VRYBURG MUNICIPALITY

Northern Cape

PRELIMINARY REPORT

on the

PROPOSAL TO OBTAIN A SUPPLY OF WATER

from the

VAALHARTS IRRIGATION SCHEME

by

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Consulting and Chartered Civil Engineers
Members of the South African Association of Consulting Engineers

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/GOVERNMENT ....

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PRELIMINARY REPORT ON THE PROPOSAL TO OBTAIN A SUPPLY OF WATER FROM THE VAALHARTS IRRIGATION SCHEME.

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INTRODUCTION.

Vryburg is situated in the Northern Cape, in an area of low rainfall, and it obtains its water supply from a system of boreholes. The amount of water available is limited, and as the town is continuing to grow and the demand for water is steadily increasing, it is advisable to investigate other sources of supply.

Conditions in the Vryburg area do not favour the collection and storage of surface water because of the low rainfall and the absence of suitable catchments and river basins. The Council has therefore turned to the river Vaal as the only major source of raw water within a reasonable distance of the town. The river itself is over 80 miles away, but the Union Department of Irrigation has, under the Vaalharts Irrigation Scheme, constructed a canal which carries a supply of water almost to Pudimoe, more than half of the way to Vryburg. We have been asked to report on the possibility of supplying Vryburg with water from this source.

NEED FOR THE VAALHARTS SCHEME.

In September, 1955, we submitted a report on proposed improvements to the town's water supply. In accordance with our terms of reference, this report dealt only with the supply available from existing sources. We gave as an estimate that, with the proposed improvements to the existing supply system, about 780,000 gallons per day could be obtained from the existing boreholes. It was also estimated that the maximum unrestricted demand for water in 1955 would be 750,000 gallons per day during the period of sustained summer peak.

Therefore, although it appears that the town's immediate needs can be met by the existing supplies, it is clear that augmentation of the water supply will soon become an urgent matter.

It is possible that the underground resources can be exploited further. When a Municipality wishes to augment the amount of water drawn from such sources, and applies for a Government subsidy, the scheme has to be approved by the Geological Survey Office of the Department

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of Mines. In order to determine the supply that can be continuously and safely pumped, this Office requires observations to be regularly taken on the water levels in the boreholes and records to be kept of the quantity of water pumped over a fairly long period.

The amount of underground water which it will be safe for Vryburg to pump, has not yet been determined. If additional water can be abstracted, the need for such a scheme as the Vaalharts will not be immediate. It seems doubtful, however, if all the town's future requirements can be met by the underground supplies, and eventually, if the progress of the town is not to be retarded by the lack of water, this, or some other scheme to obtain a surface supply will become essential.

DRAWINGS.

The following drawings are bound in at the back of this Report:-

Map showing the Vaalharts Scheme.
Graph showing the Estimated Demand for Water.
Sketch of the Proposed Layouts at Pudimoe and Vryburg.
Graph showing the most economical size of Pipeline.
Longitudinal Section of Pipeline.

THE VAALHARTS IRRIGATION WORKS.

The Vaalharts Irrigation Works commence at a weir across the Vaal River about 6 miles above Warrenton. Under this Scheme, a portion of the flow of the Vaal is diverted from its own catchment by canals, into the valley of the Harts, where there is land suitable for irrigation.

The distribution of water is entirely by gravity, and the canals decrease progressively in size as water is led off to the irrigation farms. A main canal extends towards Vryburg in a northerly direction, but when it reaches a point about two miles south of Pudimoe, there is no longer sufficient fall of the ground available for it to continue any appreciable distance without resorting to pumping.

The Irrigation Department would agree to the abstraction by the Municipality, of water from the end of the canal, which we are advised, is large enough for the extra supply required by Vryburg. The water generally contains little suspended matter and is comparatively clear. However, purification in a Waterworks would be necessary before the water could be used as a Municipal supply.

The Irrigation Canal is periodically closed down for maintenance purposes and water may be stopped for eight or nine days every three or four months. A break in the supply through damage to the canal e.g.

/by .....

by stormwater, is also possible, so that it would be advisable for Vryburg to provide for occasional stoppages of up to at least 12 days.

PERIOD FOR WHICH SCHEME IS DESIGNED.

Capital works of this kind are generally planned for a period of 25 or 30 years, the cost being met by a loan repayable over the same period.

In the case of pipelines it is found that the larger the diameter, the lower is the unit cost of the line per gallon of water conveyed, and it is economic to design pipelines for the full period of the loan. As pipelines have a relatively long life expectancy the use of the longer design period is justified. We have therefore planned the scheme for a period of 30 years.

Those sections, such as purification and pumping plant, service reservoirs, etc., which can readily be extended in the future are, however, initially designed for half the ultimate capacity and duplicated later when the need arises.

