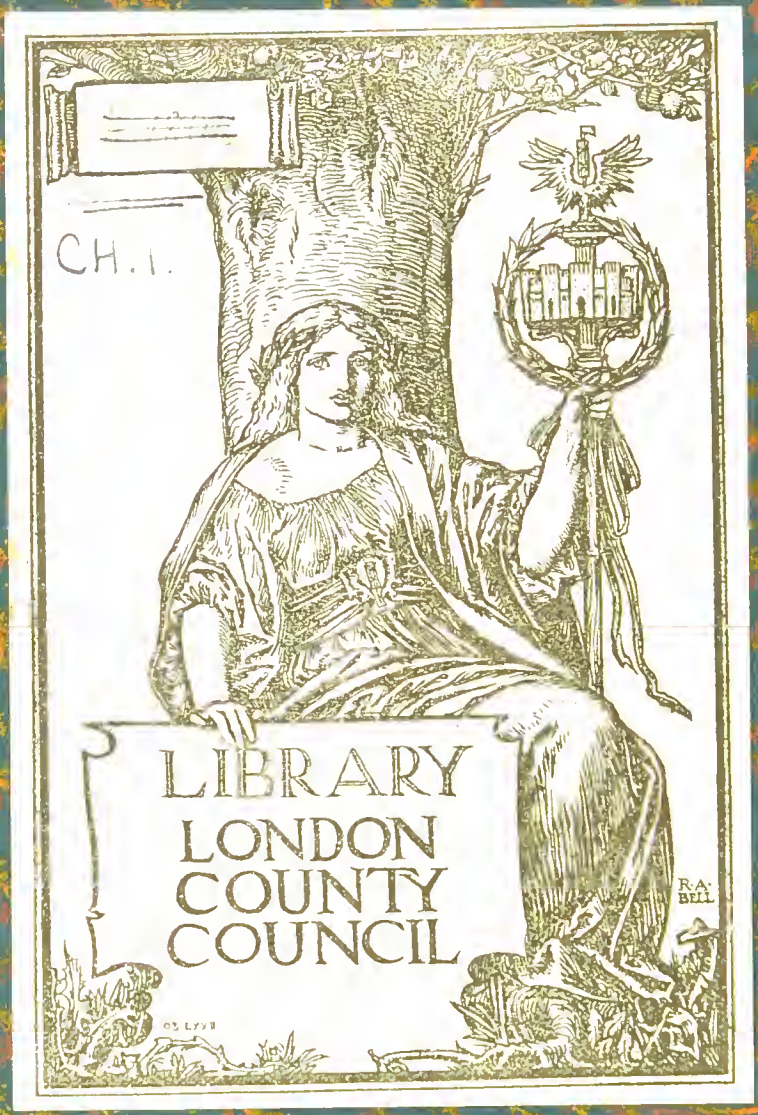
THE BIRMINGHAM WATER SUPPLY.

By THOMAS BARCLAY.



The Future Water Supply of Birmingham.

The laying of the Commemoration Stone by the Lord Mayor (Councillor James Smith), May 28th, 1897.

THE FUTURE WATER SUPPLY OF BIRMINGHAM.

BY

THOMAS BARCLAY,

SOMETIME MEMBER OF THE WATER COMMITTEE OF THE CITY COUNCIL OF BIRMINGHAM.

THIRD EDITION.

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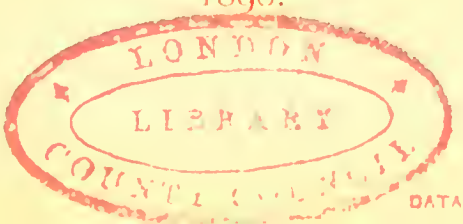

BIRMINGHAM:
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SOUTHALL BROTHERS AND BARCLAY, LTD.

DEDICATED TO

EDWARD LAWLEY PARKER, Esq., J.P.,

Alderman and sometime Mayor of the City of Birmingham,

DURING WHOSE MAYORALTY

THE BIRMINGHAM CORPORATION WATER BILL

WAS PROMOTED

BY THE CITY COUNCIL,

WHO RENDERED CONSPICUOUS SERVICE

DURING THE PARLIAMENTARY CAMPAIGN,

WHICH RESULTED

IN THE BILL BEING CARRIED INTO LAW,

AND UPON THE DEATH OF SIR THOMAS MARTINEAU,

WAS UNANIMOUSLY CHOSEN TO OCCUPY

THE HIGHLY ONEROUS AND HONOURABLE POSITION

OF CHAIRMAN OF THE WATER COMMITTEE.

PREFACE.

The first five chapters in the present edition were written prior to the passing of the Birmingham Corporation Water Act, 1892, and, as they still possess interest to those who may be desirous of learning why the scheme was undertaken, I have thought it advisable to reprint them in their original form.

The additional chapters give particulars of the passing of the Act, some account of the Liverpool, Manchester and London water supplies, the provision made for the interim supply of Birmingham, a description of the works in the Elan Valley, showing the progress made in the construction of the reservoirs on the watershed and at Frankley, and what has already been accomplished on the line of aqueduct.

Mr. E. Orford Smith, the Town Clerk of Birmingham, has rendered me valuable assistance, and also placed at my disposal

the Blue Book containing the evidence given before the Parliamentary Committee. Whilst I cannot sufficiently thank Mr. E. Antony Lees, the Secretary of the Water Department, for the exceptionally useful aid he has given me, and it is to him that I am indebted for the very graphic description of the navvy village which is included in this edition.

By the courtesy of Mr. James Mansergh, M.I.C.E., I am enabled to reproduce the coloured map and photograph of the model of the watershed used in the Parliamentary evidence. On the former will be seen the watershed of the Elan and Claerwen, the line of aqueduct to Frankley, the Birmingham and other water areas, and a sectional plan showing the hydraulic gradient, and the geological formation of the country traversed by the aqueduct. Through the kindness of Mr. Mansergh the privilege has been accorded me of publishing the series of interesting photographs which illustrate the progress of the works.

I desire to take this opportunity of expressing my gratitude to the many other gentle-

men who have helped me with information on different points touched on in the book. Among these I would specially mention the Préfet of the Department of the Seine, Sir James Sawyer, M.D., Mr. Joseph Parry, C.E., Engineer to the Liverpool Corporation, Mr. William Blackstock, Secretary to the Manchester Corporation Waterworks, Mr. G. N. Yourdi, C.E., Resident Engineer of the Elan Valley Works, and Mr. Henry Johnson, F.G.S., M.S.A.

THOMAS BARCLAY.

ARNCLIFFE,
MOSELEY,
August, 1898.

ERRATA.

PAGE

113, line 15, for "22nd," read "27th"

140, line 13, insert "highest" before "possible."

196, line 17, for "Preston," read "Prescot."

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on the Elan.

Pen=y=gareg.

THE FUTURE WATER SUPPLY OF BIRMINGHAM.

CHAPTER I.

Present Water Demand and Supply.

PERHAPS the heaviest responsibility resting on any local government is the establishment and maintenance of a proper supply of water for those under its care. How unpardonable a failure in this all-important matter! Yet how vast the task!

Few, except those whose duty it is to look closely into the matter, have anything like a correct idea of the quantity of water required for the various wants of a city like Birmingham.

Present Water Demand.

In foods, solid and liquid, it is true, that only from 3 to 5 pints per head a day are consumed. But, for all domestic purposes together, there is used in Birmingham 15 gallons a head daily. Add to this the water required for baths and other sanitary purposes, for watering streets, for hydraulic lifts, for the production of steam for manufactures, and for use in many industrial processes, and the average daily consumption is, we are not surprised to find, 23 gallons per head.

It must be borne in mind, too, that the City Council, which by Act of Parliament is constituted the Water Authority, is under obligation to supply, not only the inhabitants of the City of Birmingham, but also those of a large district outside, which together is called the Parliamentary Area, covering 83,000 acres, the inhabitants numbering in all 658,878. For these consumers the Corporation had to provide 6,141 million gallons of water for the year ending March, 1891, sufficient to form a lake 3ft. deep, with a surface of 12 square miles.

The pipes, by which the present water supply is conveyed to consumers, measure 576 miles in length.

Present Supply.

In the "Few Notes on the Water Supply of Birmingham," I issued in 1888, I showed that the resources of the Corporation were at that time :—

I. WELLS.

Aston ...	yielding	3	million	gallons a day.
Witton ...	,,	2½	,,	,,
King's Vale	,,	¼	,,	,,
Perry ...	,,	2	,,	,,
Selly Oak	,,	1¼	,,	,,

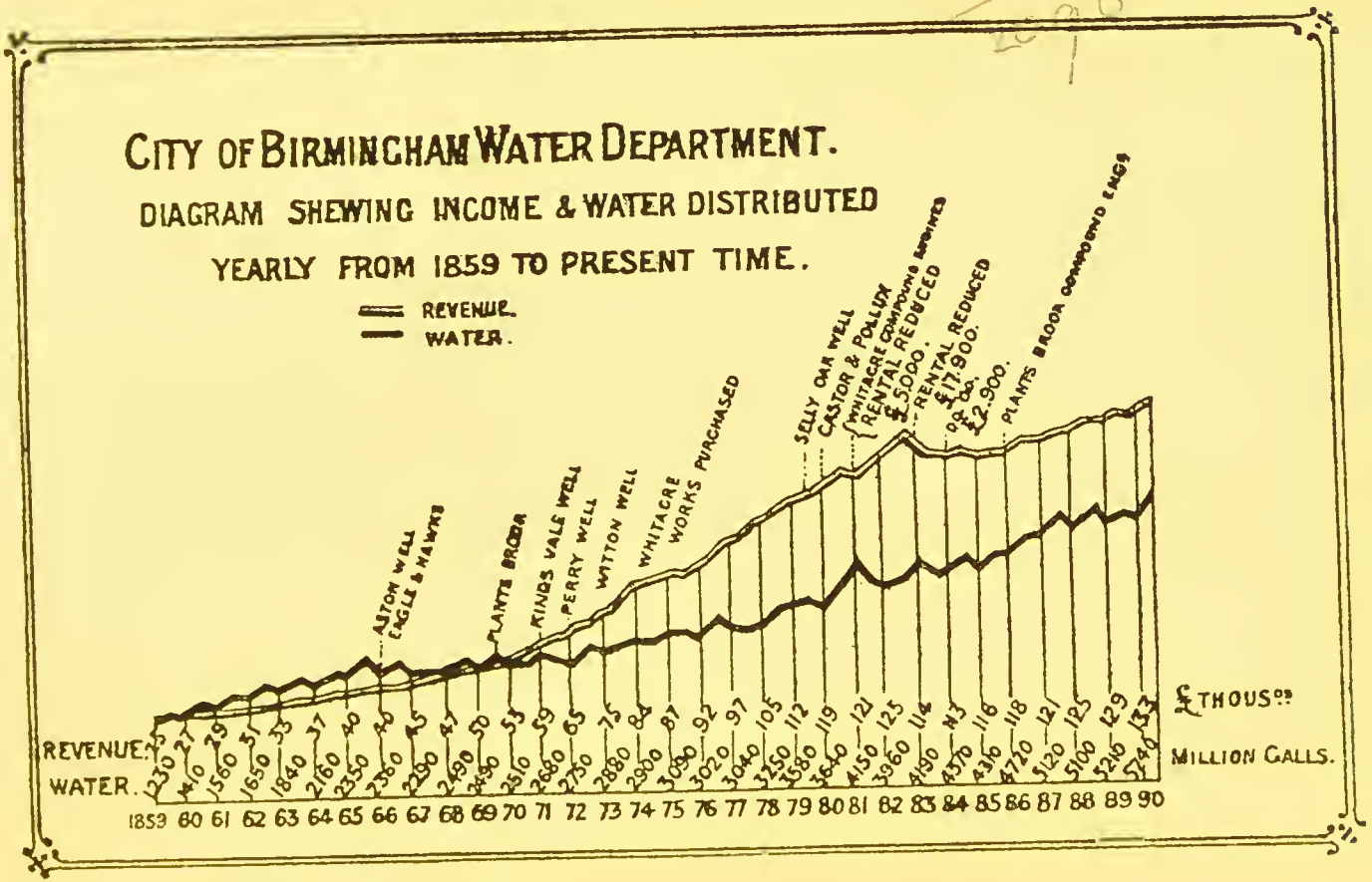
making a total of 9 million gallons a day of well-water.

II. STREAMS.

Plant's Brook,	yielding	2	million	gals. a day.
Perry and Witton Streams	,,	1	,,	,,
Blythe	,,	2½	,,	,,
Bourne ...	,,	2	,,	,,

making a total of 7½ million gallons a day of river water.

The latter is collected from five separate watersheds, having a total area of 111


CITY OF BIRMINGHAM WATER DEPARTMENT.
DIAGRAM SHEWING INCOME & WATER DISTRIBUTED
YEARLY FROM 1859 TO PRESENT TIME.
REVENUE.
WATER.
ASTON WELL
EAGLE & HAWKS
PLANTS BROOK
KINGS VALE WELL
PERRY WELL
WITTON WELL
WHITACRE WORKS PURCHASED
SELLY OAK WELL
CASTOR & POLLUX
WHITACRE COMPOUNDS LEASED
RENTAL REDUCED £5,000.
RENTAL REDUCED £17,900.
0 & D. £2,900.
PLANTS BROOK COMPOUND LAID
REVENUE £ THOUSDS
WATER. MILLION GALLS.
1859 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90
230 270 310 350 390 430 470 510 550 590 630 670 710 750 790 830 870 910 950 990 1030 1070 1110 1150 1190 1230 1270 1310 1350 1390 1430
1560 1650 1840 2160 2350 2360 2250 2490 2490 2610 2680 2750 2880 2980 3090 3020 3040 3250 3580 3640 4150 3960 4190 4370 4316 4720 5120 5100 5246 5740

square miles. Since then, another deep well has been sunk at Longbridge, near Rubery, which is expected to yield about 1½ million gallons a day. Including this, from streams and wells we obtain a supply of 18 million gallons a day. Our storage reservoirs, in time of drought, may be reckoned upon for 2¾ million gallons a day additional, so that, at present, the Corporation's supply is very little ahead of the demand, which amounts to some 17 million gallons a day on the average, but the maximum last year was 22 millions.

Future Requirements.

It would, therefore, be inexcusable to rest satisfied with the supply at present available, as a few facts will show. At a recent meeting of the Committee, the pipes sanctioned for new streets and roads measured close on a mile in length. The demand has been increasing of late years at the rate of 3% per annum. If the same rate of increase is maintained, within ten years from now the demand will be in excess of the present average supply.

The accompanying Chart shows at a glance the annual growth of the Department, both as to income and the quantity of water distributed, from the years 1859 to 1890 inclusive.

To maintain a full provision for an ever-growing population is a problem which requires much forethought, but, as I stated in the Notes already referred to, "The Council are determined to leave nothing undone to maintain the security and purity of the water supply of the district dependent upon them, and to keep well ahead of the growing needs of the consumers."

The Committee accordingly, taking thought for the future, and fearing that the local resources might prove inadequate, have for some time past been seriously considering the question of their prospective requirements, and the Engineer, Mr. J. W. Gray, M.I.C.E., was requested by resolution to report on our present position, and the best means for maintaining the water supply of the city. In response he brought up a very able report, in which he showed

that 25 years hence there would probably be required daily 11 million gallons of water more than our present supply can yield, and in 50 years 38 million gallons more.

Future Supply.

On receiving this report, the Committee felt that they must immediately take steps to secure such an additional supply of good water, as would remove all apprehensions for some time to come, if they were to discharge their responsibility to their fellow-citizens, and continue true to the Committee's tradition of foresight.

A resolution was accordingly passed requesting the Engineer to the Water Department, and also Mr. J. Mansergh, M.I.C.E., of Westminster, the well-known expert, to report what works they would recommend for giving such an additional water supply as would, with the existing sources, provide for periods of 25 and 50 years respectively.

Local Development.

Naturally their attention was directed first to the development of the supply from local sources,

and a most thorough examination was made of all possible additions. A most careful scheme was drawn up by Mr. Gray, embodying all these sources. From the facts furnished by him it is easy to estimate how far these local developments will avail.

Our Rivers.

Four reservoirs might be constructed in the watershed of the Bourne for the storage of its flood waters, which, though at present allowed to flow down the river, might, if collected in the reservoirs, with time to deposit the suspended matter, flow along the present stream to the existing reservoir at Shustoke.

Bourne.

The whole drainage area of the Bourne above the Shustoke reservoir being 10,880 acres, and the mean rainfall about 28 inches, the surface of the reservoirs which would have to be made, would cover an area of 275 acres, and if the banks of the Shustoke reservoir were raised, additional storage would be provided for 1,131 million gallons; but after making the usual allowances for unstorable water and evaporation, the Engineer is of opinion that

the area and rainfall are not competent to provide continuously more than 7 million gallons a day. The Engineer further reported that in the valley of the Plant's Brook, various pools by Sutton Park might be purchased by arrangement or under Act of Parliament, but not more than half a million gallons a day could be relied upon from this source during a six months' drought. He also shewed that it would be necessary, if the flood waters of the Bourne were taken, to double the engine power and filter beds at Whitacre within the next 20 years; but that the increased supply would be insufficient for the requirements of the consumers at that period. Further, that there is no other river-water suitable for our purpose in the local area. It was certainly suggested by a correspondent in the Daily Press that the city might be supplied from the upper reaches of the Rea. I recently inspected this famous river some little distance from its source, and had an analysis made of its water, the results of which are shown later on, where it will be

Plant's Brook.

Rea.

seen that the quality of the water is not by any means unimpeachable, and, moreover, there is too little of it; and what there is, has already been turned to very practical use by manufacturers, as it makes its way to Birmingham. Therefore the Rea is out of the question.

Shenstone.

There is, besides those belonging to the Corporation, only one local stream worthy of consideration—the Shenstone Brook, which rises north-east of Barr Beacon—but as this flows through the district which is supplied by the South Staffordshire Water Company, it would be fatal to our obtaining it for Birmingham. Consequently, if we are to depend upon local resources, we cannot look to streams for our provision, but shall have to turn to deep wells in order to obtain the necessary quantity to supply the city.

Increase of Wells.

The present deep wells average a daily yield of about 1½ million gallons each; it would, therefore, require 20 to 25 of them to complete the supply if the same average yield were

maintained. The question immediately arises, would it be possible to find water in sufficient quantity by boring so many wells in the district, and if so, would the water be suitable in quality for the general supply of the inhabitants ? Further, if these questions could be satisfactorily answered, would it be prudent for the city to rely mainly on wells for a permanent supply of water ?

It may be said at the outset, that there is no considerable town in Great Britain, with the exception of Wolverhampton, which is supplied mainly from wells. Liverpool and Manchester have both within recent years been compelled to increase their water supply, but in neither case has it been thought advisable to attempt this by means of deep wells. In Liverpool several of the old sandstone wells have had to be abandoned in consequence of the deterioration of the water. Since 1850 the hardness of the water in their principal well has gradually increased from $7\frac{1}{2}$ to $30\frac{1}{2}$ degrees, which is due to the well having had to be

sunk deeper and deeper to obtain the necessary supply. The total yield of these deep wells in Liverpool is only 6½ million gallons a day.

Wells and Springs at Paris.

It has been stated that the city of Paris is supplied mainly by water from deep wells, but that this is not the case is shown by the following extracts from an official letter I received from the Préfet, in reply to an enquiry I addressed to him respecting the water supply of Paris :—

"The capital is supplied in very unequal proportions—(1) by waters confined in the Canal de l'Ourcq ; (2) by river water ; (3) by spring water ; (4) in a very small quantity by the water of artesian wells.

"The water specially used for domestic purposes is derived from two small rivers, the Dhuis and the Vanne. These two rivers being notoriously insufficient for the supply of the city ; the Water Committee has recently obtained authority to draw from additional springs. The artesian wells

furnish only very small quantities of water —that of Grenelle only gives 77,000 gallons; those at Passy yield about 130,000 gallons a day. Their water serves for the supply of the lakes in the Bois de Bolôgne. The boring of two other artesian wells was commenced several years ago, but their completion has up to the present been delayed."

Water is also obtained for the flushing of sewers and gutters, the supply of fountains and industrial purposes, from the Canal de L'Ourcq and the rivers Marne and Seine. Each street is provided with a double set of pipes, the one for carrying drinking water, the other for public services and industrial needs.

Warning from London.

In a very interesting article on the London water supply (one of a series which have recently appeared in the *British Medical Journal*), it is pointed out that that supply is very insecure. The article states that "in the valleys of the Colne and Lea, and in the main valley of the Thames, springs which

were perennial 30 years ago are now run dry. Mills are being abandoned for lack of water power, and rivers which once flowed regularly are now lost in holes, or flow scantily for a few weeks in the season. The level of the water in deep wells has fallen 20ft. in as many years. In 1821 the water in a well in East London stood at Trinity high water mark 22ft. above sea level; in 1851 its average height was 43ft. below, and in 1881 it was 105ft. below, a lowering of 127ft. in 60 years. This is not due to diminished rainfall, which has been nearly 2in. above the average of the previous 30 years, but the cause lies wholly and solely in the fact that water has been, and is being, increasingly drawn from the chalk basin in excess of the supply."

Our Wells.

Our own experience also in the matter of deep wells is far from encouraging. When the King's Vale Well was sunk, the opinion of experts was taken, and it was considered the best site in the Red Sandstone. It was confidently expected that 6 million gallons a day would

be obtained from it, but the actual yield was found to be only 300 thousand gallons a day.

Then, recently, a site for a deep well was selected at Harborne after a careful examination of the neighbourhood. A trial bore-hole was made at a cost of £400, but the yield of water was so small that the site was abandoned. Fortunately arrangements had been made with the owner of the land to take it back if the experiment proved unsatisfactory. The result, however, was loss of time and about £400 for expenses.

Then, again, at Longbridge, near the Lickey Hills, our last sinking, which is in the most likely part of the whole district for obtaining a good supply, the yield is much less than was anticipated. If we get 1½ million gallons a day, the average quantity of the other wells, it is all we may expect.

The Opinion of an Experienced Mining Engineer.

The uncertainty, both as to the quantity and quality of water from additional wells, is clearly demonstrated by Henry Johnson, Esq., F.G.S., M.S.A., past President (1883),

and Member of Council of the South Staffordshire and East Worcestershire Institute of Mining Engineers; than whom no one is better qualified to speak on the geological formation of the district, as it was his father and he who projected and carried out the scheme for the sinking of the Sandwell Park Colliery; during which operation they went right through the Red Sandstone formation into the coal measures below. The depth to the bottom of the Permian Formation being 600 feet, and to the thick coal 1,254 feet, whilst the total depth of the shaft is 1,313 feet. In his interesting letter published in Chapter V., he says:—

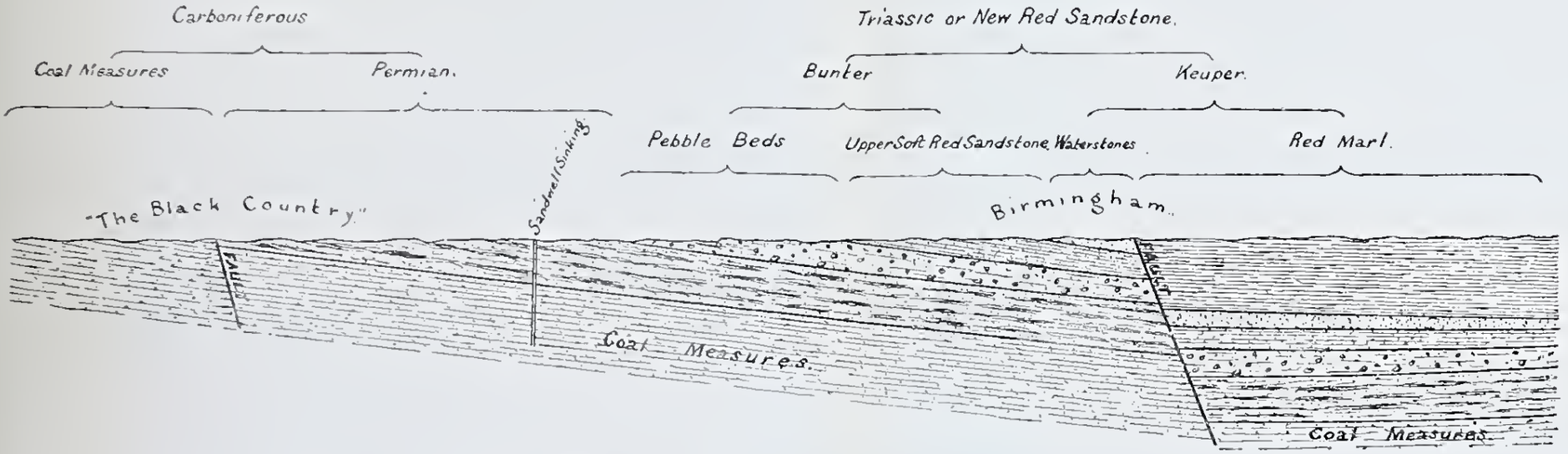
"It would appear that there exists a general impression that districts of the New Red Sandstone Formation are capable of yielding inexhaustible supplies of *underground* water, an impression, no doubt, founded upon an erroneous impression as to the circumstances regulating the circulation of underground water.

"The 'New Red Sandstone' around

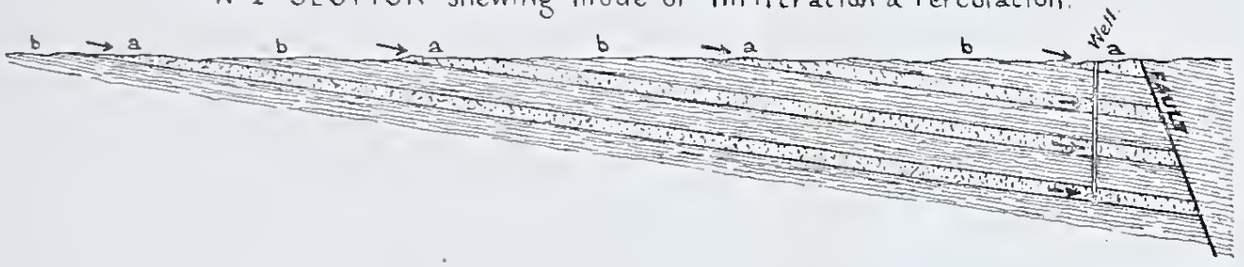
"The Future Water Supply of Birmingham."

←N.W. S.E.→

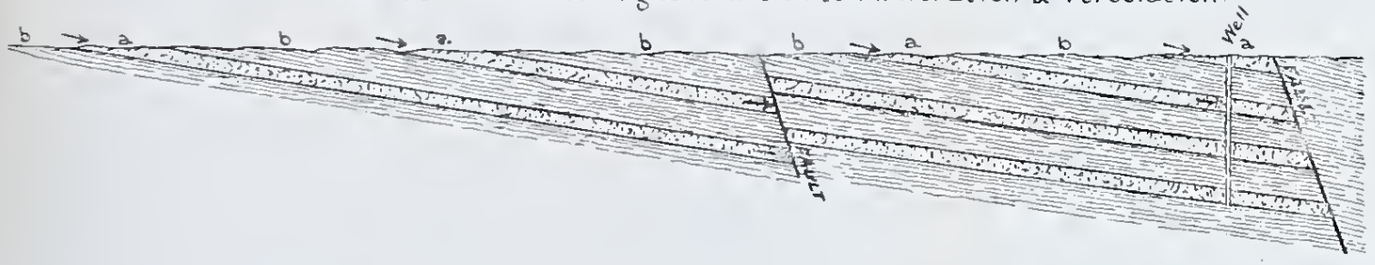
N° 1. SECTION shewing General Order of Strata.



N° 2 SECTION shewing mode of Infiltration & Percolation.



N° 3. SECTION shewing obstruction to Infiltration & Percolation.



a. a. a. a Porous Strata
b. b. b b Impervious Strata

[Hand Sketch]

Henry Johnson. Dudley.

Birmingham is no doubt inadequate as a receiver (absorber) of the local rain-fall to supply the wants of the city for the following reasons :—

"Capacity for collecting rain-fall is governed by the area of the *exposed* edges of the porous strata, and these occur at outcrops situate Westward of Birmingham and within the 'Black Country' area, and, consequently, are calculated to pollute the supply at its source.

"A supply can only enter at the surface exposure of the porous strata of the New Red Formation, and, therefore, must be proportionate to the area of *exposed* porous strata. (See Chart, Section No. 2.)

"The New Red and Permian Formations are, no doubt, saturated or charged to the full when first 'tapped' by bore-hole or shaft, which is quite a natural condition of things, and to be accounted for by a reference to the Law of Gravitation; but there can be no doubt (at least so far as my

experience goes) that the capacity of the porous strata to take up at their outcrops and convey the rain-fall, is inadequate to replenish the enormous quantity withdrawn by continuous powerful pumping at spots where the same strata are more deeply seated.

"Speaking briefly, a well supply is a passage of rain-fall from the surface through porous strata to varying depths, and there raised up to the surface again.

"This has been conclusively proved in the Sandwell Park Colliery, where, during the process of sinking the trial shaft, the 'come' or maximum quantity of water which had to be dealt with, was 750 gallons per minute, but after pumping for a short period, the sandstones and other porous strata were drained to their outcrops (including several shallow wells), and ceased to yield that quantity, which gradually became less and less until the regular average yield was only 41 gallons per minute.

"It was originally intended to make the sinking a pumping station for a water supply, but in consequence of the ultimate unexpected very small yield, together with the fact that on analysis the water proved to be very highly contaminated with ammonia (no doubt the product of the manure in the land and surface drainage) the project was abandoned.

