THE WEST BRANCH OF THE SUSQUEHANNA RIVER.

This noble tributary has its sources in the mountains of Cambria county, at an elevation probably not less than that of the sources of the North branch, for the divide between its waters and those of the Allegheny lies at a height of 2,000 feet or more above the sea. Flowing first in a northerly direction, and receiving some tributaries from Indiana county on the west, the stream enters Clearfield county, and gradually bending to the right it flows northeast between Center and Clinton counties, and then east through Clinton into Lycoming, where it bends suddenly to the right again, and flows nearly south between Union and Northumberland to join the North branch at the town of Northumberland. Its total drainage area measures about 6,466 square miles, and it receives a number of important tributaries, a list of which, with their drainage areas, will be found on page 79. The river washes the towns of Clearfield, Lock Haven, Williamsport, Muncy, Milton, Lewisburg, and Northumberland, and is navigable, by means of the canal along its banks, to Lock Haven and beyond, there being four canal dams on the stream, the ponds of which are used for navigation. The character of the stream will be understood from the following quotation from Dr. Rogers' *Geology of Pennsylvania:*

> The upper part of the West branch of the Susquehanna, and also its tributaries, the Sinnemahoning, Kettle creek, Pine creek, etc., draining the high plateau northwest of the Alleghany mountains, flow through deep trenches in the horizontal strata, very analogous in their features to those which give passage to the Delaware and the main or North Susquehanna, in the northeastern part of the state. From the mouth of the Sinnemahoning out into the Bald Eagle valley, the river hills are very high and steep, and admit extremely narrow strips of level ground between their feet and the river, except near the openings of the lateral streams. The trough through which the lower half of Pine creek flows is equally profound. Entering the valley between the Alleghany mountain and the Bald Eagle ridge, the river pursues a beautiful winding course the whole way from Lock Haven to the neighborhood of Muncy, alternately sweeping toward the middle of the cultivated valley and back again, close in to the base of the steep and wood-covered ridge. Near Muncy it turns with a broad majestic curve round the end of the Bald Eagle mountain, and in a few miles deflects from a southwest to a west course, through a highly fertile, richly cultivated open country, till it strikes the base of the Blue Hill, or range of red sandstone cliffs above Northumberland. Southwest of Muncy the river crosses a singular belt of deeply-eroded country, full of conical hills.

The fall of the stream is shown by the following table:

Slope of the West branch of the Susquehanna river.

Locality.	Distance from mouth.	Elevation above tide.	Distance between points.	Fall between points.	Fall per mile between points.
	Miles.	*Feet.*	*Miles.*	*Feet.*	*Feet.*
Mouth	0	429			
			7	2	0.29
Lewisburg dam, water below	7	431			
			0	3	.....
Lewisburg dam, crest	7	434			
			16	28	1.75
Muncy dam, water below	23	462			
			0	7	.....
Muncy dam, crest	23	469			
			16	29	1.81
Williamsport dam, water below	39	498			
			0	10	.....
Williamsport dam, crest	39	508			
			26	31	1.19
Lock Haven dam, water below	65	539			
			0	11	.....
Lock Haven dam, crest	65	550			
			4	1	0.25
Queen's Run dam, water below	69	551			
			0	6	.....
Queen's Run dam, crest	69	557			
			36	138	3.83
Keating	105	695			
			55	422	7.67
Curwinsville	160	1,117			

It will be seen that as far up as Queen's run the fall of the river is small, while above that point, in the true mountain region, it is much larger. Above that point, too, the banks of the stream and of its tributaries are generally high, and there are few low grounds subject to overflow, while below that point the river traverses a wide and fertile valley, without, however, overflowing its banks to any considerable extent. The bed of the stream is generally gravel and sand, with sometimes a rock ledge in the upper parts. The flow is quite variable, but as no gaugings are at hand, exact figures can not be presented, and I am therefore obliged to resort to estimate. On account of the larger proportion of mountain district, and the steeper slopes in the basin we are considering, I should judge the flow to be even more variable than that of the North branch; and this opinion is strengthened by the absence of lakes of importance. But the fact that a great part of the basin is still thickly wooded may have an important effect, perhaps more than compensating for the absence of lakes and the steepness of the slopes. The forests, however, are being rapidly destroyed in many places, and the lumber is being floated down to the main stream from numberless tributaries. The facilities for artificial reservoirs are probably good, and the flow of

many of the tributaries might no doubt be regulated to a considerable extent. The rainfall in the basin is about 38 or 40 inches, with a tolerably uniform distribution, but with less in winter than in any other season. The stream is easily accessible except in the upper part of its course, being followed as far as the mouth of the Sinnemahoning by the Philadelphia and Erie railroad. As it is ascended, the first dam is the canal dam at Lewisburg, 920 feet long and 3 feet high. Its pond is used for navigation for over a mile. The next dam is the Muncy dam, 3 miles below the town of the same name, and which might be used for power, its height being 7 feet and its length 1,020 feet. Its pond is navigated by canal-boats for over 4 miles. The minimum flow of the stream at this point is probably not less than 900 cubic feet per second, but only a small proportion of the total power that this would afford could be used with advantage at the Muncy dam.

The next dam is that at Williamsport. It was built in the years 1867 and 1868 by the Susquehanna Boom Company, to back the water and afford a pond for the booms for collecting the lumber which is floated down the river to this place. The dam is built of crib-work, filled with stone and backed with gravel, and is 1,000 feet long and 10 feet high above low water, with a chute 60 feet wide for the passage of rafts. The power afforded at this place is already utilized by several mills, namely: Noble & Sons' flour-mill, and Taylor & Son's saw-mill, probably using together, however, only a couple of hundred horse-power. The fall used is 8 or 9 feet, and the mills are at times obliged to stop on account of high water or ice. There is no doubt that a considerably greater amount of power than is now used could be advantageously utilized at this place. The drainage area being about 5,300 square miles, it is not probable that the minimum flow will be much less than 800 cubic feet per second, and this would afford, with a fall of 10 feet, a gross power of over 900 horse-power; while at ordinary stages a very much larger amount would be available. The fall, however, is scarcely large enough to warrant the full development of the power.

The Williamsport dam backs the water a number of miles, and the fall of the stream is small all the way to Lock Haven, where we meet the next canal dam. This dam has an overfall of 850 feet, and is 11 feet high above low water. It is not used at all for power, although it could be so used without much difficulty and a considerable amount of power developed. The drainage area is about 3,040 square miles, and the minimum flow probably never less than 400 cubic feet per second, which would afford, with a fall of 10 feet, about 450 gross horse-power, while in ordinary years a very much larger quantity—perhaps double—would be available almost uninterruptedly. This power and the one at Williamsport are the two principal powers on the stream, and in fact the only important ones. Although the falls are not large, and there would be occasional interruption on account of high water, there seems to be no reason why both powers should not be utilized to a considerable extent. The location at Lock Haven and the facilities for races and buildings are good.

The Lock Haven dam backs the water for about 4 miles to the last canal dam on the river, at Queen's run. This dam is 6 feet high above low water, with an overfall of 614 feet, and a raft-chute 31 by 500 feet. Its pool is used for navigation for about 3 miles. No power is utilized at the place, and although some might be developed, the low fall renders the site an unfavorable one. Between this point and the mouth of the Sinnemahoning, although the fall is greater, there are no important powers; neither are there any below Clearfield, so far as I could learn. The declivity of the stream is quite uniform, and although the fall is considerable, there are no rapids of consequence. Power could doubtless be developed at many places by damming, but I can specify few particular sites. At Buttermilk falls, about 20 miles above Keating (at the mouth of the Sinnemahoning), the fall is 6 feet in about 2,000 feet; and there are a few other rapids of similar character. I am indebted to Mr. Edwin H. Welch, civil engineer, for a profile of the stream from Keating to the mouth of Moshannon creek, a distance of 25¼ miles, from which it appears that the average fall in that distance is 6.57 feet per mile, the greatest fall in a mile being in the first mile above Keating, viz, 16 feet; while at several places there are falls of 9 or 10 feet in a mile. There are, however, no specially fine sites for power, and little if any power is utilized on the stream below Clearfield. Above that point there are a number of small saw- and grist-mills run by the stream, the latter generally with two or three pairs of stones. Power would probably be utilized below Clearfield were it not that the river is very inaccessible. The table of utilized power gives all the additional data I have regarding the stream.

The flow of the upper part of the Susquehanna, as well as of its smaller tributaries, is modified to some extent by the operations of the lumbermen. On most of these streams "splash-dams" are built, ponding the water sometimes over considerable areas, and serving to hold the logs which are sent down, until a sufficient number have been collected, when the gates in the dams are raised, letting the water out suddenly, so that the logs are carried down on the swell or wave to the next dam or to the main river, where the natural current is sufficient to carry them along. These artificial reservoirs, although now of no benefit to the water-power of the stream, being in fact rather the contrary, could be utilized as storage reservoirs to regulate the flow. Their effect on the water-power of the streams is probably small at present, as the flushing of the logs does not occur at the time when the streams are lowest; in fact, some mill ponds are even used for the same purpose. Their effect on the larger tributaries or on the main stream is, of course, too small to be noticed. Regarding the size of the reservoirs formed I could obtain no accurate information, but probably few cover over 100 acres. The dams are almost always of crib-work, and the sites are chosen with a view of overflowing as much land as possible.

Before leaving the West branch of the Susquehanna, attention must be called to the statements on page 64 regarding the power available from the canal. At present very little power is utilized from this source, there being only one small grist-mill using water from the canal, with a head and fall of 11 (?) feet and 20 or 30 horse-power.

THE TRIBUTARIES OF THE WEST BRANCH OF THE SUSQUEHANNA RIVER.

The water-power of the tributaries of the West branch of the Susquehanna is at present of little importance. That utilized is altogether insignificant; that potential, although theoretically large, is practically not very available, partly because many of the streams are very inaccessible, draining a wild and very little developed country, and partly because they flow with uniform declivities over beds of drift, offering few precipitous falls and few powers likely to be of any but local interest or value. The information that I could collect regarding these streams is very meager. Most of them are used for rafting or logging much more than for power, and their utilized power is very small. On account of their uniform slope I could learn of but few sites for power not used, and can say little regarding the facilities for the development of power. It may be presumed, however, that they are tolerably good. The flow of the streams is subject to considerable fluctuations, but I could not learn that the freshets are specially violent. Muncy creek, the first important tributary encountered as the river is ascended, rises in Sullivan county and flows southwest into Lycoming. It has three splash-dams and several lakes tributary to it, all of small extent. Loyalsock creek, which empties at Williamsport, is a much larger stream, also with several small lakes tributary to it. On some of its small tributaries there are said to be precipitous falls, but they are almost valueless for power. There are ten or a dozen splash-dams on the stream and its tributaries, and a number of saw-mills. Lycoming creek is a similar stream. It has a nail factory near its mouth, besides saw- and grist-mills. Twenty miles from its mouth there is a site not utilized, formerly used by a mill, with a fall, it is said, of 15 feet; and just above this is another similar site. Pine creek, the largest tributary below the Sinnemahoning, is similar to those already mentioned, but I have no details regarding its power. Just below Lock Haven a stream comes in from the south which is perhaps the best water-power stream in the vicinity, viz, Bald Eagle creek. It rises in the southern part of Centre county and pursues a northeasterly course into Clinton county, its length being about 45 miles, measured in a straight line, and its drainage area about 725 square miles. It receives as tributaries Beech, Fishing, and Spring creeks, all good water-power streams. The value of the stream arises from its constant flow, for, although there are no lakes in the basin, the stream is fed by springs to a large extent, and is said to vary less in flow than any stream in the neighborhood, though I know of no measurements regarding this point. Especially is this true regarding Spring creek, which is said to flow remarkably well in dry weather. All of these streams have beds generally of gravel, with some rock in place. They are not subject to very violent freshets, and their slope is quite large, though generally gradual. Bald Eagle and Spring creeks are quite accessible from the Bald Eagle Valley railroad. The first dam on the Bald Eagle creek is about 3 miles above Lock Haven and above the mouth of Fishing creek. It is a canal dam, used for feeding the branch canal extending from Lock Haven to this place, and used as a feeder of the main West Branch canal. It is 314 feet long, 5 or 6 feet high, and backs the water about 2 miles. On this branch canal there are two mills—a grist-mill at Flemington, feeding to a lower level, and using a fall of 10 feet and about 75 (?) horse-power, and a paper-mill near Lock Haven, with about the same fall and power, it is said. These mills have a full supply of water all the year, the water remaining in the canal during the winter.

Above this canal dam there are several grist-mills on the stream, and at Howard there are the Howard iron works, consisting of a forge and rolling-mill, with a fall of 6½ feet and about 60 (?) horse-power.(a) Full capacity can be obtained during only about ten months. At Rowland there are two powers, owned by Curtins & Co.; the upper one a rolling-mill, with a fall of 7 feet, the dam being 200 feet long and 2½ feet high, and the lower one a grist-mill, furnace, and forge, with a fall of 12 feet. These powers are below the mouth of Spring creek. Above this point there are several small grist-mills, but no large powers. It will be seen that there are no large falls on Bald Eagle creek, and there are said to be no powers not utilized.

The tributaries of Bald Eagle creek are also utilized to a considerable extent by small mills, and their fall is greater than that of the main stream. On Fishing creek, besides a number of grist-mills, there are two ax factories and a woolen-mill, but the powers are small.

Spring creek, which has already been referred to, enters the Bald Eagle at Milesburg, at which place there is a fall of 8 feet, used to run a grist-mill, saw-mill, ax factory, foundery, and machine-shop. Above, there are various mills, specified in the table of utilized power. I learned of several unimproved sites on the stream, near Bellefonte. The first is that of the Bellefonte Car Manufacturing Company, and was formerly used to the extent of about 100 horse-power. The dam is partly of earth and partly of crib-work, and is 300 or 400 feet long, while its height varies from 10 to 12 feet. The fall used was 12 or 14 feet, and it is expected that work will soon be resumed. Just above this power is a paper-mill, not now running, with a fall of 10 feet, and farther up is an ax factory with a fall of 18 feet, not used "on account of expense of hauling". Logan branch, a tributary of Spring creek, just above Bellefonte, is very constant and has a very rapid fall. It runs various mills, and has several sites not used.

a The power is stated at 150 horse-power in the returns of the enumerators. It was returned to me as 60.

The remaining tributaries of the Susquehanna resemble those below Fishing creek from the north. They are more variable in flow than Spring creek, and are utilized only for saw- and grist-mills, with now and then a woolen-mill. Many of them have splash-dams, and are used extensively for logging. Such are Young Woman's creek, Paddy's run, and Kettle creek. Sinnemahoning creek, the largest of all, is little utilized, but I heard of no good sites not used, though at Moccasin falls, below Driftwood, there is said to be a fall of 5 feet or so in 200 feet. I have no further data regarding its numerous tributaries, but they are not very reliable streams, and afford only small powers. Of the tributaries above Sinnemahoning, Mosquito creek is quite a large stream, said to be the most constant in the neighborhood. It has 7 splash-dams and a few mills. Moshannon creek and Clearfield creek are similar streams. On all of the streams in this vicinity power could be developed at many places, and abandoned sites, formerly used for saw-mills, are often met with, but the whole region is almost a wilderness.

THE TRIBUTARIES OF THE SUSQUEHANNA BELOW NORTHUMBERLAND.—The water-power of the affluents of the Susquehanna between the mouth of the West branch and that of the Juniata is not of great importance, although there are numerous sites for small mills. Their fall is quite rapid and their flow very variable. They are utilized only by small saw- and grist-mills. Shamokin creek, which enters from the east below Sunbury, drains 165 square miles, and has several mills averaging each about three pairs of stones. Penn's creek, from the west, is a much larger stream, and has its sources in Centre county, whence it flows east through Union and Snyder. Its declivity is unbroken by falls, though there are numerous ripples, and some good sites where power could be developed. The flow is said to be very steady and the power excellent. There are a number of saw- and grist-mills in operation, the grist-mills near the mouth averaging four pairs of stones, and seldom suffering much from want of water. The falls are not large, averaging only 8 or 10 feet, and obtained by damming. Middle and West Mahontongo creeks, from the west, as well as Mahanoy, Wiconisco, Armstrong's, Powell's, and Clark's creeks, from the east, are small streams. It is said that the power of Wiconisco creek is being injured by coal-dirt filling the creek, and also by the impure water pumped from the coal-mines.

THE JUNIATA RIVER.