DEMAND FOR WATER BY VRYBURG.

When drawing up our report of September, 1955, we made a careful estimate of Vryburg's demand for water for the period 1955 to 1980. The earliest the Vaalharts scheme could be put into operation would probably be about the end of 1958, and our new estimates have therefore been taken out for the period 1958 to 1988. We have adapted the figures previously used to cover this period, and the estimated demands are shown on a graph at the back of this report.

The figures for the first and last years of the proposed scheme are as follows:-

	Average	Sustained summer peak.
1958	700,000 g.p.d.	900,000 g.p.d.
1988	1,850,000 g.p.d.	2,500,000 g.p.d.

Demands for the intermediate years are shown on the graph.

The water supply, whether from the boreholes or the Vaalharts Scheme, must be able to meet the sustained summer peak demand. Some of the factors affecting the use of these two sources of supply will now be considered.

CONTINUED USE OF THE BOREHOLES.

Conservation of underground water is commonly regarded to be in the national interest and when an alternative source of supply is available to the town, the Council may be asked to reduce the pumping rate from

/the .....

the existing boreholes.

On the other hand, water from the existing boreholes will always be very much cheaper than that from the Vaalharts Scheme, under which there will be interest and redemption on a relatively large loan and the costs of chemical treatment of the water and of pumping over a high lift. On economic grounds, therefore, the maximum possible use should be made of the boreholes.

The sustained summer peak demand for water may last for weeks at a time. In addition, there are short periods each day when the demand for a few hours may be double the average. These are provided for by storage in service reservoirs. It is not economic, however, to provide for the sustained summer peak by means of such reservoirs, which would have to be unduly large, and that it is usual to make the delivery main from the source of supply large enough for this sustained peak.

However, in the case of Vryburg there is the possibility of using the natural underground storage from which the present supply is drawn, as a reservoir for balancing seasonal peak demands. This would reduce the maximum demand from Vaalharts and enable the pipeline, which is the most expensive item of the scheme, to be designed for a smaller flow.

A saving in the cost of the Vaalharts Scheme would also be effected by using underground storage to supply Vryburg during the periods already referred to, when the flow in the irrigation canal may be interrupted.

Accordingly we recommend a scheme in which the existing boreholes are used to supplement the proposed supply from the Vaalharts Irrigation canal in the most economical manner. For the information of the Council we have, however, given details of two other arrangements that would be possible.

VARIOUS SCHEMES POSSIBLE.

The three different sizes of scheme for bringing water from the Vaalharts irrigation canal to Vryburg that we have considered are:-

Scheme 1.

This scheme makes use of the town's underground supplies of water to meet the following requirements:-

(i) Keeping the town supplied during the periodical closing down of the Vaalharts canal.

(ii) Supplying the increase in demand during the period of sustained summer peak draw-off.

(iii) Supplementing the supply from Vaalharts as

/much .....

much as possible during the remainder of the year.

Scheme 2.

This scheme uses the underground supplies of water merely to supplement the water from Vaalharts at a steady rate of pumping throughout the year. The pipeline and purification works would be large enough to supply a portion of the town's average and sustained summer peak demands, and storage would be provided for periods when the Vaalharts canal is shut down.

Scheme 3.

Under this scheme no use at all would be made of the town's underground supplies. The pipeline and purification works would be made large enough to supply the town's sustained summer peak demand and, as for Scheme 2, storage would be provided for periods when the Vaalharts canal is shut down.

The pipelines would be successively larger in each case. The cost of Scheme 2 would be higher than that of Scheme 1 and for Scheme 3 it would be still more.

QUANTITY OF WATER AVAILABLE FROM UNDERGROUND SOURCES.

As already stated, the records at present available are probably insufficient for the Geological Survey Office to be able to give a decision as to the total quantity of underground water available. It is, therefore, not yet known if the amount of 780,000 gallons per day, which we recommended in our Report of September, 1955, should be pumped to meet the town's immediate needs, can be abstracted indefinitely. Accordingly, we consider it safer, for the purposes of this Report, to assume that the future amount which can be drawn continuously from the underground sources will be an average of about 500,000 gallons per day. This is the equivalent of 182½ million gallons per year, and is approximately the quantity being used by the town at the present time.

SCHEME I.

AMOUNT OF WATER TO BE SUPPLIED FROM VAALHARTS.

The underground supplies of water at Vryburg are thought to be dolomitic. Water from such sources may be pumped out at a high rate without detriment, provided that the total quantity abstracted does not exceed the amount by which the underground reserves are annually replenished.

We propose that the total annual amount of 182½ million gallons should not be drawn uniformly throughout the year, but that the rate of abstraction should be

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adjusted to meet the particular requirements of this scheme. (see Page 4).

