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THE WATERWORKS AT ROOIBANK FOR THE SUPPLY OF FRESH WATER FOR WALVIS BAY AND SWAKOPMUND

By H. W. Stengel ≈1961 ?

(This article has originally been published in "Der Kreis", fourth year, No.6/7, June/July 1961, in German language. Only small alterations have been introduced.)

About 20 miles south of Swakopmund lies the growing harbour town of Walvis Bay which the Kuiseb has bounteously supplied with fresh, sweet "Walvis water" for many years. Twenty miles further east, along the sandy bed of the lower Kuiseb, lies Rooibank, called Scheppmannsdorf on old maps, and by the Hottentots "Awahaus" which is their name for the red gneiss Bank which protrudes from the river bank there, disappears again in the sandy river bed and further on forms a natural ground sill in the river. The water flowing underground pushes to the surface here and stands in open pools the whole year round, or runs off in tills. It tastes so brackish and bitter, however, that it is quite unpalatable. In summer the water dries up due to the high daytime evaporation, and in winter it forms a stream for a few hundred yards which is a sure indication of the wealth of ground water in the wide river bed above Rooibank.

In 1846 the missionary Scheppmann of the Rhenisch Mission settled some hundred yards upstream where there is plenty of fresh water near the surface. The palm grove which he planted is still called Scheppmannsdorf to-day.

Rooibank became better known through the water supply project of the Railways Administration.

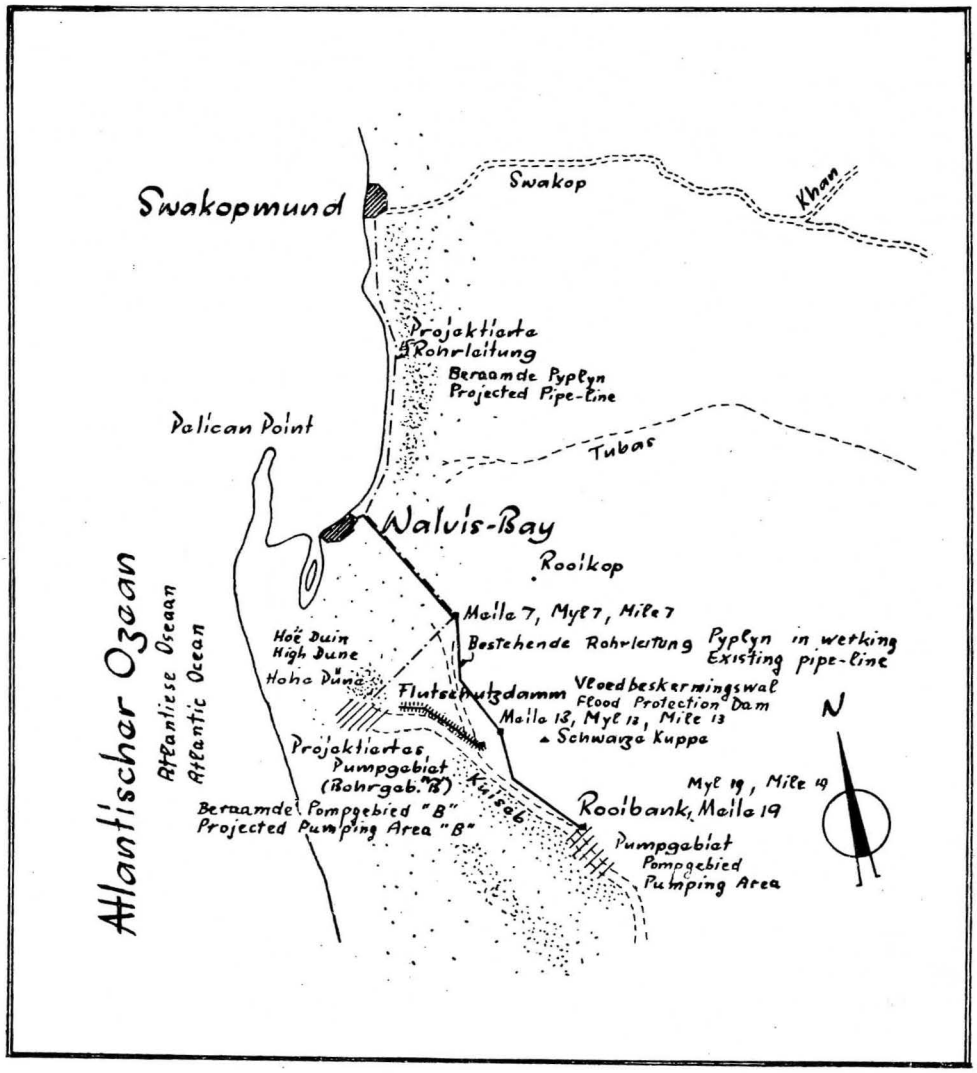
From the beginning of the century into the twenties Walvis Bay got its water from Sandfontein, two miles away. This brackish water was rolled by natives or horses in ordinary 12-25 gallon drums, to the harbour town of 200 inhabitants. Besides this, schooners brought urgently needed drinking water from Cape Town for the Europeans in Walvis Bay. The simple method of drum supply is still found to-day in many towns in Angola.

