Victorian Institute of Engineers.

SOME IRRIGATION PROBLEMS AT MILDURA.

Read by Mr. J. T. N. Anderson, 7th September, 1898.

It is unnecessary to introduce the Mildura Irrigation Colony as an unknown subject to this Institution, since most of the members are already well acquainted with it, and have followed its history with more than a passing interest. Further, many details of the engineering works of that colony have already been communicated by a paper entitled "Mildura Irrigation" and read here by Mr. Lavater for Mr. Tolley.

However, for the information of such members as may wish to investigate the problems raised with more detail than can be obtained from that paper or the public press, the writer herewith furnishes a copy of the report of the Mildura Royal Commission 1896; and has prepared the accompanying plan showing the complete irrigation system. This, however, he proposes to explain verbally not wishing to render the paper unreadable by supporting his statements by lengthy records and instances.

This paper is not intended as a history of what has been and is being done at Mildura, but has been written to bring into prominent notice some problems of particular interest to Australian Engineers. Briefly these are:

First. To what level can water be supplied by means of pumping at such a cost as will enable irrigation to be profitably conducted.

Second. How far can small areas of several hundred acres or less, be supplied profitably from a larger and more concentrated system.

Third. To what extent can we rely upon irrigation to mitigate our Australian droughts.

Mildura experience can throw much light upon these questions, but unfortunately it is fogged and obscured by a large number of external circumstances, such as the fact that it was engineered with insufficient capital. That the temperance auspices under which it was fostered made it a sort of inebriate asylum, and consequently attracted a class but little accustomed to, or suited for the hard and abstemious life of the peasant proprietor. Nevertheless the main facts can be clearly discerned, and they are:

1. That all the more industrious settlers are satisfied that if they could procure an ample supply of water they could easily afford to pay an even heavier rate than the pound per acre per annum, which at present presses so hardly upon them.

2. That it is impossible to keep the more distant isolated areas supplied without causing loss and inconvenience to the central portions of the settlements, and that if a sufficient quantity of water be available in drought seasons, a good and profitable crop of both fruit and cereals can be grown, the chief loss at such times being the extra cost of raising the additional quantity of water required to compensate for the insufficient rainfall.

A far worse enemy than drought has been found in the frosts. In clear
dry winter nights the thermometer has sometimes been as low as 26 degrees Parb., and on such nights the damage done to citrus fruit trees has been very heavy, especially to those furthest from the river and main channels.

Another serious enemy has been insufficient drainage, a few of the complaints of saline matter rising from the subsoil have been found to arise from the fact that in some basins the subsoil was clayey and the water was allowed to remain in the ground, and in consequence the trees sickened and died. In many cases, however, channels have been made through beds of gypsum gravel known locally as Copai, and the water percolates these beds and rises as salt springs in the orchards for many chains distant from the channel, thus not only causing a serious loss of water in the channel, but destroying some of the finest orchards in the settlement. Such troubles as these are mentioned as showing what the causes have been which have sent so many Mildura pioneers back to the world penniless, and have in consequence caused a strong prejudice to grow among the community at large, and which has given to many, a firm conviction that irrigation at Mildura is an unqualified failure.

The fact that so many settlers have been ruined from these causes is due to ignorance. Other similar disadvantages are to be found in both the Western States of America and even in the south of France, and in Turin.

In some of the Western States the frosts are so harmful that special precautions are enacted such as the ringing of firebells on frosty nights to warn the horticulturist to burn smudge fires, etc.

The precautions against gypsum are obvious; in most cases they will consist in rendering the channel where it passes through the gypsum country impervious, and thoroughly working and draining the orchards likely to be affected.

Having dismissed these troubles, let us consider the principal features of the problems presented. In these it is obvious that the factors to be considered are the quantity of water available and the cost of raising it.

In the second factor the chief element is the price of fuel. At present this is costing about six shillings and six pence per ton on the average, or making due allowance for the inconvenience of stacking and stoking wood fuel and the difference in calorific value, this is equivalent to Newcastle coal at about one pound a ton. With the works recently authorised by the Government, which include a tramway system, it should be possible to materially reduce this cost; but as eventually timber must rise in value it will be as well to make our calculations on this figure. (£1 per ton).