We have assumed that the periodical closing down of the canal for maintenance purposes (Requirement (i)) will occupy a total period of four weeks every year, during which time the whole of the town's needs will be supplied from the boreholes.

We have also assumed that half of the stoppages will occur during the period of sustained summer peak and half during a period of average demand. (Please see estimated average and peak demands given on page 3). The total quantity that will have to be extracted from the boreholes during the total period of four weeks will then be about 61 million gallons in 1988, leaving 121½ million gallons to meet the other requirements.

Under drought conditions, the sustained summer peak use of water may last for about 3 months. If the boreholes are to supply the extra water required during such a period, (Requirement (ii)) and to supplement the Vaalharts Scheme during the remainder of the year (Requirement (iii)), the appropriate delivery rate for the Vaalharts Scheme is found to be 1-2/3 (1.667) million gallons per day.

In 1988, the underground storage of 182½ million gallons would be used as follows:-

2 weeks @ 2.5 million g.p.d.	= 35 mill.gals.	) 61 mill.	
2 " @ 1.85 " "	= 26 " "	) gals.	
3 months @ (2.5 - 1.667) = 0.833 million g.p.d.	= 76½ " "	) 121½	
8 months @ (1.85 - 1.667) = 0.183 million g.p.d.	= 45 " "	) mill.	
		) gals.	
TOTAL	182½		

This means that for 8 months of the year the pumping rate from the borehole system will be only 183,000 g.p.d. In order to keep the pumping costs from Vaalharts to a minimum it is proposed that the initial delivery rate should be for half of the ultimate rate. i.e. For ½ x 1.667 = 0.833 million g.p.d. This will reduce the velocity of flow through the pipeline and consequently the friction head against which the pumps will have to operate.

Pumps of this capacity will be adequate until about 1971 i.e. not quite half of the life of the scheme. At that time the estimated demand for water by Vryburg will be (See graph):-

/Average .....

	Average.	Sustained summer peak.
1971	1,150,000 g.p.d.	1,550,000 g.p.d.

The underground supply of water will be used as follows:-

2 weeks @ 1.55 million g.p.d.	= 22 mill. gals.
2 " @ 1.15 " "	= 16 mill. gals.
3 months @ (1.55 - 0.833) = 0.717 million g.p.d.	= 66 mill. gals.
8 months @ (1.15 - 0.833) = 0.317 million g.p.d.	= 78 mill. gals.
	182

The present maximum rate of pumping from the borehole system will have to be approximately doubled for the first 13 years of the scheme (i.e. increased from 780,000 to 1,550,000 g.p.d.) to meet the high rate of discharge required for short periods. Later the capacity must be increased again to 2,500,000 g.p.d. These increases may be made either by replacing some of the existing pumps with new ones of larger capacity or by equipping new boreholes. The existing Kuruman borehole, now unused, which is believed to be connected to the same underground sources as the others, may be fitted with a pump.

Although the rates at which it is suggested that the boreholes should be pumped when the Vaalharts canal is closed down, are relatively high, it must be remembered that water will only have to be abstracted at these rates for very short periods. We are of the opinion that, provided the annual quantities recommended above are not exceeded, the underground storage system will be capable of supplying water at the pumping rates recommended.

The cost of the additional pumping equipment and possible additional boreholes required will be small when compared with the savings in the cost of the pumping main from Vaalharts and of the storage reservoirs, which can be effected by using the underground storage in the above manner.

OTHER CONSUMERS.

Although no detailed enquiries have been made at this stage, we understand that provision might have to be made for certain minor consumers along the route of the pipeline. We are advised that the Railway would probably require 10,000 g.p.d. at Pudimoe and a further 10,000 g.p.d. at other stations along the line between Pudimoe and Vryburg. Miscellaneous farms would require about 12,000 gallons per day and Tiger Kloof 28,000 g.p.d. The total additional demand, which would have to be provided for, would therefore be approximately 60,000 g.p.d.

Provision for daily peak draw-offs would have

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to be made by constructing storage tanks at each point of supply. The periods when the supply in the canal is interrupted would probably be best taken care of by arranging for water to be fed back from Vryburg along the pipeline.

A fuller investigation into the means of supplying these consumers will, however, be necessary before the scheme proceeds. In the meanwhile we have provided a maximum total capacity of the Vaalharts scheme as follows:

	1,667,000	g.p.d.
+	60,000	g.p.d.
	1,727,000	g.p.d.

The Purification Works, Pumping Station, etc., will be designed to operate for up to 20 hours per day to allow time for maintenance and contingencies. The final pumping rate will, therefore, be 1,440 g.p.m. (3.84 cusecs).

Initially, and then for about the first 13 years of the scheme, the rate of supply need only be half this amount, i.e. 720 g.p.m.

QUALITY OF THE WATER FROM VAALHARTS.