"The New Red and Permian Formations —which are dislocated by faults of great extent and comparatively unfissured strata— are inadequate to the filtration and circulation, and as a conduit of water, sufficient in quantity to warrant the expenditure requisite to construct and equip deep wells for a permanently increasing demand.

"Obstruction to a passage of water through the new red sandstone may be caused by the dislocation of the strata—the effect of which is that porous strata abut against impervious strata, and this may be taken to account for wells in the same locality yielding varying quantities of water. (See Chart, Sections Nos. 2 and 3.)

"It may reasonably be inferred that the longer sandstone, or any other porous strata are subjected to an unnatural (continuous and rapid) passage of water, consequent on the withdrawal of it in the dip, the less their capacity as a conduit; because, in consequence of the infiltration of foreign and solid matter conveyed along with the water in its passage from the outcrops to the pumps, the pores of the strata become gradually choked, thus causing a decreased rather than a regular permanent supply. I have myself practically proved this to the extent of hollowing out a large block of sandstone for the purpose of a filter, and supplying it with shaft-water charged with solid matter.

"The construction of additional wells to be capable of 'tapping' water-bearing strata within *moderate depths* must be the *west* of the extensive north and south Red Marl Fault, which occurs about 400 yards east of the Bull Ring, and runs a course of more than 20 miles, throwing down a vast expanse of Keuper marls against Bunter

sandstones, and thereby forming a water-tight barrier. (See Chart, Section No. 1.) Borings for water through this great thickness of red marl would be of very considerable depth, and, consequently, very expensive to equip and maintain, besides which there is the great probability—in consequence of a south easterly attenuation of the Bunter or water-bearing beds beneath the red marl—that the yield of water would be limited in quantity."

Their Quality.

I also find after an analysis of several Artesian Wells in the water area that the water is so impure, that it is unfit, not only for drinking and domestic use, but even for manufacturing purposes. In one case where the water was used for a hydraulic lift, it had to be given up through the chlorides acting on the metal. The solids in seven of these waters amount to 52, 53, 109, 127, 118, 152 and 182 grains respectively in the gallon, the hardness of the three last being 78, 75 and 68 degrees as against solids 21·5 and hardness 13·2, the amount in our present supply, and

solids 5·0 and hardness 1·8 in the proposed new supply. These remarks do not apply to the whole of the wells, as the Digbeth Artesian Well, for example, yields a very good water.

From the foregoing it is evident that it would be most unwise to trust to deep wells for the main future supply of water for the district.

Quality of additional local water.

Then as to the quality of the water if obtained locally. There can be no doubt that water drawn from watersheds which are highly cultivated and largely covered with houses, must be looked upon with suspicion, and it is only a question of time when it will become quite unfit for drinking and domestic use. This especially applies to surface water. The river Tame is an illustration. This river was originally the main supply of Birmingham, but in 1869 it had become so impure that it had to be abandoned for domestic use. It may therefore be expected that, 25 years hence, some of the streams which are

now available will have so greatly deteriorated, that they will have to be abandoned.

Local sources inadequate.

We have now reviewed all possible developments of our local sources of water supply. We have found that from these it will be impossible to rely with any safety upon obtaining the quantity required. The engineers estimate that within 20 years the demand will exceed the utmost quantity that can be obtained from these sources. Sooner or later, then, we shall have to seek some more abundant supply, which would render expenditure on any local additions useless. We have found, too, that the quality of the water derived from local sources will be lowered by increasing the quantity secured, and, that owing to the increasing population and cultivation of the area from which it is drawn, it will deteriorate. We are warned, too, that any extension to the scattered and complicated works, necessary where there are so many small sources drawn upon, will render the management difficult and cumbrous.

The Committee, when they began the

enquiry, had anticipated that additions to the local sources would meet all their requirements, but these considerations compelled them to look beyond the circle from which hitherto they had drawn their supply. They recognised that if their local resources availed for 20 years, by that time they would have to be ready with the additional water required; that this would mean that within 12 years from now, they would have to prepare a scheme for the sanction of the citizens and of Parliament; that then they would be in a worse position than now, as there would be no supply within the Midlands available, while other towns might have secured desirable sources at present open. To dally with, and tinker at, a matter of so much importance to the large district involved, seemed to them alike unworthy and imprudent.

CHAPTER II.

CONDITIONS OF A SUITABLE SUPPLY.

It is a great and grave problem with which we are face to face. We have to find plenty of good water at as small a cost as possible—a task, which the situation of Birmingham, in the centre of England, and so high above the sea, makes more complicated than in some other large towns.

Conditions of a suitable supply.

There are three primary conditions requisite :—

(1) The quality of the water must be exceptionally good, and not likely to deteriorate.

(2) There must be a sufficiency for the district 50 years hence at least ; and

(3) It must be taken from a region high enough to supply the city and district by gravitation, as far as possible.

These conditions will recommend themselves to all. Fifty years is but a short time in the history of a city, and the expense of going farther afield would be scarcely

justified, if the provision secured were for less than that period. And if every gallon of water had to be pumped into the city, how immense the expenditure of time, labour, and money! With regard to the quality of the water we have some obvious principles for our guidance. Both soil and rocks through which water flows or trickles, contain salts soluble in it. Now, the more highly the soil is cultivated, the more impure will the water be, as in flowing over its surface in streams or rivers, or passing through it to form wells, it dissolves the manurial salts. This applies in a still greater degree to water collected in inhabited areas. Hence, as sanitary science is becoming better understood, local authorities are all endeavouring to secure their water supply from thinly-populated and uncultivated mountainous districts. This has already been done for several of the more important cities, including Glasgow, Liverpool and Manchester; but the circumstances of Birmingham, on account of its height above the level of the sea, and its great distance from any suitable watershed, are exceptional.

With these conditions in mind, we now look round for the nearest gathering-ground that fulfils them.

More distant sources suggested.

Eastward and Southward we have no water at all within reasonable distance. Northward are the Trent and the Derwent, but the former fails hopelessly before the tests of quality and gravitation, and the latter as regards quality and expense.

We are, therefore, necessarily obliged to turn our attention to the West.

Severn.

The first river we meet is the Severn, but our conditions compel us to reject this. Near Bewdley, where the supply would have to be taken, the surface is only 45ft. above the sea level, that is, 486ft. below the Monument Lane Reservoir; consequently, a large outlay in expensive plant, engines, filter-beds, &c., would be required. Besides, the water is greatly contaminated.

Teme.

The next river-basin we reach is the Teme, and in many respects it deserves favourable consideration. "But,"

says Sir Robt. Rawlinson of it, in 1871, in a report he presented to the Public Works Committee, "of the 1,600 acres forming the watershed, a large proportion is cultivated land of considerable value, and the area is dotted all over with farm-houses and buildings. A very small portion of this gathering-ground rises to a greater elevation than 1,600ft. above medium high-level. This source would, it is estimated, only yield 20 million gallons a day, so that it would require to be supplemented with the supply of the next river we come to as we travel westward, the Ithon, a tributary of the Wye." But of this, Sir Robt. Rawlinson reports—"That it is of too low an elevation, and that if it were taken, the scheme would entail the submersion and destruction of the somewhat important village of Llanddewi-y-stradenny." The watershed has an area of 20,400 acres, a large portion of which, however, is cultivated, and intersected by numerous roads. For these and other reasons, it is not considered suitable for our purpose.

Ithon.

Wye.

Then as to the Wye itself, which next we reach, the area of this gathering-ground is about 12,800 acres, the greater part being mountain pasture, and a small portion being cultivated. But we should have to go so far up-stream before we came to a gathering-ground on the Wye, that we are glad to find nearer Birmingham, a source to which all the experts—Sir Robt. Rawlinson, Mr. Mansergh, and our own Engineer, Mr. Gray—without any hesitation, give the preference on every ground.

Elan and Claerwen.

This is the basin of the Elan and Claerwen (clear-white) streams which unite at Nantgwyllt, where the combined river takes the name of the Elan, afterwards emptying itself into the Wye, seven or eight miles higher up than the Ithon.

Since the supply from this source seemed most admirably to meet the conditions above referred to, its gathering-ground was visited by the Chairman of the Water Committee (Alderman Sir Thos. Martineau), the whole of the members of the Committee,

together with the then Mayor (Mr. Alderman Clayton), some of the members of the City Council, and the Medical Officer of Health (Dr. Hill). Several days were spent in exploring the district, and the unanimous conclusion arrived at was that it answered the whole of the necessary conditions, and might be termed an ideal watershed. Sir Robert Rawlinson, in his valuable Report, previously referred to, says :—" It is very much superior to those before described, and, in fact, nothing better can be found in the country, nor could better be desired."

Position.

The gathering-ground contains 45,000 acres, or 70 square miles, with an elevation varying from 800 to 2,100ft. above the sea-level. It is situated in Cardiganshire and Radnorshire, 80 miles due west of Birmingham. It consists of wild moorland. The whole population on it has been ascertained not to exceed 180 in number.

Quality.

As to the quality of the water, Dr. Hill reports as follows —" I enclose the results of my analysis of the

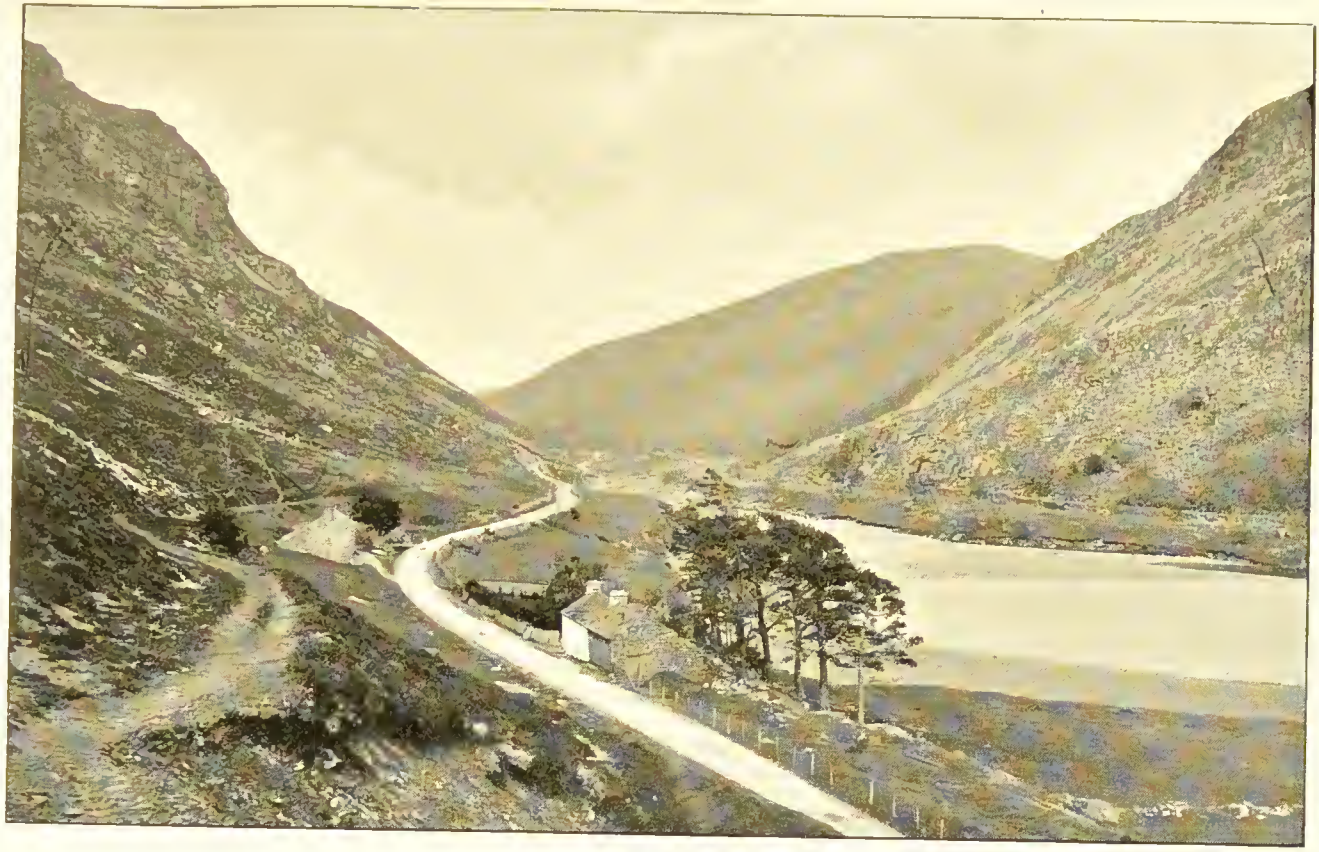
sample of water from Rhayader, delivered to me. It is a pure and most excellent water for all practical purposes, domestic and otherwise, and shows what may be considered absolute freedom from animal pollution, while its great softness is a strong economical recommendation, both as regards cooking and washing, to say nothing of boiler use and industrial applications in general."

I, myself, in the laboratory of the firm of which I am a member, have had several analyses made of the water under varying conditions, and compared it with other samples of moorland waters, including that of Loch Katrine, from which Glasgow is supplied, and that of Vyrnwy, which has been taken to Liverpool. The result is that I find the Elan water (here called Rhayader, from the name of the adjacent town) ranks as first-class, and is undoubtedly amongst the best in the United Kingdom for purity and general suitability for a town's supply.

Perhaps it will be well to explain here, that in order to form an opinion upon the suita-

bility or otherwise of a water for drinking and domestic use, the analytical expert must determine the amount of dissolved saline and organic matter in the water, and for this purpose his analytical results must show the quantity of solids in solution, the amount of free ammonia, albuminoid ammonia, and nitrites respectively; he must also determine the quantity of chlorine as representing chlorides, and nitrates, which may, to some extent, also be due to organic matter. Having these data before him, he is enabled by experience to decide, whether the water is safe, or contaminated; and if the latter, whether the contamination is of animal or vegetable origin.

The Table on page 33 indicates the proportion in grains per gallon of these constituents in the different waters enumerated, and it will be seen that the Rhayader water is very similar in quality to the new supply for Liverpool, and the water from Loch Katrine (the Glasgow supply); like the latter, it is free from nitrites and nitrates, while the total solids in the gallon are only



Site of the
Compensation and Supply
Reservoir on the Elan.

CABAN COCH.

Average of Analyses of about 60 Samples of the Birmingham Water Supply and its Sources, taken between January, 1887, and November, 1890.

IN TERMS OF GRAINS PER GALLON.

	SOLIDS.	CHLORINE.	AMMONIA.	ALBUMINOID AMMONIA.	NITRITES.	NITRATES.	HARDNESS.
From tap in Bull Street ..	21·5	1·36	0·0013	0·0084	absent	trace	13·2
Well supplies	19·0	1·15	0·00348	0·0049	absent	small trace	14·4
Rivers and Streams	24·7	1·33	0·0056	0·00802	mere trace	trace	12·5
OTHER WATERS.							
River Rea (near source) ..	19·5	0·9	0·0336	0·0098	large	traces	
Tame	77·0	10·9	0·1404	0·0224	traces	quantity	

Comparison of the present Birmingham Supply with Moorland Waters.

	SOLIDS.	CHLORINE.	AMMONIA.	ALBUMINOID AMMONIA.	NITRITES.	NITRATES.	HARDNESS.
Birmingham present supply ..	21·5	1·36	0·0013	0·0084	absent	trace	13·2
Rhayader, average of 3 samples (The proposed new B'ham supply.)	5·0	0·68	0·00093	0·0047	absent	absent	1·8
Vyrnwy (at Liverpool) ..	6·0	0.65	absent	0·0048	absent	min. trace	3·9
Sheffield	5·0	0·65	absent	0·0182	absent	mere trace	2·7
Loch Katrine (at Glasgow) ..	2·16	0·35	absent	0·0084	absent	absent	1·6

5 grains, and the hardness 1·8, as against 21·5 and 13·2 respectively of our present supply.

There is an idea prevalent in some quarters that a hard water is better than a soft water for a town's supply. This opinion is based upon the supposition that the drinking of soft water produces rickets in children, and is fully dealt with in Chapter V.

The excellence of the Rhayader water might be anticipated from the nature of the watershed. In our prospecting tour we found but little peat on the rocky surface, and this would be mostly removed in the making of the reservoirs, for the formation of which the valleys, as will be seen from the illustrations, are remarkably suitable; and with the exception of a very small portion of land under cultivation, and a small lead mine, employing about 30 men, very high up in the mountains, the moorland waste is only tenanted by a few sheep-farmers and their flocks. It is impossible to imagine anything better adapted for the purpose. Nor is there any probability of an increase of the

population, or cultivation of the watershed, which would cause any deterioration in the quality of the water supplied. The quality of the water, then, is most satisfactory.

Quantity.

Next comes the question whether the watershed will yield a sufficient quantity to warrant the enormous expenditure required for bringing it from Cardiganshire to Birmingham. The Committee, as previously stated, consider that it is their duty to provide for a period of 50 years in advance, and for this they calculate that 60 million gallons a day will be the maximum supply Birmingham will then require in dry weather.

When some of us saw the Elan and Claerwen as small streams running through the mountain valleys, it seemed absurd to suppose that they could provide the enormous quantity of water required. But, when we looked at the mountain sides and saw the many fissures made by the water rushing down into the valleys, and when we remembered that we were on a range of mountains

which reached to over 2,000ft. above the sea-level, we were convinced that the inadequacy of their narrow channels was more apparent than real, for the valleys among the mountains are so steep that the water rushes down as soon as it reaches them. Thus, although it is only when storm-water pours down the mountain side that there is anything like a flood at particular points in its course, a vast amount of water is carried down their channels in a day. The rainfall of these mountains is greatly in excess of that of our own district, owing to the nearness of the mountains to the sea and their lofty height. In the year 1871 a rain-gauge was set up at Nantgwyllt, just at the foot of the watershed, and has since been systematically kept by Mr. Lloyd, a large landowner in the district. Mr. Mansergh has put together these gaugings, and finds the mean annual rainfall for the 20 years ending 1889 was 63·78 inches. The position of the gauge was 768 feet above sea-level, and as the mean altitude of the watershed is about 600 feet higher, he calculates that we may expect the rainfall on the

Rainfall.

gathering-ground to be 66 inches. In order to verify this, four rain gauges have been placed in different parts of the area, and are being carefully registered.

The rainfall in the watershed of the Blythe and Bourne, our present gathering-ground, is only 28 inches, from which is collected from 8 to 10 inches, while Mr. Mansergh says if the rainfall in the watershed of the Elan and Claerwen reaches 66 inches, it would be possible, with sufficient storage reservoirs, to collect 40 inches, which would be ample to furnish all the water required 50 years hence.

CHAPTER III.

WORKS NECESSARY, COST, ETC.

Elevation.

Next arises the question—can this water be brought by gravitation to Birmingham? If this be possible, a great saving will be effected by doing away with the cost of pumping. This is very difficult in the case of Birmingham, as it stands on a higher elevation than any other large town in the country. The engineers agree that the elevation is sufficient to allow the water to be delivered by gravitation into the Monument Lane reservoir, which is 531ft. above the level of the sea. But, as some parts of Edgbaston, Harborne, Moseley and Handsworth rise 150ft. above Monument Lane, it will be necessary to pump the water to a reservoir to be constructed at Warley for the supply of these places. With that exception, every part of the city and district might receive the water by gravitation.

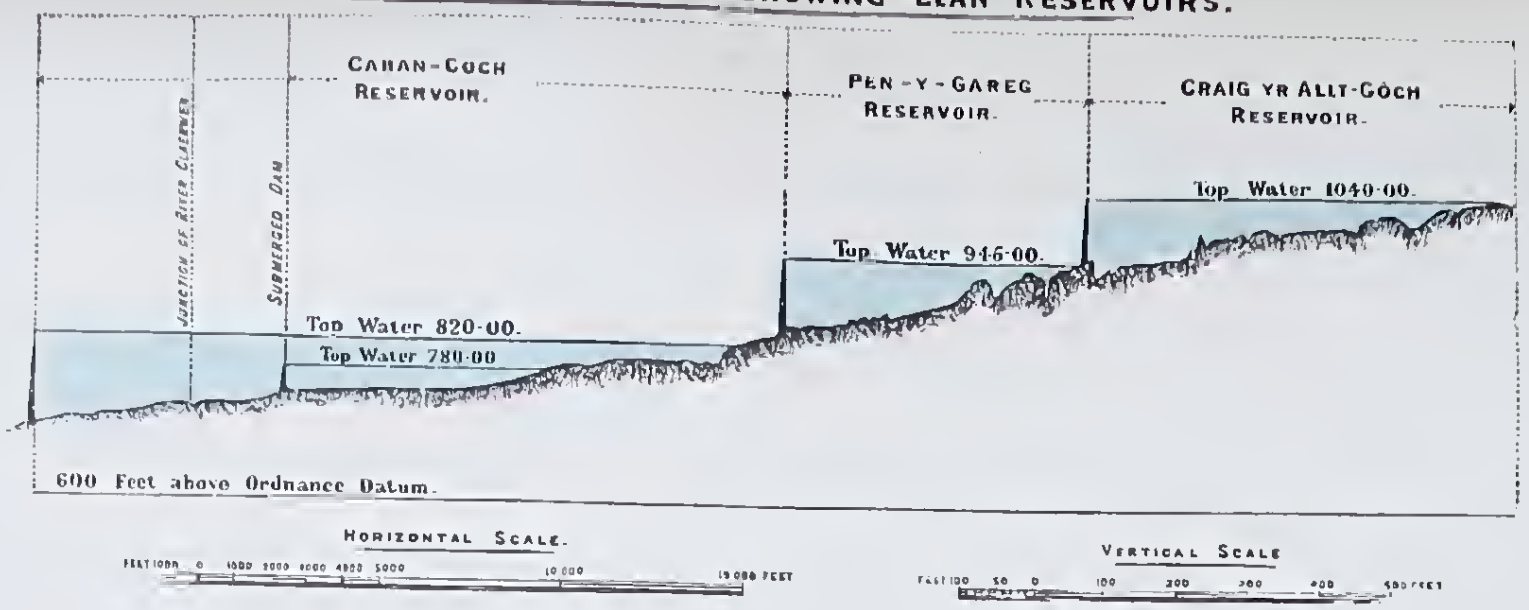
Works necessary.

The task of collecting the supply and bringing it 80 miles across the country, through mountains and over valleys and rivers, is clearly to be considered one of no small magnitude, but that it can be done, a brief outline of the proposed engineering works will show. The water must be first stored amongst the mountains in reservoirs. One of these will be required for what is called compensation water. We cannot expect to be allowed to withdraw from those living lower down the river the whole of the water flowing in their stream, on which they count for domestic and industrial purposes, all that we ask for being the unused storm-water of the uplands above them. There is no doubt that the Act of Parliament we are hoping to obtain will insist, as is usual when waters are impounded for public purposes, upon our sending into the rivers a certain quantity of water, and for this purpose it is proposed to discharge not less than 21½ million gallons a day of 24 hours into the river Elan.

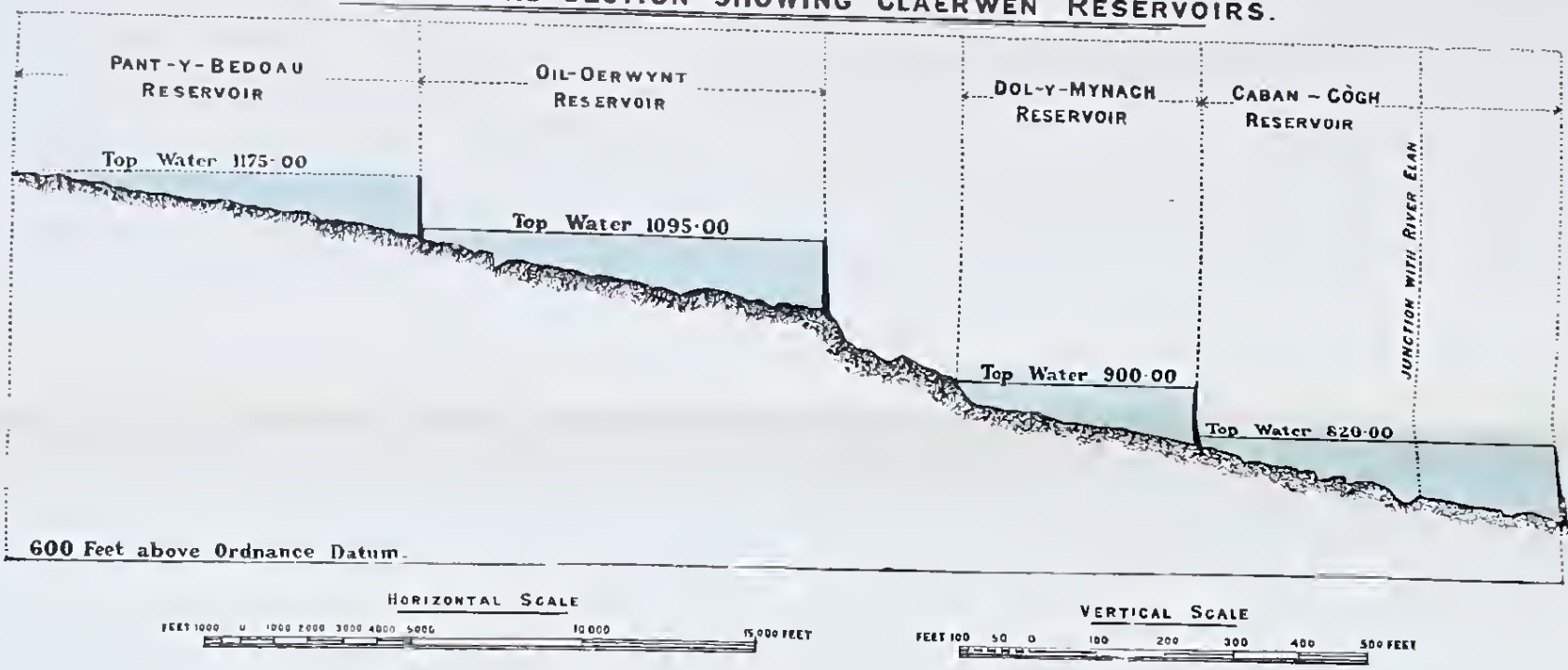
The Compensation Reservoir.

The compensation reservoir will be constructed below the junction of the Elan and Claerwen, at a height of 700 feet above the sea, by means of a dam 221 yards across the river Elan. The site is an admirable one for the purpose, for at a comparatively small cost the water could be dammed 2 miles up the Claerwen and 3½ up the Elan, forming a lake which would cover a surface of 380 acres, with its top-water 800ft. above sea-level. A gauge for measuring the quantity of water to be discharged will be constructed within 300 yards of the dam of the reservoir. Further up the valleys of both rivers, most suitable sites offer themselves for the construction of reservoirs, and it is estimated that five of these will ultimately be necessary to furnish the quantity of water Birmingham will require—two will be on the Elan and three on the Claerwen. The total storage capacity of the six reservoirs will be 17,360 million gallons, and they will cover an area of 1,499 acres. By a fortunate coincidence the presence of an enormous quantity of suitable rough stone, lying loose on the surface, will materially reduce the cost.

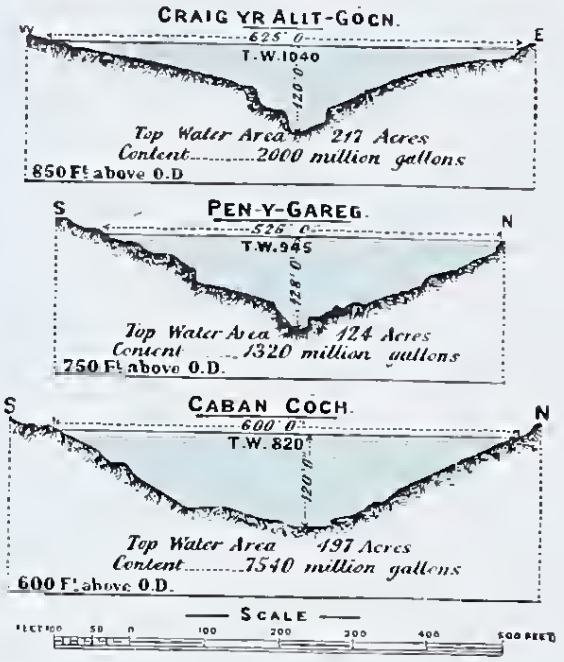
LONGITUDINAL SECTION SHOWING ELAN RESERVOIRS.



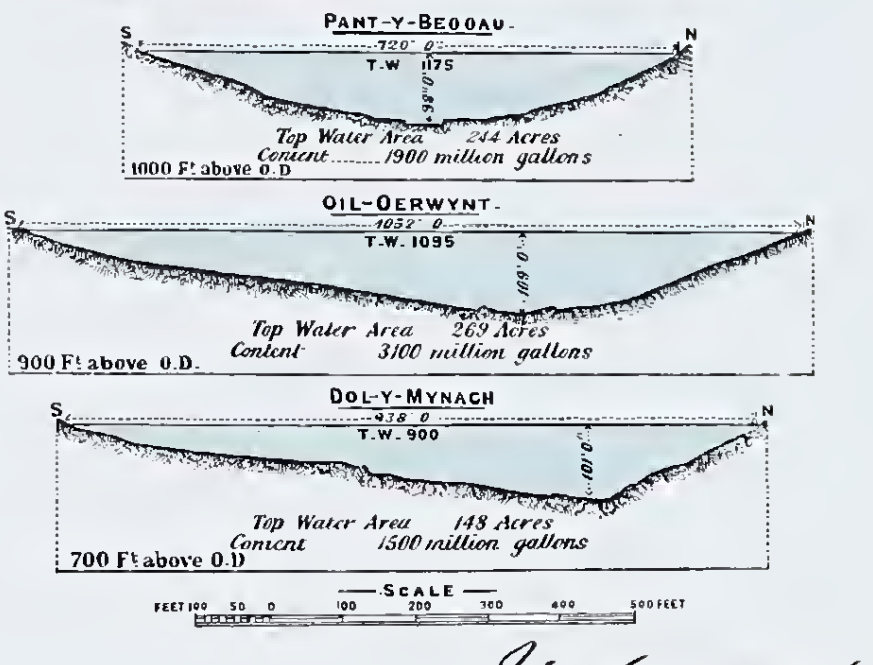
LONGITUDINAL SECTION SHOWING CLAERWEN RESERVOIRS.



