9. Melbourne's Water Supply Undertaking.

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It was natural that the earliest settlers in Melbourne should have selected a site for the city close to a permanent river, such as the Yarra, from which an abundant supply of potable water could be obtained.

The history which follows is one of increasing exploitation of the River Yarra by tapping its various tributaries at distant sources whence water uncontaminated by human settlement could be procured. Up to the present time the River Yarra is almost the sole source of supply to a city of over one million inhabitants and will be capable of supporting more than double that population; so that our forefathers made a wise choice for the capital city. In fact, it was the only choice available, for there are no large rivers in Victoria to the west of Melbourne, while to the east such rivers as discharge to the coast line are all deficient in harbor accommodation at their outlets to the sea.

The order of development in tapping the Yarra and its tributaries has been :—

(1) Pumping from the River Yarra close to Melbourne. (Abandoned.)
(2) Tapping the Plenty River to supply the Yan Yean reservoir at a location about 20 miles from the city.
(3) Tapping the Watts River, supported by the Maroondah reservoir, about 39 miles from the city.
(4) Tapping the O'Shannassy River, 55 miles from the city, with associated reservoir, the water being conveyed by aqueduct to Silvan reservoir, about 29 miles from the city.
Here surplus winter flows of the O'Shannassy aqueduct are stored for summer use. Provision is also made for storage of Upper Yarra water in addition to that from the O'Shannassy River.
(5) Tapping the Upper Yarra itself at a point about 20 miles upstream from Warburton, and about 75 miles from the city. This scheme is only partially completed and its waters will conjoin with those of the O'Shannassy River flowing into Silvan reservoir.

Historical Account of Development.

In 1835 the earliest settlers obtained their water from the River Yarra near Queen's (or what was first known as "Falls") Bridge.

At this point there was a ledge of rocks across the bed of the river. This obstruction was not sufficient to prevent saline water at high tide from intermingling with the fresh water upstream.

Various projects for raising the ledge by an artificial barrier were discussed and even attempted, but no permanent measure was effected.

Private enterprise played its part by establishing pumping plants in various parts of the river above the "Falls" site. Water so obtained was sold in barrels at prices ranging from 2s. to 10s. a barrel. Many of the residents supplemented their supplies by conserving rain water in receptacles.

Attempts were also made to obtain water by sinking wells, but did not meet with much success.

In 1849 a scheme for pumping water to a large filter at Flinders and Elizabeth Streets was successfully employed by Mr. James Blackburn, the filtered water being distributed in portable loads.

All these early efforts were more or less successful, but eventually upland sources of water supply free from saline and other contaminations, and dispensing with the use of pumps, were sought.

Much credit is due to Mr. James Blackburn, City Surveyor, who in 1850 first put forward a proposal to take water from the Plenty River, a tributary of the River Yarra at a site about 20 miles north of the city. A full report prepared in 1851 showed that the intercepted waters could be conserved in a reservoir formed by an embankment across the outlet of the Yan Yean swamp.

In 1853 this project took definite shape under a Government-nominated Board of Commissioners of Sewers and Water Supply, with Mr. Mathew B. Jackson, as engineer. The scheme provided for 30 gallons per head to 200,000 people by the construction of the Yan Yean reservoir at elevation 600 feet above sea level. The reservoir was filled by an aqueduct 2 miles in length from the Plenty River offtake, protected by flood gates, entry to the reservoir being effected through a tunnel.

The Yan Yean earthen embankment is 30 feet in height with clay puddle wall and is a little over half a mile in length. It impounds 7,234 million gallons of which 6,605 million gallons are available for consumption. The actual work of construction was commenced on 20th December, 1853, and occupied four years. Water was conveyed to Melbourne by a single pipe line of 30 in. diameter reduced in sections to 27 in. and to 24 in. at the city end.

While the reservoir works were under construction, preparation was being made at the city end for distribution by laying reticulation pipes in the principal streets of Melbourne and erecting standpipes in suitable positions.

Many of these early reticulation pipes are still in service.

A temporary supply to this pipe system was made available from an elevated cast iron tank of 150,000 gallons capacity erected in 1854 on Eastern Hill opposite the present central fire station, 160 feet above sea level or about 150 feet above the heart of the city.

Steam power was temporarily used to pump water from the Yarra into the Eastern Hill tank.

In 1857 the introduction of the Yan Yean supply brought about a final abandonment of all pumping measures.

