REPORT OF CITY ENGINEER

To the Honorable City Council of the City of Worcester.

Gentlemen: As required by ordinance, a report relative to the reservoir work of the city for the fiscal year ending November 30, 1917, is herewith respectfully submitted.

Continued work upon the Pine Hill reservoir dam throughout the season has carried the work into the hill on the northerly side of the location as far as it was possible until the structure was raised sufficiently high to care for the main stream of water by other means than through the artificial channel heretofore in use. One section of the dam between two expansion joints was raised only to the ground level, while the adjoining sections have been carried to greater height, and with dykes to lead the water to and from this low section the dewatering of the remaining excavations has been accomplished. The lower portion of the gate well has been built, and two sluice gates put in place together with the main draft pipe through the dam. These are sufficient in size to care for the ordinary flow of the stream, so that the low section in the dam can be raised without interference when the time arrives to do so.

It is now purposed to continue work in the northerly hill, and to employ the steam shovel to as low a level as it can conveniently be used. Railroad tracks, the necessary derricks and other apparatus have been arranged, and the winter months will be largely devoted to this work and the operations at the quarry. Due to our inability to procure the desired number of laborers to conduct all features of the work at the same time, it is necessary to prepare in advance considerable quantities of crushed stone and sand for the summer's use, and a number of the men will be employed for this purpose during the winter.

At times the amount of sand produced by the original plant was not sufficient to meet the demands of the concrete mixers, and to the sand plant was added a Telsmith Intercone Mill, which practically doubled the quantity of sand previously made. The lack of labor has reduced the amount of work hoped for at the beginning of the season, but the high quality of the work has been maintained.

Wood cut within the basin has been used for making steam whenever possible, but with the style of locomotives

in use and for certain other boilers it has been necessary to use coal, which we have so far been fortunate enough to procure. We were also favored in obtaining sufficient cement to complete the concrete work for this year. These materials are forwarded to the nearest railroad siding in the town of Holden, and then transported by truck or motor to the railway line connected with the work. The far removal of the site of operations from the usual means of transportation adds materially to the task of conducting a work of this nature.