The water from the existing boreholes contains over 350 parts per million of hardness (mainly of the carbonate type) which is considerably more than is usually desirable. Water from Vaalharts will be softer and when the two are mixed in the distribution system, the water that will normally be supplied will be of very good quality.

A minor objection to using the boreholes at variable rates of abstraction will be that the proportions of borehole and Vaalharts water will vary, thus altering the hardness from time to time. However, there will be a general improvement over the present quality of water and only occasionally will the water be as hard as at present. The variation in hardness should not prove troublesome.

PURIFICATION WORKS.

The Purification Works would be sited at Pudimoe, near to the raw water intake, rather than at Vryburg. Pure water containing no abrasive solid matter may then be pumped through the pipeline; the quantity of water requiring to be pumped may be reduced by the 2 or 3 percent required for backwashing filters, etc., during purification, and one superintendent can supervise both the works and the Pumping Plant.

Raw water will be pumped from the canal to the works and discharged into a mixing channel or chamber

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where chemicals will be added to promote the settlement of suspended matter. After a short period of slow stirring, to promote flocculation, the water will flow into a settlement tank for the removal of the bulk of the solids. It will then pass to rapid gravity sand filters for the removal of the remaining fine suspended matter. After sterilisation by chlorination, the water will be suitable for all domestic use and will pass into a sump for pumping to Vryburg.

The Purification Works as outlined would be of conventional design and details have not been given at this stage. The processes described are those generally suitable for water from the Vaal river, but before detailed designs of the works are prepared, an investigation should be carried out by qualified chemists to determine the most suitable chemical treatment.

The costs given in the estimate have been obtained from average costs of similar works elsewhere.

PIPELINE ROUTE.

The railway line from Kimberley to Rhodesia and the north runs almost parallel to the road along the direct route from Pudimoe to Vryburg. No official approach has been made to the Administration, but we have been unofficially advised that permission would be given for the pipeline to be laid within the railway reserve. This would have two main advantages. First, the pipeline would be protected by the railway fences and the pipes could be laid at the minimum depth required to protect them from frost and heat. Second, it would simplify the acquisition of the necessary servitudes of aqueduct. On the other hand, delivery of the pipes from the nearest railway station would probably have to be made by lorry, in which case access to the pipeline within the fenced-off reserve would be more difficult. Access for a mechanical trench excavator might also be troublesome.

All these aspects of the problem will have to be taken into consideration before the scheme is proceeded with, but for the present we have based our proposals on the assumption that the pipeline would be laid within the railway reserve for most of its route.

A longitudinal section of the line has been obtained from the S.A.R. Administration. This shows undulating ground between Pudimoe and Brussels, with a nett rise of just over 50 feet in 17 miles. In the next 7 miles, to Tiger Kloof, there is a relatively steep rise of about 240 feet, followed by more undulating ground in the remaining 5 miles to Vryburg.

Just outside Vryburg the railway line and the road separate as the former makes a detour to avoid high ground. This is the rise, to the south of the native location, on which (in our Report of September, 1955)

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we proposed that a new service reservoir should be built. From the point where the railway line commences its detour, therefore, the pipeline should follow the road directly to this reservoir.

The top water level in the proposed reservoir is about 70 feet higher than the high ground at Tiger Kloof. The pipeline will, therefore, lie below the hydraulic gradient level for the whole of its length as shown on the longitudinal section accompanying the report.

Allowing for about 2 miles from the Purification Works to Pudimoe, the total length of the pumping main will be about 31 miles, and the total rise about 360 feet.

DIAMETER OF PIPELINE.

We have investigated the most economic size of pipeline, bearing in mind that the lower initial cost of a smaller pipe will be offset by the higher cost of pumping against a greater friction head. The size recommended is 15" diameter. The friction loss, in a distance of 165,000 feet will be about 365 feet. The velocity of flow will be about 3½ feet per second.

DESIGN OF PIPELINE.

The maximum working pressure in the pipeline will be about 725 feet. For a 15" diameter pipe for this pressure a steel pipe with bitumen lining and outside sheathing will be suitable and probably the most economical. When ordering the piping, tenderers may be invited to offer other types, e.g. pre-stressed concrete pipes, and the final selection may then be made.

Steel piping with 3/16" walls will be sufficient for ordinary working pressures up to about 555 feet head of water. Thereafter pipes with walls of 1/4" thickness must be used. The lengths of each type are shown on the Longitudinal Section.

From Tiger Kloof to Vryburg the working pressure does not exceed 150 feet of water. Asbestos-cement pipes could be considered, but in this size are not likely to be cheaper than steel pipes. Reinforced concrete pipes would be cheaper but are liable to damage through water hammer shocks in a pumping main. We therefore recommend steel piping throughout.