As to the quantity of water available, so far no attempt has been made to restrict this, and irrigation must extend considerably before this question need be seriously faced. When that time comes the additional interest and maintenance for the store reservoirs needed, will greatly add to the cost of irrigation.

In Mildura, in spite of the extreme dryness of the climate, it has been found that vineyards and orchards do not require more water than in the south of France, viz., an average at each watering of five inches, that is to say water equivalent to a depth of five inches over the whole irrigated area must be used. In a wet season two such waterings may suffice but in most years three are indispensable.
Consequently these factors may be taken as five (5) inches and fifteen (15) inches respectively, or equivalent to about eighteen thousand and fifty-four thousand cubic feet per acre.

It will hardly be necessary to call your attention to the fact that to take such a supply from a suburban tap supplied by meter at one shilling per thousand gallons would cost seventeen pounds per acre per annum. To irrigate at the same cost as is done at Mildura means that the water must be supplied and distributed for a rate considerably under one penny per thousand gallons.

Having determined these factors, and assuming a rather higher value for wood fuel than should at present obtain at Mildura, namely an average of 6s. 6d. per ton, it will be found that the cost of raising water at present at the different stations at Mildura will be approximately as follows:

1. At Psyche Bend Pumping Plant (Centrifugal) a 14 feet lift costs 2s per annum per acre, equivalent to \(0.07d\) per 1000 gallons.
2. At Billabong Station Pumping Plant (Centrifugal) a 27 feet lift costs 2s 9d per annum per acre, equivalent to \(0.1d\) per 1000 gallons.
3. At Nichols Point Old Pumping Plant (Centrifugal) a 23 feet lift costs 3s 4d per annum per acre, equivalent to \(0.12d\) per 1000 gallons.
4. At Nichols Point new Pumping Plant (Otis or Worthington type) a 40 feet lift costs 3s 3d per annum per acre, equivalent to \(0.11d\) per 1000 gallons.
5. At Homestead Pumping Station (Centrifugal) a 30 feet lift costs 7s 2d per annum per acre, equivalent to \(0.25d\) per 1000 gallons.

The last of these engines is working under less than one third of its proper load, owing to the small capacity of the channel therefrom, and the centrifugal pump cannot be run up to its economic speed, and consequently this result cannot be taken as of any value; for a similar reason I omit mention of the following four pumping stations, No. 9, No. 10, Deakin Avenue and Township. At all these places, owing to various causes, in some the temporary nature of the works, and in others the unsuitability of the engines to their load, the results are valueless for our purpose. Nevertheless they contribute largely to keep Mildura in its present dependent condition.

The figures given above will be seen to provide only for raising the actual amount of water required on the land. It is notorious that a much larger quantity must be raised to provide for evaporation in the reservoirs and channels, and the losses through percolation.

The Mid-Summer irrigation is necessarily the heaviest. During the Mid-Summer irrigation of the present year the writer took numerous measurements of water at all the pumping stations, and at more than one half of the head ditches supplying the orchards. For this purpose he used at the new pumping plant a specially designed automatic recording gauge weir, and at the other plants and in the subsidiary stations and distributing channels a carefully calibrated Revé Current Meter. The result was that he established beyond question, that at the different pumping sta-

* A description of this Engine taken from *The Engineer*, 1888, is given here-with.
tions, during that pumping alone, sufficient water to give from 8 to 9½ inches deep over the whole irrigated area was raised, the larger quantity being raised at the Psyché and Billabong engines. While of this only from 4½ to 6 inches, or an average of a little over 5 inches actually found its way through the minor distributory channels on to the cultivated lands. This means that about 40 per cent. of all the water raised was lost in transit, and that to obtain the 15 inches required on the land, it is necessary to raise 25 inches from the river. Therefore the prices given above must be written up proportionately.

To these charges obviously must also be added the cost of maintenance and distribution, and a fair percentage for interest on capital values and depreciation.