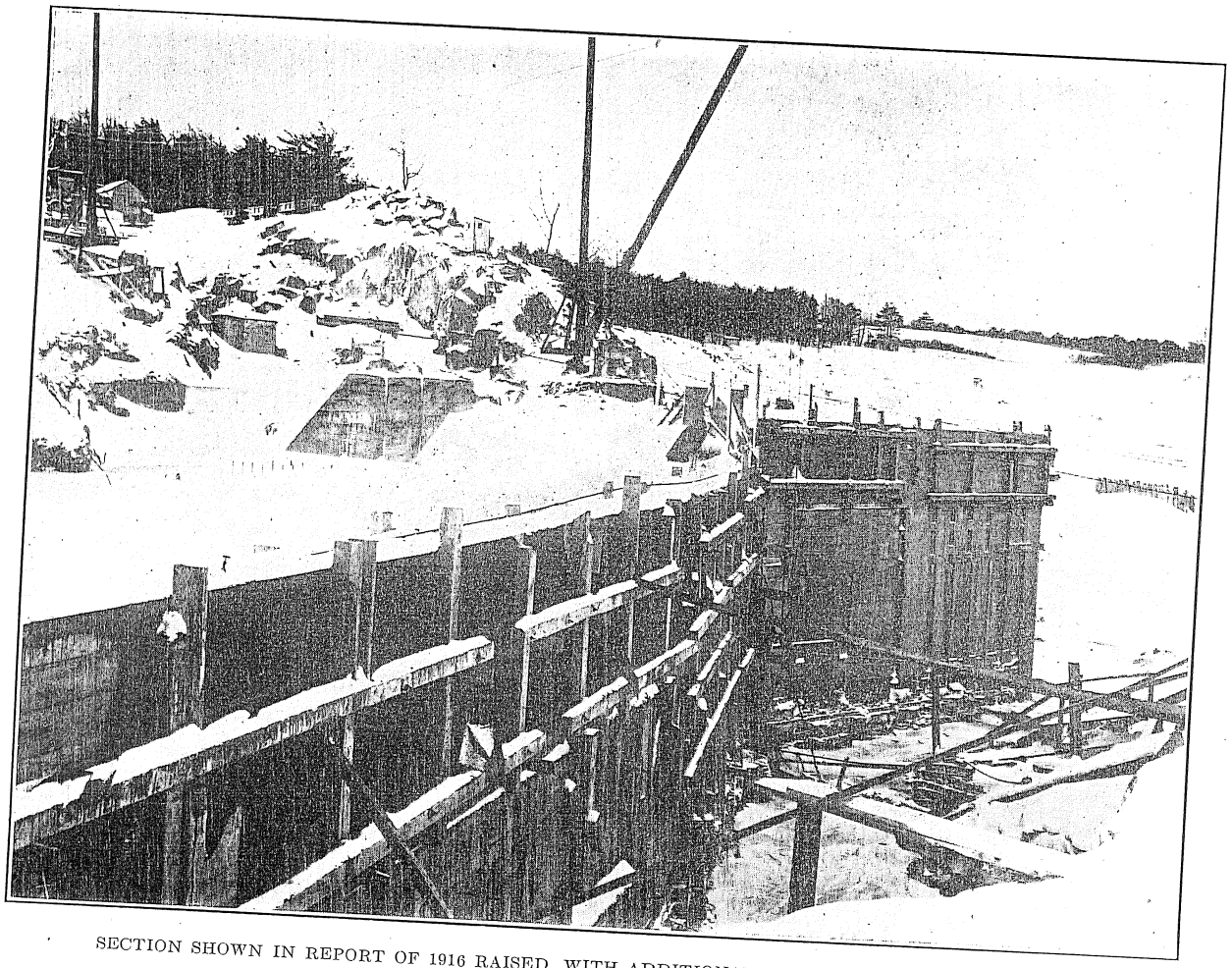
Repairs to the spillway at the Tatnuck Brook reservoir dam No. 2, made necessary by the action of ice and frost, were completed late in the season.

The remaining dams and reservoirs are apparently in good condition, lacking a few minor repairs to be made when opportunity offers.