In his book "Mit Schwert und Pflug in Deutsch-Suedwestafrika" (With Sword and Plough in German South West Africa) Sec. Lt. Schwabe gave his impressions of water conditions in March 1893 in Walvis Bay which then consisted of about 20 houses. He wrote: "Sandfontein lies in the bed of the Kuiseb River which very rarely flows and reaches the sea. However, after the exceptionally good rainy season 1892/93 it flowed into the sea near Walvis Bay through several small channels. The flowing - or as the South Africans call

it 'come down' - of the Kuiseb was a great benefit to the settlement on the Bay which though British territory, was at that time still the most important harbour for the German Protectorate. In the preceding years the water coming from holes dug in the river bed and drawn in casks by horses and donkeys to Walvis Bay, was so brackish and salty that the Europeans used it only for washing, and drinking water was brought from Cape Town every five weeks by the steamer Nautilus. The river water, however, now became less brackish so that it could be drunk by Europeans also in the years which followed."
In those days Sandfontein was a large settlement of Topnaar Hottentots and a more important settlement of this tribe existed at Scheppmannsdorf, but this disappeared completely in the Kuiseb floods of 1904 and was never resettled. The mission station at Scheppmannsdorf was washed away too and the missionary went to live on the Swakop for a few years.
At the beginning of the twenties the Railways began working on a regular water supply for Walvis Bay from Rooibank. Professor R. H. Charters of Johannesburg submitted a plan to the Railways Administration in April 1923 based on investigations he had carried out. Some test borings were made at that time in the bed of the Kuiseb above Rooibank, by the Irrigation Department of the South West Africa Administration. The plan was approved of with a few alterations, and put into effect. It provided for the construction of two wells in the southern part of the Kuiseb above Rooibank, the water of which was intended to run by gravity through a main pipe line to Walvis Bay which at that time consumed an estimated 51,000 gallons of water daily. The pipes were of cast-iron 9 inches in diameter.

Three reservoirs were built at intervals along this 20 mile pipeline: at Mile 19, the actual Rooibank, at Mile 13, and at Mile 7. Rooibank is 450 ft. above sea level. This plant served its purpose until 1934, when, during the great floods, two miles of the pipeline at Rooibank itself were washed away by the high floods of the Kuiseb. This section was replaced by six inch steel piping and as the output was thereby reduced the water had to be pumped from the reservoir into the pipes, and to cope with the increased consumption the water was also pumped out of the wells.
This installation of the railways was well and durably constructed and the two reservoirs at Mile 13 and Mile 7, are to-day working again after structural alterations: the latter only for the use of the railways. Even a section of the old cast iron piping is still in use.
After the second World War the water consumption of the town rose so much that sometimes there was hardly any water and the scarcity was reported in the press. In September 1951 for example water was stopped from 6 p.m. to 9 a.m. and the railways and the fisheries were in serious difficulties.
The Administration came to the rescue and from a favourably situated pipe well, the present Mile 21, supplied 50,000 cbm of water to the railways alone, from the middle of December 1951 until the beginning of March 1952.
In July 1952, the Administration took over the whole of the waterworks at Rooibank, the water mains in Walvis Bay, the three reservoirs and the whole distribution system in the town.
The source of the Rooibank water is the rainfall in the catchment areas of the Kuiseb, which rises 20 miles west of Windhoek. Most of its tributaries drain the Khomas Hochland and provide the river with plenty of fresh water in good rain years. A third of the catchment area lies in the Namib Desert where rare rainfalls feed the river with brackish water causing brackish lenses in the freshwater stream. The water coming down percolates in the 100 - 200 ft. deep

sand bed of the river and then proceeds downstream in the sand at a very much reduced velocity. Brackish and fesh waters often occur next to each other or overlie. Generally the brackish content increases with depth and is appreciably higher on the north bank than in midstream or at the south bank which belongs to the great dune land extending almost to Luederitzbucht. The river bed is up to a mile broad and above Rooibank water is found everywhere within a depth of ten feet. Below Rooibank the water is found 100 - 200 ft. deep and is of better quality throughout. The Kuiseb does not reach Rooibank with surface water every year and reaches the sea only in extraordinarily good rain years. It reached the sea in 1837, 1848, 1849, 1852, 1864, 1881, 1885, 1893, 1904, 1931, 1934. In 1923 the river reached the sea by way of its south distributary ("Meinerts Monatsmagazin, 1931") and in 1941/42, according to verbal reports, the south distributary came down to the sea again. In 1938 the Kuiseb flowed



as far as Rooibank without reaching Walvis Bay and again in 1942, very strongly, in 1948, and in 1950 when it passed Rooibank flowing strongly and filled the Kuiseb Lake on the old road to Swakopmund without reaching Walvis Bay. In 1953 it came down again and a native engaged on the pump service was drowned. The series of come downs continued in 1956/57, but in 1961 the river flowed only as far as the pump station at Mile 24.

A typical cross section through the pumping area at Rooibank measures 26.000 square metres within the water saturated sand. By means of laboratory tests the ground water velocity was estimated at 11.2 inches per day, which means by 30% pore volume, an effective velocity after Darcy of 3.3" (8.4 cm) per day. The daily discharge into the pump area is thus estimated at 2,200 cbm and the annual discharge at 800,000 cbm. In the pump area, extending over six miles there is a volume of ground water of 75 million cbm which is always filled up again at irregular intervals by the Kuiseb come downs. A yearly yield of 1.6 million cbm is therefore quite possible by pumping from this region.

