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DARWIN WATER SUPPLY

INVESTIGATION OF SUPPLEMENTARY SOURCES

by

John Hays

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DARWIN WATER SUPPLY : INVESTIGATION OF SUPPLEMENTARY SOURCES.

SUMMARY

Investigations at several possible dam and weir sites on the Adelaide, Manton and Darwin Rivers, have been undertaken at the request of the Director, Water Resources Branch, Northern Territory Administration, as part of the search for a supplementary water supply for the City of Darwin.

The most favourable site appears to be on the Darwin River at the railway bridge near the R.A.A.F. quarry site. Although this site is not so favourable hydrologically as the Adelaide River Gorge site (Hays 1961), it has several economic advantages including a shorter pipe line and lower pumping costs. It is recommended that diamond drilling and, where applicable, seismic testing be undertaken at both sites. Re-routing of the railway would be necessary if a dam is built across the Darwin River.

INTRODUCTION

Investigations at several possible damsites have been undertaken at the request of the Director, Water Resources Branch, Northern Territory Administration, as part of the search for a supplementary water supply for the City of Darwin. These sites include Acacia Gap on the Manton River; one damsite and several weir sites on the Adelaide River, downstream from the Marrakai crossing; and one damsite with a ponding reservoir site on the Darwin River.

This report includes a preliminary account of the geology of each site and an appendix summarising available information on the damsites and the possible damsite in the Adelaide River Gorge (reported on by Hays, 1961). The data on storage capacity, catchment areas, and run-off, have been supplied by the Director of Water Resources, and are provisional. Some of the discharge figures are based on inadequate data and the figures are included here only for comparison purposes. None of the data should be used as the basis for any calculations of expected annual yield.

CATCHMENT AREAS.

The catchment areas have many features in common and for that reason they are described together. The catchment areas of the damsites form part of the Northern Plain of the Northern Territory as defined by Noakes (1949). This plain has been produced by southwards scarp retreat across a surface sloping northwards, and in which north-flowing consequent streams have carved valleys along major structural features; it is underlain mainly by Lower Proterozoic rocks. Valley floor panplains have been formed in areas underlain by the argillaceous Golden Dyke and Burrell Creek Formations; watersheds generally consist of the more resistant arenaceous Masson Formation and parts of the Noltenius Formation. The argillaceous formations are mainly slate and phyllite that are practically impermeable at a depth of a few feet, and the danger of underground leakage out of the catchment is therefore very low. Over most of the area, bedrock is overlain by ferruginous gravel above which is recent alluvium.

Because of the way in which the valleys formed, the catchments consist of very flat areas surrounded and separated by narrow ridges. Deep storage areas are almost non-existent and the ratio of storage area to catchment area ranges from 1:9 to 1:12 for the maximum height of wall at the various proposed sites. Evaporation losses, therefore, will be high in relation to the volume of water stored. This disadvantage is inherent in almost all potential damsites on the coastal plains and can be avoided only by selecting sites very much farther south than the Adelaide River Gorge.

All the catchment areas are in the same rainfall belt, in which the annual rainfall ranges from 35 inches to 55 inches, the mean being 45 inches. As a first approximation, therefore, annual discharges may be expected to vary directly as the catchment area.

ACACIA GAP

The proposed Acacia Gap damsite is situated on the Manton River, 6 miles downstream from Manton Dam and 34 miles south-east of Darwin. Access is via the Stuart Highway south from Darwin for 40 miles and east by bush track almost parallel to the Manton River for six miles. Access is extremely difficult during the wet season. Acacia Gap has been formed by the Manton River cutting through a north-trending ridge of the Daly Range. It is a few hundred yards downstream from the Acacia Creek-Manton River confluence and is served by a catchment area of 56.8 square miles, excluding any contribution from the Manton Dam catchment.

The area was visited on the 11th of April, 1962, in a Cessna 150 on charter from the Darwin Aero Club. The site was studied from a height of 3,000 feet and appeared to be geologically suitable for dam wall construction. A series of quartz veins on the southern part of the ridge were thought to indicate strike faulting. The gap was geologically mapped by plane table and telescopic alidade, at a scale of 80 feet to 1 inch, on the 18th and 19th June, 1962, using a base map prepared by Lands and Surveys Branch, Northern Territory Administration.