This great tributary has its sources far to the west, in Bedford, Blair, and Somerset counties, at a general elevation of some 2,000 feet above the sea, though the divide between its waters and those of the Ohio attains in places a height of nearly 2,800 feet. The stream is described as follows by Dr. Rogers, in his *Geology of Pennsylvania:*

This second great tributary of the Susquehanna has two chief upper divisions, the Frankstown and the Raystown branches, both of which, like the main stream below their junction, traverse much beautiful scenery. We will trace the Frankstown branch as that which is most accessible. After gathering its head-waters from the eastern slope and the foot-hills of the Alleghany mountains, it begins to assume the volume of a small river near Frankstown. Below this point it first passes the cove of the Lock mountain, a curious district of conical hills, in structure very like the Muncy hills of the West branch. Its course is now by a wild and rocky gorge, through the Lock or Canoe mountain, into Canoe valley. Winding northeastward through this valley it next goes through Tussey mountain into Hartslog valley by an interesting curving pass of the form of the letter S. The mountain, which consists of two ridges, is trenched along its center for the passage of the river, and the Western ridge is moreover breached at Water Street by a lateral notch, which gives passage to a small tributary stream, and heightens much the picturesqueness of the place, which is further enhanced by a great stone-slide covering the ends of the mountain. Crossing Hartslog valley, it next traverses Warrior ridge, passing by the Pulpit rocks. Emerging from the Warrior ridge, and deflecting more toward the east, it crosses the Huntingdon valley and passes by the northern end or knob of Terrace mountain or Sideling hill, receiving first the Raystown branch, which nearly doubles the volume of its waters. Here bending southward it follows a picturesque gap through Stone ridge, and, turning more eastward, it presently enters the deep cleft in Jack's mountain, called "Jack's Narrows", upon the western side of which the mountain is covered with a great stone-slide, or field of naked angular blocks of sandstone, which imparts a most desolate aspect to the pass, especially when the forest is not in leaf. On emerging from Jack's narrows the river crosses a succession of open valleys divided by narrow ridges, until it meets the base of Blue ridge in Sugar valley. There it makes a great loop, turning in an ox-bow backward till it reaches Newton Hamilton, whence it flows with many large sinuosities, longitudinally, through the Juniata or Lewistown valley, to the deep synclinal ravine called the "Long Narrows", formed by the near approach of the Blue and Shade mountains. The "Long Narrows" of the Juniata is a narrow trough between mountain ridges, deeply trenched on their flanks, and thickly clothed with timber on their lower slopes and at their base, and overspread nearer their summits with extensive sloping sheets of dark-gray angular blocks. The pass is 7 miles long, and is one of the wildest and most impressive within the mountains. At the eastern end of the Long narrows the river turns southeastward, and winds between hills and valleys across the country to the base of the Tuscarora mountain, passing Mifflintown, Mexico, and other villages. Below New Mexico it sweeps the base of the Tuscarora mountain for several miles, until it turns abruptly across its eastern end a mile northwest of Millerstown. Below Millerstown the river crosses the Wildcat and Buffalo valleys, washing the end of the Buffalo mountain. Pursuing its course, the Juniata, after making two or three bends, goes through a belt of hills called the "Half-fall Mountain", where, as at nearly all its passes through the larger sandstone ridges, it is impeded by ledges of hard strata and thrown into ripples or rapids. From the Half-fall rapids it flows between steep but low cliffs and hills for about 4 miles farther, to its entrance into the main Susquehanna, at Duncan's island, having followed a winding course entirely across the central zone of the Appalachian chain, through a distance of nearly 200 miles.

The Frankstown branch, rising in Bedford county, flows northeast into Blair and Huntingdon, bending then to the southeast, and receiving the Raystown branch, which rises in Bedford and Somerset counties, and flows northeast into Huntingdon. From their junction the course of the stream lies through Huntingdon, Mifflin, Juniata, and Perry counties, and by the towns of Mount Union, Lewistown, Mifflintown, Millersburg, and others. The total drainage area measures about 3,223 miles. The valley of the main river, as will be understood from Dr.

Rogers' description, is very narrow and the banks are generally high, and the stream has a number of large tributaries, a list of which is given on pages 79 and 80. The bed is generally gravel and sand, often with rock at a very small depth, and sometimes at the surface. The declivity of the stream will be seen from the following table:

Slope of the Juniata river.

Locality.	Distance from mouth.	Elevation above tide.	Distance between points.	Fall between points.	Fall per mile between points.
	Miles.	*Feet.*	*Miles.*	*Feet.*	*Feet.*
Mouth	0	336			
			16	44	2.7
Millerstown dam, water below	16	380			
			0	8	.....
Millerstown dam, crest	16	388			
			28	54	1.9
Lewistown dam, water below	44	442			
			0	8	.....
Lewistown dam, crest	44	450			
			24	62	2.6
Newton Hamilton dam, water below	68	512			
			0	8	.....
Newton Hamilton dam, crest	68	520			
			22	90	4.1
Huntingdon dam, water below	90	610±			
			0	12	.....
Huntingdon dam, crest	90	622±			

Some elevations along the Frankstown branch above Huntingdon are given on page 75. Between Newton Hamilton and Huntingdon there is one dam, at the mouth of the Raystown branch, but its elevation is not known. The dams referred to are all canal dams, for feeding the canal which extends up the river to Huntingdon, following the stream closely for the entire distance. When it is added that the Pennsylvania railroad follows the main river, the Frankstown branch, and the Little Juniata, a tributary of the latter, almost to the summit of the mountains, it will be seen that the facilities for transportation can not be surpassed.

Regarding the flow of the stream no data could be obtained. There are no lakes to regulate it, and the drainage area is composed largely of parallel valleys drained by the tributaries of the river. The whole basin of the river is comprised in the region of corrugations, and just that part of the region where the parallelism of the ranges is most marked, so that it is traversed from southwest to northeast by a number of parallel ranges, across and between which the river winds, and from the valleys between which it receives its tributaries. The rainfall is about 40 inches—11 in spring, 12 in summer, 9 in autumn, and 8 in winter—a distribution not very unfavorable for constancy of flow; and the basin is quite well wooded, so that possibly the flow may be more uniform than one would suppose, judging from the topography. No reliable data regarding the extreme rises in freshets could be obtained, but there are few low grounds to be overflowed. The facilities for artificial storage are good, and on the tributary creeks numerous sites for reservoirs could be found. With the exception of one on the Frankstown branch, near Hollidaysburg, none exist at present, excepting mill-ponds.

As the table of utilized power given on pages 86 and 87 shows, there is very little manufacturing in the basin of the Juniata, and below the mouth of the Raystown branch there is not a mill of importance on the main stream. A number of grist- and saw-mills on the tributaries, with occasionally a mill of some other kind, make up all that there are in the basin. The reason for this is not to be sought in the absence of any water-power, but in the fact that this is not a manufacturing region, and that the small powers which it offers (for it offers no large ones) are not able to compete with those which have the advantage of being located nearer to the markets. As on the Susquehanna, there is a little power used from the canal on the Juniata, there being three mills run in this way, viz, a saw-mill at Mill creek, discharging to the river, with a fall of 10 feet; a planing-mill at Huntingdon, discharging to a lower level, and a grist-mill at Newport, discharging to the river with a fall of 15 feet. There seems to be no reason why a large amount of power could not be utilized in this way, especially at the locks, where there is generally considerable water wasting, and particularly as the traffic on the canal is quite small and the interests of navigation are less important than on the Susquehanna. (See p. 64.)

As the river is ascended there are several ripples where power could be developed, before we come to the first canal dam, 3 miles below Millerstown. This structure, like all the others on the Juniata and Susquehanna rivers, is built of crib-work, its length being 857 feet and its height 7.5 feet. It ponds the water for 4 miles, and the pond is used for navigation. A certain amount of power could no doubt be utilized at this dam, depending on the amount of water required by the canal, and an estimate of the amount available, using the total flow of the stream, will be found on page 76. Whether the facilities for building are of the best, I am not able to state.

At Lewistown dam, the next on the river, and situated 2.5 miles below the town of Lewistown, the facilities for building are not very good. The dam is located in the Long narrows, and the banks are high on both sides, while on the south the railroad and on the north the canal leave little room for building. The place could be used if

desired, but is not favorable. The north side offers the best location, but the canal would have to be diverted to leave room enough between it and the river. The dam is 412 feet long and 8 feet high, and is used only as a feeder, its pool not being navigated.

Passing over some small ripples, the next power is at Newton Hamilton dam, just below the town of the same name. It is 830 feet long and 8 feet high, and is used only as a feeder. The power theoretically available is estimated on page 76, but I am not able to state whether much could be economically utilized.

Between this dam and the next, at the mouth of the Raystown branch, there are some ripples which have been spoken of as worth developing, especially one near Mount Union, where, on account of a bend in the stream, it is said that a fall of some 20 feet (?) could be obtained with a race of a mile. I do not know who is authority for this statement, but from measurements with a pocket-level, by means of which I obtained the elevation of the canal above the river at its crossings above and below Mount Union, 2 or 3 miles apart, I think it is exaggerated, and that the fall can not be over 10 or 15 feet between the two aqueducts.

The Raystown dam, just below the junction of the two forks of the river, is a crib dam, like all the others, and is 350 feet long and 7.5 feet high; it is used only as a feeder. The power theoretically available may be found estimated on page 76. The facilities for the utilization of this power are said to be good, and the entire flow of both branches, except the small amount needed for the canal, could be rendered available.

Let us now retrace our steps to the mouth of the river, and consider the tributaries in their order ascending the stream. Under this head will then be considered the Raystown and Frankstown branches.

The tributaries of the Juniata offer few or no precipitous falls, and perhaps fewer rapids than the main river, except in cases where they themselves cut through the ranges from one valley to an adjacent one, as is sometimes the case. Their banks vary in height, and sometimes the streams overflow considerable areas of bottom-land, although this is not generally the case. Their flow is quite variable, and the mills utilizing their power, although all small, are sometimes short of water in dry seasons. On only one or two of the tributaries did I hear of there being splash-dams. All the timber which is cut is sawed near by, and not floated down the river to any central point.

There are no lakes of any consequence on these tributaries, and no artificial reservoirs. As the map will show, they are often inaccessible.

Buffalo creek, from the south, and Cocalamus creek, from the north, in Perry county, are small streams utilized by saw- and grist-mills. Tuscarora creek, from the south, is a much larger stream, rising in Huntingdon county, and flowing northeast into Juniata. Besides a few mill-dams, it is said that there are a few splash-dams on the stream. Lost and Jack's creeks, from the north, are small and unimportant streams. Kishacoquillas creek, also from the north, emptying at Lewistown, is the most important stream thus far. It has two branches, one of which flows northeast and the other southwest, uniting near Reedsville to cut through a gap in Jack's mountain, flowing from that point southeast into the Juniata. Besides a number of saw- and grist-mills, there are several mills of other kinds on the stream and its tributaries—a woolen-mill at Milroy, and several others in the neighborhood, an ax factory near Reedsville, on the main stream, with a fall of 16 feet, another near Yeagertown, with a fall of 10 feet, and the works of the Logan Iron & Steel Works, at Logan, on the main stream, with a fall of 13 feet, and using, it is said, 100 horse-power or more, together with other mills, a tannery, foundery, etc. The grist-mills average 3 pairs of stones, and the flow of the stream is said to be tolerably uniform. Near the mouth is a grist- and flour-mill with 4 pairs of stones. There are several sites now idle which were formerly used by saw-mills when lumbering was carried on more extensively. There being no precipitous falls on the main tributaries, I could obtain but little information regarding sites not used, but I learned of the following sites on Kishacoquillas creek: at Lewistown there is a grist-mill, not in operation, with a dam of crib-work, 200 feet long and 9 feet high, a race three-quarters of a mile long, a fall of 15 feet, and a gross power of probably 80 or 100 horse-power in the low season of ordinary years. The mill ran 10 pairs of stones. Between Lewistown and Logan it is said that a fall of 10 feet could be obtained; between the two ax factories named above a fall of 10 feet is claimed; and near Reedsville several sites are claimed, one of 15 or 16 feet on Laurel run. On these little secondary tributary streams there are more frequently large falls, but the powers are very small.

Great Aughwick creek, the largest tributary of the main Juniata below the forks, drains an area of about 316 square miles, comprised in Fulton and Huntingdon counties. This stream probably resembles the others which have been described. Its utilized power, however, is small, and I was unable to obtain any information regarding sites not used, although there are several, including one near the mouth, where mills were formerly located. Though the stream is of considerable size near its mouth, it is soon divided among a number of small tributaries.

The Raystown branch of the Juniata, which drains an area only a few square miles smaller than that drained by the other branch, has its sources in Bedford and Somerset counties, as already mentioned. Its drainage area measures about 909 square miles, and comprises much rolling and farming country. The stream pursues a very tortuous course in a general northeasterly direction, receiving many tributaries of small size, and flowing by the towns of Bedford and Hopewell; but its slope is generally large, as the following approximate table of declivity shows:

Slope of the Raystown branch of the Juniata river.

Locality.	Distance from mouth.	Elevation above tide.	Distance between points.	Fall between points.	Fall per mile between points.
	Miles.	*Feet.*	*Miles.*	*Feet.*	*Feet.*
Mouth	0	595			
			40	242	6.0
Near Saxton	40	837			
			13	54	4.2
Piper's run	53	891			
			26	125	4.8
Mount Dallas	79	1,016			

For the elevations in the above table I am indebted to B. Andrew Knight, esq., president of the Huntingdon and Broad Top Mountain Railroad Company. The distances were measured from a map. I was unable to obtain much information regarding the power of the stream, but its slope seems to be very gradual, with no falls and few rapids; and although power could be obtained at many places by damming, there seem to be no very favorable sites. The lower part of the stream is especially tortuous and the banks high, and possibly some sites might be found here where power could be obtained; but at present there is little power used on the stream, and a number of steam flour-mills are in operation in various parts of the basin. The bed is generally gravel, there are no lakes, and the stream is subject to considerable freshets and ice-jams. Several sites may be mentioned where formerly mills were located, among them one at Hopewell where there was once a furnace. On the whole, however, the stream can not be said to be very favorable for water-power. Regarding its flow no data could be obtained. Some of its tributaries have rapids and falls, and the table on page 87 will show that they are utilized to a very much greater extent than the main stream. On Yellow creek, a tributary entering from the west at Hopewell, there is said to be a good unimproved power at the point where it cuts through Tussey's mountain, but the stream is very small.

The Frankstown branch, which is more accessible than the Raystown branch, is also more important as a water-power stream. Its sources are in Bedford and Blair counties, and it flows by the towns of Hollidaysburg, Williamsburg, and Alexandria. It drains an area of about 933 square miles, and its basin is perhaps rather more hilly and mountainous than that of the other branch. The stream was formerly navigable, by means of locks, dams, and canals, as far as the town of Hollidaysburg, but the works above Huntingdon were abandoned for purposes of navigation 8 or 10 years ago, and the dams have partly gone to pieces, so that the Huntingdon dam, a couple of miles above Huntingdon, is now the last navigation work on the Juniata. The dam at the mouth of the Raystown branch backs the water nearly up to the town, and has been described on page 73. The first power on the Frankstown branch is at Huntingdon, where a grist-mill, plaster-mill, and saw-mill use a fall of about 10 feet, by means of two crib-dams extending from the banks to an island, one to its head, the other to its foot. The upper is 6 feet in height, and the lower 10 (?) feet; the race is a mile long, and the power utilized is probably in the neighborhood of 100 horse-power. That available is estimated on page 76. It is said that there is never lack of water.

The next power on the stream is at the Huntingdon dam (2 miles above Huntingdon), which is a crib-work structure 382 feet long and 11.5 feet high, backing the water a mile and a half with an average width of about 400 feet. No power is used at the dam, although it may be said that the total flow here is available, the canal to be used as a race; for no boats go above Huntingdon, and there is no reason why the whole discharge of the stream could not be diverted into the canal, and, with the exception of the small amount necessary for feeding the levels below, used for power at some point along the canal. A portion is so used at present, for between Huntingdon and the dam there is a lock, where the Cottage Planing Mills use a power of about 40 horse-power, with a fall of 8 feet, discharging into the canal below. During the winter they keep the water in the canal above at their own expense. The available power at the dam, taking the fall as 11½ feet, is estimated on page 76. There is very little available fall between it and the grist-mill dam at Huntingdon.

The next power is at the site of the old canal dam known as Piper's dam. Before describing it, however, it will be well to give a list of all the old dams, with their heights and elevations, copied from a profile in the office of the canal company at Harrisburg. As the elevations above tide are not given, I have calculated them, assuming that of the Huntingdon dam as 622 feet, which is probably not more than a few feet from the truth:

Profile of Frankstown branch of the Juniata river.

Locality.	Distance from Huntingdon.	Elevation above tide.	Distance between points.	Fall between points.	Fall per mile between points.	DIMENSIONS OF DAM.	
						Length.	Height.
	Miles.	*Feet.*	*Miles.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Huntingdon dam, crest	0	622				382	11.5
			2.5	6.0	2.4		
Piper's dam, water below	2.5	628				475	8.0
			0	8.0			
Piper's dam, crest	2.5	636					
			1.6	5.0	3.1		
Petersburg dam, water below	4.1	641				300	6.5
			0	6.5			
Petersburg dam, crest	4.1	648					
			5.9	45.0	7.6		
Big Water Street dam, water below	10.0	693				283	19.3
			0	19.3			
Big Water Street dam, crest	10.0	712					
			2.4	2.0	0.8		
Little Water Street dam, water below	12.4	714				213	12.0
			0	12.0			
Little Water Street dam, crest	12.4	726					
			2.0	2.0	1.0		
Willow dam, water below	14.4	728				281	13.0
			0	13.0			
Willow dam, crest	14.4	741					
			2.6	29.0	11.2		
Donnelly's dam, water below	17.0	770				220	14.0
			0	14.0			
Donnelly's dam, crest	17.0	784					
			1.7	3.0	1.7		
Smoker's dam, water below	18.7	787				182	12.0
			0	12.0			
Smoker's dam, crest	18.7	799					
			1.4	1.0	0.7		
Mud dam, water below	20.1	800				180	7.5
			0	7.5			
Mud dam, crest	20.1	808					
			2.9	23.0	7.9		
Williamsburg dam, water below	23.0	831				210	10.0
			0	10.0			
Williamsburg dam, crest	23.0	839					
			1.1	0.0	0.0		
Three-Mile dam, water below	24.1	839				390	17.5
			0	17.5			
Three-Mile dam, crest	24.1	856					
			3.1	0.0	0.0		
Crooked dam, water below	27.2	856				200	10.0
			0	10.0			
Crooked dam, crest	27.2	866					
			6.3	29.0	4.6		
Frankstown dam, water below	33.5	895				216	3.5
			0	3.5			
Frankstown dam, crest	33.5	899					
			2.9	24.0	8.3		
Hollidaysburg dam, water below	36.4	923				152	4.5
			0	4.5			
Hollidaysburg dam, crest	36.4	927					

At two of these dams mills were in operation when the canal was abandoned.

