COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES GEOLOGY AND GEOPHYSICS

RECORDS:

1967/21

INVESTIGATIONS FOR THE TOWN WATER SUPPLY FOR DARU, WESTERN DISTRICT, PAPUA

by

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SUMMARY

Investigations for a town water supply for Daru, Western District, Papua, were carried out between 1962 and 1966.

Examination of the rainfall records has shown that if adequate storage is provided, catchment from the average European-style house will be sufficient to last through the dry season with less than average rainfall. It is recommended that the rainwater storage on most buildings be increased.

Drilling for 6 bores has located supplies of marginal quality water. It is recommended that these be developed as a source of water for fire-fighting, ablutions and washing.

A detailed study of the shallow wells on the island has revealed an area which contains good quality water throughout the year. However, the yield from the shallow aquifer is low, and it is recommended that sanitary wells with low capacity pumps be constructed to supply drinking water to the villages.

The proposal to obtain water by piping from rivers on the mainland has been found to be uneconomic and it is recommended that no further investigation be made at this stage.

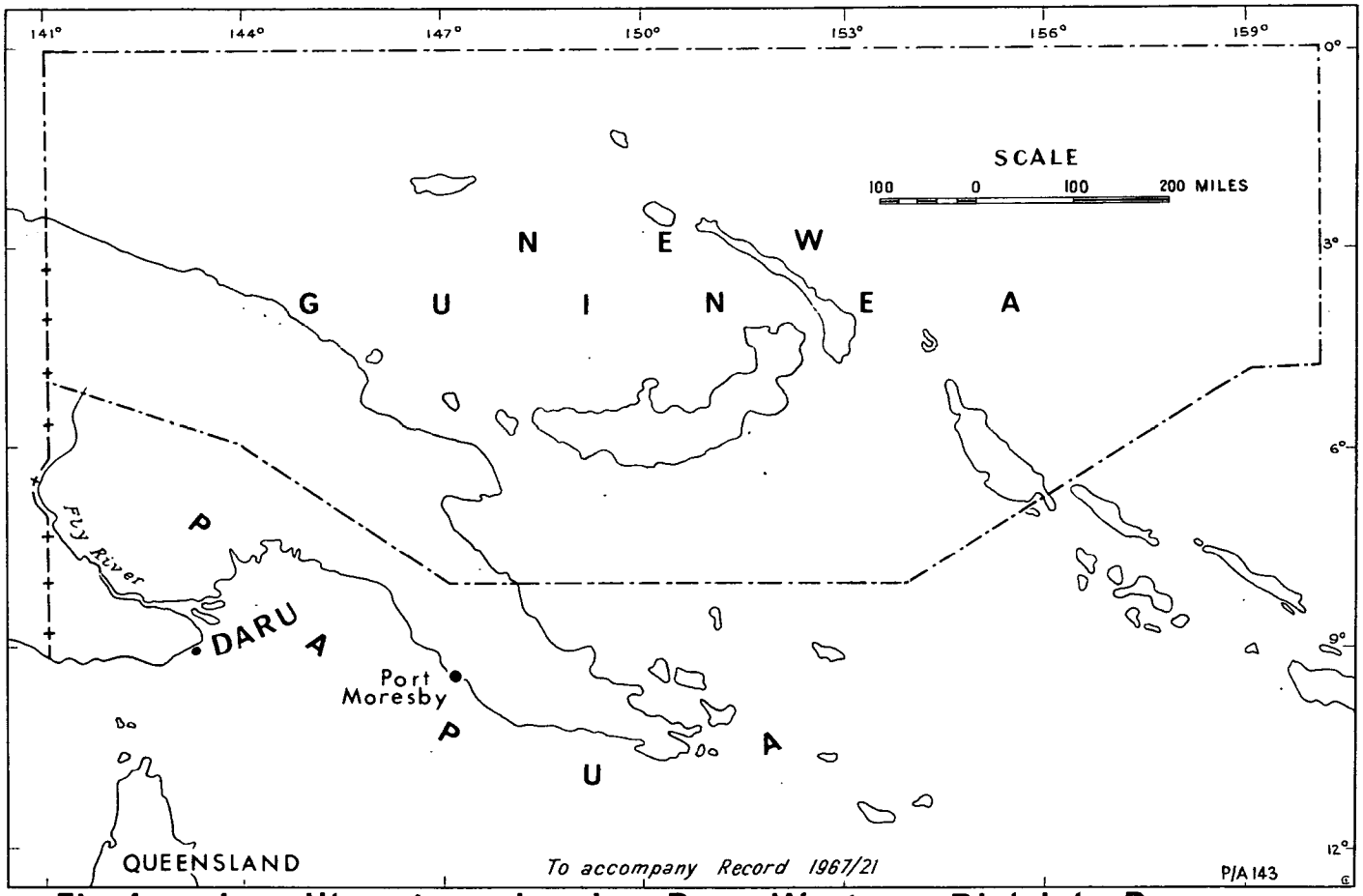

Fig. 1. Locality plan showing Daru, Western District, Papua

INTRODUCTION.

The township of Daru, the District Headquarters of the Western District, is located on a small island of the same name about 2 miles south of the mainland of Papua. (See Figure 1). The population of the island is about 3,700, including 200 non-indigenes. In addition to the Administration Departments on the island, there is a hospital, high school and several well-established private businesses.

In Daru the dry season normally extends from June to December each year. The Europeans derive their water mainly from rainwater catchment and storage while the indigenes living in native-materials buildings obtain their water from shallow wells. As the town has developed there have been numerous complaints of shortage of drinking water towards the end of the dry season, because of the lack of rain or because the wells turn salty. At the request of the Department of the Administrator, Commonwealth Department of Works commenced an investigation for the town water supply in November 1962 which involved the sinking of wells, the drilling of bores and testing of water yield and quality. The Department of Public Health and the Geological Section, Department of Lands, Surveys and Mines, have also been involved in the investigation.

On a visit to the island in November, 1966, it was found that many people in the town were doubtful of the extent of the investigation and the nature of the proposals for the town. This note is intended to summarise the investigations carried out so far, list the conclusions which can be derived from the investigation and make recommendations as to how the results of the investigation can be implemented.