Geology

The only rock exposed at the gap is quartzite of the Acacia Gap Member of the Lower Proterozoic Masson Formation. The quartzite is fine-grained and massive, but is cut by a large number of open joints. The dominant sets of joints are easterly vertical, northerly vertical, and horizontal, but other joints display a wide range of dip and strike. Bedding has not been identified but the quartzite crops out in narrow bands striking north, and these are thought to represent bedding. The bands run together and overlap, probably because of silicification along joints in places, or minor facies changes within the rock, and are parallel to the regional strike indicated on air photos. North of the gap the strike is northerly, but individual bands swing west as they approach the gap. This may be the topographic result of a steep dip to the west or may be due to faulting or folding.

South of the gap the strike is exactly the same as on the north, but bands swing east as the gap is approached, thus indicating faulting or folding. Because of these slight swings in outcrop, the quartzite bands are not colinear across the gap but are offset by between 200 feet and 400 feet.

The quartzite is traversed by a large number of quartz veinlets sealing cracks and joints that strike in all directions. The quartz in the veinlets is opaque with an earthy lustre and its presence is thought to indicate faulting. Several slickensided and mullioned blocks of quartzite were found in the rubble. Complete photo cover of the area is not available, but photos of the gap show a lineament trending north-east through the gap. It is thought that the river cut through the ridge at a small fault that offsets the resistant quartzite beds. Reconnaissance south of the gap revealed displacements that may represent faults. The area near the gap is known to be traversed by several major faults, including the Giant's Reef Fault, and subsidiary faults are to be expected.

Diamond drilling will be necessary to establish whether a fault exists, and to determine the effect on foundation conditions at the site.

Spillway

The maximum water level in the proposed dam is controlled by a small saddle 58 feet above bank level, 1,600 feet north of the gap. The saddle provides a natural spillway, but might have to be widened and would need to be concreted. It is covered with rubble of slate and quartzite, and one exposure of sheared greywacke was noted. Faulting is suspected and diamond drilling would be necessary to determine the suitability of the saddle as a spillway.

Construction and Materials

Because of the low saddle to the north, the maximum depth of water that could be impounded is about 60 feet above bank level. This involves a minimum wall height of 70 feet above bank level and a minimum crest line of 1,060 feet; concrete gravity, rockfill, or similar construction would be necessary. Probably the foundations would be adequate for such construction, but no hard rock crops out on the bank, and the depth to sound rock is not known; extensive drilling and costeaning will be needed at the preliminary and design investigation stages. Geophysical testing would also give useful information. The large number of open joints and the possible existence of a fault would make a comprehensive grouting programme essential both at the gap and the saddle to the north.

The local quartzite appears to be excellent material for concrete aggregate and as rockfill material and several good quarry sites are available, but the normal suitability tests should be carried out. However, no sand deposits are known in the area. The alluvium on the Adelaide River flats consists mainly of fine silt which is unsuitable either as sand for concrete or as material for an impervious clay core. Small sand and clay deposits could occur within the alluvium.

Catchment and Storage

The catchment area consists of 56.8 square miles of undulating country of low relief surrounded by hills up to 300 feet high. The underlying rock is thought to be mainly slate of the Golden Dyke and Burrell Creek Formations covered by ferruginous gravel. The storage area is about 4,000 acres for a depth of 50 feet of water above bank level. This area is about 11% of the catchment area.

ADELAIDE RIVER (DIRTY LAGOON):
- DAMSITES AND WEIR SITES

DIRTY LAGOON DAMSITE

The proposed Adelaide River (Dirty Lagoon) damsite is situated about 3 miles downstream from the Marrakai crossing. Access is by the Stuart Highway for 46 miles south from Darwin and thence easterly by bush track for 8 miles. The south abutment area of the dam is near the junction of the Coomalie track and the Marrakai track, near Dirty Lagoon. Access is difficult during the wet season.

