flows due north for 2 miles before turning west to join the Central Branch immediately upstream of the bridge. The bed gradient of the three branches is variable and steep in the lower portions. The gradient of the Eastern Branch, from 2000 feet above the bridge to its junction with the main stream is 70 feet to the mile. Upstream of this point the gradient flattens to less than 40 feet to the mile. In the combined Western and Central Branches the gradient is approximately 56 feet to the mile for a distance of 3300 feet above the junction. Below the bridge the gradient of the creek bed increases to approximately 95 feet to the mile. The high gradient of the beds upstream of the site restricts the storage area for a low dam.

All branches of the Smith Creek drainage system are intermittently flowing streams, the Western and Central Branches being less intermittent than the Eastern Branch. The Eastern and Central Branches have an occasional saline flow in summertime with the salinity reaching 180 grains per gallon. The difference

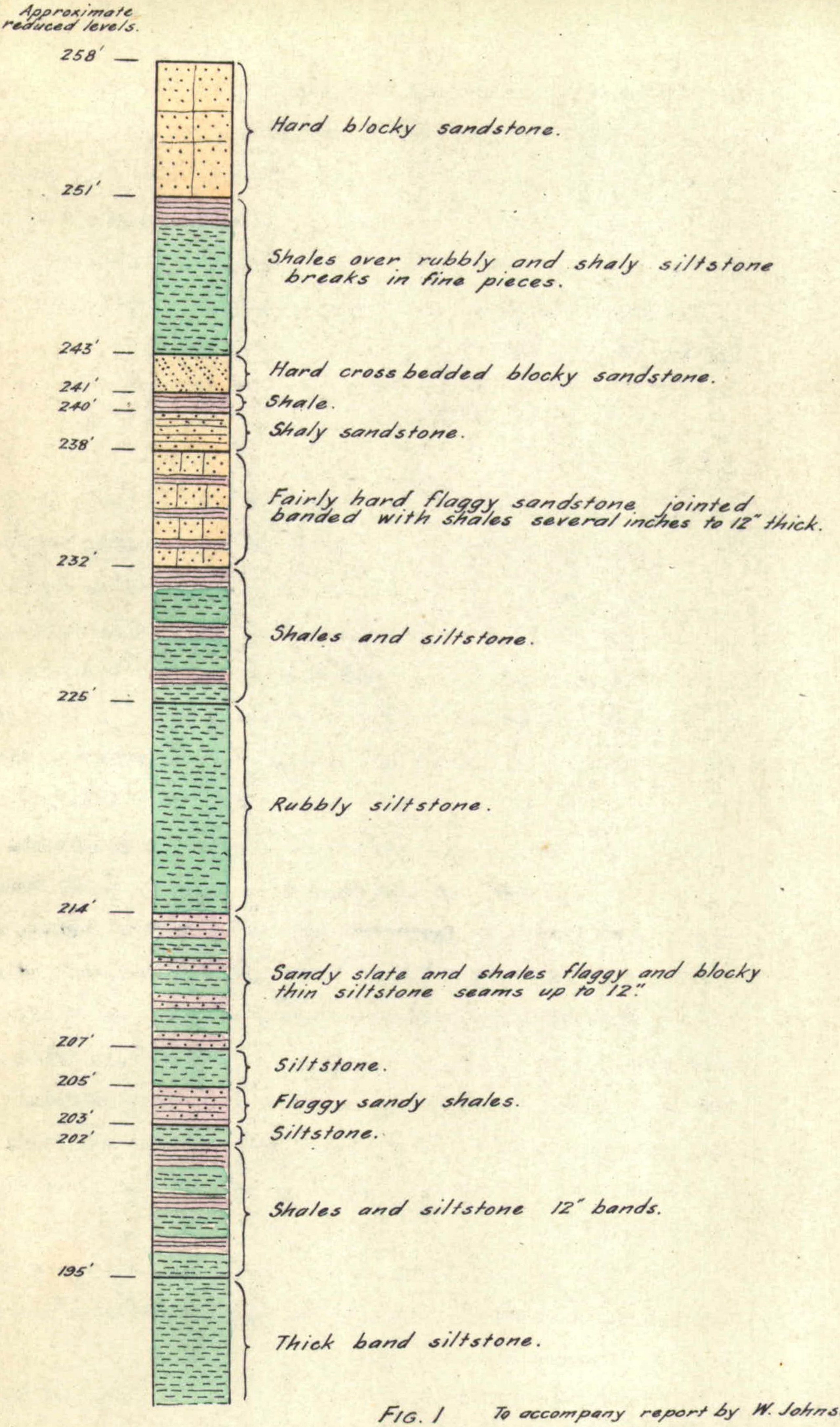


FIG. 1 To accompany report by W. Johnson.

S.A. DEPARTMENT OF MINES					
Approved	Passed	Drn.	COLUMNAR SECTION OF CAMBRIAN EXPOSED IN RIGHT BANK OF SMITH CREEK KANGAROO Is. 1000 FEET DOWNSTREAM FROM PROPOSED DAM SITE	D.M.	Scale /
	[signature]	Tcd. R.R.		Req.	S 1386 L3
		Ckd.			
Director		Exd.			Date 14-12-56

in behaviour of the various branches is probably partly attributable to the difference in gradient of the streams and partly to the rock types over which they flow. The nearest rainfall gauging station is at Smith Bay where the average annual precipitation is 20.9 inches. At Kingscote the average is 19.9 inches and at Cygnet River 17.9 inches. Average annual precipitation drops off towards the south-east.

GEOLOGY.

GENERAL:

The majority of the catchment area of Smith Creek and borderlands is underlain by Cambrian rocks belonging to the Stokes Bay Sandstone Formation of Sprigg (Kingscote, 4 mile to 1 inch Geological Series Sheet I, 53/16) Permian till outcrops on both banks of the Eastern Branch and Pleistocene laterite occurs capping remnants of the original plateau surface in the upper reaches of all branches of the creek. Late Cainozoic flow basalt overlies till in a flat topped ridge encroaching on, but mainly to the east of, the eastern border of the catchment.

The Stokes Bay Sandstone as exposed in Smith Creek consists of flaggy to laminated quartzite, hard micaceous shaly sandstone, hard shale and hard siltstone. Occasional massive beds of quartzite and sandstone occur. In the sea cliffs approximately 1 mile from the road bridge the massive sandstones and quartzites are prominently current and slump bedded. In the creek exposures current bedding has not been observed. Ripple marking is a common sedimentary structure in the flaggy sandstones.

The predominating colour of the formation is a brownish red on weathered surfaces. The fresh siltstones and shales tend to be more grayish or greenish in colour.