The writer has made a very careful estimate to arrive at the proper charge for these, and reporting to the Trust sometime since he wrote:—

"It will be seen that no great reduction in the water rate can be expected; at present the rate is insufficient (20s per acre per annum), and all the economies which can be effected will be required to make that rate cover expenses and provide that balance to meet depreciation in plant and works which will be needed if the settlement is to be permanent."

As none of the machinery or works at Mildura are of a very complicated or costly description, it will probably puzzle those who are not familiar with the details of the settlement to reconcile this statement with the prices quoted above, for even after adding 40 per cent. to the cost at the most expensive station there mentioned, the annual charge will be under 12s, and when even 10 per cent. is added of capital charges on a capital equivalent to £7 per acre there is still a balance towards the general cost of management and distribution. It is, however, in the discrepancy between the moderate cost of carrying water at the large pumping stations and the cost of supplying the settlers, while maintaining a system loaded with minor and extravagant pumping stations, and the cost of maintaining over a hundred miles of channelling to supply scattered and isolated holdings that Mildura throws so much light on the second problem we are considering, namely:

**How Far Can Small Areas of Several Hundred Acres or Less Be Supplied Profitably From a Larger and More Concentrated System.**

As the accompanying map will show, the present Mildura Irrigation Trust is confined to an area of some 46,000 acres, of which about 30,000 acres is irrigable from the Trust channels.

Of this area about 10,500 acres are in cultivation, of which about 70 per cent. is under fruit crops. The present channels are of sufficient size with good management to meet the demands. Unfortunately, chiefly from pecuniary troubles, the pumps have not worked sufficiently continuously through the Summer seasons, and there have been many heavy losses from insufficiency of water supply during the last three (3) drought years.
The situations of the different pumping stations are indicated by the red
wafers on plan.

Briefly stated they are as follows:

Pumps drawing water direct from the Murray River.

1. TOWNSHIP PLANT.

Here the domestic water for the township is raised to a level of about 70
feet. Provision is made to draw water from the town mains for irrigation
outside the town area. The engine power here is about ten times as much as
is now utilized.

2. HOMESTEAD PLANT.

This plant is a centrifugal pump driven by the sister engine of that at
the Township, and in turn as stated above at least three times greater
than the area it commands will justify. The great bulk of the land com-
manded from this plant is useless for irrigation, and the area likely to be
irrigated here has shrunk from about 800 acres to under 300 acres, or
less than one-eighth of the area the engine could command if fitted
with a second pump. In consequence a proposal to abandon this
plant and draw this supply from other sources has been adopted by the
Trust.

The accompanying copy of The Engineer, Nov. 30th, 1888, gives details of
the engines of these last mentioned plants, and the photo. shows the bend
on the river from which the Homestead plant draws its water. Here as at
the other stations the deep water in the bight of a bend has been chosen,
and a plain suction pipe has been placed in it without any fender or crib
work other than the necessary support. This arrangement is as economical
as it is simple.

THE PSYCHE BEND STATION.

Here is situated the main pumping station of the settlement. This
station is worthy of more than a passing glance. It is in fact the largest
pumping plant in this colony, probably also in Australasia.

The photo's herewith will give some idea of its size, and the accompany-
ing illustration of position of its sister plant, the Billabong engine will indi-
cate the peculiar nature of these engines.*

The general design is due to Mr. George Chaffey, and the engine is
called "The Chaffey." It is a very un-English type of engine and conse-
quently has been subject to an immense amount of adverse criticism by
engineers accustomed to the steady running and easy accessibility of parts
which usually characterises large British built engines.

As will be seen the engines have for cylinders as follows:—16 2/3”,
24 1/4”, and 2 each 31 3/8” x 17 5/8” stroke. They have three cranks, the cen-
tral which is driven by the high and intermediate cylinders, transmits
over 70 per cent. of the whole power. The arrangement whereby the valve
motion is driven is exceedingly simple, namely, by means of a Counter
Shaft driven in the opposite direction to the main shaft by equal spur wheel
gearing.