Three ground water basins can be distinguished in the lower Kuiseb Valley. The middle one is Rooibank with the above mentioned yield. By a suitable distribution of pump stations a volume of 1.6 million cbm could be produced. This basin extends over 10 miles from the red gneiss bank, the Rooibank, to Witbank. It has been systematically explored in its lower portion. The upper basin extends from Witbank upwards and has not yet been explored in detail. It is too far from Walvis Bay to be utilized economically at present. The lower basin, below Rooibank, begins at Mile 16 and extends up to 6 miles from the sea with good quality water. This basin has also been systematically bored in recent years and its water reserve is estimated to be the same as that at Rooibank. Water for Swakopmund and additional water for Walvis Bay is taken from here. More details of these preliminary works cannot be discussed here. Some water analyses and parts of two maps from which the ground water supply and water quality isopleths can be seen, are appended to this article.

The flowing or come down of the Kuiseb is of the utmost importance for replenishing the ground water supplies in the lower Kuiseb valley, for often the river flows only in the upper and middle reaches. Volume of discharge and duration of all these come downs are measured by two automatic gauges. At Rooibank an extensive network of gauge boreholes is being erected to control the water level and to record in good time a heavy pump off. For instance, it has been observed that in spite of intensive pumpings the water level rose and it can only be assumed that a much subsided ground water lens had passed the borehole. After many years all these observations lead to valuable conclusions and corresponding actions. At present the pump installations are so elastically designed that each pipe well has a period of pumping and a period of rest.

At test borings, water and sand samples are taken at random at intervals of 3 - 5 ft. The water is analized for quality and the sand is sifted as the size of the grain gives information which is important for the design of the well and for the development of the whole project. The test for water quality, is in most cases merely to determine the residue after evaporation shown here as TDS in ppm (total dissolved solids in parts per million). However, at definite intervals full analyses are carried out. According to South African norms, water up to 2000 TDS in ppm can be used as drinking water. Seawater has about 35,000 TDS in ppm. Brackish content can be tasted at little over 1000 TDS in ppm.

The simplified diagram attached, shows the occurrence of fresh and brackish water in a part of the Kuiseb valley below Ururas with test bore points and details of water quality. Another diagram shows a part of the Bore Area B with sand filling of the river bed and ground water filling. With the help of these diagrams and on the strength of the bore results the original valley can be partly determined and the best points for new borings selected.

SOME EXAMPLES OF BORE RESULTS (ABBREVIATED)
(1 ft. - 30 cms)

Borehole x8, Administration No. 5857 Bore Area "A"

Depth in feet	TDS in ppm
12 - 15	514
15 - 19	512
19 - 25	529
25 - 29	522
29 - 34	507

This borehole has a good quality water.

Borehole y9, Administration No. 5858, Bore Area "A"

Depth in feet	TDS in ppm
8 - 12	867
12 - 18	803
18 - 21	783
21 - 25	782
25 - 28	1399
28 - 32	1429

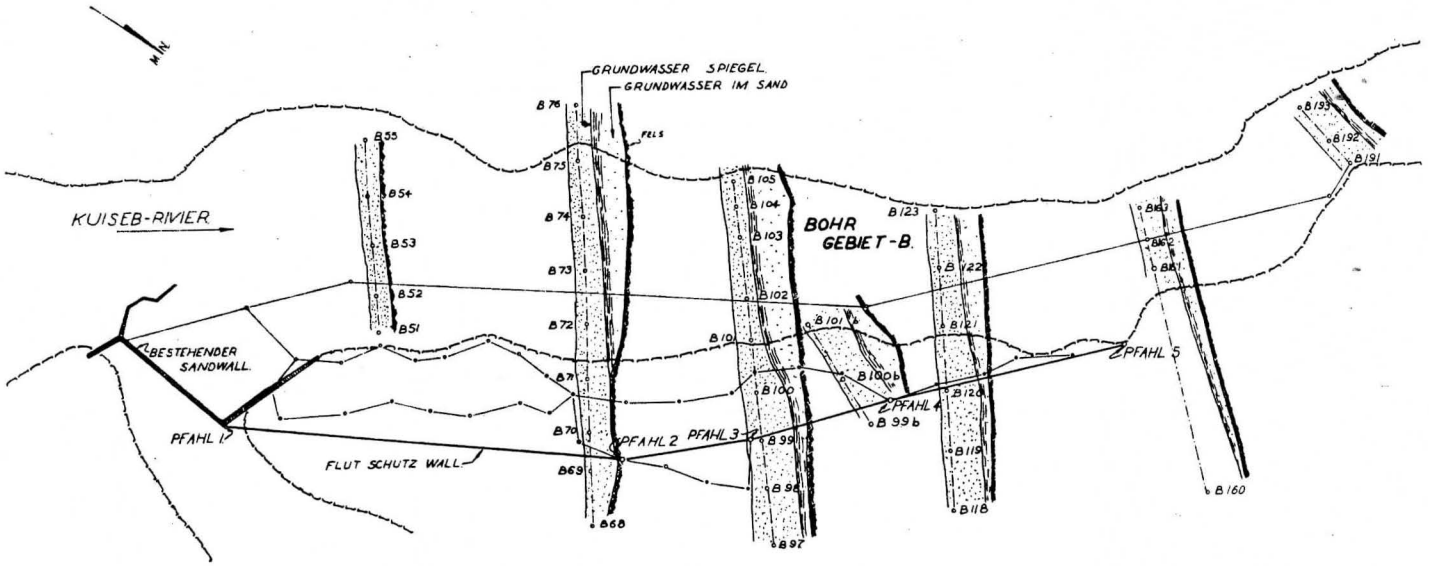
Boreholes with such results are unsatisfactory. Only ground water of 700 TDS in ppm is developed.
In Bore Area "A" TDS values up to 2500 appear in the lower horizons.