Permian till is but poorly exposed. Most of the evidence for its occurrence consists of erratic boulders which can be found on the ridges forming the east and west banks of the Eastern Branch ½ mile above the road bridge. The till on the western bank probably forms only a thin layer overlying a buried ridge of Cambrian rock. Poor outcrops of till occur in the east bank at creek bed level about ¼ mile upstream of the bridge. As exposed the till consists of horizontally bedded gray to white, sandy clay with small boulders of quartzite. It may form the whole of the divide between Smith Creek and the unnamed northerly flowing creek on the east down to a depth below the bed level of Smith Creek. Drilling has been done to test the depth of till in this divide. Hole No. 1 struck bedrock at a depth of 54 feet and the other two stopped in glacigene clay at a depth of 62 feet or approximately 18 feet below creek bed level for the hole beside the creek (No. 2 and 24 feet below creek bed level for hole No.3).

The outcrop of till is exposed in the concavity of a meander in the Eastern Branch of Smith Creek. The flood plain to the west of the meander is 100 yards wide and consists of a thin layer of sand overlying a flat floor of Cambrian sandstone or quartzite. It is probable that in this part of its course the Eastern Branch of Smith Creek is re-excavating the preglacial topography.

The Pleistocene laterite and late Cainozoic basalt have no direct influence on the dam site or the catchment area. The basalt is prismatically jointed and much weathered. It would be considered as a source of concrete aggregate.

STRUCTURAL GEOLOGY.

Within the area which will be covered by the stored water and for some distance upstream and downstream the general dip of the Cambrian sediments ranges from 5° to 12° on a bearing varying from 115° to 125° (TM). Larger variations of dip are probably associated with minor faults. Dips along the coast indicate a series of low broad asymmetrical folds in the Cambrian sediments and the Smith Creek area is probably on the south-eastern limb of an anticline.

Minor faulting was discovered by Bleys at various places along the creek. The displacement along the faults is apparently small and their effect on the rocks is confined to minor dragging and an increase in frequency of joints adjacent to the fault surface. Certain linear structures showing on aerial photographs of the area coincide with the fault outcrops in the creek sections. These are probably the continuations of the faults which are not traceable on the ground away from the creeks. No faulting was discovered at the proposed dam site.

The Cambrian rocks are very strongly jointed in two directions almost at right angles to one another. The two systems are :

(i) Strike 135° (T.M.) approximately.
Dip 80° N.E. to vertical.

(ii) Strike 230° (T.M.) approximately
Dip 80° S.E. to vertical.

The spacing of the joints in both systems varies according to their situation. In the massive sandstones and quartzites the joints are spaced 1 feet to 10 feet apart with an average spacing of about 6 feet. In the flaggy beds the joints are spaced 3 inches to 2 feet apart in the bed of the creek and somewhat farther apart in the banks. The average spacing in the creek bed may be less than 1 foot. The vertical extent of individual joints is limited. Few of them extend more than 3 to 4 feet.

One set of joints is parallel to the minor faults mentioned above and it is certain that both sets are tectonic in origin. They thus may be expected to continue in depth beneath the creek bed as well as in the banks. In the river bed the joints appear to be tight. Evidence in favour of this is given by the persistence between rains of isolated pools occurring in much jointed rock basins in the creek bed. Though it is possible that these pools are fed by ground water seeping up through the joints this phenomenon was not observed. Similarly, although the joints in the banks appeared open no water seepage occurred from them.

A third parting occurs parallel to the bedding planes. This may be caused partly by the broad folding to which the rocks have been subjected or it may be partly due to elastic rebound of the rocks on unloading due to erosion of the creek valley. This parting appears to be as tight as the other two joint systems except beneath the creek bed where leakage tests and drilling has

Fig. 3
Left abutment at proposed damsite.

Photo C. Bleys

Fig. 4.
Right abutment at proposed dam site.

Photo C. Bleys

shown that open cracks parallel to the bedding planes occur.

ENGINEERING GEOLOGY.

THE DAM SITE:

In this section only factors pertaining to the actual dam site are discussed. Other factors influencing design and construction such as the selection of a spillway site, the availability of materials of construction, and the geology of the reservoir area are discussed in later sections. It is assumed that both a concrete and an earth dam are being considered.

Lithology:- The rocks underlying both abutments and the main foundation area consist of laminated to flaggy siltstone and sandstone belonging to the Stokes Bay Sandstone Formation. To a depth of 20 feet below the creek bed, the siltstones form 90% of the rocks. They occur in layers ½ inch to 3 feet thick and in the unweathered state are hard tough, grey, green or blue gray rocks. In places they contain mica flakes but not in sufficient quantity to render them fissile. On weathering the colour changes to buff, purple and brown.

The sandstones form thin beds ½ inch to 3 inches thick. They are fine grained and buff, cream or light grey in colour. In places they form alternating layers with the siltstones.

In the unweathered state both rocks are considered more than strong enough to support a dam of the maximum proposed height, either in concrete or earth. They are not calcereous and so do not contain solution cavities due to percolating groundwater, nor are they liable to deterioration due to leakage of water through cracks subsequent to the construction of the dam.

Weathering:- Weathering, on the intensity of which depends the amount of excavation required to secure a sound foundation for a concrete dam or a sufficiently water tight cut-off trench for an earth dam, has affected the various sections of the foundations to differing degrees.

Weathering, in the geological sense, extends down to the level of the permanent water table. This level is unknown at the dam site because of insufficient borehole information, and is not significant from an engineering point of view.

However, the test diamond drill holes bored in the main foundation area showed that weathering extends to a depth greater than 20 feet below the creek bed.

Not all the weathered rock need be removed during excavation because below the surface zone of intense alteration weathering effects are mainly confined to a narrow zone surrounding the various cracks in the rocks.

Due to the fact that erosion has not kept pace with uplift at the dam site the rocks below the main foundation area are partly weathered. Diamond drill hole SC2 which is on the left bank close to the creek bed shows that the badly weathered rock is approximately 7 feet deep below the collar of the hole. This is equivalent to 3 or 4 feet below the river bed and rock may have to be removed to this depth to obtain a satisfactory cut-off.

On the right bank information is provided by two boreholes and a test pit. These show the zone of badly weathered rock to extend from 4 to 7 feet vertically below the surface. The zone of soil and completely altered rock is 1½ to 2 feet thick and below this weathering processes have broken the rocks into small angular fragments and partially converted them into clay to the full depth of the zone. Most of this zone will require removal to provide a sure cut-off. Close to river bed level some large blocks of rock, otherwise quite sound, may have to be removed because of their complete detachment from the parent rock by joint cracks.

On the left bank a narrow and low alluvial terrace occurs and the slope of the abutment is much flatter. The depth of alluvium is less than 3 feet but some weathered rock underlies it, as shown by diamond drill hole SC2. A total depth of 6 to 7 feet may have to be removed. The zone of intense weathering in the left abutment slope may be deeper than on the right abutment. Diamond drill hole SC4 at the top of the slope shows a depth of 6 feet of badly weathered rock. At lower levels on the slope the soil appears to be deeper.

It should be emphasised that estimates of depth of weathering are based on fragmentary data from widely spaced drill holes and test pits and excavation will no doubt cause revision of the estimates.

