Utilized power on tributaries of the Thames river—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized.	Total water-power utilized.	Auxiliary steam-power.	Remarks.
						Feet.	*H. P.*	*H. P.*	
All other tributaries	Quinebaug	Massachusetts	Worcester	Buttons	1	7½	8	.....	
Do	do	do	do	Spectacles and eye-glasses.	1	9	5	.....	
Do	do	do	do	Flour and grist	2	29	40	.....	
Do	do	do	do	Saw	5	38+	87	.....	
Do	do	do	do	Sashes, doors, and blinds.	1	12½	25	.....	
Do	do	do	do	Cutlery and edge-tools	3	15+	11	.....	
Do	do	do	Hampden	Woolen	3	.....	115	150	
Do	do	do	do	Saw	2	21	36	.....	
Do	do	do	do	Brick- and tile-works	1	42	45	.....	
Yantic river	Thames	Connecticut	New London	Cotton	3	107	1,275	400	
Do	do	do	do	Woolen	3	30	315	210	
Do	do	do	do	Vulcanized rubber	1	30	175	.....	
Do	do	do	do	Paper	1	24	105	.....	
Do	do	do	do	Flour, grist, and saw	1	9	60	.....	
Do	do	do	do	Fire-arms	1	17	95	.....	
Do	do	do	do	Spools	1				
Tributaries	Yantic	do	do	Flour and grist	2	28	34	.....	
Do	do	do	do	Saw	5	50	112	.....	
Do	do	do	do	Wheelwrighting	1	7	9	.....	
Sundry small tributaries	Thames	do	do	Cotton	6	139	480	245	
Do	do	do	do	Woolen	7	121	275	70	
Do	do	do	do	Paper	6	129	280	60	
Do	do	do	do	Dye woods, dye-stuffs, and extracts.	1	14	50	40	
Do	do	do	do	Flour and grist	10	208	224	.....	
Do	do	do	do	Saw	8	117	151	.....	
Do	do	do	do	Wheelwrighting	1	7	5	.....	

II.—THE CONNECTICUT RIVER AND TRIBUTARIES.

THE CONNECTICUT RIVER.

This stream, the most important one reaching Long Island sound, rises in the Connecticut lakes, in the extreme northern part of New Hampshire. It flows in a general southerly direction, forms the boundary between New Hampshire and Vermont, and, passing across the states of Massachusetts and Connecticut, empties toward the eastern end of the sound. Its length by general course is about 300 miles; following the windings as closely as possible on state maps, the length measures about 375 miles, and probably this is somewhat under the true distance. The drainage basin includes 10,924 square miles. In shape it is long and narrow, ranging from 40 to 50 miles in width in the upper course, and not much exceeding 60 miles in Massachusetts, where it is widest. In the north the section drained by the river is hemmed in by the White mountains of New Hampshire and the Green mountains of Vermont; to the southward, through Massachusetts and Connecticut, the water-shed lines are continued by ranges of high rocky hills. The character of the country thus included has been sufficiently described in the general remarks upon this part of New England. The impermeable rock which underlies the surface, the sands, gravels, and clays of the drift soil, all favor the formation of springs, which, together with numerous lakes and storage reservoirs, render the various minor streams, and in consequence the main river, steady and well sustained in droughts.

For the first 200 miles from its source the river contains numerous shoals and rapids and occasional abrupt pitches; but below Bellows Falls the general descent becomes much slower, and is broken by falls or important rapids at only three points—Turner's Falls and Holyoke, Massachusetts, and above Windsor Locks, Connecticut. At many localities along the upper course the high hills which inclose the valley approach close to the stream, and give rise to scenery which is beautiful though rather rugged; farther south, and especially in the vicinity of

Northampton, Massachusetts, the scenery is rendered less rugged, but none the less attractive, by extensive and fertile meadows. These mainly disappear near Middletown, Connecticut, and thence to the mouth the hill-slopes rise gradually from the water's edge.

The Connecticut is navigable to Hartford, 49½ miles from the mouth, for schooners and large steamboats, and by means of the Windsor Locks canal small boats are enabled to ascend as far as Holyoke; but the navigation above Hartford is of little consequence, and even in ascending to the latter city considerable trouble is experienced during low water by the larger craft. In former years, by means of canals around the various falls, navigation was carried on quite a distance above the northern Massachusetts line, or probably over 200 miles from the mouth; but the development of railroads put an end to such use of the river above the limits previously mentioned. More or less money is annually expended in dredging, and to some extent in more permanent works, such as wing-dams, on the navigable portion of the river. A plan has also been devised for a canal, to run from the head of the Enfield rapids to the mouth of the Hockanum river, a distance of about 17 miles. The estimated expense of carrying out this plan is $1,300,000, (*a*) but no appropriation has yet been made by Congress at all adequate for beginning work.

One of the most important interests on the river is that of lumbering. The timber is cut about the extreme upper waters, and consists almost entirely of spruce. At McIndoe's Falls it was stated that the annual "drive" down the river amounts to from 60,000,000 to 80,000,000 feet, of which from 10,000,000 to 12,000,000 feet are sawed at that point; the remainder passes down and is distributed among different mills as far south as Hartford, Connecticut.

The points at which the river is now utilized for power are, in order ascending, Windsor Locks, Connecticut, where a fall of about 30 feet is obtained; Holyoke, 59 feet; Turner's Falls, 41 feet; Bellows Falls, 54½ feet; Olcott falls (now being developed), 35 feet; and McIndoe's Falls, 12 feet. Above McIndoe's, in the extreme upper waters, there are said to be numerous dams, with falls of about 9 feet each, but these privileges are probably not all used for power.

Table showing the fall in the Connecticut river.

Locality.	Distance from mouth of river.	Height above tide.	Fall between points.	Distance between points.	Fall per mile between points.	Authority for elevations.
	Miles.	*Feet.*	*Feet.*	*Miles.*	*Feet.*	
Third lake	375	2,038	156			Hitchcock's *Atlas of New Hampshire.*
Second lake	369	1,882	264	31	32.4	Do.
Connecticut lake	361	1,618	533			Do.
West Stewartstown	344	1,035	150	32	4.7	Do.
North Stratford	312	885	55	27	2	Do.
Head of Fifteen-Mile falls	285	830	187	12	15.6	Do.
Lower Waterford	273	643	211	11	19.2	Do.
Foot of McIndoe's falls	262	432	25	7	3.6	Do.
Wells river	255	407	27	25	1.1	Do.
Oxford	230	380	5	17	0.3	Do.
Ledyard bridge, Hanover	213	375	36	4	9	Do.
White River Junction	209	339	35	13	2.7	Do.
Windsor	196	304	15	15	1	Do.
Beaver Meadows, Charlestown	181	289	6	11	0.5	Do.
Head of Bellows falls	170	283	49	0.5		Do.
Foot of Bellows falls	169.5	234	15	10.5	1.4	Do.
Westmoreland	159	219	13	23	0.6	Do.
Mouth of Ashuelot river	136	206	33	16	2.1	Do.
Top of Turner's Falls dam	120	172.93				W. P. Crocker, engineer of Turner's Falls Company.
Fitchburg Railroad crossing	115	109	75.24			Fitchburg Railroad profile.
Top of Holyoke dam	84	97.60	59.60			Elevation is 97.6 feet above low-water mark at Hartford, but is here referred to mean level of Long Island sound. (*a*)
Top of Enfield dam	65.6	38.09	31.80	5.2	6.1	Same datum plane as above. (*a*)
Foot of Enfield rapids	60.4	6.29	6.20	10.9	0.6	Do. (*a*)
Low-water mark at Hartford	49.5	0.09	0.09	49.5		Do. (*a*)
Mouth of river		0.00				

a From surveys by General Theodore G. Ellis, United States assistant engineer.

The volume of water flowing in the Connecticut river has been repeatedly measured at different points in its course. As stated in the introductory remarks regarding the flow of streams, the discharge at Hartford was noted daily for the eight years, 1871–'78, under the supervision of General Theodore G. Ellis, United States assistant engineer, and the results thus obtained are of the greatest value.

a Report of the Chief of Engineers, U. S. army, for 1881, page 568.

A number of careful measurements of flow have also been made at Hanover, New Hampshire, by Professor Robert Fletcher, of Dartmouth college, through whose kindness the following data were furnished.

Flow of the Connecticut river at Hanover, New Hampshire.

[Measurements (*a*) by Professor R. Fletcher.]

Date.	Stage of water.	Mean velocity of mid-stream per second.	Mean velocity per second of entire section.	Number of float observations.	Effective cross-section.	Greatest depth.	Average width.	Discharge per second.	Remarks.
		Feet.	*Feet.*		*Sq. feet.*	*Feet.*	*Feet.*	*Cub. feet.*	
September 20 and 21, 1879	Low	.....	0.57	.....	2,244	13½	.....	1,280	Not very exact.
August 18, 1880	Very low	.....	.....	.....	2,250	14½	235	No result.	
October 9, 1880	do	0.58	0.416	7	2,453	15	238	1,006	Not very exact.
October 26, 1880	Medium full banks	2	1.48	12	3,400	19.6	256	5,030	
June 9, 1881	Ordinary	1.9	1	9	3,250	17½	252	3,250	
October 14, 1881	Low	0.58	0.455	15	2,670	16½	240	1,210	
October 21, 1881	Ordinary	1.50	.....	23	3,400	19	240	4,070	Best result yet obtained.

a Professor Fletcher states that these measurements were made "by the method of floating tubes and rods reaching to within a few inches of the bottom, so that each tube or rod would give approximately the mean velocity in that thread of the current. The results are generally a little too large, owing to unavoidable clearance below the tubes".

It is stated by Messrs. D. H. and J. C. Newton, of Holyoke, that September 1, 1882, in very lowest water (the streams generally ran remarkably low during the summer and fall of that year), a measurement of flow at Sumner's falls, a few miles below White River Junction and 10 or 12 miles below Hanover, showed it to be 1,377 cubic feet per second.

The flow in cubic feet per second to the square mile of drainage area, as shown by these various measurements, may be briefly presented as follows:

Flow of the Connecticut river relatively to drainage area.

Locality.	Drainage area.	Date of gauging.	Flow per second.	Flow per second to the square mile.	Remarks.
	Sq. miles.		*Cubic feet.*	*Cubic feet.*	
Hanover, New Hampshire	3,316	September 20 and 21, 1879	1,280	0.386	Low stage; result not very exact.
Do		October 9, 1880	1,006	0.303	Very low stage; result not very exact.
Do		October 26, 1880	5,030	1.517	Medium full banks.
Do		June 9, 1881	3,250	0.980	Ordinary stage.
Do		October 14, 1881	1,210	0.365	Low stage.
Do		October 21, 1881	4,070	1.227	Ordinary stage.
Sumner's falls	4,234	September 1, 1882	1,377	0.325	Extremely low stage.
Hartford	10,154	December 15, 1874	5,208	0.513	Lowest discharge for the eight years, 1871 to 1878.
Do		.....	5,538	0.545	Average of lowest gaugings in each of the eight years, 1871 to 1878.
Do		.....	5,000	0.492	Flow at zero of gauge, or assumed low-water mark.
Do		December 12, 1878	139,410	13.730	Highest discharge for the eight years, 1871 to 1878.
Do		.....	113,291	11.157	Average of highest gaugings in each of the eight years, 1871 to 1878.
Do		May, 1854	205,464	20.235	Estimated discharge in highest freshet known.
Do		.....	20,208	1.990	Average discharge for the entire eight years, 1871 to 1878.

DESCRIPTION OF WATER-POWERS.

Power at Windsor Locks.—The privilege to be described is located about a dozen miles above Hartford, and has been developed on the west bank of the river. The latter descends for 5 miles in rapids over a rocky bed, with a fall from still water above the rapids to still water below of 31.8 feet in ordinary low water, and of 33 feet in extreme low water.(*a*) The village of Windsor Locks is of moderate size (the entire town contains a population of 2,300), and would have no importance but for the manufacturing. It is 60 miles from Long Island sound, and accessible to a very limited extent for navigation by light-draught boats. The New York, New Haven, and Hartford railroad passes through the village along the right bank of the canal, on the opposite side of which are the mills. The country is somewhat hilly on either side of the river, rising, frequently by long gradual slopes, to sandy uplands.

The hydraulic improvements consist in the main of a dam at the head of the rapids and a canal 5¼ miles long down the west bank to the foot. They are stated to have cost, in round numbers, $200,000. The dam extends

a Report by General Theodore G. Ellis, in *Report of the Chief of Engineers, U. S. army*, for 1878.

across the river in a broken line, reaching well up stream, and has a total length of say 1,500 feet, more or less. The dam was built fifty years ago, and until lately consisted of two wings running out from either side of the river, and leaving at the center an opening of 150 feet for the passage of boats and rafts. It has a height of 3 feet at the center of the stream, rising considerably toward the abutments. It is built of logs and filled in with stone, slopes at once back from the crest, and from age and exposure is getting into poor condition. The opening near the middle of the river, which has been spoken of, has recently been closed by a section of new dam, 270 feet long, overlapping the opening and built just below the old dam, so that it can in time be conveniently extended clear across the river and take the place of the old structure. This new portion is also built as a timber and stone crib-work, in part bolted upon and in part sunk into bed rock, is 30 feet wide at the base, and has a sloping back, with a level top 12 or 15 feet wide. Midway of the length there is a fish-way 40 feet long. The new dam has been built perhaps 15 inches higher than the adjacent portions of the old one, and in consequence of the obstruction which has thus taken the place of the old water-way it is claimed that the river has been set back injuriously upon the water-privilege at Holyoke, 18 miles above, and the two water-power companies are now involved in a lawsuit upon the question. The bulkhead at the entrance of the canal is of sandstone rubble masonry in cement. About one-half of it has been rebuilt, and is much better work than the older portion. The new part has cut-stone piers, between which are turned brick arches, and is faced with oak timber on the up-stream side. There are in all fourteen gate-openings, each about 3 by 5 feet in size. A guard-lock, 19 feet wide, permits the passage of boats.

High ground rises so rapidly from the river that the canal nowhere runs more than about 150 feet distant from the latter and through a great part of its course the two are separated only by an artificial embankment formed of the material excavated from the side-hills. Some 3,500 feet below the bulkhead there was formerly a set of stop-gates, by which the water in the canal above them could be raised 5 feet, so as to equalize the pressure within and without and render the embankment more secure during high freshets, but only the piers of the gates now remain. The width of the canal ranges from 44 to 160 feet, averaging about 80 feet above the village of Windsor Locks and about 55 feet through the village. The present depth at the center is stated to be 6 feet, but it is designed to increase this to 7 feet, and correspondingly to alter the locks so as to admit boats of the same size as those on the Erie canal. Stony brook, a small stream, is crossed by the canal on an aqueduct about 100 feet long, of five 15-foot spans. From long use this aqueduct has come to need repairing; it is also somewhat leaky, and has insufficient capacity for properly passing the water required in the canal. It is now being rebuilt in part, and so widened as to give a clear breadth at water-surface of 83 feet. The mills are situated in a line along the river side of the canal, opposite the lower portion of the rapids. After passing the mills the canal descends to the river through three locks, which are in very poor condition.

The concerns in 1880 supplied with power were as follows: Seymour Paper Company; Windsor Locks Machine Company; A. W. Converse & Co., foundery and machine-shop; the E. Horton & Son Company, lathe-chucks; J. R. Montgomery & Co., cotton warps; Dwight, Skinner, & Co., wool graders and scourers; George P. Clark, patent rubber rollers; Medlicott Company, knit goods; C. H. Dexter & Sons, manila paper, flour, grain, feed, and lumber; Dwight Allen, silk manufacturer; F. H. Whittlesey, tissue paper; and the Farist & Windsor Steel Works.

There is but one level in use, water being drawn from the canal and discharged directly into the river. The falls obtained at the mills, in the most favorable stage of water, range from 20 to 26 or 28 feet. According to the returns of the census enumerators, the total horse-power of wheels in use here in 1880 was between 1,800 and 1,900. The owner of this water-privilege is the Connecticut River Company, which was chartered in 1824 by the state of Connecticut. The main object of the company appears to have been originally to assist the navigation of the river by providing a passage around the rapids,(*a*) and the needs of that interest must still be first served by the company, but navigation has really sunk to a position of minor importance in comparison with the use of the improvements for water-power. The Connecticut River Company gives a perpetual lease of water and land to users of its power. The rates actually charged vary according to circumstances, but the nominal water-rental is $2 50 per square inch under 30 inches head.(*b*)

a Lying opposite the town of Enfield, these are known as the "Enfield rapids".

b Assuming the discharge to be measured through a rectilinear opening in a thin vertical plate, with complete contraction, the head remaining constant, a square inch of water under 30 inches head, is equivalent according to Trautwine, to 0.05425 cubic foot per second. This corresponds to the gross or theoretical horse-power and, at the rate of $2 50 per square inch, to the prices given below, under various effective falls:

Equivalents of 1 square inch under 30 inches head = 0.05425 cubic foot per second.

Effective fall.	Theoretical horse-power.	Cost at $2 50 per square inch.	Effective fall.	Theoretical horse-power.	Cost at $2 50 per square inch.	Effective fall.	Theoretical horse-power.	Cost at $2 50 per square inch.
Feet.		*Per H. P.*	*Feet.*		*Per H. P.*	*Feet.*		*Per H. P.*
20	0.123	$20 30	24	0.148	$16 90	28	0.173	$14 50
21	0.129	19 40	25	0.154	16 20	29	0.179	14 00
22	0.136	18 40	26	0.160	15 60	30	0.185	13 50
23	0.142	17 60	27	0.166	15 10			

NOTE.—With good turbines, from 60 to 80 per cent. of the theoretical power can ordinarily be realized.

With the fall at command at Windsor Locks the amount of power to be obtained from the Connecticut river is theoretically very great, though for realizing it most thoroughly, the present improvements are not the best suited. A canal of so great length as there employed has evident objections aside from the original cost, and by the location of the dam so far up stream a considerable amount of available storage room is lost. It is to be remembered, however, that the hydraulic works were designed mainly for the assistance of navigation, and they are therefore not to be judged wholly as water-power improvements. The question of a much greater extension in the use of power at this privilege must depend largely upon one or two contingencies. If the company should be permitted to maintain a continuous dam across the river of the height of the new section, it will have nearly the whole flow of the stream in its control, and by proper enlargements and extensions of the canal, which would no doubt be very expensive, could supply with power large additional manufacturing interests. If, on the other hand, it should be compelled to remove the obstruction caused by the new section of dam, and to leave a gap, as formerly, in midstream, the available supply of water would be no greater than heretofore. It is claimed, nevertheless, that even with that supply, with the canal of its contemplated enlarged dimensions as regards depth and width at the aqueduct, a very considerable increase in manufacturing can be accommodated, and there is much building-room still vacant along the lower course of the canal.

With the entire flow of the river at command, the gross or theoretical power at this privilege may be estimated as in the following table:

Estimate of the theoretical power of the Connecticut river at Windsor Locks under different falls.

Stage of river.	Drainage area.	Rainfall on basin.					Flow per second, average for the 24 hours.	Theoretical horse-power.							Effective horse-power utilized in 1880.
		Spring.	Summer.	Autumn.	Winter.	Year.		1 foot fall.	20 feet fall.	25 feet fall.	28 feet fall.	30 feet fall.	31.8 feet fall.	33 feet fall.	
	Sq. miles.	*In.*	*In.*	*In.*	*In.*	*In.*	*Cu. feet.*								
Low water, dry year	9,347	10	12	11	9	42	4,550	516.9	10,340	12,920	14,470	15,500	16,440	17,060	1,800–1,900
Low water, average year							4,900	556.6	11,130	13,920	15,590	16,700	17,700	18,370	
Available 10 months, average year							6,200	704.3	14,090	17,610	19,720	21,130	22,400	23,240	

Ice is a common hinderance experienced in New England in the use of water-power, and at Windsor Locks the principal inconvenience seems to arise, directly or indirectly, from that cause. Ice troubles there, both in the river and in the canal. A large amount of cake-ice runs down the river at the time of the spring break-up. The most dangerous run comes from below Holyoke, as the dam at the latter point holds back the ice in the river above, usually for a month after it has broken up in the section below, and allows it to rot before going out. The power of the floating ice is very great, and has been known easily to crush a heavy shore-wall near the Seymour Paper Company's mill, and this company, for protection, has been obliged to build a strong V-shaped ice-breaker. Even this, constructed in the most substantial manner and bound with iron straps, has been injured on at least one occasion.

On the rapids in the river thick ice cannot easily form, if it does at all; but skim-ice makes and floats down stream. On coming to an important obstruction, such as solid ice, it is pushed in under and causes a temporary gorging, until the pressure of the water is great enough to force a passage. This is natural to the river here, and has always been experienced more or less, but, being of short duration, was not formerly considered a serious hinderance. The gorge usually occurred about 1 mile below Windsor Locks. But the government having built a low pier, or wing-dam, some 5 or 6 miles below the village, a much more important and permanent gorging now occurs at that point in many winters, and is liable to occur in every winter. This causes backwater, which sets up over the foot of the rapids at Windsor Locks and permits the formation of thick ice where before it did not make. It causes a serious inconvenience to some, at least, of the mills, and the manager of the Seymour Paper Company stated that the building of the government pier had probably caused his company, indirectly, a loss of several thousand dollars. Its mill is the farthest up the river of any, and yet during an entire winter its head has been reduced constantly by as much as 5 feet. Spring high water also causes a reduction in head of perhaps 10 feet at times. The height of the flood seldom lasts more than twenty-four hours, and in some years there is an important loss of head for no more than a day or two, while in other years it continues for as much as two weeks.

Anchor-ice troubles both at the head-gates and in the canal. At the former it collects and hinders the working of the gates, while in the canal it clogs the racks at the entrances to the flumes, and gets into the wheel-pits and the wheels themselves. The Seymour Paper Company sometimes has to keep a man at work all night raking anchor-ice from its rack, and has also to introduce a jet of steam into the flume to disperse it there and keep it from the wheels. It is thought that trouble from anchor-ice in the canal has perhaps been aggravated

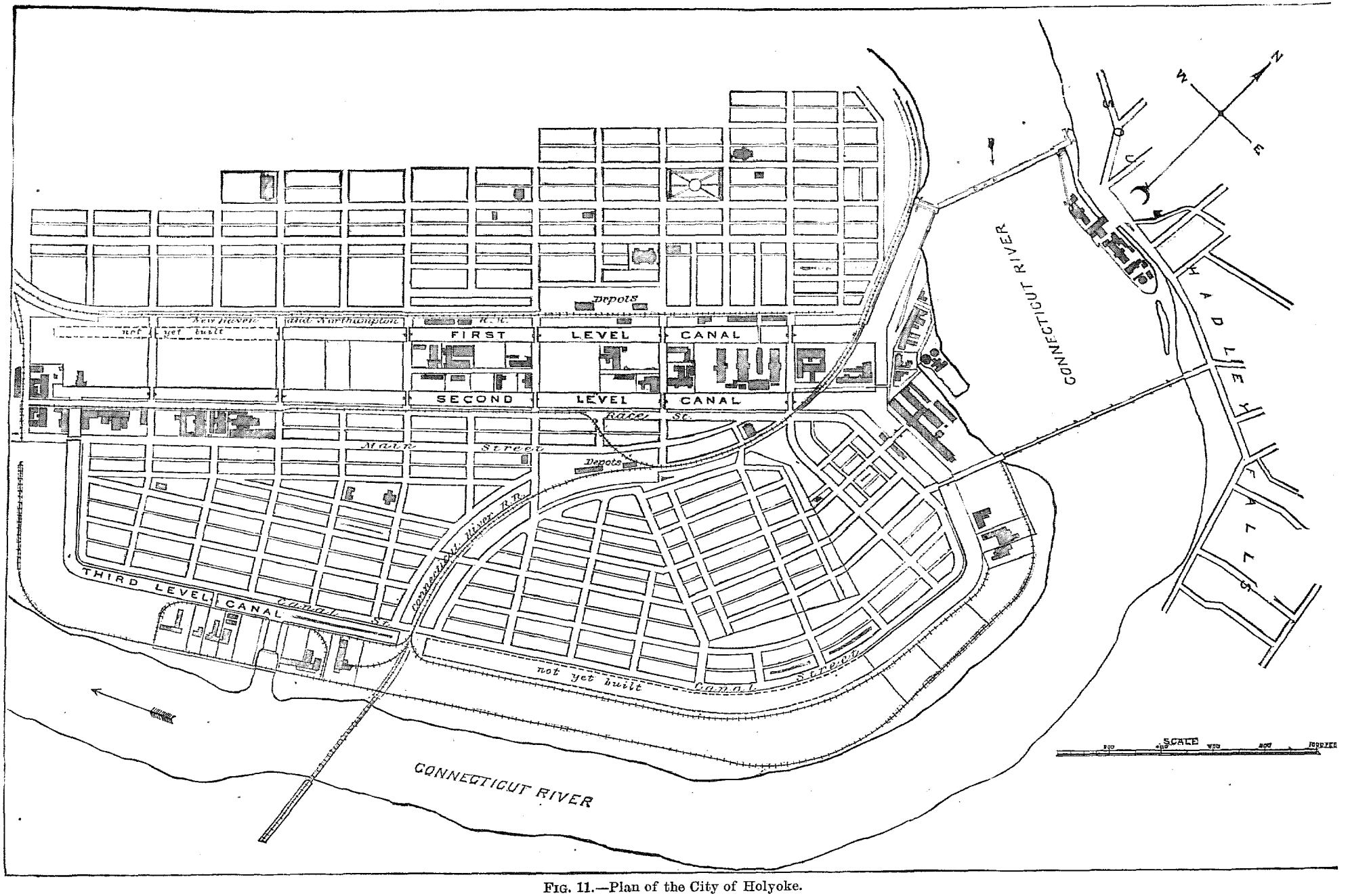

FIG. 11.—Plan of the City of Holyoke.

by the current being so swift at points that the surface of the canal did not freeze solidly over, and it is hoped that by the contemplated increase in the capacity of the latter the current will be reduced and the difficulty remedied.

In yet another way ice hinders seriously in the canal. Opposite the upper mills the current is swift enough so that thick surface-ice does not form; but below, toward the end of the canal, there is a nearer approach to dead water, and in consequence thick ice. Now, at the canal bulkhead, the direction of the dam serves to send skim-ice toward the gates; anchor-ice also forms there at times, as has been said, and from one or both causes a practical gorging ensues, and the entrance of water into the canal is much obstructed. The latter being drawn down by the mills, the surface-ice in the lower course breaks, sinks to the bottom, and there freezes to it. In this way, and perhaps by repeated occurrences, the canal becomes almost filled at the lower end with a solid mass of ice, and in extreme cases, as it was stated, "some of the mills could scarcely get water enough to put out a fire." When such an ice-clog forms, it has to be left until there comes a sufficient change in the weather to thaw it out.

Power at Holyoke.(a)—The river at this point makes a long but bold curve, and flows in rapids over a bed of gravel and ledge rock. The land inclosed by the bend is comparatively level, rising gradually away from the stream to hills of moderate height. The dam is on the upper part of the bend, while the canals run across and around it. On the north, or left bank, is the little village of South Hadley Falls, and on the opposite bank, or within the bend, is the city of Holyoke.

The first attempt to use the water-power here was made in 1831, when the Hadley Falls Company ran a 4,000-spindle cotton-mill, diverting water to its wheels by a wing-dam. As late as 1847 this and a grist-mill were the only users of power. The Hadley Falls Company failed in 1857, and in 1859 the Holyoke Water Power Company was organized, and bought out all the property and rights of the old company at a low price.

The first dam built entirely across the river at Holyoke was 30 feet high, and had a nearly vertical face, with a base of 60 feet; it was built of 12-inch square spruce timbers, forming a crib-work with a back slope of about 30° from the horizontal. To a height of 10 feet the interstices were filled with stone. The back slope was planked to the same height and covered with earth and gravel. Above this level gates were left, so that when the coffer-work was transferred to the other side of the river and that portion of the dam was being built, those gates in the already completed section served to pass the flow of the stream. The construction of the dam was finished and the gates were closed November 19, 1848. Leaks at once appeared beneath the structure, the base proved to be too small in proportion to the height, and in a few hours after the closing of the gates the dam was forced from its position and destroyed.

The second, or present, dam was completed October 22, 1849, and was built after a plan similar to that of the first, but giving greater width at base, and with greater precautions against leakage. It rests upon bed-rock throughout, to which it is strongly bolted; the various courses of timbers are also secured to each other by bolts. In construction this dam is a crib-work of 12-inch square timbers, the spaces partially filled in with broken stone. It differs from many high crib-work dams, in that the timbers running with the current are inclined up-stream; they make an angle of about 23° with the horizon, and form bents 6 feet apart. A layer of *béton* at the foot of, and carried up a short distance on, the back slope prevents leakage under the dam. The crest is protected by boiler-iron. Forty-six gates, each 16 by 18 feet, were left in the dam during construction to permit the water of the stream to flow through temporarily. This, the original portion of the present structure, and what may be considered the dam proper, has a height at the crest of about 35 feet from the river-bed, a vertical face, and a base of about 88 feet.

The wearing action of the water pouring over this high fall, gradually scoured a depression 25 or 30 feet deep in the rock immediately below the dam, and rendered necessary the present apron, which was completed in 1870 at a cost of $263,000. It is a log crib-work, filled in with broken stone, extends 50 feet down stream from the main dam, its upper surface having a slope of about 25°, and drops off vertically at the down-stream end.

The roll-way of the Holyoke dam is 1,017 feet long. The abutments, bulkheads, lock-walls, and waste-weirs are all strongly built of rock-faced cement masonry, and the up-stream face of the main bulkhead is dressed smooth. The north, or Hadley Falls abutment, extends back a distance of about 90 feet, measured from its upper edge next the river in to the lock-opening. For 12 feet back from the river it is 24 feet wide on top, and for the remaining distance 13 or 14 feet wide. Adjacent to the lock-opening is the bulkhead, measuring about 20 feet in length between the outer walls. Between the bulkhead and the bank is a lock 16 feet wide, formerly used, as well as the canal below, for navigation purposes. From the bulkhead a canal from 800 to 1,000 feet long leads down the left bank to three mills, using in the neighborhood of 35 feet fall and discharging directly into the river. This canal has a clear waste-way, just below the bulkhead, of about 30 feet, and 16 feet more taken up by an old and apparently neglected fish-way.

Measured from the south end of the dam, the distance along the top of the adjacent abutment and bulkhead to the lock-opening is 172 feet. The bulkhead is about 40 feet wide with the current, contains twelve large gate-

a Information regarding this power was kindly furnished by Mr. Clemens Herschel, hydraulic engineer of the Holyoke Water Power Company.

openings, each 8 feet wide by 15 feet deep, separated by piers about 19 inches thick; and also two smaller gate-openings, each 4½ feet wide by 10½ feet deep; it is surmounted by a brick building, in which is the machinery for working the gates. At one end of the building is a turbine, furnishing power. It acts directly to turn a long horizontal shaft running lengthwise of the building, above the gates. Each of the latter has two vertical wooden posts, 10 by 13 inches in size, fastened to it and faced on one side with iron racks. The long shaft, operated by the turbine, in turn, by connecting belts, causes a series of cog-wheels to revolve, the last of these engaging and moving the racks already mentioned, and with them the gates. Each gate can be moved independently of every other. Commonly the water stands higher outside the gates than in the canal; at such times they are not raised to the full height, and in consequence of the pressure, power is required to close them; but in low water the gates are raised entirely above its surface, and their weight alone is sufficient to close them.

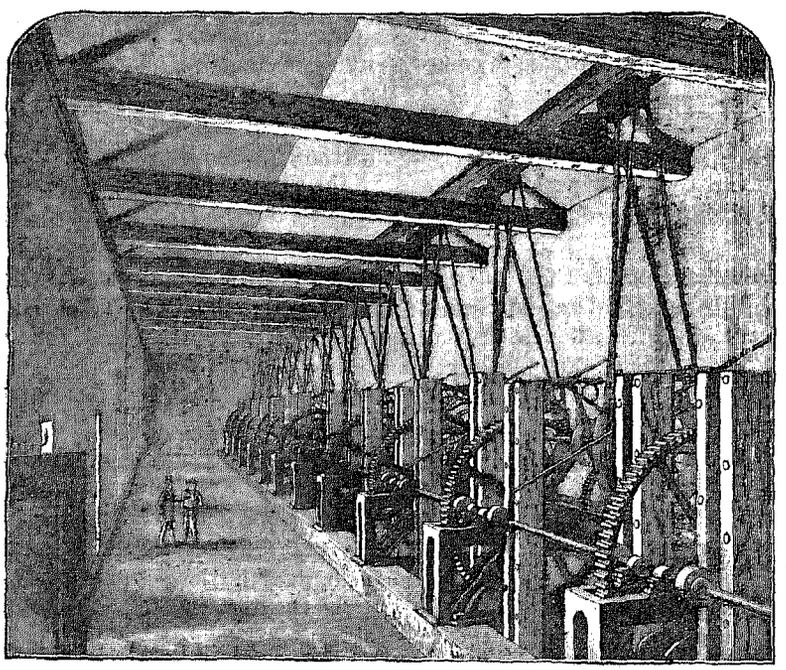

FIG. 15.—Interior view of gate-house, Holyoke.

Adjacent to the bulkhead, and forming the river-wall of the main canal, is a waste-weir 198½ feet long; it is constructed of solid masonry, and rises to within 20 or 24 inches of the top of the gate-openings in the bulkhead; for the remaining height above its crest the water-surface in the canal is controlled by temporary flash-boards. Of the 198½ feet of length, 40 feet rises above the surface of the water in the canal, and about 5 feet above the crest of the waste-weir proper. This portion is pierced by four waste-gates, their centers about 20 feet below the normal water-surface in the canal; these gate-openings measure 5 feet in width, and from 5 feet to 65 inches in depth.

The system of canals at Holyoke comprises three levels from which water is drawn. The first or upper level strikes off across the bend which the river forms, and runs at a distance of from 2,800 to 3,400 feet from the latter; it has a total length of 5,700 feet at present, and decreases in width from 150 feet near the bulkhead to say 105 feet at the lower end. The water depth is about 20 feet near the bulkhead, but through the main portion of the canal is uniformly about 10 feet. This canal is walled throughout its length with dry stone, to a height generally of 2 or 3 feet above the water-surface, and is the only one of the three canals that has been completely walled. The fall from this level to the second is 20 feet. Near the upper end a few mills discharge from it directly into the river, using falls of from 32 to 40 feet. The second level runs parallel to the first and 400 feet nearer the river, forming a straight reach of 6,500 feet; continuing from the upper end, it also sweeps around through a further distance of 2,600 feet at present, running parallel to the curving course of the river and 500 feet distant from it. Its width decreases from 150 feet at the upper end to 90 feet at the lower end of the straight reach, and in the curving portion lies mainly between 140 and 150 feet. The water depth in this level is uniformly about 8 feet. The supply of water comes from the first level, partly as tail-water from the mills and partly from the waste-weir and gates between the two levels. The fall to the third level is 11½ or 12 feet, and from the second level to the river from 25 to 28 feet. The third level, for part of its course, runs parallel to the river, at a distance from it of say 500 feet. It has a total length of from 3,500 to 4,000 feet, a width of about 100 feet, and a water depth of 8 feet. The fall from this level to the river is substantially the same for all the mills using it, but, according to the stage of river, ranges from 15 to 27 feet.

In addition to the waste-weir, already described, near the bulkhead, having a length of about 200 feet, and discharging into the river, there is another, of 40 feet, over which water descends from the first to the second level. Closely adjacent, the second level has a waste-weir 100 feet long, toward the river, which the overflowing water reaches through four arched openings underground. At the lower end of the second level there is another weir, 80 feet long, over which water spills to the third level. The latter has a similar weir, 150 feet long, connecting with the river. These various weirs do not rise to the ordinary level of the water-surface, but are surmounted by temporary flash-boards, varying from 18 inches to 2 and even 3 feet in height, used for maintaining the proper level. At each weir there are also waste-gates at or near the bottom, which may be used in connection with the flash-boards for regulating the level, or for drawing it down altogether.