The site was mapped on the 13th and 14th June, 1962, at a scale of 200 feet to 1 inch by compass and tape, and the results were compiled on a base map prepared by Water Resources Branch, Northern Territory Administration.

Geology

Cherty slate of the Lower Proterozoic Golden Dyke Formation crops out on low rubble-covered rises on both sides of the Adelaide River. Several very small faults were noted. These are thought to be associated with minor folds and contortions in the slate and would not affect any dam construction. Cleavage in the slate is nearly vertical; it strikes north-north-east and is possibly parallel to the bedding. Some sheared fine-grained greywacke is associated with the slate on the south abutment. The south abutment area consists of one large hill of slate. The north area consists of two hills, marked A and B (Plate 3), either of which could be utilised.

The abutment areas are separated by about 3,000 feet of alluvial plain. The alluvium is fine silty material of unknown depth. It is underlain by poorly cemented ferruginous gravel in some places, and may conceal old channels of the Adelaide River.

Spillway

Natural spillway sites are available for both north abutment areas.

If area A is used, a low saddle to the north-east, about 20 feet above bank level, forms a natural spillway site. The saddle would have to be widened and strengthened but the extent of such work cannot be estimated from the available data.

If area B is used, a saddle between B and the northern extension of A is a better natural spillway site, but would need strengthening.

Both saddles are floored by slate of the Golden Dyke Formation. This would be highly susceptible to scouring, and extensive concrete work might be necessary to prevent this and to protect the abutments of the dam wall. It is thought that both spillways are too small to take the peak floods of the river and provision for this would have to be incorporated in the wall design.

Construction and Materials

The depth to sound bedrock would have to be determined by seismic testing and a close pattern of auger holes, supplemented by diamond drilling, before a decision on the suitability of the foundations could be made. The maximum depth of water that can be impounded is only 20 feet and it is unlikely that the foundations would be too weak for a wall less than 30 feet high with a 3,000 foot crest line. A concrete wall involving flood gates or over-shot spillway is envisaged. No local supply of sand and aggregate is known but suitable quarry sites for aggregate can be found about 5 miles west of the river.

Catchment and Storage

Data on the catchment and storage areas are not yet available, but a brief investigation indicated that the storage area would include a large proportion of alluvial flats that are very susceptible to erosion. Silting of the dam might therefore become a serious problem. The river flows between levee banks that are bound and protected by a rich growth of vegetation, and if this vegetation is drowned by a permanent raising of the water level, the banks may collapse. It would be impossible to control such collapse until an extensive natural growth of weeds binds the alluvium. Although this would not affect storage capacity, it could impose a severe strain on the filter plant.

WEIR SITES

Several potential sites for low weirs were examined. All sites are at places where bars of Golden Dyke Formation slate crop out in the bed of the river.

Many problems are common to the sites. The river meanders over a wide plain that has been covered by ferruginous gravel, partly exhumed, and then covered by alluvium. Several abandoned channels on the alluvial flats are known and others, filled by silt, may occur. The abutment areas for any weir must be on solid rock and no such rock is known to occur on the alluvial flats. Seismic testing supplemented by auger holes, costeaning, and diamond drilling would be necessary to determine the depth to bedrock below the flats. The weir would probably have to be extended as an underground concrete membrane up to 4 miles long to avoid scouring around the ends. If this is not done, the only result of weir construction may be to divert the river into one of its old channels.

If a weir is considered to be desirable, the best site may be the proposed Dirty Lagoon damsite. Although the depth to bedrock is not known, it is thought to be less than farther downstream, and the total length of weir and membrane is only 3,000 feet. As seismic testing and a close pattern of auger holes will be needed, further investigation of foundation conditions is not recommended until all relevant hydrological and topographic surveys have been completed.

DARWIN RIVER DAMSITES

The proposed Darwin River project involves the construction of a dam near the railway bridge across the river, and a ponding reservoir downstream from the dam. Access to the damsite is via the Stuart Highway for 35½ miles south from Darwin; by a good all weather gravel road westerly for 7 miles to Southport Siding on the railway line; and thence westerly 4 miles by gravel road to the R.A.A.F. quarry site, and one mile by bush track. Access to the proposed site of the ponding reservoir is north-westerly by bush track for 4 miles from Southport Siding.