<u>Geological Structures:-</u> At the dam site the rocks strike 217° T.M. and dip 12° south-east. As the creek flows in a direction a few degrees north of west at the site the dip is predominantly upstream. This is a favourable factor as regards any tendency of the foundations to slide under stress along bedding planes. The dip is uniform within the foundation area and for a considerable distance up and downstream. Some minor slump folding occurs in the interbedded sandstones and siltstones, as shown by the diamond drill cores, but this will not affect the design or construction of the dam.

Although no faulting has been observed at the site, a large part of the left abutment is soil covered and some minor faulting may be concealed here. A certain amount of sliding along bedding planes may have occurred.

In the diamond drilling programme the worst core recovery was in hole SC2 on the left bank of the creek in the main foundation area. Some of the core loss may have been due to minor zones of cracking along bedding planes. This cracking is not considered serious and should be adequately remedied by the proposed grouting programme.

The geological structures which will most effect the design and construction are the joints. Two sets of joints occur at the site. These strike 135° TM and 230° TM and dip 80° N.E. and 80° S.E. respectively. In addition there is a parting along the bedding planes which may be mainly a surface phenomenon caused by uplift or elastic rebound of the layers of flatly dipping sediments when unloaded by erosion of the creek valley. These latter bedding plane joints extend to a depth of at least 20 feet below the main foundations according to the evidence of the boreholes.

Both the sub-vertical and sub-horizontal joints appear to be partially open and partially filled with limonite. Near the surface in the abutments they probably contain clay.

The chief effect of the joints will be to provide leakage or percolation paths for water underneath the dam when it is full. The effect of such leakage on the rock substance will not be serious during any reasonably anticipated life of the reservoir.

Information on possible leakage through the joints was obtained from a series of leakage tests on the diamond drill holes bored to explore the main foundation and abutment rocks. Water was pumped into these holes under various pressures up to a maximum equivalent to the head of water which will be imposed by the full reservoir.

In one hole in the main foundation area water was pumped in at a rate equivalent to 470 gallons per hour at 15 lb. / sq. in. pressure. This water apparently penetrated a crack system with access to levels higher than the collar of the hole, for, on completion of the test and disconnection of the pump, a back pressure of 5 lb. /sq. in. showed on the gauge and considerable water flowed out of the hole. No leakage of water to the surface was detected during this test.

The leakage rate can only be taken as a guide to possible future leakage under the completed dam as the conditions of application of pressure are different. However, it appears that a number of open cracks occurs in the main foundation rocks and that remedial grouting will be necessary in this area to prevent leakage under the dam.

In the right abutment two holes gave reliable information. The first hole SC2 is close to the creek bed, though some 15 feet above it. At 15 lb. / sq. in. pressure water from this hole broke through to the creek bank, a distance of 10 to 15 feet, laterally along a bedding plane joint or crack.

Hole SC3 at a level 40 feet above the creek bed accepted only 20 gallons of water at pressures rising to 30 lb./ sq. in. This indicates that in the higher parts of the abutment the cracks, both sub-horizontal and sub-vertical, are tight and that remedial grouting will not need to be extended under the full length of the dam.

It is suggested that the grouting in the first place be carried across the main foundation and up both abutment slopes to the 220 ft. level. The grout holes should be sloped at 10° to the vertical in a south-westerly direction so as to cut the sub-vertical joint systems. As the cracks are relatively numerous and freely communicating it is suggested that the grout-holes could be spaced 10 feet apart. The depth of grouting is a matter more for engineering decision but it should be borne in mind that open cracks have been found to a depth of 20 feet below the creek bed in the main foundation area.

It is also suggested that, if feasible from the construction point of view, grouting be done after the construction of the dam so as to minimise uplift of the surface layers of rock.

DIAMOND DRILLING:

Drilling was carried out over a period from 23.6.56 to 13.7.56. Four holes comprising a total footage of 135 ft. 6 inches were drilled. The overall core recovery was 87.4%. The worst recovery was from hole 802 in the main foundation where 80.2% of the footage drilled was obtained. Logs of the bores are given below.

TABLE 1.

LOGS OF DIAMOND DRILL HOLES SMALL CREEK DAM SITE

D.D.H. 801. Core Serial No. DD90/56

Right Bank of creek at creek side but 15' above the bed.

R.L. 215.4 Depressed 80°

Commenced 4.7.56 Completed 5.7.56

Driller - F. Noble.

Depths	Description
0' 0" - 1' 6"	Dark brown soil.
1' 6" - 3' 0"	Brown weathered sandstone rubble in clay matrix.
3' 0" - 5' 6"	Purple hard micaceous siltstone with some sub-horizontal limonite lined cracks along bedding planes.
5' 6" - 7' 6"	Greenish-brown hard micaceous siltstone.

7' 6" - 10' 4"	Dark greenish-brown hard massive siltstone, numerous sub-vertical and sub-horizontal cracks clay filled at about 8'10" depth.
10' 4" - 11' 6"	Greenish to purplish brown massive siltstone and sandy siltstone.
11' 6" - 12' 0"	Olive green siltstone with clean-vertical cracks.
12' 0" - 12' 6"	Cream fine grained sandstone, current or slump bedded.
12' 6" - 17' 6"	Alternating beds of green siltstone and grey fine grained sandstone. Prominent sub-vertical joint with limonite filling at 15'10"; also sub-horizontal limonite filled joints at intervals. No particularly badly cracked zones.
17'6" - 32' 0"	Green and light green siltstone alternating with grey fine grained sandstone (micaceous and showing current and / or slump bedding). Run finishes on a bedding plane joint in a band of dark blue grey slate or very hard siltstone. Numerout sub-vertical joints partly open, limonite filled or lined, also sub-horizontal bedding plane joints. Core broken into small pieces.

Weathering Zones:

0' 0" - 3' 6"	Badly weathered.
3' 6" - 21' 0"	Weathered
21' 0" - 32' 0"	Weathered along joint cracks only.

Core recovery 92.2%

Bore ends at 32 ft. 0 ins.

<u>D.D.H. SC 2.</u> <u>Bore Serial No. DD87/56</u>

Left bank of creek at creek side.

R.L. 203.8 Depressed 80° S.W.

Commenced 29.6.56 Completed: 2.7.56

Driller : W. Noble.

Depths	Description
0' 0" - 1' 8"	Soil
1' 8" - 5' 9"	Grey-green fine grained sandstone in fragments bounded by sub-horizontal and sub-vertical limonite and clay filled cracks.
5' 9" - 6' 3"	Green-yellow sandstone.
6' 3" - 6' 6"	White and red fine grained sandstone.
6' 6" - 7' 0"	Purplish fine grained sandstone with many cracks.
7' 0" - 16' 3"	Grey-green micaceous siltstone interbedded with buff fine grained sandstone - numerous cracks.
16' 3" - 21' 6"	Dark blue grey siltstone alternating with light grey sandstone and some buff fine grained sandstone in thin bands. Numerous sub-vertical and sub-horizontal cracks with limonite.

Weathering zones:

0' 0" - 7' 0"	Badly weathered.
7' 0" - 16' 0"	Weathered
16' 0" - 21' 6"	Weathered along cracks only.