Holyoke is distant by rail 144 miles from New York, 106 from Boston, 103 from Albany, and 84 by water from the mouth of the Connecticut, with a very limited navigation over the latter distance. The Connecticut River

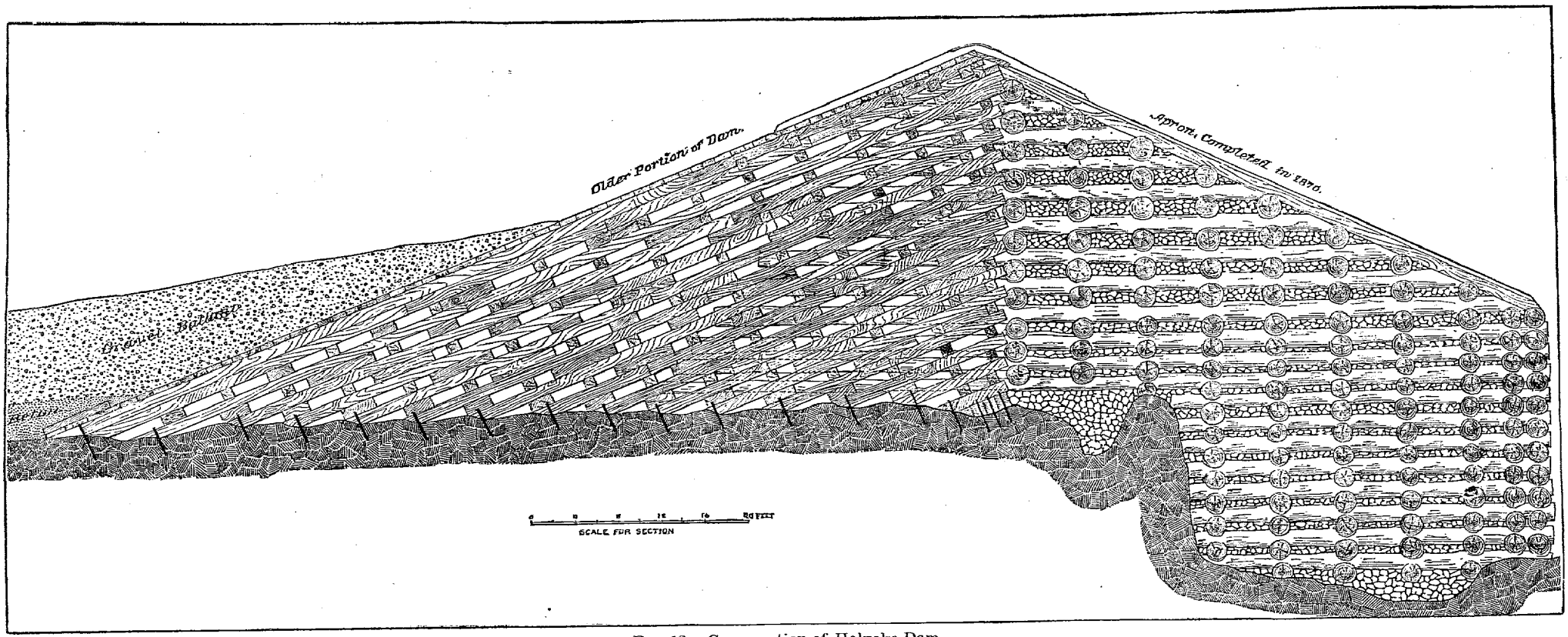

FIG. 12.—Cross-section of Holyoke Dam.

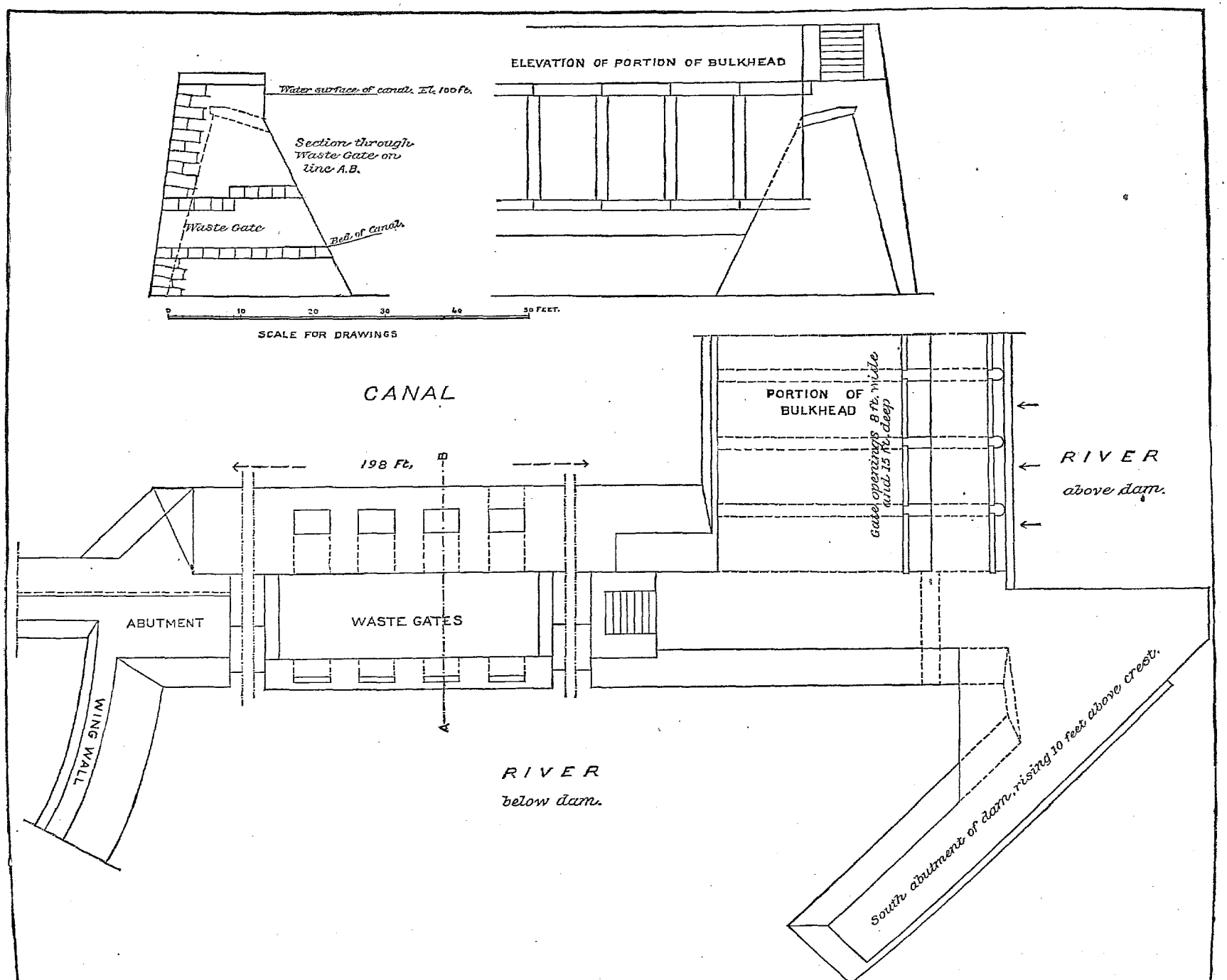

FIG. 13.—Drawing of Bulkhead, Waste weir, etc., Holyoke.

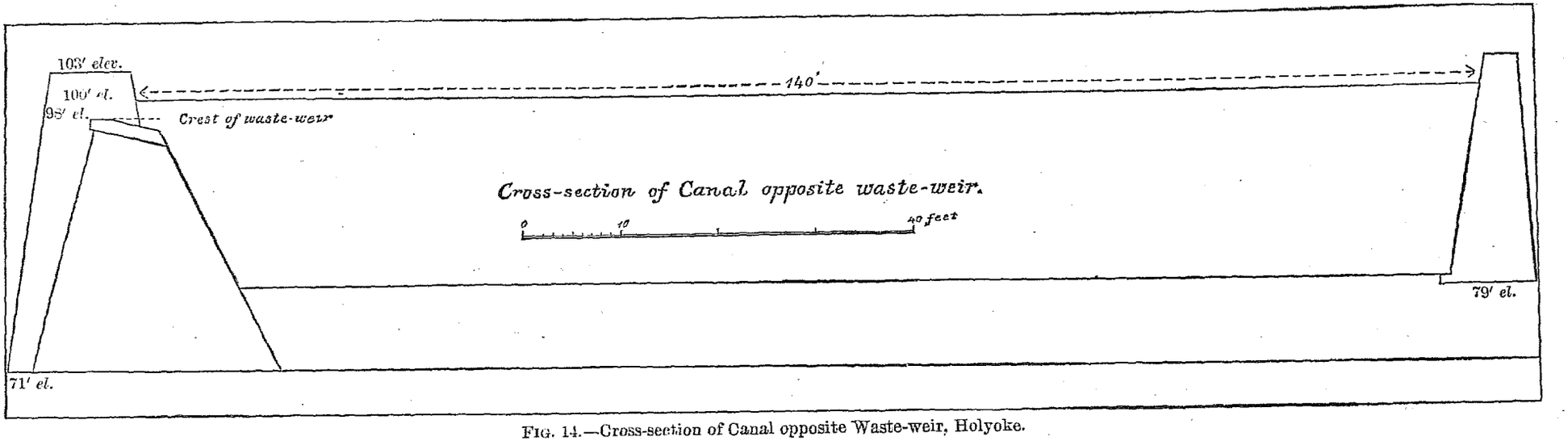

FIG. 14.—Cross-section of Canal opposite Waste-weir, Holyoke.

railroad, running from Springfield northward, passes through the city, and the latter is also entered by a branch from Westfield of the New Haven and Northampton railroad. Spur-tracks from these roads skirt almost the entire courses of the canals, giving great convenience to the mills for shipping. From the mere village of twenty-five years ago Holyoke had grown to be a city of 22,000 inhabitants in 1880, having doubled her population in the preceding ten years. It would be difficult to find any manufacturing city giving greater evidence of substantial development and prosperity than this. The interests are very considerably diversified; the mills are fine modern structures of brick, and in numerous cases of great size. The city contains handsome churches, schools, and other public buildings; the signs of life and great activity are everywhere present, and at the basis of all is a splendid water-power, admirably developed and enjoying a thoroughness and scientific method of management that are probably nowhere surpassed.

The water-privilege and such manufacturing sites and other lands as have not already been disposed of are controlled by the Holyoke Water Power Company, having a capital stock of $600,000.(a) This company owns undisputed about 56 feet of fall from the top of its dam down to smooth water at a low stage below the third level; it also claims about 3 feet more fall, but that is involved in a dispute and lawsuit with the Connecticut River Company, proprietors of the privilege at Windsor Locks. Not only does the company sell land and lease power to be improved by other parties, but it has itself built several fine mills in which it rents room and power to various concerns. When there is abundant surplus water it uses that as a source of power for these mills, but at other times steam.

Two articles in the "Proposals by the Holyoke Water Power Company for the sale of its mill-powers and land at Holyoke, Massachusetts", are as follows:

ARTICLE II. Each mill-power at the respective falls is declared to be the right, during sixteen hours in a day, to draw from the nearest canal or water-course of the grantors, and through the land to be granted, 38 cubic feet of water per second at the upper fall, when the head and fall (b) there is 20 feet, or a quantity inversely proportional to the height at the other falls; and in order to prevent dispute as to the power of each mill privilege in the variations of the height of the water from changes of the seasons or other causes, it is understood and declared that the quantity of water shall be increased in proportion to the reduction of the height, 1 foot being allowed and deducted from the height of the actual head and fall, and also from that with which it is compared before computing the proportion between them; thus, on a head and fall of 32 feet, the quantity of water to be used would be 23 cubic feet and $\frac{3}{17}$ parts of a cubic foot per second. And the respective parties, where either has any lawful interest therein, may at all reasonable times, in a peaceable manner, and after due notice to the principal steward or agent then on duty at any mill, enter the race-way thereof to measure and compare the quantity of water used with the quantity granted, and in the measurement all wastage shall be included; and may also adopt and use such other mode of making or verifying the said measurement as the circumstances of each particular case may require.

* * * * * * * * * *

ARTICLE V. In order to continue in the grantors an interest in common with the grantees for the preservation and support of the mill-powers which may be granted, and to secure a fund to indemnify the grantees for expenses which may be incurred by them for making repairs, if the grantors should improperly neglect to make them, it is proposed that part of the consideration of every sale, and all that is to be allowed the grantors for the repairs, etc., by them assumed, should be paid or secured to them in the form of a reservation of rent.

It is therefore declared, That each mill-power, with the land to which it is annexed, shall forever be subject to a perpetual annual rent of at least 260 ounces, troy weight, of silver of the present standard fineness of the silver coin of the United States, or an equivalent of gold, at the option of the grantee, at the time of payment; which rent is to be paid in yearly payments forever, free from all charges or deduction whatever for taxes or assessments of every description which may be assessed or levied upon any granted premises after the making of the deed, all of which are assumed by the grantees; and a perpetual annual rent at least equal to the above shall be reserved for every mill-power hereafter sold.

As regards rights to water, no priority is observed among those having lease of permanent power. The rates charged for power have varied at different periods in the company's history, and according to the peculiar circumstances of each case. The rental per mill-power, which is often expressed as the rate charged at Holyoke, indicates but little as to the actual cost of the power to a manufacturer. It is merely a *minimum reservation* to insure a permanent income for keeping the power in order. When a company wishes to secure power it also buys land, and, the transaction being made as a whole, the actual cost of the power alone is to a certain extent therein included, and can not well be stated separately. The rates charged now, when the city has a population of over 20,000, are naturally higher than they were when the place was in its infancy and only a small village existed.

There are two classes of power in use at Holyoke, permanent and surplus. As many as twenty-five of the latter will soon be employed. Every lessee of permanent power is entitled to use a surplus, when it can be furnished, of 50 per cent. of his lawful amount, at the rate of $2 50 per day, or night, per mill-power. (c) For all over 50 per cent. surplus he must pay at double this rate. There is a limitation, however, in time of drought; then only a certain total surplus,

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a In March, 1883, the shares, $100 par, were quoted at $220 bid.

b The term "head and fall" is an old one, and has but little significance at the present time. When overshot or other vertical wheels were more commonly in use it was convenient to distinguish between that small portion of the entire available fall employed in giving velocity to the water as it strikes the wheel, and the remainder of the fall through which the water acts by its weight; a similar distinction might perhaps be made where a small portion of the entire head is consumed in producing a fall over a weir for the purpose of measuring the water used by the wheels; but for all ordinary purposes the terms "head", "fall", "head and fall", may be taken as synonymous unless otherwise stated.

c As defined in Article 2, previously quoted, a mill-power is, under ordinary circumstances, equivalent to 38 cubic feet per second under 20 feet fall, or about 86.3 theoretical horse-power. Accordingly as the efficiency of the turbines employed ranges say from 60 to 80 per cent., the net or effective value of the mill-power will range from 51.8 to 69 horse-power.

as, for instance, 40, 20, 10 per cent., and so on, depending upon the supply of water in the control of the water-power company, can be drawn. The company fixes the percentage of surplus that shall be allowed, and changes it when necessary, without preliminary notice. All the mills are to be connected with the company's office, so that instantaneous notification can be given to decrease the use of water. If, notwithstanding the notification, a manufacturer persist in using surplus beyond the allowed amount, then he must pay ten times what would otherwise be due. During the summer of 1882, one of the driest on record, the first limitation went into effect August 4, and for about three weeks during the season the mills were subject to limitation of some kind. In order to insure having sufficient power always to enable them to fill their orders, some of the mills are putting in steam for auxiliary use.

In October, 1882, the amount of effective horse-power in use at Holyoke was stated to be about 8,000 by night and 15,000 by day, or an average of say 11,000 or 12,000 for the twenty-four hours. It is difficult to say just how much power can be depended on here in low stages of river. During the very dry summer of 1882 there was some scarcity of water during four nights, and it was stated by Mr. Herschel as probable that on some days the average power in use for the twenty-four hours did not exceed 10,000 effective horse-power. Every possible economy is practiced at Holyoke, by the water-power company, in the use of water, and the river is carefully watched; from as far up as Bellows Falls any important rise is telegraphed down during the dry season, so that it may be anticipated, and the possible necessity of curtailing the supply to the mills be avoided. The slope of the river above Holyoke is small and a large pondage is secured; with 2 feet of flash-boards on the dam the effect of back-water becomes imperceptible, at a low stage of river, 20 miles above. So far as concerns an increase of power, the pondage is of much less consequence here than upon a cotton-manufacturing stream such as the Quinebaug or Shetucket. At Holyoke the great bulk of the water is used by paper-mills which run steadily night and day, and thus give little opportunity for concentration of power within a part of the twenty-four hours. The pond is not allowed to be drawn down more than 2 feet below the crest of the dam, or 4 feet below the top of the flash-boards.

Regarding an increased use of water-power at this point, it may be said that the company can guarantee power in the future only to a very limited extent and on certain levels. During the continuance of the present dispute with the Connecticut River Company, which affects the third level, it does not wish to dispose of any more power on that level. There is a particularly large number of paper-mills on the third level, requiring a considerable amount of night water to be drawn through the two upper levels for their use; it therefore happens that permanent night power can still be obtained on the first level (October, 1882), and between the second and third levels there is a large unoccupied mill-site, for which power can be obtained that shall be permanent in night and practically so in day.

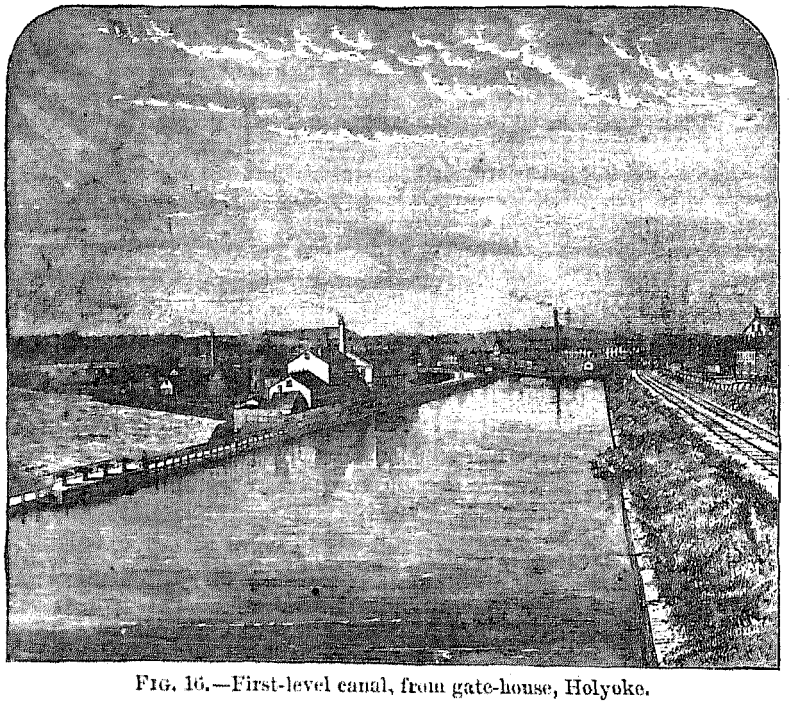

FIG. 16.—First-level canal, from gate-house, Holyoke.

Within a quarter of a mile or so of the dam, and located on either bank of the river, there are several important mills which draw water from the adjacent level and discharge directly into the river, without utilizing the entire fall that the water would have if discharged successively from one level to another and then into the river finally at the foot of the rapids. This difficulty is a common one, however, with large water-privileges. The development of a great power is a costly enterprise, and can seldom be carried out, in the start, as a completed design; canals are extended and other improvements made only as business and revenues warrant, and so it often happens that some sites are disposed of which are unfavorable to the full utilization of the available power. It is not unlikely that the same fault sometimes arises from too sanguine ideas as to the capacities of a privilege relatively to the demands which will be made upon it.

No measurements of the volume of the river at this locality could be learned of, other than one said to have been made in the summer of 1847, when the discharge in a low stage was found to be 6,000 cubic feet per second. From a careful examination of the results obtained for the discharge at Hartford, by General Ellis, during the years 1871–'78, the following estimate has been made of the power at Holyoke:

Estimate of theoretical power at Holyoke.

Stage of river.	Drainage area.	RAINFALL ON BASIN. Spring.	Summer.	Autumn.	Winter.	Year.	Flow per second, average for the 24 hours.	Theoretical horse-power. 1 ft. fall.	50 ft. fall.	59 ft. fall.	Power utilized.
	Sq. miles.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Cu. feet.*				
Low water, dry year	8,000	10½	12	11	9½	43	3,800	431.68	24,170	25,470	In October, 1882, there were stated to be in use about 8,000 effective horse-power by night and 15,000 by day. According to the census enumerator's returns there were in 1880 12,260 effective horse-power of wheels in use.
Low water, average year							4,100	465.76	26,080	27,480	
Available 11 months, average year							4,450	505.52	28,310	29,820	
Available 10 months, average year							5,250	596.40	33,400	35,190	
Available 9 months, average year							5,700	647.52	36,260	38,200	
Available 8 months, average year							6,650	755.44	42,300	44,570	
Available 7 months, average year							8,100	920.16	51,530	54,290	
Available 6 months, average year							9,700	1,101.92	61,710	65,010	

NOTE.—The estimates of power available for 9, 8, 7, and 6 months, respectively, must be regarded as less reliable than the others; they may have no especial practical value, but may be of interest in showing the great increase in the use of power possible for a part of the year by using steam for the remainder.

As to freshets, there has on several occasions been a depth of 6 feet of water on the dam, and such was the case after the heavy rains of September, 1882. At one time, years ago, there is said to have been a depth of 11 feet (*a*) on the dam, but at that time 4-foot flash-boards extended part-way across, and it cannot be known how far they affected the height; it is certain, however, that the water rose above the tops of the abutments. Surface-ice usually rots in the pond before moving out. As a precaution, a V-shaped piece is cut in the ice above the dam, and when it does run out the sides of this opening close together and relieve the abutments from pressure. Anchor-ice causes no trouble worth mentioning, affecting for a day or two only a single mill, and the difficulty might easily be overcome there.

In noticing the manufacturing interests of Holyoke, the paper industry must of course be given the greatest prominence. So far as known, this city is the most important center of that enterprise in the United States. In October, 1882, twenty-three concerns were engaged in the manufacture of paper, employing over 4,000 hands, and turning out a finished production of from 150 to 160 tons per day. Almost every variety of paper seems to be made, though fine writing-papers occupy the chief place. Paper is also here made into blank-books, envelopes, and paper boxes. Spool-cotton, cotton yarn, and cloth are extensively manufactured, the Lyman, Hadley, Merrick, Hampden, and Glasgow mills together running 180,000 spindles. Other leading manufactures comprise woolen goods, silks, water-wheels, pumps, and various other kinds of machinery, screws, cutlery, rubber goods, wire-cloth, and, in a less prominent degree, numerous other articles.

The following table, which embraces all the most important manufacturing establishments of the city, will give in more detail facts regarding the above interests:

Statistics of manufacturing at Holyoke, October, 1882.

[The figures below are approximately correct, but were not intended to be given with minute accuracy.]

Firm.	Manufacture.	Number of hands employed.	Production, etc.
Carew Manufacturing Company	Superfine writing paper	100	2½ tons per day.
Hampshire Paper Company	Extra superfine writing paper	175	3 tons per day.
Parsons Paper Company	White and tinted writing and envelope paper; also bond, bank-note, parchment, linen, ledger, and record papers.	350	10 tons per day.
Whiting Paper Company	Fine writing paper	600	14 tons per day.
Wauregan Paper Company	Superfine book and superfine engine-sized writing papers.	130	6 tons per day.
Robertson Brothers	Tissue, manila, and toilet papers	12	35 cases per day.
Holyoke Paper Company	Fine writing paper	275	7 tons per day.
Whitman Manufacturing Company	Lithograph, white-plated, and chromo papers, and card-board.	.....	
Beebee & Holbrook Company	Fine writing paper	115	3 tons per day.
Massasoit Paper Company	....do	200	3 tons per day.
Chemical Paper Company	Manila papers	250	20 tons per day.
Newton Paper Company	Building, carpet-lining, and heavy wrapping papers.	60	12 tons per day.
Excelsior Paper Company	Machine-finished book papers	55	3 tons per day.
Franklin Paper Company	Colored, flat, writing, and envelope papers	80	3 tons per day.

a General Ellis states the greatest depth above the dam at 13 feet, in April, 1862 (see page 54, *Report of Surveys and Examinations of the Connecticut River*).

Statistics of manufacturing at Holyoke October, 1882—Continued.

Firm.	Manufacture.	Number of hands employed.	Production, etc.
Union Paper Company	Fine writing paper	175	From 4 to 5 tons per day.
Riverside Paper Company	....do	225	5 tons per day.
Winona Paper Company	Engine-sized writing and super-calendered book papers.	130	11 tons per day.
Syms & Dudley Paper Company	Engine-sized flat and ruled writing, card-board, and book papers.	180	12 tons per day.
Nonotuck Paper Company	Engine-sized flat writing, and book papers	200	10 tons per day.
Albion Paper Company	Book paper	250	15 tons per day.
Crocker Manufacturing Company	Various kinds of engine-sized papers	75	From 4 to 5 tons per day.
Valley Paper Company	Fine writing paper	225	5½ tons per day.
Dickinson & Clark Paper Company	Engine-sized writing and book papers	65	From 3 to 4 tons per day.
National Blank Book Company	Blank books	200	Value of yearly production, from $300,000 to $400,000.
Holyoke Envelope Company	Envelopes	100	1,000,000 envelopes per day.
James D. Whitmore & Co	Envelopes and paper boxes	80	
Connecticut River Pulp Company	Wood-pulp	50	10 tons per day.
Glasgow Company	Dress goods, ginghams, and yarns	425	13,000 spindles; 400 looms. Production, 75,000 yards per week.
Hampden Cotton Mills	Heavy duck	500	15,000 spindles; 350 looms. Production, 1,250,000 pounds of finished goods per year.
Lyman Mills	Sheetings, shirtings, and lawns	1,200	75,000 spindles; 1,600 looms. Production, 14,500,000 yards of finished goods per year.
Holyoke Warp Company	Cotton warps	125	1,500 pounds per day.
Merrick Thread Company	Spool-cotton	.....	35,000 spindles. Production, 3,000,000 dozen spools of cotton per year.
Hadley Company	Spool-cottons, yarns, warps, and twines	725	42,000 spindles. Spins 1,325,000 pounds per year.
Farr Alpaca Company	Alpaca	1,000	577 looms run.
D. Mackintosh & Son	Dyed cottons	.....	75 cards. Production, 8,500 pounds per day.
Germania Mills	Beavers, fancy goods, cloakings, and overcoatings	300	74 looms; 16 sets of cards. Production, 6,000 pieces per year.
Connor Brothers	Fancy cassimeres	.....	11 sets of cards; 65 looms.
Beebee, Webber, & Co	.....do	135	32 looms; 8 sets of cards. Production, 30,000 yards per month.
Springfield Blanket Company	Horse-blankets	300	180 looms. Production, 1,800 blankets per day.
William Skinner & Son	Silk and mohair braid, machine-twist and sewing-silk, satin sleeve-linings.	350	
George W. Prentice & Co	All kinds of iron and soft steel wire	60	3 tons of wire per day.
Holyoke Machine Company	Mainly water-wheels, mill-gearing, and paper-mill machinery.	300	Value of production, $500,000 per annum.
Massachusetts Screw Company	Wood-screws	75	3,000 gross of screws per day.
Henry Seymour Cutlery Company	Shears and scissors	70	From 2,400 to 2,600 dozen pairs per month.
Deane Steam Pump Company	Pumps and machinery of all kinds	120	
John C. Smith	Machine-shop	50	
Watson Ely & Son	Carpentry, mill-work, and sawing	20	
T. F. Keegan	Steam-fitting	10	
Tuttle Rubber Works	General rubber goods	26	Value of production, $60,000 per year.
Ferguson & Gardner	Leather belting and top-roll covers	.....	
B. F. Nichols	..... do	10	Covers, 10,000 rolls per week.
Buchanan, Bolt & Co	Wire-cloth	.....	
B. F. Perkins	Machine jobbing	10	

Power at Turner's Falls.(*a*)—The village of Turner's Falls is beautifully located in northern Massachusetts, a short distance from Greenfield. It is about 120 miles from the mouth of the Connecticut, though without water communication; it is only 2 or 3 miles from the main lines of the Fitchburg, the New London Northern, and the Connecticut River (*b*) railroads, but is directly reached only by branches of the Fitchburg and the New Haven and Northampton roads.

In 1792 the state of Massachusetts incorporated the "Proprietors of the Locks and Canals on Connecticut River", for the purpose of rendering that stream passable from the mouth of the Chicopee river northward. In 1794 this corporation was formed into two, one bearing the old title and the other known as the "Proprietors of the Upper Locks and Canals". The former built the dam and canal at Holyoke, while the latter improved the river at Turner's Falls. The dams and canal at this point were completed in 1798, and the upper dam, near the mouth of Miller's river, was built in 1800.

For more than half a century this company transacted a profitable business in passing boats and lumber through their locks and canals, until the construction of railroads on the banks of the Connecticut river put an end to the business of transportation by water, and the works of the company went into disuse. In 1865 every share of the original stock was purchased by a number of gentlemen, * * * and in 1866 an amendatory act of the legislature was passed, giving to the corporation the name of "Turner's Falls Company". During the same year additional lands were purchased, making an area of about 700 acres; a substantial bulkhead was constructed at an expense of $24,000, and a permanent dam was completed March 20, 1867, at a cost of $105,000.(*c*)

a Facts regarding this privilege were kindly furnished by Mr. William P. Crocker, engineer of the Turner's Falls Company.
b Opposite side of the river.
c From prospectus of Turner's Falls Company.

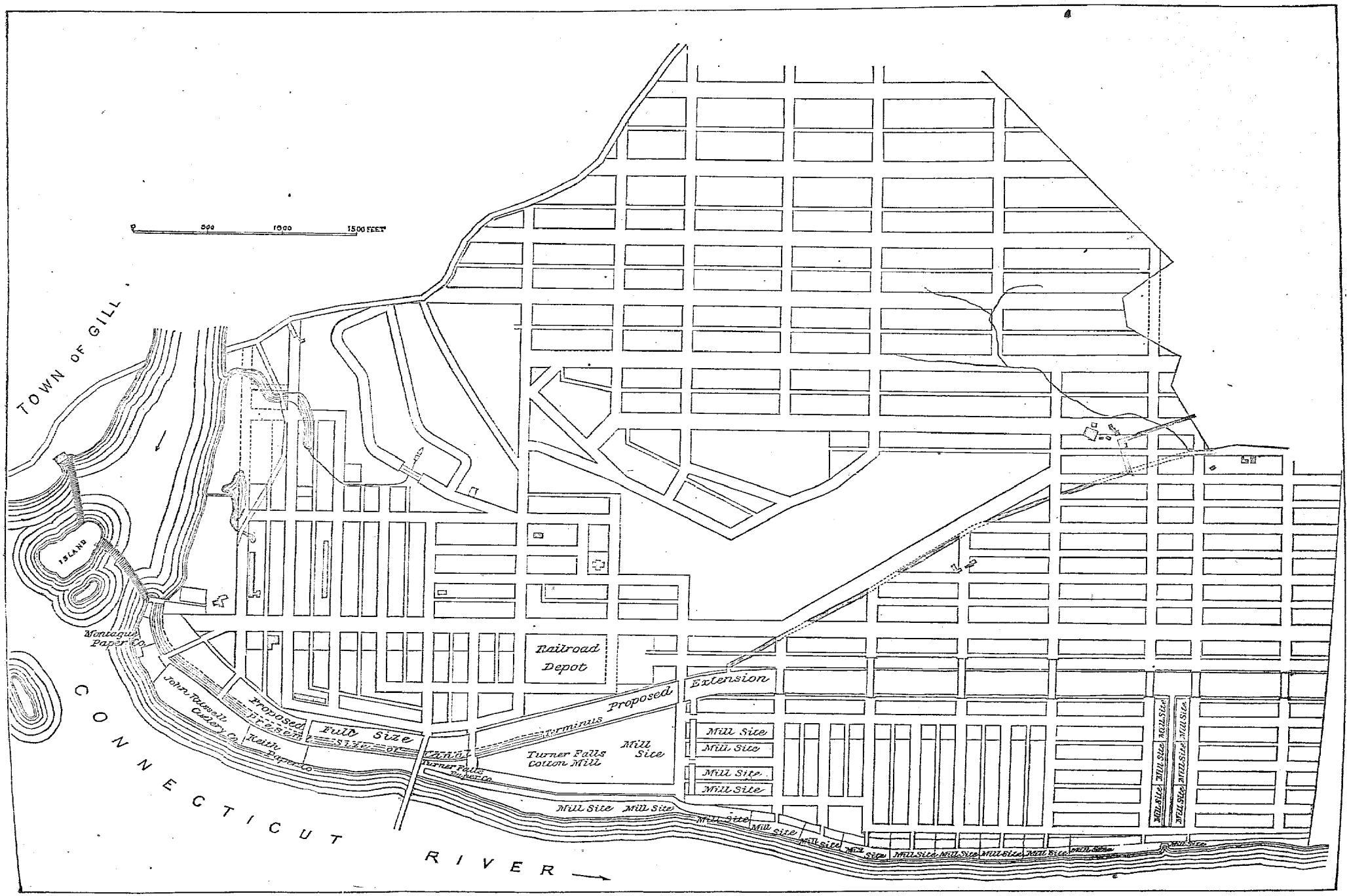

FIG. 17.—Plan of the Privilege at Turner's Falls, showing proposed extension.

At Turner's Falls the river runs northerly for a short distance and then bends sharply to the west and south. The right bank is steep and rocky; the mills and village are on the left bank, which rises somewhat rapidly from the river, but is succeeded beyond by gently hilly ground. Passing a short distance down stream, or toward the foot of the canal, the hills recede from the river on this side, and leave a fine level plain which is not yet built up.

On the upper part of the bend in the river is the dam. It runs across from the left bank, with a slight curve up stream, to a rocky island in midstream, and then continues with straight course to the right bank. In the autumn of 1866 a portion of the present dam, then in process of construction, was destroyed by a timber raft, which broke loose from its moorings during a freshet and came down against the coffer-work with irresistible force. Work was recommenced and carried on through the winter of 1866–'67; the structure was finished March 20 of the latter year, only three days before the occurrence of a heavy freshet. In 1880 the entire cost of the roll-way of the dam was placed at $113,000, and of the bulkhead at $35,000. The Turner's Falls dam rests throughout on ledge rock, and varies from 20 to 30 feet in height. It is a log crib-work, the interstices packed with loose stone. The face has a slight batter, while the back has a long slope, giving, for a height of 20 feet, a base of perhaps 50 or 60 feet. The roll-way is very nearly 1,000 feet long. The elevation of the crest is stated to be 172.9 feet above sea-level.

The dam abuts against natural ledges everywhere except on the Turner's Falls shore. Here is an artificial masonry abutment and bulkhead, about 150 feet long by 35 feet wide, and rising 15 feet above the crest of the dam.(*a*) It is solid for a short distance back from the end of the dam; farther inshore are five arched openings through which water passes to the gates. There are five gate-openings, each 8 feet wide and 10 feet deep. Water also enters a side-opening into a wheel-pit, and drives a turbine for operating the gates. After passing through the rectangular gate-openings the main body of water continues through arched openings similar to the ones already mentioned, till, having passed entirely through the bulkhead, it enters the canal.

The canal is at present confined to one level, extending about 3,000 feet, approximately parallel to t he river, and at a distance from it varying from 100 to 250 feet in the main part of its course, but increasing to 500 or 600 feet toward the end. It has an average width of 50 feet as at present constructed, and a water depth of 10 feet. Close to the dam the fall to the river is about 28 feet, and the greatest fall utilized on the line of the canal is 41 feet. This race has been largely excavated through rock, and has therefore been expensive; according to a report by the president of the company, made in June, 1871, its cost up to that time had been $82,000. One hundred feet of land on the easterly side of the race is reserved for giving it additional width when occasion shall demand.