SECTIONS ON CENTRE LINES OF ELAN DAMS.



SECTIONS ON CENTRE LINES OF CLAERWEN DAMS



JULY 1892

Supply Reservoirs on the Elan.

The first supply reservoir on the Elan will be made at Pen-y-Gareg by a dam 192 yards across the river, and the second at Craig-yr-Allt—Gôch, where the dam across the river will measure 239 yards.

On the Claerwen.

The first of the three supply reservoirs on the Claerwen will be made at Dol-y-Mynech, where the dam across the river will measure 325 yards; the next at Cil Oerwynt, the dam being 371 yards across; and the third at Pant-y-Beddaw, where the dam will measure 254 yards. The storage capacity, area, and height above the level of the sea of these reservoirs are intended to be as follows :—

Name.	Storage capacity in million of galls.	Area in Acres.	Height above level of sea.
Caban Côch ...	7,540	497	800
Pen-y-Gareg ...	1,320	124	945
Craig-yr-Allt—Gôch ...	2,000	217	1,040
Dol-y-Mynech ...	1,500	148	900
Cil Oerwynt ...	3,100	269	1,095
Pant-y-Beddaw ...	1,900	244	1,175

The compensation reservoir will be completed first, and two out of the five supply reservoirs will be proceeded with as soon as possible.

The remaining supply reservoirs will only be constructed when required by the increased demand for water during the next 50 years.

Service Reservoirs and Filter Beds.

From the storage reservoirs it is proposed to bring the water to a large service reservoir and filter beds 200ft. lower at Frankley, near Birmingham, by means of tunnels through the hills, and cut and cover work over the level, whilst five iron pipes will be used in crossing the valleys and rivers. There will be about $8\frac{3}{4}$ miles of tunnels, $35\frac{3}{4}$ miles of cut and cover, and $34\frac{1}{2}$ miles of iron pipes. The cut and cover and tunnels will be 8ft. and the iron pipes 42in. in diameter.

Route.

The extent of the gathering-ground in Wales, and the route by which the water will be brought to Birmingham, are shown on the map. It will be seen that the conduit passes a little to the south of Rhayader and near Knighton, Ludlow, Cleobury-Mortimer, through the Wyre Forest, then by Kidderminster, Stourbridge, and Hagley on to Frankley, where there is to be a reservoir. It is also intended

to make a covered service reservoir at Northfield. The conduit will in its passage cross the following rivers:—The Wye, a little south of Rhayader; the Ithon and four of its tributary streams; the Teme three times; two tributaries of the Teme; the Severn to the North of Bewdley; the Stour and one of its tributaries.

The important question of Cost *remains to be considered.* At a Meeting of the Council on October 13th, 1891, the Water Committee, through their Chairman (Sir Thos. Martineau), presented a report stating that the Engineer, Mr. Mansergh, had completed the detailed survey, and had submitted estimates for the necessary works. The first portion of the works, which includes the tunnels, cut and cover work, two out of the five iron pipes, three reservoirs in Wales, and the reservoirs and filters at Frankley, affording as a whole a daily supply of 26 million gallons of water, is estimated to cost £3,340,700. The third, fourth and fifth iron pipes, and three out of the five supply reservoirs included in the complete scheme, to be put down

Cost of Reservoirs, Iron Pipes, etc., £3,340,700.

from time to time, as required by the increased demand for water, will, when completed, cost £2,314,253, making with the amount previously expended £5,654,953. The Engineer of the Department, Mr. J. W. Gray, estimates that the extension of the reservoirs at Northfield and Warley for the supply of the high level districts, will cost £86,250, and that £195,000 will, during the next 10 years, and £480,000 for the 40 years following, be wanted for the extension of mains, etc. These figures when added to the £5,654,953, shew that it will be necessary, in order to carry out the entire scheme, to borrow the sum of £6,416,203; but the Committee, feeling that they ought to have a margin to enable them to become owners of the watershed, and thus prevent all possibility of future pollution, have recommended that the borrowing powers in the bill to be submitted to Parliament should stand at £6,600,000. The following summary shows how the Engineers make up this amount.

Second, third, and fourth supplies, £2,314,253.

Additional local Reservoirs and mains, £761,250.

Total Cost, including the purchase of the Watershed, £6,600,000.

PROPOSED WATER SUPPLY FROM THE RIVERS ELAN AND CLAERWEN.

SUMMARY OF APPROXIMATE ESTIMATE SUPPLIED TO THE COMMITTEE BY MR. MANSERGH.

	Description of Work.	For two lines of Pipes.	For five lines of Pipes.
1	Railway	45,000	65,000
2	Reservoirs	634,000	1,265,000
3	Aqueduct	1,698,000	2,746,000
4	Service Reservoirs and Filters	179,225	328,062
5	Land for Reservoirs on Water-shed	120,000	200,000
6	Land for Aqueduct (easement) and for Frankley Reservoir and Filters	115,680	115,680
7	Mains to Monument Lane and City Boundary	113,072	243,258
		2,904,977	4,963,000
	Add 15% for Contingencies, &c.	435,723	
	Add 10% on £1,050,000 (3rd, 4th, and 5th Mains		105,000
	Add 15% on £3,913,000 ..		586,953
	Totals	£3,340,700	£5,654,953

For cost of additional works see next page.

Brought forward		£5,654,953
To these figures our own Engineer, Mr. J. W. Gray, adds—		
For local reservoirs at Warley and Northfield	£86,250	
For the extension of Mains, etc., in the district of supply, during the next 50 years	675,000	
		761,250
The Committee recommended the Council to add a covering sum for the purchase of the land on the watershed and other contingencies of	183,797	183,797
Making a total of		£6,600,000

The Committee felt it incumbent upon them to lay before the Council the outline of a scheme showing how this vast expense might be met.

It will of course be necessary to borrow the capital required. This, it is proposed to repay, with the interest upon it by annual instalments, as is being done in the cases of Manchester and Liverpool, which will involve the formation of a Sinking Fund.

Expenditure Gradual.

It has been pointed out that the outlay of capital will only be gradual, so that the £6,600,000

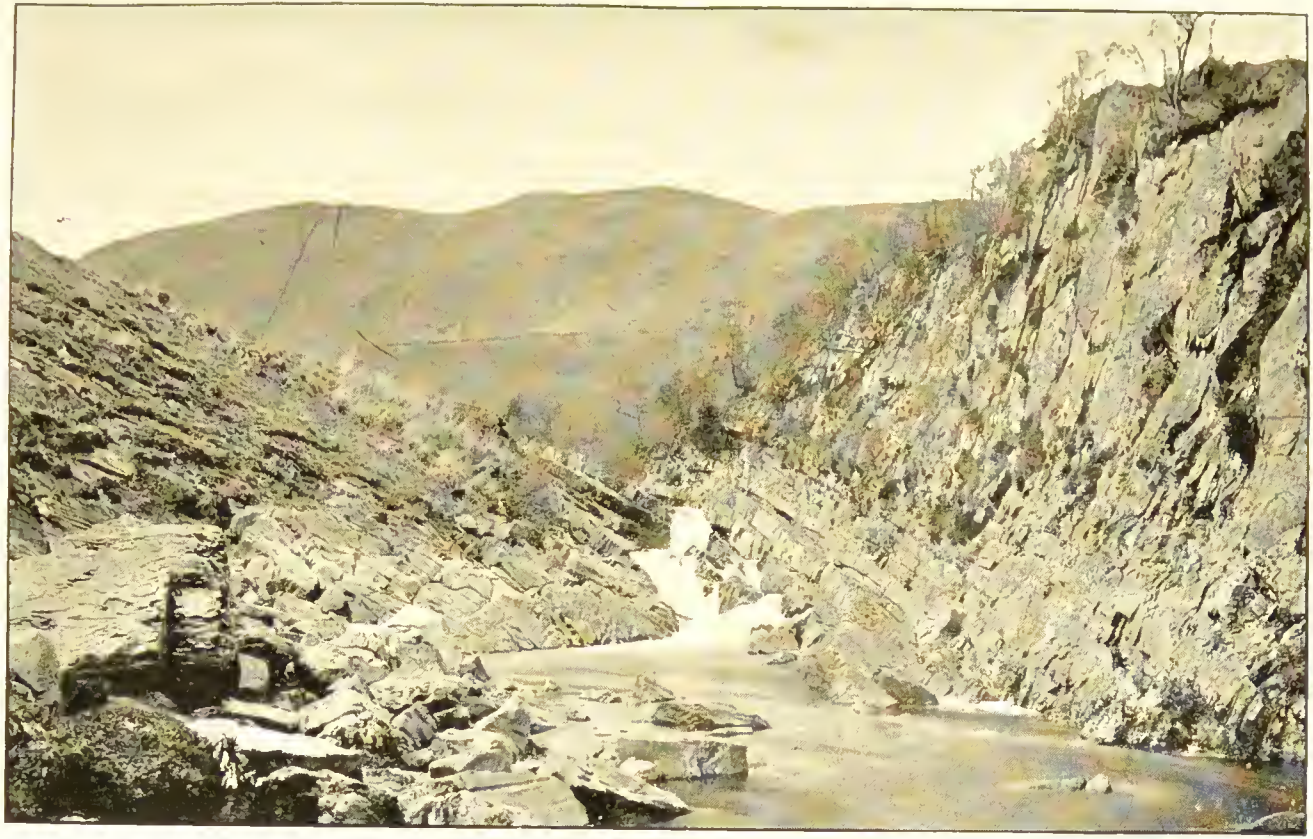
need not all be borrowed at once. When complete the scheme will bring 60,000.000 gallons of water daily from the Welsh rivers Elan and Claerwen to Birmingham, in a conduit large enough for that purpose, and in five iron mains as aqueducts to cross the valleys. The whole of these, as has been previously stated, will not be required for 50 years. It is expected that two of these mains will be sufficient for our requirements until the years 1914 to 1918, when the third will be laid, whilst in 1925 the fourth is expected to be necessary, and the fifth only after a lapse of 40 years. Similarly the reservoirs, as already stated, would not all be needed at once, but could be made as they are required. The expenditure, therefore, being gradual, the item for interest and sinking fund would not be so heavy at first. But even assuming that the whole scheme is completed in 1914, it is thought that without any excessive burden the expense may be fully met.

The Manchester Corporation Waterworks Act, 1879, provided that the repayment of

capital expended on the new works should be deferred for 10 years from the date of their commencement, and that 60 years beyond that time was to be allowed for paying off the money borrowed for the completion of their scheme.

Sinking Fund.

If this precedent be followed, no payment from the Sinking Fund will be required till 1903, from which year an annual instalment will be paid commencing in 1903 with £22,189, and, gradually increasing until 1940, when the yearly payments will be £38,994. These figures are based upon the capital being expended at the rate contemplated, and as shown in the table prepared by the Engineer. In these calculations we reckon upon a steady growth of the income derived from water-rents, consequent on the increase of the population and industries of the district, a growth which at one period, possibly during the time when so many insanitary wells were being closed, ranged for several years from 6 to 8 %, and if it be maintained at its recent rate will amount to 3 % per



Site of the
Second Storage Reservoir on
the Claerwen.

Cil Oerwynt.

annum, but, to be on the safe side, Mr. Mansergh calculates the increase as follows:—

From 1891	to 1900	inclusive,	an increase of	3 %
,, 1901	,, 1910	,,	,,	2¾ %
,, 1911	,, 1920	,,	,,	2½ %
,, 1921	,, 1930	,,	,,	2¼ %
,, 1931	,, 1940	,,	,,	2 %

Saving in Pumping.

As soon as the new works shall have provided the necessary supply of water by gravitation, the Engineer estimates that £20,000 a year in the present cost of pumping will be saved.

Since 1876, when the Corporation took over the Waterworks, reductions in the water-rates have been made in the years 1881, 1883 and 1884, resulting in an annual saving to the consumers, which in 1891 was at the rate of £33,000 a year.

When Mr. Gray, our Engineer, presented the report to the Water Commtttee, referred to on page 7, he suggested that if a portion

of this reduction were re-imposed, it would, with the saving effected by the distribution of the water supply by gravitation, be sufficient to provide the annual charges for sinking fund and interest on the capital required for the great Welsh scheme without any addition to the rates. Messrs. Howard Smith, Slocombe and Co., the accountants to the department, then prepared tables showing (*a*) the yearly income and expenditure, under various heads, since the Corporation acquired the water undertaking, and (*b*) the estimated income and expenditure for the next 25 years, based on the experience of the past, with certain modifications, from which it appeared that if Mr. Gray's suggestions were adopted there would be sufficient income to provide the annual charge on the capital required. The information supplied by the accountants has been used by Mr. Mansergh in the preparation of his table, of which there is an abstract on page 58.

Reductions Re-imposed.

It is estimated that the ends sought by this proposal would be gained by an addition

of £28,000 to the rental. This re-imposition will still leave the consumers in possession of better terms for their water supply than they obtained from the Company before the Corporation took over the works, and in view of the advantages to be gained, it is thought nobody will grudge it for a few years. The yearly surpluses thus secured, will, in 1902, have accumulated to £81,613, so that in 1903, when the first repayment must be made, the amount of these surpluses accumulated during the previous ten years, will be available for this purpose.

The calculations made by Mr. Mansergh show that if the consumers are willing to submit to this slight increase for a time, in 1914 there will be a surplus on revenue account of £13,290, which will so increase year by year, that by 1918 the rate may again be reduced.

Expenditure met.

It will be seen that in 1901 and 1902, when the Welsh water may be expected to be delivered, the saving in the cost of pumping takes effect, but in 1903 the pay-

ments of the Sinking Fund have to be brought into the account. These figures serve to illustrate how a scheme costing over £6,000,000 may be dealt with, and how the city may be supplied with pure water from the distant watershed in Wales, without the imposition of a special rate, the only burden being the temporary recall of a portion of the reductions previously made by the Corporation.

The Schemes Financially Compared.

It may even be shown that this project would cost but little more in the end, even at the sacrifice of the whole of the existing works, than it would, if the supply were raised from local sources, supposing that to be possible. For the purpose of making a financial comparison, let us assume that sufficient water could be obtained from the Bourne and Blythe, and from deep wells, to bring up the present supply to 60 million gallons a day. In comparing the two schemes, establishment charges and the interest and Sinking Fund on the present works may be omitted, as they would neces-

sarily be the same in both cases, unless in course of time the reservoirs, engines, etc., now in use were sold, which would be to the advantage of the Welsh scheme.

Mr. Gray, the Engineer, calculates that he could obtain an additional supply from the river Bourne and from the Witton streams, at a cost of £1,000,000. He further states that since the yield of each of our deep wells averages 1½ million gallons a day, 25 of such wells, in addition to the works costing £1,000,000, would be needed to make up the quantity of water required in 60 years, assuming that the supply from the new wells was equal to the yield of those we have at present.

The capital charges for these extensions he estimates as follows :—

For Impounding the Bourne and Witton Streams,	£1,000,000
25 Deep Wells, including mains for delivering the Water, Engines, &c. £45,000 each ..	1,125,000
Total	£2,125,000

The additional annual charges for these would in round numbers be as follows :—

For Interest and Sinking Fund at 3 % on £2,125,000		£76,784
On £761,250 ditto made up as follows—		
Reservoirs—Northfield and Warley ..	£86,250	
Extension of mains and improvement of the present supply during the next ten years	195,000	
Ditto during the following forty years ..	480,000	
	£761,250	27,506
Cost of Pumping the additional supply of Bourne Water		11,000
Cost of Pumping the Water from the 25 additional Deep Wells at £1,500 each		37,500
Annual Charges		£152,790

Now let us compare this with the Welsh scheme :—

Assuming the cost to be £6,600,000, the Annual Charges for Interest and Sinking Fund would be, at 3% ..	£238,474
Deduct the saving from Pumping, as the Water would flow to Birmingham by gravitation	20,000
Annual Charges	£218,474

That is, the local scheme, with all its uncertainties as to supply, would involve an

annual cost of £152,790 for 60 million gallons of an inferior quality of water, as against £218,474 for bringing an almost unlimited quantity of pure water from Wales.

Heavy Perpetual Charges.

It must be remembered, moreover, that in the local scheme there would, by the time the 60 million gallons a day were pumped, be a greatly increased annual outlay for pumping, which, as before stated, has been estimated at £64,000 a year; this would be a perpetual charge; but if the Welsh scheme were adopted, the annual cost of pumping would be reduced to £5,000, and taking the sum of £6,600,000 as the cost of the scheme, then by 1914, *i.e.*, 23 years hence, if the five-sixths of the former reductions in the water-rate had been in the meantime re-imposed, there would, in that year, be a surplus of over £13,000, which surplus would increase year by year as more water was required. By means of these surpluses the water-rate might be reduced, and by the year 2000 the whole capital paid off, and the Corporation become

possessors of a large estate, yielding a perpetual and abundant supply of pure water for the inhabitants of this great city and district.

The £6,600,000 is the sum named in the Water Bill. This largely exceeds the £4,000,000 mentioned when the scheme was first submitted to the Council, but at that time, as then stated, no detailed survey had been made, whereas now the figures are based on careful estimates to cover the capital expenditure for 50 years.

The Water Committee, after receiving the Engineers' report and estimates, gave the matter their further serious consideration, with the result that they were fully convinced of the wisdom of adopting the scheme, and, by an unanimous vote, recommended its adoption by the Council.

The Council, at its meeting on October 13th, 1891, approved the Committee's report, and authorised them to take all necessary steps for the promotion of the

BIRMINGHAM CORPORATION WATER.

YEAR ending March 31.	Probable Daily Demand for Water.	Anticipated increase of Water Consumers.	Water Rents, Natural Growth.	EXPENDITURE. Pumping and Repairs of Engines.	Maintenance and Management.	Charges for present Loans less Rents, Fittings and Fishing Rights.	Total exclusive of New Capital. — Sum of Columns 5, 6 and 7.	NEW CAPITAL. To be expended during Year. — Evenly over Year.	Total expended at end of Year.	Interest at 3 per cent. on the amount in Column 10, added to one-half the capital spent during the Year.	Redemption at 3 per cent.	Total Charges. — Sum of Columns 11 and 12.	Total annual Expenditure on existing Works and New Capital. — Sum of Columns 8 and 13.	Balance for Year. — Difference between Columns 4 and 14. Surplus.	Balance for Year. — Difference between Columns 4 and 14. Deficiency.	Reimposed Charges. — Estimated to increase at same rate as present charges.	Effect of Reimposed charges on balance for year. Surplus.	Effect of Reimposed charges on balance for year. Deficiency.	Accumulated Balance at end of Year. Surplus.	Accumulated Balance at end of Year. Deficiency.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
	Gallons.	£	£	£	£	£	£	£	£	£	£	£	£	£	£	£	£	£	£	£
1890	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	17,145
1891	15,500,000	3 per cent.	133,850	25,250	25,500	81,250	132,000	10,000	10,000	150	...	150	132,150	1,700	...	...	1,700	...	...	15,145
1892	15,965,000	3 per cent.	137,865	26,007	26,265	81,000	133,272	20,000	30,000	600	...	600	133,872	3,993	...	...	3,993	...	...	11,452
1893	16,444,000	3 per cent.	142,001	26,788	27,053	80,750	134,591	100,000	130,000	2,400	...	2,400	136,991	5,010	...	28,000	33,010	...	21,558	...
1894	16,937,000	3 per cent.	146,261	27,591	27,865	80,500	135,956	130,000	260,000	5,850	...	5,850	141,806	4,455	...	28,840	33,295	...	54,853	...
1895	17,445,000	3 per cent.	150,649	28,419	28,700	80,500	137,619	200,000	460,000	10,800	...	10,800	148,419	2,230	...	29,705	31,935	...	86,788	...
1896	17,968,000	3 per cent.	155,169	29,272	29,561	80,500	139,333	500,000	960,000	21,300	...	21,300	160,633	...	5,464	30,596	25,132	...	111,920	...
1897	18,508,000	3 per cent.	159,824	30,150	30,448	80,500	141,098	500,000	1,460,000	36,300	...	36,300	177,398	...	17,574	31,514	13,940	...	125,860	...
1898	19,063,000	3 per cent.	164,619	31,054	31,362	80,500	142,916	500,000	1,960,000	51,300	...	51,300	194,216	...	29,597	32,459	2,862	...	128,722	...
1899	19,635,000	3 per cent.	169,557	31,986	32,303	80,500	144,789	500,000	2,460,000	66,300	...	66,300	211,089	...	41,532	33,433	...	8,099	120,623	...
1900	20,224,000	3 per cent.	174,644	32,946	33,272	80,500	146,718	600,000	3,060,000	82,800	...	82,800	229,518	...	54,874	34,436	...	20,438	100,185	...
1901	20,831,000	2¾ per cent.	179,883	33,934	34,270	80,500	148,704	600,000	3,660,000	100,800	...	100,800	249,504	...	69,621	35,496	...	34,152	66,033	...
1902	21,404,000	2¾ per cent.	184,830	10,000	35,212	80,500	125,712	8,000	3,668,000	109,920	...	109,920	235,632	...	50,802	36,444	...	14,358	51,675	...
1903	21,992,000	2¾ per cent.	189,913	5,000	36,181	80,500	121,681	8,000	3,676,000	110,160	27,009	137,169	258,850	...	68,937	37,448	...	31,489	20,186	...
1904	22,597,000	2¾ per cent.	195,135	5,000	37,176	80,500	122,676	8,000	3,684,000	110,400	27,058	137,458	260,134	...	64,999	38,477	...	26,522	...	6,336
1905	23,218,000	2¾ per cent.	200,502	5,000	38,198	80,500	123,698	8,000	3,692,000	110,640	27,107	137,747	261,445	...	60,943	39,535	...	21,408	...	27,744
1906	23,857,000	2¾ per cent.	206,015	5,000	39,249	80,500	124,749	60,000	3,752,000	111,660	27,156	138,816	263,565	...	57,550	40,622	...	16,928	...	44,672
1907	24,513,000	2¾ per cent.	211,681	5,000	40,328	80,500	125,828	60,000	3,812,000	113,460	27,523	140,983	266,811	...	55,130	41,740	...	13,390	...	58,062
1908	25,187,000	2¾ per cent.	217,502	5,000	41,437	80,500	126,937	60,000	3,872,000	115,260	27,891	143,151	270,088	...	52,586	42,887	...	9,699	...	67,761
1909	25,880,000	2¾ per cent.	223,483	5,000	42,576	80,500	128,076	382,000	4,254,000	121,890	28,259	150,149	278,225	...	54,742	44,066	...	10,676	...	78,437
1910	26,591,000	2¾ per cent.	229,629	5,000	43,747	80,500	129,247	382,000	4,636,000	133,350	30,602	163,952	293,199	...	63,570	45,278	...	18,292	...	96,729
1911	27,323,000	2½ per cent.	235,944	5,000	44,950	80,500	130,450	8,000	4,644,000	139,200	32,946	172,146	302,596	...	66,652	46,523	...	20,129	...	116,858
1912	28,006,000	2½ per cent.	241,843	5,000	46,074	80,500	131,574	9,000	4,653,000	139,455	32,995	172,450	304,024	...	62,181	47,686	...	14,495	...	131,353
1913	28,706,000	2½ per cent.	247,889	5,000	47,226	80,500	132,726	9,000	4,662,000	139,725	33,050	172,775	305,501	...	57,612	48,879	...	8,733	...	140,086
1914	29,423,000	2½ per cent.	254,086	5,000	48,406	80,500	133,906	9,000	4,671,000	139,995	33,105	173,100	307,006	...	52,920	50,101	...	2,819	...	142,905
1915	30,159,000	2½ per cent.	260,438	5,000	49,617	80,500	135,117	9,000	4,680,000	140,265	33,160	173,425	308,542	...	48,104	51,353	3,249	...	...	139,656
1916	30,913,000	2½ per cent.	266,949	5,000	50,857	80,500	136,357	9,000	4,689,000	140,535	33,215	173,750	310,107	...	43,158	52,037	9,479	...	...	130,177
1917	31,686,000	2½ per cent.	273,623	5,000	52,128	80,500	137,628	9,000	4,698,000	140,805	33,270	174,075	311,703	...	38,080	53,953	15,873	...	...	114,304
1918	32,478,000	2½ per cent.	280,463	5,000	53,432	80,500	138,932	9,000	4,707,000	141,075	33,325	174,400	313,332	...	32,869	55,303	22,433	...	...	91,871
1919	33,290,000	2½ per cent.	287,475	5,000	54,768	80,500	140,268	9,000	4,716,000	141,345	33,380	174,725	314,993	...	27,518	56,684	29,166	...	...	62,705
1920	34,122,000	2½ per cent.	294,662	5,000	56,136	80,500	141,636	9,000	4,725,000	141,615	33,435	175,050	316,686	...	22,024	58,101	36,077	...	...	26,628
1921	34,975,000	2¾ per cent.	302,028	5,000	57,540	80,500	143,040	9,000	4,734,000	141,885	33,491	175,376	318,416	...	16,388	59,558	43,165	...	16,537	...
1922	35,762,000	2¾ per cent.	308,824	5,000	58,835	80,500	144,335	70,000	4,804,000	143,070	33,546	176,616	320,951	...	12,127	60,889	48,762	...	65,299	...
1923	36,567,000	2¾ per cent.	315,772	5,000	60,158	80,500	145,658	70,000	4,874,000	145,170	33,975	179,145	324,803	...	9,031	...	...	...	56,268	...
1924	37,390,000	2¾ per cent.	322,877	5,000	61,512	80,500	147,012	70,000	4,944,000	147,270	34,404	181,674	328,686	...	5,809	...	...	...	50,459	...
1925	38,231,000	2¾ per cent.	330,142	5,000	62,896	80,500	148,396	300,000	5,244,000	152,820	34,834	187,654	336,050	...	5,908	...	...	...	44,551	...
1926	39,091,000	2¾ per cent.	337,570	5,000	64,311	80,500	149,811	320,000	5,564,000	162,120	36,674	198,794	348,605	...	11,035	...	...	...	33,516	...
1927	39,971,000	2¾ per cent.	345,166	5,000	65,758	80,500	151,258	10,000	5,574,000	167,070	38,637	205,707	356,965	...	11,799	...	...	...	21,717	...
1928	40,870,000	2¾ per cent.	352,932	5,000	67,238	80,500	152,738	10,000	5,584,000	167,370	38,698	206,068	358,806	...	5,874	...	...	...	15,843	...
1929	41,790,000	2¾ per cent.	360,873	5,000	68,750	80,500	154,250	10,000	5,594,000	167,670	38,759	206,429	360,679	194	...	...	...	...	16,037	...
1930	42,730,000	2¾ per cent.	368,992	5,000	70,297	80,500	155,797	10,000	5,604,000	167,970	38,820	206,790	362,587	6,405	...	...	...	...	...	...
1931	43,691,000	2 per cent.	377,294	5,000	71,879	80,500	157,379	10,000	5,614,000	168,270	38,882	207,152	364,531	12,763	...	...	...	...	...	...
1932	44,565,000	2 per cent.	384,841	5,000	73,316	80,500	158,816	11,000	5,625,000	168,585	38,943	207,528	366,344	18,497						
1933	45,456,000	2 per cent.	392,538	5,000	74,783	80,500	160,283	11,000	5,636,000	168,915	39,010	207,925	368,208	24,330						
1934	46,365,000	2 per cent.	400,388	5,000	76,278	80,500	161,778	11,000	5,647,000	169,245	39,078	208,323	370,101	30,287						
1935	47,293,000	2 per cent.	408,396	5,000	77,804	80,500	163,304	11,000	5,658,000	169,575	39,145	208,720	372,024	36,372						
1936	48,239,000	2 per cent.	416,564	5,000	79,360	80,500	164,860	60,000	5,718,000	170,640	39,213	209,853	374,713	41,851						
1937	49,203,000	2 per cent.	424,895	5,000	80,947	80,500	166,447	60,000	5,778,000	172,440	39,581	212,021	378,468	46,427						
1938	50,187,000	2 per cent.	433,393	5,000	82,566	80,500	168,066	60,000	5,838,000	174,240	39,949	214,189	382,255	51,138						
1939	51,191,000	2 per cent.	442,061	5,000	84,218	80,500	169,718	296,000	6,134,000	179,580	40,317	219.897	389,615	52,446						
1940	52,215,000	2 per cent.	450,902	5,000	85,902	80,500	171,402	300,000	6,434,000	188,520	42,132	230,652	402,054	48,848						
1941	53,259,000	1¾ per cent.	459,920	5,000	87,620	80,500	173,120	11,000	6,445,000	193,185	43,972	237,157	410,277	49,643						
1942	54,191,000	1¾ per cent.	467,969	5,000	89,153	80,500	174,653	11,000	6,456,000	193,515	44,039	237,554	412,207	55,762						
1943	55,140,000	1¾ per cent.	476,158	5,000	90,714	80,500	176,214	11,000	6,467,000	193,845	44,107	237,952	414,166	61,992						
1944	56,105,000	1¾ per cent.	484,491	5,000	92,301	80,500	177,801	11,000	6,478,000	194,175	44,174	238,349	416,150	68,341						
1945	57,086,000	1¾ per cent.	492,970	5,000	93,916	80,500	179,416	11,000	6,489,000	194,505	44,242	238,747	418,163	74,807						
1946	58,085,000	1¾ per cent.	501,596	5,000	95,560	80,500	181,060	11,000	6,500,000	194,835	44,310	239,145	420,205	81,391						
1947	59,102,000	1¾ per cent.	510,374	5,000	97,232	80,500	182,732	11,000	6,511,000	195,165	44,377	239,542	422,274	88,100						
1948	60,136,000	1¾ per cent.	519,306	5,000	98,934	80,500	184,434	11,000	6,522,000	195,495	44,445	239,940	424,374	94,932						
1949	61,189,000	1¾ per cent.	528,394	5,000	100,665	80,500	186,165	11,000	6,533,000	195,825	44,512	240,337	426,502	101,892						
1950	62,260,000	1¾ per cent.	537,641	5,000	102,427	80,500	187,927	11,000	6,544,000	196,155	44,580	240,735	428,662	108,979						
1951	63,349,000	1½ per cent.	547,049	5,000	104,219	80,500	189,719	11,000	6,555,000	196,485	44,647	241,132	430,851	116,198						
1952	64,299,000	1½ per cent.	555,255	5,000	105,783	80,500	191,283	11,000	6,566,000	196,815	44,618	241,433	432.716	122,539						
1953	65,264,000	1½ per cent.	563,584	5,000	107,369	80,500	192,869	11,000	6,577,000	197,145	44,502	241,647	434,516	129,068						
1954	66,243,000	1½ per cent.	572,038	5,000	108,980	80,500	194,480	11,000	6,588,000	197,475	43,682	241,157	435,637	136,401						
1955	67,236,000	1½ per cent.	580,619	5,000	110,619	80,500	196,119	12,000	6,600,000	197,820	42,641	240,461	436,580	144,039						

Surpluses equivalent to 10% reduction on present charges.