Borehole No. B 102 in Bore Area "B"

Depth in feet	TDS in ppm
75 - 83	468
83 - 92	483
92 - 106	481
106 - 123	465
123 - 134	463
134 - 141	475

Borehole No. B 75 Bore Area "B"

Depth in feet	TDS in ppm
104 - 111	572
111 - 115	555
115 - 120	777
120 - 123	566
123 - 130	577
130 - 135	572
135 - 139	580
139 - 143	408



EIN TEIL DES BOHRGEBIETS "B" MIT QUERSCHNITTEN (KUISEB-RIVIER) - 'N DEEL VAN DIE BOORGEBIED "B" MET DWARS-DEURSNITTE DEUR DIE KUISEB-RIVIER - A PART OF BORE AREA "B" WITH CROSS SECTIONS THROUGH THE KUISEB RIVER

MASZSTAB:	SKAAL:	SCALE:
Laengen - 1: 35000	Lengtes: - 1: 35,000	Lengths - 1: 35,000
Hoehen - 1: 5700	Hoogtes - 1: 5,700	Heights - 1: 5,700

VERTALINGE/TRANSLATIONS: Grundwasserspiegel - Grondwaterspieël - Ground water table; Grundwasser im Sand - Grondwater in sand - Ground water in sand; Bohrgebiet "B" - Boorgebied "B" - Bore Area "B"; Bestehender Sandwall - Bestaande sandwal - Existing sand wall; Pfahl - Paal - Pole; Flutschutzwall - Vloedbeskermingswal - Flood protection dam.

Borehole No. B 104 Bore Area "B"

Depth in feet	TDS in ppm
57 - 90	496
90 - 110	486
110 - 125	476
125 - 138	515
138 - 154	441

Several hundreds of these boreholes exist and depending on the surface features of the land, are often only 200 yards apart. With a great many of them the brackish content increases with depth. With the water slowly penetrating downstream in the sand, changes are possible in the quality of borehole water because although the borehole may have been sunk into fresh water, this has, in course of time, been displaced by a brackish stream. Since the Administration took over the water supply at Walvis Bay consumption has increased more than threefold in ten years. In 1951 it was 300,000 cbm a year and in 1961 it had risen to 1 million cbm. The attached graph shows the increase in total consumption and the amounts used by the fisheries, households, railways and other industries.

In June 1961, 110,000 cbm were consumed, apportioned as follows:

S. A. Railways & Harbours	2,409,400 gall.	11,000 cbm
Fisheries	9,661,300 "	44,000 "
Households	5,734,000 "	26,000 "
Ovambo Compound and Location	4,880,800 "	22,000 "
Other Industries	1,702,000 "	7,700 "
	24,387,500 gall.	110,700 cbm

The pump output measured by the control meter at Mile 7 is about 27 million gallons so that the loss of water in the Walvis Bay pipe network is estimated at 9.5% which is a very favourable figure.

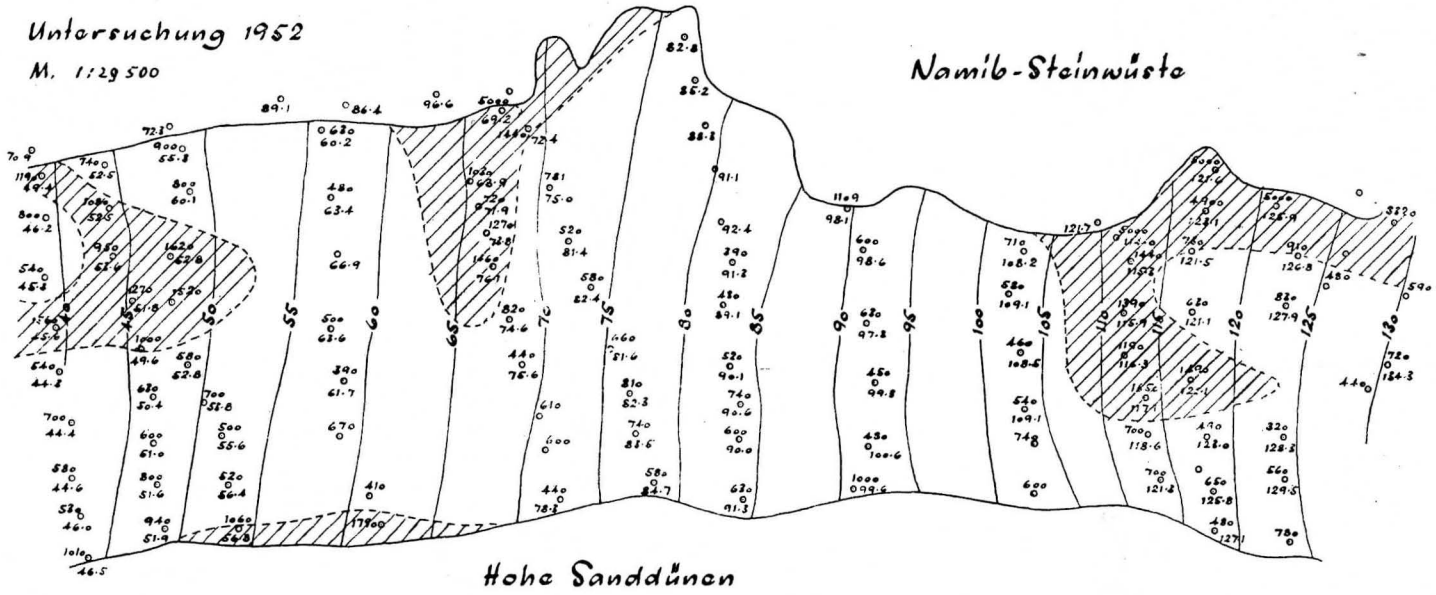
In order to cover the tremendous water consumption of Walvis Bay, a building programme for the extension and improvement of the wells, pipe lines, pumps, machine installations, dwellings for employees and compounds for the natives had to be worked out for the purpose of supplying a million gallons daily to Walvis Bay. During the course of 1959 the programme was carried out to the last detail and to-day Rooibank can supply 1.2 million, i.e. 5,450 cbm, gallons of water to the town daily.