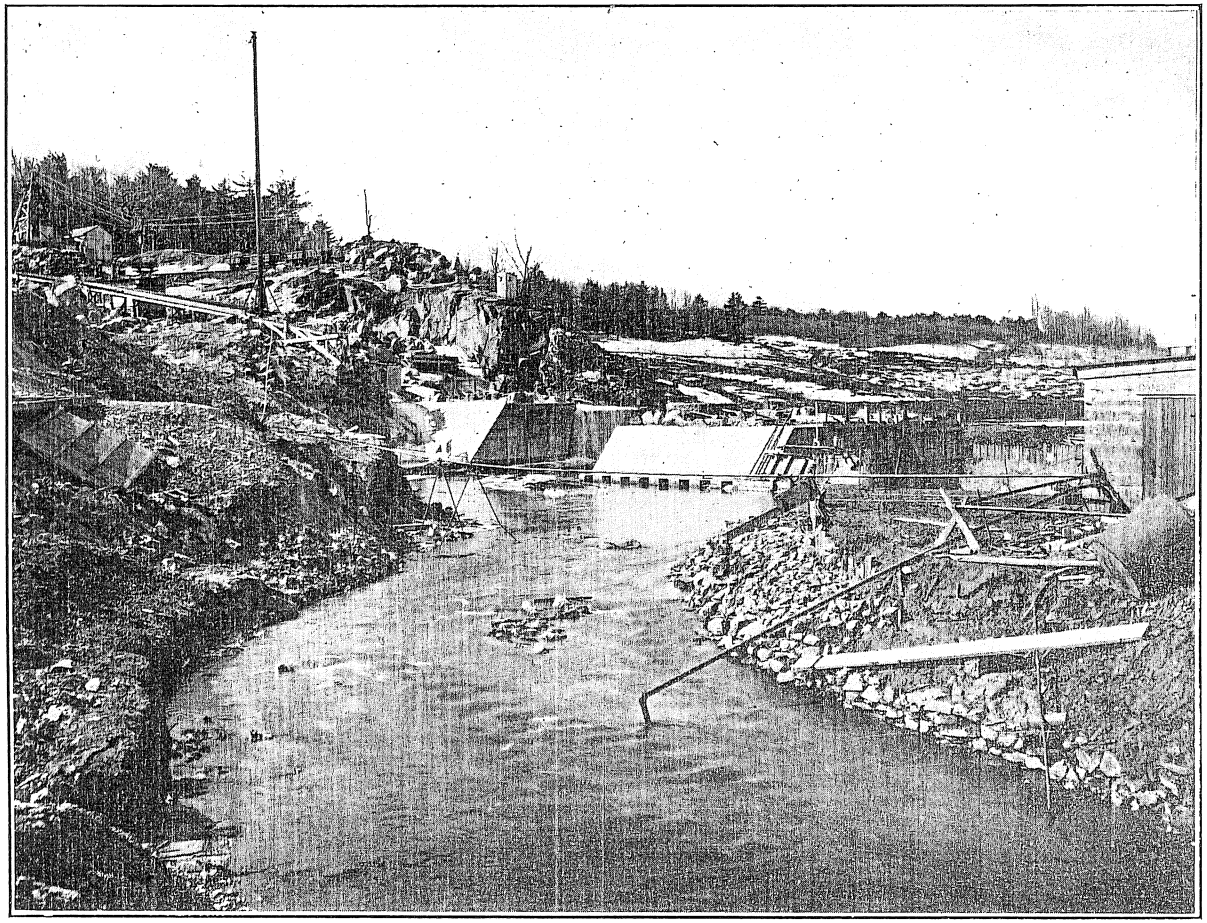
A schedule of the property, stock and machinery in use on the work can be seen at the office of the Water Commissioner.

Respectfully submitted,

FRED'K A. McCLURE,
City Engineer.



SECTION SHOWN IN REPORT OF 1916 RAISED, WITH ADDITIONAL SECTION AND CHANNEL WALL.



DIVERSION OF BROOK THROUGH SECTION OF NEW DAM

On December 31, 1917, the following order, introduced by Councilman A. H. Moss, was passed by the City Council:

"CITY OF WORCESTER

In City Council, Dec. 31, 1917.

Ordered: That the City Engineer or other city officials who have in charge the construction of the Pine Hill water system embody in their annual report a comprehensive financial statement of the same, giving the original detailed estimate of amounts and costs, both of land and unit quantities, together with progress report as to amounts of unit quantities completed, such as excavation, earth excavation, stripping of basin, construction of R. R., cu. yds. of concrete or other masonry, etc. (or however said estimates may have been determined); totalling up same to show total amounts expended, balance still on hand, whether actual cost runs under or over estimated costs, and an estimate both as to cost and quantities for the completion of the work and probable time of same—in other words, a detailed engineer progress report.

Approved, Jan. 4, 1918.

PEHR G. HOLMES, Mayor,
W. HENRY TOWNE, City Clerk."

The first order of the City Council appropriating money for the further development of the Asnebumskit water supply preliminary to the construction of the Pine Hill dam and reservoir was passed by the City Council on December 29, 1913, appropriating the sum of $50,000.00, with which operations were commenced for the carrying out of the order, by building a railway to the site of the work for the transportation of the machinery, materials, and all supplies and labor necessary to its building, and for the seizure of land bordering the main stream and the southerly portion of the land upon which the dam was to be erected.

From the beginning thus made appropriations for the work have been provided by the City Council, and additional lands seized and purchased as became necessary, or was deemed advisable for the proper maintenance and guarding of the completed work, together with additional machinery, tools, buildings and appliances for the work.