The power in use at this point in the fall of 1882 was stated to be about 4,000 horse-power, which exceeded, however, the amount actually leased. The concerns using power at that time were as follows:

1. The Clark & Chapman Machine Company.

2. The Shawmut Manufacturing Company (rents power from the above concern), employing 6 hands in the manufacture of leatheret.

3. The Montague Paper Company, printing paper; 260 hands; production, 15 tons per day.

4. The John Russell Cutlery Company, general cutlery; 700 hands; turns out 3,000 dozen pieces per day.

5. The Keith Paper Company, fine writing paper; 225 hands; production, 5 tons per day.

6. The Turner's Falls Paper Company, news paper; 35 hands; production, 5 tons per day.

7. The Turner's Falls Cotton Mill, light cotton goods; 5,100 spindles; 300 looms; 150 hands; annual production, 4,500,000 yards.

8. On the opposite (Gill) side of the river, the Turner's Falls Lumber Company, saw-mills, employs 35 or 40 men, and turns out about 27,000 feet of lumber per day.

The Turner's Falls Company owns a large tract of land available for manufacturing and other building sites, which it sells. Power is disposed of to manufacturers under a perpetual lease. The usual rate has been $7 50 (*b*) per annum per horse-power, rental reserved, but there is no established rate for the future. In the use of water no priority of rights is considered to exist, all the concerns standing on the same footing. The amounts used are determined by weir measurement in the tail-races, made as often as there is any change in the wheels run, or oftener at the option of the company. The greater part of the utilized power is in use night and day, being employed by paper-mills; and though there is, generally speaking, a large surplus power, yet, on account of the filling up on Sunday of a great many ponds on the various tributaries above, there is a slight scarcity of water here on Mondays during a dry season. There is a considerable pondage above the dam, extending 3 or 4 miles up stream, but mainly included within 3 miles. The power at this point has been developed gradually, and on account of the initial expense of extending the canal to the foot of the rapids, mills have been located close to the dam and from there down stream; in this way it happens that the fall is not utilized to the best advantage.

The interests of Turner's Falls as a manufacturing point have become solidly established, and its future growth seems to be assured. The village is distant by rail about 100 miles from Boston and 175 from New York. The precise plan to be adopted in further improving the power is stated not to have been fully decided upon. The first,

a Eleven feet is said to have been the greatest freshet depth noted on this dam.

b According to the president's report, June 13, 1871, some of the earliest leases were at rentals ranging from $5 to $7 50, and even $10, per horse-power.

or upper level, which constitutes the present canal, can be widened and extended, and, as will be seen, would thus render available a much larger fall than at present. Its widening would probably be expensive in the upper portion, on account of the rock to be cut through, but its extension and other work on the lower course would be easy, as it there enters upon a flat sandy plain. A second level may or may not be introduced. In time, if desirable, the wheel-pits near the dam will be sunk lower, and a tail-race run from them down stream so as to utilize the fall fully, instead of partially as now.

From the crest of the Turner's Falls dam to the crest of the Holyoke dam, according to the most reliable figures that are accessible, there is a fall of 75¼ feet. In an ordinary low stage Holyoke backwater extends to the vicinity of Hatfield. From that point up there are no rapids until we reach what are known as the "lower falls". These are about a mile and a half below the Turner's Falls dam, and the locality is also called the "stone dam", because a natural ledge here runs diagonally across the stream and causes an abrupt fall of several feet, said to be 7 feet. The right bank is succeeded by a small meadow shut in by high steep hills, which form the banks of the stream on that side, thence for a mile, more or less, to the Deerfield valley, where are wide flat meadows. The left bank rises steeply, and is composed apparently of a light sandy soil, to a height of 50 or 60 feet above the river, beyond which stretches a fine level plateau, continuous with that already described as lying along the lower course of the Turner's Falls canal. The privilege at the lower falls can probable best be utilized in connection with that owned by the Turner's Falls Company, by an extension of their canal system.

From the top of the Turner's Falls dam down to smooth water below the lower falls there is stated to be a fall of 62½ feet. Of this the Turner's Falls Company has already improved 41 feet; it also owns land along one side of the river covering 9 feet more; and the remaining 12½ feet is said to be owned by a party interested in that company. No gaugings on this part of the river having been learned of, the flow and power at this point are placed, by estimate, at the figures given below:

Estimate of total power available at Turner's Falls, Massachusetts.

Stage of river.	Drainage area.	Rainfall on basin.					Flow per second, average for the 24 hours.	Theoretical horse power.				Effective horse-power utilized in 1880.
		Spring.	Summer.	Autumn.	Winter.	Year.		1 foot fall.	41 feet fall.	50 feet fall.	62½ feet fall.	
	Sq. miles.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Cubic feet.*					
Low-water, dry year	6,902	10	12	11½	9	42½	3,100	352.16	14,440	17,610	22,010	4,320
Low-water, average year							3,500	397.60	16,300	19,880	24,850	
Available 10 months, average year							4,500	511.20	20,960	25,560	31,950	

TURNER'S FALLS TO BELLOWS FALLS.—From the top of the Turner's Falls dam to the foot of Bellows falls, a distance of about 50 miles, there is a rise of 61 feet, corresponding to an average slope of say 1.2 foot per mile. The stream runs nearly all this distance with smooth water, rapids occurring at but one or two points.

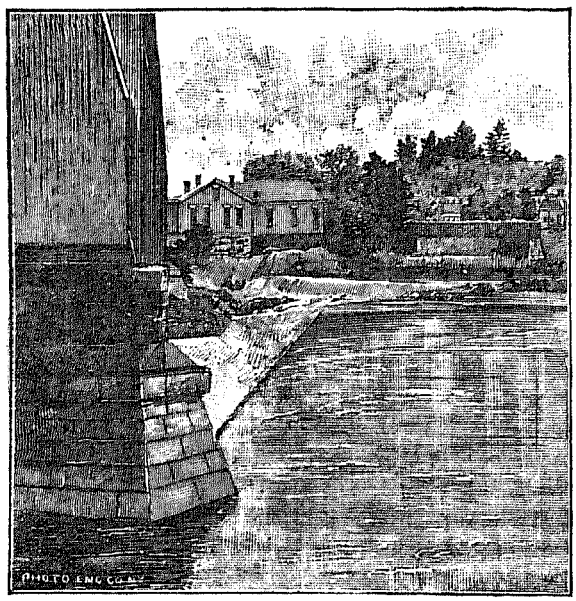

FIG. 18.—Dam at Bellows Falls.

Three and one-half or 4 miles above Turner's Falls, and about a third of a mile above the mouth of Miller's river, are what are known as the "French King" rapids. A ledge of rock runs diagonally in a broken line across the river, and large bowlders of conglomerate also appear in the bed. These rapids extend only a few hundred feet, and the fall in that distance cannot be more than 2 or 3 feet, with smooth water above and below. Below this vicinity, down to Miller's river, the banks appear firm, and are in places of solid rock. From the rapids down, the east bank rises high and steep, directly from the water; the opposite bank is less abrupt, but does not offer a favorable site for the large use of power.

Power at Bellows Falls.—At Bellows Falls the immediate valley is probably less than a mile wide and is inclosed by steep hills. The river here descends over a series of ledges and through a narrow gorge, where it is hemmed in by high walls of solid rock; between these it rushes down in falls and rapids, but reaching the foot of the gorge spreads out again in smooth water, resuming its characteristic appearance. A dam extends across at the head of the rapids, and a canal conveys water thence, at some distance from the river-bank, down to the foot of the falls, where are located the mills.

At the site of the dam the river contains huge outcropping ledges, between which the structure has been built in an irregular line projecting well up stream. The distance across in a straight line is 550 feet, but the actual

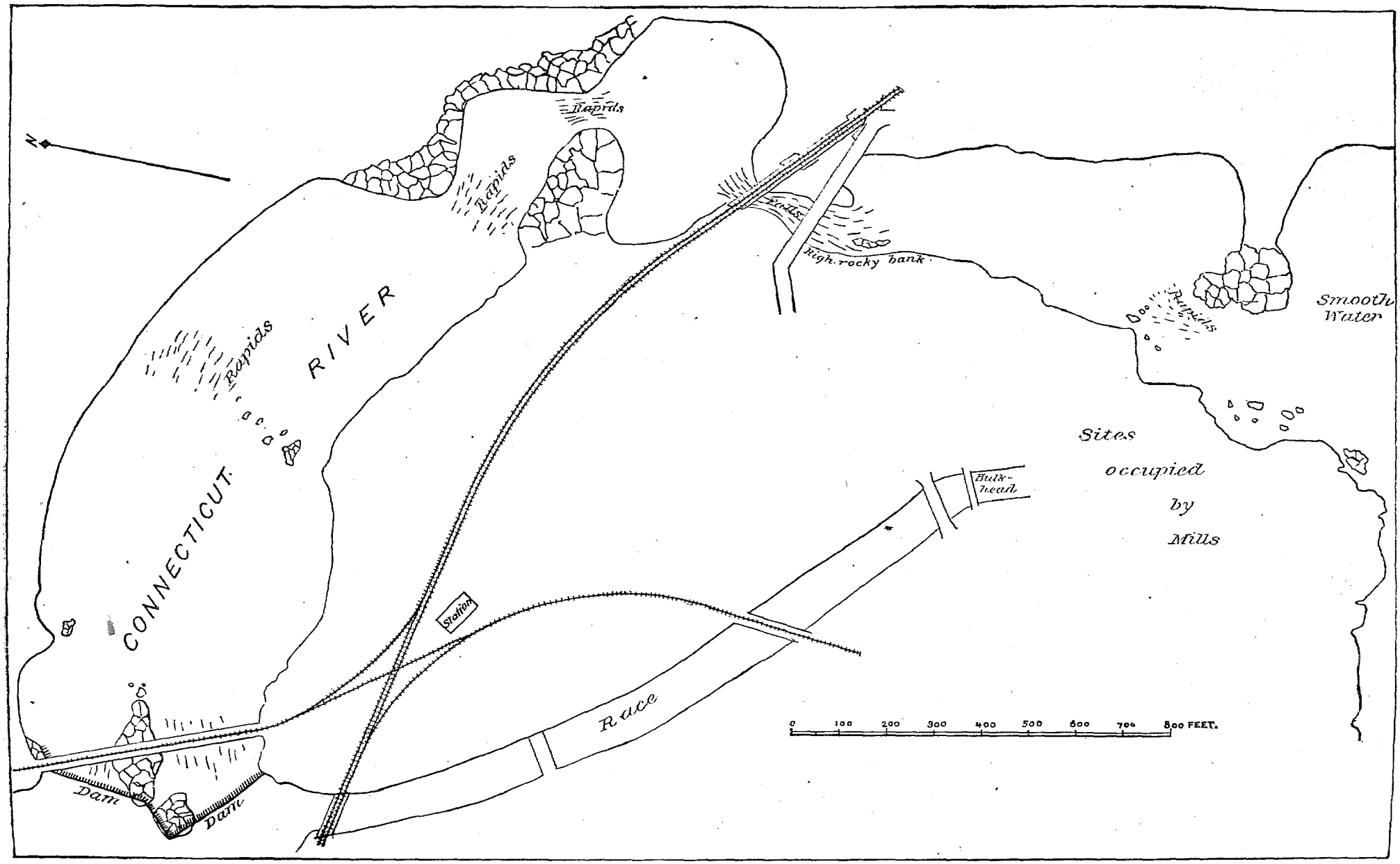

FIG. 19.—Water Privilege at Bellows Falls.

length of roll-way is probably as much as 600 feet. The iron bridge of the Sullivan County railroad spans the stream close to the dam, and its piers are founded upon the same ledges against which the latter abuts. The dam was originally built about 1795, but was rebuilt in 1869 at a cost stated to have been about $25,000. It is constructed of logs, rests throughout upon solid rock, to which it is firmly bolted down, and has natural rock abutments. The influence of slack-water from this dam is thought to extend at least 8 miles up the river.

The canal opens out a short distance from the end of the dam, and in its upper course has about 65 feet width of water-way. Before reaching the bulkhead, which is 1,500 feet from the entrance, it is an excavation in earth and is walled only to a small extent. At the first or upper bulkhead it narrows to about 30 feet and runs through a passage-way blasted in the solid rock. This bulkhead is of wood, and contains three gates, raised by a screw and cog-wheel arrangement, worked by a hand-wheel. A short distance beyond there is a second bulkhead, also of wood, and built in two sections at right angles with each other. The main canal here divides into two branches, which run short distances and in turn subdivide to convey water to the mills, which are close at hand. In certain improvements which are contemplated the upper bulkhead is to be entirely removed and the canal made as wide there as above. The lower bulkhead is to be replaced by a new structure of stone, in which there will be for each set of gates, *i. e.*, for each of the two branches of the canal, two openings 4 feet wide and two 8 feet wide, each opening to extend 10 feet below the water-surface.

The total fall from the top of the dam to smooth water below all the rapids is commonly given as from 52 to 54½ feet.(*a*) A fall of 22 feet is taken up from the main canal, or upper level, to the lower, and the balance thence to the river. Some of the mills draw from the upper level and discharge directly into the river, and in a number of cases the fall available at mills is not entirely utilized.

The water-privilege here is owned by the Bellows Falls Canal Company, which leases power to the various manufacturers. The nominal rate charged is $450 per annum per mill-power of 60 horse-power. No accurate measurements are made of the amounts of water used, but the quantities rated for the wheels are accepted in practice. In the fall of 1882 there were the following lessees of power:

Lessees of power at Bellows Falls, October, 1882.

Firm.	Manufacture, etc.	Production, etc.
Fall Mountain Paper Company	News and manila papers, and card middles	Employs 300 hands. Production, 25 tons per day.
Moore, Arms, & Thompson	Manila and other papers	Employ 80 hands. Production, 10 tons per day.
Willard Russell & Company	Wood-pulp and manila paper	Employ 27 hands. Production, 2½ tons of pulp and 4 tons of paper per day.
J. T. Moore	Tissue manila paper	Employs 11 hands. Production, from 1,200 to 1,500 pounds per day.
Flint & Fisher	Tissue and medium manila papers	Production, from 1 to 2 tons per day.
John Robertson & Son	do	Production, from 2,000 to 4,500 pounds per day.
Vermont Farm Machine Company	Various implements for dairy farming	Employs from 60 to 70 hands.
Bacon Brothers	Planing and sawing	
Osgood & Barker	Machinists	
Lucien Barbour	Picture-molding	
Adams	Grist-mill	

Several of the smaller powers are supplied by wheels put in by the canal company. Steam is not used for power at any of the mills; the water-supply is commonly sufficient, though for one week during the summer of 1882 it was necessary to shut down half of one mill. The various mills are built in very closely and irregularly upon a rocky slope, and though the firm foundations which they obtain are an advantage, still the location appears poorly suited by nature to the convenience of extensive manufacturing. On one occasion, at least, the river has risen so as to overflow the lower portion of this site. The ordinary rise, however, at the foot of the rapids is not excessive, and for the five years preceding 1882 had probably not exceeded 8 feet; a large mass of rock which obstructed the river there was being removed by blasting during the year mentioned, and an enlarged water-way will thus be afforded with less danger of overflow. Of the freshets in this part of the Connecticut river, those of 1862, 1869, and 1872 have been notable ones; during the heavy rains of September, 1882, there was a depth of 5 feet on the Bellows Falls dam. Surface-ice usually remains long enough above the dam to become thoroughly rotted. The ice in the canal breaks up every few days, and is then removed. There is very slight trouble from anchor-ice except in an open winter.

There is some vacant space still available for new mills, and the widening out of the canal at the upper bulkhead will permit a considerably increased supply of water at its foot. Following is an estimate of the power of the river at this privilege:

a This is somewhat greater than the figure previously given (49 feet) for the descent from the head to the foot of the falls, in the general table of elevations on the Connecticut river, as taken from Hitchcock's *Atlas of New Hampshire*. The disagreement may be due to the measurements having been made between slightly different limits, or not at the same stage of river.

Estimate of power at Bellows Falls.

Stage of river.	Drainage area.	RAINFALL ON BASIN.					Flow per second, average for the 24 hours.	Theoretical horse-power.				
		Spring.	Summer.	Autumn.	Winter.	Year.						
	Sq. miles.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Cubic feet.*	*1 foot fall.*	*49 feet fall.*	*50 feet fall.*	*52 feet fall.*	*54½ feet fall.*
Low water, dry year (*a*)	5,211	9½	11½	10½	8½	40	1,950	221.52	10,850	11,080	11,520	12,070
Low water, average year							2,300	261.28	12,800	13,060	13,590	14,240
Available 10 months, average year							3,000	340.80	16,700	17,040	17,720	18,570

a In extreme cases the power may sink somewhat lower than the figures here given, but in the very lowest stage of river the effective horse-power is stated by the president of the canal company not to fall below about 8,000.

NOTE.—Total effective horse-power utilized in 1880, as returned by enumerators, 4,210. Up to October, 1882, this amount had been increased, by the introduction of two new mills and increasing the power at the old ones, to 7,040 horse-power, of which 6,847 was employed in paper manufacture.

RIVER ABOVE BELLOWS FALLS.—*Sumner's or Quechee falls.*—This is the first water-privilege met in ascending above Bellows Falls, and is located 2 miles below the mouth of the Ottaquechee river, and 7 miles below White River Junction; it is owned by Messrs. Moses, D. H., and John C. Newton, all of Holyoke. There was formerly a dam 8 or 9 feet high at this point, by which a total fall of 13 feet was obtained; with obstructions removed, the available fall of the privilege would now be 15 feet. For 1,000 or 1,500 feet the river is full of ledges, which rise above the surface at many points, and among these it runs in a series of rapids, having thus a natural fall of 8 feet.

A division of the Central Vermont railroad runs along the west bank, which is high and steep. The east bank is rocky and of fair height, and is succeeded by a fine open stretch of comparatively level ground. The power is at present entirely unimproved, and no sign remains of the old dam, unless it be a short piece of rude crib-work next the west shore. It is said that the Messrs. Newton had made arrangements to build a new dam here, but that the opposition of a neighboring mill-owner, on a side stream above, who claimed that his privilege would be within reach of backwater from the proposed dam, interfered with carrying out the enterprise.

September 1, 1882, the volume of water at this locality, in a very low stage, was gauged and found to be 1,377 cubic feet per second. By estimate, the power to be obtained in different stages may be given as below:

Estimate of power at Sumner's falls.

Stage of river.	Drainage area.	RAINFALL ON BASIN.					Flow per second, average for the 24 hours.	Theoretical horse-power.		
		Spring.	Summer.	Autumn.	Winter.	Year.				
	Sq. miles.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Cubic feet.*	*1 foot fall.*	*13 feet fall.*	*15 feet fall.*
Low water, dry year	4,234	9½	12	10½	8½	40½	1,500	170.40	2,220	2,560
Low water, average year							1,800	204.48	2,660	3,070
Available 10 months, average year							2,350	266.96	3,470	4,000

Olcott or White River falls.—Nine miles above Sumner's falls, and about 2 miles above White River Junction, is the Olcott Falls privilege, probably the best on the Connecticut river above Bellows Falls. It is said to be owned mainly, if not entirely, by Messrs. Wilder & Co., paper manufacturers, of Boston, and in October, 1882, was being developed by the Olcott Falls Company. A series of rapids and falls here extend for some distance down the river, while the west bank presents a fine level plain for mills and a village. At the time mentioned a substantial crib-work dam, located at the upper falls, was already far advanced in construction. It rests throughout upon ledge rock, to which it is bolted down, and the logs are also bolted together at each intersection. The dam runs in a long curve diagonally across the river, with a roll-way about 600 feet in length. It was designed to have a height in midstream of 18 or 20 feet, and a corresponding base of 54 or 55 feet, but these dimensions decrease as the dam runs in on the ledges. The structure has a long back-slope covered with 4-inch hemlock planking, while the crest is protected by boiler-iron. The face of the dam slopes down stream from the crest a short distance, and then drops off vertically.

The crib-work consists of hemlock logs ranging from 10 to 16 inches in diameter. The logs were first sawed so as to give two parallel faces, each log being sawed to its best advantage, and selection was made from these so that timbers of uniform thickness came in the same layer. When completed the dam was to contain over 1,000,000 feet of timber.

On the east bank there is a natural rock abutment. At the west end of the dam there were being constructed an artificial abutment and bulkhead of granite masonry rising 9 feet above the top of the dam. The bulkhead was designed to be 27 feet wide with the current, and to contain eight gate-openings, each 8 feet wide in the clear; these were to connect with a canal about 80 feet wide, running thence to the level ground before mentioned.

The fall on this privilege is 35 feet. It is stated by Messrs. Wilder & Co. that they intend to use a portion of the power in the manufacture of wood-pulp and paper, probably with works of a capacity for 10 tons of each per day. They estimate that they will have from 3,000 to 5,000 horse-power surplus to dispose of, with all the land necessary. A spur-track from the Passumpsic railroad will run directly to the grounds. The privilege is an

excellent one, though as there is now no settlement at the locality, a village will have to be built up. The measurements of flow made by Professor Fletcher at Hanover, a couple of miles above, and already given in the introductory remarks on the river, will serve as a guide to the volume that may be depended on at certain stages of water. For low water of dry and average years, and for the amount available ten months in average years, the volume and corresponding theoretical horse-power are here estimated at the following figures:

Estimated volume and power of the Connecticut river at Olcott falls.

Stage of river.	Drainage area.	RAINFALL ON BASIN.					Flow per second, average for the 24 hours.	Theoretical horse-power.	
		Spring.	Summer.	Autumn.	Winter.	Year.			
	Sq. miles.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Cubic feet.*	1 *foot fall.*	35 *feet fall.*
Low water, dry year	3,373	9½	12	10½	8½	40½	1,100	124.96	4,370
Low water, average year							1,400	159.04	5,570
Available 10 months, average year							1,800	204.48	7,160

Passing above Olcott falls there are no shoals worth mentioning below Dodge's falls. Between the villages of Woodsville and Wells River the stream is narrow, and has a rocky bed with high rocky banks, and it is said that the plan has been considered of building a dam there 10 or 12 feet high, and running a canal to a flat a short distance below. There is no shoal at this point, and a fall only equal to the lift of the dam could be obtained. From here up to Dodge's falls the banks are of good height, and in places rocky. At intervals they are succeeded by level plateaus stretching back from the river, while at other points the hills rise at once on either side from the water.

Dodge's falls.—These are 4¼ miles by river above Wells River. Rapids here continue for 1,000 or 1,500 feet, with two principal pitches a few hundred feet apart. In the narrow part of the rapids the width between banks is perhaps 350 feet. The stream is full of rocky reefs, rising here and there a few feet above the water. The banks are of good height, and for 10 or 15 feet above low water are of solid ledge. Below the falls the east bank is high and abrupt, but on the west side there is a wide level tract of land. The location is good, the railroad being close at hand, and there is a fine site for a secure dam.

According to a table previously given, the descent from the foot of McIndoe's falls, the next above, down to Wells River, a distance of about 7 miles, is 25 feet. The pocket-level indicates a total fall on the rapids of 12 or 15 feet. The privilege is owned by Mr. George Van Dyke, of McIndoe's Falls, and was formerly used by a saw-mill, but the mill and dam are said to have been carried away in a freshet a few years ago. It is claimed by Mr. Van Dyke that a dam 12 feet high can be built on the site of the old one, somewhat above the foot of the falls, without injury to the privilege above.

Estimate of power at Dodge's falls.

Stage of river.	Drainage area.	RAINFALL ON BASIN.					Flow per second, average for the 24 hours.	Theoretical horse-power.		
		Spring.	Summer.	Autumn.	Winter.	Year.				
	Sq. miles.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Cubic feet.*	1 *foot fall.*	12 *feet fall.*	15 *feet fall.*
Low water, dry year	2,219	9	12	16½	8½	40	650	73.84	890	1,110
Low water, average year							850	96.56	1,160	1,450
Available 10 months, average year							1,150	130.64	1,570	1,960

McIndoe's Falls.—The power at the west end of the dam is owned by the creditors of R. E. Peabody, of Saint Johnsbury, Vermont, but is leased by George Van Dyke, who runs a large saw-mill here, at which 10,000,000 or 12,000,000 feet of lumber are sawed annually. The dam is an old and not very tight structure of logs, extending out from either shore to an outcropping ledge in the center of the river; the fall is 12 feet. Van Dyke has wheels of from 300 to 400 horse-power capacity, and with a good dam would have surplus water at the lowest stage of the river. On the east side of the river the power is owned by Messrs. Hadlock & Willey, who operate a grist-mill with about five runs of stone.

Estimate of power at McIndoe's Falls.

Stage of river.	Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power.		Effective horse-power utilized.
	Sq. miles.	*Cubic feet.*	1 *foot fall.*	12 *feet fall.*	
Low water, dry year	2,205	650	73.84	890	350–450 (?)
Low water, average year		850	96.56	1,160	
Available 10 months, average year		1,150	130.64	1,570	

Barnet bridge.—Passing up stream, the next fall is close by Barnet bridge, where there is an abrupt pitch of about 4 feet. The stream narrows to a low-water width of 50 feet under the bridge, and flows between high steep rocky banks. The natural site for a secure dam is fine, and there is good building-ground just below on the east side, but there are several features which probably deprive the privilege of practical value. The freshet-rise in so contracted a place is great, and in extreme cases reaches the railroad track which runs along the west bank and below the falls is 17 feet above low water. It would not therefore answer to raise the river here with the railroad as at present. Above the falls are extensive low meadows which would be overflowed if a dam were built, and it is probable also that a dam of much height would cause backwater at the East Barnet privilege on the Passumpsic.

Summary of water-privileges on the Connecticut river below the Passumpsic river.

Locality.	Drainage area.	Fall used or available.	Theoretical horse-power, average for the twenty-four hours.			Effective horse-power utilized.	Remarks.
			Low water, dry year.	Low water, average year.	Available ten months, average year.		
	Sq. miles.	*Feet.*					
McIndoe's Falls	2,205	12	890	1,160	1,570	350–450	Power used by 5-run grist-mill, and large saw-mill turning out 10,000,000 to 12,000,000 feet of lumber annually.
Dodge's falls	2,219	12	890	1,160	1,570	.....	Power formerly used by saw-mill, but dam is now gone, and the privilege is entirely unoccupied.
Olcott falls	3,373	35	4,370	5,570	7,160	.....	A splendid power, recently developed by Wilder & Co., of Boston. They will erect extensive works for the manufacture of pulp and paper, and will have a large surplus power for disposal.
Sumner's falls	4,234	15	2,560	3,070	4,000	.....	A fine privilege, but entirely unimproved. Owned by the Messrs. Newton, of Holyoke.
Bellows Falls	5,211	*a* 52	11,520	13,590	17,720	7,040	Power largely employed, mainly in the manufacture of paper. See description.
Turner's Falls	6,902	*b* 62½	22,010	24,850	31,950	4,320	See description.
Holyoke	8,006	50	25,470	27,480	35,190	15,000±	Do.
Windsor Locks	9,347	*a* 30	15,500	16,700	21,130	1,800–1,900	Do.
Total at above falls	.....	277½	83,210	93,580	120,290	28,500±	
Total effective power available, assuming an efficiency of 80 per cent	.....	.....	66,570	74,860	96,230	.....	
Total effective power available, assuming an efficiency of 60 per cent	.....	.....	49,930	56,150	72,170	.....	

a Approximately. *b* Only 41 feet thus far developed.

Fifteen-Mile falls.—These falls begin shortly above the mouth of the Passumpsic, and are said to continue substantially unbroken to Dalton, the rise in this distance amounting to nearly 400 feet. Near the junction with the Passumpsic the Connecticut river runs in a wide open valley and is bordered by low meadows. Its bed is there gravelly, its banks are low, and there is a moderately rapid current. Both rivers have worn several channels across these meadows, by which their waters are dispersed and form islands.

Two or 3 miles farther up stream, near Mulligan's mill, which is on a little tributary brook, the main river was found to be full of rapids, the bed gravelly, and apparently ledgy at points. The west bank is there of good height and is composed of solid rock; the east bank rises high and steep and is sandy. Except for this latter feature the locality would afford a splendid site for power, the west bank being very favorable for buildings and a canal. A very good pondage could be obtained over poor land. At Lower Waterford bridge the river is 275 or 300 feet wide, and flows in rapids over a gravelly bed. The banks are high and composed of gravelly soil.

It may be said in general of the section between Barnet and Lower Waterford that the country is sparsely settled and but little cultivated. Corn and grass seem to be the principal productions, while to the south of Barnet considerable land is devoted to sheep-pasturage. Very little meadow-land is to be seen along this part of the river, and at times the valley is narrow and deep with steep side slopes. The adjoining country rises to high hills with generally rounded outlines, though rocky and precipitous in places. The most noticeable feature from the river valley is the extent to which the timber has been cut away, the hills appearing much more bare than 200 miles farther south; what trees do remain are of young growth. A short distance above Barnet the Passumpsic railroad leaves the main river and follows up the valley of the Passumpsic. The immediate valley of the Connecticut is then without any railroad throughout the length of the Fifteen-Mile falls; but from their head, near Dalton, the Boston, Concord, Montreal, and White Mountains railroad and the Grand Trunk railway follow the river, in the order named, for about 25 miles, above which it is distant from any line.

The examination of the Connecticut river did not extend above Lower Waterford, but the upper course has been described by Dr. C. H. Hitchcock, in the *Geology of New Hampshire*, and the liberty will be taken of quoting from the account there given. Writing of the surface features of the surrounding region, Dr. Hitchcock

states that "the extreme northern part of New Hampshire is covered by a continuous primeval forest, and the surface of the country is broken by undulating ridges which here and there rise to mountain heights". The northern basin of the Connecticut river in Vermont is of similar character to that in New Hampshire. The statement which has been quoted was made eight or ten years ago, and since that time serious inroads have yearly been made upon the forests of this section, though they have not yet been sufficient materially to alter the general proportion of timber.

The extreme source of the Connecticut river is in the Third lake, or lake Sophy, which lies within half a mile of the Canada border. Four miles to the south it reaches the Second lake, which is of considerably larger size. Five miles in an easterly direction from Second lake the water-shed of the Connecticut river just touches the boundary of Maine. The Second lake and the course of the river below are thus described by Dr. Hitchcock:

This lake is 2¾ miles in length, and in the widest part it is little more than a mile, and the height above the sea is 1,882 feet. Its area is about 1¼ square mile. It is one of the most beautiful of our northern lakes. The graceful contour of its shores, the symmetry of its projecting points, the stately growth of its primeval forests, the carpet of green that is spread along its border and extends through the long vista of the woods, the receding hills and the distant mountains, present a combination of the wild, the grand, and the beautiful that is rarely seen. Near its northern border, besides the Connecticut, it receives two tributaries, one from the northeast and one from the northwest.

Its outlet is on the west side, near its southern limit; it is 40 feet in width and has a depth of 18 inches. Twenty rods from the lake it has a fall of 18 feet or more; then its descent is quite gradual, but forms here and there deep eddies. A mile from the lake it becomes more rapid, and rushes down between precipitous walls of rock in a series of wild cascades, which continue for half a mile. It receives two tributaries from the west before it flows into Connecticut lake. Here we find a sheet of water exceedingly irregular in its outline. Its length is 4 miles, and its greatest width 2¼, and it contains not far from 3 square miles. * * * On the west shore of this lake the country is settled, and the grassy pastures extend down to its border; but for the most part it is still surrounded by a primeval forest. * * * The water at the outlet flows over a rocky barrier, the stream falling abruptly nearly 37 feet. The fall is quite rapid for 2½ miles; then the flow is more gentle for about 4 miles; then it becomes more rapid again, and continues thus until after it passes West Stewartstown. It is then nowhere a sluggish stream, and has rapids in many places until it gets below the falls of Northumberland; then it is the most placid of streams until it reaches the Fifteen-Mile falls, which begin in Dalton.

The country along the Connecticut above Hall's stream is moderately hilly, but not rugged, and in 1874 more than nine-tenths was still covered with the original forest. Thence to the head of the Fifteen-Mile falls are fertile intervales, varying from half a mile to a mile in width. The surface back from the immediate river valley rises in bold hills and mountains.

Regarding the use of power on this extreme upper section of the river but little information can here be given, and that was mainly derived from correspondence. Above McIndoe's Falls there is no dam until we reach Guildhall, where 10 feet fall and 120 horse-power are in use at a saw-mill.

The next power is at West Stewartstown, about 80 miles by river above McIndoe's Falls. The dam is a wooden structure about 200 feet long and 10 feet high, and was built fifty years or more ago. Ten feet head and 100 horse-power are used for a saw-, grist-, and starch-mill, and it is stated that no additional power could be run, except in spring and fall. Where flowing freely the river has in that vicinity an average width of about 150 feet, with a summer depth of 2 and a winter depth of 3 feet.

Mr. W. F. Allen, proprietor of the saw-mill at West Stewarstown, wrote, in 1880, that there were thirteen dams above him on the Connecticut, having an average fall of 9 feet; and that there were dams at the outlet of both the First and Second Connecticut lakes, the former capable of being raised 12 feet and the latter 8 feet. Probably these dams at the headwaters are utilized mainly for the purposes of log-driving.

Drainage areas of the upper Connecticut river.

Locality.	Square miles.
At outlet of Second lake	47
At outlet of Connecticut lake	93
Below the mouth of the Nulhegan river	794
Below the mouth of the upper Ammonoosuc river	1,176
At Dalton	1,431
Below the mouth of the Passumpsic river	2,139

TRIBUTARIES OF THE CONNECTICUT RIVER.

From the hills, and even mountains, which rise higher and higher as we depart from the immediate valley of the Connecticut, numerous swift-running streams, frequently broken by rapids and falls, flow down to the main river, and, being sustained by springs, lakes, ponds, and artificial reservoirs, furnish valuable water-powers which are largely utilized. Some of the more important of these streams will be described, beginning toward the mouth of

the Connecticut, and taking up, in order, Salmon, Hockanum, Farmington, Scantic, Westfield, Chicopee, Mill, Deerfield, and Miller's rivers, and, in less detail, some of the tributaries received in New Hampshire and Vermont, the names and drainage areas of which are included in the list given below:

Principal tributaries of the Connecticut river.

Name.	Lies on which side of main stream.	Lies in what state.	Drainage area.	Name.	Lies on which side of main stream.	Lies in what state.	Drainage area.
			Sq. miles.				*Sq. miles.*
Perry stream	North	New Hampshire	27	Black river	West	Vermont	152
Indian stream	do	do	67	Williams river	do	do	103
Hall's stream	do	New Hampshire and Canada.	88	West river	do	do	363
Nulhegan river	West	Vermont	132	Ashuelot river	East	New Hampshire	422
Upper Ammonoosuc river	East	New Hampshire	252	Miller's river	do	Massachusetts	396
Israel's river	do	do	129	Deerfield river	West	Vermont and Massachusetts.	646
John's river	do	do	86	Mill river	do	Massachusetts	58
Passumpsic river	West	Vermont	485	Chicopee river	East	do	706
Wells river	do	do	94	Westfield river	West	do	514
Lower Ammonoosuc river	East	New Hampshire	388	Scantic river	East	Massachusetts and Connecticut.	118
Wait's river	West	Vermont	156	Farmington river	West	Connecticut	584
Ompompanoosuc river	do	do	123	Little river	do	do	76
White river	do	do	623	Hockanum river	East	do	79
Mascomy river	East	New Hampshire	190	Salmon river	do	do	159
Ottaquechee river	West	Vermont	192				
Sugar river	East	New Hampshire	272				

THE SALMON RIVER.

The main portion of this stream is formed in the western part of the town of Colchester, Connecticut, by the union of Black Ledge river and Salmon brook. It runs thence southwesterly and southerly a distance of 9 or 10 miles to the Connecticut, forming the boundary between the towns of East Haddam on the one hand, and Chatham and Haddam on the other, and empties at East Haddam Landing. Its basin comprises 150 square miles.