* A description of these Engines will be found in Engineering, Vol. XLVII.,
page 70.
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Owing to the inequality of the number of teeth in the gear wheels, the wear of the teeth is uneven and the result is a very noisy engine. Though it is beyond question that the engines have run well and shown a fair economy of fuel, nevertheless the fact that they have given more than the usual amount of wear and tear, and noise from the gearing, are factors which have helped to confirm the bad name given to these engines.

It certainly is not reassuring to experience when standing on the plate of a stationary engine, noise and vibration which exceed those one expects on the plate of an express locomotive. At the same time the writer refuses to condemn engines, merely because they do not accord with the British views of what an engine should be.

This plant is designed to drive 4 40 inch centrifugal pumps, each capable of passing up to 4500 cubic feet a second, giving a total equal to 162 million gallons a day equivalent to more than four times the actual demand of the Settlement, which in turn is rather more than equal to the daily supply of the Melbourne and Metropolitan Board.

As erected, however, only two of these pumps have been connected, and the boiler power supplied is insufficient even for these when the river is low and consequently, the lift above the average; and the result has been that during the last Summer when the demand for irrigation in the Settlement reached its maximum, owing to the recent improvements, this plant had to work from 12 to 15 hours a day. Consequently among the works being carried out at present is the provision of additional boiler power at this station and the attaching of a third pump which should enable the plant to discharge up to the forty million gallons a day actually required, in less than 8 hours.

As will have been gathered from this description there is nothing peculiar about the requirements of this station, and its claim to interest is merely due to its size. Of course the lift to which the water must be raised will vary with the level of the water in the river. When the river is at lowest Summer level and the reservoir is full this lift will be over 24 feet, but under average conditions the lift will not exceed 16 feet.

In the accompanying photograph the water discharged is shown flowing in a stream 65 feet wide over the crest of a weir—with a drop of 4½ feet. This drop obviously means a great loss of power, and all this water must be subsequently raised at another pumping station before it can be utilized for irrigation. The first improvement work carried out by the writer in Mildura was to raise the Summer level of the reservoir so as to do away with this loss, the result is that the pumping plant which draws its water from the reservoir has been enabled to raise twenty per cent more water with a consumption of less fuel than hitherto.

This added to the additional pumping plant he erected at Nichols Point enabled the Settlement to raise and distribute 800 cubic feet a minute more water during the whole of the last Summer’s pumping than had ever been raised before, and the fuel consumed was slightly less than on previous occasions.

*Equivalent to about 700 million gallons for the annual demand.
And from raising the level in the reservoir a further but less obvious benefit has been conferred on the settlement. Formerly, in case of a break down at the Psyche Bend Pumping Station, there was grave danger of a stoppage of pumping throughout the whole system of pumps dependent on it, since the reservoir contained less than a week's supply. The reservoir now contains three week's supply and consequently it is only in the event of a very serious accident at Psyche Bend that the dependent pumps would require to stop.

Among the improvement works at present in hand is a reflux connection whereby, when the river is in flood, water may flow direct from it into the reservoir. Formerly at the low level which was maintained in this reservoir during a considerable portion of each irrigation season, the water flowed from the river into the reservoir, and Psyche Bend plant was allowed to stand idle. The accompanying (No. 5) diagram, which shows graphically the result of the engine logs at the different stations, will indicate this point, as will be seen by referring to the months from September to December in 1893 and 1894.

Before passing on to mention the subsidiary pumping stations and channels it might be as well to study this diagram, which gives the means of roughly estimating the cost of irrigating the areas supplied from each plant. To facilitate such an estimate the capacities of each plant will now be given with the area supplied therefrom. As a rule the channels supplied by each pump have capacities of almost exactly the capacity at which these pumps are usually worked, and in no case can cheap efficient irrigation be conducted where the capacity of the pump (and channel) are less than a cubic foot for every two acres irrigable therefrom. As the maximum water right granted by the State is equivalent to only half this, it is evident that if the main pumps are to keep pace with the demands of these subsidiary pumps then the irrigation must be conducted by sectionising in such a way that only half of the distributing pumps will be working simultaneously. This sectionising is now admitted as a necessity by the Mildura Trust.