The damsite was mapped on 2nd and 3rd May, 1962, by tape and compass survey at a scale of 50 feet to 1 inch, using a base map prepared by Water Resources Branch.

Mapping of the wall site for the ponding reservoir has not been completed pending an extension of the topographical survey downstream to confirm the existence of a more suitable site than the one selected initially.

Geology

The damsite is at a gap in a north-north-east trending ridge of quartzite of the Acacia Gap Member of the Masson Formation. The true strike is approximately at right angles to the river, ranging from 015° to 025°, and the dip ranges from about 40° to 65° west-north-west. The section exposed in the railway cutting on the north bank of the Darwin River shows that the quartzite is not homogeneous, but that the main ridge is more than 70% quartzite with minor phyllitic intercalations. Some of the intercalations lens out in the 20 feet width of the cutting. Minor facies variation along strike are abundant.

One tiny shear plane was mapped in the railway cutting, but no large scale faults or folds are known or suspected. Strong easterly joints occur, but no dominant joint direction is apparent. Since no bedrock is exposed in the river bed, seismic testing and drilling or deep excavation will be required to indicate the depth to fresh rock beneath the alluvial gravel that forms the river banks and the foundation conditions likely to be encountered in this bedrock. Probably grouting will be necessary.

Spillway

No natural spillway is known and it may be necessary to incorporate a spillway in the wall or to excavate a side spillway. However, during a flight to Wave Hill a saddle was noted about 2 miles west of the damsite, and this may be worth investigating as a possible spillway. The final

decision would depend on the amount of excavation needed, and the extent to which the excavated material could be utilised, and the cost of transport from the spillway to the wall.

Construction and Materials

The quartzite is excellent material for concrete aggregate and is quarried for that purpose but no local source of sand has been located. The foundations are probably suitable for any type of dam construction, and the controlling factor in such construction will probably be the spillway.

The length of crest line would be 625 feet for a wall 50 feet above bank level, and 850 feet for a wall 65 feet high.

Catchment and Storage

The catchment area is 78.1 square miles and the storage area at 50 feet above bank level is about 3,700 acres or about 9% of the catchment. The catchment is floored by ferruginous gravel resting upon slate of the Golden Dyke and Burrell Creek Formations.

DARWIN RIVER PONDING RESERVOIR

To supplement the Darwin River dam it is proposed to build a small wall downstream to hold a few days' supply of water in a ponding reservoir, replenished by flow from the main dam. Water from this reservoir could be piped to Darwin, the main advantage of such a scheme being the reduction in pipe line and pumping costs; the ponding reservoir also has a catchment area of 29.6 square miles additional to that of the damsite. The final survey of the proposed site for this wall has not been completed pending completion of the topographic survey.

In the area concerned, the Darwin River runs for about one mile through a shallow gorge in Depot Creek Sandstone.* Bedding is flat to undulating. The sandstone is strongly silicified in places and is well jointed. Some of the joints are sealed by sandstone breccias comparable to those found in the type areas of Depot Creek Sandstone.

The sandstone would provide adequate foundation material for the 400-feet-long and 25-feet-high wall needed for the reservoir and the final site selection depends on the topographic survey. If this is favourable, it may be possible to select a wall site at which the dip is upstream, to minimise the danger of leakage out of the ponding reservoir.

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* Southport 1 Mile Map shows the rocks in the gorge as Golden Dyke Formation.

COMPARISON OF DAMSITES

From the attached table (Appendix 1) it appears that the Adelaide River Gorge and the Darwin River sites offer the most attractive prospects. If the capacity of the Darwin River project is considered to be adequate, the final decision would depend on the economics of the two schemes.

The shorter walls and greater storage of the Adelaide River Gorge will have to be offset against the shorter pipe line and lower pumping costs of the Darwin River project. It must be pointed out that the construction of a dam near the Darwin River railway bridge would necessitate re-routing of the railway line and construction of a new bridge, as the present line and bridge would be submerged in the storage area. As the railway line and bridge may need extensive reconstruction if an iron ore exporting industry is developed, an early decision on the damsite is necessary.