Core recovery 80.2%

Bore ends at 21 ft. 6 ins.

<u>D.D.H. SC3.</u> <u>Bore Serial No. 98/56</u>

Right abutment near limit of foundation.

R.L. 246.0 Depressed 90°

Commenced 9.7.56 Completed 10.7.56

Driller : W. Noble.

<u>Depths</u>	<u>Description</u>
0' 0" - 3' 6"	Soil and badly weathered rock
3' 6" - 5' 6"	Grey hard fine grained micaceous sandstone or quartzite with open cracks.
5' 6" - 6' 6"	Olive-green to brown siltstone broken into small fragments.
6' 6" - 8' 6"	Purplish-brown to greenish-yellow brown siltstone and buff sandstone in alternating bands. Numerous sub-horizontal and sub-vertical cracks.
8' 6" - 11' 3"	Olive green-brown laminated siltstone with some sub-horizontal and sub-vertical cracks.
11' 3" - 17' 8"	Olive green-brown siltstone and buff fine grained sandstone in alternating bands cut by sub-horizontal and sub-vertical cracks. Bands of varying thickness.
17' 8" - 19' 10"	Olive green-brown and purplish brown laminated siltstone, few cracks.
19' 10" - 26' 9"	Buff fine-grained sandstone and greenish brown and purplish brown laminated sandstone interbedded in beds $\frac{1}{8}$" to 12" thick, many sub-horizontal and sub-vertical cracks, some slump breccia and bedding.
26' 9" - 28' 10"	Purplish-brown siltstone some cracks.
28' 10" - 30' 1"	Grey fine grained sandstone and purplish brown siltstone, much cracked.
30' 1" - 33' 0"	Purplish-brown siltstone and purplish grey fine grained sandstone interbedded in beds $\frac{1}{8}$" to $\frac{1}{2}$" thick and some sub-horizontal bedding plane cracks.
33' 0" - 38' 1"	Chiefly dark green laminated massive siltstone with some grey to buff sandstone bands. Limonite lined sub-horizontal cracks.
38' 1" - 42' 0"	Green siltstone and buff fine grained sandstone interlaminated in thin lens-like laminae. Some thicker sandstone bands up to 2" thick. Slump

structures prominent. Sub-vertical crack limonite lined or filled from 40 ft. 3 in. to 41 ft. 9 in.

Weathering zones:

0' 0" - 6' 6"	Badly weathered.
6' 6" -16' 6"	Weathered
16' 6" -42' 0"	Weathered along cracks only.

Core Recovery 87.5%

Bore ends at 42 ft. 0 ins.

<u>D.D.H. SC4.</u> <u>Bore Serial No. DD99/56</u>

Left abutment near limit of foundations.

R.L. 241.7 Depressed 90°

Commenced 12.7.56 Completed 13.7.56

Driller : W. Noble.

Depths.	Description.
0' 0" - 0' 5"	Soil
0' 5" - 6' 2"	Yellow-brown weathered hard micaceous very fine grained sandstone. Joints in three directions filled with limonite. Some clay at top and bottom of section. May be some clay filling joint cracks.
6' 2" - 8' 0"	Dark brown to grey hard micaceous siltstone. One tight vertical joint at middle of section.
8' 0" - 13' 3"	Dark brown hard micaceous siltstone - joints at bottom of section.
13' 3" - 14' 9"	Yellow brown very fine grained sandstone or siltstone. Sub-vertical joints with siliceous clay
14' 9" - 26' 4"	Dark grey hard micaceous shale. Some joints limonite filled cracked zone at 16 ft. 6 in. to 17 ft. 0 in. Jointing at 22 ft.
26' 4" - 27' 0"	Brownish grey siltstone or mud stone with sub-vertical joint, tight and cemented by limonite.
27' 0" - 32' 0"	Dark grey and yellow grey laminated shale or siltstone with a 7" thick sandstone bed at 29ft. 6in. This bed has a zone of brecciation with porosity at its top and someapparent porosity along bedding plane cracks outlining its boundaries.
32' 0" - 35' 0"	Grey and yellow grey laminated micaceous siltstone or shale. Buff medium grained quartzite from 34 ft. 6 in. Cracks at junction of quartzite and siltstone.
35' 0" - 37' 6"	Buff quartzite or sandstone to 36 ft. 2 in. with limonite impregnation towards the base. Underlain by 6 in. greenish graywacke and 10 in. dark grey laminated siltstone or shale.
37' 6" - 41' 0"	Grey green laminated shale with bands of buff very fine grained sandstone. Many limonite filled joint cracks towards bottom.

Weathering zones

0' 0" - 6' 2"	Badly weathered
6' 2" - 17' 0"	Weathered
17' 0" - 41' 0"	Weathered along joint cracks only.
	Core Recovery 88.9%
	Bore ends at 41 ft. 0 ins.

LEAKAGE TESTS.

The leakage tests were carried out on the diamond drill holes by pumping water into the holes through a water meter and a casing tight head. A pressure gauge was connected to the thighthead so that the pressure at the collar of the hole was obtained. Casing was grouted into the holes to a depth sufficient to prevent access of the pressure water to the surface badly weathered zone. Results of the tests have been interpreted and discussed in a previous section. They are thought to indicate that some leakage under the dam will occur, chiefly in the main foundation area, unless grouting is done.

TABLE II.

RESULTS OF LEAKAGE TESTS ON DIAMOND DRILL HOLES SC1 to SC4, SMITH CREEK, DAM SITE, KANGAROO ISLAND

Date of Tests 13th and 14th August, 1956.

D.D.H. SC1.

Situated at R.L. 215.4 on a bench on right abutment. Lateral distance between the hole and the creek at creek bed level approximately 15 feet.

Pressure lb./sq.in.	Quantity Gallons.	Time	Hourly Equivalent Gallons
5	5	4 min. 10 sec.	72
10	5	3 min. 45 sec.	80
	10	7 min. 35 sec.	79
15	5	2 min. 50 sec.	106
	10	3 min. 46 sec.	159 *
20	10	3 min. 42 sec.	162
	20	5 min. 32 sec.	217
	30	7 min. 38 sec.	236

Total quantity of water pumped in = 81 gallons.

* Water broke through to surface at base of low cliff 3 feet above river level.

D.D.H. SC2.

Situated on river bank left side 5 ft. above river bed.

Pressure lb/sq.in.	Quantity Gallons.	Time	Hourly Equivalent
5	10	3 min. 55 sec.	153
10	10 20	2 " 0 " 3 " 57 "	300 303
15[1]	10 20 30 40 50	1 " 22 " 2 " 40 " 3 " 55 " 5 " 10 " 6 " 23 "	441 450 459 464 470
RETESTED AFTER 5 MIN. INTERVAL WITHOUT DISCONNECTING			
15[2]	10 20	1 min. 5 sec. 2 " 10 "	554 554
APPARATUS DISCONNECTED & THEN RECONNECTED			
13[3]	10 20 30	1 min. 20 sec. 2 " 40 " 4 " 0 "	450 450 450
RETESTED ON FOLLOWING DAY			
13[4]	190	25 minutes	456

NOTES:

1. Pressure at start of first test could be raised to 20 lb/ sq. in. At later stage it would not be raised beyond 15 lb./ sq. in.
2. After disconnecting, pump gauge showed a back pressure of 5 lb. / sq. in. and a considerable quantity of water flowed out of hole.
3. Pressure could not be raised beyond 13 lb. /sq. in.
4. After testing for 25 minutes back pressure was 7 lb./sq. in.
5. Total quantity of water pumped in during first days test = 300 gallons approximately.