Four possible sources of drinking water for the town of Daru have been considered : (a) rainwater catchment, (b) groundwater from bores, (c) groundwater from shallow wells and (d) piped water from the mainland of Papua. Each of these is dealt with in some detail.

RAINWATER CATCHMENT

Investigation

Rainfall records were first kept in Daru in 1894. Several years' records are incomplete but the average rainfall for 50 years with complete readings is 82.55 inches. Of these, in 23 years the rainfall was above the average, with a maximum of 156.34 inches; in 27 years it was below the average, with a minimum of 45.79 inches. In 4 years the fall was under 50 inches, in 8 years under 60 inches, in 9 years under 65 inches and in 14 years under 70 inches. Thus the chance of getting less than 65 inches of rain in one year is less than one in five.

The average European-type house has a roof area of 1200 square feet. One inch of rainfall on this roof would yield 624 gallons of water of which, on an average, two-thirds or 415 gallons could be collected in tanks. For a year of 65 inches of rain this would average 74 gallons of water per day from this size of roof.

Effect of Dry Season

For an average dry season the rainfall in June is 380 points, July 330, August 220, September 170, October 220, November 460 points giving 7,360 gallons from a 1200 square foot roof catchment. With a full 6000-gallon storage tank at the end of November an average supply of 73 gallons per day would be available throughout the six-months long dry season.

However, in an exceptionally dry season such as 1965 the rainfall was considerably less than average : June 181 points, July 124, August 78, September 133, October 86, and November 29 points. This would have yielded a total of 2610 gallons from a 1200 square foot catchment. For a house with a 1000-gallon storage this would provide an average of 20 gallons per day (gpd) for the 6 months of drought, with a 2000-gallon storage 25 gpd, with a 4000-gallon storage 36gpd, and with a 6000-gallon storage 47 gpd, or more than 9 gallons per head for a family of five. The value of increased storage is obvious.

A 1200 square foot roof requires 14.4 inches of rain to fill a 6000-gallon storage. A house of half the roof area would require double the rainfall to fill the same storage; however, precipitation in the rainy season on Daru is great enough to do this. A house of 600 square foot catchment with a 6000-gallon storage in 1965 would have been able to sustain a demand of 40 gallons per day throughout the 6-month dry season.

Storage

In a report on the water supply for Daru presented on 14th November, 1962, Mr. E.L. Douglas of the Commonwealth Department of Works recommended the increase of rainwater storage at all European-type houses to 6000 gallons. On a visit to Daru in November 1966 it was observed that very few of the houses possess storage of this capacity. This was especially obvious on the privately owned houses. There were also several large buildings, both government and private, with little or no storage; these buildings could provide a considerable quantity of water for people who do not have the necessary roof catchment.