The Rooibank waterworks comprises not only the power station, workshop and dwellings for employees, but also all installations from Mile 7 to Mile 25. The term "Mile" was originally used by the Railways and has been retained. Mile 7 forms the boundary between the two services "water distribution" (Walvis Bay) and "water supply" (Rooibank). There are two reservoirs at Mile 7, the old one of the railways, recently reconstructed with a capacity of 550 cbm, and a new one of 4,500 cbm which covers the maximum demand of Walvis Bay and a small reserve in case of pipe breakage. A third reservoir will become necessary when Swakopmund is connected to the Rooibank water supply and its capacity will be 9,000 cbm. The railway reservoir serves the railways and harbour exclusively and is connected to Walvis Bay by a six inch pipe line belonging to them. In 1952 a 12" main was laid to the town from the large reservoir. This narrows to 10" after one mile. An additional 15" main was completed in 1959. All water flowing through these pipelines to Walvis Bay is controlled by water meters, and it is chlorinated when it flows into the reservoir. The tiled chlorine

Brack und Süßwasser
im Flußbett des Kuiseb
unterhalb Uruas

Untersuchung 1952
M. 1:29 500

460 DTS in ppm (Abdampfungsrückstand)
über 1000 DTS in ppm, Brackwasser
94.2 Flußbetthöhen in Fuss
-75- Unterirdischer Wasserspiegel



VERTALINGE: BRAK EN VARS WATER IN DIE BED VAN DIE KUISEB-RIVIER ONDERKANT URURAS. Skaal: 1:29,500. Toetse uit die jaar 1952. TDS in ppm (Verdampings-restant) - oorskry 1,000 TDS in ppm, Brakwater - Hoogtes van rivierbedding in vt. - Ondergrondse waterspieël. Klipperige Namibwoestyn. Hoë sandduine.

TRANSLATIONS: BRACKISH AND FRESH WATER IN THE BED OF THE KUISEB RIVER BELOW URURAS. Scale 1:29,500. Tests in 1952. TDS in ppm (Evaporation residue) - over 1,000 TDS in ppm, brackish water - Heights of river bed in feet - Underground water table. Namib Stony Desert. High Sand Dunes.

installation consists of two chlorinators one of which is kept as a standby. Two natives are stationed at Mile 7 to control the pipelines and to report the daily fluctuations of the water level in the reservoir to the office at Rooibank.