All expenditures of whatever nature have been published annually, but are herewith classified in units to the end of the fiscal year just closed, as follows:

EXPENDITURES PINE HILL RESERVOIR FROM NOV. 30, 1913, to NOV. 30, 1917

Automobile—costs, maintenance, hire		$4,376.06
Chauffeur		3,031.11
Basin—cutting and piling logs and wood, burning brush		10,452.90
		7,508.23
Buildings—labor, constructing and maintenance		4,595.27
Clerical—labor and supplies		573.00
Cement—on hand		
Dam:		
Diverting and care of water	$9,874.42	
Earth excavation, 9,100 cu. yds.	21,477.49	
Rock excavation, 8,800 cu. yds.	42,478.64*	

*Removed by picks and points to avoid disturbing foundation.

Drilling and grouting	5,716.79	
Concrete—Labor and materials, quarrying stone and placing	94,981.58	
Pipes, gates and fittings	3,063.65	177,592.57
Dynamite and exploders—on hand		1,092.62
Engineering		15,990.80
Fuel—Coal and wood, and hauling and handling		12,714.73
Incidental labor—Storehouse and repair men, etc.		7,494.97
Watchmen		11,817.44
Incidental supplies—gasoline, grease, oil, paint, waste, packing, etc.		10,038.63
Land—Purchased and maintained		20,960.40
Lumber—Cost and handling		9,234.89
Machinery and tools—Pipes, fittings, hardware, cost and maintenance		44,549.07
Medical and Workmen's Compensation Act		1,191.00
Quarry—Stripping and other work		15,243.59
Railroad—Material, construction and maintenance 2.8 miles		14,991.94
General operating and transportation		1,532.43
Removing old dam		518.95
Roadways and drives		538.88
Telephone—Rental and cost of erecting lines		641.07
Transportation—of workmen, car fares		17,234.48
Trucking—Materials and supplies		673.16
Vacations—Qualified workmen		5,606.76
Water Supply—Tank, piping and pumping		6,003.48
Water Damage and Expense—Noack case		5,629.06
Total		$411,827.49
Unexpended balance		$201,123.14

The unit costs of rock and earth excavations exceeded the original estimates.

In the above list of expenditures the cost of labor, which has been distributed in the items stated, amounted to $253,510.30.

The above statement shows the expenditures which have been applied to the work so far accomplished, including a considerable part of the difficult foundation, and much other preliminary work before any of the actual building of the dam could proceed. It was not until the month of August, 1916, that any masonry of the dam was put in place because of the difficult foundation work, which in places exceeded forty feet in depth. With the foundation secured the work becomes simpler and less expensive as the height increases.

Other work of importance was the opening of the quarry, entailing the removal of large quantities of soft stone and sap unsuited for use before proper material was reached.

Much other work necessary not only to what has been accomplished but to future operations has been done,

such as the extension of the railroad system to all parts of the work and into the basin above the dam. A portion of the tracks so built simplified the getting of wood that had been cut within the flowage lines to the main steam plants. This wood is now being used when coal is unobtainable.

To date 170 acres have been cleared, mostly during the winter months when the temperature was too cold for building. Also the work of quarrying for production of the plums used in the main structure of the dam and the crushing of stone and making of sand for concrete uses, in order to supply the amount required during the building months.

In the matter of labor it has been impossible to obtain a sufficient number of men to push the work to the point desired. At no time has it been possible to engage more than about one-fourth the number of men needed, so that the work must be confined to certain limits without the advantage of doing many features at the same time, or to keep in continuous production the work being performed, making it necessary to shift operations of construction to preparatory work and back again. The Italian labor formerly employed has left us, the last few being lured to other employment by larger pay and less hours, so that the forces now engaged are to a large extent citizens, and this fact requires their transportation back and forth where formerly camps were used. These additional hours of transportation have proved a great handicap in procuring men in sufficient numbers. We have been favored, however, by retaining many of our skilled foremen, engineers, carpenters, machine and men of like character who have been employed in the department for many years and without whom it would have been impossible to proceed.