Surpluses equivalent to 20% reduction on present charges.

Bill in Parliament, and to enter into provisional agreements for the purchase of land, and for the employment of the necessary professional assistance. On Nov. 25th the Council approved the Water Bill, and authorised the Committee to proceed with the same, and to submit it to a statutory meeting of the ratepayers, in the Town Hall, on Saturday, December 5th, 1891, at 2 o'clock.

Statutory Town's Meeting.

This meeting was duly held, and the resolution authorising the Council to proceed with the Bill was carried with practical unanimity, less than one dozen hands being held up against it; but it being within the right of one ratepayer to demand a poll of the burgesses, this was called for, and the poll took place on Monday, Tuesday, and Wednesday, the 7th, 8th, and 9th December, 1891, with the result that there were 7,837 votes for the resolution, and 997 against it.

Result of Poll.

These votes were given by 4,016 Ratepayers for, and 563 against.

The Financial Table* given here is prepared from figures supplied to the Water Committee by Mr. Mansergh, and is intended to illustrate the financial changes which are expected to come into operation as the scheme advances. In column 2 is shown the probable demand for water, in column 3 will be seen the anticipated increase of water consumers, while column 4 gives the income from rates estimated to increase according to the previous column. In column 5 it will be seen that, in 1902, when the first instalment of the Rhayader water is delivered, the pumping charges will be greatly reduced, and in 1903 and subsequent years they will have reached a minimum, as the amount standing in the table from that date onward represents the estimated charges for pumping the Rhayader water to the Warley Reservoir for the supply of the high parts of the town. Column 10 shows how the capital outlay is gradually

Financial Scheme.

* The figures in the Table were those used in the Parliamentary Committee.

expended. In column 11 the figures for each year represent the charges for interest at 3 % on two amounts added together—the one being the capital expended at the end of the previous year, and the other being half the capital outlay of the current year. In column 12 it will be seen that in 1903 the sinking fund comes into operation. Column 13 represents the total charges, and is the sum of the two preceding columns, which in each case will be sufficient to redeem the principal in 60 years from the date of borrowing; so that the annual payments for redemption of capital will gradually lessen towards the end, in the same proportion as they will increase during the early and middle stages of the undertaking. Column 17 shows that the re-imposed charges take effect in 1893, and how the amount will grow year by year as new customers for water are added. It is interesting to notice that in the year 1922 this item disappears, and in the following year the rate may again be reduced. In columns 20 and 21 the accumulated balances are shown, and it

Expenditure Gradual.

will be seen that the deficiency account ceases in 1920, while in 1921 there is a surplus.

The payments to the sinking fund continue for 60 years after the borrowing of each amount of capital, consequently it will probably be the year 2015 before the final payment is made; but no rate in aid will be necessary. On the other hand, if it were possible to develope the local resources, there would, as previously stated, be a perpetual charge of £64,000 a year for pumping.

CHAPTER IV.

ACTION OF MOORLAND WATER ON LEAD, ETC.

We have seen that the Rhayader water can be brought to Birmingham in sufficient quantity by gravitation, and that its quality is excellent. It only remains to consider the question of its safe distribution to the consumers. From the analysis of the water, it will be seen that it is much softer than that now supplied to Birmingham, and, as it is known that all waters, especially soft moorland waters, exert a chemical action on lead, it was necessary for the Committee to determine, before recommending the scheme to the Council, whether this water might be safely supplied to the inhabitants for domestic use through leaden pipes.

The knowledge that there have been numerous cases of lead-poisoning in other towns, due to the action of moorland waters on lead, caused the Committee to make a close investigation into the matter. For

Analysis of the Liverpool Supply taken from Lake Vyrnwy; the same after it has passed through the filter-beds at Oswestry; and then again at the Reservoir at Prescot, Liverpool.

IN TERMS OF GRAINS PER GALLON.

	SOLIDS.	CHLORINE.	AMMONIA.	ALBUMINOID AMMONIA.	NITRITES.	NITRATES.	HARDNESS.	*SOLVENT ACTION ON LEAD.
Lake Vyrnwy	2·33	0·55	0·00448	0·00616	absent	absent	1·86	350
Oswestry, after filter beds (about 17 miles from Liverpool)	5·33	0·70	0·00056	0.0070	absent	min. trace	3·6	80
Prescot, Liverpool (68 miles from Lake Vyrnwy	6·0	0·65	absent	0·00448	absent	mere trace	3·9	34

* 100 has been adopted as the standard in water suitable for drinking, see page 63.

that purpose several well-known experts, together with the City Analyst, were requested to report on it. They have shown that this water, like all such waters, produces a chemical action on a bright surface of lead, but that it may be rendered perfectly safe, and similar in that respect to our present supply, either in the process of filtration or during the course of its journey through the tunnels, etc., to Birmingham.

There are at least three remedies by which this can be accomplished. **Remedies.**

1*st.*—*It has been found that in some cases moorland water, which when taken at its source exerts a powerful solvent action upon lead, loses that power almost entirely after transmission to distant towns, on account of the modifying influence of the culverts; the Liverpool supply may be taken as an illustration.*

In these notes which follow, the amount of lead, which, on the authority of a distinguished expert, may with safety be permissible in the water supply of a town, is taken as a standard, and represented by the figure 100.

Liverpool Supply.—By the courtesy of Joseph Parry, Esq., C.E., Engineer to the Liverpool Corporation, I have obtained several samples of the water from Lake Vyrnwy, and have examined the action of this water on lead at the following points:—

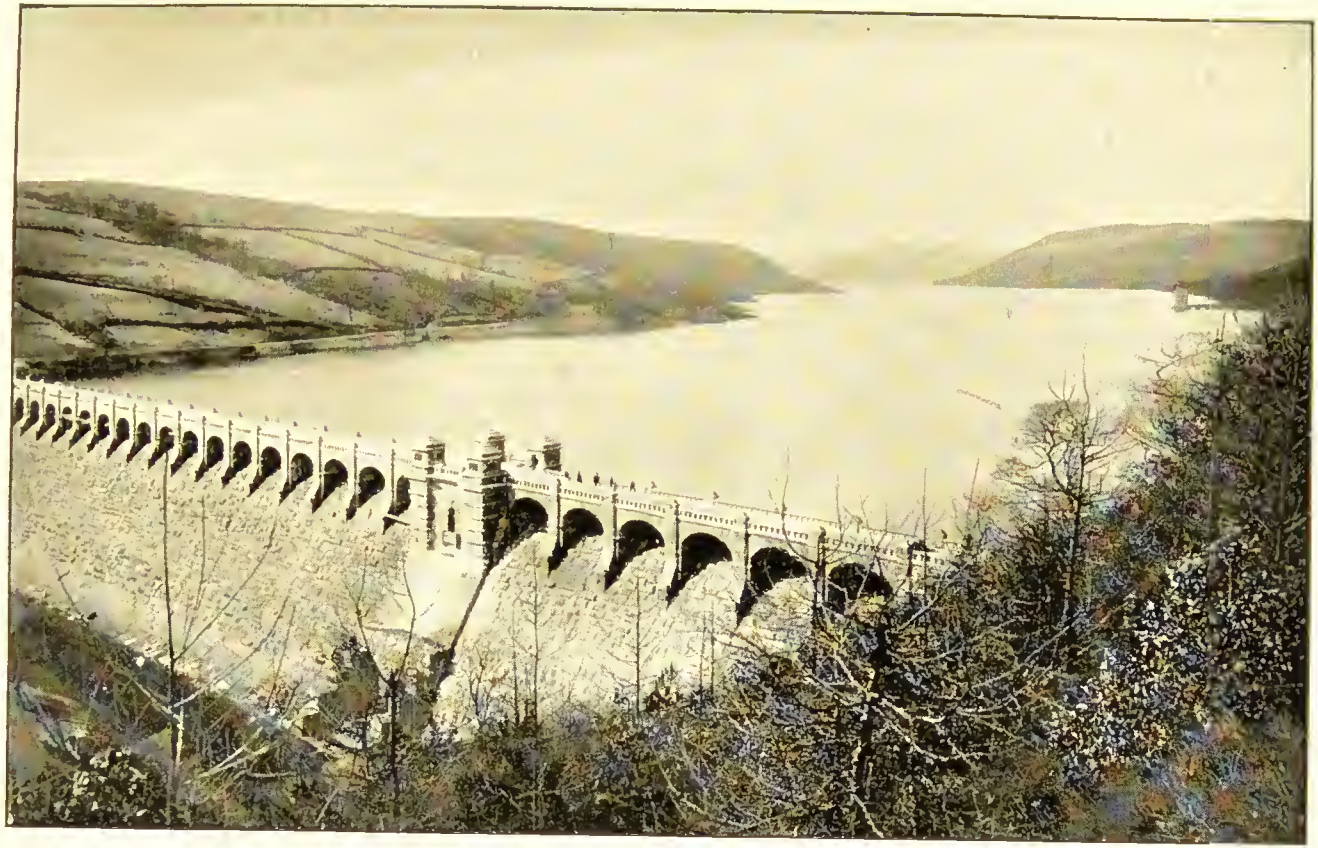
1st.—At its source (Lake Vyrnwy), where its action on lead is represented by 350.

2nd.—After filtration at Oswestry, 80.

3rd.—At Prescot reservoir, Liverpool, 34.

It ought to be explained that the aqueduct by means of which the water is brought from Lake Vyrnwy to Liverpool, a distance of nearly 68 miles, consists of $4\frac{1}{4}$ miles of tunnelling and the rest of iron pipes.

The Hirnant Tunnel, beteewn Vyrnwy and Oswestry, is $2\frac{1}{4}$ miles long, about a sixth being lined with brickwork in Portland cement, and the remainder—that is about $1\frac{3}{4}$ miles—is cut out of the compact rock, and is without any artificial lining.



Source of the
Liverpool Water Supply.

Lake Vyrnwy.

The Aqueduct is divided into six parts, with an open tank or reservoir at the end of each division, from the bottom of which the water is drawn off and then resumes the journey to Liverpool. The reservoirs are built of brick in Portland cement.

At Oswestry there is a reservoir about 1,500 feet long and three filter beds about three-quarters of a mile away from the town, the filtering medium being silicious sand and gravel.

It will be seen that the water, after it has been brought through the Hirnant Tunnel and has passed the filter beds at Oswestry, is perfectly safe, and that it is still further improved after it has reached Liverpool.

On referring to the table on page 62, showing the analysis of the Vyrnwy, it will be seen that it increases in hardness on its journey from 1·86 to 3·9, due no doubt to its passage through the tunnels, reservoirs, etc., and to the action of the filter beds on it at Oswestry, this further explains the cause of its greatly decreased solvent action on lead at Liverpool as compared with what it was at the Vyrnwy.

2nd.—It has been proved—and the "low level" Sheffield supply is an illustration —that when a water which acts powerfully on lead is allowed to mix with a water holding lime in solution, it loses that property, and may, with perfect safety, be used for a town supply.

SHEFFIELD "LOW LEVEL" SUPPLY.—This is a moorland water which, at its source, acts so powerfully on lead that it would be unsafe for use as a drinking water, but in its passage to the town, a distance of from seven to ten miles, it becomes mixed with a water coming from millstone grit, and holding lime in solution. It also runs through a tunnel three miles in length, one-half of which is lined with a cement containing lime. This "low level" water, when delivered at Sheffield, is only 50, and therefore perfectly safe; it has never caused any trouble.

3rd.—When water which produces a chemical action on lead is placed in contact with limestone or chalk, it is rendered perfectly safe for drinking purposes and domestic use.

SHEFFIELD "HIGH LEVEL" SUPPLY.—This is an example of the efficacy of this remedy. This water some time since caused serious trouble in Sheffield from the number of cases of lead-poisoning arising after its use as a drinking water, but by a very simple remedy, namely the addition of a small quantity of limestone or powdered chalk to the filter bed, it has for some time been rendered perfectly safe, without any deterioration of the quality of the water. The figure representing its solvent action on lead at its source is 400, whilst after it has passed the filter beds it is only 73. There have been no other complaints since this method was adopted.

The Rhayader water, so far as its action on lead is concerned, is superior to the Vyrnwy and Sheffield waters at their sources, as will be seen by the following figures:—

Rhayader, 220; Vyrnwy, 350; Sheffield, 400.

It has been shown by the foregoing that when the two latter reach their destinations

at Liverpool and Sheffield, they then are perfectly safe; but of the two, the conditions of the Vyrnwy supply most nearly approach those of the Rhayader; and as the Vyrnwy, during its passage of 68 miles to Liverpool, loses most of its property of dissolving lead (see page 62), then it may be reasonably expected that the Rhayader water, coming 80 miles across the country, through 35¾ miles of Portland concrete conduit, 34½ miles of iron pipes, and 8¾ miles of tunnel cut through millstone grit and Silurian rock, containing limestone, will undoubtedly be greatly improved during its transit. And like the Vyrnwy, without any treatment being necessary, will most probably be rendered perfectly safe, so far as its action on lead is concerned. Moreover, it is likely that the water will be met in the tunnels by other water, which, coming from rocks containing limestone, will tend to neutralise the slight natural acidity of the Rhayader water, and so further reduce its action upon lead. Further, the filter beds will doubtless have a considerable effect upon it in this respect, for it will be seen by the table on

page 62 that the water from the Vyrnwy, after it has passed the filter beds at Oswestry, only 17 miles from its source, has had its solvent action on lead reduced from 350 to 80, and it is only reasonable to expect that the Rhayader water will be similarly affected.

Then again, when the service pipes have been in use for a lengthened period of time, they become coated internally with a deposit which is formed by the continuous passage of water. This deposit tends to prevent the water acting on the lead. It is also known that where the CONTINUOUS SUPPLY SYSTEM is in force, as in Birmingham, the pipes being kept *quite full*, the water exerts no solvent action on lead.

We may, therefore, banish all apprehension. A soft water has, on the other hand, some great advantages, and the new supply will be so much softer than the present that its use has an important economical aspect. Although there will not at first be any direct reduction in the water-rate, yet, as water is used by all classes of the

Economic Advantages, Boiler Incrustation and Soap.

community, the financial benefits now to be mentioned will be shared by all. As I stated in the Council Chamber, on the authority of Mr. Gray, of the 17 million gallons of water required daily in our district, the quantity used for washing purposes may be roughly estimated at 5 million gallons, and for boiler use 2 million gallons. I estimate that the excess of lime in the present supply over that which it is proposed to bring from Wales, would cause 320 tons of scale, *i.e.*, boiler incrustation, more than will be found if the Welsh water is used, while when the town requires 60 million gallons a day, the excess of scale on this quantity of water, if used in the same proportion for boiler purposes would be 1,130 tons.

Then for washing purposes. If we take the Engineer's calculation of 5 millions, and deduct half of this quantity for rinsing, and, make allowance for temporary hardness, the inhabitants will save, if they pay 2½d. per lb. for soap, £35,000 a year, and on 60 million gallons a day in the same

proportion the saving would be £120,000 a year. But if the present water supply is continued, and the additional quantity required is drawn from deep wells, that water being so much harder, the difference between the amount of soap used with the Rhayader water and with local water, would be largely increased.

In Glasgow it was estimated that when they took the soft water from Loch Katrine instead of that from the Clyde for their public supply they saved £40,000 a year in soap. The Clyde water being softer than our present supply their saving would be much less in proportion than ours will be.

This, then, is the scheme which after careful consideration the Water Committee felt it their duty to lay before the Council. The Rhayader water seems best to fulfil the necessary conditions. Its quality is unobjectionable, the quantity will be amply sufficient for our district for many years to come, and the elevation of its watershed enables it to be supplied by gravitation alone to the greater part even of our own high town.

Present Position.

The cost, although very great, will not be a burden on the rates, but may be met from the revenues of the Water Department alone, with less charge to the consumers than they paid ten years ago, while the quality of the water will save them expense in other directions.

The scheme is by far the largest and most important that the City Council has ever undertaken, and marks an important epoch in the progress of our city.

Coincidences.

The little town of Rhayader, which lies near the watershed of the Elan, is already in a fever of excitement over the prospect of the large increase of business which must result from the influx of the army of workmen who would be required to construct the reservoirs and other works in the Elan Valley. I find that Rhayader was long ago made famous through the quality of its water. The inhabitants obtain their water from a spring at the extremity of Maes-y-dref by means of an artificial channel. This stream is now named Bwgey, or Bwch-gwy, and the

guide books state that the comeliness and beauty of the children of this town have been the subject of observation by every traveller, as is recorded in the following short but ancient adage :—

"Adam Bwgey glanha yughymry"

a free translation being—

"The fairest children Wales can have
Are those that drink bright Bwgey's wave."

Strange to say, it was from the Cwm-y-stwith lead mines, 14 miles from Rhayader, that Sir Hugh Middleton in the reign of James I., realised the vast fortune which he contributed to the formation of the New River, from which the most important of the great London water companies draws its supply. It is, therefore, a curious coincidence that through him the inhabitants of London are indirectly indebted to the neighbourhood of Rhayader for a large portion of their purest supply.

Great as is the task before us, we possess advantages which may encourage us to undertake it with hope. While London, burdened with its unwieldy parochial government, is endeavouring to create a representative authority, which

Advantages

shall be empowered to buy up the property of the eight companies which now provide its inhabitants with water, and to improve and increase its supply—the citizens of Birmingham, with their representative Council, have their water supply in their own hands, unhindered by troublesome prescriptive rights, and free from all but physical difficulties.

Then, too, we have the advantage of time. True to its motto, our Corporation has taken time by the forelock, and seeing that something like ten years will be required to bring the work to completion, has commenced its preparations already. It has not waited till the competition of other cities for its natural sources of supply should compel it to struggle with them for their possession, but while others are but desiring, it has decided to acquire, these treasures of untold value.

Birmingham, too, has been extremely fortunate in the Chairmen of its Water Committees. The town cannot be too grateful for the splendid services which

Mr. Alderman Avery rendered when presiding over the Water Committee with most distinguished ability for so many years.

The new scheme is so vast in its proportions, and of such immense importance to the welfare of the inhabitants, that the city ought to be thankful in this emergency to have as Chairman of the Water Committee one who possesses such sound judgment and great administrative ability as Sir Thomas Martineau. We therefore may hope that, notwithstanding the great difficulties before us, the scheme may be brought to a successful issue.

To our Engineer, Mr. J. W. Gray, I am greatly indebted for the readiness with which he has supplied me with much technical information, and I may add that the town is to be congratulated, especially at this juncture, in having at their disposal the services of such a competent and experienced Engineer.

Though the scheme is great and important, with just regard to its own responsibility, the

Committee cannot but recommend that it be undertaken. The boon is too great to lose, the necessity too pressing to blink. Should the Council succeed according to its expectations, the citizens of Birmingham may well be congratulated. For, at but slight annual cost, they will in due time acquire a possession of inestimable value—a supply of exceptionally pure water in sufficient quantity to meet the needs, during the next fifty years, of the constantly increasing population dependent upon their care.

Forward.

And while other cities are with prudence and public spirit making adequate provision for their future needs, every true citizen of Birmingham will demand that his city, hitherto always the leader in municipal enterprise and foresight, shall continue to hold its place in the van, and not, in a matter of such vital importance, be second to any.

CHAPTER V.

OBJECTIONS ANSWERED.

It may be useful to reply to the principal objections which have been raised to the scheme since it has been brought before the public. These may be stated as follows:—

Financial Objections answered.

OBJECTION.—*If the scheme costs £7,000,000, and the capital be borrowed at 3% per annum, there would be an annual charge of £210,000 for interest, and, as a penny rate produces £7,000, a 2/6 water rate would be required to meet it.*

REPLY.—If the report of the Committee be read it will be seen that it is not contemplated that the whole scheme shall be carried out for many years to come, although Parliamentary powers are asked for the whole; but, on the contrary, the reservoirs and iron pipes shall only be constructed and laid at different periods as the increase of population in the water area requires.

The proposal is at first to construct three of the six reservoirs in Wales, and two of the five iron pipes, which will be sufficient for the requirements of the next 24 or 25 years. The expenditure will therefore be gradual, and for the first instalment will be £3,340,700.

The remaining capital included in the £6,600,000 will not be required unless the demand for water necessitates the construction of the remaining reservoirs and pipes; and, if such should be the case, the additional revenue from the then water consumers will provide the amount required for interest, etc., without being in any way a burden upon the present generation.

Supposing this to have been done, the new water consumers will without difficulty pay the amount required for sinking fund and interest on capital expended; for it must be remembered, that, since the first outlay includes the whole cost of tunnels, cut and cover work, and compensation reservoir, the water rate will by that time

admit of reduction. It should also be added that the date for bringing the second instalment of water could, if necessary, be postponed for a considerable time. To do this it would only be necessary during the summer months, when the demand for water is at a maximum, to supplement the first instalment of the Welsh supply from the wells at present in use, thus rendering the former adequate for a much longer time.

To meet the charges for interest and sinking fund there will be a saving of £20,000 a year on pumping, which amount together with the £28,000 obtained by the re-imposition of a portion of the charges formerly levied by the old Water Company, will, with the additional revenue from the increased population in the water area (see page 49), be sufficient to pay the annual charges for interest, and provide a sinking fund for the extinction of the debt.

It will, therefore, be seen that a 2/6 rate will not be required, nor, indeed, any special rate whatever.

Should we have Double Sets of Pipes?

OBJECTION.—*There is an abundance of well water in the district for drinking purposes and domestic use; such being the case, it would be more economical to lay down a duplicate system of pipes than to incur the heavy expenditure of bringing the Welsh water to Birmingham.*

REPLY.—There is a general impression that deep well water which is clear and sparkling must necessarily be a good drinking water; this is altogether a mistake, for it will be seen by referring to page 33 that I have had analyses made of several artesian wells in the water area, the solids of which I have found to range from 52 to 182 grains in the gallon, and the hardness to reach as high a figure as 78 degrees, whilst in our present mixed supply the solids average 21·5 and the hardness 13·2, and in the proposed new supply 5·0 and 1·8 respectively. These well waters, although clear, sparkling, and pleasant to the taste, are, on account of the large quantity of solid matter and excessive hardness, quite unfit for drinking

Site of the
Second Storage Reservoir
on the Elan.

Craig-yr-allt Goch.

and domestic use, or for manufacturing purposes.

To bore new wells is a very risky undertaking, for the sandstone is so broken up by "faults" that it is seldom one can be sunk which yields water sufficient in quantity and quality. On page 14 it has been shown that at King's Vale, Harborne, and Longbridge, the well-sinkings have either proved a total failure, or the yield has been much below what was expected. In other districts, notably Liverpool and London, the amount of water obtainable from deep wells has suffered diminution owing to the continued pumping. At Liverpool to meet this, it has been necessary either to sink the old wells deeper, or to bore new ones; the effect of sinking deeper was, as might have been expected, to increase the hardness of the water. A similar result is to be anticipated in our own district.

The consideration of these facts, together with the important data contained in Mr. Johnson's letter, can lead to no other conclusion than that a double system of pipes

would be worse than useless, if, like a "Will o' the wisp," it leads the authorities of the town to abandon the only suitable watershed in Wales which is available for the supply of the inhabitants of this city and district.

No large town in Great Britain, with the exception of Wolverhampton, depends mainly upon deep wells for supplies, and Wolverhampton is now desirous of securing some of the Rhayader water from the Birmingham Corporation.

Will the water deteriorate by running through 80 miles of pipes ?

OBJECTION. — *The Welsh water, although pure at its source, will deteriorate in quality by the time it has been brought through the* 80 *miles of mains to Birmingham.*

REPLY.—As to the statement that the water will deteriorate if brought so many miles through iron pipes, tunnels, etc. ; this could only be the case if they were open, and the districts through which they pass in an unsanitary condition.

There need be no fear on this head. The

water for the supply of Liverpool travels 68 miles across the country, and, from the analysis I have had made, I find that it is in the same excellent condition at Liverpool as when it leaves Lake Vrynwy. Indeed, it will be seen by the table on page 62 that it is actually better in quality after its arrival at Liverpool, mainly, no doubt, due to filtration, but partly to the action of the tunnels upon the water during its transmission to Liverpool.

The action of Moorland Water on Lead.

OBJECTION.—*The action of soft moorland water on lead pipes is so great, that—as has been proved by numerous cases of lead-poisoning in some of the northern towns—its use would be attended with danger to the consumers.*

REPLY.—On referring to pages 61 to 63 it will be seen that this question has been well considered by the Council. The experts in water analysis, who have been consulted, are unanimous in their opinion that there is no risk or danger to be apprehended on this head.

OBJECTION.—*It will be impossible to bring the water through so many miles of pipes, tunnels, etc., without great loss of water from leakage, and heavy expenditure in repairs.*

Can the Engineering difficulties be overcome?

REPLY.—The Engineers do not anticipate any serious difficulties in bringing the water to Birmingham, either from tunnelling, crossing the rivers, or the nature of the sub-soil. No coal measures worth working have been found on the line of route. Indeed, more than one fortune has been lost in trying to find coal. The out-crop of coal beds appears to work itself out as it comes South; but, even if coal were found, it must be remembered that the whole of the South Staffordshire works, mains, etc., are laid on working coal-fields, and no serious difficulties have arisen in consequence.

OBJECTION.—*The drinking of soft moorland water, such as it is proposed to bring from Wales, through its deficiency in lime salts, produces rickets in children; and the well water, which contains lime, is much superior to it.*

Are Lime Salts necessary, and does the drinking of soft water produce rickets?

REPLY.—This opinion can only be that of people who consider that the presence of lime salts in drinking water is essential to health. This being a Physician's question, I have asked Sir James Sawyer (who showed his great interest in the Water Scheme by his speech at my Lecture) his views as to the sanitary bearings of the presence of lime salts in drinking water. *He replies:*—

"The question is a very wide one; but it may be stated generally that drinking water is better without lime salts, as their presence in it does not prevent rickets or any other disease. These salts may produce special morbid effects, such as goître and its attendant evils, calculi, and probably also some other diseased conditions in the human subject."

The following letter is from Henry Johnson, Esq., F.G.S., M.S.A., past President (1883), and Member of Council of the South Staffordshire and East Worcestershire Institute of Mining Engineers, whose knowledge on the question of the water absorbing quality of the Red Sandstone Formation in

the district is, as will be seen on page 16, quite exceptional.

THOMAS BARCLAY, ESQ.

DEAR SIR,—Having had the pleasure of attending your very interesting and instructive lecture on the 7th September last, and since having perused the published pamphlet report of it, and with a desire to render some little aid in the consideration of this important local question, I have ventured to address the following remarks to you, which you are at liberty to publish if you should consider that they would assist in the general or public consideration of the question :—

It would appear that there exists a general impression that districts of the New Red Sandstone Formation are capable of yielding inexhaustible supplies of *underground* water, an impression, no doubt, founded upon an erroneous impression as to the circumstances regulating the circulation of underground water.

The 'New Red Sandstone' around Birmingham is no doubt inadequate as a receiver

(absorber) of the local rain-fall to supply the wants of the city for the following reasons:—

Capacity for collecting rain-fall is governed by the area of the *exposed* edges of the porous strata, and these occur at outcrops situate Westward of Birmingham and within the 'Black Country' area, and, consequently, are calculated to pollute the supply at its source.

A supply can only enter at the surface exposure of the porous strata of the New Red Formation, and, therefore, must be proportionate to the area of *exposed* porous strata.—(See Chart, Section No. 2.)

The New Red and Permian Formations are, no doubt, saturated or charged to the full when first 'tapped' by bore-hole or shaft, which is quite a natural condition of things, and to be accounted for by a reference to the law of gravitation; but there can be no doubt (at least so far as my experience goes) that the capacity of the porous strata to take up at their outcrops and convey the rain-fall, is inadequate to replenish the

enormous quantity withdrawn by continuous powerful pumping at spots where the same strata are more deeply seated.