The river has not been much developed, but it is looked upon with great favor by those using it, and would admit of considerable improvement and further use. It drains a hilly section, thickly timbered and having small agricultural value. The immediate valley is, as a rule, narrow and deep; toward the mouth, though, it opens out, and the river is bordered by low lands subject to overflow. During eight months in the year a small steamer can ascend about 2 miles from the mouth, or to within a mile or so of Leesville. This route is said to be used generally by the merchants for freighting, and will be by the Moodus manufacturers whenever it becomes possible to ship directly to New York by this channel. At present the Leesville factory sends merchandise by team to Goodspeed's Landing, while the mill at Comstock's Bridge, a few miles above, ships by the Air Line railroad from Lyman Viaduct. The bed of the river at Leesville and above is either ledge rock, or gravel underlaid by ledge rock at a slight depth; granite and mica schist are the prevailing varieties. The banks are gravelly. Below Leesville the stream is under the influence of backwater from the Connecticut, but above that point it has a pretty steady fall, and is mainly made up of shoals. At Comstock's Bridge the width is 50 feet, and at Leesville about 90 feet.

Since Pine brook and Moodus river both enter the Salmon below the lowest water-privilege, the reservoirs on those important little streams are no help to manufacturing on the main stream, and the latter really receives but moderate assistance from any reservoirs. The only ones draining into its upper course are as follows:

1. North pond, on the line between Hebron and Lebanon, is estimated to contain 200 acres, but measures 244 acres upon Clark & Tackabury's map of the state (1859). It is fed almost entirely by springs, can be drawn down 10 feet from full-water line, and usually fills, though it did not do so for the two years prior to the fall of 1882. There is no wastage, and the supply could not therefore be substantially increased by raising the dam. The reservoir is controlled by A. G. Turner.

2. Marlborough pond is controlled by H. A. Blakeslee, of Hartford. It is described as being nearly a mile long and about a third of a mile wide. It can be drawn down 9 feet from full-water line to the bottom of the gate, and after leaving the lake the water falls 52 feet within a short distance. The pond fills regularly every spring, and keeps well filled during the entire year, its supply being largely from springs. It is thought that the surface might be raised 3 or 4 feet higher at no great outlay.

3. Whitmore's reservoir, in the town of Colchester.

It is claimed on Salmon river that these reservoirs, as they are now operated, are of not much assistance to the stream in the dry season. There was formerly a paper-mill on the outlet of Whitmore's reservoir, but it has been removed, and the reservoir now acts only as a natural pond. There are also stated to be mills at the outlets of North and Marlborough ponds; consequently these ponds, being drawn down upon for more or less continuous use, cannot be managed strictly as storage reservoirs, and are not therefore of the benefit they might otherwise be to the main stream. Manufacturers on the latter consider, however, that new storage reservoirs might conveniently be built, and that the low-water flow might thereby be doubled, or even trebled. The stream drains a considerable area, receives many tributary brooks supplied by springs, and the valleys are favorable to storage, exhibiting, as the eastern Connecticut streams generally do, frequent intervales shut in on all sides by hills. The water of the stream is very clear and pure.

As it now is, Salmon river is subject to considerable fluctuations in volume, and rises rapidly after rains. In the highest freshet observed at Comstock's Bridge the water poured over the 250-foot roll-way 8 feet deep. The ordinary spring-freshet rise on this dam is about 4 feet, and in the river below the Leesville dam 6 feet is looked upon as a heavy rise. There is a large run of cake-ice down stream in spring, but usually sufficient depth of water on the dams to carry it over without injury to them. The ice sometimes gorges in the narrows and causes backwater. At Comstock's Bridge this has been sufficient to hide the dam completely from sight, though the gorges last but a short time. They also form below Leesville, and cause some backwater there for perhaps half an hour at a time. But, generally speaking, backwater is not considered a serious hinderance on this river. The Leesville mill has been known to stop a day from that cause but not a minute, even, during the five years preceding 1882.

At the village just mentioned the first power met in ascending the stream is in use by the East Haddam Duck Company, running 1,080 spindles. The river-bed is at this point solid ledge rock. The dam rests upon that foundation, and is a framed structure having three rows of vertical braces. The roll-way is 120 feet long, 12 feet high, and is supplemented by a gravel embankment. There is a considerable amount of leakage through the dam. The ponds set back a mile or a mile and a half, and is alone sufficient to run the mill for a day. Water is brought 225 feet to the mill through a wooden tube. This is made of 2½-inch white pine, is 54 inches in internal diameter, and is secured by ¾-inch round-iron hoops at intervals of 15 inches. The tube showed no leakage whatever. The fall at the mill is 17½ feet, and the rated wheel capacity 70 horse-power. It is stated that in ordinary years this can be realized throughout, with a waste over the dam nearly all the time, but in extraordinarily dry seasons, such as prevailed in the years 1880–'82, there is some scarcity of water, though the effective horse-power is estimated never to run below 50.

From Leesville up to Comstock's Bridge, a distance by river of 3¼ miles, the traveled road runs high up on the side of the valley, which is much of the way very narrow and deep. Though a mill-site could probably be found, it would not be very easily accessible, nor would there be good opportunity for much of a village.

The privilege at Comstock's Bridge is occupied by Brown Brothers, manufacturers of card paper. They have a stone dam, raised 2 feet on top by a wood addition. The roll-way is 250 feet long and 7 feet high. Water is brought to the mill 50 or 60 rods in a race. The fall is 16 feet, and 100 horse-power is used twenty-four hours in the day. In an average year this can be obtained for about eleven months, but in an exceptionally dry season the power sinks as low as 30 horse-power, which is considered the minimum. In ordinary years there is a large waste over the dam for eight months.

The stream was not examined above this point, but there were reported to be another paper-mill and a grist-mill within 3 miles. There is some unimproved fall on this part of the stream, though no data are accessible showing accurately its amount. The manager of the Leesville mill estimated the rise to be from 15 to 20 feet between that point and Comstock's Bridge, and at the latter point it was thought that a good privilege might be secured within half a mile either above or below, and with a very considerable pondage in one case. The theoretical power of the stream there may be estimated as below:

Estimated flow and power at Comstock's Bridge.

Stage of river.	Drainage area.	Average flow per second for the 24 hours.	Theoretical horse-power per foot fall.
	Sq. miles.	*Cu. feet.*	
Low water, average year	103	35	3.98
Available 10 months, average year	103	55	6.25

NOTE.—Average rainfall on basin, 11 inches in spring, 14½ in summer, 10½ in autumn, 12 in winter, and 48 for the year.

Salmon river receives in its lower course two important little tributaries, known as Moodus river and Pine brook.

Moodus river flows from the east through the town of East Haddam, and is but a few miles in length, measured to its extreme source. Bashan and another small brook unite some distance above the village of Moodus to form Meadow brook, and this, from a point about a mile and a half above the village, is called Moodus river. This stream drains a hilly wooded district well supplied with springs. Its bed is rocky, the stone being rather soft and of no value for building dams or mills. The principal variety of timber found near is chestnut, with some hickory, oak, and maple. The descent of the stream is rapid, amounting to 350 feet or more in about 2 miles. The hills shed water freely and there is a quick rise after rains. The flow is, nevertheless, well sustained in summer, being supplied by two completed reservoirs, as follows:

1. Bashan pond, a natural lake raised by a dam. It covers about 300 acres when full, and can be drawn the equivalent of 220 acres to an average depth of 14 feet. If drawn down to the utmost it does not ordinarily fill up again in a single season; indeed, it has only been full twice since it has been used as a reservoir. It receives no tributary streams of any importance.

2. Fall Brook reservoir drains through Fall brook into the main stream about a mile and a half above Moodus. It is much smaller than Bashan pond, but furnishes a good supply of water and fills regularly, the brook running into it from above. It is estimated to flow about 140 acres when full, and can be drawn down the equivalent of 100 acres to an average depth of 5 feet.

These reservoirs are some little distance away from the mills, on side streams, and the water being allowed to run steadily from them, night and day, during the dry season, there is considerable wastage, the mill-ponds having very little capacity for storage. It is said that on opening the gates it takes three days for water from Bashan pond to reach Moodus in sufficient quantity to be of any avail, as much is in the intervening distance soaked up by the ground and retained in swamps and other low places.

The reservoir capacity can yet be largely increased, and it is estimated that the low-water volume of the stream even now can be doubled. In September, 1882, there was in process of construction a new storage-reservoir a mile and a half above the village of Moodus. It lies directly upon the main stream, to which it will prove a great help. The dam at its outlet was designed to have a roll-way 135 feet long, and to be built upon the site previously occupied by a very low dam which raised the stream perhaps 3 feet. It will be raised at present 5 feet above the old dam, and will give a flowage of 328 acres to a shallow depth. A storage of 40,000,000 cubic feet will thus be obtained, which is estimated sufficient to maintain the supply at the mills for six weeks during summer. The total expense of the improvement, including damages for flowage, is placed at $12,000. Being just above the mills, this reservoir can be easily controlled, and will permit a very economical use of the water of the stream. It is stated that the stream can be raised, in all, 15 feet at this point above its natural surface. By raising the reservoir surface 5 feet still higher than at present contemplated, a total flowage of 448 acres can be obtained, and a corresponding storage of 120,000,000 cubic feet. Without the assistance of the new reservoir, the ordinary spring flow of the stream, when not wasting at the upper reservoirs, has been found to be about 38 cubic feet per second at Moodus. All three of the reservoirs which have been mentioned are owned by an association composed of the various mill-owners benefited.

The manufacturing on this stream is mainly in the village of Moodus, but is scattered along 2 miles of its course. The mills are rather small, and of the thirteen, all but three make seine-twine; two establishments manufacture duck, and one, the Moodus Yarn Company, makes yarns and threads. The goods are mostly sent to New York, being shipped by team to Goodspeed's Landing, and thence by water during the period of steamboat navigation. The traffic thus brought about by the manufacturing on this mere brook is quite large, and Goodspeed's Landing is said to rank next after Hartford and Middletown in importance as a shipping point on the river.

The dams on the stream are in some cases stone, and in others framed; they probably average 50 feet in length of roll-way. Water is carried to the mills in races of moderate length. The falls used are large, but turbine wheels are employed except at the Williams Duck Company, where there is a breast-wheel. The wheels are stated, however, to be generally of old patterns and wasteful of water. Owing to this waste, and to that arising from the manner in which it is found necessary to manage the old reservoirs, the stream is not economically used. Still it is a good little stream for power, and is so considered by those using it. Hitherto the mills have been stopped about a month in summer by low water, but with the new reservoir completed it is expected that they will run steadily through that season. It is estimated by good authority that the wheels now employed in the village have a total of about 800 horse-power. The Moodus Yarn Company is the only concern employing steam for power at all; it uses steam all the time, but with new water-wheels can probably dispense with it.

Statistics of manufacturing at Moodus in August, 1882.

[Furnished by Mr. Greene, of the Moodus Yarn Company.]

Firms in order below new reservoir (no mills above).	Manufacture.	Fall.	Number of spindles.	Production per week in finished goods.
		Feet.		*Pounds.*
New York Net & Twine Company		68	2,160	5,000
Atlantic Duck Company		36	1,798	5,500
Williams Duck Company		23	1,280	4,500
A. E. Purple	Seine-twine	19	1,424	3,200
J. O. Cone	Saw-mill	12		
W. L. Fowler, jr	Seine-twine	20	728	2,100
New York Net & Twine Company		21	1,184	3,800
Brownell & Co	Seine-twine	20	1,152	3,000
H. Boies	Twine and yarns	24	1,500	4,000
A. E. Purple	Seine-twine	16	1,216	2,400
Moodus Yarn Company		42½	5,496	6,800
E. Johnson	Seine-twine	20	1,024	2,500
Do	....do	25	1,024	2,600
		346½	19,986	45,400

The fall on the stream is practically all taken up. A few feet remain here and there, but not enough to constitute separate privileges.

Pine brook enters Salmon river from the north, near its mouth, heading in and deriving an important supply from Pokatopaugh lake, which lies in the town of Chatham. It is stated that the fall from the lake to the mouth of the stream, as determined by actual survey, is 460 feet in a distance of not over 7 miles. The lake is a natural sheet of water, the surface of which has been raised a little by a low dam. It is not known to have been recently surveyed, but is estimated by two or three manufacturers familiar with it to cover 800 or 900 acres. On the old state map which has been employed it measures 475 acres, but may not be correctly shown there. It receives no important tributaries, but seems to be largely fed from hidden springs. It is quite deep, probably 40 feet in places, and consequently a great part of the water cannot be drawn out. The Bevin Brothers Manufacturing Company owns the land at the outlet and controls the gates. From high-water mark the lake can be drawn down 6 or 8 feet. At an estimated expense of $2,000 the bottom can be dredged near the outlet and the gates lowered 4 feet; or at the same expense the pond can be raised 2 feet above present full-water mark. It would indeed admit of being raised a number of feet higher still, but it is thought that it could not be depended upon to fill more than the 2 feet mentioned. Two years ago, with the dam as at present, the lake did not fill, but it commonly does, and for two months or more water runs to waste.

The lake holds back freshets and ice. Its waters are very clear and pure, and Pine brook, which they supply, is regarded very highly by the manufacturers upon its course as a source of power, not so much from its size, which is small, as from its permanency. The Gong Bell Company's works have not been compelled to stop a single day in thirty years for lack of water. It is estimated that, with the lake full, the stream, under 20 feet head, will supply 35 effective horse-power throughout the year. The dams are short, and in most cases rude and cheap. Water is commonly conducted to the water-wheels through wooden flumes. The wheels are, with one exception, all turbines.

The manufacturing on Pine brook is almost entirely confined to the village of East Hampton, which is at the outlet of the lake; it is a place of about 700 inhabitants, located on the Air Line division of the New York, New Haven, and Hartford railroad. It is interesting to notice how, in passing from one small stream to another, we come upon industries the productions of which are familiar to every one, but the locations of which are known to but comparatively few. We also have frequent illustration of the tendency of members of a single trade to congregate. The chief enterprise at East Hampton is the manufacture of bells of all kinds, the yearly production of which has been estimated (in 1874) to exceed in number 25,000,000; in the particular industry of making sleigh-bells this point is claimed to be the most important in the United States. The first sleigh-bells ever made in this country were produced by William Barton, who in 1808 came from New York to East Hampton and engaged in their manufacture; he was the first man to cast sleigh-bells whole in their present form, and the first to turn them in a lathe. This branch of industry has continued to flourish, and there are now six bell-manufacturing concerns in the village.

The water-privilege nearest the lake was once occupied by a forge, where it is said that cannon-balls were made during the Revolutionary war.

Principal water-privileges on the outlet of Pokatopaugh lake.

Title of firm or privilege (in order from lake).	Manufacture.	Fall.	Remarks.
Above the village.		*Feet.*	
Old Forge privilege		12	Unoccupied.
Buell & Veazey privilege		7	Do.
Stewart D. Parmelee privilege		8	Do.
Bevin Brothers Manufacturing Company	Bells	13	
Merrick & Conant Manufacturing Company	Thread and silk	20	
Starr Brothers Bell Company	Bells	12	
Do	do	7	
East Hampton Bell Company / Gong Bell Manufacturing Company	do	19	
D. W. Watrous & Co	Bells and coffin-trimmings	7	
D. B. Niles & Sons' privilege		15	Unoccupied.
William E. Barton privilege		14	Unoccupied; mill burned.
Barton Bell Company	Bells	16	
Henry Skinner	Saw- and grist-mill	20	
Sexton privilege		7	Unoccupied.
H. B. Brown & Co	Bolt-cutting machines	12	
Below the village.			
Old gun-shop privilege	In use for some kind of manufacturing.	60	
Pine Brook Duck Company's privilege	do	30	
Wetherell privilege	do	30	
House's paper-mill	Paper	30	
Total		339	

NOTE.—The facts concerning these privileges are as stated by a manufacturer long familiar with the stream; they are undoubtedly correct in the main, although the falls may not have been given with exactness in all cases.

It will be seen from this list that there are several privileges unoccupied. The falls as given foot up 339 feet, or about 120 feet less than the total descent of the stream from the lake. There is said to be considerable undeveloped fall on the lower part of the stream, and especially on J. S. Markham's property, below H. B. Brown & Co.

THE HOCKANUM RIVER.

This important little manufacturing stream has its principal source in Shenipsit lake, which lies on the boundary between the towns of Tolland and Ellington, Connecticut. It flows thence through portions of the towns of Vernon, Ellington, Manchester, and East Hartford, running in a southwesterly course, and empties into the Connecticut opposite Hartford; it measures 18 or 20 miles in length below the lake.

Shenipsit lake is a natural pond raised by an embankment having a stone roll-way about 50 feet long. It flows 680 acres, and can be drawn down from a full stage about 23 feet at the gates. The drainage area above the outlet is 15.4 square miles. Such an extent of country of course furnishes a great amount of surface water, but the reservoir is also largely fed by hidden springs. Probably two years out of three it fills up in spring, with a little wastage at the dam for a short time; but although the latter would admit of being raised still further, it is probable that the storage could not be substantially increased over its present amount. This reservoir is owned and controlled by the Rockville Water Power Company, an association of which nearly or quite all the Rockville mill-owners are members. The Rock Manufacturing Company is perhaps the largest user of power in the village, and sufficient water is drawn from the lake to run the wheel at one of its privileges. The amount thus supplied is about 60 cubic feet per second. The lake is drawn upon throughout the year, and the amount of water stated can always be obtained, the supply having run short but once in ten years. This stream was visited August 30, 1882, and although there had been no rain whatever since July 5, there were still remaining 21 feet of water in the reservoir. A very permanent and valuable water-power is furnished along the course of the stream below, which is also freed from freshets of importance.

After leaving Shenipsit lake the Hockanum river flows down through the village of Rockville in a narrow rocky valley among high hills. It then enters upon a more open country diversified by low hills, but showing some broad stretches of comparatively level land. Tobacco is in this section the principal crop, more or less corn, potatoes, and grass also being raised. Through this portion of its course the fall in the stream is moderate, and the banks are either gravelly or soft. For a mile below Adams' paper-mill, at Manchester, the bed contains much quicksand; but for a mile below that stretch, to and including the Burnside privileges, it is composed of red-sandstone rock. Still farther down stream the bottom is soft, the river entering upon alluvial lands which border its own course and that of the Connecticut river.

The Hockanum drains an area of 79 square miles. According to the report of General Theodore G. Ellis,(*a*) its greatest discharge at the mouth is 6,167 cubic feet per second, its mean discharge 132 cubic feet per second, and its least discharge 60 cubic feet per second.

a See page 55, Appendix B 14, *Report of the Chief of Engineers, U. S. army*, 1878.

With the exception of a moderate fall, variously estimated at from 8 to 12 feet,(a) situated in the town of Manchester, between Adams' paper-mill privilege and that of the Hartford Manila Company, no unimproved fall on the stream sufficient to constitute a separate privilege could be learned of.

At Rockville, manufacturing began to assume importance about forty years ago, and now there is a line of fine mills in close succession down through the valley. The place has a population of about 6,000. The fall is most rapid in the upper part of the village, and the Rock company is the first concern below the reservoir requiring a canal of much length. The dams are generally short and inexpensive. An equal number of breast-wheels and turbines are in use, and are considered to be of a good class. Steam is also employed for supplementary power at several of the mills. The principal manufacturing is of cassimeres, besides which cotton-warps, sewing-silk, stockinet, ginghams, satinet, and envelopes are also made.

Water-privileges on the Hockanum river at Rockville (in order below reservoir).

Company.	Manufacture.	Fall.	Horse-power of water utilized.
		Feet.	
Adams Manufacturing Company	Cotton-warps	16	
C. White	Cotton		
Belding Brothers	Sewing-silk	44	
Samuel Fitch & Sons	Stockinet		
American Mills	Cassimeres	40	
Rock Manufacturing Company	do	27	
Do	do	22	1,300–1,400
White Manufacturing Company	Ginghams	20	
New England Company	Cassimeres	20	
White, Corbin, & Co	Envelopes	19	
Springville Company	Satinets	18	
Hockanum Company	Cassimeres	18	
Do	do	10	
Total		254	

Passing below Rockville, the first privilege is that of the Ellington Manufacturing Company, at Windermere, running ten sets of cards on cassimeres. This mill has 24 or 25 feet head, and wheels of about 125 horse-power, of which only 90 is in use. Water is brought to the mill in a race a mile long. This holds a sufficient quantity to supply the wheels for an hour and a half, or until the water gets down in the morning from the Rockville mills. This long canal gives considerable trouble, however, in winter on account of ice; if it is drawn down much, the surface-ice sinks and freezes to the bottom, thus clogging the channel, and in this way the mill is forced to stop several times during the winter, though not more than a couple of hours at a time.

Below this mill all the other privileges on the stream, with one exception, are occupied by paper-mills. The most recently developed power is that of the Hartford Manila Company, at Woodland station, in the town of East Hartford. The dam was built in 1881, and is a framed structure resting on rock; it has a roll-way 100 feet long and 13 feet high, with masonry abutments. The water-wheels run under 14 feet head, and have a capacity of 220 horse-power. The water from Shenipsit lake does not reach this mill till late in the forenoon, and in general through the day the supply comes down stream very irregularly; but the Manila company, having a large pondage, stated to be at least 100 acres, is enabled to run steadily through the twenty-four hours. Full capacity cannot be realized from the wheels throughout the year, but the power is estimated not to fall below 60 horse-power, and the mill has conveniences for using steam in low water.

Water-privileges on the Hockanum river below Rockville.

Locality.	Firm.	Manufacture.	Fall.	Horse-power of water utilized.	Remarks.
			Feet.		
Windermere	Ellington Manufacturing Company.	Cassimeres	24–25	125	
Talcottville	Granite Mill	Paper	10	40	Has also a reservoir of a few acres above on the stream, with dam 8 or 10 feet high.
Oakland	Oakland Paper Company	do	23	125	Uses steam in low water.
Manchester	Union Manufacturing Company	Ginghams	20	250	Uses steam in low water. Pond estimated at 30 acres.
Do	Keeney & Wood	Book-papers	12–14	100–110	
Do	Peter Adams	Paper	16	180	Stone dam, built in 1877; 175 feet long, 14 feet high; cost $7,000. Pond estimated at 30 acres.
Woodland	Hartford Manila Company	do	14	220	Framed dam; 100-acre pond.

a It is said that a large storage could be obtained at this privilege, though with the necessity of a long dam.

Water-privileges on the Hockanum river below Rockville—Continued.

Locality.	Firm.	Manufacture.	Fall.	Horse-power of water utilized.	Remarks.
			Feet.		
Burnside	F. R. Walker & Son	Paper	10-11	90	
Do	East Hartford Manufacturing Company.	Fine paper	11	190	Wooden dam, built in 1858; 102 feet long; cost, $750.
Do	The Hanmer & Forbes Company	Paper	18	262	Can obtain full capacity from wheels about eight months in an average year; even in a very dry season the power is estimated not to run below 50 horse-power. Steam used constantly for supplementary power. The pond is small, and it has just been connected with a side reservoir of 26 acres, to gain more storage. In very high stages the Connecticut backs up to this privilege and causes a stoppage of the mill for a day or two by back-water.

At Talcottville the Hockanum is joined by the Tancanhoosen, a small stream which is supplied by a reservoir of a few acres at the head, owned by the various mills below. This reservoir avails only a short time, and can be drawn down in two weeks by Talcott Brothers' mill. The lowest privilege on the stream is occupied by a small grist-mill with about 10 feet fall. Next is Talcott Brothers' mill, running six sets of cards on cassimeres, and using 21 feet fall and 60 horse-power. This amount can be realized about eight months in an average year, but in low water this mill, as well as the other principal ones on the stream, has to rely upon steam. The next power is owned by E. E. Hilliard, of Manchester, and used by John A. Smith, agent, for a shoddy-mill. Still above, the Ravine Mills Company has two mills for the manufacture of cotton-warps; and yet farther up stream there are two small saw- and grist-mills.

At Manchester the Hockanum receives another little stream, supplied by a reservoir, and furnishing power to several small mills; but no particulars concerning them were gained.

THE FARMINGTON (*a*) RIVER.

As regards extent of area drained, the Farmington river stands fourth in order among the tributaries of the Connecticut river, comprising within its basin 584 square miles. The West branch heads in the town of Becket, in Berkshire county, Massachusetts, and running southerly and southeasterly enters Litchfield county, Connecticut; it passes across the northeastern part of this county, and in the town of New Hartford is joined by the East branch. The main stream thence pursues rather an unusual course: flowing southeasterly about 12 miles by straight course, it then turns in the town of Farmington, through considerably more than a right angle, and runs for 14 miles almost due north; at Tariffville it again turns as sharply as before, and, striking through a picturesque gorge in the hills, takes a curving southeasterly course to the Connecticut, into which it empties about 5 miles above Hartford. Its length from the extreme source of the West branch is, by river, 75 miles.

No data showing accurately the elevation at the source of this river could be obtained. At Becket station, a neighboring point on the Westfield river, the Boston and Albany railroad is about 1,200 feet above tide, and the headwaters of the Farmington probably have at least that altitude. It is stated by Mr. Robert R. Smith, agent of the Greenwoods Company, at New Hartford, that actual survey has shown a fall of 260 feet from Otis reservoir to the mouth of its outlet, and 625 feet thence to the top of the company's dam. The latter distance being about 21 miles, the fall given for it corresponds very nearly to 30 feet per mile. The fall in the river below New Hartford, as shown by railroad elevations, is given in the accompanying table:

Table showing the fall in the Farmington river.

Locality.	Elevation above mean tide.	Fall between points.	Distance between points.	Fall per mile between points.	Remarks.
	Feet.	*Feet.*	*Miles.*	*Feet.*	
Mouth of Otis Reservoir outlet	1,034				
		625	21	29.76	Approximate.
Top of Greenwood Co.'s dam	409				Elevation obtained by adding 30 feet to that at Pine Meadow.
		30			
Pine Meadow (*a*)	379				At crossing above dam.
		84			
Collinsville (*a*)	295		13	17.54	At crossing above village.
		22			
Do (*a*)	273				At crossing below village.
		92			
Farmington (*a*)	181				At crossing north of station.
		178	29	6.14	
Mouth of river	3				Estimated elevation at extreme low water above mean level of Long Island sound.

a Elevation of water-surface referred to mean sea-level. From profile of New Haven and Northampton railroad.

a Indian name, "Tunxis."

The flow of the stream was measured at Unionville, July 31, 1877, by General T. G. Ellis, in connection with a plan for supplying the city of Hartford with water from the river, and was found to average about 190 cubic feet per second for the twenty-four hours.(a) In his report upon the Connecticut river between Hartford and Holyoke,(b) General Ellis gave the least discharge of the Farmington at its mouth as 450 cubic feet per second; mean discharge, 944 cubic feet per second; greatest discharge, 24,375 cubic feet per second. In their work upon the *Construction of Mill Dams*, Messrs. James Leffel & Co. state the average discharge for the twenty-four hours, at New Hartford, in time of ordinary drought, at 168 cubic feet per second. These various results may be thus presented:

Data concerning the flow of the Farmington river.

Locality.	Stage of river.	Drainage area.	Flow per second, average for the 24 hours.	Flow per second per square mile.	Remarks.
		Sq. miles.	*Cubic feet.*	*Cubic feet.*	
New Hartford	Ordinary drought	225	168	0.75	Flow as given by Jas. Leffel & Co.
Unionville	Drought	357	190	0.53	Measurement of July 31, 1877.
Mouth of river	Least discharge	584	450	0.77	Discharge as given by General T. G. Ellis.
Do	Mean discharge		944	1.62	
Do	Greatest discharge		24,375	41.74	

The surface of the main portion of the Farmington River basin is hilly, with the ridges generally wooded and the valleys more or less cleared for farming purposes. As shown in the foregoing table, the flow of the stream is well maintained in the dry season, comparing favorably with the best New England streams. This character is due in part to natural conditions, the wooded character of the surface and the abundant springs, and largely also to one or two important storage reservoirs. The principal of these is known as the Otis reservoir, lying in the Massachusetts town of that name, and flows a surface estimated at from 1,000 to 1,300 acres. It is a valuable reservoir, and is indeed regarded as the chief source of supply for the river in the dry season. It is owned by the Farmington River Water Power Company, a stock association, in which the Collins and Greenwoods companies own more than three-quarters, and which they therefore practically control, although some other mill-owners farther down stream are also stockholders. For economical use by these large owners this reservoir has the disadvantage of being more than 20 miles away from the nearer of them, though it is for the same reason of advantage to all the intervening portion of the river. Otis reservoir has a drainage area of 11 square miles; it usually fills in spring, and is drawn upon to the extent of about 24 feet from full-water line, the draught commonly being made from May to November.

Long lake, at Winsted, is roughly estimated to cover 800 or 1,000 acres, although on Clark & Tackabury's map of the state of Connecticut it measures only 570 acres. It is drawn upon continuously through the year, and furnishes power to numerous establishments at Winsted; its waters reach the Farmington about 7 miles above New Hartford. At the latter point, the Greenwoods Company's dam forms a pond of large size, the area of which could not be ascertained. Shepherd's pond, lying 3 miles west of New Hartford village, is owned by the Greenwoods Company and used for storage purposes; it measures 170 acres on the state map, though its flowage is probably much greater than that, and can be drawn down 8 feet. There are a number of other ponds in the upper Farmington basin, of moderate size, which may serve to some extent for storage, but no special data regarding them were to be found, and even their areas as stated below cannot be relied upon as accurate:

Principal ponds and reservoirs in the Farmington River basin.

Name of pond.	Locality—town and state.	Area.	Remarks.
Tributary above New Hartford.		*Acres.*	
Otis reservoir	Otis,(a) Massachusetts	1,000–1,300	Owned by Farmington River Water Power Company. Is drawn upon 23–24 feet.
Lower Spectacle pond	Sandisfield, Massachusetts	113	Area as given by H. F. Walling; see Appendix B, *Report of the Massachusetts State Board of Health*, 1878.
Shaw pond	Becket, Massachusetts	100	Area as given by H. F. Walling.
Cotton pond	Tolland, Massachusetts	580	Do.
Long lake	Winchester, Connecticut	570	Area measures 570 acres on state map, but is estimated by manufacturers at from 800 to 1,000 acres. Drawn upon continuously.
Burrville pond	Torrington, Connecticut	90	Area by state map. Power used at outlet.
Shepherd's pond	New Hartford, Connecticut	170	Area by state map. Pond is owned by Greenwoods Company and used for storage. Can be drawn down 8 feet.

a Walling gives among the ponds in Otis: Great pond, 335 acres, and Rand pond, 235 acres. It is uncertain to what extent, if any, these are included in the reservoir here mentioned.

a Based on two measurements, one at 7 a. m. and one at 11 a. m. See *Report on Supply of Water from Farmington River.*

b *Report of the Chief of Engineers, U. S. army*, 1878, Appendix B 14.

Principal ponds and reservoirs in the Farmington River basin—Continued.

Name of pond.	Locality—town and state.	Area.	Remarks.
Tributary above New Hartford—Continued.		*Acres.*	
Doolittle pond	Norfolk, Connecticut	190	Area by state map. Pond is there represented as without any outlet. Other authority gives the area at 175 acres, and says a small dam raises the outlet about 4 feet.
Greenwoods pond	New Hartford, Connecticut		Estimated to contain several hundred acres.
East branch of Farmington river.			
Noyes pond	Tolland, Massachusetts	276	Area as given by H. F. Walling.
Pequabuck river.			
South Mountain reservoir			Not important.

There seems to be some difference of opinion among prominent manufacturers as to whether or not the storage capacity of the stream can be further greatly increased. It is definitely stated that, if sufficient money can be obtained, a new reservoir will be built above the present one in Otis, and on the same stream, to flow 738 acres 6 feet deep. Such a reservoir, if it could be relied upon to fill regularly, would certainly be of assistance to the stream; but it is claimed that, generally speaking, the opportunities for new reservoirs of much size are very limited, on account of insufficiently-large water-sheds.

The banks of the river are usually firm and of good height, while the bed consists of ledge rock or gravel. An exception to these conditions is the portion of the stream between Farmington and Tariffville, where its course lies through alluvial meadows. The width between banks ranges from perhaps 100 feet at Unionville to 250 or 300 feet near the mouth. The volume usually runs lowest in September, when the reservoirs have been drawn down, and highest during the spring freshets which visit the river in March or April. The ordinary spring-freshet depth on the dams at Collinsville and Poquonock, with roll-ways 325 and 243 feet long, respectively, is stated to be 3 or 4 feet. Below Farmington the slight slope of the stream causes it to spread out over the meadows during freshets, and produces an ordinary rise of 9 feet, and an extreme rise of 14 feet, below the site of the dam at that village. In the upper course of the stream, above New Hartford, the fall is rapid, the drainage slopes are steep and rocky, and freshets seem to be rather more sudden and violent than toward the mouth.

In the great storm of October 3 and 4, 1869, the water poured over the Collinsville dam 10 feet deep. This storm was a most remarkable one, and caused widespread damage in New England. It appeared to be central 2 or 3 miles east of New Hartford, where a downfall of 12.35 inches was recorded; the amount was above 8 inches over the entire Farmington River basin, ranging thence up to the maximum above mentioned. Valuable data regarding the distribution of rainfall in that storm have been prepared by Mr. James B. Francis, and presented in a paper read before the American Society of Civil Engineers.(*a*) Judging from the Smithsonian records, the average rainfall over the area drained by the Farmington river is about 11 inches in spring, 12½ in summer, 12½ in autumn, 10½ in winter, and 46½ for the year, increasing from the lower course toward the upper waters.

Privileges on the upper portion of the river experience some trouble from running ice, which gorges occasionally, but more from anchor-ice, which clogs the wheels and racks. At New Hartford the fine pond of the Greenwoods Company holds back ice until it has well rotted. Toward the mouth the usual run of ice is reported to be heavy; the depth of water on the dams is insufficient to carry it clear of them, and at Poquonock, at least, the works require more or less repairing in consequence every year.

Ascending the river, the principal manufacturing points are Poquonock, Rainbow, Tariffville, Unionville, Collinsville, and New Hartford. The manufactures are rather more diversified than ordinarily upon such a stream, comprising paper, hardware, cotton duck, worsted, and silks. Except above New Hartford and below Tariffville, the stream is conveniently accessible by railroad. From Collinsville to New Hartford two lines follow its banks, the Hartford and Connecticut Western, and the New Hartford branch of the New Haven and Northampton road. From Rainbow, and it is said also from Poquonock, merchandise is shipped to and from Hartford by team, a distance in the neighborhood of 10 miles.

Although there is much power already in use on the Farmington river, there are several valuable privileges still remaining undeveloped, as will be seen in the following more detailed account of the stream:

Water-powers.—The first dam met in ascending the river is about 5 miles above the mouth, at Poquonock. Rapids extend a considerable distance below, with moderate fall, but this is not sufficient to constitute a privilege of any value. In high water the Connecticut river sets back over these rapids, overflows the banks in places, and in extreme cases even submerges the Tunxis dam, just mentioned. Below the rapids there is smooth water to the mouth, and a small boat, the "C. H. Dexter", even ascends the stream a little way and lands freight for the farmers.

(*a*) *Transactions*, Vol. VII, No. 167.

The lower privilege at Poquonock is owned by the Tunxis Worsted Company, manufacturers of worsted yarns. The dam is a log structure 4 or 5 feet high, built in 1870 at a cost of $2,000. It is 264 feet long, and gives a head at the mill of 7½ feet; 96 horse-power is used there, with surplus water always, night and day. The only especial hinderance is from backwater, which forces an occasional stoppage of work.

The next dam is in the same village, only a little way above the one just mentioned, and is owned equally by the Tunxis Worsted Company, which has a mill on the north bank, and the Hartford Paper Company, which uses power on the opposite side of the stream. The dam is framed, partly filled in with rock, and has stone abutments; it was built in 1844, is 243 feet long by an average of between 9 and 10 feet in height, and its cost is placed at $25,000. There is used altogether, on both sides of the river, about 400 horse-power, under a head of 9 or 10 feet. For eight months in the year there is usually enough water for both establishments to run at full capacity, but for the remainder of the time they are troubled more or less by low water, and the Tunxis company is about to introduce steam for auxiliary power. It has more difficulty than the mill across the river, as a favorable current sets strongly toward the latter and carries to it more water, in a low stage at least, than the north side receives. The river-banks are of good height at Poquonock; the bed is entirely composed of red-sandstone ledges much worn and broken.