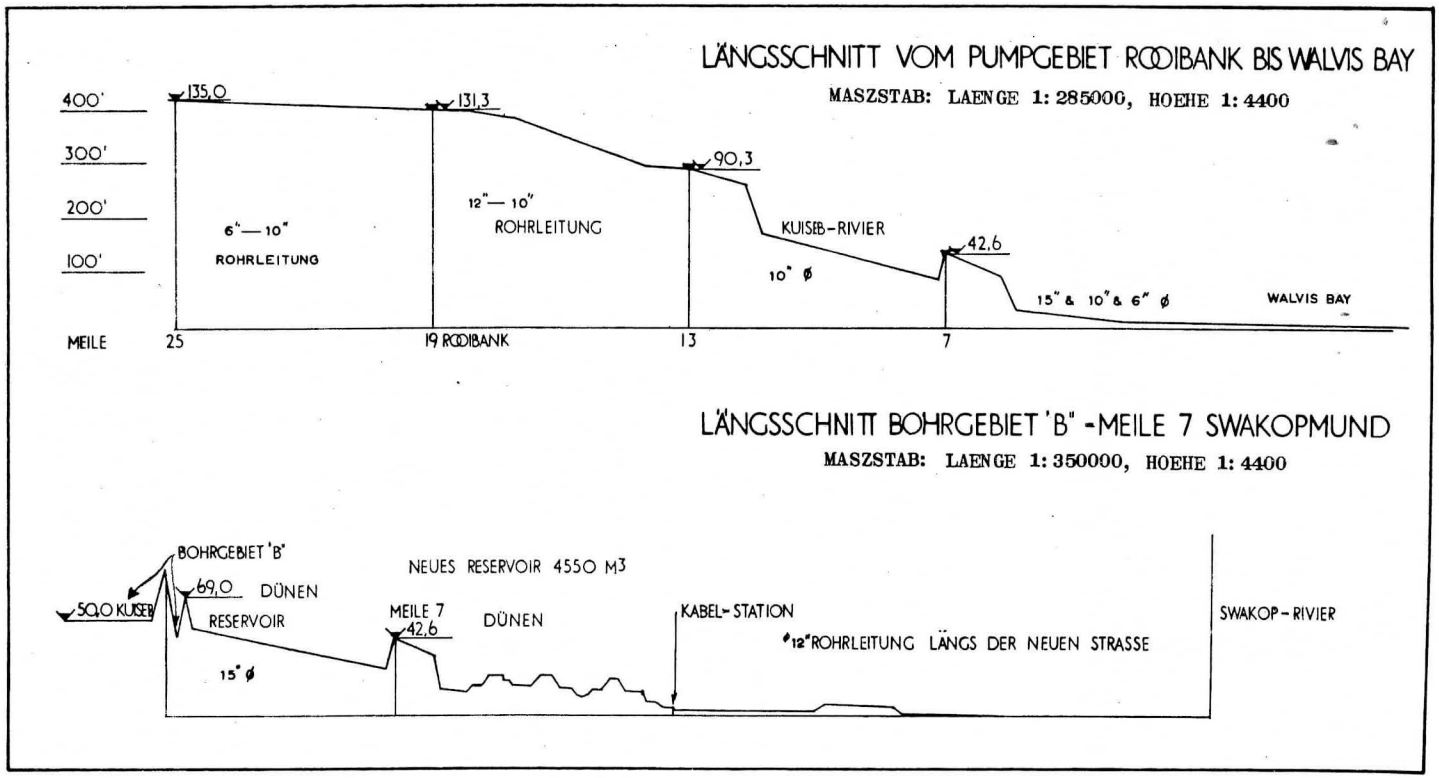
Walvis Bay is connected by telephone to Mile 7 and Rooibank and the various pump stations.

At Mile 13 the already mentioned reservoir dating from the time of the railways, has been completely rebuilt and serves as a reserve water basin. Its capacity is 900 cbm. Southwest of Mile 16 the flood protection dam for Walvis Bay begins. It is about 3 miles long and shuts off the north distributary of the Kuiseb. It is maintained from Rooibank. This is more fully dealt with in the article "Protection for the Town of Walvis Bay". Rooibank lies at Mile 19 and is the administrative centre for the water works. There are houses for the four employees, workshop and garages and a settlement of two-roomed houses with cemented yard and wind protection walls for the natives working there. Between the houses and also on an alluvial strip of the Kuiseb trees have been planted to make living conditions in the desert more homely and pleasant for the personnel. The office building houses the sluice valves for the pipelines and reservoir in the basement, and also the water meter with automatic pen for recording the volume of water pumped. The undertaking at Rooibank includes the electricity works which, by means of two aggregates each of 100 HP, supply the current necessary for the six underwater pumps forming the lower section of the project. The 900 cbm reservoir is filled routinely every evening and the water runs off automatically during the night to Mile 7. At Rooibank the river bed is crossed by a pipe bridge of 12" asbestos cement pipes because it was not possible to lay them safely in the river bed. Besides this the high salt content of the water at this point seemed to justify the crossing of the river bed by means of a bridge, and repairs can also be more easily carried out. Rock banks on both sides facilitated the building of the pipe bridge. Just above the installation is an emergency pump and 3 mobile pump sets are kept in reserve so that with high flood or strong come down of the river and unpredictable mishaps the water supply can be maintained. The emergency pump is fed by a 330 yards long filter drain gallery which reaches the fresh water zone. This was expected to be completed in 1961.

Part of the plant was electrified so as to keep it going at all costs should the river come down and there be no possibility of reaching the pump houses.

The pump area stretches 6 miles upstream from Rooibank and contains 16 pipe wells worked from 12 pump houses including the electric pump stations. Six pipe wells are worked electrically from Rooibank, two by their own diesel electric plant and eight more are equipped with diesel engines and turbines.

The site of the pipe wells were determined by test borings and water examinations. For structural reasons the bores are sunk into the water saturated sand up to a depth of 56 ft. At first a steel cylinder, consisting of single lengths bolted together, is let into the sand. This cylinder, comparable to a borehole casing has a diameter of 2 feet (60 cm). The sand inside is pumped out and the cylinder is lowered until it reaches the required depth. A filter pipe of ten to twelve inches diameter is inserted into this pipe and the space between is packed with gravel which must be of a size sufficient to prevent fine sand getting into the filter and blocking it, thus enlarging the ground water moistened mantle of the filter. A slotting of 1 mm with a filter gravel packing of 0.5 - 2 mm was considered necessary almost throughout. The most recent filter pipes were bridged slotted filters from Germany but the first



TRANSLATIONS. TOP: LONGITUDINAL SECTION FROM PUMPING AREA ROOIBANK TO WALVIS BAY. Scale: 1:285,000 for length, 1:4,400 for height. "Rohrleitung" means pipe-line, "Meile" means mile. - BOTTOM: LONGITUDINAL SECTION FROM BORE AREA "B" VIA MILE 7 TO SWAKOPMUND. Scale: 1:350,000 for length, 1:4,400 for height. "Bohrgebiet" - bore area; "Neues Reservoir" - new reservoir; "Dünen" - dunes; "Meile" - mile; "Kabelstation" - cable station; "Rohrleitung längs der neuen Strasse" - pipe-line along the new road.

ones were laboriously made in the old workshops and consisted of steel pipes with ingenious copper wire winding. Through the presence of two metals corrusion developed very quickly on the filters by electrolysis, greatly impairing the productivity of the wells. This was improved by making pipes of asbestos cement for subsequent pipe wells and ultimately for the new pump area bridge slotted filter pipes of bronze were bought.