Above Huntingdon dam, then, the next power is at the site of Piper's dam, now destroyed. The old canal led from this dam into the pool of the dam below, with two outlet locks at its lower end, and only about 2 miles above the Huntingdon dam; and it is said on good authority that by using the fall of these outlet locks, the best power in the vicinity could be obtained, with a fall of 14 feet. The power is estimated on page 76. The Petersburg dam is now used to supply power to a grist- and saw-mill at Petersburg, the fall being 8 feet, and about 20 horse-power being used; and formerly there were rolling-mills at the same place. This dam is just below the mouth of Shaver's creek.

Between the Petersburg dam and Big Water Street dam there is considerable fall, and the latter dam, which is now entirely gone with the exception of the abutments, was over 19 feet high. The power is said to be an excellent one, and, by rebuilding the old canal, a fall of over 20 feet could be obtained at Alexandria. It is also stated on good authority that at almost all of the other sites good powers could be developed by rebuilding the dams, and without doing much damage by flowage. It will be seen from the table that between Huntingdon dam and Hollidaysburg the stream has an average fall of 8.3 feet per mile. A large amount of power is therefore theoretically available, and there seems to be no reason why a large proportion could not be utilized. The Williamsburg dam is still standing and in good condition. It is a mile or so above the town, and between the two there is a lock with a lift of 8 feet, so that at Williamsburg a fall of some 15 feet or more could be obtained.

Three-Mile dam is also said to afford a good power, and also the dams above. The abutments and old locks are still in existence, although the dams have been more or less destroyed.

Two miles above Hollidaysburg there is an artificial reservoir, formerly used a feeder for the canal—the only one on the Juniata. It has an area of about 600 acres and a depth of 20 feet, and is formed by a dam 850 feet long and 30 feet high, built mainly of earth, faced with stone, and constructed about the year 1846. The water is discharged through four 30-inch iron pipes. The bed of the stream is rock. A small amount of power could be used here, with a fall of 20 feet, and the reservoir is large enough to hold several months' flow of the stream, so

that it might be made to serve a very useful purpose in regulating—though only to a small extent—the flow of the stream below. It may be mentioned that on the Conemaugh river, on the other side of the mountains, there was formerly a length of 100 miles of canal, now abandoned, and that near Willmore's station there was a larger reservoir than that at Hollidaysburg, called the "Western reservoir".

Notwithstanding the considerable amount of power which seems to be available on the Frankstown branch, but little is used, as the table on page 87 shows.

Of the tributaries of the Frankstown branch, Standing Stone creek, which empties at Huntingdon, has a few mills and some unimproved powers, but they do not seem to be important. Shaver's creek is similar in character. The Little Juniata, which rises in Blair county, near Juniata gap, and flows first northeast as far as the town of Tyrone, where it bends to the right and flows in a southeasterly direction, joining the main stream about a mile above Petersburg, is the most important tributary of the Frankstown branch. It drains an area of about 327 square miles, and is followed for its entire length by the Pennsylvania railroad, so that every point is easily accessible. Its drainage basin is mountainous, and its fall rapid, so that although its flow is quite variable and its freshets are heavy, it does not rise very high. The fall is uniform, and very little power is used on the stream, although there are numerous sites where it could be developed. The first mill is just above Petersburg, near the mouth, the dam being about 9 feet high, and the fall used 11 feet. The mill is a grist-mill, with probably 40 or 50 horse-power. At Barree there are a furnace, a forge, a saw-mill, and a grist-mill, with a fall of 13 feet. Above Tyrone, where the drainage area is about 154 square miles, there is no power of importance used, except about a mile above the town, where the Pennsylvania Axe Company is putting up two dams across the stream, intending to connect the races and utilize a fall of 11 feet, formerly used by a forge. Of sites not used I can only mention as once utilized those at Tyrone forges, and at the site of an old forge just below Tyrone. Other and perhaps better sites could no doubt be found.

None of the tributaries of the Little Juniata are worthy of special mention, though some have large falls.

The following table gives a summary of the power at various places referred to in the previous pages, based, of course, on estimates:

Locality.	Drainage area.	RAINFALL.					Fall.	HORSE-POWER AVAILABLE, GROSS. (a)				Remarks.
		Spring.	Summer.	Autumn.	Winter.	Year.		Minimum.	Minimum low season.	Maximum with storage.	Low season, dry year.	
	Sq. miles.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Feet.*					
Millerstown dam	2,990	11	12	10	8	41	7.5	300	450	1,500	525	Dam 7.5 feet high.
Lewistown dam	2,550	11	12	10	8	41	8.0	275	400	1,400	480	Dam 8 feet high.
Newton Hamilton dam	2,270	11	12	10	8	41	8.0	250	375	1,250	440	Dam 8 feet high.
Raystown dam	1,842	11	12	10	8	41	7.5	200	300	1,000	350	Dam 7.5 feet high.
Huntingdon	770	11	12	10	8	41	10.0	100	150	750	175	Race 1 mile long.
Huntingdon dam	750	11	12	10	8	41	11.5	115	160	875	190	Dam 11.5 feet high.
Piper's dam (outlet locks)	750	11	12	10	8	41	14.0	140	210	1,075	250	
Petersburg dam	750	11	12	10	8	41	6.5	65	100	500	115	Dam 6.5 feet high.
Big Water Street dam	356	11	12	10	8	41	19.3	90	130	700	150	

a See pages 8 to 11.

These figures are not of very much value, but they serve to give an idea of the amounts of power which could be developed at the places named. The table of drainage areas on pages 78 to 80 will enable any one who is acquainted with the country, and has studied the remarks on flow in this report and that on the southern Atlantic water-shed, to estimate intelligently for himself. The tributaries of the Juniata being so little used, it is scarcely necessary to give estimates for them.

The first tributary of the Susquehanna below the Juniata is the Little Juniata, a small stream and of no importance. The next is Sherman's creek, which also enters from the west, and traverses the entire length of Perry county from west to east. It is similar in character to the lower tributaries of the Juniata, and has no powers of much importance. Stony creek, from the east, is a small stream draining a narrow valley, and, although over 20 miles long, has scarcely a tributary. Conedogwinet creek, from the west, is a considerable stream, rising in Franklin county, and passing through Cumberland in an easterly direction, emptying 2 miles above Harrisburg. It drains a region rather more open and less mountainous than that along the Juniata, and its course is very tortuous. It is extensively used for power, chiefly for grist-mills, and no important unimproved sites were spoken of. The most important utilized power is at the mouth, where a crib-work dam 300 feet long and 8 feet high supplies power to a nail factory and rolling-mill, using a fall of 8 feet and 200 horse-power or over, which, however, can be obtained during only eight months. In the summer there is no waste, and the water is probably drawn down in the pond. The bed of the stream is said to consist of ledges of rock at this place and at many places above, and the banks are generally high and not favorable for large reservoirs. All the good sites on the stream are said to be occupied.

Yellow Breeches creek, which rises in the western part of Cumberland county, and in the lower part of its course forms the boundary line between that county and York, is a similar stream. Its fall is quite large, and it is utilized by a number of mills, but none are of importance. The stream and its tributaries are considered good water-power streams, and their flow is said to be not very variable. No good sites, it is said, remain unoccupied, except on some of the small tributaries. Mountain creek, one of them, is used at Laurel Forge in various ways by the South Mountain Iron Company, there being two falls, one of 24 and one of 30 feet, and the power being about 35 and 25 horse-power, respectively; and at Mount Holly Springs the same stream runs the two paper-mills of the Mount Holly Paper Company, each with a fall of 20 feet, and 110 horse-power during eight months, besides a third, with a fall of 13 feet, and 70 horse-power during eight months. Steam is used in all during the dry weather.

Conewago and Codorus creeks, from the west, are similar streams, but regarding their power I have no details. No sites of special importance were mentioned.

The first large tributary from the east below Harrisburg is Swatara creek, which rises in Schuylkill county and flows in a general southwesterly direction through Lebanon and Dauphin counties, draining an area of 536 square miles, and emptying into the Susquehanna at Middletown. The lower part of its course lies through a hilly and rolling farming country, the bed being generally gravel and sand, though sometimes rock, and the banks low and sometimes overflowed. Toward the head-waters, which approach those of the Schuylkill, the country is more broken, the banks higher, and the bed oftener rock. The fall of the stream is gradual, there being no natural falls or rapids of importance, except on the upper parts, and the slope does not exceed about 3 feet per mile for the first 25 or 30 miles. Regarding the flow I have no data. The character of the greater part of the drainage basin is not such as to cause the rapid discharge of storm-waters, the soil is cultivated, and the rainfall is quite favorably distributed, being largest in summer and autumn. The freshets are said to be not very violent, and the rises not very sudden. The stream is followed for about 25 miles by the Union canal, which connects Middletown with Reading, and for 10 or 12 miles farther by a branch of the canal extending to what seems from the map to be an artificial reservoir used as a feeder; but no details regarding it could be obtained. With this exception there are no lakes or artificial reservoirs in the basin, excepting mill-ponds. The power utilized on the stream will be found in the table on page 88, to which I can add little in the way of explanation. The grist-mills use only small amounts of power, running generally three pairs of stones. The first dam on the stream is one used as a feeder for the Pennsylvania canal, and is situated just above the mouth. It is a crib-work dam, 548 feet long and 7 feet high, backing the water less than a mile. A grist-mill is supplied from it, using a fall of 8 feet and running two pairs of stones; but as the water is diverted from the stream by a dam a short distance above, and carried by to supply a mill below, full capacity can be obtained during only about eight months. No sites of importance not utilized were spoken of, and it is probable that they do not exist. It was said, however, that the traffic on the Union canal is so small that it will soon be abandoned as a navigation canal, and that by using it as a race considerable water-power could be utilized; but at present no power is so used.

The next stream of importance from the east is Conestoga creek. Taking its rise in the southernmost corner of Berks county, it flows first west and then southwest, through Lancaster county, and within a mile or two of the town of the same name, emptying into the Susquehanna 10 or 12 miles below Columbia. It drains a rolling farming country, its bed is gravel and sand, its fall moderate, and its flow quite variable. It has no lakes or falls, and is utilized quite extensively by small grist-mills with from two to five pairs of stones, those near the mouth of the stream generally running all the year. The distribution of the rainfall is quite favorable for constancy of flow, and the stream is said to be fed largely from springs. No unimproved sites for power were discovered. Of those utilized we may mention the Slackwater paper-mills, some 5 miles from the mouth of the stream, using a fall of 12 feet and about 160 horse-power; the water-works at Lancaster, used for pumping water for the supply of the city, with a fall of 6 feet; and Levan's flour-mill, with a fall of 6 or 7 feet, and running seven pairs of stones night and day, but during only six or eight months. Many of the mill-ponds are large enough to allow of considerable storage during the night.

The remaining tributaries of the river below Columbia are small streams, and may be dismissed with a few words. From the west there are the following: Creitze creek, emptying at Wrightsville, opposite Columbia, a small stream, running a number of grist-mills with from three to five pairs of stones, some with extra steam-power, and none able to run in very dry weather; then a number of small streams running a few grist-mills, saw-mills, furnaces, founderies, etc.; Muddy creek, emptying about 3 miles above Peachbottom, with grist- and saw-mills, a forge, woolen-mill, and spoke factory on the stream and its branches; Broad creek, a smaller but similar stream; Deer creek, emptying at the head of tide-water, and running a number of grist-, saw-, and flint-mills, the former averaging three pairs of stones. These streams are all similar in general character, having a gradual fall, often quite large, beds of gravel and sand, banks generally low, no lakes or artificial reservoirs, no natural falls, and a quite variable flow. There are said to be numerous sites not used—for instance, six on Deer creek, within 12 miles of its mouth, the largest with an available fall of 12 feet. On some small secondary tributaries there are precipitous falls, some utilized.

From the west there are the following streams below the Conestoga: Pequea, Muddy, Fishing, Peter's, and Conewingo creeks, all with small mills; and Octorara creek, the most important, emptying at Rowlandville,

Maryland, about 3 miles above Port Deposit. At its mouth is the power of the McCullough Iron Company, with a dam about 170 feet long and 12 feet high. That the stream is subject to considerable freshets is shown by the fact that the original log dam at this place, built in 1828, was swept away in 1857, and that the stone dam by which it was replaced was also swept away in 1881. The present dam is of crib-work filled with stone and concrete. A race 100 yards long gives a fall of 14 feet, used for the rolling-mill, the power being stated at 120 horse-power during seven months, and one-half to two-thirds of that amount during the rest of the time. The pond is large enough to store the water in dry seasons during the four hours when power is not used. About a mile above this power is an unimproved site with a fall stated at 25 feet; and still farther up are a number of small mills, generally grist-mills, though there is one paper-mill near Rising Sun, Maryland, with a fall of 18 feet. The streams from the east have the same general character as those from the west, but seem to have more fall and higher banks. The Octorara is said to be an especially good stream for power, on account of its rapid fall and its favorable locations.

The principal fact that strikes one in considering the power of the Susquehanna is the comparative absence of large falls. And as regards the tributaries, the most prominent point is their gradual fall and the absence of cataracts like those on so many of the northern and southern rivers. On this account it has been impossible to give much of an idea of the available power which they offer or the sites which are capable of being developed with advantage.

The first of the following tables gives the drainage areas of the Susquehanna and tributaries, and the second the power utilized, tabulated from the returns of the enumerators:

Table of drainage areas of the Susquehanna river and tributaries.

Stream.	Tributary to what.	Locality.	Drainage area.
			Square miles.
North branch of Susquehanna river	Atlantic ocean	Above mouth of Oak creek	97
Do	do	Below mouth of Oak creek	212
Do	do	Below mouth of Charlotte river	713
Do	do	Below mouth of Unadilla river	1,638
Do	do	Nineveh	1,789
Do	do	Susquehanna	2,024
Do	do	Binghamton	2,270
Do	do	Above mouth of Chemung river	4,945
Do	do	Below mouth of Chemung river	7,403
Do	do	Nanticoke	9,850
Do	do	Berwick	10,059
Do	do	Mouth	10,059
Do	do	Below mouth of West branch	17,425
Do	do	Clark's Ferry	18,829
Do	do	Below mouth of Juniata river	22,052
Do	do	Falmouth	23,850
Do	do	Columbia	24,835
Do	do	Mouth	26,233
Oak creek	North branch of Susquehanna river	do	115
Cherry Valley creek	do	do	121
Schenevas creek	do	do	127
Charlotte river	do	do	178
Otego creek	do	do	106
Oaliout creek	do	do	115
Unadilla river	do	do	561
Butternut creek	Unadilla river	do	123
Wharton creek	do	do	92
Bennett's creek	North branch of Susquehanna river	do	47
Chenango river	do	Above Canasawacta creek	297
Do	do	Above Tioughnioga creek	685
Do	do	Mouth	1,540
Canasawacta creek	Chenango river	do	63
Genegantslet creek	do	do	102
Tioughnioga river	do	Above mouth of Otselic river	428
Do	do	Mouth	735
West branch Tioughnioga river	Tioughnioga river	do	103
East branch Tioughnioga river	do	do	164
Otselic river	do	do	259
Starucca creek	North branch of Susquehanna river	do	75
Owego creek	do	do	391
Cayuta (Shepard's) creek	do	do	148
Chemung river	do	Junction of Canisteo and Conhocton rivers	1,941
Do	do	Elmira	2,107
Do	do	Mouth	2,518
Conhocton river	Chemung river	do	607
Tioga river	do	do	1,394
Do	do	Above mouth of Cowanesque creek	433

Table of drainage areas of the Susquehanna river and tributaries—Continued.

Stream.	Tributary to what.	Locality.	Drainage area.
			Square miles.
Tioga river	Chemung river	Above mouth of Canisteo river	776
Canisteo river	do	Mouth	545
Tuscarora creek	Canisteo river	do	129
Cowanesque creek	Tioga river	do	288
Sugar creek	North branch of Susquehanna river	do	177
Towanda creek	do	do	220
Wysox creek	do	do	90
Wyalusing creek	do	do	204
Tunkhannock creek	do	do	409
Lackawanna creek	do	do	323
Little Wapwallopen creek	do	do	38
Big Wapwallopen creek	do	do	68
Nescopec creek	do	do	145
Catawissa creek	do	do	131
Fishing creek	do	do	353
West branch of Susquehanna river	Susquehanna river	Above mouth of Clearfield creek	476
Do	do	Above mouth of Sinnemahoning creek	1,437
Do	do	Queen's run	3,032
Do	do	Lock Haven	3,041
Do	do	Williamsport	5,300±
Do	do	Muncy dam	6,010
Do	do	Louisburg	6,308
Do	do	Mouth	6,466
Clearfield creek	West branch of Susquehanna river	do	342
Moshannon creek	do	do	233
Mosquito creek	do	do	54
Sinnemahoning creek	do	Benezette	103
Do	do	Driftwood	354
Do	do	Mouth	902
Trout run	Sinnemahoning creek	do	48
Driftwood branch	do	do	314
First fork	do	do	240
Kettle creek	West branch of Susquehanna river	do	215
Bald Eagle creek	do	do	726
Beach creek	Bald Eagle creek	do	157
Fishing creek	do	do	169
Spring creek	do	do	148
Pine creek	West branch of Susquehanna river	do	930
Big Larry's creek	do	do	85
Lycoming creek	do	do	201
Loyalsock creek	do	do	404
Muncy creek	do	do	185
White Deer creek	do	do	40
Chillisquaque creek	do	do	119
Shamokin creek	North branch of Susquehanna river	do	165
Mahanoy creek	do	do	133
Mahontongo creek	do	do	166
Wiconisco creek	do	do	83
Clark's creek	do	do	47
Penn's creek	do	do	361
Middle creek	do	do	147
Juniata river	Susquehanna river	Below junction of two branches	1,842
Do	do	Newton Hamilton	2,270
Do	do	Lewistown dam	2,550
Do	do	Millerstown	2,990
Do	do	Mouth	3,223
Raystown branch of	Juniata river	Hopewell	588
Do	do	Mouth	909
Frankstown branch of	do	Hollidaysburg	129
Do	do	Crooked dam	249
Do	do	Three-Mile dam	273
Do	do	Williamsburg	279
Do	do	Mud dam	333
Do	do	Smoker's dam	333
Do	do	Donnelly's dam	342
Do	do	Willow dam	347
Do	do	Water Street dam	356
Do	do	Alexandria	360
Do	do	Mouth of Little Juniata	374
Do	do	Piper's dam	750

Table of drainage areas of the Susquehanna river and tributaries—Continued.