Water was formally turned on in the City of Melbourne on the 31st December, 1857, amidst much rejoicing after the experience of the more or less indifferent supply of the preceding 22 years.

In thus early demonstrating the value of a gravitation supply, the engineering pioneers rendered a great service to the city of their day. Their successors have always closely followed that commendable objective.

The old iron tank was removed in 1892 and re-erected at the Metropolitan Sewage Farm at Werribee, and is still in service.

The total cost of the works at the end of 1857, including street reticulation, was about £754,000. Owing to the large numbers of men who were engaged in the eager rush for gold, labour was scarce, and the cost very high in the four years previous to 1857. During construction of the Yan Yean reservoir labourers were paid 20s. and masons 36s. per day.

In 1860 the Board of Commissioners of Sewers and Water Supply was abolished and its functions transferred to the newly-created Board of Land and Works.

In 1862 the charge for water through meter was reduced from 4s. to 3s. per 1,000 gallons. In 1863 it was still further reduced to, and still remains at 1s. per 1,000 gallons.

In 1874 the water rate, based on municipal valuations was reduced from 1s. to 8d. in the £. In 1888 it was further reduced to 6d. In 1906 it was increased to 7d., but was reduced in 1915 to 6d., and has remained unaltered up to the present time.

By 1875 the population had increased to 245,000, the number of houses supplied being 46,000. The original single cast iron main to the city was becoming overtaxed and increase in delivery was effected by constructing an open aqueduct, lined part of the way with stone and part with brick, between Yan Yean and Morang, the lifted cast iron pipes being used to augment the supply from Morang.

This aqueduct crossed the Plenty River on a stone bridge of single arch 45 feet span. In the great flood of 1878 this bridge was washed away and Melbourne was entirely cut off from the Yan Yean supply. For three days a hasty resort had to be made to Yarra water, using pumps and water carts, the people attending at the Town Hall and at the tank at Eastern Hill with all sorts of receptacles for carrying water away.

Under the direction of the then acting engineer, Mr. Wm. Davidson, a temporary wooden flume over the flooded Plenty River was hastily erected to restore the supply and later was replaced by a wrought iron flume which is still in service.

In 1879 the low level of the reservoir demonstrated that further supplies were necessary for a population which had increased to about 256,000. Moreover, the quality of the Plenty River water had progressively deteriorated owing to increasing settlement.

These conditions brought about the development between 1879 and 1886, which led to a milestone in the history of the waterworks undertaking, when the old Plenty River intake was finally discarded, water being taken only from forest upland and mountain country free from human occupation.

The uncontaminated waters of the eastern branch of the Plenty River, above the township of Whittlesea, were collected in the Toorourrong reservoir, formed by an earthen embankment 15 feet in height and 15 chains in length. This reservoir of 60,000,000 gallons capacity serves to collect the waters of the eastern branch of the Plenty River and also those gathered from Wallaby and Silver Creek watersheds on the northern side of the Main Dividing Range. An aqueduct of capacity 120,000,000 gallons daily delivers this water to Yan Yean reservoir.

Silver Creek and Wallaby Creek are in the Murray River watershed, being tributaries of King Parrot Creek which flows into the Goulburn River; they are the only waters for Melbourne not derived from the River Yarra.

By means of several small diversion weirs and 15½ miles of stone lined channels, these waters were collected and diverted over a saddle in the Main Dividing Range thence by a series of stone-lined drops forming artificial cascades into Jack's Creek in the Plenty River watershed whence they flow into Toorourrong reservoir on their way to Yan Yean reservoir.

Notwithstanding the measures in progress between 1883 and 1886 for reinforcing the Yan Yean supply, a large new supplementary scheme was a vital necessity for the rapidly growing population, and surveys for the purpose of tapping the Watts River and its tributaries near Healesville were actively prosecuted.

In 1886 the construction of the aqueduct for this purpose was commenced. It was completed and brought into use in February, 1891, when the name of the river and system was changed to Maroondah.

The Maroondah aqueduct is 40 miles in length, consisting of 25 miles of open channel, 12 tunnels of aggregate length 7 miles (including three each about a mile long), also 13 inverted siphons of total length 8 miles.

The Maroondah watershed comprises about 40,000 acres of densely forested mountainous country remarkable for its tall trees and deep porous soil. These features, coupled with a well-distributed rainfall, have made the watersheds very fruitful of that perennial stream flow which has always been a distinguishing feature of all Melbourne's water supply catchment areas.