**List of Subsidiary Plant.**

<table>
<thead>
<tr>
<th>Place</th>
<th>Capacity</th>
<th>Area supplied</th>
<th>Lift</th>
</tr>
</thead>
<tbody>
<tr>
<td>Billabong in '96</td>
<td>4100 c.f.m.</td>
<td>8000 acres</td>
<td>31 feet</td>
</tr>
<tr>
<td>do. in '87</td>
<td>4800 c.f.m.</td>
<td>do.</td>
<td>27 feet</td>
</tr>
<tr>
<td>Nicholls Point</td>
<td>2800 c.f.m.</td>
<td>5000 acres</td>
<td>23 feet</td>
</tr>
<tr>
<td>Nicholls Point new  station '97</td>
<td>5500 c.f.m.</td>
<td>1000 acres</td>
<td>40 feet</td>
</tr>
</tbody>
</table>

At No. 9 Station—770 c.f.m. (prior to repairs of 1897) supplies 1400 acres; 1150 c.f.m. since repairs of 1897.

At No. 10 Station—740 c.f.m. supplies 1800 acres.

The two remaining pumping stations discharge into wrought iron mains, and consequently do not admit of accurate measurement, however, it may be assumed that the discharge of the township engine already mentioned does not exceed 100 c.f.m., while that of the Deakin Avenue traction engine taking water from Nicholls Point main engine, will be about 250 cubic feet per minute, and they supply about 400 acres.
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Summarising it will be seen that the water is first raised 1 ft, from the river into the reservoir known as King's Billabong, thence it is raised by the Billabong engine to a height 50 feet above the lowest summer level of the river. From this channel the supply is distributed over four different areas. The first is situated below this channel and is supplied retail therefrom. This represents an area of about 600 acres.

A second area is supplied from this channel by being pumped through the No. 9 pump and by being again pumped by No. 10 pump, situated over a mile distant therefrom, it supplies the highest level country in the settlement (92 feet above summer level in the river). In this level, land is still in demand and if the water supply were assured all the most available land in this area would be planted, since the soil is of the rich Murray pine quality which produces the finest citron fruit. Unfortunately this is, from its situation, a very expensive district to water. The area supplied here is about 1300 acres and the cost of supplying this area, with the limited supply it receives, exceeds 30s an acre per annum.

A third area is situated on an isolated hill (85 feet above summer level of the river) covering an area of about 2000 acres, of which half is in cultivation, this area is supplied by the newly erected Otis pump. Prior to 1897 it was supplied like the last mentioned area at fourth hand, and the supply was costly and precarious.

The fourth and last area drawn from this channel is raised by the main Nichol's Point pumps and goes to supply the largest and most prosperous portion of the whole settlement, which is situated on land from 50 to 70 feet above the summer level of the river. This represents an area of over 5000 acres, about half of which is concentrated so that it can be easily and comparatively cheaply supplied with water. The balance is supplied by four long branch channels and consists of a large number of more or less isolated settlements. The cost of supplying the more remote of these settlements with a sufficient supply would represent not less than £3 per acre per annum. As, however, with the most careful management it is difficult to watch channels so far from the main settlement, it is no unusual experience for the remote settlers to miss their supply for a whole season at a time.

Sufficient has been said to indicate how many types of irrigation settlements are contained in Mildura, and how many useful problems can be solved by carefully measuring the water and fruit and observing the conditions under which fruit will grow, and collecting statistics of the returns from the settlers.

The first two of these matters being within his commission have been carefully investigated by the writer during 1896-7. He does not, however, presume to deal authoritatively on the question of returns from horticultural, cereal and fodder crops, but he gives the following results from the information gleaned by personal intercourse with the settlers, and the published returns on the subject.

1st. The gross average return from the settlement has during the last three years averaged about £6 per acre, actually irrigated.

2nd. These years have been very hard years for Mildura, the drought, combined with severe frosts and heavy winds, having damaged the crops.
considerably, so that in the future it is unlikely that the return will ever be much below this average.