Stream.	Tributary to what.	Locality.	Drainage area.
			Square miles.
Frankstown branch of	Juniata river	Huntingdon dam	759
Do	do	Mouth	933
Standing Stone creek	Frankstown branch	do	129
Shaver's creek	do	do	45
Little Juniata river	do	Tyrone (including Bald Eagle creek)	154
Do	do	Barree	325
Do	do	Mouth	327
Spruce creek	Little Juniata river	do	94
Bald Eagle creek	do	do	54
Great Aughwick creek	Juniata river	do	316
Kishacoquillas creek	do	do	174
Jack's creek	do	do	55
Tuscarora creek	do	do	252
Swatara creek	Susquehanna river	do	536
Conewago creek	do	do	58
Sherman's creek	do	do	232
Conedogwinit creek	do	do	450
Yellow Breeches creek	do	do	247
Pequea creek	do	do	148
Conestoga creek	do	Lancaster	332
Do	do	Mouth	474
Conewingo creek	do	do	31
Octorara creek	do	do	178
Deer creek	do	do	128

Table of utilized power on the Susquehanna river and tributaries.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
North branch of Susquehanna river	Atlantic ocean	New York	Otsego	Agricultural implements	1	5	10
Do	do	do	do	Blacksmithing	1	5	10
Do	do	do	do	Cotton-laps	1	8	15
Do	do	do	do	Flouring and grist	4	32	170
Do	do	do	do	Saw	14	82+	371
Do	do	do	do	Planing	1	6	10
Do	do	do	do	Machinery	1	7	7
Do	do	do	do	Paper	1	6.5	15
Do	do	do	Delaware	Flouring and grist	1	.....	80
Do	do	do	Chenango	do	3	22	170
Do	do	do	do	Saw	1	4	20
Do	do	do	Broome	Woolen	1	7	6
Do	do	do	do	Flouring and grist	5	20	113
Do	do	do	do	Carriages, etc	2	13.5	70
Do	do	do	do	Furniture	1	5.5	25
Do	do	do	do	.....	1	.....	15
Do	do	do	do	Blacksmithing	1	4	10
Do	do	do	do	Leather	1	7.5	30
Do	do	do	do	Saw (*a*)	(?)	(?)	(?)
Do	do	do	do	Wheelwrighting	1	.....	12
Do	do	do	do	Machinery	1	5	2
Do	do	do	do	Furniture	1	.....	10
Do	do	Pennsylvania	Susquehanna	Sash, doors, and blinds	1	4.5	25
Do	do	do	do	Saw	(?)	(?)	(?)
Do	do	do	do	Flouring and grist	2	8	110
Do	do	New York	Tioga	Saw	2	.....	23
Do	do	Pennsylvania	Bradford	do	2	13	(?) 20
Do	do	do	do	Flouring and grist	3	14	86
Do	do	do	Luzerne	do (*b*)	1	10	.....
Do	do	do	Columbia	Keg (*b*)	1	10	20
Do	do	do	do	Water-works (*b*)	1	7	.....
Do	do	do	Snyder	Saw (*b*)	1	8	40

a The power on the main stream used for saw-mills can not be distinguished from that on the tributaries. The total is given under the head of the tributaries.

b From Pennsylvania canal.

Table of utilized power on the Susquehanna river and tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
North branch of Susquehanna river	Atlantic ocean	Pennsylvania	Perry	Saw (*a*)	1	7	23
Do	do	do	Dauphin	do (*a*)	1	7	.....
Do	do	do	do	Flouring and grist (*a*)	1	15	60
Do	do	do	do	Canal shops (*a*)	1	11	.....
Do	do	do	Lancaster	Saw (*b*)	1	6.5	70
Do	do	do	do	Flouring and grist (*b*)	1	.....	(†)28
Tributaries of	Susquehanna river	New York	Otsego	Woolen	2	11	28
Do	do	do	do	Cotton	6	119	436
Do	do	do	do	Agricultural implements	3	26	46
Do	do	do	do	Butter and cheese	1	6	10
Do	do	do	do	Blacksmithing	1	6	12
Do	do	do	do	Box	2	32	25
Do	do	do	do	Keg	2	19	27
Do	do	do	do	Furniture	2	12	40
Do	do	do	do	Flouring and grist	35	481	1,103
Do	do	do	do	Saw	72	980	1,758
Do	do	do	do	Leather	7	83	167
Do	do	do	do	Last	1	16	20
Do	do	do	do	Machinery	3	30	58
Do	do	do	do	Paper	1	10	55
Do	do	do	do	Sash, door, and blind	1	13	20
Do	do	do	do	Wheelwrighting	5	57	104
Do	do	do	do	Wooden ware	1	8	18
Do	do	do	Schoharie	Foundery	1	16	4
Do	do	do	do	Planing	1	18	8
Do	do	do	do	Wheelwrighting	1	18	8
Do	do	do	do	Flouring and grist	1	20	30
Do	do	do	do	Saw	5	68	92
Do	do	do	Delaware	Flouring and grist	9	110	300
Do	do	do	do	Woolen	1	9	15
Do	do	do	do	Saw	15	196	409
Do	do	do	do	Leather	1	3	24
Do	do	do	do	Machinery	1	7	4
Do	do	do	do	Wheelwrighting	1	12	5
Do	do	do	Herkimer	Box	2	17	90
Do	do	do	do	Flouring and grist	2	33	65
Do	do	do	do	Saw	1	22	30
Chenango river	do	do	Madison	Carriage	2	20	5
Do	do	do	do	Flouring and grist	2	53	50
Do	do	do	do	Saw	2	19	73
Do	do	do	do	Leather	1	8	10
Do	do	do	do	Wheelwrighting	1	9	2
Do	do	do	Chenango	Flouring and grist	5	24	249
Do	do	do	do	Fertilizers	1	4	10
Do	do	do	do	Planing	1	4.5	15
Do	do	do	Broome	Flouring and grist	4	21.5	265
Do	do	do	do	Broom and brush	1	4.5	12
Do	do	do	do	Saw	1	7	25
Do	do	do	do	Paper	1	4.5	80
Do	do	do	do	Foundery	1	4	18
Tributaries of	Chenango river	do	Madison	Keg	1	8	10
Do	do	do	do	Butter and cheese	1	10	4
Do	do	do	do	Flouring and grist	11	153	376
Do	do	do	do	Furniture	2	17	18
Do	do	do	do	Saw	19	260	550
Do	do	do	do	Planing	1	13	18
Do	do	do	do	Leather	1	22	6
Do	do	do	do	Pumps	1	24	12
Do	do	do	do	Wheelwrighting	2	16	12
Do	do	do	do	Woolen	3	50	148
Do	do	do	do	Silk	1	23.5	76
Do	do	do	Onondaga	Flouring and grist	2	42	41
Do	do	do	do	Flax-dressing	1	10	7
Do	do	do	do	Saw	1	10	24
Do	do	do	Cortland	Blacksmithing	2	7.5	5
Do	do	do	do	Woolen	1	6	4

a From Pennsylvania canal.

b From Columbia dam.

Table of utilized power on the Susquehanna river and tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
Tributaries of	Chenango river	New York	Cortland	Carriage	1	10	8
Do	do	do	do	Keg	2	12	25
Do	do	do	do	Cutlery	1	6	12
Do	do	do	do	Flouring and grist	22	317	985
Do	do	do	do	Furniture	3	32	25
Do	do	do	do	Flax-dressing	1	9	9
Do	do	do	do	Saw	28	303	785
Do	do	do	do	Leather	3	36	84
Do	do	do	do	Machinery	1	5	8
Do	do	do	do	Vegetable oil	1	6	23
Do	do	do	do	Wooden ware	1	6.5	12
Do	do	do	Chenango	Agricultural implements	2	16	43
Do	do	do	do	Woolen	3	.....	35
Do	do	do	do	Box	1	6	25
Do	do	do	do	Blacksmithing	2	18	18
Do	do	do	do	Cutlery	1	9	30
Do	do	do	do	Carpenter-shop	1	9	10
Do	do	do	do	Flouring and grist	17	198	295
Do	do	do	do	Dyestuffs and extracts	1	9	20
Do	do	do	do	Furniture	1	8	15
Do	do	do	do	Saw	10	97	210
Do	do	do	do	Lumber	36	515	1,007
Do	do	do	do	Planing	1	8	15
Do	do	do	do	Leather	2	26	20
Do	do	do	do	Machinery	1	4	4
Do	do	do	do	Wheelwrighting	1	11	38
Do	do	do	Broome	Flouring and grist	6	75	160
Do	do	do	do	.....	1	15	10
Do	do	do	do	Saw	8	77	280
Do	do	do	do	Furniture	1	7	5
Other tributaries of	North branch of Susquehanna river	do	Madison	Box	1	11	30
Do	do	do	do	Flouring and grist	4	52	130
Do	do	do	do	Saw	4	49	72
Do	do	do	do	Planing	1	8	18
Do	do	do	do	Leather	1	22	56
Do	do	do	Chenango	Keg	1	7	10
Do	do	do	do	Woolen	1	4	20
Do	do	do	do	Flouring and grist	8	161	224
Do	do	do	do	Drugs and chemicals	1	28	32
Do	do	do	do	Furniture	2	28	20
Do	do	do	do	Foundery	1	14	5
Do	do	do	do	Saw	14	163	357
Do	do	do	do	Sash, doors, and blinds	1	5	25
Do	do	do	Broome	Flouring and grist	7	63	237
Do	do	do	do	Agricultural implements	1	6	8
Do	do	do	do	Clothing	1	.....	1
Do	do	do	do	Beehives	1	.....	4
Do	do	do	do	Leather	2	10	18
Do	do	do	do	Saw	23	283	607
Do	do	do	do	Furniture	1	4.5	20
Do	do	do	do	Wheelwrighting	1	6	15
Do	do	Pennsylvania	Wayne	Saw	6	96	186
Do	do	do	do	Flouring and grist	1	11	30
Do	do	New York	Tioga	Agricultural implements	1	6.5	18
Do	do	do	do	Woolen	1	8	20
Do	do	do	do	Blacksmithing	2	11.5	18
Do	do	do	do	Cutlery	1	5	6
Do	do	do	do	Keg	2	16.5	23
Do	do	do	do	Dyestuffs	1	8	20
Do	do	do	do	Fertilizers	1	6	10
Do	do	do	do	Saw	26	215	871
Do	do	do	do	Paper	1	10	80
Do	do	do	do	Leather	2	17	45
Do	do	do	do	Wheelwrighting	2	15	28
Do	do	do	do	Flouring and grist	13	114	516
Do	do	do	Chemung	do	2	15	90

Table of utilized power on the Susquehanna river and tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
Other tributaries of	North branch of Susquehanna river.	New York	Tompkins	Saw	2	26	(?) 65
Do	do	do	Schuyler	do	3	24	77
Do	do	do	do	Flouring and grist	2	20	65
Chemung river	do	Pennsylvania	Bradford	Planing	1	5	13
Do	do	do	do	Flouring and grist	1	5	18
Do	do	New York	Chemung	do	2	10	85
Tributaries of	Chemung river	Pennsylvania	Bradford	Saw	2	40	(?) 80
Do	do	do	do	Flouring and grist	1	17	30
Do	do	New York	Chemung	do	9	92	305
Do	do	do	do	Saw	12	124	304
Do	do	do	do	Woolen	1	16	8
Do	do	do	Steuben	Saw	3	38	97
Conhocton river	Chemung river	do	do	Fertilizers	1	9	40
Do	do	do	do	Flouring and grist	10	83	485
Do	do	do	do	Saw	3	41	130
Do	do	do	do	Leather	1	6	10
Tributaries of	Conhocton river	do	do	Flouring and grist	5	75+	128
Do	do	do	do	Saw	3	.....	50
Do	do	do	Schuyler	Flouring and grist	2	52	87
Do	do	do	do	Saw	1	22	25
Canisteo river	Chemung river	do	Steuben	Flouring and grist	7	62	327
Do	do	do	do	Saw	5	41	149
Do	do	do	do	Sash, door, and blind	1	5	60
Do	do	do	Allegany	Drugs and chemicals	1	13	1
Tributaries of	Canisteo river	do	Steuben	Agricultural implements	1	12	20
Do	do	do	do	Flouring and grist	9	154	239
Do	do	do	do	Saw	11	125+	289
Do	do	do	do	Leather	1	15	21
Do	do	do	do	Paints	1	.....	5
Do	do	do	do	Woolen	1	11	15
Do	do	do	Allegany	Saw	1	18	15
Do	do	do	do	Flouring and grist	3	82	115
Tioga river	Chemung river	do	Steuben	do	2	10.5	55
Do	do	do	do	Saw	4	25	(?) 475
Do	do	Pennsylvania	Tioga	Agricultural implements	1	10	50
Do	do	do	do	Saw	8	73	278
Do	do	do	do	Flouring and grist	3	28	92
Tributaries of	Tioga river	New York	Steuben	do	1	20	30
Do	do	Pennsylvania	Tioga	Planing	1	7	20
Do	do	do	do	Wheelwrighting	1	16	20
Do	do	do	do	Saw	8	68	275
Do	do	do	do	Leather	2	26	30
Do	do	do	do	Flouring and grist	12	190	378
Do	do	do	do	Woolen	1	5	16
Do	do	do	Potter	Saw	2	41	51
Sugar creek	North branch of Susquehanna river.	do	Bradford	Carriage	1	30	60
Do	do	do	do	Flouring and grist	5	56	181
Do	do	do	do	Saw	3	45	72
Do	do	do	do	Woolen	1	7	30
Towanda creek	do	do	do	Saw	1	6	30
Do	do	do	do	Flouring and grist	7	91	223
Tunkhannock creek	do	do	Wyoming	Flouring and grist	3	25	134
Do	do	do	Susquehanna	Agricultural implements	1	8	4
Do	do	do	do	Furniture	1	12	15
Do	do	do	do	Saw	6	75	122
Do	do	do	do	Leather	1	8	15
Do	do	do	do	Flouring and grist	5	60	156
Lackawanna river	do	do	Lackawanna	Agricultural implements	1	10	55
Do	do	do	do	Cutlery	1	10	55
Do	do	do	do	Carpenter-shop	1	10	30
Do	do	do	do	Gunpowder	1	15	20
Do	do	do	do	Leather	1	12	35
Do	do	do	do	Saw	2	22	26
Do	do	do	do	Flouring and grist	4	56	71
Do	do	do	Susquehanna	Blacksmithing	1	18	8
Do	do	do	do	Furniture	1	14	18

Table of utilized power on the Susquehanna river and tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse power used, net.
						Feet.	
Lackawanna river	North branch of Susquehanna river.	Pennsylvania	Susquehanna	Saw	6	86	115
Do	do	do	do	Flouring and grist	1	20	40
Other tributaries of	do	do	Bradford	Woolen	3	.....	22
Do	do	do	do	Blacksmithing	[a]1	12	5
Do	do	do	do	Foundery	1	11	13
Do	do	do	do	Flouring and grist	24	389	564
Do	do	do	do	Saw	25	370	530
Do	do	do	do	Leather	1	20	20
Do	do	do	do	Sash, door, and blind	1	8	10
Do	do	do	do	Toys and games	1	9	60
Do	do	do	Susquehanna	Woolen	2	34	28
Do	do	do	do	Drugs and chemicals	1	.....	10
Do	do	do	do	Furniture	5	55	87
Do	do	do	do	Chair	2	26	45
Do	do	do	do	Planing	1	18	18
Do	do	do	do	Machinery	1	16	15
Do	do	do	do	Wheelwrighting	5	59	31
Do	do	do	do	Wooden ware	1	14	20
Do	do	do	do	Saw	55	761+	1,556
Do	do	do	do	Leather	9	140+	202
Do	do	do	do	Flouring and grist	26	374+	646
Do	do	do	Wyoming	Agricultural implements	2	26	24
Do	do	do	do	Blacksmithing	1	8	12
Do	do	do	do	Keg	1	27	30
Do	do	do	do	Planing	3	52	54
Do	do	do	do	Toys and games	1	21	30
Do	do	do	do	Flouring and grist	20	374	637
Do	do	do	do	Leather	2	26	32
Do	do	do	do	Saw	26	428+	599
Do	do	do	Lackawanna	Woolen	1	9	8
Do	do	do	do	Agricultural implements	1	15	10
Do	do	do	do	Baskets, etc	1	13	20
Do	do	do	do	Furniture	2	19	57
Do	do	do	do	Foundery	1	31	7
Do	do	do	do	Gunpowder	1	36	68
Do	do	do	do	Leather	1	10	10
Do	do	do	do	Saw	6	76	187
Do	do	do	do	Flouring and grist	8	107	216
Do	do	do	Luzerne	Woolen	3	.....	40
Do	do	do	do	Agricultural implements	2	12	20
Do	do	do	do	Flouring and grist	41	658	900
Do	do	do	do	Leather	2	.....	35
Do	do	do	do	Saw	37	473+	722
Do	do	do	do	Paper	1	11	30
Do	do	do	do	Wheelwrighting	1	5	6
Do	do	do	Columbia	Agricultural implements	1	9	10
Do	do	do	do	Blacksmithing	1	10	10
Do	do	do	do	Planing	1	8	20
Do	do	do	do	Woolen	2	.....	33
Do	do	do	do	Flouring and grist	33	459	843
Do	do	do	do	Leather	1	17	16
Do	do	do	do	Saw	27	385	601
Do	do	do	do	Blomary and forge	1	8	120
Do	do	do	do	Blast-furnace	1	22	170
Do	do	do	do	Paper	2	20	110
Do	do	do	do	Wheelwrighting	1	12	24
Do	do	do	Montour	Printing and publishing	3	.....	3
Do	do	do	do	Flouring and grist	5	85	108
Do	do	do	Sullivan	Flouring and grist	1	15	15
Do	do	do	Northumberland	do	1	24	25
Do	do	do	do	Saw	1	12	25
West branch of Susquehanna river	Susquehanna river	do	do	Saw (a)	1	11	20
Do	do	do	Lycoming	Flouring and grist	1	9	100
Do	do	do	do	Saw	1	9	.....
Do	do	do	Clearfield	Flouring and grist	6	36	205

a From Pennsylvania canal.