Water hammer in pumping mains can give rise to very high pressures unless special precautions are taken. To prevent these high pressures causing damage, the thickness of the steel plates used for the piping is sometimes arbitrarily increased, but considerable sums of money can be unnecessarily spent in this manner if the problem is not thoroughly investigated.

The pipeline would be provided with isolating valves and reflux valves at intervals along its length,

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and with scour valves in valleys and air release valves at crests.

We have based the estimate of cost on an average trench depth of 36". This could probably be reduced where rock is encountered. A final decision on the depth of the trench required will, however, have to be made when it is known whether the trench will be within or outside the railway reserve, and it might also be advisable when calling for tenders for the construction, to invite alternative prices for different trench depths.

In estimating the cost of the trench, we have allowed for meeting with a proportion of hard ground and rock, excavation in such material being considerably more expensive than in soft ground.

PUMPING PLANT.

We propose that there should be initially two main clear water pumps each of the centrifugal high-lift type designed for a delivery of 720 g.p.m. Only one pump would be used at a time, the other acting as a stand-by. Later on when the demand increases a single new pump capable of delivering 1,440 g.p.m. would be added, thus doubling the pumping capacity and providing a 100% reserve.

Initially, each pump will require about 200 h.p. for driving. We have been informed by the Electricity Supply Commission that it is improbable that a supply of electric power in the quantities required, will be available at Pudimoe for some years. It would not be economic for the Council to build their own electric power line. Accordingly provision must be made for operating the pumps by diesel engines. The position can be reviewed again when it is decided to proceed with the scheme or when the initial pumping capacity has to be doubled.

The Raw Water Pumps from the Irrigation Canal to the Purification Works will be for a low-lift and will also be arranged in duplicate. They will require about 7½ h.p. for driving and again diesel power will be used.

STORAGE RESERVOIRS.

In our Report of September, 1955, it was proposed that the available storage of clear water should be increased to 2,000,000 gallons by the construction of a new 1,000,000 gallon covered service reservoir south of the native location. This will provide two days' supply at the estimated average demand for water by the town in 1967/8.

In view of our proposals to provide facilities for the temporary over-pumping of the boreholes during shut-down of the Vaalharts Scheme, we consider that this two days' storage will continue to be sufficient. The sizes of the additional service reservoirs required in the future

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should be reconsidered when the need for the further storage arises.

ADDITIONS TO TOWN'S DISTRIBUTION SYSTEM.

Our previous report recommended the division of the town's reticulation into two zones, one fed from the existing service reservoir with new pumps and water tower, and the other directly from the proposed new service reservoir. Both reservoirs will have the same top water level. When the Vaalharts scheme is proceeded with, about 50% of the water will be required at the new reservoir and the balance will have to be conveyed on to the existing 1 million gallon reservoir north-west of the town. A 12" diameter pipe will be required for this purpose. If the recommendations contained in our 1955 Report are adopted, provision will already have been made for a pipe of this size to be laid down the full length of Warren Street, so that all that will be required under the Vaalharts Scheme will be to connect up to this pipe at the south end of Warren Street, with a further length of 12" pipeline. Allowance for this has therefore been made in the Estimate.

No other major additions to or changes in the reticulation system as proposed in our report of September, 1955, will be required except that it will be necessary to provide new connections from the larger borehole pumps which we are proposing under the Vaalharts scheme and connections to any new boreholes that may be required.

ESTIMATE OF COST OF SCHEME I.

A preliminary estimate of the cost of the proposed works is as follows:-

	£	£
Purification Works.		
Raw Water Pump Station:		
Structure	1,500	
Pumps and Piping	1,700	
Chemical Dosing House and Equipment	2,500	
Sedimentation Tanks	7,000	
Filter House and Clear Water Pump Station:		
Structure	8,000	
Filters and control gear	8,000	
Pumps, Engines and Pipework	10,000	
Office and Lighting Plant	2,000	
Engineering Fees and Contingencies	5,100	45,800
Pipeline to Town.		
Supply of pipes and fittings:-		
1/4" walls 60,000 ft. @ 44/9 per ft.	134,250	
Carried forward:	134,250	45,800

Brought Forward:	134,250	45,800
3/16" walls 105,000 ft. @ 39/- per ft.	204,750	
Trenching and laying:		
165,000 ft. @ 6/6 per ft.	53,625	
Engineering Fees and Contingencies	49,375	442,000
Reticulation System.		
Increasing capacity of boreholes	5,000	
Supplying, trenching for and laying 12" pipeline from proposed new reservoir to Warren Street:		
1,300 ft. @ 35/-	2,300	
Engineering Fees and contingencies	700	
	8,000	8,000
Other Items.		
Allow for legal expenses, acquisition of ground, servitudes and wayleaves.	5,000	
Superintendent's house.	3,200	
Resident Engineer's salary during construction	2,000	
	10,200	10,200
TOTAL FOR SCHEME:		£506,000

GOVERNMENT SUBSIDY.