3rd. The main effect of droughts has been to greatly increase the cost of irrigation by compelling the irrigationist to water more frequently and more heavily than should otherwise be necessary. Apart from this the higher prices likely to be obtained for produce will compensate the grower for the falling off in quality, which results from a drought.

And in conclusion he has no hesitation in stating that if any means can be adopted whereby the settlement can be concentrated and consolidated, that its future is assured. Even with the present scattered and extravagant arrangements, he sees no reason to doubt a moderate success for the settlement, since the majority of the settlers, holding from 15 to 25 acres, can make as good a living as the struggling farmers, in such parts of the colony as Gippsland, can make on ten times that area. But, in view of the very heavy renewals, which will be necessitated in time by the very temporary character of almost all the works of the settlement' he considers that the Trust will, from financial reasons, be quite unable to acquire the reserve that such a body should hold to meet the heavy strain of the almost continuous pumping which must be kept up during years of drought.
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DISCUSSION ON SOME IRRIGATION PROBLEMS AT MILDURA.

Prof. Kernot: To discuss the larger matters re Mildura is rather an impossibility at the present time, but several mechanical questions are interesting. What would it cost to put a very thin sheet-iron inside the corrugated iron channels mentioned?

Mr. Anderson: About £50 per mile.

Professor Kernot: Could not a mortice wheel be used to reduce the nuisance complained of re the slide valves of the larger engines?

Mr. Anderson: The teeth are too small, the wheels being only 1½" on the rim.

Prof. Kernot: The valve shafting might be worked by coupling rods, the crank of the main shaft being eccentric.

Mr. Anderson: If I made any alteration I would design Marshall’s gear with slippers in front.

Prof. Kernot: The latest form of high speed triple expansion engine is the 4 cylinder with 4 cranks, a high intermediate and 2 low to be adjoining cylinders with cranks beside. This appears according to all accounts to work extremely well. What is the relative merit of the Worthington as against the rotative type of centrifugal engine?

Mr. Anderson: Almost 100 per cent. better than the triple expansion engines; but, I think, the centrifugal was designed to give a heavier duty. It gives as good a duty when running against a head of 40ft. as when against a 23ft. head. Before deciding on the Worthington pump for the 40ft. head, I ascertained from one firm that they do not supply centrifugal pumps to work against more than a 30ft. head, whilst Tangye’s pumps work well up to a 35ft. head, when they would abandon them in favour of direct-acting pumps. I am inclined to take the latter limit, especially under perfectly steady conditions.

Professor Kernot: Is it possible to make a comparison between the Worthington and the more perfect centrifugal pump?

Mr. Anderson: The guaranteed duty is 70,000,000. The specification gave the pressure at 140lb. per square inch, but the contractors made the cylinder 50 per cent. larger than I considered necessary. The Worthington pump instead of requiring steam at 140lb. pressure is kept running at as low a pressure as 85lb. This, of course, affects the duty. The results are:—70,000,000 for a 40ft. head for the Worthington pump, and 50,000,000 for a 30ft. head for the best centrifugal plant. The Worthington is the best at an 1 over a 40ft. head, and is as cheap for first cost as the centrifugal pump. Regarding the maintenance, the heaviest wear in the Tangye engines is in the valves and in the lining of the high pressure cylinders. Various piston rings were used, and all seemed equally unsatisfactory. The fuel, at 6s. 6d. per ton, is by measurement.
Its value being about 3 to 1, which, with the cost of stoking and wheeling, brought it up to about equal £1 per ton for coal.

Professor Kernot: Have you considered the Reedler system of pumping? This gives a result of something like 140,000,000. It is a double acting plunger pump, with valves which are closed mechanically. That is the essence of the system. I have an elaborate test by a high scientific authority in America which seems to hold the record.

Mr. Anderson: I saw a Reedler pump in Rotterdam, in 1891, but the the result of the test of same was disastrous to the contractor. I noticed about the middle of 1897 a drawing of a new pump for Rotterdam by a Dutch firm. Perhaps within the last two years they have made considerable improvements in them. There was a large pump erected close by which was giving 83¾,000,000 duty, and was very satisfactory.
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