Diamond drilling and seismic testing would be necessary at both sites before a final decision could be made, if neither dam has marked economic advantages. The detailed drilling programme would depend upon the type of wall to be built. For that reason, detailed drilling proposals cannot be given pending consultation with the engineers concerned.

ACKNOWLEDGEMENTS

Acknowledgements are made to the Director, Water Resources Branch, Northern Territory Administration, for supplying all hydrological data and most of the base maps used in the surveys; and to the Director, Lands and Surveys Branch, Northern Territory Administration, for supplying the Acacia Gap base map.

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NOAKES, L.C., 1949 - A geological reconnaissance of the Katherine-Darwin Region. Bur.Min.Resour.Aust.Bull.16

HAYS, J., 1961 - Preliminary geological investigation of Adelaide River damsite, Northern Territory. Final Report. Bur.Min.Resour.Aust.Rec. 1961/83 (unpubl.)

APPENDIX 1 - COMPARISON OF DAM SITES

	LOCALITY	ADELAIDE RIVER GORGE	ADELAIDE RIVER DIRTY LAGOON	ACACIA GAP	DARWIN RIVER
1.	Direct Distance: Pump Station-Darwin	57 Miles	40 Miles	34 Miles	21 Miles
2.	Access	Good at all seasons	Dry season only	Dry season only	Good at all seasons
3.	Foundations	Probably good for all types of construction. Diamond drilling and seismic testing necessary.	Largely unknown. Probably adequate for low weir. Diamond drilling and seismic testing necessary.	Probably adequate for rock fill etc. Diamond drilling and seismic testing necessary.	Probably very good for alltypes of construction. Diamond drilling and seismic testing necessary.
4.	Spillway	Good natural. Diamond drilling and seismic testing necessary.	Poor natural. Diamond drilling and seismic testing necessary.	Poor natural. Diamond drilling and seismic testing necessary.	Possible natural. Diamond drilling and seismic testing may be necessary.
5.	Materials	No sand Fair aggregate	No sand No aggregate	No sand Good aggregate	No sand Good aggregate
6.	Approx. Maximum possible depth of water above bank.	120 feet	20 feet	60 feet	65 feet
7.	Crest length at maximum depth.	600-800 feet	3,000 feet	1,060 feet	850 feet.
8.	Storage at maximum depth) area) vol.	13,000 acres 640,000 ac/ft.	Not known	6,000 acres 116,000 ac/ft.	7,600 acres 143,000 ac/ft.
9.	Crest length 50 feet above bank.	400 feet	--	820 feet	625 feet

APPENDIX 1 (Cont.)

	LOCALITY	ADELAIDE RIVER GORGE	ADELAIDE RIVER DIRTY LAGOON	ACACIA GAP	DARWIN RIVER
10.	Storage at 50 feet) area) vol.	3,500 acres 80,000 ac/ft.	-- --	4,800 acres 33,000 ac/ft.	3,400 acres 57,000 ac/ft.
11.	Catchment	250 square miles	1200-1500 square miles	56.8 square miles	78.1 square miles plus 29.6 square miles ponding reservoir.
12.	Storage : Catchment Ratio) Max. depth	1:12	Not known	1:6	1:6.5
	) 50' depth	1:50		1:8	1:15
13.	Annual Discharge ($acre\ ft \times 10^{-3}$) Max.	370	920	44	± 90) Estimated
	Min.	21	180	5	± 10) Estimated
14.	Annual Rainfall Range	35 - 55 ins.	35 - 55 ins.	35 - 55 ins.	35 - 55 ins.
15.	Susceptibility to Silting	Probably low	Very high	Probably low	Probably low.