A Government subsidy will probably be obtainable for the scheme. This will be calculated on the above figures with the exception of the legal expenses and the cost of the superintendent's house, so that the subsidisable total will be £497,800.

The subsidy payable is normally as follows:-

On the first	£30,000,	33⅓%	= £10,000	
On the second	30,000,	25%	= 7,500	
On the third	30,000,	20%	= 6,000	
On the remaining	407,800,	10%	= 40,780	64,280

The nett cost of the scheme to the Municipality will therefore be about £441,720. The cost of raising the necessary loan has not been included.

/COST .....

COST OF WATER.

If a loan is raised at 5¾% repayable over 30 years, the annual interest and redemption charges will be about 7.1% per annum. The annual overhead costs of the scheme will therefore be approximately:-

Interest and redemption charges	£31,360
Staff: salaries and wages	2,000
Maintenance, repairs, transport and sundries.	1,000
Contribution to renewals fund (½%)	2,500
	£36,860

In addition there would be the costs of running the diesel engines used in pumping, and chemicals used in purification, amounting to about 9d. per 1,000 gallons of water supplied. The Irrigation Department will make a small charge for the supply of raw water. We are informed that this will be 3d. per 1,000 gallons, giving a basic cost at Vryburg of 1/- per 1,000 gallons, without overheads.

1958 - 1971.

During the first 13 years of operation of the scheme the average consumption from the Vaalharts scheme would be 425,000 gallons per day, resulting in an expenditure of 425 x 1/0d. = £21.5.0. per day, viz. about £7,800 per annum on production costs. This makes a total annual expenditure of approximately £36,860 + £7,800 = £44,660 for bringing a supply of Vaalharts water to Vryburg.

In addition to the 425,000 g.p.d. from Vaalharts, the town will also consume an average of 500,000 g.p.d. of borehole water. Therefore, in order to obtain the overall unit cost, the cost of this latter supply must be added to the figure of £44,660 arrived at above. From page 24 of our report of September, 1955, it will be seen that the estimated annual expenditure on the production of 600,000 g.p.d. of borehole water was £17,848. The only saving in cost which would result from reducing the quantity would be in respect of electricity for pumping, and we are therefore adopting an arbitrary figure of £17,500 per annum, as the cost of producing 500,000 g.p.d. of borehole water.

The distribution of a total average quantity of 925,000 g.p.d. will, however, result in increases in administration charges, and the cost of meter reading etc. for which we are allowing a total of £1,000 per annum. We therefore estimate that the total annual expenditure on the production of a combined supply of water from Vaalharts and from the town boreholes will be:

£44,660
17,500
1,000
£63,160

/Spreading ....

Spreading this over the annual average consumption of 925,000 g.p.d., the average cost will amount to 3/9d. per 1,000 gallons for the first 13 years of operation of the scheme.

First year of operation of the scheme.

Assuming that operation of the scheme is commenced in 1958 and that the initial consumption of water is an average of 700,000 gallons per day, the cost of water will be approximately 4/7d. per thousand gallons, during the first year. The cost will be lower in subsequent years as consumption increases.

1971 - 1988.

By about 1971 it will become necessary to increase the capacity of the purification and pumping plant and to provide further clear water storage at Vryburg. The cost of this work will be about £50,000. Overhead costs, including interest and redemption charges and extra wages, etc., will be increased by about £4,000 per annum.

Due to greater friction in the pipeline at the higher pumping rate, pumping costs will be increased giving a basic cost of the water at Vryburg of about 1/3d. per thousand gallons.

Allowing for the increased consumption of water and an increase in administration charges, cost of meter reading, etc., we find that the cost of the water will amount to an average of approximately 3/- . per thousand gallons, during this second period of the scheme.

SCHEMES 2 AND 3.

LOCATION OF STORAGE.

As stated, under these schemes a considerable amount of storage would be required to provide for periods when the Vaalharts canal is out of commission. It is less expensive to provide storage for raw than for clear water, as the former need not be covered and the cost of roofing forms a high percentage of the cost of a reservoir. From economic considerations therefore the bulk of the storage to be provided under Schemes 2 and 3 would be for raw water.

There is an existing earth dam behind the hospital at Vryburg and consideration was given to using this and a survey of its capacity was made. Although it would be attractive to make this a permanent lake for the town, there are too many objections to making this a practicable scheme. The main disadvantage would be that the purification works would have to be situated at the Vryburg end of the pipeline and purification at the Pudimoe end is preferable for the reasons already given.