Speaking briefly, a well supply is a passage of rain-fall from the surface through porous strata to varying depths, and there raised up to the surface again.

This has been conclusively proved in the Sandwell Park Colliery, where, during the process of sinking the trial shaft, the 'come' or maximum quantity of water which had to be dealt with was 750 gallons per minute, but after pumping for a short period the sandstones and other porous strata were drained to their outcrop (including several shallow wells), and ceased to yield that quantity, which gradually became less and less until the regular average yield was only 41 gallons per minute.

It was originally intended to make the sinking a pumping station for a water supply, but in consequence of the ultimate unexpected very small yield, together with the fact that on analysis the water proved to

be very highly contaminated with ammonia (no doubt the product of the manure in the land and surface drainage) the project was abandoned.

The New Red and Permian Formations—which are dislocated by 'faults' of great extent and comparatively unfissured strata—are inadequate to the infiltration and circulation, and, as a conduit of water sufficient in quantity to warrant the expenditure requisite to construct and equip deep wells for a permanently increasing demand.

Obstruction to a passage of water through the New Red Sandstone may be caused by dislocation of the strata, the effect of which is that porous strata abut against impervious strata, and this may be taken to account for wells in the same locality yielding varying quantities of water.—(See Chart, Sections Nos. 2 and 3.)

It is possible for an expensive boring for water to be rendered unsuccessful, consequent on its position being, unintentionally, within the angle of two faults, in which event the bulk of the underground water

would remain untapped, although in close proximity to the bore-hole.

In other words, dislocations or faults have the effect of forming separate and distinct *underground* watersheds, and isolated troughs or ponds, of "new red" water, the areas of which are governed by direction and extent of dislocation of the strata.

It is possible to have a deep well so situated that water would be almost entirely kept back from it by dislocations of strata. As a fact, I know a case where a company sank for *coal* and met with an overpowering quantity of *water*, whilst a *water* company's boring, distant only a few hundred yards, at the same depth failed to find *water*.

It may reasonably be inferred that the longer sandstone, or any other porous strata are subjected to an unnatural (continuous and rapid) passage of water, consequent on the withdrawal of it in the dip, the less their capacity as a conduit; because, in consequence of the infiltration of foreign and solid matter conveyed along with the

water in its passage from the outcrops to the pumps, the pores of the strata became gradually choked, thus causing a decreased rather than a regular permanent supply. I have myself practically proved this to the extent of hollowing out a large block of sandstone for the purpose of a filter, and supplying it with shaft-water charged with solid matter.

The construction of additional wells to be capable of "tapping" water-bearing strata within *moderate depths* must be *west* of the extensive north and south Red Marl Fault, which occurs about 400 yards east of the Bull Ring, and runs a course of more than 20 miles, throwing down a vast expanse of Keuper marls against Bunter sandstones, and thereby forming a water-tight barrier. (See Chart, Section No. 1.) Borings for water through this great thickness of red marl would be of very considerable depth, and, consequently, very expensive to equip and maintain, besides which there is the great probability—in consequence of a south easterly attenuation of the Bunter or water-

bearing beds beneath the red marl—that the yield of water would be limited in quantity.

I think it is a question worthy of consideration whether it is not an event not beyond the bounds of possibility that a continuous and excessive withdrawal of moisture (water) from sandy and porous strata may not ultimately have the effect of causing slight surface disturbance. It is an established fact that underground water, under natural conditions, in sandy strata does tend to maintain the surface at its natural level.

I am,
Yours respectfully,
HY. JOHNSON,
Mining Engineer.

Mining Offices, Dudley.
March 5th, 1892.

For Chart illustrating Mr. Johnson's letter see pages 15-16.

CHAPTER VI.

THE SCHEME BEFORE PARLIAMENT.

It will be seen, on reference to page 57, that at the Statutory Meeting of Ratepayers, held in the Town Hall on the 5th December, 1891, there was a large majority of votes cast in favour of the Welsh Water Scheme; but, notwithstanding this result, the minority were not satisfied with such an expression of opinion, but busied themselves by writing letters to the newspapers, and in other ways endeavouring to arouse public opinion so as to prevent the scheme being carried into effect.

The various objections they raised, and the alternative schemes they suggested were set forth and replied to in the Appendix to the former edition of this book, and will be found in Chapter V. of the present edition.

Bill passed Standing Orders.

In accordance with the decision of the Council and the ratepayers, already recorded, immediate steps were taken to bring the Bill before Parliament. It was at once deposited in the Private Bill Office, and on the 20th of January passed through Standing Orders without opposition.

The Town Clerk was engaged during January and February preparing briefs and proofs of evidence in support of the Bill in the Parliamentary Committee, and in assisting the Water Committee in dealing with the opponents of the scheme on the watershed, and in this way much was done to further the passage of the Bill through Parliament.

Arrangements were at this stage made with Wolverhampton and other places within fifteen miles of the aqueduct as to their right of supply. By the terms agreed upon the Corporation is required to "supply in bulk to any Corporation or urban or rural sanitary authority or any joint committee of any two or more urban or rural sanitary authorities

Arrangements for supply of Water to Towns en route.

authorised to supply water (hereinafter referred to as the authority) demanding the same, any part of whose district is situate within the counties of Montgomery, Brecknock, Radnor, Hereford, Worcester, Salop, Stafford and Warwick, or any or either of such counties, and within fifteen miles of the aqueduct and wholly or in part beyond the water limits of the Corporation, such daily quantity of water as any such authority may from time to time require and agree to take, in consideration (unless otherwise agreed) of an annual payment equal to four per centum upon such proportion of the total capital from time to time expended on the works by this Act authorised other than the Frankley Reservoir, the Warley Reservoir and the Northfield Reservoir, and the tanks and filtering beds and distributing mains connected therewith, as the daily quantity of water demanded by such authority may from time to time bear to the total daily quantity of water which the works and aqueduct so constructed are from time to time capable of providing and conveying from the rivers Elan and Claerwen together

with a proportion (calculated in manner aforesaid) of the costs necessary or proper for the maintenance, working and management of the works by this Act authorised."

Prior right of Birmingham retained.

This arrangement is, however, subject to the City of Birmingham and the present water limits of the Corporation having "a prior right of supply, from the rivers Elan and Claerwen, of a quantity not exceeding twenty-five gallons per head per day of the population."

First Reading.

The Bill, backed by Mr. Henry Matthews, Mr. Chamberlain, Mr. H. H. Fowler, Mr. Kenrick and Mr. Powell Williams was read for the first time in the House of Commons on the 16th of February, 1892.

Position of London.

London viewed with considerable alarm a project by which Birmingham was to become possessed of one of the largest and best watersheds in Wales, whilst she continued in such straits for a more abundant water supply for her increasing population.

Conferences of metropolitan and other Members of Parliament and Members of the London County Council were held in London, the object being to endeavour to get Birmingham to postpone its action until the Royal Commission on the London Water Supply had reported.

A meeting was subsequently arranged between representatives of the London County Council and the metropolitan members and the members for Birmingham, together with the Mayor (Alderman Lawley Parker), Alderman Sir Thomas Martineau and the Town Clerk. The promoters of the Bill were unable to persuade the London County Council to abandon its attitude of opposition, but certain London representatives, including Lord Compton, admitted the urgency of the case of Birmingham and agreed not to oppose the Bill.

Mr. Shaw-Lefevre, the Parliamentary champion of the Preservation of Commons, gave notice of his intention to move an instruction to consider the question of common rights and access to the hills on the watershed.

The Bill created widespread interest. Believing that it affected Wales adversely, Mr. Thomas Ellis and other Welsh members announced their intention of moving its rejection. Sir Henry James, who was interested in Hereford, gave notice of a motion for preserving the use of the waters of the Wye and other rivers affected by the Bill to the same extent as if the Bill were not passed.

Second Reading.

On Tuesday, the 8th of March, the second reading of the Bill was moved by Mr. Chamberlain; there was a large attendance of members, and the debate lasted more than three hours. When the House divided the result was—"Ayes," 244, "Noes," 102; majority for the second reading, 142.

As a preliminary to the Committee stage, a conference with counsel was called on the 10th of March, and on the following day, in the House of Commons, a Hybrid Committee was agreed to without discussion. The promoters willingly accepted Mr. Shaw-Lefevre's instruction, and Sir Henry

James withdrew his motion, being satisfied with the safeguards provided in the Bill.

On Thursday, the 31st of March, the Hybrid Committee held its first sitting, Mr. Campbell Bannerman being elected chairman. The Committee consisted of nine members, five being nominated by the House and four by the Committee of Selection.

Bill in Committee.

Mr. Pope, Q.C., Mr. Balfour Browne, Q.C., Mr. Cripps, Q.C., and Mr. G. A. R. Fitzgerald, instructed by the Town Clerk, appeared as counsel for the Corporation, Messrs. Sharpe and Co. acting as agents.

Thirty-six petitions against the Bill were read, and many of the petitioners were represented by counsel or solicitors.

After Mr. Pope had opened the case for the Corporation, the following witnesses were called in support of the Bill :—

Sir Thomas Martineau, the Mayor (Alderman Lawley Parker), Mr. James Mansergh, Engineer, supported by Mr. J. W. Gray, Mr. Thomas Hawkesley, Mr. G. H. Hill (Manchester) and

Case for Corporation.

Mr. J. M. Gale (Glasgow), Engineers; Professor Lapworth, Mr. W. Topley, Professors Boyd Dawkins and Green, Geologists; Dr. Frankland, Professor Dewar and Dr. Hill, Chemists; Dr. George Wilson, Medical Officer of Health for Mid-Warwickshire, Mr. Howard S. Smith, Accountant, Mr. F. G. Meachem, Mining Engineer, and Mr. Stephen Williams, County Surveyor of Radnorshire. The evidence given by these witnesses was on the lines followed in the earlier chapters of this book.

Mr. Pope closed the case for the Corporation on the 8th of April, the Committee having sat daily from the 31st of March.

London Opposition.

The opposition to the Bill was opened by Mr. Pember, Q.C., who, on behalf of the London County Council, urged the postponement of the scheme until the report of the Royal Commission on the water supply of London, which, he said, might be expected within a year. Since the Commission in question has not even yet reported, it is fortunate for Birmingham that his argument did not prevail.

On Monday, the 2nd of May, the Committee, after the Easter recess, resumed its sittings, when Mr. Deacon, C.E., of London and Liverpool, with other witnesses, was called on behalf of the Corporation of Hereford, the proposal of that body being to tap the aqueduct at Ludlow and to obtain a million gallons of water per day therefrom without payment. In this plan they were unsuccessful, but, in consideration of their existing interests in the river Wye, it was agreed that a clause should be inserted under which they might secure water at half the price charged to other authorities.

Hereford Opposition.

The 4th, 6th, 9th and 10th of May were occupied in the examination of witnesses in support of the petition of certain owners of property in Birmingham and district who opposed the Bill. Professor E. Hull, M.A., F.R.S., F.R.G.S., Professor Wanklyn, M.R.C.S., F.I.C., etc., Dr. Andrew Cheshire, F.R.C.S., etc., Mr. Reuben Smallman, Mining Engineer, Mr. F. W. North, F.G.S., M.I.C.E., M.E., and Mr. C. M. Powell, brassfounder,

Birmingham Opposition.

were called to prove that water sufficient for the future supply of the city and district could be obtained in the neighbourhood of Birmingham from artesian wells, and further, that the quality of the deep well water was much superior to that of the Welsh water, in addition to which Mr. Geo. Heaton, J.P., and Mr. Ernest W. Forrest criticised the financial arrangements of the scheme, and Messrs. Beriah Shepherd, Howard Lane and Edward Fletcher endeavoured to controvert the evidence adduced by the promoters of the Bill to show that it was approved by the ratepayers of Birmingham. Under cross-examination, however, the testimony of these gentlemen was considerably shaken, and many admissions favourable to the Bill were obtained.

Opinion of the Committee on the local case.

Summing up on this part of the case, the Chairman of the Hybrid Committee made the following remarks :—

"I may say that the Committee has listened very carefully and with great interest to all that has been said on the question of

the water supply, that is to say, on the possibility of finding water in or near Birmingham; and I have to say to Mr. Pope that we think it unnecessary for him to bring rebutting evidence as to the possibility of finding a sufficient additional supply in the neighbourhood of Birmingham."

And further:—

"As to finding an additional supply of water from the present sources, or anything like the present sources, of sufficient quality and in sufficient quantity for future needs, it may be regarded as unnecessary to prosecute that enquiry any further."

That all possible consideration had been given to the local opponents of the Bill is clear, from the following words of the Chairman, at the close of their evidence:—

"The Committee have had a good deal of sympathy with Mr. Gough (who conducted the case) in the position in which he was placed, and with those who have acted for him, and I think the Committee and the promoters, and all the parties to the suit,

are indebted to the Birmingham opposition for the facts they have brought forward and for the light they have thrown upon their side of the question."

Sir Hussey Vivian, M.P. and Mr. Thos. E. Ellis, M.P., also gave evidence. The former contended that the requirements of Glamorganshire, Monmouthshire and Carmarthenshire were increasing enormously because of the growing population, and that, therefore, the needs of these counties should be considered by the Committee before it decided to hand over to Birmingham the watershed of the Elan and Claerwen.

Welsh Opposition.

Sir Hussey Vivian argued that Birmingham had seized upon a spot which was practically the only one of suitable character and sufficient elevation to supply the county of Glamorgan, since in a great part of that county reservoirs could not be constructed on account of the existence of coal workings below.

It may be noted in this connection that Mr. Mansergh, when under examination

before the Committee of the House of Lords, proved that 200 million gallons a day could be obtained for Glamorganshire and 500 million gallons a day for London without touching the Elan.

Mr. Thomas E. Ellis opposed the scheme from a Welsh standpoint :—

"A community must, it seems to me, pay attention to the prospective value of the land within its boundary. Take the case of the Rhondda Valley (now a populous mining district). Fifty years ago it was amongst the quietest little glens in the whole of Wales, poorly cultivated and very sparsely inhabited. Supposing that fifty years ago it had been dammed up, in order to supply water for some great English community, I venture to think that the difference to South Wales, and the difference probably to humanity would be enormous." He also urged that the Bill should be stopped, on the ground that the water of Wales should be left for the Welsh people.

On Friday, the 13th of May, Mr. Pope made his reply.

Preamble of Bill proved.

After the Committee had retired for a short time, the Chairman announced that the preamble of the Bill was proved.

The clauses of the Bill were then discussed one by one, the following, among other new clauses were inserted :—

New clauses.

In cases where the Corporation shall have acquired a freehold interest in the sale of any lands, which are not intended for the site of any work, and are not within the limits of deviation, a lease of such lands, exclusive of any mines or manorial rights, shall be given for 999 years, at a rent equal to 3 % per annum on the capital charges of the land, and also that the Corporation shall grant leases for terms of 21 years to all tenants who require same, who, at the passing of the Act, may be in the occupation of any land which the Corporation may require (other than lands within the limits of deviation), such leases shall contain such covenants as shall be necessary for the prevention of the pollution of the water, etc.

It was provided that compensation should be given for damages, injury, loss and expense which may be incurred by reason of the bursting of any of the reservoirs or aqueduct.

Power was given to the Corporation to prohibit sheep washing, but, if this be exercised, the Corporation must provide and maintain another suitable washing place in the nearest convenient station.

By another clause authority was granted to the Corporation to make bye-laws to prevent pollution of the water, and to secure the protection of their waterworks by regulating the time, place, and manner of the taking of turf, the cutting of heather, bracken or gorse, and to regulate fishing and recreation, assemblages of persons, etc., on the land they obtained under the Bill.

Angling Rights of Rhayader.

A considerable amount of time was expended in committee in discussing the question of angling rights. It was maintained that from time immemorial the inhabitants of the district and town of Rhayader had

exercised their right to fish in the Elan and Claerwen. It was said that the whole of the Manor of Grange once belonged to the Abbey of Strata Florida, and that the monks were the owners of Dol-y-mynach (which means "the grotto of the monks"). It was finally agreed that the following clause should be inserted in the Bill:—"All rights of fishing in the rivers Elan and Claerwen and their tributaries flowing through the Manor of Grange and the Manor of Builth above the upper end of the upper reservoirs and in the lakes adjacent thereto, hitherto enjoyed by the inhabitants of the district and the town of Rhayader, and all rights of turbary and of cutting fern and rushes over such commonable land shall be preserved to the said inhabitants as heretofore, and without interruption by the Corporation, subject nevertheless to the bye-laws authorised by this Act."

The Wye Fishers.

The rod-fishers on the Wye endeavoured to obtain an increase in the quantity of compensation water which, as will be seen on page 39, was intended to be 21½ million gallons a day.

They asked for 37 millions. Mr. Mansergh showed that, for every million gallons a day of compensation water, storage for 160 times the amount, namely, 160 million gallons had to be provided, and that every million gallons of compensation water sent down the river would cost the Corporation £14,400, and further, that by the clause introduced by the Board of Trade, the Corporation will be subject to a penalty of £200 a day if they fail to supply the requisite quantity of compensation water.

Compensation Water.

The Committee decided that the quantity of compensation water should be 27 million gallons a day, and also that the Corporation should build a suitable house for the inspector or water-bailiff, near the dam of the Caban Coch, at a peppercorn rent, and further, that the Corporation should pay the sum of £7,500 to the Board of Conservators of the Wye Fishery District for the advantage of the fisheries.

According to the agreement arrived at earlier (p. 101), a clause was inserted giving

Concession to Hereford.

Hereford the rights of a town within the 15 miles limit, and laying down that, if these rights were exercised within ten years of the first supply of water to Birmingham, for any quantity not exceeding one million gallons a day of water so supplied, the charge should not exceed one half of the rate payable by any other authority under this section.

During the proceedings of the Committee it became obvious, from a consideration of the weight and character of the opposition to the Bill, that it was desirable to settle as quickly as possible with the numerous landowners, all of whom had lodged petitions, and several of whom were represented by counsel.

The Corporation was therefore fortunate in coming to terms with Mr. Lewis Lloyd, amongst others, he being the proprietor of the largest portion of the land in the watershed which it was necessary to acquire.

The withdrawal of opposition from these interested parties greatly accelerated the passage of the Bill through Committee.

On the 18th of May the whole of the clauses had been dealt with, and the Chairman was directed to report the Bill to the House. On the 26th the Bill, as amended, was reported to the House of Commons, when several amendments of which notice had been given, were discussed, the consideration of these lasting two hours. The amendments were either negatived or withdrawn, and, on the 31st of May, the Bill came before the House for the third reading; there was again further opposition, and Sir Hussey Vivian moved the rejection of the Bill, but it was read a third time without a division.

Third Reading.

The Bill was read the first time in the House of Lords on the 2nd of June, and on Monday, the 13th day of that month it passed through standing orders. It was read a second time on the 14th, and, on the following day, a select Committee, of which Lord Northington (Lord Henley) was chairman, took the Bill into consideration. Evidence similar to that given before the Commons' Committee was offered here, and speeches were made

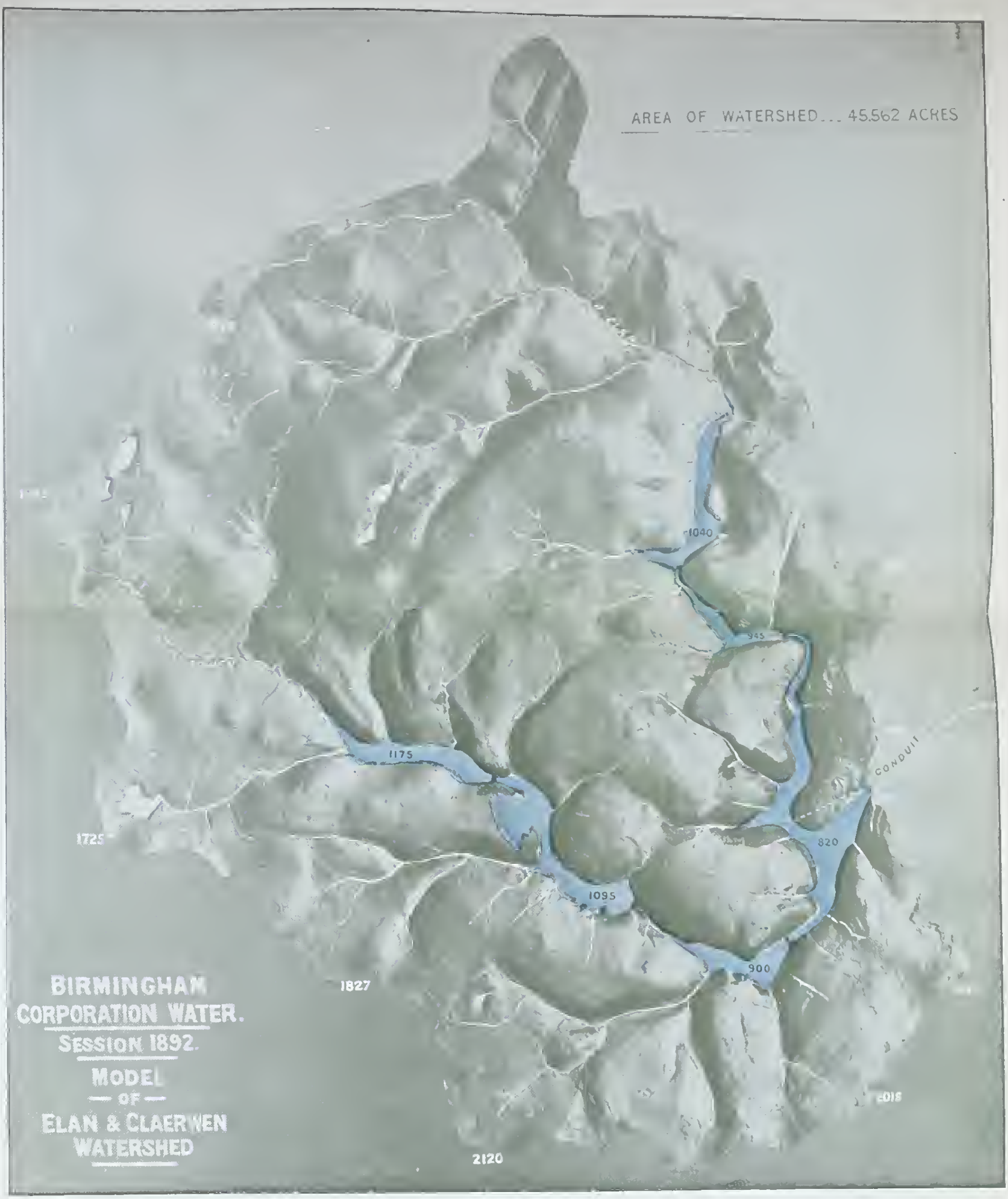
First Reading in Lords.

by counsel on behalf of the Corporation of Birmingham for the Bill, and on behalf of the London and Glamorgan County Councils and other petitioners against it. Mr. Howard Lane also wished to appear in person against the Bill, as an owner of property in Birmingham, but the Committee decided that he had no *locus standi*.

The case for the Corporation was further strengthened by the testimony of Sir Frederick Bramwell and Professor Odling, neither of whom had been called as witnesses in the House of Commons.

Mr. Alfred Lass was also called, he being an experienced waterworks accountant. Meeting the point raised by Mr. Forrest before the Commons' Committee, he gave evidence to prove that the £28,000 per annum, as shown in the tables, could be raised without any increase of the statutory powers of the Corporation. After this evidence the case for the Corporation was closed.

The case for the opposition occupied the 17th and 20th, Mr. Pope then replied for


AREA OF WATERSHED... 45.562 ACRES
1040
945
1175
CONDUIT
1725
820
1095
900
1827
2120
BIRMINGHAM
CORPORATION WATER.
SESSION 1892.
MODEL
— OF —
ELAN & CLAERWEN
WATERSHED

the Corporation, and after a short deliberation, the Chairman, on behalf of the Committee, announced that the preamble of the Bill was proved.

The clauses of the Bill were then agreed to, with a few minor alterations, and the Chairman was ordered to report the Bill to the House as amended.

The Bill was read a third time on Tuesday the 21st of June, and on Wednesday, the 22nd, the amendments made in the House of Lords were brought before the House of Commons and agreed to.

The Royal Assent.

The Royal assent was given to the Bill on the 22nd of June, 1892, and it was thereby constituted "THE BIRMINGHAM CORPORATION WATER ACT, 1892."

Birmingham has, by means of this Act, acquired an unlimited supply of pure water, and to protect the watershed from any possibility of future pollution, has acquired nearly 5,000 acres of freehold land, the common and exclusive rights of over 2,300

acres, and the manorial rights of nearly 35,000 acres, to which is added 73 miles of easement for aqueducts, and about 200 acres of land purchased outside the watershed area.

The time occupied by the business of the Bill in the two Houses of Parliament, and in Committees, extended over 82 days, and the minutes of speeches and evidence cover 1,169 foolscap folio pages. The witnesses examined by the Common's Committee numbered 49 in all, and by that of the Lord's Committee 32.

The local opposition, as will be seen by the evidence, was of a very feeble character, whilst the scientific witnesses for the Corporation, whether engineering, geological, chemical or financial, were the most eminent in the professions to which they belonged, and had but little difficulty in disposing of the arguments and data adduced by the opponents of the Bill.

The burden of the case for the Corporation rested mainly upon the late Sir Thos.

Martineau, Chairman of the Water Committee, and the then Mayor (Alderman Lawley Parker), both of whom possessed the confidence of the City Council and the unanimous support of the Water Committee, which at that time consisted of the following members:—The Chairman (Sir Thomas Martineau), Aldermen Edwards and Hart; Councillors Barclay, Fallows, Shammon, James Smith (now Sir James Smith) and Walsh. Amongst the professional experts who gave evidence for the Corporation, the following gentlemen deserve special mention, viz.:—Mr. James Mansergh and Mr. J. W. Gray, Engineers, Professor Lapworth, Dr. Ed. Frankland, Professor Dewar and Mr. Stephen Williams.

The thanks of the community are especially due to the Rt. Hon. Joseph Chamberlain, M.P., who took charge of the Bill, since by his skill and influence its passage through the House of Commons was greatly facilitated.

Last, but not least, reference ought to be made to Mr. Edward Orford Smith, the Town Clerk, regarding whom it is but fair

to say that, had it not been for his ability and assiduity, the passage of the Bill through both Houses of Parliament in one session would have been impossible. Had the Bill gone over to another session, as was the case with the Manchester Water Bill (see chap. x.), heavy additional charges, due to the necessity for duplicating the professional evidence, would have fallen upon the ratepayers.

CHAPTER VII.

THE STEPS TAKEN BY THE BIRMINGHAM WATER COMMITTEE IN REGARD TO FINANCE AND FOR THE PROVISION OF AN INCREASED SUPPLY OF WATER DURING THE CONSTRUCTION OF THE WELSH WORKS.

Being aware that the construction of the works in Wales and the making of the aqueduct to Frankley would cover a period of something like ten years, during which time the population in the area of supply might be expected to constantly increase, the Corporation of Birmingham very wisely gave their attention to the necessities of the consumers during the interim. They endeavoured both to effect economies and to open up new sources of supply.

On January 3rd, 1893, Mr. Thomas Starkey, who had been Secretary to the Water Works Company for the 22 years prior to the Corporation acquiring the undertaking, and who had occupied a

Appointment of New Secretary.

similar position under the Corporation for 17 years, found it necessary on account of his advancing years and the greatly increased responsibilities devolving on the secretary, to resign his office, and on May 16th, 1893, the Committee reported to the Council that they had, after considering 171 applications, selected Mr. E. Antony Lees as his successor.

Mr. Lees speedily proved to the Committee and the Council that he possessed special ability for the very onerous position to which he had been appointed. With his assistance the Committee determined to prevent, as far as possible, any waste of water, and to that end, gave instructions for a complete survey of the district, with a house-to-house inspection.

Economies. Annual Saving.

This was a serious undertaking, since 154,938 premises had to be visited, but it was abundantly justified by the result. The saving effected by these means is calculated to have amounted during the four years since the survey was made to 2·25 gallons per head

per day, representing an annual saving of over 500 million gallons, and a consequent reduction in pumping charges. As a proof of the wisdom of the inspection, it was found that during the past five years, although the population had increased by 60,000 in the water area, there had been no increase in the total amount of water consumed.

In the year ended March 31st, 1898, the average consumption per head per day was for

Measured Trade Supplies, Road Watering, Markets, Railways, etc.	5·18 gallons.
Unmeasured Trade Supplies estimated..	4·04 ,,
Domestic Use, Fire and Waste	13·95 ,,
Making a total of	23·17 gallons.

New Pumping Engineer.

It may here be mentioned that after the retirement of the late Mr. J. W. Gray, the Committee, recognising the fact that, pending the completion of the Welsh scheme, the Engineer to the City Water Department should be one having large experience of the working of pumping machinery (this would be unnecessary after the Welsh water was brought to Birmingham), recommended the Council to appoint Mr. Henry Davey, M.I.C.E.,

of London, well known as a specialist in pumping engineering.

The wisdom of this appointment has been abundantly manifested, for the following improvements with many others in the engineering department have been carried out under Mr. Davey's direction.

At the Aston Pumping Station, where the supply of water for condensing has for a considerable time been largely supplemented with filtered water, from half to three-quarter million gallons a day being thus permanently lost, an ingenious method has been devised whereby this water is now saved. Further, the reservoir at that place which has a capacity of thirty million gallons and which, for some years past, has only been used for storing water for feed and condensing purposes, is now available as a storage reservoir for the department.