Table of utilized power on the Susquehanna river and tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
West branch of Susquehanna river	Susquehanna river	Pennsylvania	Clearfield	Saw	4	31	134
Do	do	do	Cambria	do	1	10	36
Do	do	do	do	Flouring and grist	1	19	30
Muncy creek	West branch of Susquehanna river	do	Sullivan	Saw	5	59	131
Do	do	do	Lycoming	Carriages and sleds	1	11	12
Do	do	do	do	Carriage materials	1	6	12
Do	do	do	do	Flouring and grist	9	108	368
Do	do	do	do	Leather	1	9	27
Do	do	do	do	Saw	16	217+	334
Do	do	do	do	Woolen	1	14	20
Loyalsock creek	do	do	Sullivan	Saw	4	46	90
Do	do	do	do	Woolen	1	8	10
Do	do	do	do	Flouring and grist	3	34	120
Do	do	do	Lycoming	do	2	24	95
Do	do	do	do	Saw	10	108	433
Lycoming creek	do	do	Tioga	Flouring and grist	1	20	20
Do	do	do	Lycoming	do	4	35	235
Do	do	do	do	Saw	5	44	175
Do	do	do	do	Nail	1	10	120
Pine creek	do	do	Potter	Flouring and grist	1	12	30
Do	do	do	do	Saw	2	26	30
Do	do	do	Tioga	do	1	7	30
Do	do	do	Lycoming	Flouring and grist	2	18	65
Do	do	do	do	Saw	2	15	110
Do	do	do	Clinton	Flouring and grist	1	7	30
Do	do	do	do	Saw	1	6	24
Bald Eagle creek	do	do	Centre	Furniture	1	7	8
Do	do	do	do	Planing	1	8	15
Do	do	do	do	Stone and earthen ware	1	3.5	5
Do	do	do	do	Saw	1	6	8
Do	do	do	do	Flouring and grist	8	105	192
Do	do	do	do	Blast-furnace	1	12	.....
Do	do	do	do	Forges	2	19	.....
Do	do	do	do	Rolling-mills	2	13	.....
Do	do	do	Clinton	Paper (*a*)	1	10	.....
Do	do	do	do	Flour and grist	1	10	.....
Fishing creek	Bald Eagle creek	do	do	Edge-tools	2	17	189
Do	do	do	do	Wheelwrighting	1	5	20
Do	do	do	do	Flouring and grist	5	45	125
Do	do	do	do	Saw	1	8	16
Do	do	do	do	Woolen	1	4	12
Do	do	do	do	Blast-furnace (*b*)	1	16	.....
Do	do	do	do	Blomary and forge (*a*)	1	15	.....
Spring creek	do	do	Centre	Woolen	3	30	50
Do	do	do	do	Blast-furnace	1	12	45
Do	do	do	do	Blomary and forge	1	12	40
Do	do	do	do	Agricultural implements	1	9	8
Do	do	do	do	Rolling-mill	1	12	60
Do	do	do	do	Machinery	1	9	20
Do	do	do	do	Telegraph and telephone apparatus.	1	14	80
Do	do	do	do	Paper	1	12	30
Do	do	do	do	Saw	1	9	12
Do	do	do	do	Flouring and grist	7	87	232
Other tributaries of	West branch of Susquehanna river	do	Montour	Furniture	2	6	8
Do	do	do	do	Flouring and grist	4	37	62
Do	do	do	Northumberland	do	7	76	155
Do	do	do	Union	do	14	188	294
Do	do	do	do	Saw	3	47	52
Do	do	do	do	Leather	1	8	8
Do	do	do	Sullivan	Drugs and chemicals	1	30	8
Do	do	do	do	Saw	16	256	422
Do	do	do	do	Flouring and grist	4	84	140
Do	do	do	Tioga	Wheelwrighting	1	6	4
Do	do	do	do	Saw	7	78	140

a Not running in 1880.

b Idle.

Table of utilized power on the Susquehanna river and tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
Other tributaries of	West branch of Susquehanna river	Pennsylvania	Tioga	Flouring and grist	2	28	68
Do	do	do	Lycoming	Agricultural implements	1	9	7
Do	do	do	do	Carriage materials	1	11	12
Do	do	do	do	Marble- and stone-working.	1		3
Do	do	do	do	Flouring and grist	16	253	405
Do	do	do	do	Woolen	3	54	95
Do	do	do	do	Leather	2	16	28
Do	do	do	do	Saw	74	1,226	1,601
Do	do	do	do	Paint	1	25	25
Do	do	do	do	Shirt	1		3
Do	do	do	do	Wood-turning	1	14	35
Sinnemahoning creek	do	do	Clinton	Saw	1	3	25
Do	do	do	Cameron	do	1	9	20
Do	do	do	do	Flouring and grist	1	9	40
Do	do	do	Elk	Saw	1	16	10
Do	do	do	do	Flouring and grist	1	6	16
Other tributaries of	do	do	Centre	Rolling-mill	1	13	90
Do	do	do	do	Foundery	1	18	2
Do	do	do	do	Blast-furnaces	2		35
Do	do	do	do	Leather	1	12	8
Do	do	do	do	Saw	6	84	139
Do	do	do	do	Flouring and grist	12	156+	240
Do	do	do	do	Woolen	1	14	25
Do	do	do	Clinton	Agricultural implements	1	10	6
Do	do	do	do	Foundery	1	18	8
Do	do	do	do	Flouring and grist	10	136	295
Do	do	do	do	Saw	16	274	388
Do	do	do	do	Brick and tile	2	26	33
Do	do	do	do	Woolen	2		50
Do	do	do	Potter	Flouring and grist	1	9	6
Do	do	do	do	Saw	2	13	25
Do	do	do	Cameron	Flouring and grist	2	20	43
Do	do	do	do	Saw	3	23	80
Do	do	do	Elk	do	4	67	88
Do	do	do	do	Flouring and grist	3	46	44
Do	do	do	Clearfield	Agricultural implements	1	8	8
Do	do	do	do	Furniture	1	7	4
Do	do	do	do	Flouring and grist	18	239	438
Do	do	do	do	Saw	31	388	814
Do	do	do	do	Woolen	1	8	12
Do	do	do	Cambria	Saw	14	159	334
Do	do	do	do	Flouring and grist	5	88	102
Do	do	do	Indiana	Saw	5		38
Do	Susquehanna river below junction of North and West branches.	do	Northumberland	Flouring and grist	24	330+	453
Do	do	do	do	Saw	4	27	68
Do	do	do	Union	Agricultural implements	1	23	23
Do	do	do	do	Saw	3	36	37
Do	do	do	do	Flouring and grist	2	17	46
Do	do	do	Snyder	Leather	2		7
Do	do	do	do	Saw	12		200
Do	do	do	do	Flouring and grist	27	223+	554
Do	do	do	Centre	Agricultural implements	1	8	4
Do	do	do	do	Foundery	1	12	3
Do	do	do	do	Planing	1	12	3
Do	do	do	do	Wheelwrighting	1	5	4
Do	do	do	do	Saw	28	310+	374
Do	do	do	do	Flouring and grist	16	215+	516
Juniata river	Susquehanna river	do	Perry	do (a)	1	15	
Do	do	do	Huntingdon	Saw (a)	1	10	
Tuscarora creek	Juniata river	do	do	Flouring and grist	1	14	18
Do	do	do	Juniata	do	2	28	17
Do	do	do	Franklin	do	2	24	18
Do	do	do	do	Leather	1	14	10
Kishacoquillas creek	do	do	Mifflin	Cutlery and edge-tools	1	24	202

a From Pennsylvania canal.

Table of utilized power on the Susquehanna river and tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
Kishacoquillas creek	Juniata river	Pennsylvania.	Mifflin	Furniture	1	3	3
Do	do	do	do	Flouring and grist	6	76	196
Do	do	do	do	Saw	2	18	16
Do	do	do	do	Woolen	1	9	10
Do	do	do	do	Rolling-mill	1	13	100
Great Aughwick creek	do	do	Fulton	Flouring and grist	2	30	40
Do	do	do	Huntingdon	do	2	12	40
Raystown branch of	do	do	Bedford	Blast-furnace (*a*)	1	7	.....
Do	do	do	do	Woolen	1	4	10
Do	do	do	do	Flouring and grist	6	(?) 112	150
Frankstown branch of	do	do	Blair	do	2	.....	50
Do	do	do	do	Blomary and forge	1	14	23
Do	do	do	do	Blomary and forge (*b*)	1	12	.....
Do	do	do	Huntingdon	Planing	1	8	*c* 32
Do	do	do	do	Flouring and grist	2	16	.....
Do	do	do	do	Saw	2	16	.....
Do	do	do	do	Plaster	1	8	.....
Other tributaries of	do	do	Perry	Agricultural implements	1	5	16
Do	do	do	do	Leather	1	12	8
Do	do	do	do	Flouring and grist	12	172	183
Do	do	do	do	Saw	5	49	54
Do	do	do	do	Woolen	3	37	31
Do	do	do	Juniata	Agricultural implements	1	8	2
Do	do	do	do	Glue	1	5	10
Do	do	do	do	Founderies	2	26	50
Do	do	do	do	Leather	2	36	10
Do	do	do	do	Flouring and grist	24	404	438
Do	do	do	do	Saw	6	75+	45
Do	do	do	do	Woolen	1	12	12
Do	do	do	Mifflin	Agricultural implements	1	10	8
Do	do	do	do	Machinery	1	10	8
Do	do	do	do	Woolen	3	62	51
Do	do	do	do	Leather	1	4	2
Do	do	do	do	Flouring and grist	15	259	334
Do	do	do	do	Saw	8	111+	122
Do	do	do	Fulton	Flouring and grist	7	119	117
Do	do	do	do	Saw	3	30	69
Do	do	do	Huntingdon	Cutlery and edge-tools	1	9	25
Do	do	do	do	Blast-furnace	1	11	60
Do	do	do	do	Blomary and forge	1	11	40
Do	do	do	do	Planing	1	18	25
Do	do	do	do	Flouring and grist	46	646+	961
Do	do	do	do	Saw	19	225	224
Do	do	do	do	Leather	2	.....	22
Do	do	do	do	Woolen	2	.....	18
Do	do	do	Bedford	Founderies	2	19	9
Do	do	do	do	Woolen	4	.....	32
Do	do	do	do	Leather	1	10	4
Do	do	do	do	Saw	15	181	226
Do	do	do	do	Flouring and grist	47	698	771
Do	do	do	Blair	Agricultural implements	1	4	10
Do	do	do	do	Woolen	1	3	9
Do	do	do	do	Flouring and grist	30	440	530
Do	do	do	do	Leather	1	2	4
Do	do	do	do	Saw	1	19	30
Do	do	do	do	Blast-furnace	1	20	20
Do	do	do	do	Blast-furnaces (*a*)	2	50	.....
Do	do	do	do	Hardware	1	8	10
Do	do	do	do	Planing	1	29	12
Do	do	do	do	Paper	1	33	40
Conedogwinet creek	Susquehanna river	do	Franklin	Flouring and grist	5	44	79
Do	do	do	do	Saw	2	23	27
Do	do	do	Cumberland	Flouring and grist	9	62	229
Do	do	do	do	Saw	2	11	35
Do	do	do	do	Nail and rolling mill	1	7	(?) 300

a Not in blast. *b* Not in operation. *c* From Pennsylvania canal.

Table of utilized power on the Susquehanna river and tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall utilized.	Total horse-power used, net.
						Feet.	
Yellow Breeches creek	Susquehanna river	Pennsylvania.	Cumberland	Planing	1	10	25
Do	do	do	do	Flouring and grist	21	100	700
Do	do	do	do	Saw	1	4	66
Do	do	do	do	Sash, door, and blind	1	3	9
Do	do	do	do	Blomary and forge	1	8	24
Do	do	do	do	Woolen	1	7	20
Swatara creek	do	do	Schuylkill	Saw	5	30	81
Do	do	do	do	Flouring and grist	4	45	70
Do	do	do	Lebanon	do	5	26	90
Do	do	do	do	Saw	1	3	25
Do	do	do	do	Blomary and forge	1	8	35
Do	do	do	Dauphin	Flouring and grist	5	26+	127
Do	do	do	do	Saw	1	12	50
Conestoga creek	do	do	Berks	Flouring and grist	3	48	46
Do	do	do	Lancaster	do	27	204+	668
Do	do	do	do	Foundery	1	3	12
Do	do	do	do	Saw	1	4	10
Do	do	do	do	Paper	2	18	202
Do	do	do	do	Water-works	1	6	.....
Octorara creek	do	do	Chester	Flouring and grist	5	32	65
Do	do	do	do	Plaster	1	6	50
Do	do	do	Lancaster	Flouring and grist	3	37	70
Do	do	do	do	Machinery	1	10	12
Do	do	do	do	Blomary and forge	1	14	40
Do	do	Maryland	Cecil	Rolling	1	.....	.....
Do	do	do	do	Paper	1	18	150
Do	do	do	do	Flouring and grist	1	12	72
Other tributaries of	do	Pennsylvania.	Juniata	Leather	1	3	5
Do	do	do	do	Flouring and grist	2	20	42
Do	do	do	Perry	Agricultural implements	1	10	10
Do	do	do	do	Blomaries and forges	2	44	50
Do	do	do	do	Flouring and grist	21	312	357
Do	do	do	do	Woolen	1	10	5
Do	do	do	do	Saw	12	132+	107
Do	do	do	Franklin	Flouring and grist	1	10	12
Do	do	do	do	Leather	1	12	10
Do	do	do	Cumberland	Dyeing and cleaning	1	8	5
Do	do	do	do	Woolen	1	10	10
Do	do	do	do	Leather	1	22	15
Do	do	do	do	Flouring and grist	25	263	544
Do	do	do	do	Saw (a)	9	72	152
Do	do	do	do	Paper	4	68	270
Do	do	do	do	Blomaries and forges	3	44	130
Do	do	do	York	Agricultural implements	1	11	10
Do	do	do	do	Woolen	4	35+	59
Do	do	do	do	Twine, etc	1	21	25
Do	do	do	do	Dyewoods, etc	1	14	12
Do	do	do	do	Fertilizers	2	30	25
Do	do	do	do	Gunpowder	1	22	30
Do	do	do	do	Blast-furnace (a)	1	28	.....
Do	do	do	do	Paper	2	16	135
Do	do	do	do	Saw	36	476	530
Do	do	do	do	Leather	6	90	60
Do	do	do	do	Brick and tile	1	11	3
Do	do	do	do	Flouring and grist	134	2,024	2,667
Do	do	do	Adams	Leather	1	7	4
Do	do	do	do	Woolen	2	.....	22
Do	do	do	do	Saw	22	240	250
Do	do	do	do	Flouring and grist	33	438	633
Do	do	do	Schuylkill	Agricultural implements	1	6	16
Do	do	do	do	Saw (a)	3	12	75
Do	do	do	do	Woolen	1	8	10
Do	do	do	do	Leather	1	13	14
Do	do	do	do	Flouring and grist	14	167	208
Do	do	do	Lebanon	Agricultural implements	1	6	8

a Not in operation.