Succeeding the privilege just described is the one at Rainbow, a mile and a half by river above, occupied by three manufacturing concerns—the Hartford Paper Company, the Springfield Paper Company, and W. C. Hodge. The river-bed is here of the same character as at Poquonock, and ledge rock also crops out in the right bank. The dam is a crib-work of squared timbers, the back having a long slope, while the face slants more steeply a short distance from the crest, and then drops off vertically. It is supplemented by an embankment in which is a bulk-head of sandstone masonry. The length of the dam is 308 feet and its height 10 or 10½ feet; it was built in 1857, and its cost is stated at $51,000. The canal has a total length from head-gates of perhaps 1,500 feet or more; it at first enlarges into a small pond, with a waste-way at the lower end, and then passes on to the mills. As usual with paper-mills, these run twenty-four hours in the day, and they all rely entirely upon water for power. The fall obtained ranges from 10 to 13 feet, according to position on the race, and the wheels in use have a total rated capacity of about 350 horse-power. In the dry season the supply of water is apt to be low on Mondays and Tuesdays, from its being held back over Sunday in the ponds on the upper river, but for nine months in the average of years there is a large waste over the dam. The canal gives trouble in severe winter weather by becoming clogged with ice.

Between Rainbow backwater and the foot of the Spoonville dam, the next one above, there is claimed, on good authority, to be a fall of about 30 feet. Of this, 24 feet 4 inches was actually surveyed, and the balance arrived at by a careful estimate. It is considered that the lower 4 feet could best be utilized by raising the Rainbow dam and incorporating it in that privilege. The succeeding 20 feet constitutes an unimproved privilege owned by Mr. R. D. Case, of Rainbow. Ascending above slack-water caused by the Rainbow dam, rapids are encountered which extend steadily for some distance up stream. The right, or south, bank is gravelly, steep, and high, rising abruptly from the water. The north bank is also steep at first, but soon the elevated ground recedes, and there is a gentle, steady rise from the river, presenting an extremely favorable site for building. Passing a little farther up stream, the south bank remains steep and high, while the north bank grows sandy. The river, which below shows gravel shoals, now exhibits several ledges of red sandstone extending regularly across its course and forming slight falls. Ledges also appear here in the south bank. The rapids extend some little way above, and are then succeeded by smooth water. A dam could be built under favorable conditions either on the rock ledges near the head of the rapids, or farther down stream; if the former site be chosen, a natural depression offers a convenient course for a canal. In any case, the north side is the one which would be chosen for building upon; two or three clear and permanent little streams run down the hill on that side, and are an advantage worth mentioning if the power were to be used for paper-manufacturing. It is considered by those interested that the privilege would best be developed by building a dam 9 or 10 feet high on the ledges mentioned, and extending a canal for say 1,000 feet down the north bank, thus increasing the fall to about 20 feet. Mr. Case wishes to dispose of the privilege; it is a good one and ought to be improved. What storage could be obtained above the dam is uncertain. During the dry season the same disadvantage would probably be experienced as at the mills below, namely, a scarcity of water on Mondays as compared with the rest of the week. Making an exception of this temporary and artificial reduction of power, the amount of which has not been ascertained, the capacity of the privilege may be estimated as follows:

Estimated power of Case's privilege at Rainbow.

Stage of river.	Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power.	
	Sq. miles.	*Cubic feet.*	1 *foot fall.*	20 *feet fall.*
Low water, dry year	566	290	32.94	660
Low water, average year		340	38.62	770
Available 10 months, average year		440	49.98	1,000

The privilege here described is not especially convenient to the railroads at present, being 2 or 3 miles from the Hartford and Connecticut Western railroad at Spoonville, and some 4 miles from the nearest station on the New York, New Haven, and Hartford railroad.

The next power is at Spoonville, a small village, and is used by James Watson in the manufacture of horse-blankets. The mill is a small wooden one, and stands at one end of the dam, which is a framed structure and very leaky. The fall is 8 feet, and only about 16 horse-power is estimated to be used, although a large amount of water passes through the wheels, which are old and wasteful.

Estimated power at Spoonville.

Stage of river.	Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power.		Effective horse-power utilized.
	Sq. miles.	*Cubic feet.*	*1 foot fall.*	*8 feet fall.*	
Low water, dry year	555	290	32.94	260	16
Low water, average year		340	38.62	310	
Available 10 months, average year		430	48.85	390	

After leaving the alluvial meadows which border in common the Connecticut and the Farmington, near its mouth, the country along the latter stream rises somewhat and becomes level and sandy. The soil is largely cultivated, the better class for tobacco and corn, while on the sandy plains corn is almost the only production. There is a moderate amount of timber, mainly pine, chestnut, oak, and birch. Passing to the westward of this tract the soil becomes a red loam of good quality, well cultivated for tobacco. Shortly above Spoonville we encounter a trap ridge which runs north and south through the state. Through this ridge the river has found its way in a deep and narrow gorge, the precipitous sides of which display trap, ironstone, and some red sandstone, none of it of much value for building-purposes. The stream itself comes foaming down over a rocky bed.

Not far above the blanket-mill at Spoonville, H. A. Case has for many years had a 3-run grist-mill, where a fall of 6½ feet was in use. This privilege has now been purchased and incorporated in a much larger one by Mr. Horace Smith, of Springfield, Massachusetts. Mr. Smith owns about 50 acres of land bordering the stream in this vicinity, and also all the water rights for flowage from a point 4 feet below the level of the dead water in the tail-race of the Hartford Silk Company's mill down to the level of the water in the pond of the blanket-mill. The fall thus practically available is 30 feet, which is soon to be developed and used, it is said, in paper-manufacturing. A masonry dam 30 feet high and 225 feet long is to be built, and will give a pondage of 30 acres. Water will be taken directly from the pond in trunks, without the use of a canal. The privilege is 10½ miles by railroad from Hartford, and a spur from the Hartford and Connecticut Western railroad will run directly to the mill-sites.

The next power is a short distance above the gorge, and succeeds the one just described. It is occupied by the Hartford Silk Company, which manufactures all kinds of dress goods, upholstery goods, handkerchiefs, plushes, and velvets. The company began running in the spring of 1882, and at the time it was visited, in the fall of that year, was employing about 200 hands. The privilege has previously been occupied in turn by the Hartford Carpet Company, the Connecticut Screw Company, and the Hartford Cutlery Company. The dam is of crib-work, filled in with stone, and is 13 feet high and 160 feet long. About 300 horse-power of wheels are in place, under a head of 13 feet, but probably not over 100 horse-power was in actual use at the time mentioned. The pond sets back a long distance up the river, and thus gives a large storage, though mainly confined within the natural banks of the stream.

From Tariffville nearly to Unionville, through a distance of perhaps 16 or 17 miles, the course of the river is bordered by meadows, very fertile, well cultivated, and liable to overflow during spring freshets. The stream itself is described as having a fair current, though without shoals of any importance; its direction is winding, its bed is soft, and its banks are caving, these being usually of normal height on one side with low flats opposite. As Unionville is approached the meadows contract, the hills close in, shoals are encountered at intervals, the bed becomes gravelly, and some rock ledges appear.

The only dam in this stretch of river is at the village of Farmington, the privilege being owned by Messrs. J. E. and E. B. Cowles, of that place. The power is at present rented for a small 2-run grist-mill, using 4 or 5 feet fall and a single wheel of about 40 horse power. The dam is a log structure over one hundred years old, filled in with loose stone and planked over; it has settled somewhat, and would admit of being raised a little above its present height. The principal trouble at this point is from backwater during freshets; more or less hinderance is thus experienced during four or five weeks in the year, and an occasional stoppage of work for a few days is rendered necessary. During the six years preceding 1882 the longest continuous period in which a stoppage was forced by freshet backwater was six days. Ice sometimes gorges in the river below, at a place known as the "Aqueduct", and backwater results at Farmington from that cause also. This difficulty has arisen twice in perhaps ten years, and on one of those occasions the mill was stopped for two weeks. The owners of this privilege are anxious to sell it. Aside from the period of high water, the effect of which in reducing the power may be judged to some extent from what has already been said, the available power may be estimated as follows:

Estimate of power at the Messrs. Cowles' privilege, Farmington, Connecticut.

Stage of river.	Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power.		Effective horse-power utilized.
	Sq. miles.	*Cubic feet.*	1 *foot fall.*	5 *feet fall.*	
Low water, dry year	431	250	28.4	140	40
Low water, average year		280	31.8	160	
Available 10 months, average year		330	37.5	190	

The meadow-lands in this vicinity are valuable for corn and grass, and some of them are held at from $150 to $175 per acre. Succeeding the alluvial meadows, on the higher ground is a strip of gravelly soil extending up and down the valley, and best suited to corn and tobacco; still higher up, on the hills, the soil is a red loam.

The next privilege to be noticed properly includes the one last described, and is not in use, although it might be considered partly developed. It is owned by Mr. Edward Norton, of Farmington, who would be glad to see the power improved, but does not himself wish to undertake the enterprise. In order to a clear understanding, it may be stated that in the neighborhood of 1840 the New Haven and Northampton canal was in operation for several years. It had but little traffic, never paid as an investment, and was finally bought up by the present railroad, known as the New Haven and Northampton Company, and then abandoned. This canal, coming down from Northampton, Massachusetts, on the west side of the river, crossed over to the east side on an aqueduct about 2 miles below the village of Farmington, and continued thence southerly toward New Haven. Before crossing, the main canal received an important feeder, which, starting from the Farmington river, about a mile below Unionville, struck across the bend which the river here forms, until it joined the principal canal near the aqueduct. This feeder had a length of about 3 miles, and at its entrance was a dam, said to have been 18 feet high, across the river. The dam was carried out in the period from 1840 to 1850, and at about the same time the main canal was abandoned. There was no further use for the feeder, and the land along its course reverted to the former owners. At present, Mr. Norton owns the land at both extremities of the feeder, and much of the way along its line.

Nothing now remains of the old feeder-dam except one or two logs next the east shore, and all that shows of the entrance gate to the feeder itself is a little of the stone-work and two wooden posts. Midway between these posts the bed of the canal is about 4½ feet above low-water surface in the river immediately below the old dam. The canal seems to have been designed for a water depth of about 4 feet at the center, and a surface width of from 20 to 25 feet. It is now overgrown much of the way with saplings and brush. Some little way back from the river, near the aqueduct, the main canal received the feeder; it then approached the river on a high embankment, terminating in an abutment of red-sandstone masonry. This abutment is now in fair condition, though the mortar is worn from the joints. The abutment on the east side appears more dilapidated. The piers, five in number, which supported the aqueduct, still remain, and preserve tolerably well their original shape.

In the fall of 1877 Mr. C. H. Bunce, city surveyor of Hartford, ran a line of levels from opposite the entrance of the feeder to the aqueduct, to determine the intervening fall in the river, which he found to be 29½ feet.(*a*) The fall at the aqueduct, from the bed of the main canal to the river, is 34 or 35 feet, and it is this amount which Mr. Norton considers practically available for power.

Estimate of power at "Aqueduct" privilege, Farmington, Connecticut.

Stage of river.	Rainfall on basin.					Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power.		
	Spring.	Summer.	Autumn.	Winter.	Year.					
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. Miles.*	*Cubic feet.*	1 *foot fall.*	18 *feet fall.*	34 *feet fall.*
Low water, dry year	9	14	14	9	46	360±	210	23.80	430	810
Low water, average year							240	27.20	490	930
Available 10 months, average year							280	31.81	570	1,080

The plan of development which is considered to be best suited to this power is to build a new dam 1,400 or 1,500 feet above the old one. It would have to be a very low affair, not over a couple of feet high, on account of danger of causing backwater on the Unionville privilege above. It would be inexpensive of construction and would rest upon a rock bed. On account of this danger of causing backwater at Unionville, I understand that it would not be practicable to raise the river sufficiently to utilize the feeder-canal in its present condition; or that, at least, any such attempt would be resisted by the Union Water Power Company. From the proposed site of the dam a canal would run down the east bank of the river to the entrance of the old canal. The starting-point of the latter was formerly located as has been described in order to avoid a rock-cutting which the new route would pass through,

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but which it is thought would be more economical than a high dam at the site of the old feeder-dam. The whole length of new canal, 1,468 feet, would be a cut through red sandstone, which is stated to have been examined and found to be in part suitable for building-purposes. After striking the old feeder the course of that canal would be followed thence 3 miles to the vicinity of the aqueduct, although it would have to be deepened 4 or 5 feet and correspondingly broadened.

It is claimed that, if desirable, 18 feet of the fall on this privilege can be used within a mile of the head of the canal. The present line of the feeder is there from 100 to 120 rods from the river, but the ground is quite level and by a side-cut water can be conveyed to within 30 or 40 rods of the stream. The power can also be used, either entirely or in part, in the vicinity of the aqueduct. Above that point the west bank is comparatively level, and subject to overflow during high freshets. Below the aqueduct the immediate bank is 10 or 15 feet high and sandy. Farther back it rises and is above overflow. Here it is thought the power could be conveniently utilized, probably to the best advantage in two levels. There is ample room for mills and a village, and a mile or two of spur-track would connect with the New Haven and Northampton railroad.

An important power might evidently be obtained at the aqueduct, but a great disadvantage toward development is the length of canal necessary, the construction of which would probably involve a heavy expense. Backwater would be experienced in freshets, as at the Farmington mill, and the privilege occupied by the latter, which is intermediate between the head and foot of the old canal-feeder, would have to be purchased.

The power at Unionville, which is next to be noticed, was developed about 1830 by Messrs. Cowles, Morton, & Bidwell, and later came under the sole control of Mr. Cowles. Water was originally leased according to the flow through an opening 1 foot square, under a certain head. The question of measuring the water having arisen, the manufacturers claimed that measurement should be made through an aperture with rounded edges, to admit as large a discharge as possible, while the lessor insisted that the edges must be square, and extended law-suits arose in consequence. About the year 1878 the manufacturers here combined to form a stock company, which took a long lease of the entire property, with the right to purchase after due notice, which has since been given. They obtain the whole property, including two factory buildings, for $50,000. The title of the new proprietors is the Union Water Power Company; they own a total fall of 36 feet, which is used from two levels, with 18 feet fall from each. The company sells the land to manufacturers and gives a perpetual lease of power. The established rental for the latter is $175 per mill-power, a mill-power being assumed at 7½ cubic feet of water per second under 18 feet head.(*a*) In practice, the wheel ratings are employed to determine the amount of water used. In the fall of 1882 about 1,000 effective horse-power had been leased, and it was stated that within a few months the full amount would be in actual use. So far as regards its capacity to supply permanent power, this privilege is considered to be fully developed, and the company can not therefore insure constant power to new concerns. In priority of rights during low water the various lessees are claimed to rank according to date of lease. Four of the largest concerns employ steam for auxiliary power, during low water at least. The paper-mills run twenty-four hours in the day, and the other establishments ten or twelve hours.

The river-bed at Unionville is composed of gravel, bowlders, and frequent rock ledges, inclined at a large angle. The dam rests upon a gravel foundation, and is a log crib-work filled in with loose stone. The logs are from 10 to 12 inches in diameter, with transverse binders once in 5 or 6 feet. The dam rises 10 feet above the river-bed, is 4 feet wide on top, and has a back slope of 1 in 3. From the crest the face pitches down stream for 12 feet, with about the same slope as the back, and is succeeded by a horizontal apron 12½ feet wide; at the end of the apron there is a drop vertically of 5 feet to the river-bed. The apron is a continuation of the crib-work of the dam, and is covered with two layers of heavy planking, the lower 6 and the upper 4 inches in thickness. At the foot of the dam a row of round piles was driven into the river-bed. The abutments and bulkhead are of granite rubble masonry, rising about 12 feet above the crest of the dam. Below the dam the east bank is protected by a shore-wall, and the west bank by timber and stone crib-work. The bulkhead has seven rectangular gate-openings, through which water is admitted to the canal. The main canal follows down the east bank, running much of the way along a side-hill; it is about a mile and a half long, and, though varying in width, averages perhaps 25 feet, with a water depth of 5 or 6 feet. At its extremity surplus water passes down into the second or lower level and is discharged thence into the river. The lower level canal is about 1,000 feet long, with a width of 20 feet and a water depth of 4 or 5 feet. The concerns using power are as follows:

From the upper level—

1. The Ripley Manufacturing Company; has now a turning shop, and will soon engage in the manufacture of paper.
2. The Meach & Hart Manufacturing Company, cutlery; sublets some power to the Standard Rule Company.
3. The Platner & Porter Manufacturing Company, two paper-mills.

From the lower level—

1. The Delaney & Munson Manufacturing Company, paper.
2. The Union Nut Company, bolts and nuts.
3. The Cowles Paper Company.

These concerns employ in all about 450 hands, mostly men.

a Accordingly as the wheel efficiency ranges from 60 to 80 per cent. will the value of a mill-power range from about 9½ to 12½ effective horse-power.

It requires three hours for the water used at Collinsville to reach Unionville. The amount stored above the dam at the latter point will run the mills only about six hours. For three or four days every year, while the Collins Company shuts down for inventory, which time the Greenwoods Company generally improves for repairs and other work, the water is held back above, and the mills at Unionville are also obliged to shut down.

In winter anchor-ice clogs the head-gates at the entrance of the main canal, and the level being drawn down, the surface-ice in it sinks, freezes to the bottom, and hinders the passage of water. The trouble is a serious one, lasting sometimes for two or three weeks, until there is a sufficient change in the weather to loosen or melt the ice, but might be avoided by temporarily shutting down the mills when the head-gates become clogged.

Estimate of power at Unionville.

Stage of river.	Rainfall on basin.					Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power.			Effective horse-power utilized.
	Spring.	Summer.	Autumn.	Winter.	Year.						
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. miles.*	*Cubic feet.*	1 *foot fall.*	18 *feet fall.*	36 *feet fall.*	
Low water, dry year	9	14	14	9	46	357	210	23.86	430	860	*a* 750–1,000
Low water, average year							240	27.26	490	980	
Available 10 months, average year							280	31.81	570	1,140	

a 750 horse-power of wheels in 1880 by census enumerators' returns; about 1,000 horse-power said to be leased in 1882.

Intermediate between the Union Water Power Company's dam and the foot of its privilege is a low dam, similar in construction to the one already described. It diverts water into a race on the west side of the river, supplying George Richards & Co.'s 3-run grist- and saw-mill. This firm has 9½ feet head and uses about 50 horse-power. Reliance is placed entirely upon surplus water from the upper dam, and for about nine months in an average year the mill can be run at full capacity.

Above Unionville backwater the river is a succession of shoals and pools. The bed is covered with gravel, and in some places with bowlders. The New Hartford branch of the New Haven and Northampton railroad follows the west bank, usually at an elevation of 15 or 20 feet above the water-surface. It was stated that the railroad company had expressed its willingness to raise the track if it should prove necessary in the development of the water-power. The west bank is nearly all the way steep and high, and does not present good opportunity for building. The east bank shows rock ledges in places, and is also much of the way quite abrupt, rising to hills; but in two localities there is ample building-room. One of these is shortly above the Unionville pond. The other is near a stone-quarry, not over a mile below Collinsville. At the latter point the river makes a bold curve, and incloses a large piece of gently-sloping ground, finely suited to building. This privilege is owned by the Collins Company, which roughly estimates the available fall at 10 or 12 feet. No data showing the exact fall between the present Collinsville and Unionville developed powers have been obtained, but, judging from the elevations previously given for the New Haven and Northampton railroad, it is probably not less than 35 feet.

Estimate of undeveloped power on the Farmington river, between Unionville and Collinsville (assuming a fall of 35 feet).

Stage of river.	Drainage area.	Flow per second, average for the 24 hours. (*a*)	Theoretical horse-power.	
	Square miles.	*Cubic feet.*	1 *foot fall.*	35 *feet fall.*
Low water, dry year	*b* 334–*c* 357	200	22.72	800
Low water, average year		230	26.13	910
Available 10 months, average year		270	30.67	1,070

a Above Unionville the mills run only ten or twelve hours per day, and the stream is so controlled that its flow is concentrated within that time; consequently during low stages double the flow and power here given could be realized for the ordinary working hours.

b At Collinsville. *c* At Unionville.

The power at Collinsville is owned by the Collins Company, manufacturers of edge-tools, axes, plows, and other iron and steel goods. The works were established about 1826, and now give employment to 600 men. The various shops and other buildings extend 1,800 feet down the east bank, and an average of 400 feet back from the stream. The dam rests upon huge outcropping ledges of granitic rock, and is built of cut-granite blocks, rock-faced; the roll-way is 325 feet long, and from the bulkhead a canal leads 1,500 feet down the bank to the different shops. The pondage above the dam is sufficient to run the works for about four hours. It requires six hours for the large volume of water in use at New Hartford to reach this point, but an arrangement exists with the Greenwoods Company by which the water is sent down in time to meet the Collins Company's needs. The maximum power in use is 1,150 horse-power. The privilege has a fall of 20 feet, and is commonly rated by the owners at 1,000 horse-power for the working-hours of the day, but for two or three weeks in a dry season there is a scant supply of water, and it is estimated that the power probably sinks as low as 800 or 850 effective horse-power.

Between Collinsville and New Hartford the hills now and then close in upon the river, while at intermediate points the valley is comparatively open, with a gradual rise to high wooded ridges. The stream-bed is gravelly, with frequent shoals. The profile of the New Haven and Northampton railroad shows a descent of 84 feet from the water-surface above the Pine Meadow dam to that above the Collinsville dam. Of this, 17 feet is in use at Pine Meadow, leaving 67 feet unimproved. This fall is largely owned by various farmers whose land is adjacent to the stream, and, so far as could be learned, there are only two or three points at which the ownership is in such condition that a distinct water-privilege is claimed.

A short distance above Collinsville, Mr. Julius Case, residing near by, claims an available fall of 12 feet, to be obtained by a dam 6 feet high and a canal 50 rods long.

At a point nearly 4 miles above Collinsville, known as "Satan's Kingdom", Mr. D. B. Smith, of Pine Meadow, owns a privilege extending from the foot of the old "Puddletown sluice" to the foot of the gorge through which the river runs at the "kingdom". Mr. Smith formerly considered his privilege to embrace 18 feet fall, but claims that the action of the railroads in throwing excavated rock into the stream has resulted in shifting 8 feet of the fall to below the limit of his ownership, leaving the present fall on his privilege 10 feet. The gorge to which reference has been made is not unlike the one farther down stream at Tariffville; it is narrow, and hemmed in by high, almost vertical, walls of solid rock. A branch of the New Haven and Northampton railroad runs along the west side, about 20 feet above low water in the stream; and on the opposite side is the Hartford and Connecticut Western railroad, 5 or 10 feet higher. In this confined passage-way the freshet-rise is large, and within ten years is said to have reached the Northampton track. It would not therefore answer to build a dam in the narrows, but by giving sufficient length of roll-way at some point below, an undue rise there could be avoided. The gorge is about 800 feet long, the river falling perhaps 5 feet in that distance. Below the gorge the river widens and forms a deep, quiet pool. The hills recede and the west bank becomes low and sandy; 1,500 feet below the narrows there is a second pitch, of 4 or 5 feet in 200 feet. The river is there wide, incloses a low island, and has a gravelly bed; the west bank rises about 10 feet, and the New Haven and Northampton Railroad track is about 15 feet, above low water. Perhaps the best method of improving this portion of the river, and one that would use safely a part, at least, of the fall at Satan's Kingdom, would be to locate a dam at a point about half a mile down stream, at the foot of a long meadow.

At a place called Puddletown, a short distance below Pine Meadow, a low dam formerly ran across the river, and a canal down the west bank carried water to puddling-works, using 8 feet fall. The former owner and Mr. D. B. Smith carried on a lawsuit for six years over the question of backwater from this dam setting upon the privilege above. Mr. Smith was successful in the suit, and the dam was afterward removed. The privilege is now said to be owned by Mr. William Caul, of Pine Meadow, and is for sale.

The extent to which the 67 feet of unimproved fall between Pine Meadow and Collinsville can be utilized is to be determined only by careful examination; supposing that it were possible to use the whole amount, the corresponding power, as well as the power for lesser falls, may be estimated as follows:

Estimate of unimproved power between Pine Meadow and Collinsville.

Stage of river.	RAINFALL ON BASIN.					Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power. (a)				
	Spring.	Summer.	Autumn.	Winter.	Year.							
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. miles.*	*Cubic feet.*	*1 foot fall.*	*8 feet fall.*	*10 feet fall.*	*12 feet fall.*	*67 feet fall.*
Low water, dry year	9	14¼	14¼	10	48	b225-c291	170	19.31	150	190	230	1,290
Low water, average year							200	22.72	180	230	270	1,520
Available 10 months, average year							230	26.13	210	260	310	1,750

a In low stages of river the power could be doubled for ten or twelve hours in the day. *b* At New Hartford, *c* At Satan's Kingdom.

The Pine Meadow privilege embraces a fall of 17 feet. A half-mile above the mills a low dam, old, and built of logs, extends across the river, presenting an angle up stream. Water is conveyed thence for use through a canal 30 feet wide and 6 feet deep. Mr. D. B. Smith owns one-half of the power, and uses it in the manufacture of cotton duck, furniture, and hardware; he has also a brass- and iron-foundery, a grist-mill, and a saw-mill. Seven-sixteenths of the power is owned by H. Chapin's Son, and used for a machine-shop, iron-foundery, and in the manufacture of carpenters' tools. The remaining one-sixteenth of the privilege is owned by Mr. Robert R. Smith, of New Hartford.

Probably the finest privilege, all things considered, on the Farmington river, is that of the Greenwoods Company, at New Hartford. The fall of 30 feet is equaled by that designed for the new Tariffville power, but is only surpassed, among the improved powers, at Unionville, where there is a total fall of 36 feet. The Greenwoods Company has the advantage of a very large storage above its dam, which enables it easily to control the low-water flow of the stream. The management of the large reservoir in Otis, 24 miles above, is directed from this point, there being communication by telephone, and every possible economy is practiced in the use of water. It is stated to require twenty-four or forty-eight hours for water to reach New Hartford from this reservoir, accordingly as the gates there are opened entirely or only half-way. The Greenwoods Company manufactures cotton-duck, running

25,000 spindles and employing 700 hands; it uses about 800 horse-power. Water is used in two falls, of 18 and 12 feet, respectively; first, near the east end of the dam, whence it is conveyed in a race some distance down to the lower mill.

The roll-way of the dam is variously stated at from 210 to 230 feet in length; it is 25 feet high, and is supplemented by an earthen embankment 35 feet high and nearly 400 feet long. It was built in 1848, and by its long endurance gives evidence of having been well designed and constructed. The details of construction are given at considerable length in James Leffel & Co.'s work on the *Construction of Mill Dams*, from which these notes are mainly taken.(*a*) The river-bed at the site of the dam is composed of cobble-stones, gravel, and quicksand. The banks are gravel and sand. The structure itself is a crib-work of timbers from 9 to 12 inches thick, and slopes both up stream and down from the crest, at angles of about 27° with the horizontal. The foundation timbers are laid crosswise of the stream, the next layer with the stream, and so on. Those timbers running with the stream are 6 feet apart from center to center, the ends coming flush with the face and back of the dam; those running transversely leave a clearance of 2 or 3 feet. The intersections are fastened with spikes of ¾-inch round iron 20 inches long. Throughout the structure all spaces are filled in with loose stone. At the foot of the back slope is a line of sheet-piling, designed to prevent leakage under the dam. At the end of, and partially supporting, the apron is a row of piles. The apron itself is composed of timbers 12 inches thick, placed close together; it is securely bound to the main portion of the dam by extending a timber, once in 6 feet, 25 or 30 feet under the latter, while the remainder extend under only 2 or 3 feet. The apron projects 14 feet from the foot of the dam. Timber and stone cribs placed in the river-bed below the apron and secured to the latter prevent scour from the overfalling water.

Summary of water-privileges on the Farmington river, from New Hartford to the mouth.

Locality.	Drainage area.	Fall.	Gross or theoretical horse-power.(*a*)			Remarks.
			Low water, dry year.	Low water, average year.	Available ten months, average year.	
	Sq. miles.	*Feet.*				
New Hartford	225	30	.....	.....	.....	Power utilized by Greenwoods Company.
Pine Meadow	.....	17	.....	.....	.....	Power utilized for several kinds of manufacturing.
Puddletown (near Pine Meadow)	.....	8	150	180	210	These privileges are particular ones brought to notice, and do not cover the entire fall from Pine Meadow to Collinsville.
Satan's Kingdom	291	10	190	230	260	
Short distance above Collinsville	334	12	230	270	310	
Total from Pine Meadow to Collinsville	.....	67	1,290	1,520	1,750	This fall is entirely unimproved, and probably not all could be developed to good advantage.
Collinsville	334	20	.....	.....	.....	Utilized by the Collins Company.
Collinsville to Unionville	.....	*b*35	800	910	1,070	Unimproved.
Unionville	357	36	860	980	1,140	Owned by Union Water Power Company, and largely utilized.
Do	.....	9½	.....	.....	.....	Intermediate between dam and tail-race of above privilege. Used by grist-mill.
Farmington (aqueduct power)	360±	34	810	930	1,080	Unimproved.
Farmington (Cowles' power)	*431*	*5*	*140*	*160*	*190*	*Intermediate on above privilege. Small power in use by grist-mill.*
Tariffville	.....	13	.....	.....	.....	Occupied by the Hartford Silk Company.
Spoonville	555	30	990	1,160	1,470	To be improved by Horace Smith, esq., of Springfield, Massachusetts.
Do	.....	8	260	310	390	Small power used in Watson's mill in the manufacture of horse-blankets.
Rainbow (Case's power)	566	20	660	770	1,000	Unimproved. A fine privilege.
Do	.....	10-13	.....	.....	.....	Utilized by three paper-mills.
Poquonock	.....	9-10	.....	.....	.....	Power utilized by Tunxis Worsted Company and Hartford Paper Company.
Do	.....	7½	.....	.....	.....	Power utilized by Tunxis Worsted Company.

a Estimated on basis of average flow for the twenty-four hours. *b* Estimated.

Ascending the West branch of the Farmington river above New Hartford, we find the surrounding country hilly and wooded, with many steep and rocky slopes. The timber is largely the younger growth and confined to the ridges, having been cut lower down. Farming is carried on to a moderate extent, but the land does not appear very productive. The river is almost a constant succession of shoals, with a bed of gravel and bowlders, and firm banks. The discharge from Otis reservoir passes down this branch, and is, of course, a great assistance during the dry season; but that reservoir, controlled by the companies farther down stream, is drawn upon rather irregularly, so that while much of the time a large amount of water wastes past the mills, there are intervals when the supply is insufficient. This disadvantage is especially noticeable above Riverton, where the water from Winsted comes in. The method of using the upper river is by low dams and long races; in consequence very little water is stored, and so there is no safeguard against the irregularities of flow that have been mentioned.

a There may have been minor changes since that description was published, but it is without doubt substantially correct.

Generally speaking, however, this part of the stream is naturally favorable for improvement. The gravelly bed offers good foundation for dams. The hills close in at points so as to leave no good building-room, but there are frequent intervales where there is abundant space. At such localities one bank or the other is apt to be rather low, but toward the head or foot of an intervale the banks are usually of fair height. A dam high enough to set back the river over one of these intervales, or over any considerable part of one, would give a large pondage; the land covered would be the best in the valley, but could not be of great money value. One objection to the use of power on this section of the stream is the lack of railroad facilities, which extend only a little above New Hartford. A line is said to have been graded between Lee, Massachusetts, and Colebrook River, Connecticut, but the company failed and the work ceased.

North of New Hartford the first privilege is at Pleasant Valley, just above the Greenwoods pond. A couple of low dams, several hundred feet apart, rudely made of bowlders, serve to divert water into a race on either side of the river. On the east side are a number of unoccupied buildings; carriages were formerly manufactured there, but a suit regarding the water-power arose with the Greenwoods Company, and the property was finally purchased by it. On the west side perhaps 15 horse-power and 7½ feet fall are used by Albert Baker & Son in the manufacture of sashes, doors, and blinds.

The next power is also in Pleasant Valley, and is occupied by Messrs. D. & E. J. Youngs for a saw-mill. They have a log dam 200 feet or more in length and 5 or 6 feet high, from which water is brought in a race about a quarter of a mile to the mill, where 12 feet fall is obtained. The ordinary freshet-rise on the dam is about 4 feet; a much higher rise carries the water on to flats which extend back on the east side.

Between Pleasant Valley and Riverton there are two unimproved powers. The lower is owned by the Messrs. Youngs, of the former place, and has a fall estimated at 12 or 15 feet. The second, which might, if desired, be separated into two privileges, extends from the Youngs privilege to within three-quarters of a mile of Riverton, and embraces 24 feet fall. It is owned by Mr. H. Goodwin, of Riverton, who also owns in connection 120 acres of land, 25 of which, on the east side of the river, is claimed to be suitable for building-purposes.

At Riverton, above the mouth of Sandy brook, Stephens & Co. use 8 feet fall and 20 horse-power in the manufacture of rules; they can run at full capacity nearly all the year.

In the same village, farther up stream, Ward Brothers have a manila-paper mill, where they use 12 feet fall and 135 horse-power. They run twenty-four hours in the day, and are short of water perhaps one month during the year, in periods of a few days at a time when the Otis reservoir is not being drawn upon. The dam is a timber structure, 180 feet long and 4 or 5 feet high, and was the first built between New Hartford and Colebrook River. Water is brought to the mill through a race about a quarter of a mile long.

Between Riverton and Colebrook River, a distance of about 5 miles, there is considerable unimproved fall, said to amount to 100 feet or more. The stream is 70 or 80 feet wide, and of the same general character as below Riverton. At Colebrook River, H. S. Sawyer has a cotton-duck factory running 3,600 spindles and employing 115 hands. About 100 horse-power is probably in use, from wheels rated at 170 horse-power and working under 18 feet fall. The pondage is small and would not supply the mill more than four hours. In the low water of September, 1882, without receiving any supply from Otis reservoir, this mill could be run at about three-quarters capacity.

The stream was not visited above this point: there were reported to be several small establishments above, but no important use of power was mentioned.

TRIBUTARIES OF THE FARMINGTON RIVER.—*The East branch.*—This stream empties just below Pine Meadow, and has at present but little value for power. So far as ascertained it is not supplied by any reservoirs, although it is said that some storage room might be put to use in the upper waters. Its lower course lies through a somewhat narrow valley, the side slopes of which are wooded, often very abrupt, and occasionally display huge precipitous ledges of bare rock.

The only dam within 10 or 12 miles of the mouth is at Barkhamsted Hollow, where Wallace Case uses 13 feet fall for a small grist- and saw-mill. He has one water-wheel, rated at 47 horse-power, and thinks that with a tight dam it could be run, on the average, ten months in the year at full capacity.

The stream is very flat in this part of its course, and is said to continue thus well up toward its head. Mr. Case states that for 6 miles above his privilege the slope is so small that by raising his dam from 4 to 6 feet he considers that the stream would be set back over the whole distance and the surrounding meadows flooded. Between Case's mill and the mouth, at least, the river-bed is gravelly, the banks are low and are composed of sand or gravel; the water is very clear, and in a low stage there is to be seen only a series of quiet pools, between which the shoals are scarcely covered with water. The general slope being small, storm-waters are not promptly carried off, and a heavy shower 3 miles above Case's mill is sufficient to bring the stream out of its banks into the bordering meadows. Ordinarily, in its lower course, the stream begins to rise about 6 hours after the beginning of a rain, and to fall at an equal interval after its cessation. Below Case's dam a common freshet-rise is 5 feet, and an extreme rise 13 feet.