Consideration was given to using one of the natural vleis at Pudimoe for storage. However, in our opinion, these are unsuitable. They are shallow and losses from

/seepage .....

seepage and evaporation would be high. The vleis are used for watering cattle and are the home of innumerable birds, with the result that the quality of water is inferior to that delivered by the canal. Purification costs would, therefore, be higher.

In our opinion, it would be necessary to construct an artificial dam to provide the requisite storage. This would probably take the form of a circular excavation, with the excavated ground banked up to provide a retaining wall. The bottom of the excavation and the wall would be consolidated and stabilised, using the principles of soil mechanics. A thin lining of reinforced concrete or gunite would then be applied to prevent loss of water by seepage. Occasional cleaning out would be necessary, but whilst this was being done the water supply would be maintained by pumping direct to the purification works.

SCHEME 2.

Deducting this from the town's estimated maximum rate of demand of 2,500,000 gallons per day, 2,000,000 g.p.d. remain to be obtained from Vaalharts.

Adopting a working day of 20 hours, as with Scheme 1, this gives a delivery rate of 1,670 g.p.m. Again allowing 50 g.p.m. for the intermediate consumers, we arrive at a pumping rate of 1,720 g.p.m. It is found that the economic size of pipeline for this flow will be 16" in diameter. The velocity of flow would be 3¼ feet per second, and the maximum working head 715 feet of water.

We estimate that the cost of this pipeline would be as follows:-

Supply of pipes and fittings:

1/4" walls	62,000 ft. @ 47/3	per ft. =	£146,475
3/16" walls	103,000 ft. @ 41/6	" " =	213,725

Trenching and laying:

165,000 ft. @ 7/- per ft.	=	57,750
Fees and contingencies	=	52,050
		£470,000

This represents an increase of £28,000 over the pipeline required for Scheme 1.

The purification works and pumping plant required will also be larger and we estimate that the additional cost of these items will be £10,000.

Under this scheme we consider that increased clear water storage will be required at Vryburg. We have allowed for storage equivalent to 2 days' pumping from

/the .....

the boreholes, viz. 2 x 500,000 = 1,000,000 gallons plus an amount equivalent to 3 days' average consumption from Vaalharts. In 1971 the latter will amount to 1,150,000 g.p.d. - 500,000 g.p.d. so that 3 days' storage is, say, 2,000,000 gallons, making a total clear water storage of 3 million gallons.

Under the scheme dealt with in our Report of September, 1955, 2 million gallons' storage has already been allowed for so that under Vaalharts Scheme No. 2 an additional 1 million gallom service reservoir will be required. The cost of this is estimated at £17,000.

With regard to the raw water storage at Pudimoe, we have stated that we consider it advisable to provide for interruptions in the supply of up to 12 days. Although it is possible for such an interruption to occur during a period of sustained summer peak demand in the town, the period for which the Irrigation Department normally shuts the canal down is only 6 or 7 days. In view of this and of the allowance of clear water storage in Vryburg equivalent to three days' average supply from Vaalharts, we consider that it will be adequate to provide raw water storage at Pudimoe equivalent to 10 days' average draw-off from the canal. It would be economic to make this artificial dam big enough at the commencement of the scheme for the estimated ultimate demand. The capacity required is, therefore, 10 x (1,850,000 - 500,000 gallons) = 13½ million gallons. The estimated cost of this uncovered raw water storage reservoir is £33,000.

To summarise, therefore, the extra cost of Scheme 2 over Scheme 1 will be as follows:

	£
Raw Water Storage	33,000
Additional cost of Purification Works.	10,000
Additional cost of Pipeline	28,000
Additional Clear Water Storage	17,000
	£ 88,000
Less saving on equipment for increasing output of boreholes	5,000
	83,000
Less Government Subsidy (10%)	8,300
Total additional cost of Scheme 2 to Municipality.	74,700

This increased capital outlay will result in an increase in interest and redemption charges (7.1% per annum) of approximately £5,300 per annum.

/Cost .....

Cost of Water.

The total quantity of water pumped annually from the boreholes and from the Vaalharts scheme will be the same as under Scheme No. 1, so that other costs will be as already estimated for the latter scheme.

The unit cost of water under Scheme 2 will therefore, exceed that under Scheme 1 as follows:-

(i) Extra average cost for first 13 years of operation of scheme when the average demand will be 925,000 g.p.d. ..... 4d. per thousand gallons.

(ii) Extra cost during the first year of operation of the scheme when the average demand will be 700,000 g.p.d. ..... 5d. per thousand gallons.

SCHEME 3.

The boreholes would not be used under this scheme. The pipeline would therefore have to be capable of delivering water to the town at the estimated maximum rate of demand of 2,500,000 g.p.d. Again, adopting a working day of 20 hours and allowing 50 g.p.m. for intermediate consumers, the required pumping rate is found to be 2,140 g.p.m. The economic size of pipeline will be 18" in diameter, with a velocity of flow of 3¼ ft. per second and a maximum working head of 660 feet of water.