Table of utilized power on the Susquehanna river and tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
Other tributaries of	Susquehanna river	Pennsylvania	Lebanon	Blomary and forge	1	7	30
Do	do	do	do	Flouring and grist	24	264	654
Do	do	do	do	Saw	3	30	48
Do	do	do	Dauphin	Flouring and grist	53	671	995
Do	do	do	do	Cotton	1	14	10
Do	do	do	do	Dyeing and cleaning	1	.....	5
Do	do	do	do	Blomary and forge	1	10	70
Do	do	do	do	Saw	18	112+	232
Do	do	do	do	Leather	3	35	32
Do	do	do	do	Woolen	1	15	10
Do	do	do	do	Tin, copper, and sheet-iron ware.	1	.....	2
Do	do	do	Berks	Flouring and grist	9	121	107
Do	do	do	Lancaster	Agricultural implements	1	8	12
Do	do	do	do	Woolen	6	67+	96
Do	do	do	do	Blacksmithing	1	10	2
Do	do	do	do	Blomaries and forges	2	35	47
Do	do	do	do	Carpenter-shop	1	11	20
Do	do	do	do	Carriage materials	1	20	15
Do	do	do	do	Flouring and grist	168	2,214	3,666
Do	do	do	do	Fertilizers	1	7	8
Do	do	do	do	Furniture	1	3	10
Do	do	do	do	Foundery	1	10	8
Do	do	do	do	Leather	2	18	13
Do	do	do	do	Saw	21	281	364
Do	do	do	do	Machinery	1	10	8
Do	do	do	do	Wheelwrighting	2	19	16
Do	do	do	Chester	Flouring and grist	5	99	59
Do	do	do	do	Saw	2	30	26
Do	do	do	do	Paper	2	41	76
Do	do	Maryland	Cecil	Saw	2	24	17
Do	do	do	do	Flouring and grist	10	196	241
Do	do	do	Harford	do	21	346	410
Do	do	do	do	Saw	12	166+	173
Do	do	do	do	Fertilizers	1	15	45
Do	do	do	do	Agricultural implements	1	27	12
Do	do	do	do	Bark	1	24	15
Do	do	do	do	Kaolin	4	59	196
Do	do	do	do	Woolen	1	22	8

VII.—THE DELAWARE RIVER AND TRIBUTARIES.

THE DELAWARE RIVER.

The Delaware, like the Susquehanna, takes its rise beyond the mountains proper, on the high plateau of central New York, its sources lying in Greene, Schoharie, and Delaware counties. The West branch, commonly called the main stream, rises in a small lake almost on the line between Delaware and Schoharie counties, at an elevation above the sea of about 1,886 feet.(*a*) Pursuing a devious course in a southwesterly direction through Delaware county for a distance of about 70 miles, to the line of Broome county, where it is within 10 miles of the Susquehanna river, and passing the towns of Delhi and Deposit, it suddenly turns to the southeast, and 6 or 7 miles below becomes the boundary line between Pennsylvania and New York. About 7 miles farther down it receives from the left the East branch, or Pepacton, which rises in Delaware and Greene counties, about 50 miles to the northeast in a straight line, and pursues a course nearly parallel to the main branch. From the junction of the two the river proceeds in a southeasterly direction for a distance of about 90 miles, receiving from the right the Lackawaxen river, and from the left the Neversink creek. At its junction with the latter, at Carpenter's point, about a mile below the town of Port Jervis, New York, it turns to the southwest along the base of the Kittatinny

a McCullough's *Geographical Dictionary*, Vol. I, p. 739.

mountains, until it crosses the range about 40 miles below, through the breach called the "Delaware Water Gap". It then flows in a southerly direction for a distance of about 37 miles, receiving at Belvidere the Pequest creek from New Jersey, at Easton, Pennsylvania, and Phillipsburg, New Jersey, the Lehigh river from the right, and, a few miles below, the Musconetcong from New Jersey, where it passes the gap in the South mountains. Then flowing toward the southeast for a distance of about 48 miles by the cities of Lambertville, Trenton, and Bordentown, New Jersey, it changes its course at the latter place, and runs onward, past Philadelphia and Camden, through Delaware bay to the ocean. From Carpenter's point it forms the boundary between New Jersey on the left, and Pennsylvania and Delaware on the right. Following all its windings, the length of the stream from its source to Trenton is about 280 miles, and its average fall is about 6.7 feet per mile, or much larger than that of the Susquehanna. The total length of the stream, down to the "capes of the Delaware", or to the Atlantic ocean, is about 410 miles; and the area drained, down to and including the Schuylkill, which enters at Philadelphia, is about 10,100 square miles, of which area about 2,580 square miles are comprised in New York, 5,720 in Pennsylvania, and 1,800 in New Jersey. The table of drainage areas on pages 78 to 80 gives detailed information regarding the areas drained by the various tributaries, and the accompanying map will show their locations.

The general topographical features of the Delaware have been described in the following words by Professor Rogers:(a)

This noble river, the eastern boundary of Pennsylvania throughout its entire breadth, exhibits, along its immediate valley, a considerable variety of topographical features and scenery. From its head streams in New York, to where it emerges from the Pocono, or Catskill, mountain, it flows in a tortuous course through a deep narrow trough in that elevated table-land. The mean level of the plateau remaining nearly constant, and the valley growing progressively deeper, the river-hills, which are all that the traveler at the river-side usually beholds, grow higher and steeper as he descends. Meandering much more than the valley containing it, the river sweeps sometimes close by the base of the bounding hills, the lower parts of which are, in many cases, faced by high, naked cliffs, exposing the reddish-brown shales and sandstones of the district, in beautiful contrast with the mixed green hues of the foliage. The perspective of jutting and retreating hills, clothed for the most part with a combination of coniferous and deciduous forest to their summits, and washed at their base by long, bending reaches of the broad river, are very attractive, notwithstanding a prevailing sameness in general feature. After leaving the plateau in Pike and Wayne counties, the river emerges into a broad open valley, wholly different in aspect and structure from that which it has left. The waters which carved a way for it seem to have been impelled in their momentum southward with great energy against the strong, stony barrier of the Kittatinny, or Shawangunk, mountain, and to have scooped their deepest trench near the base of that high ridge. The river, therefore, turns abruptly at Carpenter's point from a southeast to a southwest course, and follows the foot of the mountain, sometimes hugging its base, sometimes sweeping a moderate distance from it into the plain, until it finds a passage through it by the great breach called the "Delaware Water Gap". The scenery along this stretch of the river is eminently beautiful. Low within the valley, the river is bordered by fertile cultivated flats, variously carved in one or more terraces, and behind these, particularly on the northwest, rise numerous rolling hills, some under the plow, some covered with timber, all deeply cut by ravines, in the steeper of which are many beautiful water-falls, while still beyond the hills we see ascending the long slopes or bold escarpments of the plateau of the Upper Delaware. All the way along our left the view is bounded by the forest-covered flank and straight crest of the Kittatinny mountain.

Turning at the water-gap, the Delaware, in issuing through the main ridge of the mountain, passes between steep, nearly perpendicular, mural cliffs of gray sandstone, rising on either side to its very crest.

Leaving the water-gap, the river descends gently southward, obliquely across the entire breadth of the Appalachian plain or valley, to where it enters the hills called "the South mountains", below Easton. This portion of its course is marked by no striking features, the surface of the country being elevated only 100 or 200 feet above it, and being, from the softness of the slates and limestones, smoothed down into rather inexpressive lines.

Below the mouth of the Lehigh the Delaware is bordered by an alternation of hills and narrow intervening valleys, the river-hills being but the ends of the intersected ridges of the low chain of the highlands of New Jersey; but from the southern edge of these hills, at Durham, the scenery for many miles southward wears a wholly different character. It is that of a table-land elevated 300 or 400 feet above the level of the river, cut on one or both sides of the valley into long ranges of perpendicular precipices or extremely steep slopes. One stretch of precipice, on the Pennsylvania side, known by the name of the "Nockamixon rocks", is an exceedingly striking and picturesque range of beetling cliffs, rising sheer for 200 or 300 feet from the brink of the river, with only a narrow roadway between them, through a length of nearly 3 miles. Some of the views from the base of these crags are almost grand, and the pictures they make with the river below are beautiful. Tufts of bushes and trees and climbing vines brighten by their green hues the rich brown tints of the rocks, to the bold faces and narrow ledges of which they lend a grace which no cliffs without vegetation ever possess.

Farther down its valley the Delaware passes, in the vicinity of New Hope, some bold ridges of trap-rock, which impart a pleasing variety to banks elsewhere, in this part of its course, comparatively tame. Passing Trenton, its borders presently put on a totally-changed aspect. Ceasing to be a gay running stream full of bushy islands and rocky reefs and rapids, it becomes a wide tidal river, rising and ebbing between shores which are in many places only low banks of sand or gravel, and in others broad, slimy marshes, covered with reeds and grass. Turning at Bordentown southwestward, the river maintains these features all the way to its wide estuary, the Delaware bay.

The Delaware crosses the fall-line at Trenton, which is the head of tide-water as well as of navigation, there being at present a navigable depth at low water of 5 feet up to this point, 133 miles from the Atlantic. Up to Philadelphia, 100 miles from the ocean, there is a navigable depth at low water of 24 feet; and the mean rise of the tides is 3.5 feet at Trenton, 6 feet at Philadelphia, and 4 feet at the "capes of the Delaware", or mouth of Delaware bay. From the report of Prof. Merriman on that part of the river between Trenton and Easton, to which I am very much indebted for valuable information, I extract the following notes in regard to the navigation of the stream,(b) which apply at the present time without much change:

The only navigation at present upon the Delaware river, above Trenton, is that of the rafts which come down during the spring and fall floods. Previous, however, to the construction of canals and railroads, the river, although difficult to navigate, was an important

a *Geology of Pennsylvania*, Vol. I, p. 47.

b *Annual Report of the Chief of Engineers*, 1873, Appendix U, page 51.

highway of commerce. The boats first used appear to have been narrow flat-bottomed scows, from 25 to 40 feet in length, which were allowed to float down with the current, and on their return up were propelled by poles. About the year 1750 "Durham" boats were introduced, so called from having been first built at Durham village, 10 miles below Easton.

These were round-bottomed boats, pointed at both stern and bow, about 60 feet long, 10 wide, and 5 deep, with a low cabin for sleeping apartment, and one aft for provisions; the center of the boat was thus left free for the load. The crew consisted of three men, two with long setting-poles, and one at the rudder, who also used a shorter pole. When fully loaded the boats drew about 30 inches; the usual load on the down trip being 20 tons, on the up trip 5 to 10 tons. The time usually required for a trip from Easton to Trenton was one day, while the return trip ordinarily occupied three days. About 1810 coal began to be carried down the river in "arks", which were simply rectangular pine boxes, usually hinged in the middle like canal-boats, and being from 50 to 80 feet long and 16 wide, and drawing 2 feet of water. These were furnished with oars for use on the reaches of the river between rapids. On arriving at the market in Philadelphia, after discharging their cargoes, the arks were taken apart, the lumber sold, while the iron-work was carried back across the country to the Lehigh, to be used again in the construction of others. The Delaware division of the Pennsylvania canal, finished in 1830 from Easton to Bristol, caused both Durham boats and arks to be but little used after that time. It is proper to mention here that the river was navigated by Durham boats as far as Lackawaxen creek, 75 miles above Easton, and probably much farther.

The completion of the Belvidere Delaware railroad, in 1857, rendered any further navigation of the river, except by rafts, unnecessary. Previous to that time, however, it was often customary during the winter season, while the canal was closed, to send canal-boat loads of coal down the river. This could, however, only be done at times of freshet, as several feet of water were required for their safe passage.

In the summer of 1851, in order to facilitate communication with Easton, and the railroad only being built as far as Lambertville, a steamboat, the "Major William Barnet", drawing, when loaded, only 18 inches, was run from Lambertville to Easton, the time occupied in making the trip of 36 miles being about eight hours.

The lumber business of the river probably began at an early date. Beginning at the lower part of its course, its inclosing banks have been stripped of their forest growth, the work continually receding up the river, until now the lumber production is confined mostly to the counties of Broome, Delaware, and Sullivan, in New York, and Wayne and Pike, in Pennsylvania. The most valuable woods—pine and oak—were first brought to market. In the year 1824, when these timbers were becoming scarce and hemlock was beginning to be cut, the lumber trade appears to have been about two-thirds as large as at present. From 1835 to 1850 it was greater than ever before, and probably exceeded the present production by one-third or one-half. The trade on the Delaware is now declining, and it is estimated that in 25 or 30 years will cease altogether. A large item in the marketing of lumber is the hauling of it to the river-banks to be formed into rafts. The forests are every year receding from the banks of the river and its tributary creeks, and the time must certainly come when the cost of transportation will be too great to allow it to be brought to market by way of the Delaware. The timber is principally hemlock; occasionally a raft is composed of ash, basswood, and hard maple, but they are rare. The timber for piles is also in part white pine. It is cut mostly in the months of May and June, drawn to the river-bank, and rafted during the next winter and floated to the market by the following spring floods.

The principal lumber depots on the upper Delaware are Delhi and Deposit, on the West branch; Walcott, on the East branch; Hancock, at the junction of the two branches; and Callicoon and Cochecton, 25 miles below Hancock. The time required to bring a raft from these points to Easton varies with the height of the water and the direction and force of the wind. In ordinary rafting-freshets of 5 to 10 feet, however, the time appears to be: from Delhi to Easton, 165 miles, 40 to 48 hours; from Walcott to Easton, 165 miles, 40 to 48 hours; from Hancock to Easton, 125 miles, 30 to 36 hours; from Callicoon to Easton, 100 miles, 24 to 30 hours; from Easton to Trenton the time is from 10 to 12 hours; so that the entire trip from Walcott or Delhi to tide-water is performed in from 50 to 60 hours, showing the mean velocity to be from 4.3 to 3.6 miles per hour.

The declivity of the river is shown more in detail by the following table:

Table of declivity of the Delaware river.

Locality.	Distance from Trenton.	Elevation above tide.	Distance between points.	Fall between points.	Fall per mile between points.
	Miles.	*Feet.*	*Miles.*	*Feet.*	*Feet.*
Trenton, below falls	0	0			
			3	8	2.67
Yardley, railroad crossing (*a*)	3	8			
			23	66	2.90
Bull's island	26	74			
			28	85	3.00
Easton, crossing of Lehigh Valley railroad (*b*)	54	159			
			14	76	5.40
Belvidere	68	235			
			13	66	5.10
Water Gap, Walker's ferry	81	301			
			46	149	3.20
Erie Railroad crossing 4 miles above Port Jervis (*c*)	127	450			
			19	150	7.90
Lackawaxen (*c*)	146	600			
			66	384	5.80
Deposit (*c*)	212	984			
			68	902	13.30
Head-waters	280	1,886			

a This elevation was kindly furnished by Mr. Lorenz, chief engineer of the Reading railroad.

b For this elevation thanks are due to Mr. Robert H. Sayre, chief engineer of the Lehigh Valley railroad.

c These elevations are liable to considerable error, being found from the Erie Railroad profile by subtracting the *estimated* height of the rails above the water.

The flow of the river is subject to great variations, and the freshets are quite severe, as the following extracts from Prof. Merriman's report will show:

Concerning the floods or freshets of the river I have been unable to collect very exact statistics, particularly of those during the last few years. Their times of occurrence seem to be quite irregular, as well as the heights to which they rise. In general it may be said that the river is subject to three classes of floods: the ice-floods, which happen at the breaking up of the river; the rafting floods, occurring

later, from the spring rains; and the fall floods, caused by the storms of September and October, which, however, are very irregular. The heights of these floods I have only been able to ascertain for Easton and points below; at places above they are known to be similar in their character and occasionally to produce very disastrous effects.

The ice-floods are usually at Easton 10 to 20 feet in height, but on many occasions have been known to rise much higher, the "great flood" of 1841 having reached 35 feet. The great accumulation of water here is owing to the influx of the Lehigh, a very turbulent stream in time of freshet, and to the narrow steep banks between which the Delaware is confined, its width being less than 600 feet. The following description (*a*) of the effects of the flood of 1841 may perhaps here not be inappropriate:

"It becomes our painful duty to record a scene of destruction and desolation such as never before was witnessed in this section of the country. The late excessive rain, carrying with it the snow which had covered the ground, caused our streams to rise beyond all precedent. On the morning of the 8th instant they came tearing down with awful rapidity, producing waste and ruin on every side, bearing on their angry waters every kind of property, houses, barns, storehouses, fences, stacks of grain, and furniture of all descriptions. The Lehigh river, one of the most unruly of streams, has caused the greatest damage. As far as heard from, not a bridge is left spanned across it. The beautiful bridge here went about 4 o'clock on the morning of the 8th instant. The flats below South Easton, containing the collector's office of the Lehigh Coal and Navigation Company, and a small village, were completely inundated, so as to hide the dwellings; all but a storehouse was carried off. The lower part of Williamsport is almost destroyed, and both sides of the river here present but one scene of ruin. The Delaware, so remarkable for its mildness as to be called 'the silvery Delaware', also assumed a new character. It was estimated that it was 35 feet above low water, 6 feet higher than ever was heard of before. The destruction of the bridge across it was looked for during the whole of the 8th, but it stood the flood, although much injured and torn. Report has it that below this every other bridge on the Delaware is gone. The state works along the Delaware and the Lehigh company's improvements are damaged to a great extent. At many places no traces of the canal are left, the current having swept the banks away to low-water mark for great distances, and all along the line they are more or less injured."

At Bull's island this flood appears to have risen 23 feet, at Lambertville 20 feet, and everywhere to have caused very much damage. For 10 miles above Trenton the river becomes much wider, and its banks less steep, so that floods are rarely more than 10 or 12 feet. On one occasion, when the ice became jammed at Perriwig island, causing a blockade, the water was known to rise about 15 feet at Trenton.

The rafting freshets in the spring are of less rise, but of longer duration than the ice-floods; at Easton ranging from 3 to 10 feet, at Lambertville 1 to 8 feet, and at Trenton 1 to 6 feet. A very remarkable rise, however, occurred on June 8, 1862, which was 32 feet at Easton, and, next to that of 1841, the greatest flood on record.