The purchase of all alienated land and the razing to the ground of the whole of the tourist township of Fernshaw was completed so as to secure clean water areas.

Up to the time of the commencement of the Maroondah aqueduct works in 1886, all the weirs, open channels, and tunnel lining of the waterworks were of cut stone construction with a small amount of brick work.

The age of concrete was to commence with the Maroondah aqueduct, concrete being thereafter used for nearly all channels, tunnel linings, weirs, basins, etc.

At this time also, wrought iron was first used in the construction of large pipes, a new main of riveted construction, 30 in. in diameter being laid in 1886 from Preston reservoir to Melbourne.

The Maroondah aqueduct siphons, 53 or 50 inches in diameter, were also constructed of riveted wrought iron.

The age of wrought iron for large pipes was rapidly to be succeeded by the use of mild steel, while riveted forms of construction were followed by lock bar, and still later by electrically-welded pipes. Wrought iron and mild steel pipes have played a great part in the development of the Melbourne water supply system, both in its main conduits and its principal distributing mains. The total length of these pipes in use in the Melbourne system up to 1934 was 314 miles 55 chains, the largest pipes being 75 inches in diameter.

The Maroondah aqueduct delivers its water to Preston reservoir at 320 feet above sea level, furnishing supply by gravitation to all the central and western parts of the metropolitan area but is too low to be of service in the eastern suburbs.

The aqueduct was originally constructed for a delivery of 25,000,000 gallons daily for siphons and open channels but the tunnels were made to deliver 50,000,000 gallons.

The level of the Maroondah aqueduct was determined by the site for the Maroondah dam, later to be constructed in the valley of the Watts River about three miles from Healesville.

The limitations of the Maroondah system necessitated the provision during 1891-92 for the rapidly-growing eastern

suburbs of a 32 in. main laid direct from Yan Yean reservoir across country, a total length of 20½ miles to Surrey Hills service reservoir, which is 430 feet above sea level. Subsequently this reservoir became the discharging end of the high level O'Shannassy scheme and one of the main distributing points for the whole of the eastern and south-eastern suburbs.

It is at this stage fitting to refer to the work of Mr William Davidson, I.S.O., M.Inst.C.E., because the works passed out of his control and were in 1891 handed over from the Public Works Department to the Melbourne and Metropolitan Board of Works, the newly-constituted Water and Sewerage Authority, with Mr. William Thwaites, M.A., M.C.E., M.Inst.C.E., as Engineer-in-Chief and Mr. William Dowden, C.E., Engineer of Water Supply.

Mr. Davidson's name will always have an honored association with the Melbourne water supply, firstly, because of the Wallaby and Silver Creek construction works and the establishment of clean catchment areas for the Yan Yean reservoir; secondly, because he constructed the Maroondah aqueduct, and again established clean catchment areas; and thirdly, because he had the vision and foresight to obtain a liberal future provision by Government reservation of 115,000 acres of the Upper Yarra watershed for future Melbourne water purposes.

At the time of transfer to the Metropolitan Board of Works, the capital expenditure on the Melbourne water supply amounted to £3,378,246 for a total population of 486,620, and the revenue to £197,339. The total length of aqueducts, mains, and reticulation was 1,130 miles. There was one storage reservoir at Yan Yean and seven service reservoirs.

Immediately afterwards came the collapse of the land boom, a falling-off in population, and with it a severe curtailment of water supply expenditure. The lowest ebb was reached in 1894-5 with a total population of 444,340, while the revenue based upon valuations fell to £155,931 in 1896-7.

Until 1906-7 there was no definite signs of such substantial population increase as would necessitate major additions to the water resources.

At that time the total population was 530,655, expenditure on water supply works £3,793,389, and the mileage of aqueducts and pipe lines 1,272 miles.

On the death of Mr. William Thwaites in 1907, and the retirement of Mr. W. Dowden, Mr. Calder E. Oliver, M.C.E., M.Inst.C.E., became Engineer-in-Chief of the Board, and the writer, who had been assistant to Mr. Dowden since 1896, was appointed Engineer of Water Supply.

The following years were to see a great expansion of the water supply system. During 1909 an interim tributary supply from Coranderrk Creek, the catchment area of which forms part of the Maroondah watershed, was constructed.

At that time the outstanding consideration was the abnormal tendency for population increase towards the higher levels of the eastern and south-eastern suburbs.