It was felt by the Committee, well aware though they were that any works which they might construct would be of a temporary character, and required during the interim

New supply. The Perry sinking.

period only, that something further should be done to increase the supply. The late Mr. J. W. Gray, engineer to the department, for that purpose made a trial boring at Shustoke, going down 120 feet, but the result proving unsatisfactory, the project was abandoned. The Committee have, however, since that time, under the direction of the City Council, arranged for the acquisition of the pumping rights of the Perry Sinking, Perry Barr. This is a shaft which was sunk to a depth of 1,488 feet about 25 years ago, as a boring for coal, but afterwards abandoned. Here, fortunately, the quality of the water was found to be satisfactory, and a trial period of 18 months was allowed for erecting the plant and testing the quantity of water obtainable from the sinking. The works are now completed, but the quantity not having proved so great as was hoped, it is feared that there are no other local sources of supply on which the Corporation can draw, and the Water Department will find it very difficult to keep the population fully supplied during the four years still remaining before

the Welsh supply can be brought to Birmingham. No more complete proof of the necessity for resorting to a distance for the future water supply of Birmingham could possibly have been afforded than this inadequacy of local resources. It is difficult to imagine what the condition of the city would have been at the end of fifty years if the views of those who urged that a sufficiency could be obtained in the neighbourhood had prevailed.

Adjustment of Charges.

Then, again, the Committee, in order to increase the financial resources of the department, in view of the expenditure on the Welsh works, and, at the same time, to remove anomalies in the charges which had crept in during a long series of years, decided to make a careful examination of the account of each consumer. This having been done, after a fair adjustment, by which some rents were increased and others reduced, the Committee were able to increase their water revenue by the sum of £6,000 a year.

Various economies have also been made in the engineering department. For example, the engine slack, required for the different stations, is now tested at Plant's Brook (each test being made with 25 tons of slack), with the result that a saving in coal has been effected, for it was proved that the steam-producing quality of coal did not always vary with the price.

At the Aston Pumping Station important improvements have been carried out, by means of which there will not only be a considerable saving in fuel but additional pumping power will also be provided, the maximum demand on the station will be met without a large expenditure of capital. When it is remembered that the bulk of the water obtained from the various local sources is brought to the Aston station to be pumped into the Monument Road Reservoir, and that any additional water, which may be utilised as a temporary supply, pending the arrival of the Welsh water, will also have to be pumped at Aston, the importance of these improvements will be understood. The

Saving in Fuel.

greatest care has, in fact, been exercised to maintain a supply of water equal to the demand.

During the summer months, in dry seasons, great pressure has been put on the department, even to the extent of occasionally causing inconvenience to consumers.

Special appeals have, therefore, had to be issued from time to time to prevent waste and excessive use, and although the consumers have co-operated with the Committee, the demand for water has at times far exceeded the daily supply. At such times the deficiency has been provided for out of the reserve storage in the reservoirs, and these have sometimes been drawn perilously low.

Whilst, as already shown, the Committee have been cutting down their expenditure and increasing their revenue, it is most gratifying to learn that the increase of income has exceeded the forecast. As will be seen by a glance at the Financial Table facing page 58, the water-rents were expected to increase at the rate of 3 per cent. per

annum, until the year 1901, but the last report of the Committee, as presented to the Council, shows that the average rate of increase for the past four years is actually over 4 per cent., and it is even more satisfactory to learn that the figures last year came out at 6·01, being thus more than double the estimated increase.

This increase is no doubt exceptional, and is due to the extra demand for water required for manufacturing purposes, owing to better trade, and also to the great increase in the number of dwelling houses, owing to the same cause; but, whatever the explanation, the fact remains the same.

The estimated increase in water-rents, based upon previous experience, and set forth in the Table referred to, has during the years 1894-97, been exceeded by over £25,000, and the amount which it was estimated that the rental would reach in the year 1900 has already been passed.

In referring to the finances of the department it ought, however, to be stated that

the surplus from accumulated balances for the year ending March 31st, 1898, should according to the Table, column 20, be £128,722, instead of which it stands on the Committee's report at £108,988. This discrepancy is more than accounted for by the fact that the scheme was a year late in coming into operation, so that the first item of £28,000 for re-imposed charges (column 17), was not brought into the account. Other special causes, such as the occurrence of severe frost, have combined to prevent the growth of the accumulation. It must not be forgotten, however, that the income from rental (being the permanent income) is the most important factor in gauging the financial position of the undertaking.

Capital Expenditure.

The report of the Committee shows that the capital expended on the scheme to the end of the financial year 1898 is over £600,000 less than was estimated, initial delays having interfered and rendered the progress of the work less rapid than was expected. The estimated figures were £1,960,000 (column

10), whilst the actual expenditure was £1,309,048.

The Committee, while realising the importance of preventing waste, of increasing their interim supply of water, and further, of husbanding their financial resources to meet the charges due on the Welsh scheme, have not been unmindful of their responsibility in regard to the quality of the water.

Tests of Quality.

For some years past the Health Committee, acting independently of the Water Committee, have at their discretion, taken samples of the Corporation water in different districts for analysis, and the Medical Officer of Health has in due course reported on them. This independent check has been of great value, but the Health Committee, in face probably of the Maidstone epidemic, are taking additional precautions, and have arranged for Professor Frankland, of Mason College, to make a report to them on samples of water taken monthly for bacteriological examination from each of the three zones of supply.

Bacteriological Examination.

The Committee will have, in addition to these bacteriological examinations by Professor Frankland, the customary chemical reports of Dr. Hill.

The Committee, with a view to testing the efficiency of the filter beds, have also made arrangements for a bacteriological examination, by Professor Frankland, of the water before and after filtration, at each of the stations.

In addition to which the Water Committee, in order to protect the sources of supply, is co-operating with the Health Committee, to secure early notification of any cases of typhoid fever which may occur in any of the districts constituting the gathering grounds of the streams contributing to the supply, so that, if necessary, action could at once be taken to protect the streams from any pollution liable to render the water dangerous to the health of the city and district.

CHAPTER VIII.

THE SCHEME COMMENCED—ENGAGEMENT OF MR. MANSERGH AND STAFF—PLAN OF OPERATIONS—CONSTRUCTION OF THE FIRST RAILWAY—MR. LEES' ACCOUNT OF THE NAVVY VILLAGE.

Mr. Mansergh appointed.

The Royal assent to the Birmingham Corporation Water Act was obtained on June 27th, 1892, and on October 31st of the same year the City Council formally instructed Mr. James Mansergh to prepare plans, etc., and to proceed with the work.

Before any part of the work was begun however, a most important question had to be settled by the Committee and the Council, viz., whether the whole or any part of the works should be undertaken by the Corporation, they employing the necessary labour, or whether the whole should be let by tender to contractors in the ordinary way.

Mr. Mansergh, the engineer, strongly urged that the reservoirs should be con-

structed by the Corporation without the intervention of any contractor, and the Committee wisely resolved to act upon his recommendation. The reasons given for their decision were set forth as follows :—

Important decision of the Committee.

"Your Committee felt that it was essential that these dams should be constructed in the way that would best secure their being absolutely safe and water-tight, and in view of the immense responsibility, both legally and morally, resting on the Corporation with respect to these works, considered that the question of safety was of primary importance."

This decision applied only to the dams, and the works connected therewith on the watershed. All the other work, including the railway to the watershed, and the aqueduct, were to be carried out by contractors under the direction of the engineer.

Mr. Yourd appointed.

Mr. G. N. Yourdi, M.I.C.E., who had served under Mr. Mansergh in similar undertakings, was engaged as resident engineer, and other

members of the staff were duly appointed. The former entered on his duties in June, 1893.

The old manor house at Nant Gwillt was put in repair as a residence for Mr. Yourdi; and accommodation was here also provided for the Water Committee and certain Birmingham officials when they require to visit the works.

Cwm Elan, the only other house of any importance on the watershed, is similarly utilised to provide accommodation for members of the engineering staff.

The first Railway.

The work first to be done in connection with the scheme was the construction of the railway connecting the mid-Wales section of the Cambrian system with the Elan Valley for the conveyance of plant and materials. This was let by contract to Mr. Henry Lovatt of Wolverhampton, the well-known contractor, to whom the order was given on the 16th August, 1893. The main portion of this line of railway, which is some two and two-thirds miles in length, runs parallel with the

existing public highway, and the latter being intersected, had to be diverted in places.

The railway was completed in July, 1894, As soon as the line was open and the material could be brought to the site, active operations were at once commenced in connection both with the navvy village settlement on the Brecon side of the valley, and with the shops site and clerical staff houses on the Radnor side.

By the experience gained in the construction of this railway, the inconvenience of having workmen employed by both contractors and by the Corporation on the ground together was demonstrated. The Corporation, therefore, decided that in future they themselves would carry out all the remaining work on the watershed by their own workmen.

The Navvy Village.

A difficulty which the Corporation had to encounter at the outset was providing accommodation for such a multitude of workers in a wild mountainous region far away from any town.

It is therefore greatly to the credit of the Committee that they have in so admirable a manner carried out this part of the scheme, for to provide accommodation for a population of over one thousand, the greater proportion able-bodied workmen, is obviously no easy task.

The settlement designed by the Committee may be regarded as a model village, and should serve as an example to other public bodies of the provision which a high-minded and intelligent Corporation, engaged in the construction of important works, regards as its duty to provide for the workmen and their families placed under its charge.

Thinking that a full account of the organization of the settlement would prove of much interest, I am indebted to Mr. E. Antony Lees, the able Secretary of the Water Department, for the following graphic description of the village.

This description, with the exception of that portion relating to the canteen, formed part of a most useful and instructive lecture on the Welsh Water Scheme which Mr. Lees

has delivered before several Birmingham audiences, notably at the Grand Hotel, Birmingham, under the auspices of the Central Literary Association, and which was attended by, amongst others, the Chairman of the Water Committee, Mr. Alderman Lawley Parker, J.P., and other members of the City Council.

The statistics and much useful information respecting the canteen are taken from the evidence given by Mr. Lees on July 5th, 1898, before the Royal Commission at Westminster on Liquor Licensing Laws, Viscount Peel in the chair.

Mr. Lees description.

"The village is situate on a fairly level piece of land, running along the right bank of the Elan, just below the site of the Caban Coch dam, being bounded on the north by the river and on the south by the abrupt mountain side. On the opposite side the rocks rise in a series of bold crags to a height of about 800 feet above the river, along the left bank of which runs the road from Rhayader. The village is thus on the opposite side of

the river to the road, and access is given to it by a suspension bridge constructed by the Corporation. The position of the village in that it has to be approached by this bridge, and that it is erected on private ground to which there is no public right of way, is fortunate, inasmuch as the Corporation have thereby the means of exercising a beneficent supervision which would be impossible were the village in the ordinary sense of the word a 'public place.' Nor is the supervision of the Corporation merely nominal; no strangers are allowed in the village without permission. Every tradesman who wishes to deliver goods is required to furnish himself with a pass on which somewhat stringent regulations are laid down. For instance, the owner undertakes that he will not deliver any intoxicating drinks within the Elan village, and the Sunday quiet and rest of the inhabitants are protected by a regulation that, with the exception of milk, no goods shall be delivered or sold on that day; and these regulations are not a dead letter, for at the

Trading Regulation.

end of the bridge, on the village side, a gate is situate at which the bridge-keeper, who is constantly in attendance, examines the contents of every cart before it is permitted to proceed. All the erections in the village are constructed of wood, the only brick or stone in the houses being the hearth and seatings for the grates and the chimney flues. Externally the buildings are weather-boarded and internally match-boarded, the space between being lined with coarse felt; the roofs are covered also with felt over the boards, and the whole is then tarred, and the roofs thoroughly sanded in addition. The village has a complete system of sewerage, scavenging, public lighting and water supply. Fire hydrants are fixed on the water mains, and fire extinguishing appliances are provided at convenient points. In the middle of the village there is a small fire station surmounted by a fire bell. This is the rendezvous of the fire brigade, some members of which are on duty every evening. The village is perambulated throughout the night by two watchmen; all of the huts, moreover, are inspected weekly

Shops and Huts.

by the village superintendent, with a view to the removal of all refuse and the prevention of the use of oil lamps of dangerous type, and of any other articles likely to occasion an outbreak of fire. The police arrangements are carried out by the county constabulary of Brecon as regards the village, and by the Radnorshire police as regards the works generally. A police station has been erected on the Radnorshire side."

"The huts are of four classes: the first is the ordinary lodgers' hut. This provides accommodation at one end for the hut-keeper, his wife and family, and at the other end for eight lodgers, each of whom is provided with a separate cubicle or sleeping room. Midway between the two ends of the hut the common living-room is placed."

"The second class of huts is for gangers. These are constructed for the overseers and gangers of the workmen, and accommodate only the man and his family, lodgers being permitted in these huts only under exceptional circumstances, and by special permit of the resident engineer."

"The third type of huts is for officials. In these the accommodation is somewhat more extensive. In the village itself there are two huts of this type, one of which is occupied by the missioner and the other by the schoolmaster. Most of the houses for officials are erected adjoining the chief offices, and together form a separate and picturesque group."

"The huts of the fourth type comprise only three rooms each, and afford accommodation for married workmen."

"In speaking of the huts of the second type for the gangers, it may be well to state what is the organization of an army of navvies. The unit of organization is not the individual man, but a band of men called a gang, over whom is a ganger. The general custom on public works has been for the gangers to be also hut-keepers, that is to say, the ganger's wife has been the landlady of a hut capable of accommodating a number of lodgers. In many cases she has been his banker and general provider, and as the ganger himself has the power of picking out men to be discharged, on account of slackness of work

or other reasons, it is easy to see (without any wide condemnation of a generally worthy class of men) how, under such conditions, a ganger seeking his own interests is able to exercise considerable tyranny over men in his gang who are at the same time his lodgers. In view of this, the Water Committee determined at the beginning that no ganger should be permitted to take lodgers, and this regulation is regarded, by persons having a wide acquaintance with navvy life, as a regulation of a most beneficent character, and calculated in itself to give the ordinary navvy a degree of freedom impossible under the usual circumstances."

"The public institutions of the village comprise the school and mission-room, the public hall, the hospital, the canteen, the bath-house, and (not in the village, but adjoining) the doss house and the infectious diseases hospital."

"The school and mission-room (in which the day school is held on week days, and school and service are conducted on Sundays) first deserves notice. The village day school is placed

School and Mission Room.

under the Education Department, the school managers being the Chairman of the Water Committee, with three officials, two of whom are resident at the works, and one in Birmingham. The buildings are certified by the department as sufficient for the accommodation of 168 scholars. At first considerable difficulty was experienced in bringing the navvy children under the discipline of regular instruction, but now good progress is being made, and, at the last examination by the Government Inspector, the general school earned the possible grant."

Mr. Lees says, "I wish that the ratepayers could have been present at a public meeting of parents and friends recently held in the public room, at which I was present and distributed the prizes, and after which a concert and entertainment was given by the scholars to a crowded and appreciative audience of their parents and friends. A peep at that gathering would convey, as no words could do, the truly beneficent work being carried on by the Corporation in providing for the education and the social

and moral advancement of the little community collected under its ægis in this remote valley of Wales. The most important item in the programme which had been provided by the schoolmaster was a negro entertainment by a body of youngsters, dubbed the Elan Snowflakes, and the effect produced was most grotesque when, after the performance, many of the aforesaid Snowflakes, in a still unwashed condition, presented themselves to carry off the honours of the evening in the shape of well-earned prizes for efficiency in school work. Some of the work I saw in the Elan school was such that it is worthy of being placed side by side with some of the work in the Birmingham Board Schools; the girls' needlework, and the boys' drawing, alike manifested the diligence and application of the scholars and assiduity of the teachers."

Recreation Room.

"The public hall and recreation room are open every evening, and on wet days in the daytime also. Here are provided daily and weekly newspapers, a free lending library, replenished

from time to time to time by the overflow of the Birmingham Free Libraries, and by gifts of books from interested friends. In this room, on Sunday afternoons, the missioner conducts a writing class in which the men are helped and encouraged to write to their friends; and, when it is remembered that most of the men are in lodgings, and of necessity living far from home, the forethought of this arrangement will be appreciated. The navvy leads a peculiarly roving life—a very large proportion of the class being quite cut off from their friends—and there have already been several cases of death in the community, where the men have been entirely unknown, and have been laid to rest without the knowledge of any of their relatives. All navvies have nicknames, and many pass under assumed names, so that to trace the relatives or friends of the men is often quite impossible."

"In the public hall concerts and entertainments of various kinds are frequently held, generally by local effort, in aid of various charitable objects, but sometimes

travelling companies and entertainers visit the village and enliven the monotony. Here, too, is a well-furnished gymnasium where the missioner acts as instructor to squads of 'nippers' and young men. There are also two good bagatelle tables which are well patronised."

Hospital

"A hospital for the treatment of accidents is, unfortunately, a necessary adjunct to every public works. It may be said that 203 in-patients and 1,320 out-patients were treated from October, 1894, when it was opened, to November, 1897. Most of the cases arise through the men either falling on the rocks, or through rocks falling on them. Injuries to the eye are also frequent in the masons' yard. Occasionally an accident occurs through the careless use of explosives, and there have in addition been two or three deaths through men being crushed on the railways, so that, in the construction of the works, the Corporation has already had to pay a certain toll in human life. The hospital contains three wards, and affords accommodation for 18

patients. Usually only one ward is occupied, though there have been occasions when three wards have been in use at the same time. As the village is situate three miles from Rhayader, and there was no doctor nearer, a doctor is regularly resident in the hospital, and he attends to the ordinary cases of sickness in the village. The works extend for about seven miles above the village, and in cases of accidents happening at the more distant works, the injured men have to be conveyed long distances, and, as a precaution, tourniquets to arrest bleeding are available at various points, as are also stretchers for carrying the injured. The infectious diseases hospital is outside the village. During the severe epidemic of smallpox in the West of England and South Wales, in the year 1896, notwithstanding the large number of tramps coming to the works, the village was fortunately preserved from any outbreak of smallpox, and it is only reasonable to suppose that the precautions taken prevented what would, under the special circumstances of the place, have proved a dire disaster."

Elan Village, April 1895.

Street in Elan Village.

The Dosshouse Junction, April 1895.

Elan Village Hospital, Main Ward, Feb. 1897.

"The doss house is not, strictly speaking, in the village, as it is situate on the opposite or Radnorshire side of the river. The doss house serves a double purpose. It is first a kind of working-man's hotel, or model lodging house, and second, a quarantine. It affords accommodation for thirty-six lodgers, and the charge is 4d. per night for bed, attendance and use of common fire. The doss house keeper is permitted to sell provisions at fixed rates, and the navvies, who are excellent cooks, prepare for themselves the provisions they bring with them, or purchase at the time. The need of accommodation for working men will be evident when it is remembered that the works are some miles distant from any town, and that consequently men on tramp arriving of an evening require accommodation before they are able to apply for work on the following day. It is further very desirable that new arrivals should not be permitted to sleep in the village until they have been cleansed and kept under medical observation for a few days; consequently all men who are engaged

Doss House

are required to spend their first week in the doss house. All who are not engaged are allowed to remain one night only. Every man applying for admission is required to take a good hot bath. In the meantime all his belongings are passed through a disinfector. In times of epidemic, such as the small-pox of last summer, the doctor, moreover, examines every arrival, and any suspicious cases are at once isolated in the infectious hospital." The arrangements in connection with the doss house required a good deal of careful planning, and in this connection the experience of the Salvation Army with their London doss houses was taken advantage of, and the advice cheerfully given to Mr. Lees by Mr. Bramwell Booth was, in certain particulars, of great value.

"The doss house fulfils a most useful, and indeed necessary function in connection with the social economy of the works. It is self-supporting, the men appreciate its privileges, and often, when their week is up, wish to remain on, but of course cannot be permitted. In very few cases do they object to the

bath, although many of them express themselves in a peculiar way concerning it and the disinfector.

The supply of Intoxicating Drinks.

"The question of the supply of intoxicating drinks was, from the first, felt to be one of grave importance, not only from a moral point of view, but as touching the material interests of the Corporation, it being felt that if unrestricted facilities for obtaining drink were permitted, the probable result would be considerable loss of time by the men, and consequent disorganisation of the work."

"Before the commencement of the works, namely, in the autumn of 1892, a license was granted by the Radnorshire magistrates to a farmer in the district, for the establishment of a public house in the neighbourhood of the works. The Corporation being of opinion that it was very undesirable that licensed premises should be established in the neighbourhood of the works but beyond the control of the Corporation, asked to be heard in opposition to the granting of this license,

but the magistrates declined to hear the Corporation and granted the license. The public house in question, known as the Elan Valley Hotel, is still in existence, and in October of the year 1895 a foot-bridge on private ground was erected by the owner of the public house, giving additional facilities for communication between the Corporation village and the public house in question. The distance from the middle of the village to the Elan Valley Hotel *via* the suspension bridge is one mile, and *via* the footbridge 1,500 yards; from the end of the village nearest the suspension bridge 1,520 yards, and from the end of the village nearest the footbridge *via* the footbridge 970 yards."

The Canteen.

"To the canteen a special interest attaches, as it is an experiment embodying some of the suggestions thrown out for the regulation of the liquor traffic. In point of fact the canteen is a municipal public house, and is believed to be the only instance of the kind in the United Kingdom. On the question of the drink traffic there were the three proverbial courses open to the

Water Committee: first, to do nothing, and allow any enterprising publicans who could obtain licenses to set up their establishments and conduct their trade in the usual manner; second, to attempt to prohibit the traffic altogether; third, to undertake the provision of beer for the use of the community, but under such regulations as should render it least hurtful."

"The objection to the first course is obvious. The navvies, in common with many others, readily yield to temptation to drink when they have the means of gratifying the appetite, and during the summer months, when regularity in the gangs is of the utmost importance, and at the same time when earnings are highest, there would be the greatest likelihood of the demoralising and disastrous effects of drunkenness asserting themselves."

"To the second course the objection was none the less marked. The people, rightly or wrongly, will have their beer, and without facilities to obtain it in a legitimate manner, they would decline the place altogether, or

resort to illicit means to supply themselves. It was held, therefore, to be impolitic to attempt prohibition."

"The third alternative course then was adopted, viz., to provide beer under stringent regulations. Application was accordingly made for a license, the Corporation submitting to the magistrates a scheme for the establishment of a house for the sale of beer in the village, which scheme, after considerable discussion, was finally settled, and the common seal of the Corporation was affixed to a copy of the conditions agreed to, which copy was lodged with the Magistrates' Clerk. The magistrates thereupon granted the license, which has since been renewed on the understanding that the canteen shall be conducted substantially on the rules that have been made, although the license itself is not limited, and the observance of the regulations is a matter of honour on the part of the Corporation. The canteen is placed in charge of a manager, in whose name the license stands; the manager has no interest whatever in the sale of the drink.

His salary is fixed, and is sufficiently liberal to command the services of a thoroughly reliable and respectable man. The canteen keeper lives on the premises rent free, and out of his wage has to pay his own barman, also for the cleaning of the house, drinking vessels, etc. All the goods for sale at the canteen are ordered by the Secretary of the Water Department on requisitions from the canteen-keeper, who does not know what is paid for anything, as all the goods are charged to him at selling prices. Stock is taken every week, and the canteen-keeper has to account either in cash or stock for the goods supplied and brought forward. The goods sold are limited to beer and porter on draught and in bottle, aerated waters, tobacco and cigars. The points against which he must guard himself are incivility towards customers on the part of himself or his assistants, lack of cleanliness in the house and drinking vessels, adulteration of the liquors, selling out of hours, and disorder and drunkenness on the part of his customers. If he is able to avoid offence in any of these respects, he is thought no worse of if the

takings fall off, and no better of if they increase. To promote the objects in view, stringent regulations have been enacted, which are not merely printed and hung on the walls, but are actually enforced. The sale of drink is refused to men who show signs of having had enough, or who have already been supplied up to the stipulated limit."

"There are 120 to 150 women in the settlement, and none of these are allowed to enter the ordinary bar, although they can obtain in the jug department liquor for consumption off the premises. No young fellow under 18 is served in the bar, and in the jug department no boy under 16, and no woman under 21 is served. One of the rules of the establishment is that no person shall be supplied with more than one quart of liquor in the morning opening, and with not more than two quarts of beer or porter for consumption in one evening. No hut-keepers are supplied with more than 1½ gallons of beer in any one evening, nor with more than two gallons for the mid-day meal from the jug department, except on

The Canteen Regulations.

Saturday evening, when a hut-keeper may purchase double the quantity. The canteen is open between the hours of 12 noon and 2 p.m. for 1½ hours only, and from 5-30 p.m. to 9 p.m. on all week days save Saturday, when it is open from 1 p.m. to 4-30 p.m., and from 5-30 p.m. till 9-30 p.m. Formerly it was kept open continuously from 1 p.m. till 9 p.m. on Saturday; but it was found that an interval of closing corrected a tendency which some men displayed to remain upon the premises during the whole of the time. On Sundays the house is closed all day. There is considerable difficulty in regulating the quantity of liquor to be allowed to any person in the evening. In the rush of business it is impossible to keep a strict account of the quantity of drink supplied to any individual customer. In practice, however, the rule which prohibits the serving of drink to any person in the slightest degree intoxicated, serves to prevent excess, and that rule is strictly enforced. The inspection and co-operation of the police are courted in every way. Every effort is made to sell a thoroughly wholesome and pure beer.

A regular system of sample-taking and testing is carried out, samples being taken without notice, from time to time, and forwarded to Birmingham for analysis, in cases marked with numbers only, so that the analyst cannot tell from what brewers the beers are purchased."

"As to the social results, the canteen has on the whole been very popular with the men, particularly the steadier portion of them, but undoubtedly the more rowdy element have found their way to other places where there is less regulation. For instance, the prohibition of games and singing in the canteen tends to keep away the men who look to the public house as a place of amusement rather than merely as a place of refreshment, and while it cannot be said that the attempt to regulate the drink traffic has created a Utopia, it may be asserted, and, indeed, it is claimed, that the evil results of drinking have been reduced to a minimum. Persons qualified to judge speak in the highest terms of the results of the experiment."

The Social Result.

Mr. Edmund Gwynne, the Chief Constable of Breconshire, in whose county the village and canteen are situated, in reply to a question of Mr. Lees, wrote him on October 5th, 1896, as under:—"In reply to your letter of the 29th September, drunkenness in the Elan village is undoubtedly suppressed through the stringent rules and measures adopted at the canteen, and further, I have no hesitation in saying it is attributable to those regulations;" and, in a further communication dated June 14th, 1898, he says: "Drunkenness has slightly increased in the village; I do not, however, think it is attributable to any bad management of the canteen. I still adhere to my former opinion expressed in my letter to you dated October 5th, 1896."

"The takings at the canteen vary considerably. It was opened in September, 1894, but at that time the works were not fully started. Taking the beginning of the year 1896 as representing the commencement of the full operations, the takings have varied from a minimum of £41 to a maximum of £126 per week.

The Canteen profits.

The takings usually run up during a holiday time, when the wages are lower; indeed, this coincidence of lower wages and high canteen takings is a constant feature. The total sales from the time of opening to March 31st, 1898, amounted to £14,750, the purchases for the same period being £9,250, giving a gross profit of £5,500. The working expenses amounted to £1,932, and there was in addition set aside to cover the cost of the building a sum of £305, leaving a net profit of £3,262, that is about 22 per cent. on the turnover. The original cost of the building, including fittings, was £720. To this must be added say £150 for stock, giving a total capital of £870. The sum of £1,000 may, therefore, be assumed as ample capital for the business, and on an assumed capital of this amount the earnings for 3½ years show a profit on capital of a fraction over 93 per cent. per annum. The understanding with the magistrates provides for the application of the profit to the good of the village community, and the profit up to date has been applied in the following manner:—"

"The village day school has received £730, this amount representing the whole cost of the school beyond the Government grants, and including a due proportion of the cost of the school building."

"The expenses connected with the public rooms and staff institute have absorbed £1,510, this amount covering the salary of the missioner and a proportion of the original cost of the rooms, also the provision in the recreation room, of free library, reading-room, bagatelle, gymnasium and table games. £190 has been applied to cover a deficiency on the bath house account. £700 has gone towards the expenses of the accidents hospital, and grants have also been made for the provision of recreation grounds and for other purposes connected with the social well-being of the people."

Farm-house Accommodation.

"As the village is insufficient in itself to accommodate the whole of the workers, considerable numbers lodge in the farm-houses around, some of which have been enlarged by the addition

of wooden annexes, and in all cases the number of lodgers permitted is defined, and made a condition of the tenancy on the Corporation estate. This regulation was found necessary to prevent overcrowding, as at first some gross cases of the kind transpired."

"In addition, a few huts have been erected adjoining the principal works on the upper reaches of the river; the residents in these are in most cases too remote from the village to be able to derive advantage from its institutions. This difficulty particularly asserted itself in connection with the children—the distance from the school, in the case of one of the settlements, being no less than seven miles. To meet this difficulty a special railway carriage has been provided which brings the children down by train in the morning, and takes them back in the afternoon, and it is scarcely necessary to say that, since that arrangement was brought into operation, there has been no difficulty in securing the attendance of the youngsters concerned."

"Since the village and works are situate on the banks of the Elan, an elevation suited for the supply of water to Birmingham is insufficient for them, and consequently, it was necessary to construct a small reservoir on one of the tributary streams by building a little dam across its valley at a convenient point; a small reservoir is thereby constructed with the capacity of about one million gallons. From this reservoir the water is conveyed in pipes into the village and into the workshops, and from these again tanks are filled from which the locomotives, steam cranes, and other steam machinery derive their supplies."