After the filter pipe has been inserted and the gravel packed in, the casing is pulled out again and the construction of the pump house follows. As all boreholes lie in the river bed, pump houses stand on a pile driven three legged structure 33 ft. deep, the head of which is anchored about 5 ft. below the floor of the river bed in a steel reinforced concrete slab. On this is a streamlined pillar through which the borehole is led to a second concrete slab which carries the pump and the diesel engine or the high tension mast and transformer. This pillar is made very narrow so as to offer the smallest possible surface of resistance to the flood water. Eight of the pump houses are constructed according to this design. From the pictures appended to this article the different stages in pump house construction can be seen.

Four of the pump towers depicted are equipped with diesel motors. In order to fit the diesel motor and the gear of the turbine pumps onto the limited space available, the cooling of the motors is so arranged that a small portion of the pumped water is used as cooling water by an exchange of heat.

The pipe system of the Rooibank Waterworks consists of the following sections:

Pipe diameter	Length of line	
12"	8,800 ft.	pipe line to Mile 7
10"	76,266 ft.	pipe line to Mile 7
10"	23,466 ft.	
6"	about 16,666 ft.	

Not taken into consideration in the above table are the connexions between the various pump houses and the main pipe line beginning at the pump tower at Mile 25 with a 6" pipe and ending at Rooibank with a 12" pipe. The electrically operated pumps have their own pipe network of 6" diameter through 10" to 12" up to Rooibank reservoir.

The pump area Rooibank is considered to be fully developed. According to present knowledge and experience of water conservation and the amount of water which can be taken from a given area, it has been extended to the permissible size and must nevertheless be worked with necessary precautionary measures.

The pipe system for water distribution in Walvis Bay has been systematically renewed and expanded since 1952 as the old pipes were completely rusted. It is now in the form of a ring system by which each part of the town is supplied with fresh running water and not water that has been standing for some time. Mainly asbestos cement pipes were used and later also plastic pipes for domestic connexions.

The length of the pipelines within the pipe network is as follows:

Pipe diameter	Length of pipes	Remarks
15"	42,900 ft.	
12"	5,366 ft.	
10"	37,533 ft.	
10"	16,200 ft.	partly forming the ring system
8"	6,050 ft.	partly forming the ring system
6"	28,000 ft.	
4"	10,166 ft.	
3"	98,500 ft.	

In the above list the main pipe line from Mile 7 to Walvis Bay is included but not the 6" pipeline belonging to the Railways which has its own pipeline from Mile 7 to Walvis Bay. From Mile 7 onwards the town is served by two pipelines, a 15" and a 12" to 10" pipeline.

About 1400 domestic connexions with a corresponding number of meters have been installed in the network. These connexions represent a total pipe length of 58,330 ft. For the connexions to the different consumer stations, houses, factories, etc. the diameter of 2" - $\frac{3}{4}$" were used, the latter mainly plastic pipes.

Water distribution in Walvis Bay with all the accompanying work is still being done by the Administration i.e. the technical service of the Water Affairs Branch, and the finances are handled by the magistrate's office. In the near future a new depot will be erected in the industrial area for the technical division and the old dilapidated quarantine station will be vacated.

The distribution net will probably be handed over to the municipality and the waterworks retained as a state project.

The Water Affairs Branch has a work team of four white artisans and a foreman stationed in Walvis Bay, and they maintain a skeleton staff on Sundays and holidays.

The Rooibank waterworks will be greatly extended. The town of Swakopmund is also now being supplied from the ground water reserves of the Kuiseb. The supply to the holiday resort will be about 3000 cbm daily. From the pump area yet to be developed a further 4500 cbm daily will be reserved for Walvis Bay. This means a dozen more pipe wells including reserve wells. The new extension will be fully electrified and the existing electricity work at Rooibank correspondingly enlarged.

An electricity supply from Walvis Bay is proposed for later on and with the planning of the high tension cables this will be taken into consideration.

Near the new pump area a reservoir of 900 cbm capacity will be built from where the water will run by gravity over Mile 7 to Swakopmund, and to the distribution net of Walvis Bay.

A 15" pipeline from the new reservoir to Mile 7 is being planned and from Mile 7 to Swakopmund one with 12" diameter, which will supply the water to the Swakopmund waterworks outside the town. After the water has passed through a meter the municipality will distribute it.