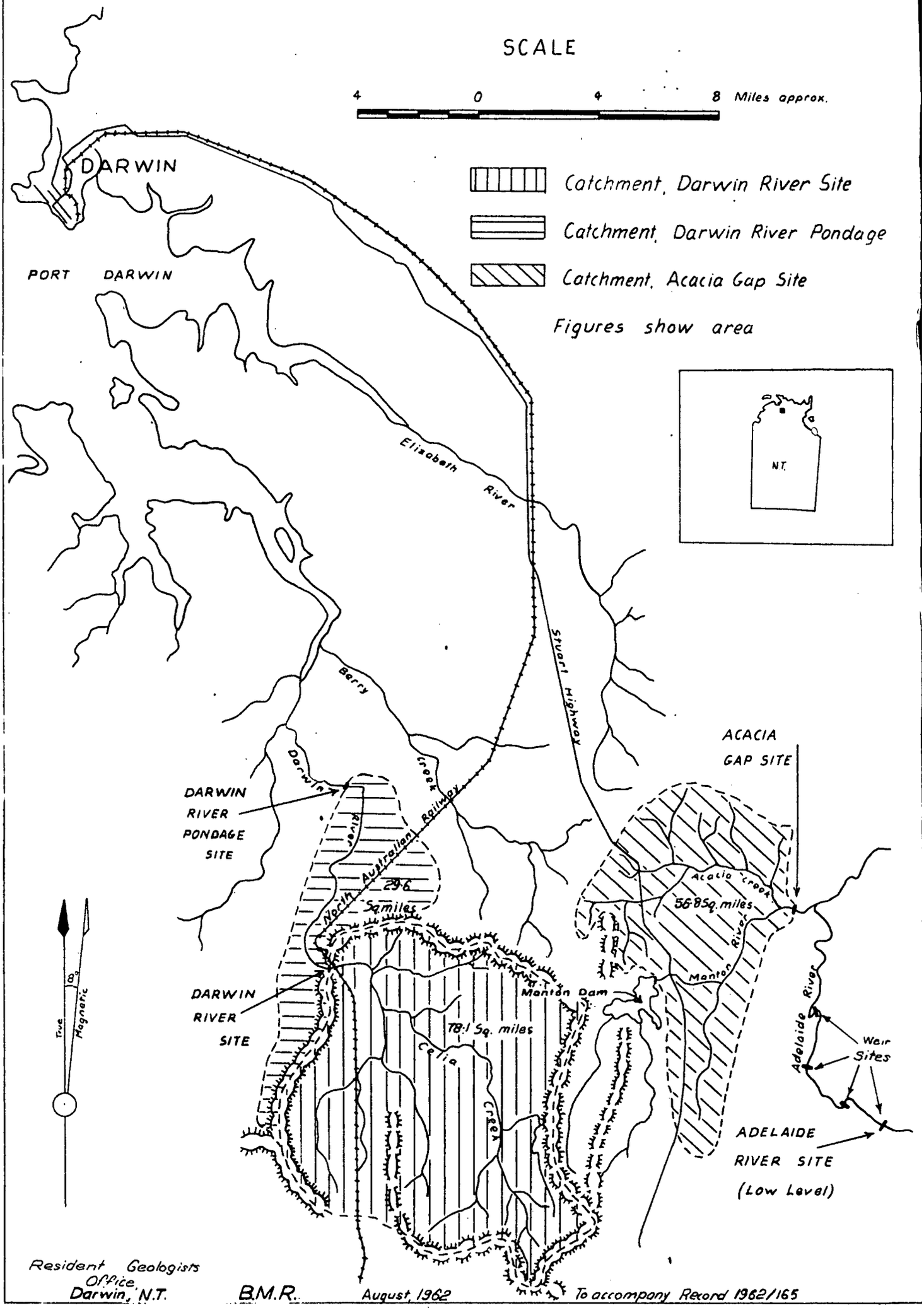
PLATE 1

LOCALITY MAP

DARWIN WATER SUPPLY.

SCALE

4 0 4 8 Miles approx.