Power at Winsted.—It is interesting to note the number and variety of manufactures which have here developed a thriving borough of 1,800 inhabitants, and which are supported by little streams. These industries have started from small beginnings, and have grown steadily in size and number. The manufactures are nearly all in metal, and

employ a good many hands in the aggregate, with a large production of goods, without, however, requiring very large powers. The main village and two other villages, called, respectively, East and West Winsted, lie scattered along a rather narrow valley among high hills. Three streams are in use. Mad river comes down from the town of Norfolk, and is the main stream as regards length and size of drainage area. At Winsted, just above Persons' dam, it receives what is called the "Lake stream", and a short distance below the Strong Manufacturing Company's privilege it unites with Still river, which comes from Burrville and gives its own name to the succeeding portion of the stream. Most of the mills receive the benefit of the Lake stream, which is the principal and most reliable source of supply. The lake holds back ice and freshets, and the village would be almost free from the latter but for an occasional large rise in Mad river. The mills are mainly of moderate size, but there are several large and wealthy manufacturing concerns. Water furnishes the sole motive power in nearly all cases, though a few of the larger establishments also employ steam more or less of the time. The fall is practically all improved in Winsted along the course of the Lake stream, but there is some yet undeveloped on Mad river above the Empire Knife Company's works.

Long lake is about 2½ miles in length, and is estimated to cover from 800 to 1,000 acres, though on the state map published in 1859 it measures only 570 acres. It is a natural pond that has been raised, and though it can be drawn down 10½ feet from a full stage, there then remains a depth of 60 feet in places. One or two little streams drain into it, and its entire water-shed includes 6.5 square miles. In the average of years it fills to within about a foot of full-water line. In 1882 it lacked a little over 2 feet of filling, while in 1874, for a time, water is said to have wasted 9 inches deep over two waste-weirs of 100 feet each. The borough water-supply is from this lake, and absorbs a considerable amount of its water. The lake affords a very steady power to the mills on the stream below; it is drawn upon throughout the year to the amount of 1,600 cubic feet per minute, which it seldom fails to furnish. Twice in eleven years the supply has run somewhat short, at one time for a period of five months and at another for three months. September 9, 1882, after a very dry season, the water surface was 6¾ feet below full-water line, and was being drawn down about three-quarters of an inch a day. The dam would admit of being raised higher, and a plan is under consideration to tap Mad river at a point above the borough, and by means of a canal 2 or 3 miles long convey its surplus waters to the lake.

The uppermost establishment in Winsted, on Mad river, is the Empire Knife Company. A short distance up stream it has a reservoir of several acres, which can be drawn down 25 feet, and between this reservoir and its factory it owns several unimproved powers.

The various falls in use at Winsted, and some facts regarding the manufacturing, may be learned from the following table:

Water-privileges at Winsted and vicinity (in order descending).

Firm.	Manufacture.	Fall. (a)	Rated horse-power of wheels. (a)	Remarks.
Lake stream.		*Feet.*		
.....	Turning-shop	17	.....	
.....	Saw-mill	19	.....	
Henry Spring Company	.....	16	45	
Beardsley Scythe Company	.....	28	110	
Winsted Manufacturing Company	Scythes	20	.....	
Hulbert Iron Works	.....	14–16(?)	.....	
T. C. Richards Hardware Company	.....	12	30	Transfers small power by cable to Winsted Silver Plate Company.
Winsted Hoe Company	.....	21	55	
Mad river.				
Empire Knife Company	.....	18–20	.....	35-inch National wheel. In average year can run full capacity eleven months.
George Dudley & Son	Tannery	.....	.....	
John T. Rockwell	... do	13	30	
Wing Persons	Feed-mill	8½	22	Lake stream empties into pond above the dam.
Thayer Scythe Company	.....	10	.....	Works closed permanently.
Winsted Foundery & Machine Company	.....	6½	15(?)	
New England Pin Company	.....	9	54	Can run at full capacity by water-power about nine months. Uses steam in addition. Rents occasional surplus power to a grist-mill.
Winsted Hoe Company	.....	10	40	
Strong Manufacturing Company	Undertakers' hardware	7⅞	38	
Still river below Mad river.				
William L. Gilbert Clock Company	.....	18	72	Large concern, employing 200 hands. Can run at full capacity by water-power nine or ten months. Uses steam in low water. Leaky wooden dam on rock ledge.
Winsted Manufacturing Company	Scythes, corn-knives, etc	14–16	.....	
Franklin Moore & Co	Norway bolts and nuts	13–14	.....	One privilege.
R. Cook & Sons	Fine carriage-axles			

a Approximate.

Shortly below Winsted, F. Woodruff & Son use power for a grist-mill. About a quarter of a mile above Robertsville the stream passes through a rocky gorge and over an abrupt fall. It is said that with a high dam 35 feet fall is available there.

At Robertsville, not far above its confluence with Sandy brook, Still river runs through another narrow passage-way in the rocks, falling over 40 feet in a little distance. Fourteen feet of this fall and 25 or 30 horse-power are here employed by the Union Chair Company.

Below the junction of Sandy brook and Still river, sometimes the one name and sometimes the other is given to the main stream. Thence to the Farmington only one power is in use, and that is at Riverton, near the mouth, where the Eagle Company uses 14 feet fall and from 60 to 75 horse-power in the manufacture of scythes. A grist-mill is supplied from the same privilege.

The Pequabuck river is a small stream draining 60 square miles, embracing portions of the towns of Burlington, Harwinton, Plymouth, Bristol, and Farmington, in the latter of which it joins the Farmington river from the south. It is very flat near the mouth, but falls more rapidly above, and has a gravelly bed. Formerly it was supplied in part by Mine pond, which it is stated has now been drawn down and will no longer be used. Above Forestville the stream branches, the south branch being the more important and receiving considerable assistance from South Mountain reservoir, said to be half a mile long, but the area of which could not be ascertained. The reservoir fills regularly, and can be drawn down some 12 or 14 feet from full-water line. Although the Pequabuck furnishes a large number of small privileges,(*a*) it is of no especial importance for power, and all the principal manufacturing concerns on its course have to rely largely upon steam. The most prominent users of power are the E. N. Welch Manufacturing Company and Welch Spring Company, practically one concern. They have seven factories at Forestville and Bristol, employ 400 hands, and have four dams on the Pequabuck; they can realize full capacity from their water-wheels perhaps six or eight months in the year, but consider steam the principal power.

THE SCANTIC RIVER.

This stream joins the Connecticut river from the east a couple of miles above the mouth of the Farmington. It rises a few miles above the Massachusetts boundary, running thence southwesterly into Connecticut, and drains a total area of 118 square miles. The fall of the stream is not large, and in the main portion of its course seems to be mostly taken up. The section constituting the lower basin has a slightly broken and undulating surface, but as a whole is comparatively flat. The soil is generally light and sandy, though clayey in some sections and more or less alluvial along the streams; it has been quite thoroughly cleared of timber, and is well cultivated in tobacco and corn.

At intervals along its course the bed displays ledge rock, usually red sandstone, and much of it shaly and inferior in character. The dams at Scantic, Hazardville, and Scitico are built upon these ledges, and the same stone is used in the construction of some of them. For a third of a mile above the Scantic dam the bed is of rock, and this again crops out just above the mouth of Broad brook. Where the stream passes through meadows it is flat and winding, the bed composed of sand and clay, and the banks are alluvial and low, rising from 4 to 8 feet above low water. In those sections it is therefore impracticable to build high dams without flowing considerable meadow-land, which, between Scantic and Hazardville, has been valued at $100 per acre, though it is probably somewhat lower now. The volume is tolerably well sustained in the dry season, though less so, as some claim, than formerly, when the timber had not been so much cut away. The drainage basin being rather flat and its surface receptive of water, the stream is not seriously affected by ordinary rains. A rise of 3 feet on the roll-way of the Scantic dam, about 100 feet in length, is considered large. The effect of a heavy rain at the headwaters is ordinarily felt forty-eight hours later at the mouth; a heavy spring rain brings the stream up in half that time, and in the great storm of October, 1869, it reached a very high stage in twelve hours. It commonly runs lowest in August. General Ellis gives the least discharge as 35 cubic feet per second, and the mean discharge 139 cubic feet per second.

The Scantic river is without any storage reservoirs, properly so called, though the mill-pond at Somerville is reported to be of good size; it would be possible to obtain a large flowage at other points, but on account of submerging valuable farming-land the plan would be expensive. It is practicable to build a dam 20 feet high at the site of the present one at Scantic, near the mouth, and the owner of the latter roughly estimates that it would give a flowage of 100 acres.(*b*) Again, a dam might be built at Scitico to give a very large flowage, but the pond would set back over the Hazard Powder Company's upper privilege.

The Connecticut Central (*c*) railroad crosses at Scitico, some 12 miles by general course above the mouth, and below that point runs parallel to the stream at a distance of a mile or a mile and a half from it. Ascending from the mouth to Scitico the water-privileges are, in order, as follows:

1. At Scantic village, 3½ miles from the mouth, is N. S. Osborn's saw-, grist-, and plaster-mill. The privilege has been in use since 1729, and for a hundred years in the present family. Upon a rock ledge rests the dam, a log

a As nearly as can be learned there are 17 on the main stream and South branch.

b This plan would involve purchasing the lower privilege at Broad Brook, occupied by a grist-mill.

c Leased to the New York and New England railroad, and by it denominated "Springfield Division".

structure, with the mill at one end. A fall of 5½ feet is obtained, under which are run five tub-wheels, rated at 15 horse-power each. For five months in an average year they can all be run at full capacity, with a wastage at the same time on the dam, but in an extremely low stage only one wheel can be run without drawing down the pond.

Below the dam the stream is about 40 feet wide, and thence to the mouth has a fall, in low water, of 18 feet. In high stages the Connecticut river sets back to the dam, and in exceptionally high floods, such as that of 1854, has been known to cover it entirely from sight. In some years no trouble is experienced from backwater, while in others it hinders more or less for four or five weeks.

Estimate of power at Scantic village.

Stage of river.	Rainfall on basin.					Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power.		
	Spring.	Summer.	Autumn.	Winter.	Year.					
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. miles.*	*Cubic feet.*	*1 foot fall.*	*5½ feet fall.*	*20 ft. fall.(a)*
Low water, dry year	11	11	12	10	44	104	25	2.84	16	57
Low water, average year							40	4.54	25	91
Available 10 months, average year							45	5.11	28	102

a See preceding remarks.

2–4. From Scantic to Hazardville, a distance of 6 miles, the stream has a meandering course through meadows, and is mostly smooth water. At Hazardville is the extensive property of the Hazard Powder Company, embracing a total fall of 46 feet, divided into three privileges, each improved by a dry-stone dam. Canals, enlarging at various points into ponds of moderate size, convey water from the dams to the different mills, which are much scattered. The company also owns two privileges at Scitico, one of them in use for its works and one unimproved. The aggregate number of wheels in use on all the four utitized privileges is twenty-four, with an estimated total of about 300 horse power; 200 horse-power of steam is also employed. In an average year the wheels can be run at full capacity for about eight months.

5. Paper-mill privilege, with 12 (?) feet fall.

6. Privilege at Scitico, occupied by Spencer & Charter's 4-run grist-mill. The dam is of horseshoe shape, and is a fine cement-masonry structure, about 80 feet long, 20 feet wide at the base, and nearly as wide at the top. A fall of 12 feet is in use.

7. Fall of 9 feet, unimproved except by the remains of some old work; owned by the Hazard Powder Company and held for its own use.

8. Hazard Powder Company's upper privilege, 16½ feet fall.

Broad brook is a small stream joining the Scantic at Broad Brook village. It has but slight value for power, and is used by only one concern of importance—the Broad Brook Company, manufacturer of fancy cassimeres, and running 16 sets of cards. There is a pondage of about 8 acres above the dam, but there is no storage reservoir on the stream for improving its dry-season flow, although it is said that one could be built at Melrose. The Broad Brook Company runs its mill principally by steam, but it has two water-wheels, each of 60 horse-power, operating under 24 feet head. About 30 horse-power in all can be obtained in the lowest stage of water, but the full power of the wheels is not realized more than one month in the year. There is a small grist-mill below and there are two saw-mills above on the stream.

THE WESTFIELD RIVER.

The main branch of the Westfield river rises in the town of Savoy, in the northeastern part of Berkshire county, Massachusetts. It flows thence southeasterly through portions of Hampshire and Hampden counties, and empties into the Connecticut at Springfield, having a total length of 55 miles. Twenty-two miles from the mouth it receives the West branch, and 2 miles above, the Middle branch. The Boston and Albany railroad follows up the main river from Springfield to Huntington, and then continues up the course of the West branch; the New Haven and Northampton railroad crosses at right angles to the course of the stream, at Westfield, but otherwise the drainage basin of the river, comprising 514 square miles, is without railroad facilities. The following data will give some idea of the slope of the West branch and a portion of the main stream:

Table showing the fall in the Westfield river.

Locality.	Elevation of water-surface above sea-level.	Fall between points.	Distance between points.	Fall per mile between points.	Authority for elevations.
	Feet.	*Feet.*	*Miles.*	*Feet.*	
Becket, West branch	1,200	628	9	69.8	Boston and Albany Railroad profile.
Chester, West branch	572	217	7	31.0	Do.
Huntington, main river	355	123			Do.
Top of Salmon Falls dam, Russell	232		11	20.3	
Top of Horton's dam, Westfield	132	100			Report of committee for protection of Westfield from floods.
Top of canal company's lower dam, Mittineague.	93	39	11	8.5	
Mouth of river at low water	38	55			

The country drained by this river is very hilly, and toward the headwaters is even mountainous, with many steep and rocky slopes; and as the storage reservoirs are neither numerous nor very large, rainfall quickly finds its way into the main water-courses and produces rapid fluctuations in volume. Low water lasts usually from the middle of July to the middle of September. There is often a period of high water from the first to the middle of October, while the spring rise comes in March or April. The ordinary spring-freshet depth on Chapin & Gould's dam, below Huntington, about 200 feet in length, does not exceed 6 feet, though that is sometimes also reached in a summer storm; but on December 10, 1878, water poured over the dam 12 feet deep, flooded the lower part of the mill, and brought down stream huge masses of rock, tons in weight. The circumstances of this memorable flood were, briefly, as follows: On the date of its occurrence there was already on the ground a moderate depth of snow, not exceeding 6 or 8 inches. It rained steadily during the day, but the falling water was absorbed and held by the snow, without either running off or penetrating the frozen surface underneath, and the streams gave no indication of a dangerous rise. At four or five o'clock in the afternoon, however, the weather changed and became very warm. The snow melted with great rapidity, the ground was soon bare, and by ten o'clock at night an immense volume of water was pouring down the channel of the stream. The flood was not of long duration, its height being maintained but an hour or so, but great damage was done along the whole course of the Westfield river; dams were injured, the railroad was overflowed and washed out in places, and farms and villages were inundated. Of the main portion of the river there is nothing especially important to be said as regards ice. Surface-ice is sometimes held back in the mill-ponds, and sometimes runs out when yet thick and strong. It is well broken up in going over the dams, and does not appear to cause serious trouble, although it occasionally gorges and produces a temporary set-back in the river.

It is difficult here, as with the other streams that have been described, to get any accurate data concerning the reservoirs, but such facts as could be obtained as to their location and size are given below:

Principal lakes and reservoirs in the Westfield River basin.

Name.	Locality (town).	Approximate area.	Remarks.
		Acres.	
Windsor pond	Windsor	107	Tributary to main river. Area as given by H. F. Walling—see Appendix B, *Report of the Massachusetts State Board of Health*, 1878.
Reservoir owned by L. L. Brown Paper Company.	Near Cummington village	200 (?)	Power used at outlet. Area as stated by officer of company at South Adams. Tributary to main river.
Norwich pond	Huntington	128	Tributary to main river, but not now in use as a storage reservoir, though formerly so employed. Area as given by Walling.
Center pond (reservoir)	Becket	163	Tributary to West branch. Area as given by Walling.
Yokum pond (reservoir)	do	118	Do.
A new reservoir	Probably in Becket		Tributary to West branch, and said to be larger than either Center or Yokum pond.
Wheeler reservoir	Becket	100	Tributary to West branch. Area as given by Walling.
Rudd pond (reservoir)	do	96	Do.
Church's reservoir	Middlefield (?)		Tributary to West branch.
Long pond	Blandford	150	Tributary to Little river. Area as given by Walling.
Blair pond	do	215	Do.
North Meadow pond	do	80	Do.
Congamuck pond	Southwick	589	Outlet through Great brook. Area as given by Walling.

General Theodore G. Ellis has given the least discharge of this river as 500 cubic feet per second.(a) This is a high discharge, corresponding very nearly to a cubic foot per second per square mile of drainage area, and, judging also by the experience of the mills on the river, seems considerably too large. In the same report, written in 1874, General Ellis placed the greatest discharge at about 28,600 cubic feet per second, but subsequently, in the great

a *Surveys and Examinations of the Connecticut River*, page 55.

freshet of December, 1878, this figure was certainly much exceeded. In his report upon a plan for protecting the town of Westfield from damage by floods, Mr. Hiram F. Mills, of Lawrence, gave the greatest flow of the river during the freshet alluded to at 53,000 cubic feet per second on the Salmon Falls dam and 46,000 cubic feet per second on the Agawam Canal Company's dam.

Ascending the Westfield river, smooth water continues from the mouth to within a quarter of a mile or so of Mittineague, where is located the first dam. A rocky shoal then begins and stretches up past the village, being interrupted only by the fall and slack-water of the dams. The banks are rather high and steep, and in places rise vertically from the river, being composed of a shaly red sandstone which crumbles away with exposure.

The lower privilege at Mittineague is owned by J. L. Worthy. A low timber dam, resting on a rock ledge, runs diagonally across the river, with a mill at each end. On the south side power is leased to the Worthy Paper Company, manufacturers of fine writing- and ledger-papers. The tail-race on this side runs for an eighth of a mile down stream beside the bank, in order to gain advantage of the shoals below the dam. The fall on the privilege is nominally 10 feet, but is practically only about 8 feet much of the time, the tail-race having filled up somewhat. At the north end of the dam is a 2-run grist-mill owned by Mr. Worthy and leased to H. C. Bouton. The paper-mill runs part of its machinery 10 hours and part 24 hours per day. It has the first right to water, and throughout ordinary years has a sufficient supply, but for two months in the summer of 1882 could only run at two-thirds capacity, and the grist-mill was shut down altogether during that time. Backwater from the Connecticut troubles here during freshets, and especially when the two streams are high at the same time. The ordinary depth of backwater on the wheels from freshets is perhaps 2 feet, and 6 feet is reached in extreme cases; the former amount may last three or four days, but the paper-mill is never entirely stopped by backwater for more than two days. Ice-gorges sometimes form in the river below and produce a temporary set-back, but hinderance from this source is neither serious nor lasting.

The Agawam Canal Company's privilege, in the same village, succeeds the one just described. A timber dam, with roll-way 457 feet long and 18½ feet high, extends across the river half a mile or more above the mills. A canal runs down the north bank past the rapids, and supplies, in order, the Southworth Company, manufacturers of fine writing and ledger paper; the Agawam Canal Company, owners of the power and manufacturers of cotton goods—sheetings, shirtings, and drillings; and the Agawam Paper Company, engaged in the manufacture of fine writing paper and bristol-board. Backwater from this dam reaches only about a third of a mile, and is succeeded by a second dam, a log structure with roll-way 358 feet long and 6 feet high, which sets back the stream perhaps 2 miles with an average width of say 300 feet. No power is used here, and the reservoir merely serves to pond water for the use of the mills below.

Including both falls, the canal company owns in all about 39 feet, 6 feet at the reservoir dam and 33 feet at Mittineague. At the latter point the fall from the canal to the river varies from 29 feet at the Southworth mill, to 33 feet at that of the Agawam Paper Company. The canal company has leased 132 horse-power to each of the other two companies, and itself runs wheels having an aggregate rated capacity of 350 horse-power. There is good building-room near the railroad station for another large mill, but unfortunately power is lacking, and the privilege is, practically, fully developed; an additional mill could not be sure of water for more than six or eight months in some years. For four years previous to the summer of 1882 there was constantly enough water for all the mills, but during that season the supply ran short and caused more or less stoppage at the lower mill. For two months it was necessary to rely largely upon the reservoir; for one month it did not fill at night, and the water-surface was at times from 26 to 32 inches below the crest of the dam in the morning. The practice is to draw down the reservoir not more than 45 inches, as below that level sufficient water is not obtained to be of much assistance.

Anchor-ice runs in the canal and bothers somewhat by clogging the wheels, but they are never stopped more than two or three hours from that cause. As has been mentioned concerning other New England privileges, so here trouble has occasionally been experienced from the canal having been drawn down in winter so that the thick surface-ice settled; the water afterward rose on top of the ice, and, freezing, formed so thick a mass as seriously to interfere with the flow.

At Mittineague the land rises from the river to hills of moderate height, and then spreads out gently undulating. It is fairly cultivated in tobacco and corn, and shows occasional patches of timber. Above the village the stream comes through a range of hills, and then, for a long distance above, its course lies through a level plain, in which is Westfield, the most important place on the river. The stream appears to be generally quite flat in this section, and although the table of elevations, previously given, indicates a fall of 39 feet from the top of Horton's dam at Westfield to the top of the lower Agawam dam, or over 20 feet between the foot of Horton's dam and the top of the upper Agawam dam, this latter fall seems to be nearly all utilized in giving the stream a smooth, uniform flow without shoals of any importance; and diligent inquiry only elicited the opinion that there is no available privilege in this distance. It was stated that some years ago the Agawam company talked of raising its upper dam 4 feet, and that objection was made by the owners of the lower privilege on Little river from fear of backwater.

The dam at Westfield is close by the Boston and Albany railroad station, and near the foot of what were formerly called the "Half-mile rapids", a series of rocky shoals. It rests mainly upon a rock ledge, which also

extends out under the north bank, but which suddenly drops away on the south side of the river before reaching the bank. The old dam rested entirely on the ledge, but after the flood of December, 1878 (*a*) it was extended at the south end in beyond the ledge, over a quicksand bed, and there rests upon a foundation of piles. The present length of the roll-way is stated to be about 450 feet and its height 6 or 7 feet; it is built of logs. The mills and shops are located at either end of the dam, and are of small size, there being two or three establishments in a single building. On the north side are a saw-mill and planing-mill, a 4-run grist-mill, a machine-shop, the Acme Whip Company's works, the Warren Thread Mill, the Pierce Steam Heating Works, and a concern for the manufacture of cotton-waste; on the south side are two shops manufacturing, respectively, whip-snaps and whip-stocks.

This privilege is owned by Mr. Samuel Horton, who rents power to the various manufacturers. The fall is about 10 feet, and the effective horse-power is estimated at from 300 to 500 for the greater part of the year; 150 or 200 horse-power is now in use. The pondage above the dam is not large, being confined within the natural banks of the stream. In the dry season the supply of water is liable to be very irregular; when the mills farther up stream are allowing their ponds to fill, scarcely any water comes down, and the power sinks very low for a time. Such occurrences are exceptional, however, and aside from those times the available power may be estimated as below:

Estimate of power at Horton's privilege, Westfield.

Stage of river.	RAINFALL ON BASIN.					Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power.	
	Spring.	Summer.	Autumn.	Winter.	Year.				
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. miles.*	*Cubic feet.*	1 *foot fall.*	10 *feet fall.*
Low water, dry year	12	13½	14	12½	50	360	80	9.09	90
Low water, average year							140	15.90	160
Available 10 months, average year							210	23.80	240

For 3 or 4 miles above Westfield the course of the river continues through a flat country, with no woods or consequence, but settled and cultivated; the bed is gravelly, the banks are of only moderate height, and there is but slight fall to the stream. Near what is known as the "Four-mile house" it issues from the mountains, and it is said that by building a dam just above this point and running a canal out upon more open ground a fine privilege could be developed. The fall in this section is owned by various parties having land adjacent to the course of the stream and the amount available for such a power as has been mentioned would of course be governed by the height of dam and length of canal. Between the foot of the Vernon property at Salmon Falls and the top of Horton's dam at Westfield there is an unimproved fall of 54 feet, the power of which can be judged by comparison with the estimate made for Horton's privilege.

For a mile above the Four-mile house, to Salmon Falls, the stream lies at the bottom of a deep valley, the mountains rising on either side with steep and rocky faces. The Boston and Albany railroad and a carriage road follow the valley, high up from the stream, the former on the north and the latter on the south side. The space is too contracted for the improvement of water-power in this portion, but at Salmon Falls, 5 miles above Westfield and 2 miles below Russell, the valley widens out somewhat and the stream foams down over great outcropping masses of granitic rock.

On the upper part of the falls a heavy masonry dam, the stones tied together with iron dogs, runs in an irregular line across the river from one ledge to another, the mill being built close to the dam on the south bank. The privilege is owned by Vernon Brothers, of New York, and is occupied by the Vernon paper-mill for the manufacture of all kinds of fine writing paper. The fall in use is 24 feet, and the proprietors also own an additional fall of 22 feet immediately below, extending to a pool at the foot of the falls. Five water-wheels, with an aggregate capacity of 540 horse-power, are in use, and in an average year can be run at full capacity about nine months. For the rest of the time the supply is more or less short, but it is estimated that 240 horse-power can be obtained 10 hours per day in the lowest stage of the river. A 350 horse-power steam-engine is run during low water. From November, 1881, to July, 1882, the works were run entirely by water-power, but from that time on to at least the middle of September, when the stream was visited, steam had to be used as auxiliary power. The pondage here is not great, but is sufficient to run the mill for several hours without any assistance from the stream during that time. Two hundred hands are employed, and part of the works are run 10, and part 24, hours per day.

Between Salmon Falls and Huntington the rise continues rapid, amounting to 123 feet in the distance named; the bed is gravelly or rocky, and the valley is much of the way narrow. It is probable that several good privileges might be developed here. Perhaps three-quarters of a mile above Salmon Falls there are gravel shoals, and on the south side of the stream the land rises gradually from the immediate bank, which is of fair height.

About a quarter of a mile below the present depot at Russell the Boston and Albany railroad formerly crossed the river; it then continued, say three-quarters of a mile, up the west bank and recrossed. At the lower crossing a

a During that flood the water rose 14 feet above the crest of the dam. The roll-way was afterward made 80 feet longer in order to give greater length of overfall and thus to diminish the rise bove the dam in future freshets.

granite ledge rises 20 feet above the water and extends across the river, forming most of the way a natural dam. Three piers and the west abutment of the old bridge still remain. At the road bridge, a quarter of a mile up stream, the river is from 175 to 200 feet wide. It continues rapid down to the ledge, and probably falls 6 feet in the last 600 feet. Approaching the ledge it contracts, runs between two adjacent bridge-piers, and at one point, indeed, is at low water confined to a width of 10 or 15 feet. There is good building-ground immediately below on the east bank, adjacent to the railroad, and possibly the ledge itself could be conveniently used in part for foundation. The present railroad grade is about 23 feet above low water at the old bridge site, and in improving the privilege it would be necessary to provide a sufficiently long roll-way to guard against a rise on to the track in high water, but probably a dam 10 or 12 feet high could be raised without any danger. Or, if desired, a dam could be built somewhat above, and a canal run down the west bank. Immediately below the natural dam there is smooth water for some distance.

Estimate of power one-fourth of a mile below Russell station.

Stage of river.	Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power.		
	Sq. miles.	*Cubic feet.*	1 *foot fall.*	10 *feet fall.*	15 *feet fall.*
Low water, dry year	325	70	7.95	80	120
Low water, average year		120	13.63	140	200
Available 10 months, average year		190	21.58	220	320

The upper of the old railroad crossings, three-quarters of a mile, more or less, above, has also been suggested as a good site for a dam. The bed and banks are there gravelly, the latter rising 25 or 30 feet above low water, and the railroad track is about 25 feet above the stream on the east side. If a dam of good height were built there and a canal run down the west bank, advantage might perhaps be taken, part of the way, of a depression inside the old railroad grade; but if carried far the canal would be likely to encounter some rock.

Between Russell and Huntington, and about 2¼ miles by road below the latter point, is Chapin & Gould's paper-mill, employing 120 hands in the manufacture of blank-books. The dam has a roll-way about 200 feet long, and runs out upon massive ledges which here fill the stream. It is in two sections, which from the shores make an angle with its vertex down stream. Formerly the structure was entirely of stone, but in the flood of 1878 it was partially carried away, and one-half has since been replaced by a crib-work bolted to bed rock and filled with loose stone. The fall on this privilege is 21½ feet, and the wheels used have an aggregate capacity of 316 horse-power. The mill runs 24 hours per day, and can be operated at full capacity by water-power ten or eleven months in an average year. Messrs. Chapin & Gould also own, and hold for their own use, 18 or 20 feet of fall immediately below this privilege.

The next power is at Huntington, a short distance above the mouth of the West branch. It is owned and occupied by the Chester Paper Company, employing 70 hands in the manufacture of writing paper. The dam is built upon a rock ledge most of the way across, but the ledge drops away before reaching the east bank, and there a portion of the dam and the east abutment rest upon quicksand. *The structure is a log crib-work with stone filling.* It was originally started as a stone dam, but the foundation proving unsuitable the plan was changed and the dam built as stated. It has a straight roll-way about 266 feet long between abutments; the height at the crest is 14 feet, from which point there is a slope both ways, the down-stream slope being prolonged by an apron making a small angle with the horizontal. The width at base, from the foot of the back slope to the end of the apron, is about 50 feet. The main part of the dam was built in 1870, but the flood of 1878 carried away the east abutment and made it necessary to extend the roll-way 60 or 70 feet. The mill was also injured at that time, and a three months' stoppage of work was forced. The original dam cost $14,000, and the repairs made in 1879 cost $8,000. The east abutment is now a crib-work. The west abutment, which rests upon rock and is upon the same side of the river as the mill, is heavily built of cemented masonry, measures, at the top, 11 feet with the stream by 20 feet inshore, and rises about 10 feet above the crest of the dam. It is continued in shore and up shore by a masonry bulkhead and river-wall, the former pierced by three gate-openings each about 2½ by 4 feet in size. The pond is of moderate size, and flows but very little beyond the natural banks of the stream. At the mill, which is immediately below the bulkhead, a fall of from 14 to 16 feet is obtained, and old wheels, estimated to furnish in the aggregate about 140 horse-power, are run. This amount of power can be realized, it is thought, 24 hours in the day for nine months in the average year; the flow is quite variable, however, and during the two months of July and August, 1882, the works could not be run at more than one-fourth capacity a part of the time.

The Chester Paper Company owns the right to a reservoir on Norwich hill, in the town of Huntington. It is a natural pond of 100 acres or more, raised by a dam so as to flow not over 200 acres, and could be drawn down 8 or 10 feet. A dispute with the county commissioners as to the character of certain improvements in the dam caused the use of this reservoir for storage purposes to be given about the year 1880 or 1881. It could be relied upon to fill only once during the year. It is a general opinion, and undoubtedly a correct one, that the main branch of the Westfield river might be well reservoired.

Immediately succeeding the privilege last described, and situated close to the village of Huntington, on the main stream, is a power owned, two-thirds by W. P. Williams and one third by H. E. Stanton. It is used for the manufacture of ax-handles, and by a saw-mill and a grist-mill. When all the works are running it is estimated that about 75 horse-power is in use, and in very low stages of the river there is no surplus water. The dam is a log crib-work with stone filling, has a sloping face, and a horizontal apron 11 feet wide. It rests partly on ledge rock and partly on gravel; the east abutment is of crib-work, and the west, next the mill, of stone. The dam is 260 feet long between abutments, 8 or 9 feet high, 36 feet wide at the base, including the apron, and was built in 1875 at a cost of $9,000. The flood of 1878 washed around the east abutment, and 75 feet into the adjacent high gravelly bank, but did not injure either the abutment or the dam. Immediately from the gate at the west end of the dam water is carried through a wooden tube of 4 feet internal diameter, first to the grist-mill and then to the saw-mill. The present fall is about 10 feet, but by excavating the tail-race it is to be increased to 12 feet. The freshet-rise on the dam is ordinarily from 3 to 5 feet, but in December, 1878, it was 12 feet.

Ascending the main or East branch of the Westfield river above Huntington the fall is found to be rapid and constant; it is said that a railroad survey has shown the average descent from West Chesterfield to Huntington, a distance of 12 or 14 miles by general course, to be 18 feet per mile. The river-bed is composed of ledge rock at many points, and elsewhere of gravel and bowlders. The banks are variously of gravel or rock, and are of good height. The flowage would not commonly be large, although such might be obtained in places by a high dam. The valley is frequently narrow, with high steep banks to the stream; but there are numerous intervales where the hills recede and the river is bordered, usually on one side only, but sometimes on both sides, by narrow meadows. The immediate valley is sparsely settled, and often contains the poorest land. The hill-slopes rise on either side abrupt and rocky, well wooded, and where cleared are mainly devoted to pasturage. But ascending out of the lower valley the country stretches away, still hilly, but with long, gentle, and beautiful slopes of fine farming land. Grass, corn, potatoes, and stock are principally raised. In the vicinity of Huntington chestnut and red-oak are the chief varieties of timber. Chestnut continues for 10 miles up the main stream and 4 miles up the Middle branch, and is succeeded by hard wood and hemlock above on both streams. In the neighborhood of West Chesterfield beech, birch, and maple are the more common trees.

Freshets and ice-runs are probably more noticeable on this part of the main river than toward its mouth, where there are more dams and a greater storage. The stream rises from 6 to 12 hours after a heavy rain, and then rapidly recedes. An important disadvantage to the use of water-power in this section is the absence of railroad facilities, the Boston and Albany railroad leaving the main river at Huntington and running up the West branch.

There is no power in use between West Chesterfield and Huntington, although there is a large fall, of probably over 200 feet, in this distance. A considerable portion of this might doubtless be put to use, and a few of the more prominent sites will here be considered.

At Norwich Bridge, a mile and a half above the point of union with the West branch, a rude dam of cobble-stones years ago diverted water into a race which ran 250 feet down the east bank to a satinet-mill. The dam was carried away in an October freshet and the power went into disuse. The location is fair, but it would not be practicable to build any but a low dam, because the banks are low above. The river is about 140 feet wide at Norwich Bridge, and between that point and the next privilege to be described the Middle branch comes in.

The next power is owned by Mr. S. S. Stowell, who resides a short distance below Norwich Bridge on the east side of the river. The stream cuts through a gorge, and is hemmed in by rocky walls rising almost vertically from 30 to 50 feet; it dashes through this cut with rapid fall over rock ledges. Every facility is offered for a dam, strong and secure, of almost any desired height; while above and below the gorge the hills recede so as to offer, in the one case large flowage, and below, a fine site for canal and buildings. Two rocky shoulders projecting on either side of the river present natural abutments for a dam, which would run diagonally across the stream, with a length of probably from 200 to 250 feet. A canal could then be carried out on the west bank a little way, that side of the river being the more favorable for building; some rock-blasting would very likely be necessary. Mr. Stowell's privilege is 2½ miles by road from Huntington, and certainly possesses fine natural advantages. One-half or three-quarters of a mile above Stowell's privilege there is another fine site. The river here runs south and then bends sharply to the west. The east bank is gravelly, and rises steeply from the water 25 feet to the highway. A short distance back from the water the west bank also rises to a hill. A dam of good height could be built. The canal would naturally be carried on the west bank, and would soon strike a broad flat, surrounded in part by the river-bend and with abundant building-room. The river-bed at this point is covered with gravel and bowlders, and is about 150 feet wide between banks.