D.D.H. SC3.

On right abutment near assumed crest level of dam.

Pressure lbs./sq.in.	Quantity Gallons	Time	Hourly Equivalent Gallons
7 to 8	1 2	3 min. 15 sec. 6 min. 40 sec.	19 18
10	1 2	2 min. 30 sec. 4 min. 40 sec.	24 25
15 to 16	1 2 3	1 min. 40 sec. 3 min. 16 sec. 4 min. 45 sec.	36 36 38

Pressure lbs./sq.in.	Quantity Gallons.	Time	Hourly Equivalent Gallons
20	1	1 min. 2 secs.	58
	2	2 min.12 secs.	54

NOTE

A total of 19.1 gallons was pumped into the hole in 34 minutes at varying pressures. Hole would not accept any more even at pressure of 25 to 30 lb./ sq. in.

D.D.H. SC4.

On left abutment near assumed crest level of dam.

Casing in this hole was only 2 feet deep below the surface and water broke through to the surface all around the hole at low pressure.

SPILLWAY AREA:

If, as recommended by the Project Investigation Engineer of the Engineering & Water Supply Department, an earth fill dam is constructed, the spillway will need to be in the saddle in the right abutment as this is the only site where one could be built economically.

No special geological difficulties occur in this area. The chief factor influencing the design and construction of the spillway will be the condition of the rock as affected by weathering.

Depth of excavation necessary will be approximately 20 feet which will put the bottom of the spillway in the zone of partially weathered rock. Except towards the surface, rocks in this zone are relatively hard and strong, and it is probable that the bottom of the spillway could be left unlined unless required to satisfy the hydraulics of the design.

The sides of the spillway will require lining only if the water level during floods reaches some height up the walls, as the lower part of the sides should be in rock sound enough to resist erosion from the spilling water. However, the top part of the sides will need to be battered back to prevent the badly weathered rock at the surface collapsing into the excavation.

The outfall of the spillway will be down a soil covered slope well away from the toe of the dam. The soil covering is relatively thin and erosion by the spillway will soon remove it and the badly weathered rock beneath. It is thought that this stripping could be allowed to proceed without any danger to the dam or the spillway as it will be arrested when solid rock in the partially weathered zone is reached at depth varying from 4 feet to 8 feet below the original surface. No protection of the spillway outfall is considered necessary.

If a concrete dam with overflow spillway is built the loose rock in the creek bed below the dam will have to be removed and possibly a narrow concrete apron provided to protect the toe of the dam.

RESERVOIR AREA.

Leakage from the Reservoir:- The principal feature in the reservoir area likely to affect the feasibility of the project is the presence of a mass of Permian fluvio-glacial sediments forming part of the divide between the Eastern Branch of Smith Creek and the unnamed creek to the north. These consist principally of blue-grey, yellow-grey and green-grey clays with a considerable silty fraction and a small sandy fraction. They are calcareous and in places contain lenses of gravel with a clay matrix. Glacial boulders are sparsely spread throughout the clay and consist principally of Cambrian quartzite.

The till outcrops in the right bank of the Eastern Branch of Smith Creek and for a distance of 700 feet along this bank will be up to 10 feet below the proposed top water level of the reservoir. If sandy lenses of any considerable lateral extent occur in the till leakage could take place through the divide. To explore and guard against this possibility three percussion drill holes were put down in the divide either to bed rock or to a depth considerably below the bed level of the creek. These showed that the till is mainly clay or slightly sandy clay of a type which could be expected to be practically impervious to percolating water. One thin bed of gravel was penetrated in borehole 3. The gravel was in an impervious clay matrix and this, together with its lenticularity, would be sufficient to prevent it allowing leakage. The absence of groundwater in two of the holes also emphasises the generally impervious nature of the tillite. It is, therefore, considered that there is no danger of leakage from the reservoir through the Permian fluvio-glacial sediments and the reservoir will be generally water-tight except in the vicinity of the dam itself. This area has been discussed in an earlier section.

Percussion Drilling:- The logs of the percussion drill holes put down in the divide together with other relevant information are given in full below.

TABLE III.

LOGS OF PERCUSSION DRILL HOLES, RESERVOIR AREA SMITH CREEK DAMSITE

PDH 1. Bore Serial No. PD1342/56

RL 277.3 Driller : V. Casson

Commenced 29.10.56 Completed 2.11.56

0' - 5' Yellowish-grey clay slightly calcareous some white lime blebs.

5' - 34' Yellowish-grey slightly calcareous clay some sand fraction and small sub-angular rock grains.

34' - 50' Blue-grey calcareous clay with small sub-angular rock fragments and slight sand fraction.

50' - 54' Slightly greenish-grey clay with small sub-angular rock fragments.

54' - 57' Purplish fine grained quartzite or hard sandstone (Cambrian bedrock)

Water struck at 40 ft. depth stood at 35 ft. said to be salty.

Bore ends at 57 ft. 0 ins.

P.D.H. 2. Bore Serial No. PD1387/56

R.L. 284.6 Driller : V.Casson

Commenced 5.11.56 Completed 9.11.56

0' - 5' Yellowish-grey marly clay with white lime blebs and some quartz sand fraction.

5' - 11' Yellowish sandy calcareous clay.

11' - 15' Buff-grey clay.

15' - 30' Yellowish-grey clay with dark grey coarse grained sub-angular rock fragments.

30' - 60' Yellowish-grey clay with very coarse sand or fine gravel consisting of sub-angular rock fragments.

60' - 62' Yellowish grey sandy gritty clay.

No water struck.

Bore ends at 62 ft. 0 ins.

P.D.H. 3.

Serial No. PD1412/56

RL 277.6

Driller : V. Casson

Commenced 12.11.56

Completed 14.11.56

0' - 5' Greenish grey clay with lime blebs and a sandy fraction.

5' - 10' Greenish-grey and blue-grey mottled clay with gravelly rock fragments.

10' - 30' Yellowish-grey clay.

30' - 36' Blue-grey clay with very coarse sub-angular rock fragments.

36' - 37' Grey sub-angular fine quartzite gravel in grey clay.

37' - 62' Blue-grey silty clay with medium grained sub-angular rock fragments.

No water struck.

Bore ends at 62 feet.

Siltation:- The problem of siltation of the reservoir can only be discussed in general terms owing to the lack of data on present silt loads carried by the various tributaries in flood times.