The lift of a galvanized iron rainwater tank close to the coast is short; it varies from 3 to 7 years, depending on its situation and maintenance. Replacement costs are therefore high. However, there are now fibreglass tanks on the market which can be bought for comparable prices and which should have an almost indefinite life. The construction of large concrete tanks - possibly sharing the catchment of more than one house - should prove to be an economic proposition in the light of the cost of alternative provision of adequate drinking water supplies.

GROUNDWATER FROM BORES

Investigation

Six bores for groundwater have been drilled by Commonwealth Department of Works on Daru.

Bore No.1, situated between the District Commissioner's house and the new Hospital, reached a depth of 124 feet and located water between 111 feet and 123 feet. The bore was test-pumped at 4000 gallons per hour with a 2-foot drawdown, but a chemical analysis of the water indicated a total soluble salt content of over 2500 parts per million (ppm).

Bore No.2, close to the old town storage tank and at present equipped with an electric pump and supplying the Daru Hotel, was drilled to 600 feet and encountered water in grey sandstone between 236 feet and 279 feet and also at the bottom of the hole. The water from 600 feet gave a salt content of over 3000 ppm and the hole was back-filled and plugged with concrete at 274 feet. Salinity tests of water from the upper zone gave a total soluble salt content of 2300 ppm, with chloride content 1050 ppm.

Bore No. 3, beside the Public Works Department Office and at present fitted with a hand pump, was drilled to 105 feet and obtained water from yellow sandstone between 87 feet and 105 feet. This bore was tested for 7 days at 1400 gph with a 2-3 foot drawdown. The water contained 1600 ppm soluble salts including 700 ppm chloride.

Bore No. 4, at the Recreation Ground, at present equipped with a diesel pump and supplying water to the hospital well, was drilled to about 100 feet. No details of this bore are known but they are probably similar to bores Nos. 3,5 and 6. Salinity tests on water from the bore showed a total soluble salt content of 1600 ppm and 780 ppm chloride. No pump tests have been carried out.

Bore No. 5, beside the L.M.S. Mission and now equipped with a hand pump, was drilled to 139 feet and located water in yellow sandstone between 129 feet and 139 feet. The bore was tested for 7 days at 1400 gph with a small drawdown and water quality tests indicated a total soluble salt content of 1300 ppm with 600 ppm chloride.

Bore No. 6, near the High School and fitted with an electric pump to supply water for the airfield construction, was drilled to 115 feet and obtained water from limestone between 94 and 115 feet. The bore was test-pumped for 7 days at 1400 gph with a 4-6 foot drawdown and gave water with a total soluble salt content of 1500 ppm and 640 ppm chloride.

Water Quality

The World Health Organisation recommends that the total soluble salt content of drinking water should not exceed 1500 ppm and the chloride content should not exceed 600 ppm. The water from Daru Bores No. 1 and No. 2 considerably exceeds this figure and these bores have been rejected. However, Bores Nos. 3., 4, 5 and 6 yield water close to the maximum allowable and although hard, and with a brackish taste, would not cause any danger to health. In some parts of continental Australia town supplies have higher salt contents than this water. Testing of the water from the bores over a period of years since they were drilled has shown only slight fluctuations in water quality even after extended pumping.

Water Quantity

Bores Nos. 3, 5, and 6 were test-pumped in November 1965 for 7 days at 1400 gph (the maximum output of the pump available) with a drawdown to 1-4 feet above sea level. These results indicate that the bores would be capable of supplying at least this amount of water indefinitely. Bore No. 4 has not been test-pumped but would probably give similar results.

Development of Bore Supplies

The marginal quality of the water obtained from the bores indicated that it is not suitable for reticulation as a drinking water supply. However, as a fire-fighting precaution, and for washing, ablutions and drinking in the case of extreme drought, the Commonwealth Department of Works proposed two schemes, one with piped mains throughout the town and fitted with hydrants costing an estimated $120,000 and the other consisting of tanks with hydrants on Bores Nos. 3,5 and 6 costing an estimated $15,000. The second scheme was approved by the Administration and installation is now in hand.

GROUNDWATER FROM SHALLOW WELLS

Investigation.