At Knightville, 4 miles above Huntington, the river runs for several hundred feet between almost vertical cliffs, with swift current and rapid fall. These cliffs rise from 30 to 50 feet at once from the water, and are composed of strata of mica-schist, dipping to the westward at an angle of at least 75 degrees. The stream varies in width from 50 to 75 or 100 feet. A little below the foot of the gorge a ledge of gray granite runs diagonally across the river and affords a splendid site for a dam. The rocks project from 3 to 7 feet above low water, and so completely close the channel as to cause an abrupt pitch of about 2 feet. At the west end of the ledge the bank rises, rocky and nearly vertical, 30 feet or so. The east bank also shows ledge rock close to the water, but farther back it is

covered with a gravelly soil and has a gentle rise. A high dam could be built here, and a mill located either at its east end or upon a short race to be run down that bank. The valley is sufficiently open to accommodate a mill of good size and a moderate number of houses within a convenient distance, but the location is not suited to a large village. A number of years ago the power here was in use by a saw-mill, a grist-mill, a bedstead-shop, and a large factory for the manufacture of children's carriages and sleds. The owners at that time had not much capital, and the power was never fully improved. The dam was built upon the granite ledge which has been mentioned, and was a wooden structure; it was partially destroyed in 1869, and two years later the remainder was swept away. At present two-thirds of the privilege is owned by Alonzo Clark, of New York city, and one-third by Webster Herrick, of Northampton, Massachusetts. The available fall owned is stated at 21 feet, the power corresponding to which may be estimated as below:

Estimate of power at Knightville.

Stage of river.	RAINFALL ON BASIN.					Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power.	
	Spring.	Summer.	Autumn.	Winter.	Year.				
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. miles.*	*Cubic feet.*	1 *foot fall.*	21 *feet fall.*
Low water, dry year	11½	13	13½	10	48	158	30	3.41	70
Low water, average year							50	5.68	120
Available 10 months, average year							80	9.09	190

At the road bridge shortly above Knightville the river measures from 90 to 100 feet in width. A half-mile or so above that village a dam could be built, though the banks are not especially favorable, and a canal could be run down the left bank to a fine open spot. Above this point the highway is low and near the river, and any but a low dam at the locality mentioned would probably cause it to be overflowed during high water.

Within about 5 miles of West Chesterfield the valley grows narrower, and building-room is not so abundant as below. Some 4 (*a*) miles below the village, and close by the carriage-road, a rock ledge crosses the river between high banks. A canal could be extended a short distance on the right bank, and room would be obtained for a mill of moderate size, but the space is rather limited. Below the ledge the left bank is alluvial and sandy in places. The river is here from 75 to 100 feet wide, and the rock strata are, as elsewhere in this section, nearly or quite vertical. The privilege is a fairly good one.

Just above this locality there is an old log dam running in a V-shape across the stream on a ledge. It is leaky, and in poor condition generally; the north end is broken away, and all the water of the stream passes through the breach and through the old dry-stone bulkhead immediately adjacent. The mill is gone, and there is but little building-room close to the dam, though by carrying a race 100 feet down the bank abundant open space would be reached where a valley puts back from the river. The fall over the dam is probably not more than 6 feet.

About a mile below West Chesterfield the stream is inclosed for a considerable distance by smooth vertical walls of solid rock, rising on the west side 20 or 25 feet from low water, and still higher on the opposite side. The river is perhaps from 100 to 150 feet wide, and the west bank is succeeded by open ground suited to building. Many years ago the river is said to have been dammed at this point and power to have been used by a woolen-mill and two saw-mills, but they were all carried away in a great flood in January, 1839. The stream is so confined by the vertical walls which hem it in that a dam of any considerable height in the gorge would probably cause a dangerous rise during high freshets. In December, 1878, the river is said to have risen here 34 feet above low water and to have overflowed its high banks.

The last privilege to be noticed is in West Chesterfield and is owned by Seth A. Healy. A V-shaped log dam extends across the river, with dry-stone abutments, and a roll-way about 150 feet long. A race perhaps a third of a mile long runs down the east bank to a small factory, where are made plane-handles, saw-handles, and gun-tubes. The fall on the privilege is stated to be 17 feet.

No examination was made farther up this stream. There is said to be no other power in use before reaching Cummington, where there is a paper-mill, with some other concerns of small size. At West Chesterfield the ordinary spring-freshet rise, where the river runs freely, is about 4 feet; but in December, 1878, there was a depth of 12 feet on the dam, the banks were flooded, and much damage was done. Ice of an ordinary thickness of about 2 feet runs down the stream in spring, and occasionally gorges in this section, though not often.

a These distances were estimated, and may not be accurate.

Principal water-privileges on the Westfield river, from West Chesterfield to the mouth.

Locality.	Drainage area.	Fall.	Theoretical horse-power. Low water, dry year.	Low water, average year.	Available ten months, average year.	Remarks.
	Sq. miles.	*Feet.*				
West Chesterfield	109	17	.....	.....	.....	Power used, in part at least.
One mile below West Chesterfield (*a*)	.....	.....	*b* 2.27	*b* 3.98	*b* 6.82	Rocky gorge.
Four miles below West Chesterfield (*a*)	116	.....	*b* 2.27	*b* 3.98	*b* 6.82	Has log dam, say 6 feet high.
Half-mile above Knightville (*a*)	.....	.....	*b* 3.41	*b* 5.68	*b* 9.09	Good site.
Knightville (*a*)	158	21	70.00	120.00	190.00	Power formerly used.
Say 3 miles above Huntington (*a*)	.....	.....	*b* 4.54	*b* 7.95	*b* 13.63	Good site.
Say 2½ miles above Huntington (*a*)	.....	.....	*b* 4.54	*b* 7.95	*b* 13.63	Stowell's privilege. Fine power.
Norwich Bridge (*a*)	220	.....	*b* 4.54	*b* 7.95	*b* 13.63	Formerly used. Small power.
Huntington	.....	12	.....	.....	.....	Privilege owned by W. P. Williams and H. E. Stanton. In use by saw-mill, grist-mill, and ax-handle factory.
Do	.....	14–16	.....	.....	.....	140 horse-power in use by Chester Paper Company.
Say 2¼ miles below Huntington	.....	21½	.....	.....	.....	316 horse-power in use by Chapin & Gould's paper-mill.
Do	.....	18–20	.....	.....	.....	Owned by Chapin & Gould. Not utilized, but reserved for their use.
Say ½ mile above Russell station	.....	.....	*b* 7.95	*b* 13.63	*b* 21.58	Old Boston and Albany railroad crossing.
Say ¼ mile below Russell station	325	.....	*b* 7.95	*b* 13.63	*b* 21.58	Old Boston and Albany railroad crossing. Rock ledge and good site.
Huntington to Salmon Falls	.....	82±	650.00	1,120.00	1,770.00	Total amount of undeveloped fall.
Salmon Falls	340	24	.....	.....	.....	540 horse-power in use by Vernon paper-mill.
Do	.....	22	.....	.....	.....	Not utilized. Owned by Vernon Brothers.
Say 4 miles above Westfield	340	.....	*b* 9.09	*b* 15.90	*b* 23.86	Stream issues from mountains.
Salmon Falls to Westfield	.....	54±	490.00	860.00	1,290.00	Total amount of undeveloped fall.
Westfield	360	10	90.00	160.00	240.00	Horton's privilege; from 150 to 200 horse-power in use.
Mittineague	.....	6	.....	.....	.....	Reservoir dam. No power used.
Do	.....	33	.....	.....	.....	Utilized for paper and cotton manufacturing.
Do	.....	8–10	.....	.....	.....	Utilized by paper-mill and grist-mill.

a In the sites here mentioned it is not pretended to embrace all that might be utilized, but only some of the more prominent ones. As previously stated, there is probably a fall of over 200 feet between West Chesterfield and Huntington. Its exact amount is uncertain; none of it is in use, and its division into privileges must depend upon circumstances.

b Per foot fall.

Middle branch of the Westfield river.—The Middle branch rises in the town of Peru, flows thence southeasterly between Worthington and Middlefield and through Plainfield, joining the main river a mile or two above Huntington. It drains 54 square miles. This stream was examined for about 8 miles above its mouth. In general features it is not unlike the upper part of the main river. The valley is shut in by high hills, well wooded and, where cleared, mainly devoted to pasturage. The width between the bases of the hills is, in the lower valley, perhaps half a mile in places, but farther up stream it seldom exceeds a quarter of a mile, and at times the hills rise on either side at once from the water's edge. Their slopes are, generally speaking, steep, and frequently very rocky. The narrow strips of meadow-land bordering the stream are devoted to grass, corn, and potatoes, and along the lower course sell at about $25 per acre.

So far as this branch was examined it differs from the main stream in not running through the narrow cañon-like gorges such as are found along the latter. There is no difficulty in finding banks of good height, but there are also many places where, on one side at least, the land immediately bordering the river is low. The carriage-road now and then runs along these low places, and would be overflowed by raising the water-surface much. The fall is rapid, especially in the upper waters, and on that account and because of the narrow character of the valley a large pondage would not in general be practicable; still it could doubtless be obtained at points by a high dam at the foot of an intervale and by flooding back over good meadow-land. The bed and banks are gravelly or rocky, and the former displays many bowlders; here, as on the upper main river, the rock strata are almost vertical, dipping a little north of west.

A large amount of fall remains undeveloped, and though the stream has some good natural advantages for power its value is lessened by lack of any railroad facilities. At present it is not supplied by any storage reservoirs, and the volume runs very low in a dry season; but it is said that reservoirs are practicable on the upper waters, and, in particular, that in West Worthington there is a large tract of swamp-land, estimated at several hundred acres, which could be flowed to good advantage. The manufacturing on this stream is mainly in small articles of wood, and years ago seems to have been more important than now, no less than five privileges, once improved, having gone into disuse on the portion of the stream which was visited.

Principal water-privileges on the Middle branch of the Westfield river.

Locality.	Owner or user.	Manufacture or kind of mill.	Fall.	Remarks.
			Feet.	
Town of Worthington	George H. Miller	Saw-mill and variety woodwork.	10	North Chester post-office. Uses 2 wheels and about 40 horse-power. Considers privilege good for 40 horse-power 8 months in an average year; during the remaining time it may run as low as 10 or 15 horse-power. During the summer of 1882 it ran below 10 horse-power, and for one month the pond did not fill at night; but there is considerable leakage at the dam. The latter is a framed and log structure on a rock ledge. It makes an angle down stream, and is 105 feet between abutments by 12 feet high. It was built about 1875, and cost approximately $500.
Say 8 miles from Huntington	Heirs of Elias Howe	Unoccupied		Formerly in use, and part of dam still remains.
North Chester	Herman Powers, of North Chester.	do	17½	Seven and a half miles from Huntington. Dam is about 100 feet long between abutments; 25 feet of this is stone, and the balance framed. It is 30 years old and needs replanking. Years ago woolen goods were manufactured here, and afterward cotton, and, in 1845, 150 hands were employed, but later on the mill was burned.
Do	Herman Powers	do	14	Good location, with rock ledge on left bank. The old log dam remains, but is decayed and half broken away. The mill stands in part, but is of no value.
Dayville	M. B. Prouty & Son	Shoe-pegs and 1-run gristmill.	14-15	Log dam on ledge; 30 years old, about 120 feet between abutments and 7 feet high. Race several hundred feet to mill. Can run full capacity about 9 months in an average year.
Do	H. E. Day	Shoe-pegs, whip-butts, and saw-mill.	9-11	Five miles from Huntington. Low framed dam about 100 feet long, with level plank apron and dry-stone abutments, diverts water into a canal 15 or 20 feet wide and 200 or 300 feet long.
Dayville to Littleville		Fall unimproved		Stream 50 or 75 feet wide. Near Littleville there was a large power in use 30 years ago by a bedstead factory, which was afterward burned; 40 or 50 men were employed, and the buildings were of large size.
Littleville	B. B. Eastman	Whip-butts	3	Three saws are run, and about 12,000 butts are made per week. A log dam, 3 feet high and 90 feet long, turns water into a short race. The water-wheel was made by Mr. Eastman, and is novel because of its shallow depth and the small head under which it runs. It is of wood, is 4 feet in diameter and only 4 inches deep. It is estimated by the owner to furnish several horse-power, and will run the mill, it is claimed, when other mills on the stream can not run.
Do	Oliver Eastman	Wooden bowls and saw-mill.	8	Log dam over 100 years old; on rock ledge; about 100 feet long and 8 feet high. Perhaps 18 horse-power in use.
Littleville to Sloan's privilege		Unimproved		Distance of 1½ or 2 miles.
Not over half-mile from mouth	John Sloan, of Hartford, Connecticut.	Unoccupied	10½	Formerly used in the manufacture of wooden bowls. Old log dam remains; it is from 75 to 100 feet long and rests on ledge. The wooden flume is partly gone, but the old mill stands. Not in use for two years previous to 1882.

The stream rises and falls rapidly. Three feet on Miller's dam, the uppermost of those mentioned, is regarded as a large rise, and the ordinary depth does not exceed 18 inches; but in the great storm of December, 1878, the rise on the dam was 8 feet, and the banks were flooded. The dams below on the stream were injured more or less, and nearly all the bridges were swept away.

West branch of the Westfield river.—This stream possesses the two advantages over either of the other branches of the Westfield, of being skirted through almost its entire length by the Boston and Albany railroad, and of being well reservoired. Its fall is very rapid, and its bed is composed of gravel and bowlders, with frequent outcropping ledges. The immediate valley is seldom more than a quarter of a mile wide between the bases of the hills, and often these ascend at once from the stream. Their slopes may be described as in general steep, quite rocky, and fairly well wooded. There are occasional small villages along the stream, but the surrounding country is sparsely settled. Much of the timber has been cleared away and replaced by pastures, and to some extent by cultivated fields, on which corn and potatoes seem to be the chief crops. The rock of this section appears to be largely granitic, and along the valley are found deposits of quartz and feldspar in the pure state. The reservoirs are all on the headwaters, and nothing more definite could be learned about them than as follows:

The Bancroft company, at Middlefield, controls three reservoirs: Center pond is perhaps three-quarters of a mile long and a quarter of a mile or so in width; it is a natural pond raised by a dam, fills regularly every year, and can be drawn down about 10 feet. Yokum pond is of smaller size, a natural pond raised, can be drawn down 10 feet, but does not fill regularly. The third reservoir is a new one, made artificially by flowing a tract of swamp-land; it is the largest of the three, has an extended water-shed, fills readily, and can be drawn down 12 or 13 feet. It is stated that this reservoir can be raised 5 feet more, and can also be connected by a horizontal cut with Yokum pond, which is near at hand, so as to insure the filling of the latter. Another large tract of swamp-land was reported which might be flowed to good advantage, and which was considered somewhat as a site for the reservoir last described.

At Becket a company whose mill is not now in operation controls two reservoirs, known as Rudd pond and Wheeler reservoir.

On a side stream emptying just below the Bancroft mill, at Middlefield, Church Brothers are said to have a reservoir and to use power at the outlet for a woolen-mill.

Six reservoirs have been mentioned. Regarding the area of two of these no information whatever has been obtained; the remaining four, Center, Yokum, Wheeler, and Rudd ponds, have a combined area, as given by H. F. Walling,(a) of 477 acres.

Water-privileges in use on the West branch of the Westfield river from Middlefield to the mouth.

Locality.	Firm.	Manufacture.	Fall.	Remarks.
			Feet.	
Middlefield	Bulkley Dunton Company	News and wall-paper	20	Low log dam with long race. Uses overshot wheel of 150 horse-power. Employs 20 hands.
Do	Bancroft Mill	Wall-paper, mainly	21	Cheap log dam, roll-way estimated at 125 feet long and 7 feet high; water brought to mill through a long race. Uses overshot wheel of 110 horse-power, and can run at full capacity by water-power 10 months in an average year.
Chester	Timothy Keefe and Gurdon Bill owners of privilege.		12	Log dam, and race 150 feet or more in length. Two wheels used, of 40 horse-power each, and can be run at full capacity 9 or 10 months in an average year. J. Keefe makes bedsteads and Frank Grant & Co. make corundum wheels.
Do	Hampden Emery Company	Emery and corundum	10¼	Log dam with log apron; roll-way say 140 feet long by 10 feet high. Uses 100 horse power, and can usually run at full capacity by water-power about 9 months in the year, but during the summer of 1882 the power is estimated to have fallen to from 15 to 25 horse-power much of the time.
Do	E. Wilcott owns privilege		10	Rude dam of cobble-stones, and race from one-quarter to one-third of a mile long. Perhaps 10 horse-power in use. Wilcott makes toy whips in a small way, and leases power to Nelson & Judd for grinding quartz and feldspar.
Spar Hill, just above Huntington.	Chester Mica and Porcelain Company.			Grinds quartz and feldspar obtained from neighboring mines, and ships the product to be used in making porcelain and sandpaper. Has a log dam 70 or 75 feet long and 6 feet high, with sloping face 18 feet in length. Race several hundred feet long to mill.
Huntington	Highland Mill	Woolen suitings	14	Runs 5 sets of cards. Log dam with stone filling, and canal 500 feet in length. Has sufficient water 10 months in an average year.

Above Middlefield there was reported to be no power in use except by one or two small saw-mills in Becket. This portion of the stream has a bed of gravel, ledge rock, and bowlders, and a fall of 80 feet or more to the mile. The abrupt, rocky slopes quickly shed rainfall into the river, but the descent of the latter is so great that the water is quickly carried off, and freshets cause no serious trouble. Slight hinderance is experienced from anchor-ice in the races at Middlefield.

The privileges which are described in the preceding table of course include but a small part of the aggregate fall of the stream. According to the profile of the Boston and Albany railroad, there is a total descent of 845 feet from Becket to Huntington, of which probably not more than 15 per cent., at the most, is utilized. Much more fall might be improved than has been, but a considerable portion of the stream has but little value, because it is not easily accessible. About a quarter of a mile below its paper-mill at Middlefield, the Bancroft Company owns and holds for sale 30 feet of unimproved fall; this privilege has the benefit of the water from Church's reservoir. Thence down to Chester, in which distance the fall is probably in the neighborhood of 300 feet, there are no dams on the river. The carriage-road leaves the stream and makes a wide detour over the mountains; the railroad winds along in the narrow valley, crosses the stream frequently, and is without any intermediate stations, and the stream is too inaccessible to have any importance for power.

Little river.—This is an important branch joining the main river from the south between Westfield and Mittineague, and draining 87 square miles. Its lower course is through flat meadows, where it has low banks and slight fall. These meadows are well cultivated in corn; though low, they are out of reach of ordinary freshets from Little river, and it has overflowed them but twice in 20 years.

The first privilege above the mouth is that of the Westfield Power Company. A crib-work dam crosses the river, and has abutments of piling filled in with gravel. The dam is 297 feet long between abutments, 5 feet 8 inches high above the top of the mud-sill, and has an extreme width at base of 24 feet, including the apron; the front of the dam rests on a row of piles, and at the back a line of 3-inch priming prevents leakage. From the dam, water is carried, in an old feeder of the abandoned New Haven and Northampton canal, to the main canal and thence into Westfield, a total distance of about a mile and a half; a tail-race a mile or more in length returns the water to Little river. The power company owns three large brick buildings, and a smaller building of wood; in these it rents room and power to twelve different concerns. One of these makes coffin-trimmings, another emery-wheels, and the remainder are all engaged in the manufacture of whips, for which industry Westfield is well known to be the main center. The power employed is small, being obtained from a 60 horse-power steam-engine, and from an 18 horse-power water-wheel running under 10 feet head.

a Appendix B, *Report of the Massachusetts State Board of Health*, 1873.

The next privilege, only a short distance above the first dam, is occupied by Crane Brothers, manufacturers of fine ledger and all-linen paper. They own 20 feet of fall, 18 of which is practically available and in use. The wheels are of an aggregate of 200 horse-power, all of which is in use when it can be obtained, which is ordinarily about eight months in the year. The stream not being well sustained, however, the power sometimes falls very low, and for two months in the summer of 1882 not more than 20 horse-power could be realized for 24 hours in the day. The roll-way of the dam is 200 feet long and 18 or 20 feet high. It has stone abutments, and from the north end an embankment 250 or 300 feet long extends to the gate-opening, closely adjacent to which is the mill. The dam was at first entirely of wood, but in the flood of 1878 water worked around the south abutment and carried it away in part, though the roll-way stood almost entire. The water at that time rose so as just to trickle over the embankment, but the giving way of the abutment relieved the pressure and saved it. The force of the water pouring over the dam was tremendous, and tore up from the river-bed below great masses of rock, some containing from 100 to 150 cubic feet, and piled them up in a line across the stream 50 feet below the dam. The abutment and adjacent 25 feet of the roll-way were rebuilt, the latter of stone this time as well as the abutment. The main portion of the dam is of timber, with a sloping back supported in front by vertical and farther back by inclined braces. It is bolted down to a rock ledge and is very tight, showing no leakage of consequence.

A short distance up the river is the third privilege, utilized by the Pultze & Walkeley Company for the manufacture of manila paper. This company employs 11 feet fall and 70 horse-power of wheels. The dam is about 30 years old, and is a framed structure built upon a rock ledge of hard red sandstone.

Above this point there are said to be no important powers in use on Little river. Its upper course lies through a hilly wooded country, in which it has a moderate fall, a generally rocky bed, and firm gravelly banks. Except that it runs low at times, the stream is considered a good one for manufacturing purposes. Its water is soft and pure. It rises and falls rapidly, but might be rendered much more uniform and better sustained in droughts by the construction of reservoirs. These are perfectly practicable, and have been talked of somewhat, though there is no present prospect of their being built. It is reported that land for flowage is cheap in the upper waters, and that in the town of Blandford the stream drains three natural ponds which might be made useful for storage.

THE CHICOPEE RIVER.

The Chicopee river drains a large section in central Massachusetts, embracing portions of the four counties of Worcester, Franklin, Hampshire, and Hampden. It is the largest tributary of the Connecticut river in respect to drainage area, its basin containing 706 square miles. The main stream is formed at Three Rivers by the union, near that point, of the Quaboag, Ware, and Swift; it runs thence westerly through a distance of 15 miles, and joins the Connecticut river approximately midway between Springfield and Holyoke. This stream and its tributaries offer fine facilities for the use of water-power, which have already been largely availed of. The railroad communications are good, the Boston and Albany railroad and lines controlled by it reaching the greater part of the main river and its three principal affluents. The country drained is hilly, but the valleys are sufficiently open to accommodate large villages and important towns. The main Chicopee itself has gained great prominence by reason of the extensive cotton and other manufacturing interests carried on along its course. Its slope is considerable, averaging 15 or more feet per mile. The greater part of this fall has already been put to use, and in the autumn of 1882 but three undeveloped privileges were found along the whole course. One of these, at Southworth falls, was then being improved; another, the second privilege below Three Rivers, was about to be developed; and the third, immediately below Three Rivers, was owned and held for its own use by the Otis Company.

Elevations of points on the Chicopee river and tributaries (at railroad crossings).

Locality.	Elevation of water-surface above sea-level.	Fall between points.	Distance between points.	Fall per mile between points.
Quaboag and Chicopee rivers.	*Feet.*	*Feet.*	*Miles.*	*Feet.*
East Brookfield	600			
		4	8	0.5
West Brookfield	596			
		19	3	6.3
Warren	577			
		271	11	24.6
Palmer	306			
		268	18	14.9
Mouth of Chicopee, low water in Connecticut river	a38-39			
Ware river.				
Cold Brook station	655			
		80	3	26.7
Barre Plains	575			
		28	8	3.5
Gilbertville	547			
Swift river.				
Enfield	393			
		52	10	5.2
Bondsville	341			

a See *Surveys and Explorations of the Connecticut River*, by Warren and Ellis.

NOTE. T[illegible]

In his report upon the Connecticut river, General Ellis gives the least discharge from the Chicopee at 669 cubic feet per second. This corresponds to 0.95 cubic foot per second per square mile of drainage area, and, judging both by comparison with other streams and from the statements of manufacturers, seems too large. It is certain, however, that the dry season flow of the river is very well sustained, though probably less so than it was twenty-five or fifty years ago. This valuable feature is, doubtless, largely contributed to by the numerous lakes and ponds which drain to the river through its tributaries, and is certainly assisted materially by the presence of extensive tracts of low marshy ground along the upper course of the Quaboag river. It was found impracticable to gain much reliable information regarding the reservoirs tributary to the Chicopee. Those used strictly for storage to meet the demands of the dry season seem to be few in number. The following list includes all the more important lakes and ponds in the very complete statement prepared by Mr. H. F. Walling for the Massachusetts State Board of Health.(*a*) It is probable that at the outlets of many of these small powers are in use, and that more or less control is exercised over their storage. At all events, they serve an important purpose, by reason of their number and large aggregate surface, in holding back the water of storms and melting snows, and yielding it gradually to the streams:

Principal lakes and ponds in the basin of the Chicopee river.

[From report by H. F. Walling.]

Locality (town).	Name of pond.	Area.	Tributary to what stream.
		Acres.	
Prescott	On West branch of Swift river	154	West branch of Swift river.
New Salem	Thompson's pond	235	Middle branch of Swift river.
Greenwich	Curtis pond	155	Do.
Do	Luce pond	124	Do.
Do	West pond	94	Do.
Petersham	Reservoir, name not given	175	Do.
Dana	Neeseponsett pond	118	Do.
Greenwich	Davis pond	100	East branch of Swift river.
Dana	Pottapaug pond	160	Do.
Phillipston	Phillipston pond	202	Burn Shirt river (to Ware).
Do	Pond northeast of above	130	Do.
Hubbardston	Reservoir near Westminster line	90	Ware river.
Do	Moosehorn pond	*a* 160	Do.
Do	Asnyconic pond	*a* 238	Do.
Hardwick	Muddy pond	202	Do.
Barre	Reservoir, name not given	200	Do.
Rutland	Pond west of center	135	Do.
Do	Long pond	160	Do.
Do	Demon pond	138	Do.
New Braintree	Two ponds near center	94 75	Quaboag river.
Oakham	Browning pond	140	Do.
West Brookfield	Wickaboag pond	*a* 323	Do.
North Brookfield	Brooks pond	178	Do.
Do	Furnace pond	305	Do.
Brookfield	Podunk pond	508	Do.
Do	South pond	340	Do.
Spencer	Cranberry Meadow pond	107	Do.
	Total area of 28 principal ponds	5,040	

a Said to be used for storage.

The bed of the Chicopee river is to a large extent gravel, with ledges of red sandstone crossing at intervals as at Chicopee Falls, Ludlow, and other points. The banks are of good height, rising occasionally at once to low hills, while again they are succeeded by level or gently-rolling meadow-land well cultivated. The surrounding country is comparatively level along the lower river, but becomes hilly toward Three Rivers. The first use of power in ascending the river is at Chicopee, but a short distance above the mouth. The river is there about 300 feet wide, and runs in rapids over low sandstone ledges. The main power is that of the Dwight Manufacturing Company, but intermediate between their dam and the foot of their property are two other dams, at which small powers are in use, depending, of course, for water upon the wastage from the upper privilege.

The lower dam is a log structure, varying from 3 to 6 feet in height and crossing the river in a very irregular line. The privilege is owned by Mr. E. Wood, and 12 feet fall and 40 horse-power are in use at the north end of the dam for a small grist-mill and a bobbin-shop. The supply of water is limited to waste at the upper dams and to the tail-water from the Ames factories, but is always sufficient for the power in use. This dam being the farthest one down stream, and a low one at that, considerable trouble is experienced from backwater from the Connecticut river, which at times sets up over the dam so as to hide it from sight and causes a stoppage of work for two weeks or more.

a See Appendix B to Report for 1873.

The next was formerly known as the Gaylord privilege, but is now owned by the Ames Sword Company. The dam is a fine structure of stone, having a natural rock abutment at the north end and an artificial one, of heavy masonry, at the south end, next the factory. About 100 men are employed in the works. The amount of power in use was not ascertained, but it is probably not large. The supply of water comes from the waste at the Dwight company's dam, and even when none is running over the latter the leakage through it during the 24 hours, stored in the small pond below, is sufficient to carry on the works, and so for five years it had not been necessary to run the engine a day.

The third privilege, including within its limits the two falls already mentioned, is owned chiefly by the Dwight Manufacturing Company, and in part also by the Ames Manufacturing Company; it takes up practically all the fall between Chicopee Falls and the Connecticut river. The dam is of cut stone part-way up from the base, with timber-work above, and is backed in with brick. The abutments and bulkhead are of masonry. The canal runs down the south bank to the mills, and, just below the dam it is provided with a waste-weir from 90 to 100 feet long; it has a total length of about 4,000 feet, and opposite the cotton-mills varies from 20 to 40 feet in width. Its capacity is said to be rather limited for the demands that are made upon it. First in order, descending the race, are the works of the Ames Manufacturing Company; 550 men are here employed in the manufacture of tools, sewing-machines, and bronze statuary. A fall of from 20 to 23 feet is obtained, and the company has a right to 130 cubic feet of water per second, only a portion of which is in use, however. Occupying the rest of the race are the great mills of the Dwight Manufacturing Company. They stretch along between the race and the river, and were formerly seven in number, but by connecting adjacent pairs have been consolidated into four. Both fine and coarse cotton goods are made, comprising sheetings, handkerchiefs, towelings, and other varieties. In September, 1882, there were being run about 112,000 spindles and 3,011 looms; 1,400 hands were employed, and 350 bales of cotton used per week. It was the intention soon to add 5,000 spindles and 240 looms to the works. Mill No. 7 discharges tail-water into the Connecticut river through a long race; the other mills discharge through short races directly into the Chicopee. The Dwight company employs a total wheel capacity of 2,268 horse-power, the heads in use ranging from 24 to 30 feet, according to position on the canal.

As regards priority in rights to water, the two manufacturing companies alternate, the Ames coming in first for a certain amount, then the Dwight, and then the Ames again. The supply of water is estimated to be sufficient to meet all demands that are made upon it for 8 or 9 months in the year. The pondage above the dam is small and of little assistance. A 400 and a 750 horse-power steam engine are in use for auxiliary power during low water and, if necessary, in high water. The smaller engine is first put into service; when that becomes insufficient it is stopped and the larger one started, and finally both may be put in operation. In the very dry summer of 1882 the large engine was started July 13, and for perhaps two or three days in a month during the season both engines together were unable to make up the deficiency in water-power.

The ordinary reduction of head due to spring freshets amounts to 6 or 8 feet, and is liable to remain at that figure for three or four weeks; in extreme cases the reduction has reached 15 or 20 feet. Anchor-ice runs in the canal and is a serious hinderance through the greater part of the winter, clogging on the racks and in the wheel-pits. Every winter morning when surface-ice of any amount is found on the canal it is broken up and floated out over a waste-way at the end of the race; the latter is thus kept open, and the danger of its packing full of cake-ice, as sometimes happens at Windsor Locks and other points, is avoided. Many men are required, however, in the work of removing the surface-ice and anchor-ice, and considerable expense is incurred.

The next privilege to be noticed is at Chicopee Falls, only a short distance farther up the river. Here, as at Chicopee, there is an intermediate dam opposite the main privilege. In this case it is owned by the Lamb Knitting Machine & Manufacturing Company, located on the south bank. This company obtains 9 feet fall, and for about eleven months in the year is enabled to run a 66 horse-power wheel, but during low water it relies upon steam. It has the benefit of any wastage at the upper dam and, except in low water, of the tail-water from two factories located on the upper privilege. Its dam is a log structure built some fifty years ago, measuring about 400 feet in length, and varying in height from 3½ to 7 feet, according to the contour of the rock ledge on which it runs. At the north end of the dam Messrs. J. Stevens & Co., manufacturers of guns and pistols, use 6 feet head and 25 horse-power during the nine months, more or less, in which there is surplus water.

The Chicopee Manufacturing Company's dam is next in order. It is a timber structure, roll-way 306 feet long, with a vertical face, and is built 30 or 40 feet back from the edge of a sandstone ledge, over which there is an abrupt fall of several feet. The abutments are of masonry. The one at the south end is 10 feet wide and 20 feet long at the top, and contains two waste-gates, say 3 by 4 feet in size; it rises about 6 feet above the crest of the dam, and is prolonged inshore as a bulkhead 60 feet long and 8 feet wide, with 9 gate-openings, each about 5 feet square. The canal runs 2,000 feet down the south bank; through the Chicopee company's yard it is walled with granite masonry, and has a width of 50 feet and a depth of 10 feet, measured from the top of the walls.

At the north end of the dam the Belcher & Taylor Agricultural Tool Company uses 16½ feet fall and 90 horse-power during the eleven months in an average year in which there is surplus water. On the south side of the river, a short distance below the bulkhead, B. & J. W. Belcher, manufacturers of agricultural tools, take water from the canal, using 10 or 12 feet fall and a 20 horse-power wheel. They have the first right to a small amount of water, but in practice shut down during low stages.

The great user of power at this privilege is the Chicopee Manufacturing Company, engaged in the production of canton flannels. In September, 1882, this company was employing 1,300 hands, running 62,000 spindles (22,000 of them day and night), 1,849 looms, and using 300 bales of cotton per week; the works were about to be extended, the number of looms was to be increased, and 30,000 spindles were to be added to the machinery then in use. There are four large mills, as follows:

No. 1, 438 by 95 feet, 4 stories high. No. 2, partially completed and in use, 220 by 95 feet, 4 stories high; length to be increased to 420 feet. No. 3, 150 by 50 feet, 5 stories high; with extension 140 by 38 feet, 3 stories high. No. 4, 234 by 50 feet, 5 stories high.

The head at the mills is 25 feet, and it is estimated that 1,100 effective horse-power is realized in the lowest stage of the river. The pond above the dam flows back 2 miles and is used in part as a reservoir; when full its surface is 3 feet above the water in the canal, and it can therefore be drawn down that amount without reducing the head along the latter. During the summer of 1882 it was regularly drawn down during the day about the depth mentioned, and at night did not fill sufficiently to cause a waste over the dam.

The ordinary freshet-rise on the dam does not exceed from 3 to 5 feet. In order to avoid trouble from ice the practice of the Chicopee company is to flush out its canal in winter whenever ice of any important thickness forms, and during a "cold snap" is done every morning. All the water is first drawn from the canal, allowing the ice to break and sink; water is then let in with a rush at the head-gates and carries the broken ice along with it and out through gates at the end of the canal. The magnitude of the pond and the absence of important rapids above are given as reasons why anchor-ice does not trouble here more than two or three mornings during the winter. It is also to be noted that as a rule the Chicopee company does not use nearly all the water, and frequently it is wasting over the dam at times when the Dwight company is receiving about the entire flow of the river into its race. Consequently, if anchor-ice is running in the stream, the latter company is likely to get much more of it than the former. The same is true of leaves in autumn, which are a serious hinderance to the Dwight company, but cause the Chicopee company very little inconvenience.

Just above slack-water from the Chicopee company's dam, there was being erected, in the summer of 1882, a new and fine dam of Monson granite. The site is about 2 miles above Chicopee Falls. The privilege is owned and was being developed by Messrs. J. H. Southworth & Sons, the power to be utilized in a large mill for the manufacture of fine writing papers. It was stated that there would be for rent four or five mill-powers, of 65 horse-power each, on the same side of the river with the Southworth mill. A supply of clear water, 1,000 gallons per minute, has been obtained at a distance of a third of a mile. It was estimated that the expense of grading for this privilege would be heavy, and it would be necessary to build a dike above the dam to prevent overflow, but the work was all being done in the most thorough manner. At the site of the dam the river-bed is composed mainly of ledge rock, but it was thought that some gravel might be met, and the design was for the corresponding portion of the dam to be modified by having the masonry rest directly upon a crib-work, about 3 feet deep, of squared timber, the interstices filled with broken stone. The design also provided for this portion an apron, extending, as a continuation of the crib-work already mentioned, some 10 or 11 feet down stream from the foot of the dam and supported at the end upon round piles; sheet-piling was also to be driven beneath the foot of the front and back slopes of the dam proper. The crest of the structure rises 15 or 16 feet above the river-bed, and has a length, transversely to the stream, of 250½ feet. The main portion of the dam is rubble-work, surmounted by an inclined coping between 6 and 7 feet wide of cut stone. The front slope of the dam has a batter of about 1 in 7, and the back slope of about 1 in 3. The masonry abutments rise 8 feet above the crest. The bulkhead is 50 feet long across the current, 16 feet wide, and is pierced by 7 gate-openings, each 5 feet wide. Wastage from the canal to the river is provided for by a weir 60 feet long immediately below the bulkhead.