The fall floods, which are also employed by the lumbermen in sending their timber to market, are irregular in their occurrence and the stage to which they rise. Several seasons have been known in which no floods occurred at this time, while in others, as in 1845 and 1869, they were very great. The following is a partial list of the "great floods", with the heights to which they rose, as nearly as can now be ascertained:

Name of flood.	Date of occurrence.	Height to which it rose above low water.
Pumpkin fresh	October 6, 1786	16 feet at Lambertville.
Do	1798	Not as high as last, but exact height not known.
Jefferson fresh	1801	14 feet at Lambertville.
Do	1814	Do.
Do	March —, 1832	12 feet at Lambertville.
Do	April —, 1836	14 feet 6 inches at Lambertville.
Do	April —, 1839	Do.
Great flood	January 8, 1841	35 feet at Easton, 23 feet at Bull's island, 20 feet at Lambertville, 28 feet at Lamsin's island.
Do	October 13, 1843	14 feet at Lambertville.
Do	Marc 15, 1846	17 feet 6 inches at Lambertville.
June fresh	June 8, 1862	42 feet at Easton.
October fresh	October —, 1869	Exact height not known.

The point which has been particularly forced upon my attention, in connection with this subject, is the great frequency with which floods now occur as compared with the time previous to 1835. While the preceding table is supposed to contain the record of every "great freshet" previous to 1841, it by no means shows those occurring since that date. In fact, they have become too common to be a matter of record. Previous to 1835, floods of 12 feet at Lambertville were considered very high, while 14 feet had been attained only three times within the memory of man—in 1786, 1801, and 1814. But since that time floods of 14 feet have become common, while three have occurred—1841, 1846, 1862—in which probably one-third to one-half more water has been discharged than in any previously known. This is undoubtedly to be attributed to the clearing away of the forests in the river basin.

While the floods of the river rise higher than formerly, the stage of low water seems to have been becoming lower every year. The observations of the inhabitants appear to show that in times of low water the water of the river is fully 6 or 8 inches below the most unusual low stage of forty years ago.

To recapitulate, then, this branch of my subject, I may say that the stage of the river throughout the year is ordinarily as follows: January, frozen and medium height; February and March, breaking up and high; April, May, and June, high; July, subsiding; August and September, low; October, low, but subject to high freshets; November, low—often very low; December, rising a little and freezing.

The flow of the stream would, no doubt, be much more variable than it is at present were it not for the great number of lakes which are tributary to it from northern Pennsylvania and New Jersey as well as from New York. A glance at the map will show that a large part of the drainage basin is dotted with lakes and ponds of various sizes, but generally quite small, making up somewhat in number, however, for their small size. Their influence in moderating the floods must be considerable. From the fact that they exist in such numbers, too, it would seem

a Easton *Whig and Journal*, January, 1841, quoted by Rapp, *History of Northampton County*, page 53.

to be a just conclusion that the facilities for storage are good in the greater part of the basin, and by either raising the level of some of these lakes or constructing artificial reservoirs in other places the flow might be regulated to a considerably greater extent than it is now.

As regards the actual discharge of the river, no extended series of measurements has been made. Mr. Ashbel Welch, of Lambertville, New Jersey, past president of the American Society of Civil Engineers, however, gives the discharge as varying from 2,000 to 350,000 cubic feet per second, and it is probable that the former is very near the minimum.

The rainfall over the basin of the Delaware varies from 38 inches in the upper part to 45 and over near the mouth of the stream. It is distributed through the seasons with tolerable uniformity, yet with a decided excess in the summer. The table on page 9 gives more detailed information on this point.

As regards facilities for the utilization of power, the bed and banks are as a rule favorable. The former is principally gravel, sand, and bowlders, and often rock in place, while the latter are generally high. The floods are so violent that the maintenance of dams is said to be difficult, especially on account of the great quantities of ice which the river brings down; yet, inasmuch as the only dams across the river below the forks are a few very low ones, there can hardly be said to be much experience on this point, and there seems to be no reason why the construction of secure dams should offer any particular difficulty. The rafting and fishing interests on the river are opposed to the extensive use of the stream for power, and at present no dam can lawfully be built entirely across the river. Some difficulty has been experienced from the conflict of these varied interests, as will be seen. The following are the laws of the states of New Jersey and Pennsylvania concerning dams on the river, taken from Prof. Merriman's report:

Laws of Pennsylvania concerning the navigation and improvement of the Delaware river between Easton and Trenton.

Act of March 9, 1771 (v. *Laws Pennsylvania*, vol. 1, page 322), declares that, whereas the improvement of the navigation of rivers is of great benefit to commerce, and whereas many persons have subscribed large sums of money for this purpose; therefore, etc., the Delaware and Lehigh rivers shall be common highways for the purposes of navigation.

Twenty-six commissioners are appointed to receive subscriptions and to improve the navigation by widening, enlarging, straightening, or otherwise improving the channel.

Provides a penalty of "twenty pounds good and lawful money of this province for constructing dams to impede navigation".

Act of September 20, 1783, ratifies New Jersey act of May 27, 1783, which see, page 45.

Act of March 13, 1817 (*Laws of Pennsylvania*, vol. 6, page 422), appoints three commissioners to improve the river from Foul rift(*a*) to the bridge at Trenton. Appropriates $10,000 for the work.

Act of March 29, 1819, same as New Jersey act of March 1, 1820, which see, page 50.

Act of April 6, 1825 (*Laws of* 1825, page 144), authorizes the Delaware and Raritan Canal Company to supply the said canal with water from the river, provided no injury is done to either ascending or descending navigation, but reserves the right to withdraw this privilege if, in consequence, the water of the river is lowered 1 inch, and also provides that this privilege shall cease whenever the state of New Jersey shall refuse to grant a similar right to Pennsylvania to take the same amount of water.

Act of March 26, 1826 (*Laws of* 1826, page 155), repeals last act and passes another essentially the same, except "2 inches" is substituted for "1 inch".

Act of April 9, 1827 (v. *Laws of* 1827, page 196), provides for survey of Delaware valley from Bristol to Carpenter's Point with a view of constructing a navigable communication, and provides that if after this survey the navigation can be built for $12,000 per mile it shall be done, provided the existing natural navigation shall not be impaired.

Act of April 23, 1829 (*Laws of* 1829, page 312), appoints three commissioners to meet commissioners from New Jersey to decide where and how water may be taken from the Delaware for canals and water-powers.

Act of April 10, 1832 (v. *Laws of* 1832, page 638), appoints three commissioners to ascertain facts about a certain dam of which complaint has been made, and to examine the river near Welles' falls to ascertain the best way to supply the Delaware division of the Pennsylvania canal with water.

Act of February 8, 1833, orders the above commissioners to report how the obstructions in the river can best be obviated with regard to both navigation and the use of its waters for canal.

Act of April 20, 1846, authorizes canal commissioners to erect a dam at Welles' falls to supply canal with water and to facilitate navigation between the outlet locks, provided it does not interfere with the passage of fish or Durham boats, or the raft navigation. Repealed February 9, 1848.

Act of April 4, 1866 (*Laws of* 1866, page 436), provides that, whereas the natural and artificial obstructions in the Delaware river above tide-water are such as to render the running of lumber in rafts to Philadelphia and other points extremely hazardous, causing every year the destruction of large quantities of the same, and thereby increasing its price in market, and whereas said river is the only outlet from the upper lumber region of the Delaware; therefore the sum of $10,000 is appropriated to remove these obstructions, etc. I. T. Barnes, Wayne county; John Shause, Pike county; John Fisher, Bucks county, are appointed commissioners(*b*) to improve the river at such points as they may deem best to carry out the true intent of this act, the appropriation to be expended within two years.

Act of March 7, 1872 (*Laws of* 1872, page 259), authorizes the Delaware and Raritan Canal Company, or their lessee, the Pennsylvania Railroad Company, to construct permanent wing-dams in the Delaware river, from the head of Bull's island, and also from the Pennsylvania shore to the raft-channel, not exceeding 18 inches high above common low water, and to complete and maintain the wing-dam heretofore built for the improvement of the raft navigation at Welles' falls; also to erect such temporary structures in said channels in times of low water as may be necessary to keep up the supply of water to the canal of said company, and to maintain sufficient depth of water to enable loaded boats to cross to said canal from the Delaware Division canal: *Provided*, That nothing in this act shall authorize the obstruction of the raft-channel or interfere with the running of rafts.

a Foul rift is about 12 miles above Easton, and is a very dangerous place.

b All of these commissioners are now dead.

Laws of New Jersey concerning the navigation and improvement of the Delaware river between Easton and Trenton.

Act of May 27, 1783 (see *Revised Statutes*, 1846, page 41), declares that the river Delaware, from the northwest corner of New Jersey to the place upon the said river where the circular boundary of Delaware toucheth upon the same, is, and shall continue to be and remain, a common highway, free and open for the use of both New Jersey and Pennsylvania.

Act of November 26, 1808 (see *Revised Statutes*, 1846, page 480), provides that if any person shall erect, set up, build, or maintain any wing-dam, except such as may be put up in pursuance of any special act of the legislature, or placing any other obstruction injurious to the navigation of the river Delaware, he shall be subject to the penalty of $100.

Act of March 1, 1820 (v. *Revised Statutes*, 1846, page 547), provides that no dam, wing, or other device, creating, drawing, or using a water-power, shall hereafter be erected in the Delaware river, between New Jersey and Pennsylvania, without a view first had by three skillful and respectable freeholders in each state residing near the spot of the proposed construction; said freeholders to be appointed by the court of quarter sessions, and to report to said court. If they report favorably, and that it will not injure the navigation, the court may grant permission for the construction of the wing or dam. Penalty of not less than $500 nor more than $1,000 for violating the provisions of this act.

Act of February 18, 1829 (see *Laws* 1833, page 246): Whereas the waters of the river Delaware may, by a proper arrangement between the two states, be used for feeding canals and water-powers, to the great and lasting advantage of both: Therefore, *Resolved*, That three commissioners be appointed to meet a similar commission from Pennsylvania, to decide how and where the waters may be most advantageously used for these purposes, and their agreement, when duly ratified by the legislatures of both states, shall be binding and conclusive.

Act of April 15, 1868 (see *Laws* 1868, page 1036), authorizes the Delaware and Raritan Canal Company to make such a structure as may be necessary for the protection of their feeder at Bull's island, not exceeding 18 inches above low water, and not interfering with the raft navigation; also to complete the wing-dam at Welles' falls for the improvement of raft navigation; also to erect temporary structures at these places in times of low water, for the protection of their feeder and the canal navigation.

The latter list of laws is incomplete. The following are to be added:

Act of February 16, 1831: Trenton Delaware Falls Company incorporated. It is made lawful for the company to erect a wing-dam in the Delaware between the mouth of the Assanpink and the head of Welles' falls, and a race-way along the bank of the river; provided such dam be so constructed as not to impede the passage of rafts, fish, arks, or boats, in said river.

In virtue of this act, a dam was built at the head of Scudder's falls.

Act of February 14, 1844: Name of company changed to Trenton Water Power Company.

Act of February 19, 1847, authorizes the company to extend the race along the river, not beyond the head of Taylor's rift; provided the same shall be so constructed as not to impede the passage of fish, rafts, arks, or boats, or obstruct the free and uninterrupted navigation of the river.

The act of February 22, 1870, provides as follows:

Whereas the commissioners appointed by the state of Pennsylvania for improving the navigation of the Delaware have restored and improved the dam erected many years ago at the head of Scudder's falls by the commission duly appointed for that purpose, and connected the same with the wing-dam of the Trenton Water Power Company, whereby the navigation of said river has been greatly improved, and the supply of water to the race-way of said company been made sufficient for the various mills depending thereupon for power; and whereas the term of office of said commissioners has expired, and it is desirable that the said improvements should be maintained and protected from damage: therefore, be it enacted by the senate and general assembly of the state of New Jersey, that the Trenton Water Power Company is hereby authorized, empowered, and required to maintain and protect said dam at Scudder's falls, and the chute or passage-way thereon for rafts, boats, or fish, as now constructed, so that the navigation of the river and the supply of water to the race-way of said company may be secured and maintained.

It is evident from the above that no high dams can be built on the river, and that if large falls are anywhere utilized it must be with canals of considerable length, considering that there are no precipitous falls.

As regards accessibility, the facilities on the Delaware are of the best. From tide-water at Trenton up to Deposit, on the West branch, the stream is followed closely by railroads and canals, except for a short distance below Port Jervis, so that every point is easily reached. This very fact, however, may in some cases render the utilization of power difficult, especially on the portion of the river above Port Jervis, where the valley is narrow and the banks are often high, while the Erie railroad is on one side and the Delaware and Hudson canal is on the other, often leaving little room between them and the river for races and buildings.

Having presented the main general facts regarding the stream, I will now describe the various powers which it presents, beginning at the mouth.

The first power met with as the stream is ascended is at Trenton, the head of tide-water. A dam of timber and stone, 6 miles above the city, at the head of a rift known as Scudder's falls, raises the water about 2 feet, and diverts a portion to the canal leading to the city. The elevation above tide of the river at this point is 21 feet. The dam is about 800 or 1,000 feet long, extending in a broken line across the river, but is by no means tight, and has a chute for the passage of rafts. It is 4 or 5 feet high, and is roughly built of timber, brush, and stone. The bed of the stream is gravel and rock. This dam has been the cause of considerable trouble. It was built originally many years ago, and was improved in the interests of navigation by the commissioners appointed in 1866 by the state of Pennsylvania; but their term expiring before the dam was quite completed, the water-power company was sued by fishermen, who claimed that the dam was an injury to the navigation and fishing interests; and, although the statements regarding the case vary much, it appears that the company can not maintain or complete the dam, so that it is now in a very dilapidated condition. The canal leading from it is 7 miles long, 70 feet wide at top, and nominally 6 or 7 feet deep, but it is said to be much obstructed at its head by silt and grass. The fall at its lower end varies from 10 to 15 feet, according to the tide and the season. The privilege is owned by the Trenton Water Power Company, and power is generally leased to mills at the annual rate of $4 per square inch under a

head of 3 feet, while to some original customers it is $3, and some persons own the right to draw a certain amount of water, paying no rent to the company. The quantity of water used by the various mills was at one time measured for the company by Mr. William E. Worthen, of New York, and the prices paid have since been in accordance with that measurement. *No detailed measurements are now made by the company.* At $4 per square inch under a head of 3 feet, and a head and fall of 12 feet, the price is approximately equivalent to $50 per gross horse-power per annum. The mills supplied are some 15 in number, and consist of small saw-, flour, planing, woolen, and other mills, together with machine-shops, carpenter-shops, the rolling-mills of the Trenton Steel & Iron Company, and the city water-works, using in all about 360 cubic feet per second, or, with an average fall of 12 feet, about 500 gross horse-power. The mills can not obtain full capacity, however, during several months, the power sinking as low as one-half at times, so that many of the mills have steam in reserve. The leases provide for the water being out of the canal for not over two months in the year, for repairs, etc.; but the water being often very low for three months or more, such allowance is made to the mills as circumstances require. In the summer-time, then, no additional power is available with the existing dam and canal, while in winter a considerable amount goes to waste. The pond above the dam affords, of course, no storage. Freshets and ice cause little trouble to these mills.

I have measured the drainage area above Trenton and found it to be about 6,916 square miles. The theoretically available power may therefore be estimated as follows:

Estimate of power available at Trenton.

State of flow (see pages 8 to 11).	Drainage area.	Fall.	Flow per second.	Horse-power available, gross.	
	Sq. miles.	*Feet.*	*Cubic feet.*	*1 foot fall*	*10 feet fall.*
Minimum	6,916	10–15	2,000	227	2,270
Minimum low season			2,350	267	2,670
Maximum with storage			5,000	568	5,680
Low season, dry years			2,700	307	3,070

The rainfall is given on page 9. As regards the maximum power given as available with storage, it is doubtless practically unavailable, as in the case of all large streams, on account of the enormous expense it would involve, though the facilities for storage are probably good. The power, however, could not well be concentrated into less than 24 hours, for no storage could be obtained at the dam.

Trenton is very favorably located for manufacturing, the facilities for transportation, both by land and by water, being excellent. The power is remarkable for the great length of the canal; and, in fact, I have met with no other case where the length of canal was so great in proportion to the fall obtained.

The next site above Trenton is at Lambertville, New Jersey, about 15 miles above, and at this point there are two powers. Just below the town is a rift known as Welles' falls, where the fall at low water is 14.31 feet in a distance of 4,100 feet, the river being crossed by one of the trap ridges which are so prominent in the highlands of New Jersey. For nearly a century there have been wing-dams on either side of the river at this place, leading the water to saw- and grist-mills; and in 1830 they were improved by the state of Pennsylvania "so as to furnish a supply of water to the Delaware Division canal by means of a power- and lift-wheel. In 1848 the canal was connected with the Raritan by outlet-locks and a rope ferry, and the dams were still further improved. In 1866 there was expended about $7,000 out of the appropriation of that year, and probably as much more by the canal companies, in putting in additional dams". At present the dam is of rough crib-work and stone, about 1,700 feet long and from 3 to 10 feet high, forming wings extending down stream from the left bank and up stream from the right bank, the latter wing being curved down stream at the center, leaving a chute for the passage of rafts, which, however, is closed in low water by a temporary dam. The dam is built on a rock bottom, and raises the water about 2 feet at low water at the center. The width of the stream is about 800 or 1,000 feet. When I was in Lambertville no power was used except a very small amount for raising water into the Delaware Division canal, on the right bank, but a paper-mill was being constructed on that side, at the end of the dam, to use a fall of 9 or 10 feet and a power of 165 net horse-power. The tail-race is 400 feet long and 25 feet wide, carried level from low water at its lower end.