Because of this, the advocacy on behalf of the Metropolitan Board of Works was for delaying the construction of Maroondah reservoir and the consequent enlargement of the Maroondah aqueduct.

It was contended that the O'Shannassy and Upper Yarra high level scheme should first be put in hand so as to provide a foundation supply to all those higher levels which the Maroondah aqueduct scheme was too low to serve by gravitation.

This involved handing over to the Metropolitan Board of Works the O'Shannassy River catchment area, comprising 32,650 acres of the 115,000 acres of Upper Yarra watershed reserved in 1888 for future water supply purposes.

Considerable antagonism to these proposals developed from a section of the press and public which sought the creation of the Maroondah reservoir and much delay naturally resulted.

Eventually the Government appointed a Royal Commission which, after exhaustive inquiry, issued a report on August 11th, 1909, entirely upholding the O'Shannassy project as against the completion of the Maroondah scheme. So was averted the necessity of providing pumping plant to deliver Maroondah water to the higher levels, and a far-reaching and economical basis for supply by gravitation to every part of the metropolitan area was established for all time.

The O'Shannassy aqueduct construction was commenced in July, 1911, and by October, 1914, the scheme was in full operation. The aqueduct consisted of 23 miles of open or covered channels, three tunnels aggregating a little over half a mile, and 25½ miles of steel pipes 34 inches to 36 inches in diameter, the delivery being 20,000,000 gallons daily.

The completion of the O'Shannassy aqueduct practically synchronized with the outbreak of the Great War, and was just in time to avert a shortage of water which every other important city in the Australian Commonwealth experienced more or less during the exceptional drought of 1914.

In 1915 and 1916 exploratory work and investigations costing £9,715, fortified by independent geological reports, finally confirmed the choice of the Maroondah dam site and showed that an expensive structure requiring a firm rock base throughout could be safely commenced.

The work of clearing the area of submergence was commenced in 1917, and of diverting the river in 1918.

In 1918, on the retirement of Mr. Calder E. Oliver as Engineer-in-Chief of the Metropolitan Board, this position was abolished and the duties of Chief Engineer were divided between the Engineer of Water Supply and the Engineer of Sewerage, the Water Supply Department thereafter remaining under the control of the writer up to the present date.

In October, 1920, the Maroondah dam was commenced and was completed in 1927. The dam is of gravity section constructed in cyclopean rubble concrete. Particulars are as follow:—

Maximum height	...	...	135 feet.
Total length on top	...	...	946 feet.
Total capacity	...	...	6,274,000,000 gallons.
Water surface area	...	...	488 acres.

The dam is curved in plan to a radius of 1,500 feet and is provided with a complete drainage system to prevent the infiltration of water through the concrete.

While the dam was under construction, the Maroondah aqueduct was enlarged to 50 million gallons per day to deliver the additional stored water.

The Maroondah reservoir ensured for many years the supply for the lower levels of the city proper and western suburbs (extending 18 miles out from the city to Werribee).

The increasing tendency for abnormal growth in the eastern and south-eastern suburbs, however, necessitated considerable augmentation of the O'Shannassy supply for these suburbs. Works for this purpose were actively prosecuted during the whole period of Maroondah dam construction.

In 1917, the Engineer of Water Supply reported the location of two most favorable reservoir sites about three miles off the main O'Shannassy aqueduct line near Mount Dandenong in the vicinity of the township of Silvan.

This development opened a very wide field for the economical exploitation of the O'Shannassy and Upper Yarra watersheds. Moreover, the Silvan reservoirs secure the metropolis against the risks of breakdown attendant upon 28½ miles of mountain aqueduct and siphon lines from between Silvan and the O'Shannassy weir.

But for the military contour map of Ringwood just then issued, it is doubtful whether these reservoir sites would ever have been discovered. Their existence on two small tributaries of the Olinda Creek and their possibilities in connection with the O'Shannassy system of supply had not been suspected before and the great value of topographical survey maps for public works was thus demonstrated.

Economic considerations and the urgency for augmented supplies called for construction of the O'Shannassy dam first to make good the deficiency in stream flow of the O'Shannassy River, as shown by the record drought of 1914.

Construction was commenced in 1922 and completed in 1928. The dam is an earthen structure with solid reinforced concrete core wall backed by puddle clay on the upstream side. On the downstream side of the core wall is a broken stone diaphragm to carry away any percolations of water through puddle and concrete.