Most of the local inhabitants of Daru obtain their supplies of drinking and washing water from numerous shallow wells located mainly on the northern and western side of the island. These wells normally consist of open holes, sometimes lined with steel drums, which vary in depth up to 25 feet and obtain the water from an aquifer of grey tuffaceous sandstone which underlies the island. Cuttings recovered from the bores drilled by Commonwealth Department of Works indicate that this sandstone is almost horizontal and ranges from 10 to 50 feet in thickness. It is usually found immediately beneath the top-soil. The bottom of the sandstone is found up to 12 feet below sea level and it is underlain by a thick layer of yellow and blue clay.

In 1964 and 1965 the Geological Section of the Department of Lands carried out a survey of the potential of the shallow wells on the island. In March 1964, 92 wells were topographically surveyed, the depth to standing water measured and samples of water from each well were taken for chemical analysis. As the survey had been carried out in the wet season the water levels were not significant and the quality of the water was good. In September. 1965, in the middle of a very dry period, the survey was repeated and water levels and samples taken from 59 wells. The remainder of the wells were either dry or had been filled in. The interpretation of the results of this survey has not yet been completed but Plate 1 shows the total soluble salt determination for each of the wells sampled in 1965 with isohalines drawn to indicate areas of equal salinity. Most of the wells which had dried up were very shallow and deepening would probably have located water.

This survey has shown that even in the middle of the dry season there is a body of good quality groundwater at shallow depth beneath Daru.

Yield from Wells

The flow of water into the shallow wells on the island is slow due to the low hydraulic head and also to the relatively low permeability of the sandstone aquifer. The only way to obtain a considerable quantity of water is to ensure that the wells are properly constructed and to use a large number of wells. One way of increasing the yield in each well is to ensure that the well is deepened to the base of the aquifer, i.e. until the blue or yellow clay is reached. Thus the total thickness of the aquifer can be used to provide the maximum inflow of water. The average depth of well would be between 15 and 30 feet depending on the relative position of the sandstone. This is considerably deeper than most of the wells at present in use.

The hospital is at present partially supplied by low capacity electric pumps fitted on wells Nos. 6, 9, 22 and 23 on Plate 1. These wells supply good quality water but not in sufficient quantity for the hospital's needs.

Pollution of Water in Wells

All the open wells on the island are polluted. This pollution can be derived in two ways; from pit latrines within 100 yards of the well and from contamination of the water in the well from the surface. The first source of pollution can be easily remedied but the protection against pollution by frogs, leaves, buckets and other objects including surface water is more difficult. The only way to ensure that the water in the well is free from harmful bacteria is to line the well with concrete (or fiberglass), seal it from all surface water and fit the well with a hand or power pump with the outlet at some distance from the well. The Department of Public Health has produced drawings of a Standard Sanitary Well which will fulfil all requirements. The lining of the well with iron drums, even if galvanised, eventually contaminates the water by the introduction of rust.

Development of Shallow Well Supplies.

The chemical quality of the water from shallow wells in the centre of the Daru Island as indicated on Plate 1 is considerably better than that produced from the bores, and is quite acceptable as drinking water. It seems, however, that because of the number of wells which would be required to cope with the estimated demand, and the cost of reticulation, that a town supply solely derived from shallow wells is not an economic proposition. Further investigation would be needed to establish whether enough water is contained in the shallow aquifer and whether the recharge rate of the aquifer is sufficient to cope with the demands of the developing town.

The provision of several, suitably positioned, properly constructed and protected, shallow wells, fitted either with a hand-pump or low capacity power pump and storage tank, would provide an adequate supply of good quality drinking water throughout the year to the inhabitants of the island. As a further extension of this proposal it might be possible to pipe water from some of these wells to a central hydrant in the villages close to the coast which have no prospect of obtaining good water from wells.

PIPED RIVER WATER FROM MAINLAND

Two schemes have been proposed for a piped water supply from a river on the mainland of Papua. One scheme involves pumping from the Oriomo River and the other from the Binaturi River. Assuming that the water quality is good, both schemes would involve the construction of a pumping and treatment plant, the laying of 7 to 9 miles of pipe-line which would have to include 2 miles on the sea floor and probably the installation of booster pumps en route. On Daru Island storage and reticulation throughout the town would have to be provided to justify the cost of installation of the scheme.

No detailed investigation has been carried out of either scheme but preliminary estimates place the cost in the region of $500,000 and the Administration has rejected both schemes on economic grounds.