Resident Geologists Office, Darwin, N.T. B.M.R. August 1962 To accompany Record 1962/165

PLATE 2

GEOLOGICAL MAP OF ACACIA GAP DAM SITE

NORTHERN TERRITORY

SCALE

80 0 80 160 240 320 400 Feet

REFERENCE

LOWER PROTEROZOIC { Masson Formation Acacia Gap Member

- QUARTZITE — Line of outcrop
- QUARTZITE — Concentrated rubble probably concealing near-surface rock in situ
- SHEARED GREYWACKE
- Strike and inferred dip of bedding — Vertical / Steeply dipping
- Concrete bench mark
- Uniform vehicle track
- 100 — Contour line: Darwin town datum

Slate and quartzite rubble

NATURAL SPILLWAY

Quartzite and slate rubble

Coarse quartzite rubble

Quartzite blocks and very coarse rubble

Coarse quartzite rubble

Alluvial flats

Acacia Gap Lagoon

Photo Lineament

CENTRE-LINE OF WALL

Quartzite rubble

Quartzite rubble

Alluvial flats

Resident Geologist Office. B.M.R. Darwin. August 1962

To accompany Record 1962/165

PLATE 3

GEOLOGICAL MAP
ADELAIDE RIVER LOW LEVEL DAM SITE

SCALE

200 0 200 400 600 800 feet

REFERENCE

- Recent Alluvium
- LOWER PROTEROZOIC Golden Dyke Formation {Ferruginous Slate, Slaty Greywacke, Chert
- 70° Strike and dip of bedding
- Cleavage - Vertical
- 30° Strike and dip of joints
- C.B. Survey mark
- 80 Contour line - Darwin town datum

ABUTMENT AREA 'B'

ABUTMENT AREA 'A'

SPILLWAY 'B'

SPILLWAY 'A'

Slate rubble hill with numerous small outcrops

Slate rubble

Chert fragments in Slate rubble

Slate rubble hill with numerous small outcrops

Slaty greywacke blocks

Slate rubble

Chert rubble

Chert

Slate and slaty greywacke rubble hill

Lagoon

Levee Bank

CENTRE-LINE of WALL

To Stuart Highway

To Marrakai

Dirty Lagoon

ADELAIDE RIVER

C.B.

Resident Geologist, Mt. Isa, N.T. August 1962

To accompany Record 1962/165

PLATE 4

LOCALITY SKETCH MAP
ADELAIDE RIVER
WEIR SITES

SCALE (miles approx)

0 ½ 1 1½

Alluvial flats

ADELAIDE RIVER

Possible Wier Site

Lagoon

Channel

Zone of possible concealed old channel

Limit of alluvium (approx)

Resident Geologists Office, B.M.R. Darwin. N.T. August 1962

To accompany Record 1962/165

PLATE 5

Railway cutting

Quartzite blocks and rubble

Quartzite rubble

Spoil from cutting

DARWIN RIVER

Alluvial or ferricrete flats

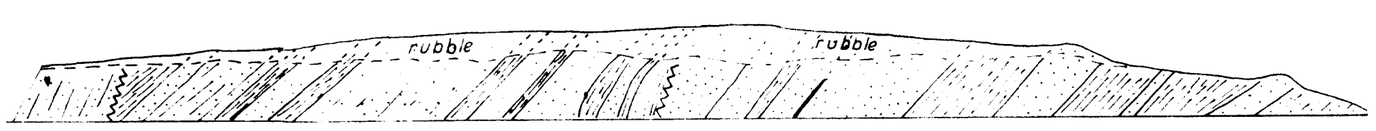
North Australian Railway

Quartzite blocks and rubble

Quartzite rubble

155' 150' 145' 140' 135' 130' 125' 120' 115' 110' 105' 100' 95' 90' 85'

Simplified section north face of railway cutting



Simplified section south face of railway cutting

GEOLOGICAL MAP OF THE DARWIN RIVER DAM SITE

SCALE

50 0 50 100 150 200 250 feet

REFERENCE

LOWER PROTEROZOIC — Masson Formation, Acacia Gap Member

- Quartzite
- Interbedded quartzite and slate
- Phyllitic slate
- Small fault or shear
- Quartz blow
- Boundary of outcrop
- Boundary of probable sub-surface outcrop
- 150' Contour line; Darwin town datum
- Uniform vehicle track

Resident Geologists Office, B.M.R., Darwin, N.T. August 1962

To accompany Record 1962/165