Next in order is the fine privilege of the Indian Orchard Mills. The company manufactures sheetings, shirtings, and fancy cotton goods; runs 52,000 spindles and 1,168 looms, employs 675 hands, and uses 8,500 bales of cotton per year, turning out 250,000 yards of finished goods per week. It has two mills, 325 and 476 feet long, respectively. The improvements of this power are of the most substantial and workmanlike character. The dam rests on ledge rock, and has a face of cut stone, battering about 1 in 6 and backed by rubble-work. The crest is 28 feet above bed-rock, while the dam has a width at base of 30 feet and a roll-way 401 feet long. The top of the structure is covered with a course of sloping timbers, reaching out 4 or 5 feet from the stone-work and supported at the end by timber braces resting on a projecting course of stone in the face of the dam. The bulkhead has 9 gate-openings, each 3 by 4 or 4½ feet in size, besides a large one 20 by 12 feet. The canal is walled with masonry, and has a waste-weir to the river, immediately below the bulkhead, about 80 feet long.

In the heavy storm of October, 1869, there was a depth of only 4 feet on the dam, but this was considered a large rise. Above the dam there is a handsome pond of 80 or 90 acres, with a storage estimated to be sufficient for running the mills for five hours without any additions from the river. It is never drawn down more than about 33 inches below the crest of the dam, and fills up again at night, with a wastage before morning, through nearly the whole year. The fall along the canal ranges from 28 to 33 feet, and 1,034 horse-power of wheels is in use. Steam is not employed for power, but in a low stage of water the mills use about the full capacity of the river.

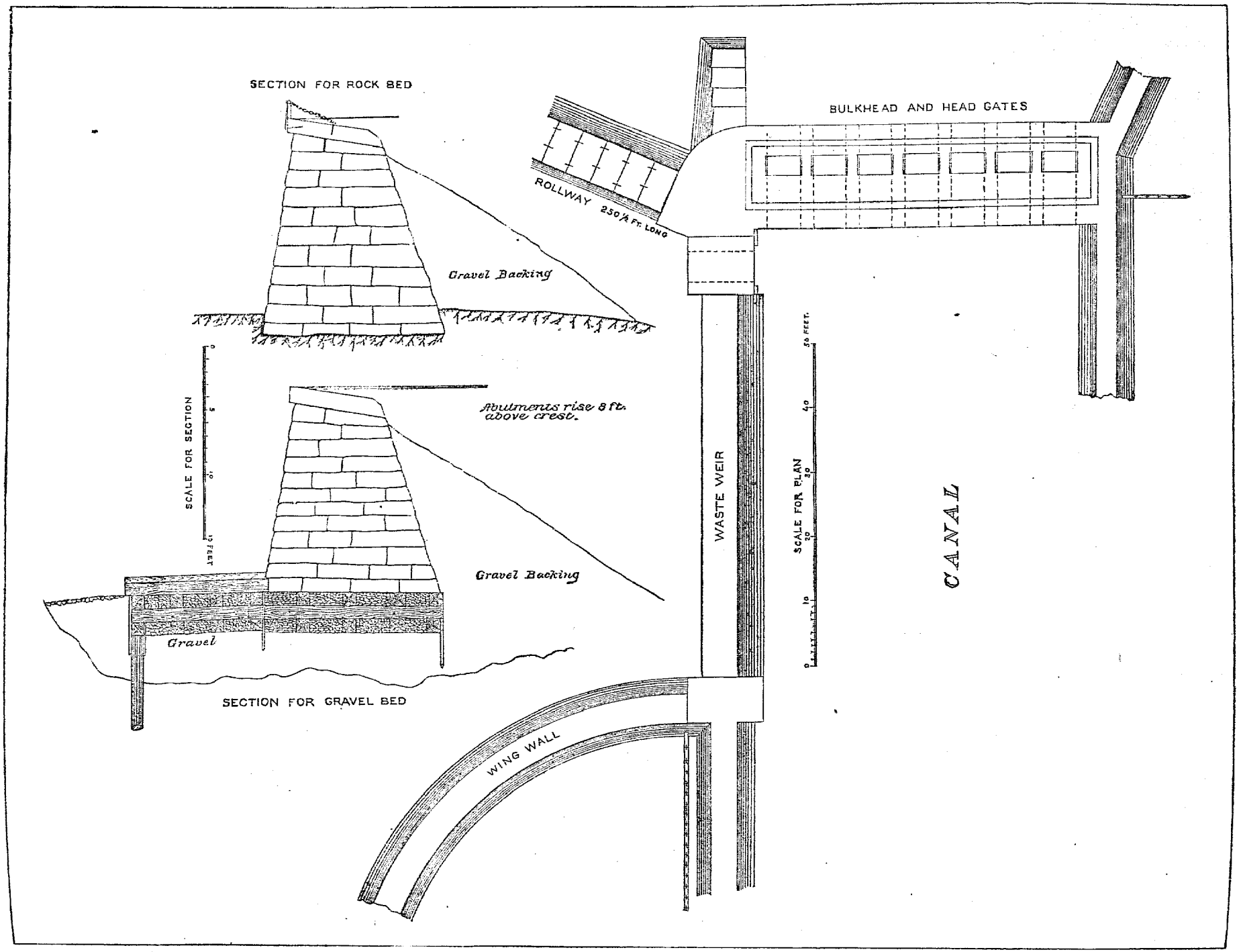

FIG. 20.—New Dam and Connecting Works at Southworth Falls.

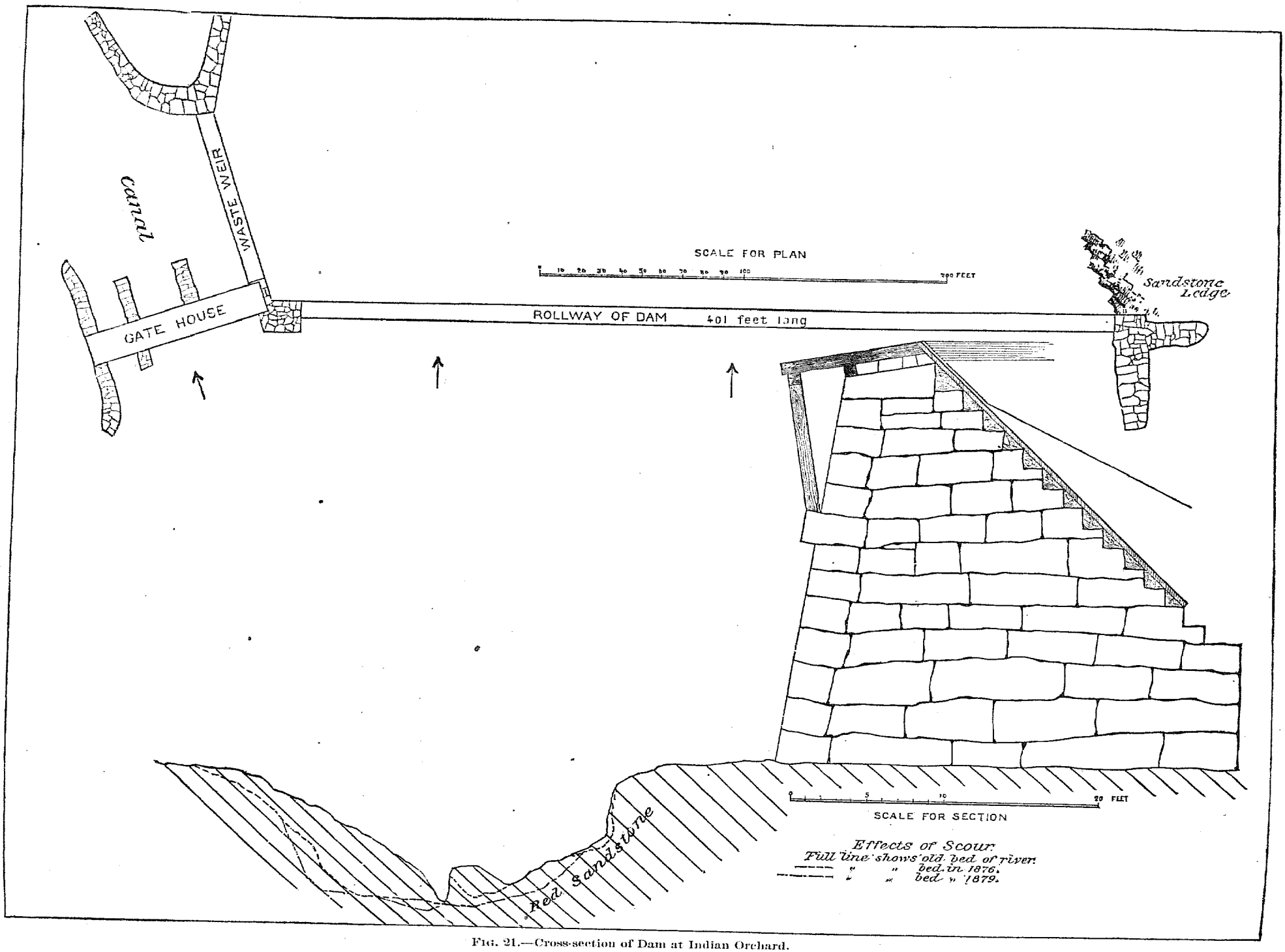

FIG. 21.—Cross-section of Dam at Indian Orchard.

Continuing above Indian Orchard, the river-banks are found to be generally of good height. The surrounding country is gently hilly, with some extensive level plains. The immediate valley has been quite thoroughly cleared of timber, but the distant hills are well wooded. Sandstone ledges continue to crop out in the river-bed.

Immediately above the Indian Orchard pond the Chicopee comes down through a rocky gorge and falls rapidly over ledges. It is there about 175 feet wide between banks, the latter 20 or 25 feet high. The Ludlow Manufacturing Company has here two water-privileges, with dams but a short distance apart. The lower dam is a log structure, resting upon and abutting against solid rock. It is about 140 feet long, 14 feet high, and is to be replaced by a new dam of the same construction. The manager of the company does not consider it safe to build a stone dam here, because of the seamy nature of the rock and its liability to be thrown out of position by frost. The great power both of frost and of water was strikingly exhibited at this point some years ago. The action of frost had separated from the solid bed of the river, just below the dam, a mass of rock measuring 24 feet in length, from 4 to 6 feet in width, and from 3 to 5 feet in depth. It lay pointing diagonally away from the dam; but when the Barre reservoir gave way, the great volume of water which came rushing down the stream turned the rock end for end, and left it supported upon one of the long edges and resting against the dam.

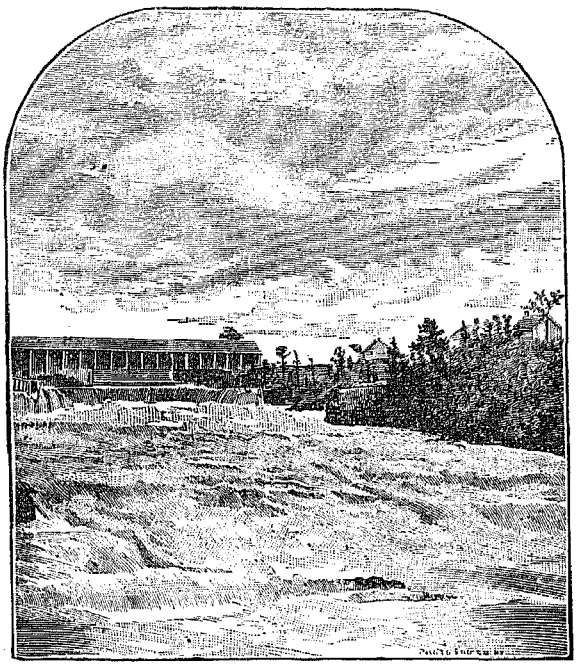

FIG. 22.—Falls at Ludlow.

The mills of the Ludlow company are on the north bank; three are located immediately below the dam, while a separate race, several hundred feet long, leads to No. 4. The manufacture comprises carpet-yarns (both jute and linen), crashes, twines, and gunny-bagging. The extreme fall on the privilege is 30 feet, and about 700 horse-power is in actual use. The company also holds for sale about 600 horse-power with ample building-room on the south bank. The available power of the privilege may be estimated follows:

Estimate of power at Ludlow.

Stage of river.	RAINFALL ON BASIN.					Drainage area.	Flow per second, average for the 24 hours. (a)	Theoretical horse-power.		Effective horse-power utilized.
	Spring.	Summer.	Autumn.	Winter.	Year.			1 *foot fall.*	30 *feet fall.*	
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. miles.*	*Cubic feet.*			
Low water, dry year	11½	12	12	10	45½	672	300	34.08	1,020	700
Low water, average year							390	44.30	1,330	
Available 10 months, average year							450	51.12	1,530	

a In low stages a very material increase of the flow and power as here given can be realized for ten or twelve hours in the day by pondage above.

The upper dam is built of logs, runs upon and abuts against ledges of rock, and presents an angle up stream; it is about 200 feet long and 12 feet high. The fall on this privilege is 13 feet, and at the north end of the dam the Ludlow company had, at the time it was visited, from 60 to 75 horse-power employed in making window-frames and in preparing building materials. A new mill, 248 feet long by 60 and 76 feet wide, was soon to be built for the manufacture of twine. At the south end of the dam the company rents about 65 horse-power to a grist-mill having a capacity for grinding from 1,200 to 1,500 bushels of corn per day. Both the dams which have been mentioned were built fifty or more years ago. Above the upper dam there is a large storage, the pond setting back to the Collins Manufacturing Company's privilege.

The power just alluded to is about 11 miles, by water, from the mouth of the river. It is improved by a dam of rubble cement masonry, with abutments of the same construction, and a plank apron extending 30 feet down stream. The abutments rise 7½ feet above the crest of the dam. The bulkhead is from 55 to 60 feet long, 8 feet wide, and has 9 gate-openings. The canal runs perhaps 1,000 feet down the south bank, to the mill, with a width of about 45 feet, and just below the dam has a 50-foot waste-weir. The Collins Manufacturing Company employs 200 hands in the production of fine writing papers. A fall of 12 or 13 feet is obtained at the mill, and about 500 horse-power of wheels is in use day and night. Commonly there is a sufficient supply of water throughout the year, but for one month in the summer of 1882 it fell short and the mill could be run only 18 hours per day, water being scarce in the morning.

Between backwater of the privilege just described, and the Otis Company's utilized privilege at Three Rivers, there is stated to be a fall of about 40 feet, divided nearly equally into two powers. The lower of these was formerly

owned by the A. & W. Sprague Manufacturing Company, but has recently been sold, and has passed into the control of Mr. Edwin D. Metcalf, of Springfield. Mr. Metcalf states that his intention is to build a stone dam, and that he will probably so improve the power as to afford facilities for a cotton-mill and a paper-mill. By mutual agreement with the Otis Company the dam is to be so constructed as to give a fall of between 21 and 22 feet.

Estimate of power at Metcalf's privilege.

Stage of river.	Drainage area.	Flow per second, average for the 24 hours.	Theoretical horse-power.	
	Sq. miles.	*Cubic feet.*	*1 foot fall.*	*21 feet fall.*
Low water, dry year	650	290	32.94	690
Low water, average year		380	43.17	910
Available 10 months, average year		440	49.98	1,050

The remaining 20 feet, or thereabout, of fall from Three Rivers is owned by the Otis Company and reserved for its own future needs.

The last power on the Chicopee river is at Three Rivers, and embraces 20 feet fall, although only 18 feet is actually in use. It receives the benefit of the water from each of the three tributaries, Quaboag, Ware, and Swift, which unite near this point to make up the main river. The dam is 175 feet long between abutments, and about 10 feet high; it is constructed of hewn timbers, has a vertical face, and rests upon a rock foundation. The abutments are of dry stone, faced with planking. Through a wooden bulkhead with 5 gate-openings, water is admitted to the race, which leads down the south bank to the Otis Company's mill. About 500 horse-power is there in use, and can always be realized during the day-time, even in the lowest stage of the river, without drawing down the pond so but that it will fill up again within two hours after the gates are shut. The main mill is 290 by 75 feet in size, 4 stories high, with an L of 204 by 50 feet. The principal productions are seersuckers, fancy denims, and apron checks and stripes; 22,500 spindles and 700 looms are run here and 700 hands employed. The company has still more important mills above, at Ware.

Summary of water-privileges on the Chicopee river.

Locality.	Distances from mouth.	Company.	Manufacture.	Extreme fall on privilege.	Remarks.
	Miles.			*Feet.*	
Three Rivers	15½	Otis Company	Seersuckers, fancy denims, and apron checks and stripes.	20	18 feet fall and about 500 horse-power in use; 700 looms, 22,500 spindles.
Between Three Rivers and Collins station.	13–14	Owned by Otis Company	Unimproved	20±	Held for company's use.
Do	11–12	Held by E. D. Metcalf, of Springfield.	....do	21.3	To be improved.
Collins station	10–11	Collins Manufacturing Company.	Fine writing papers	13	513 horse-power in use.
Ludlow	7½	Owned by Ludlow Manufacturing Company.	Power used by grist-mill and wood-working shop.	13	About 125 horse-power in use. Ludlow company will erect a large twine-mill.
Do		Ludlow Manufacturing Company.	Carpet-yarns, crashes, twines, and gunny-bagging.	30	About 700 horse-power in use. Company holds for sale 600 horse-power and land on south side of river.
Indian Orchard	6½	Indian Orchard Mills	Sheetings, shirtings, and fancy cotton goods.	33	1,168 looms, 52,000 spindles; 1,034 horse-power in use.
Southworth falls	4–5	J. H. Southworth & Sons	To be used in paper-manufacture.	16–18	Privilege was being developed in fall of 1882. There were to be for rent 4 or 5 mill-powers, of 65 horse-power each.
Chicopee Falls	2	Chicopee Manufacturing Company.	Canton flannels	25–28	Company owns privilege and obtains 1,100 horse-power in lowest stage of river; 1,849 looms, 62,000 spindles (spindles and looms to be increased).
Do		Belcher & Taylor Agricultural Tool Company.	Agricultural tools		On main privilege. Has 10½ feet fall and 90 horse-power 11 months in the year.
Do		B. & J. W. Belcher	....do		On main canal. Use 20 horse-power most of the year.
Do		Lamb Knitting Machine & Manufacturing Company.			Uses 9 feet fall and 66 horse-power at intermediate dam.
Do		J. Stevens & Co	Guns and pistols		Use 25 horse-power part of the year from the Lamb company's dam.
Chicopee	2	Dwight Manufacturing Company.	Sheetings, handkerchiefs, towelings, and other goods.	30	Principal owner of privilege, and uses 2,268 horse-power.
Do		Ames Manufacturing Company.	Tools, sewing-machines, and bronze statuary.		On main canal. Entitled to 130 cubic feet of water per second.
Do		Ames Sword Company	Swords		At intermediate dam.
Do		Privilege owned by E. Wood	Grist-mill, and power rented to bobbin-shop.		At a second intermediate dam.

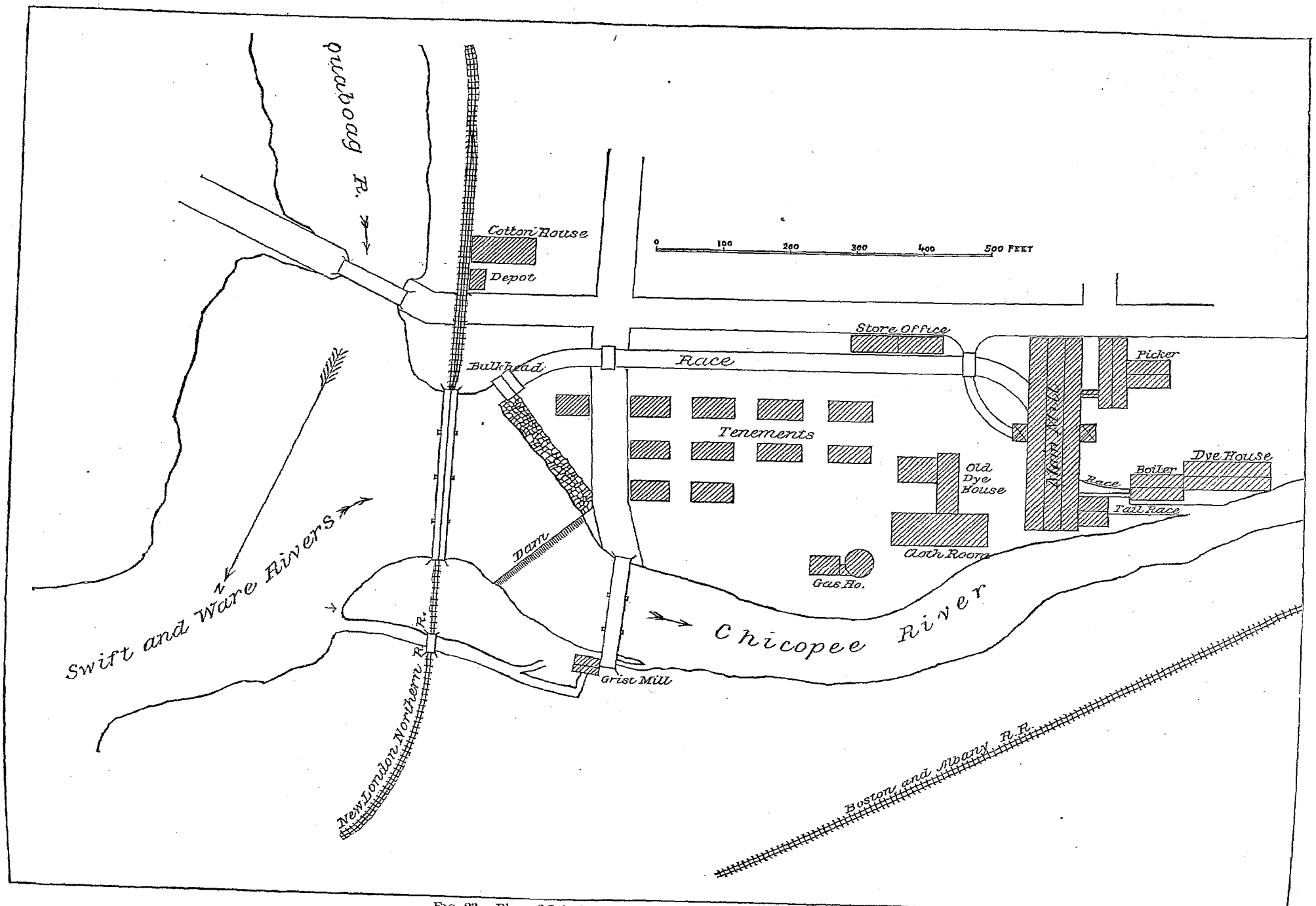

FIG. 23.—Plan of Otis Company's Water-Privilege at Three Rivers.

TRIBUTARIES OF THE CHICOPEE RIVER.

The Quaboag river.—The Quaboag is the most southerly of the three principal streams which unite to form the Chicopee. Two or three small streams come together near East Brookfield, in the southwestern part of Worcester county, and make up the main Quaboag, which then takes a westerly course, through about 25 miles, to Three Rivers. For the greater part of this distance the Boston and Albany railroad follows the river closely. The drainage area comprises 210 square miles. From East Brookfield to Three Rivers there is a fall of 300 feet, of which only 100 feet is in use; in other words, two-thirds the fall of the stream, and that toward the mouth, where the volume is greatest, is not utilized.

The stream is especially valuable for power on account of its well-sustained flow. There is an absence also of disastrous freshets. On Knowles and Gould's dam, at Warren, about 100 feet long, the largest freshet-rise is only 2 or 3 feet; and on the West Warren dams, about 110 feet long, the depth in a common spring freshet does not exceed 18 inches. At East Brookfield there is said to be a large pondage above the dam, but the only strictly storage reservoir learned of as supplying the stream is in West Brookfield. It is known as the Brookfield reservoir, is the property of the West Warren Cotton Mills; it fills regularly, flows 350 acres,(*a*) and can be drawn down 6 feet from a full stage. But though there are not many artificial reservoirs, the stream derives great assistance from the natural reservoir afforded by the extensive meadows, said to contain thousands of acres, which border its course most of the way between Warren and East Brookfield. The fall of the stream in this distance is very small, amounting to but 4 feet in 8 or 9 miles. The meadows are almost on a level with the stream, and though commonly dry are overflowed in high water. The bogs and grass which cover them retard the draining off of water and contribute greatly to the uniformity of the stream. They yield an inferior quality of grass, but it is thought that the expense of flooding them permanently by a dam would be rendered unbearable by reason of the damages for flowage.

Backwater from the Otis Company's dam at Three Rivers stops considerably short of Palmer, but thence up to Blanchardville, 2½ miles by river above Palmer, the fall is reported too small to be of importance.

The first privilege to be noticed is owned by Mr. Franklin Blanchard. An irregular ridge of stones across the river forms a dam a couple of feet high. The river makes a bend below, across the neck of which a race leads. This formerly carried water to a factory where Blanchard Brothers made plow-handles, but the factory burned. The river is about 100 feet wide at the dam. The privilege is a fair one, but the canal is on the opposite side of the river from the railroad, and the available fall, as the power was formerly used, is only 6 or 7 feet. A portion of this fall, however, might be incorporated to good advantage into the privilege immediately above.

This second privilege was in use some years ago by a large grist-mill and by scythe-works, and they also burned. The framed dam still remains in fair condition; it has dry-stone abutments, between which it is 144 feet long. On the south side power is rented to J. H. Smith for a small shoddy-mill, and on the north side is the old race leading to ruins of the scythe-works. Messrs. A. V. Blanchard & Co. own this privilege and hold it for sale. The fall is 10 feet at the dam, which can be raised 4 feet, overflowing thus a moderate amount of rather poor land. The pond is at present long and narrow, setting back 200 or 300 rods. The power is a good one and well located; the railroad is close at hand, and crosses the highway only a few hundred feet from the dam. On the same side, a short distance below, is an admirable site for a mill and a village.

Above Blanchardville the river continues shoal and descends rapidly over a gravelly bed. The surrounding country rises to quite high hills, fairly wooded with a young growth. In places the hills are steep and rocky, but in general their slopes are moderate. Up to the vicinity of West Brimfield the immediate course of the stream is flanked by low meadows. Beginning at a point about 3½ miles by road from Palmer, Joseph King, who resides near by, owns the land on the north side for a mile up stream, and claims a privilege with a fall of 15 or 20 feet available.

At West Brimfield the valley is open, there is a railroad station and a small village, and the site is an excellent one for the use of power. A. W. Crossman & Son, of West Warren, own 20 feet of fall here.

A short distance above the West Brimfield station the hills close in and the valley becomes contracted. It continues substantially the same up to West Warren, and though in the intervening distance there is a large unimproved fall, owned and held for sale by the George H. Gilbert Manufacturing Company, of Ware, the facilities for building large mills and the accompanying villages are not favorable.

A little way below West Warren power was formerly used to run a forge, and portions of a framed dam are still left. The river here narrows to 50 feet or less, and has a rapid descent; the valley is narrow below the dam, and does not offer a very good building-site. The privilege is claimed to have an available fall of 18 feet, and is owned by A. W. Crossman & Son.

a This is probably the same body of water mentioned by Walling as Wickaboag pond, containing 323(?) acres (see list of lakes and ponds previously given).

From West Warren to Palmer there is an unimproved fall of, in round numbers, 200 feet. It is not to be supposed that all of this would or could be utilized to good advantage in practice, and the proportion really available can be determined only by a more thorough examination than was made; but some idea of the gross power corresponding to the fall at the various points mentioned, and for the whole distance, may perhaps be obtained from the following estimate:

Estimate of unimproved power on the Quaboag river between West Warren and Palmer.

Stage of river.	Drainage area.	Flow per second, average for the 24 hours. (*a*)	THEORETICAL HORSE-POWER.						
			Blanchardville.		King's privilege, say 15 feet fall.	West Brimfield, say 20 feet fall.	Old forge, say 18 feet fall.	1 foot fall (mean).	200 feet fall.
			7 feet fall.	14 feet fall.					
	Sq. miles.	*Cubic feet.*							
Low water, dry year	*b*142, *c*179	60–70	55	110	110	150	120	7.38	1,480
Low water, average year		80–100	80	160	150	200	160	10.22	2,040
Available 10 months, average year		90–120	95	190	180	240	180	11.93	2,390

a A considerable increase of the flow and power as here given could probably be realized for ten or twelve hours in the day, by reason of the control exercised over the stream above.

b At West Warren.

c At Blanchardville.

NOTE.—Rainfall on drainage area, 11½ inches in spring, 12 in summer, 12 in autumn, 10 in winter, and 45½ for the year.

The lower privilege at West Warren is occupied by A. W. Crossman & Son, manufacturers of edge-tools. They have a fall of 12 feet, and two 40 horse-power water-wheels, but do not use their full capacity.

The principal users of power here are the West Warren Cotton Mills, running 770 looms and 32,000 spindles in the manufacture of denims, tickings, and dress-goods; 650 hands are employed, and 30 bales of cotton consumed per week, with a production of 150,000 yards of goods in the same time. The company has four mills—one just completed and not in use when visited—occupying successive privileges and scattered perhaps half a mile along the river. The valley widens out at this point, yet the ground is rather hilly along the stream, and the expense of grading for the mills and other works is said to have been large. The improvements are of the most substantial character. The mills are of brick and the dams of stone in cement. The races are short and do not exceed 300 or 400 feet in length, except at mill No. 2, which has a race 1,450 feet long. The pondage above the dams is small, estimated at possibly 25 or 30 acres in all for the four privileges.

Ascending the stream the powers occur in the following order:

Mill No. 3, 200 by 60 feet, 4 stories high; dam 109 feet long, fall 16 feet.

Mill No. 1, 300 by 75 feet, 2 stories high; dam 111 feet long, fall 16 feet.

Mill No. 2, 180 by 51 feet, 4 stories high; dam 110 feet long, fall 15 feet.

Mill No. 4, 170 by 51 feet, 4 stories high; dam 130 or 140 feet long, fall 12 feet.

At the three lower mills a total of 650 horse-power is in use, and can be obtained nine or ten months in an average year; for the remaining time about three-quarters of that amount is realized.

This company also owns, and holds for its own use, 8 or 9 feet of unimproved fall between the No. 4 mill and the privilege at Warren.

At Warren, Messrs. Sayles, Owen, & Co., manufacturers of fancy cassimeres, use 11½ feet fall and 125 horse-power; they run 9 sets of cards. The river-bed is here composed of gravel and bowlders. The dam is mainly of dry stone, but is surmounted by a log addition. The pondage is small, and allows water to waste past the mill even in seasons when it is needed.

The next privilege, also at Warren, is owned jointly by Messrs. Knowles and Gould. L. J. Knowles runs 1,300 spindles in the manufacture of cotton-warp, obtaining 5½ feet fall and using one 35 horse-power wheel. John B. Gould takes power for a 3-run grist-mill, and a blacksmith shop also uses a little power at times. Above the backwater from Knowles and Gould's dam there begins the long flat reach of river previously described, and the stream was not examined farther.

Chicopee brook is a small stream running northerly through the town of Monson, and joining the Quaboag a little east of Palmer. It drains 23 square miles. Near Monson village a fine quality of granite is quarried in large quantities. The country in this section is hilly but open, and the soil is largely composed of a sandy loam. Springs are abundant, and the stream is as well sustained as could be expected considering that it is without storage reservoirs. Opinions vary among the mill-owners as to whether these could be constructed to good advantage. It is said that there is swampy land in the upper waters which could be flowed. But whether that is true or not, some of the manufacturers are averse to reservoirs, because of their alleged expense and the danger from their failure. In its present condition, however, the stream certainly runs very low at times. It is overloaded with

machinery, and nearly all the mills use steam in part for power. The fall is about all taken up in the main portion of the stream. The mills are of moderate size, and in nearly every case manufacture fancy cassimeres.

Principal water-privileges on Chicopee brook.

Locality.	Firm.	Manufacture.	Fall.	Horse power of wheels.	Remarks.
			Feet.		
South Monson	C. W. Holmes, jr	Plain cassimeres	22	20	2 sets of cards. Uses steam all the time, in part.
Do	D. W. Ellis & Son	Fancy cassimeres	23		4 sets of cards. Use steam in low water. Pond night-water in the dry season.
Do	J. L. Reynolds	do	15	40	3 sets of cards. Uses steam in part for power.
Do	R. M. & Theo. Reynolds	do	17	50	3 sets of cards. Use steam in part for power. Store night-water 6 months in the year.
Monson	S. F. Cushman	do	10	30	4 sets of cards. Uses steam in part for power.
North Monson	H. C. Day	Grist-mill	9	20	2 runs of stone.
Do	John F. Heery & Brother	Fancy cassimeres	12	50	7 sets of cards. Can get 50 horse-power by water 8 months in the year, but use steam more or less at all times.

The Ware river.—The main stream may be regarded as formed in the town of Barre, Worcester county, although the Burn Shirt river and Canesto brook, which go to make it up, have their sources to the northward, in Phillipston and Templeton. The drainage area is 214 square miles. From the junction of the Burn Shirt and Canesto to Three Rivers the Ware is 28 miles long. The surrounding country is hilly, but in the lower course, at least, the immediate valley is in general open, accessible, and very well suited to the establishment of villages. The timber has been largely cleared away and the land given up to pasturage. The stream is well sustained in the dry season, but more rapid in rise and fall than the Quaboag, and, so far as could be ascertained, is destitute of the extensive marshes which characterize a portion of that river. Moosehorn and Asnyconic ponds, lying in the town of Hubbardston, and together containing about 400 acres, are used for storage to meet the demands of the summer season, and there may be one or two other ponds in the upper waters serving a similar purpose. The two above mentioned are owned by the Otis Company, and prove sufficient, in a dry season, to maintain the necessary volume at Ware for from four to six weeks. The reservoir capacity of the stream can be largely increased, and a plan looking to that end has already been developed. At Barre falls, by a dam 25 feet high and from 300 to 400 feet long, a flowage of 1,178 acres can be obtained, with a storage of about 490,000,000 cubic feet; and it is estimated that the reservoir could be filled three times in each year. Some $12,000 has already been expended in buying land and engineering and other work, and it is estimated that as much as $70,000 would be required to complete the enterprise. Toward the actual construction of the reservoir no work has yet been done, on account of a disagreement among the mill-owners as to bearing the expense. Nearly all the companies along the river are interested in the project, which is still under consideration.

A number of years ago a small pond of about 70 acres, known as the Barre reservoir, gave way and caused a large amount of damage. The accident occurred on the night of September 30–October 1, 1869. The cause is supposed to have been that the waste-way had become choked with brush and floating drift, and that during a very heavy rain and strong northwest wind on that night the waves were forced with considerable power against the top of the gravel dam, and, gullying out little by little, soon produced a large channel, which the violent rains helped to wash down, and the failure of the whole structure then naturally followed. The loss by this disaster is estimated to have been $200,000.

The first power on this stream above the mouth is at Thorndike, where the Thorndike Company has two falls and large mills for the manufacture of colored cotton goods—tickings, denims, and stripes; 110 bales of cotton are used per week, the company running 33,000 spindles and 700 looms, and employing about 500 hands. The lower dam is built of stone in cement, and has a vertical face. The roll-way is 150 feet long, with an average height of 12 feet; it is 20 feet wide at the base, and narrows but little till near the top, which is covered with 8-foot coping-stones. The main portion of the dam was built about 1872, but, the freshet-rise above it having been found too great, the length was increased 60 feet two years later. The race is merely an excavation in earth, without walls, and measures about 500 feet in length, 25 in width, and 10 in depth at the center. The head at the main mill is 19 feet, and in the addition to the mill 15 feet, 310 horse-power being used altogether.

The upper dam of the Thorndike Company is a framed structure with stone abutments. The roll-way is 175 feet long, 14 feet high, and 26 feet wide at the base; the front row of braces is vertical, the rows farther back being somewhat inclined. This dam was built about the year 1876, and cost in round numbers $7,000. Water is carried from the dam in a race across a bend of the river to the mill, where about 300 horse-power is used under 20 feet fall.

The power used at these mills will give a fair idea of the minimum capacity of the stream, since during the very dry summer of 1882 there was a lack of water for running at full capacity only two days, and then the shortage was slight. The pond above the lower dam is small and of no consequence, but the upper pond sets back for 2