CONCLUSIONS AND RECOMMENDATIONS

Rainwater Catchment

Conclusions.

1. Examination of rainfall figures for Daru have shown that over the last 72 years the average rainfall is over 80 inches per year and that the island can expect at least 65 inches of rain in four years out of five.

2. The provision of adequate rainwater storage on a European-style house would ensure ample supplies of drinking water even in a prolonged drought.

3. At present insufficient rainwater storage is provided on buildings in Daru.

Recommendations.

1. Immediate steps should be taken to increase the amount of rainwater storage on Daru.

2. Consideration should be given to the construction of tanks in concrete or fiberglass rather than galvanised iron.

3. A survey should be made of all buildings on Daru Island and recommendations made of the amount of storage which should be provided.

4. Tanks should be installed on all large buildings to conserve as much rainwater as possible and enable it to be distributed during the dry season to people without adequate roof catchment.

Groundwater from Bores

Conclusions

1. Drilling on Daru has proved an aquifer at a depth of about 100 feet.

2. The bores have been tested for an extended period at 1400 gallons per hour and at least that amount of water could be pumped indefinitely from the bores without materially affecting the quality.

3. The water from the bores contains soluble salts close to the maximum recommended values. However, the water, though brackish should be drinkable with no harmful effects and is suitable for fire-fighting, ablutions and washing. The water is hard.

4. The quality of the water is such that it is not suitable for reticulation as a town water supply.

Recommendations.

1. The installation of the tanks and water points proposed by Commonwealth Department of Works should be carried out as soon as possible.

2. Extension of this system should be considered to Bore No. 4,possibly as a supply to the hospital.

3. Consideration should be given to further test-pumping of one of the bores to establish if greater quantities of water can be obtained without affecting the quality of the water.

4. The attention of the Public should be drawn to the fact that although brackish, the water from the bores would not be harmful to health and is protected from bacteriological pollution and can be drunk if no better supply is available.

Groundwater from Shallow Wells

Conclusions.

1. Examination of the wells and bores on Daru island has shown that a tuffaceous sandstone aquifer is present at shallow depth.

2. In an area in the centre of the island good quality water can be obtained from wells throughout the year (Plate 1.)

3. The flow from the sandstone aquifer into the wells is slow.

4. Most wells are poorly constructed and polluted.

5. Pollution of the wells comes from nearby latrines and from surface contamination.

6. A properly constructed, protected and positioned well would provide an ample supply of water for a low capacity pump.

7. Further investigation is required to prove whether there is sufficient good quality water in the aquifer for a reticulated town supply.

Recommendations.

1. Several Standard Sanitary Wells as specified in P.H.D. drawings should be constructed as soon as possible and fitted with hand-pumps.

2. These wells should be sited in an area with good quality groundwater in the dry season (see Plate 1).

3. The wells should be sunk to the base of the sandstone layer regardless of water level.

4. All latrines and other wells within 100 yards radius of the new wells should be filled in and well sinking in this area should be prohibited.

5. Consideration should be given to the piping of water from some of the wells to central storage tanks in villages close to the coast, to provide drinking water.

6. Villagers should be encouraged to use the water from the wells and either fill in their present wells or use them for washing only.

Piped River Water from Mainland

Conclusions.

1. The cost of the proposed schemes make them uneconomic for a town of the size of Daru.

2. Adequate alternative sources of water exist on the island.

Recommendations.

1. No further investigation for a pumped supply from the mainland should be carried out at this stage.

ACKNOWLEDGEMENTS

The permission of the Director, Commonwealth Department of Works, Port Moresby, to examine departmental files, and the assistance of members of the Department of Public Health, Commonwealth Department of Works, Department of District Administration and Department of Lands, Surveys and Mines in this investigation are gratefully acknowledged.

WELL LOCATION AND WATER QUALITY - SEPTEMBER 1965
DARU ISLAND
WESTERN DISTRICT - PAPUA

SCALE
0 200 400 600 800 1000 feet

N

Cainozoic — Czb — Basalt pyroclasts (range from agglomerate to tuff) containing Miocene limestone fragments.

Probable former volcanic vent

Mangrove Swamp

4 — Water well.

② — Water bore

(410) — Water quality - total soluble salts in parts per million

600ppm — Isohalines

Geological Office, Port Moresby 11:11:66

PNGC54-8-4

To accompany Record 1967/2