Village Water supply.

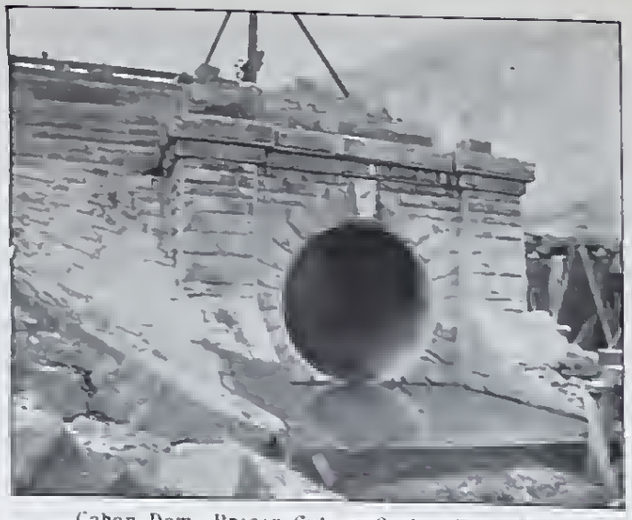
CHAPTER IX.

THE CONSTRUCTION OF THE RESERVOIRS ON THE ELAN—THE AQUEDUCT TO BIRMINGHAM, AND THE RESERVOIR AND FILTER BEDS AT FRANKLEY, WITH PARTICULARS OF THE VARIOUS WORKS CONNECTED THEREWITH.

It will have been seen from page 41 that the intention of the Corporation is eventually to build six reservoirs, the main dam for compensation and supply, at Caban Coch (Red Cabin), and a series of five higher up the streams, two of these to be situated on the Elan and three on the Claerwen.

To provide for the first instalment of 27 million gallons a day, the three reservoirs on the Claerwen will not be required. The engineers are, therefore, for the present confining their attention to the construction of the reservoir at Caban Coch, and the two others in the upper reaches of the Elan.

Caban Dam, up Stream face Brecon End. Feb. 1898.

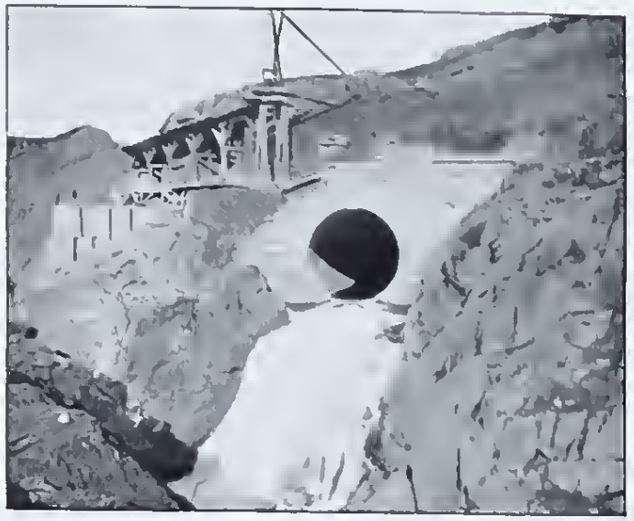


Caban Dam. Brecon Culvert Outlet. Feb. 1898.

Caban Dam. Brecon End, looking North. Feb. 1898.
(Showing Cyclopean Rubble).

Pen-y-gareg Dam Culvert Outlet and Channel Wall. Feb. 1898.

Craig Goch Pit, looking up Stream, Feb. 1898.



Craig Goch Culvert Outlet, Feb. 1898.

The Caban Coch Reservoir.

In August, 1894, the foundations of the Caban dam on the Brecon-shire side were excavated, and in the year following those on the Radnorshire side were also commenced. The whole of the excavations are now practically completed, with the exception of that portion which constitutes the river course. In August, 1896, the building of the dam itself was commenced, and from that time until now the work has been carried on uninterruptedly, except when the weather has been so rough as to compel the workmen to suspend operations.

The Brecon culvert, 16 feet in diameter, was completed, and that portion of the dam lying on the Brecon side was brought up to the level of 730 feet O.D., or 65 feet above the lowest part of the foundations, in July, 1897. It is intended to put the Radnorshire part of the dam in hand during this year, and to commence with the central portion early in 1899.

The greatest difficulty which the engineers have had to encounter in carrying out this

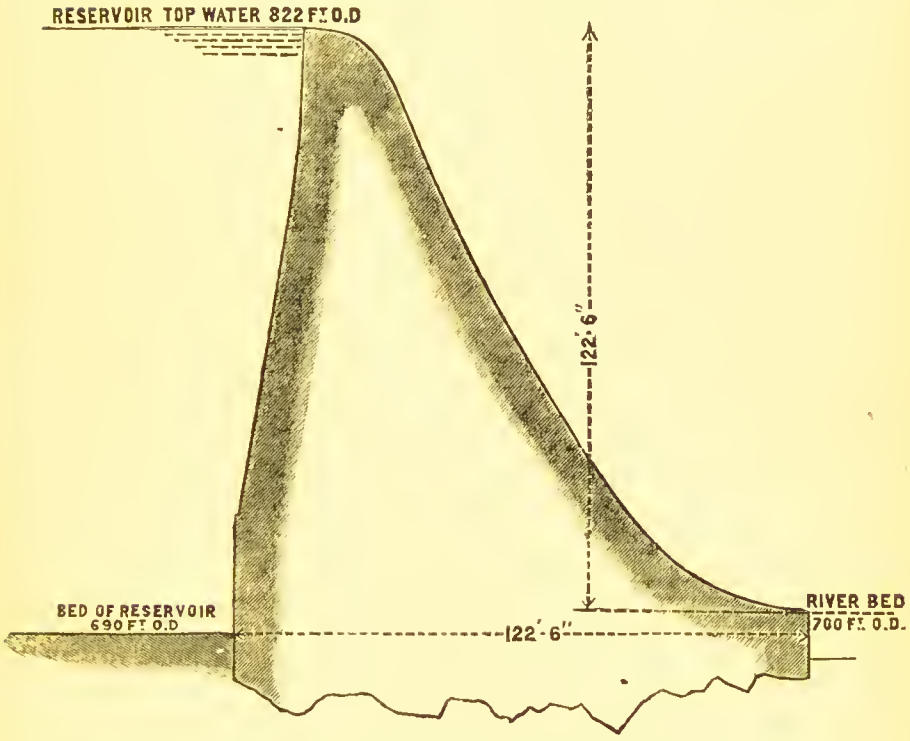
section of the undertaking, has been in dealing with the storm water, but the trouble on that head is now practically at an end.

The commemoration and foundation stones.

Pipes will be laid through the culverts capable of paying compensation water into the river (see page 39), and when the work is complete the culverts, with the exception of the compensation pipes and the valves connected therewith, will be closed by a breastwork of steel. At the side of one of the culverts, Sir James Smith, at that time Lord Mayor, laid a commemoration stone on May 28th, 1897. This stone is 25 feet above the level of the foundation stone which was laid by Mr. Alderman Lawley Parker, Chairman of the Committee, on October 8th, 1896.

The distance across the top of the Caban dam will be about 600 feet, and the height from the bed of the river to the crest, 122 feet. As will be seen from the illustration, the construction of the dam on the upstream side is nearly perpendicular, being vertical

some little way from the bottom, and sloping upwards for the remaining distance, while the down stream face will be a flowing



curvilinear slope, the thickness at the base being practically the same as the height.

In time of flood, when the storm water rushes over the crest and falls to a depth of over 120 feet, the dam at Caban Coch will present the appearance of a magnificent waterfall.

The second Railway.

Before commencing the work on the dams Careg-ddu, Pen-y-gareg, and Craig-yr-allt-Goch, situate higher up the stream, it was necessary to further extend the railway, which at some points of its construction had to be cut out of the solid rock. The line of rails passes the doss house junction round by the Foel mountain and then makes its way onwards by the future bank of the Pen-y-gareg reservoir.

The formation of the railway and the necessary road diversions, the latter operation involving the removal of enormous quantities of earth, were actively pushed forward.

In April, 1895, the railway was so far completed as to enable the workmen to commence the excavations for the Pen-y-gareg dam, that being the second in the series of reservoirs on the river Elan, and in August of the same year, the waggon roads were completed to Careg-ddu. A system of backshunts (a sort of zig-zag railway to allow of quick descent and ascent) was here required to reach the

site of the submerged dam ; as soon as this was accomplished, and the means of locomotion provided, the work in connection with the dam was at once commenced.

The engineers were hindered for some time at the deep cutting beyond Pen-y-gareg, and it was not until June, 1896, that the railway reached the third reservoir in the series on the Elan.

The length of the railway is about eight miles, it rises some 275 feet during that distance, and has two steep gradients.

The preliminary work of making the railway and road having been got through, the construction of the dams is now being vigorously proceeded with.

The Pen-y-gareg Reservoir.

The excavations for the dam at Pen-y-gareg were finished by the end of 1896, and the masonry was then commenced. During the winter it was found impossible to do much in the way of building, but in March, 1897, the work progressed more actively, and during the remainder of that year was pushed well

forward. By December the culvert, 18 feet in diameter, was completed, and the river diverted through the dam. This dam is intended to have a height of 123 feet; the top-water level will be 945 feet above O.D., and the reservoir, when full, will contain over 1,300 million gallons of water. The base of this dam will be on practically the same level as the top water of the Caban reservoir.

The Craig-Coch Reservoir.

In July, 1897, the excavations of the Craig-yr-allt-Goch (Crag on the red height) dam, the highest of the three on the Elan, were put in hand and pushed forward as energetically as possible, but here because of the wildness of the situation, the work was necessarily hindered to a greater extent than was the case with the other dams.

The tunnel, after being driven through the dam, was lined, and the river diverted through the culvert on the 29th January, 1898; building operations were commenced in the dam itself by the 4th April, 1898. The dam, when finished, will have a length of over 500 feet from side to side, will

measure 128 feet from the bed of the river to the crest, the top-water level will be 1,040 feet above O.D., and the reservoir, when full, will contain 2,000 million gallons, forming a lake two and a half miles in length.

The Submerged Dam.

In June, 1896, the masonry of the submerged dam was put in hand, and by December, 1897, two-thirds of the work was completed. It is expected that by the end of the year 1898, the whole of the masonry will be out of hand, and the piers of the viaduct brought to springing level.

The viaduct will be supported on high masonry piers 40 feet above the crest of the dam, and when built it will replace the old submerged roads and provide a passage across the reservoir.

The submerged dam being a unique engineering expedient well deserves a few words of special explanation. To understand its uses it must be remembered that Frankley, the receiving reservoir at Birmingham, is 600 feet above the level of the sea,

and in order to bring the water thither from Wales by gravitation it is necessary that there should be a fall of 170 feet from the Elan reservoir to Frankley. To obtain this fall, the commencement of the aqueduct should be 770 feet above O.D., and as the bottom of the Caban dam is only 700 feet above O.D., the invert (arched floor) of the Foel tunnel (see page 177) had to be placed 70 feet above the bed of the Caban reservoir. Since, however, this necessitated the storing of an enormous quantity of water, which could not be touched either for town supply or compensation purposes, the engineers have devised and built, some distance up the reservoir, a dam which they have placed just in front of the entrance to the aqueduct; the crest of the dam being forty feet below top water-level, explains the use of the name "submerged" dam. By means of this arrangement the water is held up to a height of 82 feet above the bed of the reservoir, and is, therefore, about ten feet above the entrance to the aqueduct. When the Caban Coch reservoir is full, the water will be divided into three sections, viz., first, a

TABLE, SHOWING NAME, APPROXIMATE LENGTH, GRADIENT, HEIGHT ABOVE O.D. OF THE VARIOUS SECTIONS OF THE AQUEDUCT AS THEY FOLLOW EACH OTHER FROM THE CABAN COCH RESERVOIR TO FRANKLEY.

Name of Section.	Approximate length.	Gradient.	Height above O.D. at commencement.	Lowest fall below gradient
Craig-y-Foel Tunnel.....	1⅜ miles.	1 in 4000	769·19	
Elan Conduit.....	1¾ ,,	1 in 4000		
Caethon Syphon.....	1 ,,	1 in 1760	765·06	
Rhayader Conduit.....	¾ ,,	1 in 4000	762·22	
Wye Syphon.....	⅝ ,,	1 in 1760	761·35	
Gigrin Conduit.....	½ ,,	1 in 4000	759·84	
Downfield Tunnel.....	⅜ ,,	1 in 4000		
Gaufron Conduit.....	1¾ ,,	1 in 4000		
Dulas Syphon.....	¾ ,,	1 in 1760	756·36	
Nantmel Conduit.....	3½ ,,	1 in 4000	754·22	
Clywedog Syphon.....	1¼ ,,	1 in 1760	749·69	
Fron Tunnel.....	⅛ ,,	1 in 4000	746·38	
Aran Conduit.....	2⅛ ,,	1 in 4000		
Dolau Tunnel.....	4⅛ ,,	1 in 3016	741·54	
Bleddfa Conduit.....	2 ,,	1 in 4000	734·14	
Lugg Syphon.....	⅜ ,,	1 in 1760	731·44	
Knighton Tunnel.....	2⅜ ,,	1 in 3016	730·46	
Frydd Wood Conduit.....	1⅛ ,,	1 in 4000	726·16	
Downton Syphon.....	9½ ,,	1 in 1760	724·68	Teme, 320 feet
Hunstay Conduit.....	1⅛ ,,	1 in 4000	696·10	
Deepwood Syphon.....	½ ,,	1 in 1760	694·55	
Whitcliffe Conduit.....	2½ ,,	1 in 4000	693·20	
Teme Syphon.....	4¾ ,,	1 in 1600	689·88	Teme, 441 feet
Knowbury Conduit.....	1¼ ,,	1 in 4000	674·57	
Studley Tunnel.....	⅞ ,,	1 in 4000		
Hints Conduit.....	⅝ ,,	1 in 4000		
Brickhouse Tunnel.....	⅜ ,,	1 in 4000		
Earl's Ditton Conduit.....	⅝ ,,	1 in 4000		
Hopton Brook Syphon.....	1⅛ ,,	1 in 1760	669·68	
Holly Waste Conduit.....	⅞ ,,	1 in 4000	666·27	
Severn and Stour Syphon..	17⅛ ,,	1 in 1600	665·18	Severn, 547 feet Stour, 490 feet
Hagley Conduit.....	2¾ ,,	1 in 4000	608·01	
Horsepool Tunnel.....	⅜ ,,	1 in 4000		
Romsley Syphon.....	½ ,,	1 in 1760	603·72	
Newbrook Conduit.....	½ ,,	1 in 4000	602·17	
Frankley Tunnel.....	⅛ ,,	1 in 4000		
Total.....	73⅛ miles.			

layer forty feet deep extending over the whole surface, representing 4,660 million gallons; second, the water held up to a height of eighty-two feet behind the submerged dam, amounting in all to 440 million gallons, and lastly, a further body of water in front of the submerged dam, measuring 2,900 million gallons.

Let us suppose the occurrence of a drought of 180 days, assuming the reservoir at the commencement of the drought to be full, Birmingham requires 27 million gallons for each day's consumption, and a further 27 million per day must be delivered for compensation purposes, making fifty-four in all. If, then, a calculation be made it will be seen that the top layer of water will be sufficient for both compensation and supply for a period of eighty-six days, but that when the water falls below the crest of the submerged dam, that beyond it on the Caban Coch side will be available for compensation purposes only, and there will be enough to provide for a period of considerably over 100 days. The water for Birmingham during the remaining ninety-

four days of drought would then be drawn from the two upper reservoirs, and as these together will afford a supply of 3,300 million gallons, it will be seen that there is here a sufficiency of water for a period of more than 120 days. Clearly, then, we may rest satisfied that no inconvenience or difficulty may be anticipated from a prolonged drought.

Below the Caban dam a gauge apparatus is to be erected for measuring the quantity of compensation water discharged into the river, and here the Corporation will provide a house at a peppercorn rent to be occupied by an inspector whose business it will be to check the quantity of compensation water discharged into the river. Houses for caretakers will also be provided at the reservoirs.

The geologists predicted that each of the dams would prove to have a good foundation, and that suitable stone would be found in the immediate neighbourhood for their construction; unfortunately, neither prediction has been verified.

The material of the foundations.

The foundation of the Caban dam is silurian grit and conglomerate, whilst the foundations of the

Careg-ddu, Pen-y-gareg and Craig-yr-allt-Goch are slatey; hence the engineers have been put to a great deal of trouble.

Similarly, as to suitable stone being found on the ground, at the Caban dam only was stone found of the required quality, and for the other dams facing stone has had to be brought by rail. Further difficulty was, however, caused by the necessity for deeper excavations than were originally intended, owing to the unsoundness of the dam foundations. As a result, the estimated cost of construction has been exceeded.

The Stone Quarries.

The stone required by the engineers for the building of the dams is grit and conglomerate, and as this is obtainable from the quarry, they are enabled to find all the stone they need for the work except that portion required for facing the dams. The Cnwch quarry, from which the stone for the dams is obtained, is situate on the Brecon side of the river above the site of the Caban dam, and stones are conveyed thence to the masons' yard, the site for the latter having been chosen at

a spot so elevated as to prevent all danger from blasting accidents, etc. The Gigfran, another quarry in use, is situate on the other side of the river almost opposite the Cnwch.

Cyclopean Rubble.

The composite material of which the dams are built is technically called Cyclopean rubble, a term including what are called "plums," which are large rough stones obtained by blasting the rock, weighing up to five or six tons each. These "plums," which try the full capacity of the lifting cranes, are weighed automatically before being placed, the object being to enable the engineer to gauge the specific gravity of the material used. The

Construction of the dams.

"plums" are roughly dressed so as to make the cement and concrete adhere to them when embedded in the dam, in which they are placed at irregular intervals. The engineer takes the precaution to have a good stock of cyclopean rubble always on hand, in order to keep the men fully employed; hence it is not unusual to see at one time at the site of the Craig-yr-allt-Goch dam as much as 8,000 cubic yards of this material on the ground ready for use.

Conditions of Reservoir Building.

In the construction of reservoirs the engineers lay down for themselves the following very important conditions:—

1st.—They have to remember that the foundations are to be weight carriers.

2nd.—They have to ascertain that the foundations are water-tight, or as nearly so as possible.

3rd.—When satisfied on these points they consider they may then begin to build, but before doing so they must have a clear conception of the work before them.

4th.—In building a dam they ought never to lose sight of the fact that the execution should always be better than the conception.

Finally, these conditions will not be sufficient unless, as a practical engineer observes, "they are continually at it and spare nobody."

The Crushing Plant.

The plant required for dealing with enormous masses of material such as are required for the build-

ing of reservoirs must necessarily be of a very powerful character. There are at the Elan works several installations of crushing plant, most (if not the whole) of which have been devised specially by the engineers. One of these deals with eighty tons of rough stone in a day. The stone is first wheeled into a hopper, is then broken up and afterwards automatically delivered into trucks in various degrees of comminution. Another of these crushing engines will break up as much as 140 tons in a day. Each of these installations, which accomplishes so much, only requires the services of eight workmen, the rock being brought in trucks close to the crushing plant by an engine. It may be observed here, in illustration of the skilful organisation of these large works, where over 1,000 men are employed, that in the whole of the operations only seven horses are in use, though one or two more will be required later on as the work increases.

Skilful Organization.

The devices for the saving of labour and time and for the furtherance of economical

construction are both numerous and ingenious. In this category may be mentioned the compressed air apparatus, known on the ground as the "wind-jammer," which needs only two men, the driver and stoker, at each station for its management. By means of tubes the power is carried to a long distance for a diversity of operations. In one direction it will be found drilling the rock for blasting in the tunnel, where it is again brought into use for clearing out the foul air. In another direction it will be seen driving the drills in the quarries, where stone of various sizes, including the "plums," are detached for building operations. In the same way its power is brought into use for excavating the foundations of the dams, and it is employed for the steam hammers in the smithies. Indeed, so widely distributed is the plant that there are something like two miles of tubes employed from the one station, and the whole thing is so carefully handled that the power is practically the same at the farthest point as at that nearest the station. If steam were employed for the purposes enumerated,

The Wind-jammer.

instead of compressed air, it would be necessary to have many boilers at different points, and so great is the saving of compressed air over steam, that it is estimated the cost of the compressed air plant will be paid out of the savings in two years.

To keep the men fully employed, and so promote the quick progress of the work and prevent the loss of workmen, special provision has had to be made. The rainfall is frequent and heavy, and for the many wet and stormy days, sheds have consequently been provided for the protection of the masons and other workmen, while at such times as it is impossible to carry on other kinds of work, the men are employed in making the permanent roads required by the Act of Parliament. These have to be constructed in various parts of the watershed above top-water level, to replace the old roads which will be submerged, and extend over something like thirteen miles in all.

In going over the works there will be found groups of houses, one set of which is used by the timekeepers and inspectors, another

Caregg-Ddu Culvert Excavation looking up Stream July. 1896.

Caregg-Ddu Dam looking up Stream from Road. Sept. 1897.

Caregg-Ddu Dam from S.W. Abutment,
Sept. 1897.

Nantgwyllt.

Inlet end of Foel Tunnel, Oct. 1895.

Railway No. 4, Deep Cutting looking South, Oct. 1896.

for the engineering staff at each of the stations, and so on. It is impossible to see the arrangements made for the execution of the work, and the accommodation of the workers, without coming to the conclusion that the organization has been most carefully planned out under the direction of a master mind.

The Foel Tunnel and Valve Tower.

The Foel tunnel starts from just behind the submerged dam, and passes through the mountain from which it takes its name. It forms part of the aqueduct for carrying the water to Birmingham, and was, in the spring of 1898, more than half-way through. The driving is limited to two faces, and since the strata to be negotiated are hard slate at the inlet end, and hard lower silurian and conglomerate grit at the outer end, the progress of the work has thereby been greatly retarded. At the inlet end a valve tower will be built, by the use of which it is intended to control the flow of the water, and also to prevent floating matter from passing into the conduit. At the outlet end of the Foel tunnel the aqueduct really com-

mences, and it is, as already stated, composed of tunnel, cut and cover, and syphon work. The latter construction is so named because when the levels make it necessary for the iron pipes to descend and ascend, the downward pressure on the one side is sufficient to make the water rise to the same level on the other. At intervals there are syphon chambers whence the water flows from the tunnels and cut and cover into the pipes and syphons. These syphon chambers are constructed for six pipes, and by the use of an ingenious contrivance to prevent flooding or damage in case of a burst, the damaged pipes are made to close automatically, and an iron gate at the inlet of the chamber is made to drop after the manner of a portcullis.

Syphon Chambers.

The floor and walls of the conduit are lined with blue brick backed with concrete, the roof is built of solid concrete, and is mostly concave, but here and there it is flat, the latter construction being necessary where dingles or valleys have to be crossed, the conduit being in such parts carried on bridges. The top and sides of

Conduit.

these portions of the conduit are bound together with iron bands.

At the summit of each syphon there is a large valve to allow of the escape of imprisoned air, which would retard the flow of the water, whilst there are also at important depressions wash-out valves which serve to remove any earthy matter which may be carried down by the running water.

The rate at which the water will travel to Birmingham is rather less than two miles an hour, and any given portion of the stream in the conduit will therefore complete its journey in a day and a half.

The aqueduct, as previously stated, extends a distance of seventy-three miles to Frankley, and is now well in hand, most of the work having already been given out in sections to several contractors. The first portion, extending from Elan to Dolau, a distance of thirteen miles five furlongs, is in charge of Mr. W. A. Legg as Resident Engineer, and was commenced in June, 1896, by

Dolau and Knighton Tunnels.

Messrs. John Aird & Son, who have already completed more than eight miles of the work. The second portion (Dolau to Knighton) ten miles one furlong, and the third (Knighton to Downton), nine miles four furlongs, are in the hands of Messrs. Morrison & Mason, Ltd., Mr. A. W. Brightmore being the Engineer in charge. Of this section, the first half of the Dolau Tunnel (four and a half miles long) and the Knighton Tunnel (two and a half miles) have been bored. In both cases the work was so skilfully carried out that when the time for joining up arrived, the centre lines from the two headings exactly coincided, a result very creditable alike to engineer and contractors. It should be explained, so as to give an idea of the skill and care required in carrying out this work, that the tunnels were started at the bottom of deep shafts at either end, and because of the gradient thence to Birmingham, the borings had thus to be commenced at different levels.

Tenders are now being invited for the construction of the fourth section of the aqueduct from Downton to Cleobury, a length

of fourteen and a half miles, wherein is included the Teme Valley syphon. For this section about 14,000 tons of iron pipes will be required.

Teme Valley Syphon.

The fifth section (Cleobury to Hagley) is a syphon of over seventeen miles in length, which in its passage to Birmingham will cross the rivers Rea, Severn and Stour. The main arch of the bridge, destined to carry the aqueduct over the Severn will have a span of over 150 feet, and a clear headway of thirty-two feet. The hydraulic gradient at that point is 638, and since the pipes laid on the bridge are only ninety-eight feet above O.D., there will be on the pipes a pressure of 540 feet, or, as the engineer estimates, a force equal to a pressure of 234 lbs. on the square inch. To make this quite clear, and to show the difficulties of construction, it should be borne in mind that the entrance to the aqueduct at the submerged dam is 770 feet above the level of the sea, and that the line of the conduit gradually descends until when it reaches Frankley it is only 600 feet

Severn and Stour Syphon.

Hydraulic Gradient.

above sea level. This fall is called the hydraulic gradient. For constructive purposes the fall is made to vary at intervals, thus, in the tunnels and cut and cover work the incline is only 1 in 4,000 to 1 in 3,016, whilst in the syphon or pipe line it is 1 in 1,760 to 1 in 1,600. The reason for the fall being made greater in the pipes than in the other parts of the aqueduct is that they offer more resistance to the passage of the water flowing through them than do the tunnels and cut and cover. It must also be remembered that since the rivers to be crossed flow through valleys lying much below the level of the surrounding country, the line of conduit instead of making a gradual descent has, at these points, to descend from a high to a low level and, after reaching the other side of the valley, again ascend so as to reach that level at which the conduit would have been carried had there been no valley to be traversed.

For example, as will be seen by a glance at the aqueduct section given in the excellent map prepared by Mr. Mansergh, and reproduced by his permission, the line

of conduit before its descent of the Severn valley is 665 feet above sea level, but when it reaches the bridge which will be specially constructed to carry the pipes over the river, its height above sea level will be only ninety-eight feet. Had there been no valley to descend, the height of the conduit at the crossing of the Severn would have been 638 feet above sea level, but since the river intervenes, the water must be carried through the pipes at a depth of 540 feet below its proper course, and having been conducted over the bridge at that low level, it has to be forced up again until it reaches conduit level at Hagley, 608 feet above sea level. The total length of this descent and ascent is rather more than seventeen and a half miles, and the engineer considers it to be necessary to use steel pipes for this section of the aqueduct, because of the enormous pressure put upon them; the contract for the supply of these pipes has been entrusted to Messrs. Piggott and Sons, of Birmingham. The laying of these steel pipes will, contrary to the usual plan which requires each contractor

The Severn Crossing.

to lay as well as provide the pipes, be dealt with in a separate contract, the rule having been departed from to meet the special exigencies of the case.

It remains to be said in reference to the aqueduct that when the contract for the Downton and Cleobury Mortimer section has been given out, fifty-one out of the seventy-three and a half miles of conduit will then be in progress.

For economical reasons the aqueduct was not begun until some time after the commencement of the construction of the reservoirs, for the reason that the latter would require a much longer time for construction than would the former operations. If both had been begun at the same time a considerable amount of capital would have been expended on the aqueduct before it was needed, whilst as it is, so carefully have the two undertakings been planned that it promises to be a neck-and-neck race as to which shall be first completed. The date fixed by Act of Parliament for the completion of both is June 22nd, 1902, and it is confidently

Outlet of Foel Tunnel, July 1896.

Caethon Syphon. Stream Crossing looking West. Feb. 1897.

Frydd Wood Dingle Crossing, July 1896.

Frydd Wood Dingle Crossing. July 1896.

Wye Syphon. preparing to lower a pipe, Feb. 1897.

Specimen of Cut and Cover, Feb. 1898.

expected that both aqueduct and reservoirs will be well out of hand by that date.

In May, 1897, the contract for the Frankley reservoir and filter beds was let to Mr. Abram Kellett. The site of these covers a space of three-quarters of a mile in one direction and one and a quarter mile in another. Sheds have been erected at various points, and about 400 men are already engaged, a number which will be increased later on to 800 or 1,000. Mr. F.W. Macaulay is the Resident Engineer under Mr. Mansergh, at Frankley, and it is his business to see that the work is properly carried out. The conduit will deliver the water into a gauge-chamber from which it will flow into the reservoir, the latter being semi-circular in shape, and capable of holding some 200 million gallons of water.

The Frankley Reservoir.

The eastern wall of the reservoir will be about thirty-five feet in height, and 1,654 feet long ; the water area of the reservoir will be about twenty-five acres, and its depth upwards of thirty feet. It will be divided by a wall into two quadrant-shaped sections,

and one or both of these will be used as required. The walls will have a curved face, and be formed of concrete faced with blue brick; between will be a thin layer of asphalt, whilst the bottom will consist of concrete, covered with a layer of asphalt.

The Filter Beds.

The water will be delivered into a series of quadrangular filter beds, of which eighteen will be sufficient for present requirements, whilst others are to be constructed as necessity arises. These filter beds will range from 150 to 220 feet square, and together will form a filtering area of 67,000 square yards. The filtering medium will consist of a layer of sand on top of graduated layers of gravel.