Judging by the appearance of a dam in the bed of the Eastern Branch of Smith Creek the silt load carried by this branch is small. The dam, which has apparently been in existence for many years, although of small capacity is only half filled with silt. The Eastern Branch has a greater proportion of its catchment cleared than the other two branches and therefore the silt load in these should normally be less.

The cleared land is used for depasturing sheep and cattle and is not subject to the worst causes of accelerated erosion. Nevertheless the soils over most of the watershed appear to be mainly sandy and generally incoherent and increased erosion could be expected if a prolonged drought, followed by heavy rainfall, ensued.

Also land use on the Island is expanding. Land formerly thought useless is now being cultivated so that in the future some of the uncleared part of the catchment may be cleared and used for pasture or cropping. The consequent increased risk of soil erosion will expose the reservoir to the danger of further siltation. Therefore, although the danger of bad siltation under conditions which have prevailed over the last few years is considered negligible, the possibility of increased siltation in the future should be borne in mind in the design of the dam and in the management of the catchment area.

MATERIALS OF CONSTRUCTION:

The availability of various local material required for construction of the dam is discussed assuming the dam will be constructed either in concrete or as an earth-fill project.

Aggregate for concrete :- A number of sources could be considered for coarse aggregate. The most convenient of these are the beds of quartzite outcropping in the banks of the creek downstream of the proposed site. The best of the beds outcrops 2000 feet due north of the site on the left bank of the creek. Where exposed it is 60 feet thick and is particularly massive and should crush to an aggregate of good dimensions and adequate durability. The lateral extent of the bed could not be determined by surface inspection but it should yield sufficient aggregate for all purposes.

Thinner beds of quartzite occur closer to the site. One of these, approximately 10 feet thick, outcrops at creek bed level in the left bank 800 feet north of the site. It would yield a much smaller quantity of aggregate and because of this could only be considered as a source for aggregate for the concreteworks appurtenant to an earth fill dam.

Other possible sources of coarse aggregate more remote from the site are the beach boulder gravel at the mouth of Smith Creek and the basalt capping of the plateau surface 2 miles to the north-east. Both deposits would require more investigation before the suitability could be finally decided.

Fig. 5. Photo C. Bleys.
Thick quartzite bed left bank of Smith Creek. Proposed for source of concrete aggregate. Bed also shows slump structures and minor faulting.

The beach gravel contains some boulders of poor durability and a high proportion of the larger sizes of boulders. The total quantity of gravel available would also have to be determined by means of test pitting. It may prove insufficient to yield the required quantity of the correct sizes of gravel. However, it is considered that the beach gravel is worthy of some attention from the engineers.

The basalt flow could be expected to yield a sound aggregate from its unweathered portions. The selection of a quarry site in the basalt would require some detailed geological investigation and its relatively lesser accessibility and greater distance from the site may make it an uneconomical proposition compared with the quartzite beds.

Some trouble will be experienced in obtaining a supply of fine aggregate. A search of the area in the vicinity of the site failed to reveal any deposits of sand of suitable type and it will be necessary to look farther afield. This wider scale search was beyond the scope of the present investigation.

<u>Earth Fill Materials</u>:- It is assumed that both impervious and semi-pervious or pervious materials are required for an earth fill dam and that the final selection will be guided by the usual soil tests. Hence this discussion should be taken only as indicating likely sources of materials for further testing.

The suggested impervious material is the glacial clay forming the right bank of the Eastern Branch of the Creek near the proposed limit of stored water. The clay is slightly calcareous and contains a portion of sand and gravel. None of these constituents appear to be present in sufficient quantity to render the clay unsuitable for an impervious core. If this clay should also prove suitable for the bulk of the dam a sufficient quantity is available upstream of the reservoir area on the right bank and is in a relatively accessible position.

For the pervious or semi-pervious material the soil of the alluvial flats downstream of the site should be tested. As these flats are not very extensive more than one will have to be utilised and perhaps supplemented by the soil covering of the flatter valley slopes downstream of the site.

Any stone required for protection of banks could be obtained from the quartzite beds suggested as a source of coarse aggregate for concrete.

SUMMARY & CONCLUSIONS.

SUMMARY:

Geological investigations of the proposed dam site on Smith Creek and of the reservoir and catchment area have shown that geologically the proposed dam is a feasible project.

The dam site is entirely underlain by hard tough Cambrian siltstone, shale and sandstone beds dipping at a low angle upstream and should prove satisfactory, with suitable treatment, for either a concrete or earthern structure.

The chief geological features likely to affect the design and construction of the dam are the weathering and jointing. Weathering is not severe but has been of an intensity requiring the excavation to an average minimum depth 5 feet below the surface either for the foundations of a concrete dam or the cut-off trench of an earthern dam.

Joints are numerous and in places are open to a depth of at least 20 feet below the surface. They appear to be more open beneath the main foundation area, and it is considered that remedial grouting will be required to a depth of 20 feet to prevent undue leakage under the main foundation.

No faults have been discovered at the dam site.

The slight saddle on the right abutment is considered a satisfactory site for a side spillway. If the excavation is suitably battered the spillway would require a minimum of lining. An overflow spillway for the concrete dam would require the excavation of a small amount of loose rock in the bed of the creek below the dam.

Investigation of the glacial sediments on the right bank of the Eastern Branch near the proposed upstream limit of stored water has shown that they consist almost entirely of clay and they are considered to be impervious to leakage. Siltation does not appear to be a problem at present but may become so in the future if more of the catchment area is brought into land use.

Possible sources of most of the bulk materials of construction occur close to the proposed site, except sand of suitable type for fine aggregate.

CONCLUSIONS:

1. Geological conditions at the proposed Smith Creek dam site are favourable to the construction of either a concrete or earthern dam of the suggested height.
2. The reservoir should be water tight providing some remedial grouting is done in the main foundation area.
3. The grout curtain should be carried up the abutment slopes to approximately the 220 feet level and the holes should be sloped 10° to the vertical in a south westerly direction. Suggested spacing of groutholes is 10 feet apartalong the line of the curtains.
4. A suitable site exists in the right abutment for a side flow spillway.
5. No further drilling is required either at the dam site or in the divide occupied by Permian glacial sediments.
6. Materials suitable for the preparation of coarse aggregate for concrete, and for an earth fill dam are available but some difficulty will be experienced in obtaining fine aggregate.