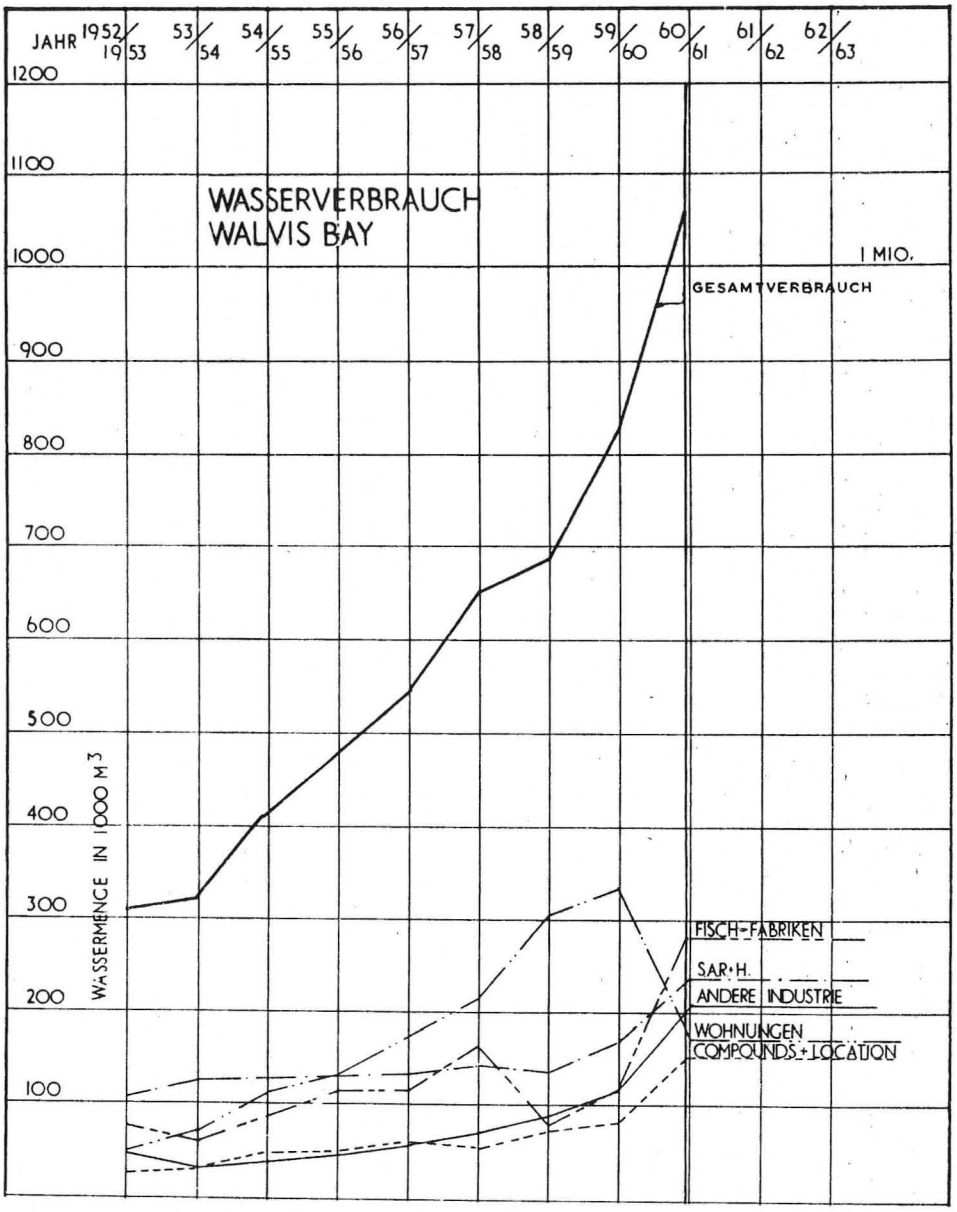
The Rooibank waterworks is the first big state water project in South West Africa. After the proposed extensions it will have a supply capacity of 3 million cbm annually, 2 million for Walvis Bay and 1 million for Swakopmund. Other water projects in South West Africa planned or already in operation are as follows:

State water project Mariental/Hardap Dam on the Fish River, 49 million cbm annually. This dam is nearly completed.

State water project Swakop Dam near Okahandja: 7 million cbm annually. This project is still being considered.

Windhoek Waterworks: consumption recently exceeded 4 million cbm.

In contrast to the schemes in the interior, the waterworks of the coastal towns have unlimited reserves in the sea and in the great brackish water reserves in the river deposits. Although the technique of seawater condensation is still at present uneconomical it makes rapid progress and it is quite possible that should a further extension become necessary at Rooibank it would be based on the distillation of brackish or sea water.



WATER CONSUMPTION WALVIS BAY. Translations: "Gesamtverbrauch" - total consumption; "Wassermenge" - water volume; "Fischfabriken" - fish factories; "Andere Industrie" - other industries; "Wohnungen" - dwellings. The apparent decline in domestic water consumption in 1960, in the opposite graph, is not real. It resulted from statistical redistribution in which, among other things, the consumption of building contractors was taken out of the section "dwellings" and incorporated into that of "other industries". SAR & H means South African Railways and Harbours Administration. Compound means the barracks where the contract workers live - a complement of 4,500-6,000 men - and location means the single dwelling settlements of the local Natives and Coloureds.

H.W. STENGEL

WASSERWIRTSCHAFT

WATERWESE – WATER AFFAIRS IN S.W.A.

Mit einem Beitrag des Direktors des südwestafrikanischen Wasserwirtschaftsamtes

Met 'n artikel deur die Direkteur van die Departement Waterwese, S.W.-Afrika

Including a study by the Director of the Water Affairs Department, S.W. Africa

Dr. ing. Otto Wipplinger

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