The final disposition of the main stream which has hitherto been a barrier to foundation work has been accomplished and further excavations are now proceeding. There remains about 163 lineal feet of this deep work yet to be done, but as it advances into the northerly hill the underlying stratum of mica schist appears to be more firm in its structure, and indicates less difficulty in preparation than similar material already passed through. From this point the excavations rapidly decrease both in depth and section. With the completion of the foundation the most difficult and expensive portion of the dam will be passed and the work will gain in evidence more rapidly.

The original estimate, made on somewhat tentative plans, in the years 1905-1906, was as follows:

Masonry rubble, 28,240 cu. yds. at $3.50	$98,840.00	
Overflow steps, 200 cu. yds. at $25.00	5,000.00	
Gate house, No. 2, foundation, 65 cu. yds. at $6.00	390.00	
Pipe line to outlet, 100 cu. yds. at $6.00	600.00	
Total, 28,600 cu. yds.		$104,830.00
Earth excavation, dam, 13,800 cu. yds. at $.35	$4,830.00	
Earth excavation, spillway, 10,200 cu. yds. at $.60	6,120.00	
Total, 24,000 cu. yds.		10,950.00
Rock excavation, dam, 1,800 cu. yds. $1.50	$2,700.00	
Rock excavation, spillway, 2,200 cu. yds. at $1.50	3,300.00	
Total, 4,000 cu. yds.		6,000.00
Weir stone, 30 cu. yds. at $30.00		900.00
Rip-rap, causeway, 35,835 sq. yds.		9,000.00
Town road, re-surfacing, 7,333 sq. yds. at $.50		3,667.00
Road (construction)		3,500.00
Road, culvert		4,000.00
Iron in dam, 102 tons at $13.00		1,020.00
Steps on face of dam		1,200.00
Bridge over spillway		2,000.00
Gate house, No. 1, superstructure		2,500.00
Gate house, No. 2, superstructure		2,500.00
Land, 400 acres at $40.00		16,000.00
Stripping, 310 acres at $600.00		186,000.00
Buildings		5,000.00
Grading		3,000.00
Fence, 4,000 lineal ft., at $.20		800.00
Fence (pipe rail), 850 lineal ft. at $1.00		850.00
36″ cast iron pipe, 200 lineal ft. at $13.00		2,600.00
Valves and sluice gates		2,500.00
Cableway		18,000.00
Forms		3,000.00
Water-proofing, granolithic, etc., 10,868 sq. ft. at $.30		3,260.00
Care of water		7,000.00
Incidentals, engineering, machinery, tools, etc.		134,427.00
Total		$534,504.00

The original project was estimated at the time when the working day was of nine hours' duration, the cost of labor about one-half the present cost, transportation in part only was necessary, before the days of vacations for every qualified employee on the force, before the Workman's Compensation Act was placed upon the statute books, and before the price of materials, such as cement, steel and lumber, which are used in large amounts, had advanced to such extreme prices. It should be realized that a matter of

twelve years' interval of time between the first conception of its plan and the final undertaking gives a vague idea of comparative costs and proportions. It should also be remembered that the structure now building is very different in character and construction, and the capacity of the reservoir will be 50 per cent. greater than that first contemplated.

As to the quantities required for the completion of the work no estimate can be given before the completion of the foundation. The underlying ledge is at such depth that with the knowledge we now have of its character, it is impossible to prophesy the amount necessary to remove, the extent of drilling for grouting the remaining ledge, the water carrying seams to be encountered and dealt with, the extent and amount of sheeting and bracing that may be required, and other features that have to do with this most costly portion of the undertaking. These features vitally affect the probable time of completion and its costs, which together with the uncertainty of the labor problem make estimates of little value. Under the conditions now existing I can not place the element of time nearer than from three to five years, and a probable cost above the foundations of $900,000.

Respectfully submitted,

FRED'K A. McCLURE,
City Engineer.