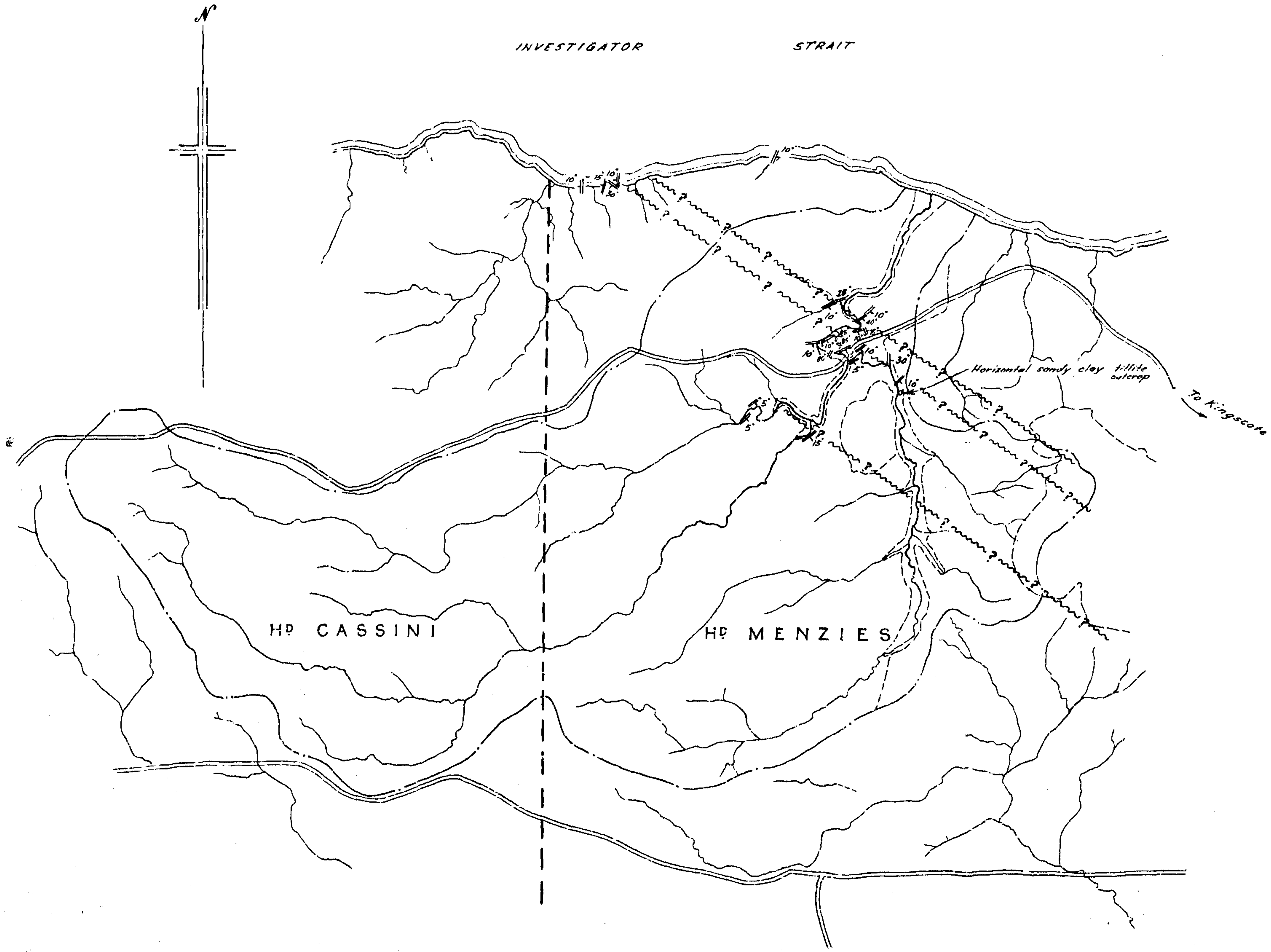
W. Johnson

W. Johnson.
GEOLOGIST
Hydrology Section.

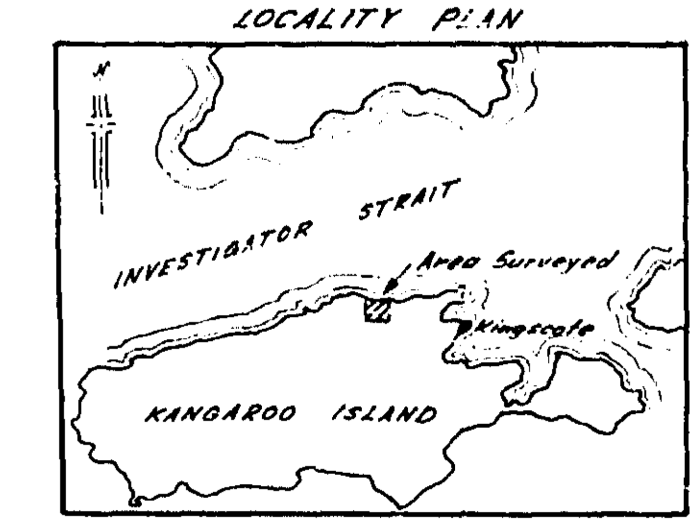
C. Bleys

C. Bleys.
GEOLOGIST.
Hydrology Section.

per W.J.



LOCALITY PLAN



— LEGEND —

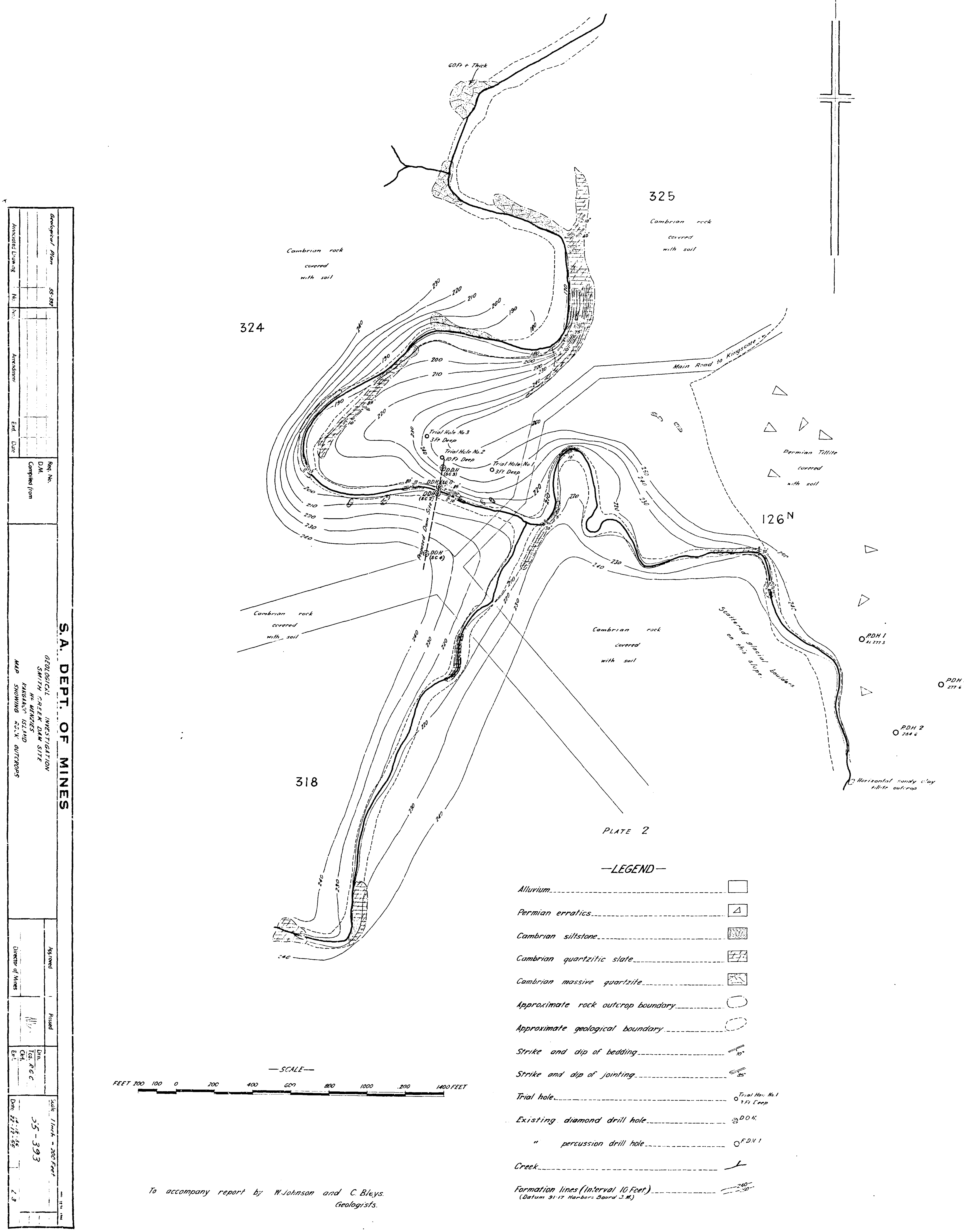
- *Alluvium*
- *Basalt : Late Cainozoic : columnar in part*
- *Permian Tillite : Boulder beds chiefly clays with quartzitic granite and gneiss erratics*
- *Cambrian : Massive coarsely current and slump bedded red and white sandstone and quartzite : quartzitic slate and grey and chocolate siltstone*
- *Watershed boundary*
- *Fault*
- *Strike and dip of bedding*
- *Strike and dip of jointing*
- *Roads*
- *Creeks and gullies*