The length on top is 740 feet.

The maximum vertical height above the lowest point of the downstream toe of the dam is 150 feet, making this the highest earthen dam in Australia.

The reservoir has a surface area at top water level of 74 acres, and contains about 930,000,000 gallons.

Concurrently with this reservoir work the O'Shannassy conduit of 20,000,000 gallons per day was enlarged to 60,000,000 gallons to provide for the greater exploitation of O'Shannassy water which would follow on the creation of Silvan reservoir No. 1.

Extensive surveys and investigations, commenced in 1917, were also prosecuted in order to make a valuation of future water supply resources and to study these in relation to the establishment of the Silvan reservoirs.

Investigations were pursued beyond the 115,000 acres of the Upper Yarra watershed in the region of the Baw Baw Plateau and as far as the Thomson and Aberfeldy Rivers near Walhalla.

In 1922 the Engineer of Water Supply submitted a report giving a complete summary of the various systems, their ultimate capacity for supplying populations being set forth as follows:—

Yan Yean	220,000	people
Maroondah	680,000	,,
O'Shannassy and Silvan	530,000	,,
Armstrong's Creek	70,000	,,
Upper Yarra above Armstrong's Creek ...	900,000	,,
Baw Baw Plateau system	600,000	,,
Grand Total ...	3,000,000	,,

It was shown that in 50 to 60 years this provision would be exhausted by a population of 3,000,000 people, and it would then be necessary to tap the Thomson and Aberfeldy Rivers. These rivers with a watershed of 184,000 acres will probably furnish supply independently for 1½ to 2 million people, but surveys of storage reservoirs have not yet been made.

Accordingly, on 18th April, 1923, the Metropolitan Board made formal application to the Government to vest in the Board for water supply purposes the whole of the Upper Yarra watershed above the O'Shannassy River, also the Baw Baw Plateau, and the watersheds of the Thomson and Aberfeldy Rivers, these comprising the only remaining Crown Lands which could be availed of for Melbourne's water supply without conflicting with other important interests.

The construction of Silvan Reservoir No. 1 was commenced in 1926 and completed in 1932, but water was turned in during July, 1931.

The dam has a maximum height of 136 feet and the length on top is 2,100 feet.

It is an earthen structure with reinforced concrete core wall of cellular construction designed to intercept percolating water and conduct it to a drainage tunnel which is incorporated in the core wall from end to end just below natural surface levels. This tunnel is drained to the outside of the dam. The cellular core wall principle is almost entirely new and represents a notable advance in the construction of large earthen dams. The foundations of the core wall extended in parts to as much as 140 feet below natural surface level.

The reservoir covers 803 acres at top water level and the capacity is 8,853,000,000 gallons. The catchment area is only 2,228 acres. The reservoir is filled from the O'Shannassy aqueduct and from a separate aqueduct constructed in 1928-29 and 9 miles 21 chains in length delivering the waters of the Graceburn and Goranderrk Creeks of the Maroondah watershed. The combined waters are introduced through a tunnel. There will be a separate tunnel and aqueduct connection from the Upper Yarra in future.

In 1929 a commencement was made to construct the Upper Yarra aqueduct to connect with the O'Shannassy aqueduct.

The open channel sections were completed over a total length of 9 miles 67 chains. The connecting siphons of total length of 3 miles 5 chains were not laid, and because of the serious economic depression which just then set in further work was temporarily deferred.

Space will not admit of any detailed description of the extensive works, including service reservoirs, for distribution at the metropolitan end of the supply systems. These were prosecuted vigorously along with the major head works.

The total capacity of the present four main storage reservoirs is 23,351,305,000 gallons, and of the 23 service reservoirs is 261,700,000 gallons.

The total mileage of aqueducts and mains up to 75 in. diameter is 2,784. These, if considered as laid along the lines of the main railway routes, would extend from Sydney to Perth.

The maximum daily consumption to date has been 148,976,000 gallons, and the total cost of the works about £11,200,000. The total population supplied with water is about 1,140,000.

Melbourne is now possessed of one of the best supplies of naturally pure water in the world, almost entirely distributed by gravitation, while very liberal supplies for increased population have provisionally been made.

The writer has been actively associated with the Melbourne water supply since 1896. Prior to that date in particular, he desires to acknowledge his indebtedness to the official record book of the Melbourne and Metropolitan Board of Works for most of the early history as set out herein.