Warley and Northfield Reservoirs.

The water after filtration will be received into a tank, from which part will be delivered into the supply mains for distribution to the City direct, and part will be pumped into the reservoirs at Warley and Northfield for the supply of those portions of the City which are at too high an elevation to be supplied by gravitation from Frankley.

From the foregoing it will be seen that all the preliminary work of acquiring land and easements, laying down railways, housing workpeople and their families, the installation of plant, the excavation of sites for reservoirs, the making of roads to take the place of those which will be submerged, together with the complete organization of the staff in the Elan Valley and at Birmingham has now been accomplished, and that the building of the reservoirs and construction of the aqueduct are making rapid progress.

The financing of so important a scheme, involving as it does the expenditure of several millions of money, is a very serious undertaking, and this also is being well looked after.

Furthermore, the husbanding of our local supplies of water, so as to prevent a further heavy expenditure of capital during the construction of the works and the bringing of the new supply to Birmingham, is a matter of great moment, since carelessness here would result in useless capital expenditure.

It is not too much to say that in each and all of these important particulars, everything has been done, and is being done, to carry the project through in a most successful manner, and the inhabitants of the City of Birmingham are to be congratulated on the public spirit shown by those who are responsible for the present satisfactory condition of the undertaking.

It is impossible to make any reference of this kind without speaking of the Water Committee, which includes amongst its members some of the most able and zealous workers in the City Council. Special mention should be made of its Chairman, Mr. Alderman Lawley Parker. The expectations which his previous training and proved capacity led the public to form at the time of his appointment have been abundantly realized. He has shown himself a worthy successor to Sir Thomas Martineau, whose loss was felt so keenly by his colleagues and by all his fellow citizens that it appeared to be almost irreparable. His name must ever be associated with the beneficent scheme which his advocacy and constructive ability did so much to forward.

The City and Council have already since the appointment of their Secretary, Mr. E. Antony Lees, shown their appreciation of his ability, and it is very fortunate for the City that at such an important crisis in its history they can command the services of so able an administrator as Mr. Lees has proved himself to be.

In the comparatively short time during which he has been engaged on the work, Mr. Lees has, under the direction of the Committee, been the means of organizing a clear system of finance in the Elan Valley and in Birmingham. By the method adopted a perfect check is kept upon the expenditure, and a great saving has been effected both in the prevention of waste in the consumption of water, and in the loss of revenue from that and other causes.

Of Mr. James Mansergh, the able water engineer, who directs the whole of the operations in connection with the Elan Valley scheme, it is only necessary to say that he has, by the work already accomplished, enhanced, if that were possible, the great reputation which he held previous to his

appointment, and he has shown that the Water Committee acted with great wisdom in selecting him as their engineer.

Mr. Mansergh is well seconded by an excellent staff, but special mention ought to be made of the Resident Engineer in charge of the whole of the works in the Elan Valley, Mr. G. N. Yourdi. His previous experience has been very considerable, and his talents in devising special machinery to meet engineering difficulties is only equalled by his ability in other directions. He is ever on the lookout for original methods to enable him to turn out the work with effectiveness, with expedition, and at the lowest possible cost.

With these favourable conditions there is every reason to hope and expect that this great scheme—the greatest of its kind that has ever been attempted in this country—will be carried through to a successful issue and that, by the year 1902, the time named in the Act of Parliament, the inhabitants of the city of Birmingham and district may count upon the acquisition of the priceless blessing of a perennial supply of pure water.

CHAPTER X.

NOTES ON THE NEW LIVERPOOL AND MANCHESTER WATER UNDERTAKINGS, WITH SOME PARTICULARS OF THE PRESENT CONDITION AND FUTURE PROSPECTS OF THE LONDON WATER SUPPLY.

The Liverpool Water Supply.

Since (both because of the distance the water has to travel and on account of the large sum of money to be expended) the Birmingham Water Scheme is of such vast dimensions it may be worth while to show how the undertakings of Liverpool and Manchester, both of which have been completed since the issue of the previous edition of this book, and which in many ways resemble the Birmingham scheme, have been carried out.

By the courtesy of Mr. Joseph Parry, C.E., Engineer to the Liverpool Corporation, and Mr. William Blackstock, Secretary to the Manchester Corporation Waterworks, I am enabled to give the following particulars:—

Liverpool Water Supply.

In the year 1877 the Water Committee of the Liverpool City Council, finding that their local resources were proving inadequate for the future supply of the city and district, instructed their engineer to report upon the river Vyrnwy, in Wales, as a new source of supply. This report being satisfactory, two years later a scheme was promoted by the City Council for obtaining water from the Vyrnwy. In 1880 the Act of Parliament was obtained authorizing the construction of the works, and, in September of the same year, the engineers were instructed to commence operations. The dam at Vyrnwy, the filter beds at Oswestry, and the conduit to Preston were completed in 1891, but the distribution of the water to the inhabitants was delayed until July, 1892, a year later, because of a leakage in laying the pipes under the river Mersey.

In constructing Lake Vyrnwy it was necessary to impound the water, thus forming an artificial lake, the extent of which is four and three-quarter miles in length by an average of half a mile

in breadth. It is said to be the largest artificial sheet of water in the world, and adds greatly to the beauty of the landscape. Its greatest depth is 84 feet and its contents in gallons 13,125 millions. The site of the lake is what was the upper valley of the Vyrnwy, and its construction necessitated the removal of the village and church of Llanwyddin. A dam was built at the south-eastern end of the valley to confine the water, the total length of which is 1,172 ft., while the base is 120 ft. in thickness, and the total height from the foundation to the top is 161 ft. At the top is a fine carriage road, with a tower at each end; this carriage road is 20 ft. wide, and is supported on a series of elliptical arches, the span of each being 24 ft.

Description of Lake Vyrnwy.

The apparatus for supplying the Vyrnwy with compensation water consists of revolving hoppers, each of which contains a measured quantity of water, and in its turn, when full to the brim, by its own weight empties itself into the river Vyrnwy. The amount discharged is as follows:— Daily, 10 million gallons, and once a month,

40 million gallons per day on four successive days, during eight months of the year, equal to a daily average of 3,506,000 gallons. The total average quantity of compensation water per day for the year is, therefore, 13,506,000 gallons. The roadway is continued right round the lake, forming a unique carriage drive of about 12 miles; wherever it has been necessary to carry the road over the waters of the lake, handsome stone arches have been built. In the lake itself a graceful spiral tower has been erected, from which the conduit to Liverpool commences. This tower, which is quite an artistic feature of the works, is 154 ft. high and tapering in shape, its diameter at the base being 30 ft. The water, which is drawn from the upper surface of the lake, is strained by means of a revolving wire cage arrangement in the interior of the tower before it starts through the tunnel on its journey to Liverpool.

Compensation Water.

Straining Tower.

The watershed is 18,000 acres in extent, but the Corporation, in their Water Bill, have secured

Area of Watershed.

the right to take a larger area, and when the scheme is complete, the watershed of the lake will extend to 23,200 acres.

The distance from Lake Vyrnwy to Prescot is 68 miles, and from Prescot to the Town Hall, Liverpool, another nine miles, making 77 in all. The top water of the lake is 825 ft. above sea-level, and since Prescot is only 308 ft. above sea-level, the water travels by gravitation and in its course passes through 4¼ miles of tunnels and the rest of the distance through iron pipes, having a diameter of 38 in. to 42½ in., according to the available head in the different sections. (For an account of the filtering beds at Oswestry, and the construction of the aqueduct, see page 65.)

The water brought by gravitation.

The total quantity of water available from the Vyrnwy, 40 million gallons per day, will be conveyed in three instalments of 13 million gallons each by three pipes, one only of which has at present been laid. The average quantity of water drawn from the Vyrnwy for the

Present supply and future resources.

year 1896 was 10,149,000 gallons per day, the total supply of 22,287,000 gallons required being made up as follows:—

From wells	4,350,000 gallons.	
,, Rivington Pike ...	7,788,000	,,
,, Vyrnwy	10,149,000	,,
Making a total of ...	22,287,000 gallons.	

Cost of present and future supplies.

The total cost of the first instalment of 13 million gallons was £2,180,000, and each future instalment is expected to cost £750,000, a sum which will include the outlay for the necessary additional works at the reservoir.

It may be added, in confirmation of the statement on page 11, that the Liverpool Corporation has been obliged to cease drawing water from the deep well at Bootle, because of the organic impurity and excessive hardness of the water which it yields.

The Vyrnwy water is filtered (as will be the Birmingham supply) and as a further precaution, Mr. Parry, the engineer, makes a daily test by means of the "tintometer."

With this instrument he can ascertain the colour of both the top and bottom water at Vyrnwy, and also of the water at Oswestry, before it enters the filtering beds and afterwards. He further tests it at Liverpool, and by means of his tabulated reports, he is enabled both to test the efficiency of the filtering beds, and to determine whether there is any abnormal condition of the water either at the lake itself, or at any point *en route*.

The New Supply for Manchester.

On July 4th, 1877, the Water Committee of the Manchester Council brought forward a scheme for conveying the water from Lake Thirlmere, in Cumberland, to supply the inhabitants of Manchester and district. The permission of the Council to take the necessary steps for carrying into effect their recommendation was requested and, consent having been given, a bill was prepared. In December, 1877, it was deposited in the private bill office of the House of Commons, powers

Manchester Water Bill.

being sought to construct the works and raise the necessary capital—a sum estimated at £3,425,000. There was considerable local opposition, and, at the Statutory Meeting of the owners and ratepayers of the city, held in the Town Hall, a small minority demanded a poll, which was taken, with the following results :

Opposition to the scheme.

For the scheme	43,362
Against	3,530
Majority	39,832

In addition to the local opposition, a Thirlmere Defence Association, formed of those persons up and down the country who, on æsthetic grounds, objected to the Manchester Corporation interfering with the natural beauties of the lake, was appointed, and in all thirty-three petitions against the Bill were presented. Some of these opponents were very wroth. The Bishop of Carlisle wrote to the *Times*, and in his letter said :—

"The time may come when, instead of a trip to the lakes, we shall hear of a trip to the tanks, or a month at the reservoirs."

Professor Ruskin said :—" Manchester should be at the bottom of Thirlmere, as it was a plot to steal and sell the waters of Thirlmere and the clouds of Helvellyn."

The Water Committee of the Corporation were known as "the Vandals," who had gone to destroy the district.

The enormous undertaking was viewed with ridicule by the country people of the district, one of whom was heard to say, pointing to Alderman Grave, the then Chairman of the Committee :—

"The owd fellow has gittin't intul his heid to take t'watter fra Thirlmere ta Manchester."

"Has he," responded another countryman, "Why, theear's nut munny aneuf in aw t'world as wad deuh't."

The Times, *Saturday Review*, *Standard*, *Pall Mall Gazette*, *Yorkshire Post*, and *Medical Press* and *Examiner* were all against the Corporation, but the *Daily News*, to its credit, spoke in their favour.

The Bill, in its progress through Parliament, met with many difficulties, and for that reason the Corporation failed to get it through in one session, and, as a consequence, it had to be re-introduced into Parliament at an enormous cost. It was not until May 23rd, 1879, that it received the Royal assent.

Even after the Act was obtained, many difficulties had to be faced. Of these no better illustration can be given than the following. It was necessary to acquire the Countess Ossalinsky's property, which consisted of five farms, containing in all 850 acres, and of 714 acres on Armboth Fells, of which Mr. Jackson, the grandfather of the Countess, and the copyholder, had purchased the manorial rights.

New point raised on Land Purchase.

The rental derived by the Countess was only a little over £500 per annum, and its value was estimated, on what was considered a liberal scale by the Corporation, at from £20,000 to £25,000. The valuations made on behalf of the Countess ranged from

Source of the
Manchester Water Supply.

Lake Thirlmere.

£72,000 to £100,000—these figures being based upon the SUITABILITY OF THE LAND FOR WATERWORKS PURPOSES! Since these figures were so wide, the appointment of an arbitrator under the Lands' Clauses Act, 1845, was unavoidable.

Under this Act, unless both sides agreed upon an arbitrator, each party had to nominate one. The Corporation tried to arrange with the Countess so as to agree upon a sole arbitrator, but she would only consent to this course on the condition that one of four gentlemen, whom she nominated, was appointed. The Corporation, thinking they could trust one of the four, acquiesced in his appointment. At the Court of Enquiry, held in London on the 13th October, 1881, seven valuers upon oath gave the valuations set forth upon page 202, and on the 17th August, 1882, the valuations on page 203 were submitted on oath by the assessors appointed by the Corporation :—

COUNTESS OSSALINSKY AND THE MANCHESTER CORPORATION.

STATEMENT OF VALUATIONS.

VALUATIONS FOR COUNTESS OSSALINSKY.

Valuers.	Actual Rental of Land.	Valuers' Rental of Land.	Increase over Actual Rental.	Total Valuers' Rental of Lands and Woodlands.	No. of Years Purchase.			Compulsory Sale.	Gross Value, Exclusive of Timber and Sheep.
					Lands.	Stints.	Houses.		
	£ s. d.	£ s. d.	£ s. d.	£ s. d.					£ s. d.
John Holme	522 11 0	924 6 4	401 15 4	982 17 9	60 & 50	40	20 & 25	50%	72846 16 2
Crayston Webster....	522 11 0	883 15 11	361 4 11	941 14 0	60 & 52	...	30	50%	75525 0 0
F. Punchard	522 11 0	1027 5 7	504 14 7	1099 2 11	60 & 50	30	40	50%	76408 0 0
James Hudson	522 11 0	951 4 7	428 13 7	1024 2 0	60	...	...	50%	85427 18 0
Thomas Gow.....	... ...	... ...	... ...	... ...	...	...	...	50 & 25%	* 90100 0 0
John Coleman	522 11 0	868 2 0½	345 11 0½	932 8 11	60	...	...	50%	† 93550 19 1
Thomas Fenwick		... ...	... ...	... ...		...	...	33⅓%	‡ 101893 0 0

* Including £53,350 as extra value for Waterworks purposes. † Including £16,168 as extra value for Waterworks purposes.
‡ Including £29,400 as extra value for Waterworks purposes.

COUNTESS OSSALINSKY AND THE MANCHESTER CORPORATION.

STATEMENT OF VALUATIONS.

VALUATIONS FOR CORPORATION.

Valuers.	Actual Rental of Land.	Valuers' Rental of Land.	Increase over Actual Rent.	Total Valuers' Rental of Lands and Woodlands.	No. of Years Purchase.			Compulsory Sale.	Gross Value, Exclusive of Timber and Sheep.
					Lands.	Stints.	Houses.		
	£ s. d.	£ s. d.	£ s. d.	£ s. d.					£ s. d.
John Addie	522 11 0	532 13 6	10 2 6	625 15 6½	33 & 26	...	...	25%	20966 15 2½
Elias Dorning	522 11 0	591 8 1	68 17 1	625 17 5	33⅓ ,, 25	...	...	33⅓%	23514 4 10
Thomas Paisley	522 11 0	539 5 8	16 14 8	570 18 2	33 ,, 25	...	...	50%	23960 16 8
John Heelis	522 11 0	540 7 3	17 16 3	569 13 6	33 ,, 25	...	...	50%	24207 17 10
George H. Dixon	522 11 0	544 8 6	21 17 6	576 0 3	33 ,, 25	...	...	50%	25021 1 6
Joseph M. Richardson	522 11 0	538 6 0	15 15 0	580 13 11	33 ,, 25	...	...	50%	25245 18 10
John Green	522 11 0	581 10 9	58 19 9	614 4 6	33 ,, 25	...	...	50%	25451 9 3

On October 28th, 1882, Mr. Huskinson, the arbitrator, presented his award, the amount being £64,447 for the estate, in addition to a further sum of £6,000 for the lake, making a total of £70,447.

If this amount were invested at 3 per cent. it would produce £2,100 per annum, and it ought to be stated that the Countess had no interest whatever in Lake Thirlmere, which had previously been purchased by the Corporation.

On receipt of this award the Corporation took steps to set it aside in the Queen's Bench Division of the High Court of Justice. A compromise was, however, effected, and the action was not proceeded with. This case was considered so unjust that the Association of Municipal Corporations presented a memorial to the Rt. Hon. Joseph Chamberlain, M.P., then President of the Board of Trade, in which they respectfully asked him to "introduce a Bill into Parliament for the purpose of amending section 28 of the Lands' Clauses Consolidation Act, 1845, by vesting in the Board of

Trade the appointment of an umpire in relation to the works of Municipal Corporation."

A Bill having this object in view was brought into the House of Commons by Mr. Jacob Bright, and received the Royal Assent on the 18th of June, 1883, the difficulties which had hampered Municipal Corporations being thereby removed.

Work let out to Contractors.

In the construction of the works the Manchester Corporation decided to let it out to contractors, and a considerable amount of trouble, through failures and re-letting of contracts, resulted. From first to last there were ten. In November, 1885, the first contract was accepted, and on October 12th, 1894, the first supply of water was obtained. There have been two bursts in syphon pipes on the line of aqueduct, but the automatic valves came into operation and shut the water off, so that little damage resulted.

Length and description of Conduit.

The distance from Thirlmere to Manchester is nearly 96 miles, and the water passes through 14⅛ miles of tunnel, 36¾ miles of cut and cover and 45

miles of pipes. The area of the watershed is 11,000 acres. One pipe only, capable of delivering 10 million gallons of water to Manchester per day, has been laid. When the scheme is completed there will be five pipes and the available quantity will be 50 million gallons per day.

In 1896 the daily consumption of water in Manchester averaged 27,683,449 gallons, 7,140,161 of which came from Thirlmere and 20,543,228 from Longendale.

Cost of first instalment.

The cost of the first instalment has largely exceeded the estimates, the land alone, it may be said, cost £400,000 more than was expected. It was calculated that the cost of the first instalment, including the lake, tunnels, cut and cover, way-leave, etc. for the 50 million gallons, would be £1,740,000, but the actual cost has proved to be £2,696,925.

Total estimated cost of scheme.

Each of the other four additional instalments to bring 10 million gallons per day of water is expected to cost £500,000 or, in other words, when the five lines of pipes are all laid, and the

lake is raised 50 feet (which will be necessary to enable it to contain a sufficiency of water) it is estimated that the cost will be between £4,000,000 and £5,000,000. The water, unlike the Liverpool supply, and that which is intended for Birmingham, is not filtered, but simply passes through a strainer.

The elevation of the lake is 533 ft. above the level of the sea. It is about three miles long, a little over a quarter of a mile broad at its widest part, and is delivered at Prestwich at 353 ft. above sea level. The diameter of the aqueduct, which is constructed to carry 50 million gallons per day, is seven feet. Five and a half million gallons of compensation water are discharged daily into St. John's Beck.

The London Water Supply.

How different the condition of London; for there the eight great Water Companies still hold a monopoly of supply over an area of 620 square miles, of which 350 are occupied by consumers, 120 being within London and 230 outside. The total population in this

area was, in 1896, 5,606,920, and the average daily consumption of water was 197,988,052 gallons, giving an average of 35·31 gallons daily for each person. The companies have four sources of supply—the Thames, the Lea, the wells in the Lea Valley and the Kent wells.

How seriously the population is inconvenienced by this monopoly is illustrated by the questions recently put to Mr. Chaplin, President of the Local Government Board, in the House of Commons, by metropolitan members. He was asked by one of these if he had had his attention drawn to the fact that the Southwark and Vauxhall Water Company were giving an intermittent supply of water, and thus creating great danger to the public health. He could only reply that, if such were the case, "he had no compulsory powers of interference."

Intermittent Supply.

Another member enquired "if the President of the Local Government Board would represent the great danger and inconvenience to which the inhabitants were being

exposed by the failure of the water supply of the Lambeth Water Company."

Then, as to the water rates, it was recently stated in evidence before the Royal Commission that one of the companies was charging 2s. 5¼d. in the £, just under 12½ per cent. on the rateable value of a house—an amount which is largely in excess of that charged by any representative public body.

Action of the London County Council.

The London County Council, established in 1888, have had the question continually before them. The Council, in spite of the fact that it represents 87 per cent. of the rateable value, and over 79 per cent. of the population of the whole area supplied by the water companies, is helpless until it obtains compulsory powers to enable it to buy up the water companies. The Couucil has had several reports from its engineers as to the best method of dealing with the question. The last and most important was presented on March 26th, 1897, by Sir Benjamin Baker, K.C.M.G., and Mr. George Frederick Deacon. In drawing up

their report they had, amongst other things, to consider whether or not it would be more advantageous to bring into London from Welsh sources the additional quantity of water over and above the quantity now supplied, and which will be required for the supply of the population, or whether the Thames should be used.

The engineers, in their report to the Council, say of the two schemes that they cannot offer a final opinion without the necessary details and surveys; but, with the information before them, they think the Wye sources would prove the most generally advantageous.

In their concluding observations they say, "we would remark that the Thames and the Lea are actually and seriously polluted."

The whole history of the London water supply shows a steady and continuous demand on the part of the public for increased purity of water.

Apart from sentimental objections and hygienic doubts, the adoption of the Welsh

project for additional supplies would have the further advantage of introducing a volume of soft water to London, and of leaving a corresponding body of land water in the river to dilute the sewage and to clear the bed and banks of deposit.

It is necessary to remember that, for the next 10 or 15 years, the Thames must be "the chief source of supply, and in 1911 the quantity of water required for London will not, at the present rate of increase, exceed the existing powers of the water companies, which include 165 million gallons from the Thames and 120 million gallons from the Lea and elsewhere, *i.e.*, 285 million gallons in all."

They consequently report that no difficulty need arise from the necessary delay incidental to a Welsh project. The engineers then go on to say:—

"Personally we should feel no hesitation in deciding that the *additional* supply of water should, as far as possible, come from Wales; because we should then, in our

opinion, have had all reasonable regard both to true economy and to existing and future prejudices and sentimental or real objection to an initially polluted or subsequently more or less purified supply. We should, in short, be doing for the population what we should be doing for ourselves individually in going to a pure spring, if there were one available for our domestic supply, although it might involve a little more trouble and expense."

"The extra trouble and expense to individual households in London, on the basis of the figures given in this report for the first 200 million gallons a day would be less than a penny per week for an average household, whilst, for the second installation of 200 million gallons, the Welsh water would be the cheaper of the two."

The London County Council, after some discussion at its meeting on March 16th, 1897, resolved:—"That the Engineer be instructed to proceed with the plans and sections of the Wye portion of the Welsh scheme of water supply."

On the 16th July of the same year they adopted the following resolution :—That, in the opinion of the Council, the undertakings of the Metropolitan Water Companies should forthwith be purchased at a fair and reasonable value of the same, regard being had to the rights, special circumstances and obligations of the companies.

The County Council are making strenuous efforts to get the water supply into their own hands, and are appearing at the House of Lords by their agents before the Royal Commission on the London Water Supply, which commenced its sittings on November 27th, 1897, with the Right Hon. Viscount Llandaff in the chair. Sir A. Binnie, the Chief Engineer to the Council, stated in his evidence that, if the Council became the authority, he would recommend that they should continue to take 185½ million gallons daily from the Thames, and that he would "begin as soon as possible to supplement the present by outside sources."

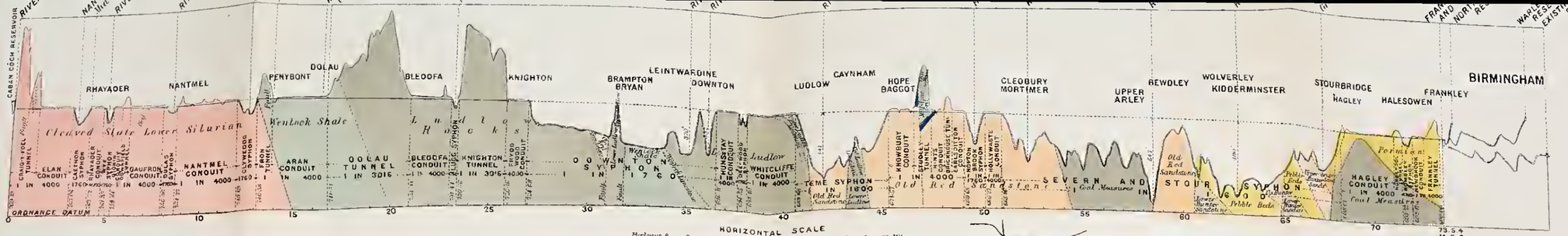
Royal Commission.

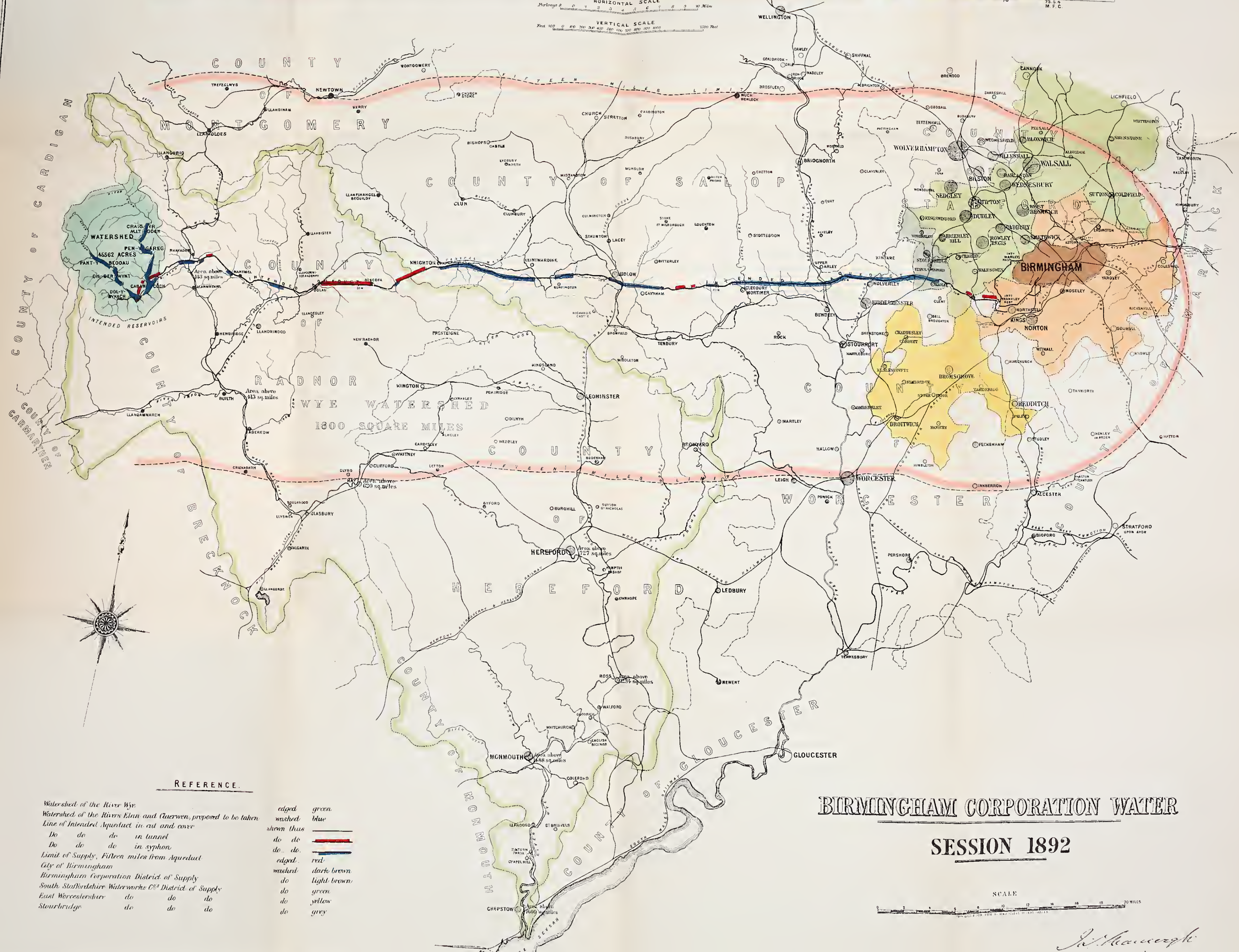
The source he recommended the additional

water to be taken from in Wales was the Yrfon, a tributary of the Wye, and he calculated that by 1931 the quantity required would be between 442 and 447 million gallons per day, but, since 300 million gallons was the limit that could be drawn from the Thames and the Lea, the difference would have to be made up from outside sources. The cost of bringing the water from Wales, to supplement the Thames supply, would be £14,000,000, and to provide for a future period, up to 1948, the extra cost would be £12,000,000, making £26,000,000 in all.

Proposed Welsh Auxiliary Supply.

The last election of members for the County Council has clearly demonstrated that it is the wish of the ratepayers that the water supply of the metropolis should be in the hands of a representative authority, and it is to be hoped that the finding of the Royal Commission will favour their view, and that, before long, a Bill may be carried through Parliament which will give effect to the very reasonable desire of the public.





REFERENCE.

Watershed of the River Wye	*edged*	*green*
Watershed of the Rivers Elan and Claerwen, proposed to be taken	*washed*	*blue*
Line of Intended Aqueduct in cut and cover	*shewn thus*	———
Do do do in tunnel	*do do*	———
Do do do in syphon	*do do*	———
Limit of Supply, Fifteen miles from Aqueduct	*edged*	*red*
City of Birmingham	*washed*	*dark brown*
Birmingham Corporation District of Supply	*do*	*light brown*
South Staffordshire Waterworks Co.s District of Supply	*do*	*green*
East Worcestershire do do do	*do*	*yellow*
Stourbridge do do do	*do*	*grey*

BIRMINGHAM CORPORATION WATER

SESSION 1892

SCALE

J. W. Haywood

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