PLATE 1

To accompany report by W. Johnson and C. Bleys. Geologists.

S.A. DEPARTMENT OF MINES

Rock Outcrops 55-393	Req. No. / D.M. / Compiled from	GEOLOGICAL INVESTIGATION SMITH CREEK DAM SITE HD. MENZIES KANGAROO ISLAND REGIONAL GEOLOGY	Approved / Director of Mines	Passed	Drn. / Tcd. RGC / Ckd. / Exd.
Associated Drawing / No. / No. / Amendment / Exd. / Date					Scale: 1 Inch = 40 Chains 55-392 Date 14-12-55 20-12-55


S.A. DEPT. OF MINES
GEOLOGICAL INVESTIGATION
SMITH CREEK DAM SITE
Hd MENZIES
KANGAROO ISLAND
MAP SHOWING ROCK OUTCROPS
Geological Plan 55-392
Associated Drawing
Amendment
Compiled from
Approved
Director of Mines
Passed
Scale 1 inch = 200 Feet
55-393
N
60Ft + Thick
325
Cambrian rock covered with soil
324
Cambrian rock covered with soil
Main Road to Kingscote
Trial Hole No 3 3Ft Deep
Trial Hole No 2 10Ft Deep
Trial Hole No 1 3Ft Deep
DDH (SC 3)
DDH (SC 2)
DDH (SC 4)
Proposed Dam Site
Permian Tillite covered with soil
126N
Cambrian rock covered with soil
Cambrian rock covered with soil
Scattered glacial boulders on this slope
PDH 1
PDH 3
PDH 2
Horizontal sandy clay tillite outcrop
318
PLATE 2
—LEGEND—
Alluvium
Permian erratics
Cambrian siltstone
Cambrian quartzitic slate
Cambrian massive quartzite
Approximate rock outcrop boundary
Approximate geological boundary
Strike and dip of bedding
Strike and dip of jointing
Trial hole
Existing diamond drill hole
" percussion drill hole
Creek
Formation lines (Interval 10 Feet) (Datum 31.17 Harbors Board J.M.)
—SCALE—
FEET 200 100 0 200 400 600 800 1000 1200 1400 FEET
To accompany report by W. Johnson and C. Bleys. Geologists.

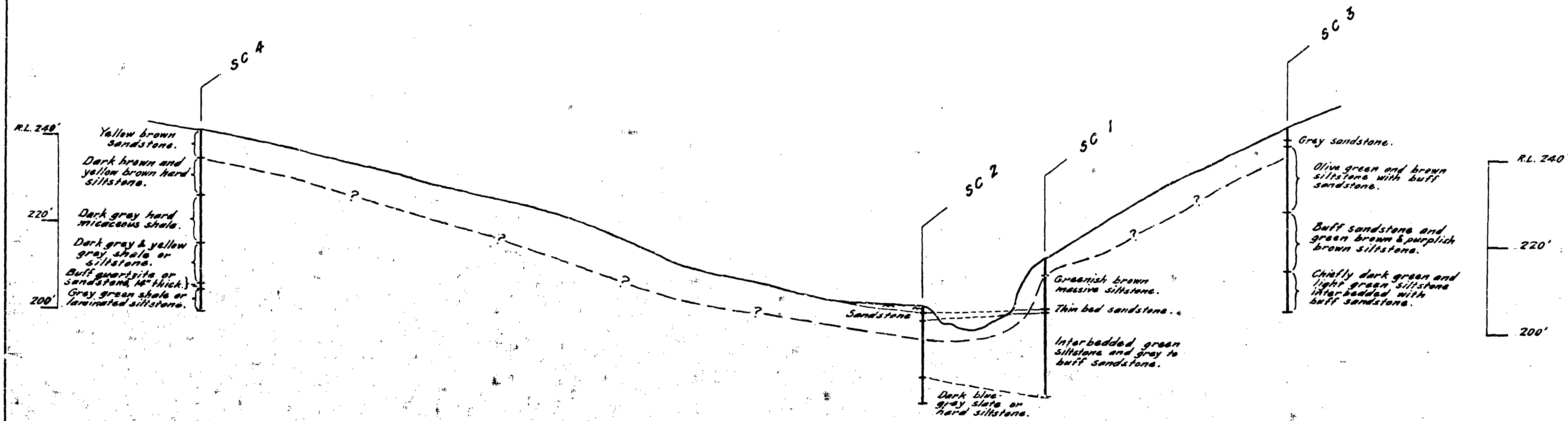
No.	Amendment	Exd.	Date

S.A. DEPARTMENT OF MINES

GEOLOGICAL INVESTIGATION
SMITH CREEK DAM SITE
HD. MENZIES KANGAROO ISLAND
CROSS SECTION AT PROPOSED DAM SITE

Approved	Passed	Scale: Hor. 40'=1" Vert. 20'=1"
Director	Drn. Trd. R.R. Ckd. Exd.	56-319 L3 Date 14-12-56

To accompany report by W. Johnson. Geologist.



Zone of badly weathered rock, boundary approximate between bores ▭

SCALES: Horizontal 40 feet to 1 inch
Vertical 20 " " 1 "

PLATE 3