We estimate that the cost of an 18" diameter pipeline will be as follows:-

Supply of pipes and fittings.

19,000 ft. of 5/16" @ 62/6 per ft.	=	£ 59,375
62,000 ft. of 1/4" @ 53/9 " "	=	166,625
84,000 ft. of 3/16" @ 49/- " "	=	205,800

Trenching and laying.

165,000 ft. @ 8/- per ft.	=	66,000
Fees and Contingencies	=	62,200
		£560,000

This represents an increase of £118,000 over the pipeline required for Scheme 1. The purification works and pumping plant required will again be larger and we estimate the additional cost of these items to be £20,000.

Again, providing storage equivalent to 3 days' average consumption in 1971, the service reservoir storage required will be 3 days at 1,150,000 g.p.d. = 3,450,000 gallons. The additional reservoir capacity required is,

/therefore .....

therefore 1½ million gallons and the estimated cost of such a reservoir is £24,000.

Allowing raw water storage at Pudimoe equivalent, as before, to 10 days' ultimate average demand, the storage required is 10 days at 1,850,000 g.p.d. = 18½ million gallons. The estimated cost of an artificial dam of this capacity, similar in construction to that proposed under Scheme 2, is £45,000.

To summarise, the extra cost of Scheme 3 over Scheme 1 will be as follows:

	£
Raw Water Storage	45,000
Additional cost of purification works.	20,000
Additional cost of pipeline	118,000
Additional clear water storage	24,000
	£207,000
Less saving on equipment for increasing the output of the boreholes.	5,000
	202,000
Less Government Subsidy (10%)	20,200
	£181,800

This increased capital outlay will result in an increase in interest and redemption charges (7.1% per annum) of approximately £12,900 per annum.

Cost of Water.

In the case of this scheme there will be extra annual expenses in respect of purchasing from the Irrigation Department, purifying and pumping 500,000 g.p.d. of raw water which, under Schemes 1 and 2, would be obtained from the boreholes. Under Scheme 1 the total cost of purchasing, purifying and pumping raw water was taken as 1/- per thousand gallons. Under scheme 3 we shall take this at 10d. per thousand gallons to off-set the cost of pumping from the boreholes as this pumping can now be dispensed with.

The additional cost per annum will, therefore, amount to 500,000 g.p.d. at 10d. per thousand gallons = £7,600 per annum.

The total additional cost per annum of water, under this Scheme, is therefore:-

£12,900 + £7,600 = £20,500

The unit cost of water under Scheme 3 will, therefor, exceed that under Scheme 1 as follows:-

/(i) .....

(i) Extra average cost for first 13 years of operation of scheme when the average demand will be 925,000 g.p.d. ..... 1/2½d. per thousand gallons.

(ii) Extra cost during the first year of operation of the scheme when the average demand will be 700,000 g.p.d. ..... 1/7d. per thousand gallons.

SUMMARY OF UNIT COSTS OF WATER.

	SCHEME NUMBER		
	1	2	3
1st year of operation	4/7	5/-	6/2
Average for period 1958-1971	3/9	4/1	4/11½
Average for period 1971-1988	3/-	-	-

CONCLUSION.

The cost of water under the three different schemes is considerably higher than that of the present underground supply. Nevertheless, the charges which would have to be levied are less than those paid by many towns that have installed new water schemes in recent years, and are not unduly high considering the long distance from which the supply must be obtained.

Scheme 1, the least expensive of the three we have put forward, would be an economic scheme and the cost of the water, even in the first year of operation, would not be unreasonable. The average price of water during the second period of the scheme is not much more than that paid in Johannesburg. We are of the opinion, therefore, that it would be practicable for Vryburg to augment its water supply from the Vaalharts Irrigation Scheme.

The question of the size of the pumping main to be installed is, however, to some extent, a matter of policy for the Council to decide, in so far as it is bound up with the future development of Vryburg.

We have stated that the soonest the Vaalharts scheme could be put into operation would be about the end of 1958. This would necessitate the scheme being put through all the stages of Council, loan and subsidy approval with the least possible delay. If, however, the scheme were not proceeded with until a later date, it might be necessary for us to revise our calculations and to take a new design

/period .....

period running from a later anticipated date of commencement of operation of the scheme. A slightly larger pipeline might then be found to be more economic due to the normal increase in population and consequent increase in demand for water. This would raise the capital cost of the scheme, but, owing to increased consumption, there would probably be no increase in the unit cost of the water.

If we can be of any further assistance, we shall be pleased to place ourselves at the disposal of the Council.

H. Osborn.

for HAWKINS, HAWKINS & OSBORN.