The facilities for utilizing the total fall of 14 feet within the mile below the dam are not very good. On the right bank there are no railroad facilities, and the canal is close to the river; while on the left the railroad follows the stream closely, and on account of the high banks it is doubtful whether it would be profitable to develop much power. Nevertheless, it could be done if necessary, and in the table on page 98 I have estimated the total power available. No storage during the night could be secured, and in regard to the estimates the same remarks apply as in the case of Trenton.

The second power at Lambertville is obtained from the feeder of the Delaware and Raritan canal, on the left side of the river. This feeder is supplied from a dam on the Delaware, situated about 7 miles above the town, at the head of Bull's island, turning the water between the island and the New Jersey shore, and thence into the canal. The dam is composed of a wing from each bank, with a chute 120 feet wide between them, and is 900 feet long, or more, and 2 or 3 feet high, but raising the water only a few inches. It was built about the year 1873.

At Lambertville the canal has a lock with a lift of about 10 feet, while the upper level is about 18 or 19 feet above the river; and not only the fall of the lock, but also that to the river, is utilized for power, the following table giving information regarding the mills at present in operation:

A.—*Mills discharging water to river at Lambertville.*

	Approximate net horse-power.
Lambertville iron-works and machine-shop	100
Ely's flour-mill	45
Flour- and saw-mill	75
Lambertville Paper Manufacturing Company	65

B.—*Mills discharging water to lower level of canal at Lambertville.*

Twine-mill	60
Amwell Cotton Spinning Company	65
McDowell's paper-mill	65
Weeden's paper-mill	65
Total power utilized (approximately)	540

All these mills can be run at full capacity during about eight or nine months, and are obliged to stop their wheels entirely during a month or more when the water is drawn from the canal; so that all but two have steam-power in reserve. There is little trouble on account of freshets in the river, but the canal, which is about 60 feet wide and 6 feet deep, has not sufficient capacity to supply much more than the wants of the mills at certain times. The power is owned by the Pennsylvania Railroad Company, lessees of the Delaware and Raritan canal, and is leased by them, the mills to obtain only the surplus water, and no fixed amount being guaranteed to them. Although the water is nominally rented at the rate of $3 per square inch under a head of 3 feet, special agreements are sometimes made, and no pains are taken to regulate exactly the quantity used. The water that is returned to the lower level of the canal is controlled by a separate water-power company, known as the Lambertville Water Power Company, the waste or flume water being carried around the lock in a canal 1,400 feet long and 18 feet wide. The company leases water to the mills at certain fixed prices, the mills to take the risk of low water themselves. These mills are probably able to run a little more regularly than those discharging the water to the river, because they do not waste the water from the canal, and are therefore less liable to be shut off in dry seasons. It may be mentioned here, in connection with power used from the feeder-canal, that between Lambertville and Trenton there are three small grist- or saw-mills taking water from the canal and discharging it to the river.

As already mentioned, the table on page 98 gives estimates of the total available power at Lambertville; but in regard to whether it is practically available, circumstances must decide. There seems to be no good reason why, if a dam could be extended entirely across the river at Bull's island, the capacity of the canal above Lambertville might not be increased so as to render a very large power available there, with a fall of 18 or 19 feet, and without interfering with the power at Welles' falls. At present, however, it is evident that scarcely any additional power is available from the canal at certain seasons. As regards transportation, Lambertville is very favorably situated.

Between Lambertville and Easton there are several shoals on the river, many of which might be used, and probably would be used, if dams could be built across the river. The table below gives information regarding them:

Falls and rifts on Delaware river between Easton and Trenton.	Distance from the railroad bridge at Trenton to the head of each rift.	Length of each rift.	Fall of each rift.	Falls and rifts on Delaware river between Easton and Trenton.	Distance from the railroad bridge at Trenton to the head of each rift.	Length of each rift.	Fall of each rift.
	Miles.	*Feet.*	*Feet.*		*Miles.*	*Feet.*	*Feet.*
Phillipsburg rift	49.3	3,900	5.85	Rush rift	26.2	300	5.08
Whippoorwill rift	47.0	1,200	.....	Wharford's rift	25.5	2,700	4.17
Clifford's rift	45.9	1,500	4.05	Little and Big Tumble falls	24.8	4,600	10.37
Old Sow rift	44.7	2,650	4.74	Bull's falls	22.0	1,800	4.12
Ground Hog rift	43.5	2,000	2.56	Eagle rift	19.6	1,500	.....
Rocky falls	42.5	3,900	3.04	Howell's rift	18.8	2,000	.....
Gravelly rift	41.7	800	1.20	Bird's Point rift	17.3	500	.....
Durham falls	40.3	500	3.16	Limestone rift	16.0	700	.....
Old Fry rift	39.0	100	0.42	Welles' falls	13.7	4,100	14.31
Lynn's falls	38.0	2,000	8.81	Bucktail rift	12.3	400	.....
Nockamixon falls	36.4	1,300	4.44	Beaumont rift	11.3	150	.....
Ferman's falls	33.0	1,000	5.36	Carr's rift	9.0	300	.....
Stuhl's falls	31.8	600	1.50	Scudder's falls	6.0	2,600	.....
Man-of-War's rift	29.0	400	1.00	Gould's rift	3.4	1,600	4.69
Buttonwood rift	28.4	700	2.30	Trenton falls	0.5	3,400	7.57
Little Howlo's rift	27.0	1,500	8.52				

At present there are a few small mills on the river within this distance, with wing-dams, and using falls of 4 or 5 feet, and there have been other such mills in times past. The banks of the stream are quite steep for several miles below Easton, while the railroad on one side and the canal on the other follow the river quite closely. At Easton there is a low dam extending part way across the stream, and a rope ferry, to enable boats to cross between the Morris and Essex canal and the Delaware Division canal. About 4 miles above Easton, at Wycott, there is a fall of about 8 feet in a mile, which could be utilized if necessary, and which could perhaps be made to afford a good power without interfering with raft navigation. No power is used there at present. Passing a few small rapids, where falls of up to perhaps 6 feet could be obtained, the next power, and one of the most important on the stream, is the "Foul rift", just below Belvidere. The rapids extend over a distance of about $1\frac{1}{2}$ mile, the fall at low water amounting to 22.8 feet, according to a survey made in 1847 by Caleb H. Valentine. The bed of the stream is of solid rock, and the banks are quite high, particularly on the Pennsylvania side, where a rock bluff 20 or 25 feet high extends for some distance. On the New Jersey side the banks are high along the lower part of the fall, and the railroad follows the stream closely, gradually receding from it toward the head of the shoal. The rift is divided into two parts, the upper being called the "Little Foul rift" and the lower the "Big Foul rift", and the head of the former is just below the mouth of the Pequest creek. No power is at present used at the place, but formerly there was a grist-mill on the left bank, taking water by means of a wing-dam between Big and Little Foul rifts. By using the fall of Little Foul rift and part of that of Big Foul rift it is probable that a fall of 15 or 18 feet could be rendered available, but the utilization of the total fall of 23 feet would probably be very expensive. The width of the stream at the head of the rift is about 600 feet. In the table on page 98 will be found an estimate of the total power available at this place for a fall of 23 feet.

Continuing up the river, there are said to be several places between Belvidere and Port Jervis where falls of 5 to 8 feet could be utilized, though none of them are used at present. The following rifts were named to me by persons acquainted with the river: Long rift (5 feet or thereabout), Mack's and Buttermilk, Sliding rift, Indian rift, Esp rift, Smithfield rift, Sambo and Mary, Fiddler's Elbow.

At Port Jervis, New York, some power is used, but from the Delaware and Hudson canal, and not from the river. The right to take all the surplus water from the canal-level, which is 12 miles in length, and the lowest on the canal, is owned by the estate of H. H. Farnum. The amount of water available depends, of course, upon the amount of traffic, but is always considerable, and generally quite sufficient to supply all the mills at present using power from that source, although I was told that at times even the traffic on the canal is interrupted for want of water. It may be mentioned here that the canal, which, starting at Honesdale, Pennsylvania, follows the Lackawaxen and Delaware rivers to Port Jervis, and then the Neversink and a tributary of the Hudson, terminating at Rondout, on the Hudson, is fed from the Lackawaxen, the Delaware, various tributaries of the latter which it crosses, and the Neversink; and that a number of artificial reservoirs have been constructed for the purpose by damming the outlets of lakes, of which there are so many in the neighborhood. The following are some of these lakes feeding the Neversink portion of the canal: Yankee pond, 640 acres; Lord's pond, 450 acres; Sheldrake pond, 250 acres; Wolf pond, 350 acres; Beaver Dam pond, 150 acres; McKee's pond, 250 acres; Masten pond, 100 acres. These ponds are dammed to heights of from 5 to 25 feet.(*a*)

The fall from the Port Jervis level of the canal to the river is 30 feet or over. A race 10 feet wide and 5 or 6 (?) feet deep leads from the canal, and supplies the following mills: A grist- and plaster-mill and spoke factory, in one building, using in all about 95 (?) horse-power, with a fall of 20 feet; a planing-mill, furniture factory, sash- and-blind factory, turning-works, etc., all in one building, using a fall of about 25 feet and 80 (?) horse-power. The tail-race is from a quarter to a half mile long, with a fall of several feet. All these mills are owned by the estate of H. H. Farnum. Those leasing them state that they can obtain full capacity during only about seven or eight months, and that during a month or so no power can be obtained, the water being drawn from the canal for the purpose of making repairs. During the summer, generally, more power is available than is used, but during the winter the supply is short, probably because the canal company, which does not guarantee any special quantity of water, shuts off its feeders to a certain extent during the winter, when there is no traffic, so that almost all the water available is what flows directly into the canal from a few small streams which are intercepted by it. There seems to be no doubt, therefore, that a considerably larger amount of power could be used here if arrangements could be made with the canal company to supply the water. In summer, except in very dry seasons, when traffic is sometimes interrupted, there is generally considerable waste from this level over waste-weirs.

Above Port Jervis the Delaware has no falls or rapids of special importance, so far as I could learn, although there are rifts of minor importance, such as Saw-mill rift, 4 miles above Port Jervis; Butler's falls, a mile above; Megick falls, 4 or 5 miles still farther up; Narrow falls, 2 miles above the mouth of the Lackawaxen; Cedar falls; Cochecton falls, a little below Cochecton, and others. Regarding the amount of fall available at these places I can give no accurate information. None of them are abrupt, but they are rapids extending sometimes over distances of a mile or more, and, according to estimates of persons acquainted with the river, the falls vary from 5

a I am indebted to Mr. Charles St. John, of Port Jervis, for valuable information regarding the streams tributary to the Delaware, as well as regarding the river itself.

to 10 feet. Neither can I give detailed information as to whether these falls are easy to develop. The banks are generally high and favorable for dams, and the bed will also probably be found favorable; but, as already remarked, the closeness of the canal and railroad to the banks may in some cases leave no room for building, while the freshets are said to be very violent, and to render it difficult to maintain dams. A dam was built in 1873 or 1874 at Lordsville, 8 or 10 miles below Hancock, but the first heavy freshet carried it away, owing, however, it is said, to faulty construction. The general testimony of those acquainted with the river seems to be that, as far as location and fall are concerned, numerous fine sites for power exist, but that the heavy freshets and ice-jams, and the frequent want of building-room, constitute the principal objections to their utilization. Indeed, a glance at the table of declivity on page 91 is sufficient to show conclusively that the stream possesses a large amount of power which might be utilized if no local difficulties should be encountered. No power is at present used on this part of the stream, the only dam being the canal feeder-dam just below the mouth of the Lackawaxen, a crib-work structure about 400 feet long and 2 feet high, with a chute 160 feet wide for rafts. The height may be increased to 5 feet by means of flash-boards.

We proceed to consider the tributaries of the stream, among which will be described the two branches which unite at Hancock:

Summary of power at principal points on the Delaware river.

Locality.	Distance from Trenton.	Drainage area.	RAINFALL.					TOTAL FALL.		HORSE-POWER AVAILABLE, GROSS. (a)				UTILIZED.	
			Spring.	Summer.	Autumn.	Winter.	Year.	Length.	Height at low water.	Minimum.	Minimum low season.	Maximum with storage.	Low season, dry years.	Fall.	Horse-power, net.
	Miles.	*Sq. miles.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*		*Feet.*					*Feet.*	
Trenton	0.0	6,916	11	13	11	9	44	7 miles....	10–15	2,270	2,670	5,680	3,070	10–15	500
Welles' falls	13.7	6,820	11	13	11	9	44	4,100 feet..	14.31	3,300	3,850	8,000	4,400	9	165 (b)
Lambertville (from canal)	15.0	6,750	11	13	11	9	44	7 miles....	18	4,100	4,800	10,000	5,450	10 and 18	515
Foul rift	68.0	4,700	10	13	10	8	41	2 miles....	23	3,000	3,500	9,500	4,000	0	0

a See pages 8 to 11.

TRIBUTARIES OF THE DELAWARE RIVER AND OF DELAWARE BAY.

Beginning at the Atlantic ocean, the first tributary of importance is the Maurice river, from New Jersey, rising in Gloucester county and pursuing a southerly course, forming the boundary line between Salem and Cumberland counties, and finally flowing through the latter to empty into Delaware bay about 20 miles north of Cape May. Its course measures in a straight line about 35 miles, and it drains a total area of about 380 square miles, lying in the eastern division of the Atlantic water-shed (see page 2). The stream is navigable as far as Millville, the head of tide-water, about 15 miles from its mouth, and the only important town along its course. The stream, like all those in southern New Jersey, is a sand-hill stream, the general character of which class of streams will be found described in my report on the southern Atlantic water-shed, and to some extent on pages 114 and 115 of this report. The first power which it offers is at Millville. A dam, built partly of earth and partly of stone, and measuring in all about half a mile in length (the stone part being 200 feet long) and 23 or 24 feet in height, forms a pond which covers, it is said, twelve or fourteen hundred acres. The dam was built in 1879, and is said to have cost $100,000. That part which is of earth is 15 or 20 feet wide on top, with flat slopes on each side, while the stone part is rectangular in section, with four buttresses on the face, 8 feet wide and 20 feet high, stepped off in front. The bed of the stream in front of the stone dam is protected by an apron of logs. From the pond a race 1,500 feet long, 40 feet wide, and 7 feet deep leads to the mills, where the fall is 24 feet at mean tide. The following list gives the mills now running, with the net power used: Water-works, 40 horse-power; grist- and flour-mill, 40 horse-power; blacking-mill, 50 horse-power; foundery, 60 horse-power; bleachery, 100 horse-power; cotton factory, 400 horse-power—making a total of 690 horse-power. Full capacity can be obtained during eleven months, and three-quarters during the remaining month; but this is by drawing down the water in the pond at all seasons, so that no water is wasted. In addition to the water-power, steam-power is used continually in the cotton factory and part of the time at the bleachery, to the extent of 150 horse-power in each. All the mills are owned and operated by the Millville Manufacturing Company. The power is one of the best and largest in southern New Jersey, and the facilities for transportation are good. Boats drawing 7 feet come up to the factory, but a great desire is expressed to have the navigation of the stream improved so that larger craft, which now have to be partially unloaded 2 miles below the town, can ascend.

There are no large powers on the stream above this point, so far as I could learn, although on the stream and its tributaries there are some small mills. It is said that about 6 miles above Millville a fall of 10 feet could be obtained by damming, affording a good power, with quite a large pond. The declivity of the stream is very gradual, and the bed sand.

The next tributary worthy of mention is Cohansey creek, New Jersey, which rises in Salem county and flows south into Cumberland county, flowing by the town of Bridgeton, which is the head of navigation and of tide-water, and finally nearly west into the Delaware. It is a small stream, draining only about 100 square miles, and resembles the Maurice river in general character. Its only power of importance is at Bridgeton, up to which point (15 miles) there is a navigable depth of 7 feet at low water. An earthen dam about a quarter of a mile long and 11 or 12 feet high forms quite a large pond, and from it a race a mile long leads to the town, where a fall of 14 or 15 feet is used at mean tide. The mills supplied are: A flour-mill, owning the right to a certain quantity of water, and using a fall of 12 feet, with 25 or 30 horse-power, and the Cumberland Nail & Iron Company, using a fall of 14 feet, and running a nail factory, foundery, machine-shop, and blacksmith-shop continuously by water-power, about 90 horse-power being used, while another nail-mill of the same company uses about 60 horse-power part of the time, steam being used for several hours every day during high tide. These mills can obtain full capacity all the time, at nearly all seasons, by drawing down the water in the pond during the day-time. There are several ponds on the stream above this, so that the flow is remarkably constant, and there is no trouble with freshets or with ice. There are no other large powers, however, and only a few small grist- or saw-mills. On a tributary to the Cohansey which flows through Bridgeton a pond called East lake is used to run a grist- and saw-mill and the city water-works, the fall being 19 feet; and formerly a woolen-mill was run from the same pond, suffering, however, for want of water. In fact, many of the small streams in this part of the state are dammed at various places, affording excellent small powers, with considerable storage.

The other tributaries from New Jersey below Trenton (the fall-line) are similar to those just described, though with no large powers. The largest is Rancocas creek, a stream utilized to a considerable extent. On the north branch there are some grist-mills, and the works of the H. B. Smith Machine Company, at Smithville, using a fall of 8 feet and about 100 horse-power to run their various mills. Full capacity can be secured all the time, probably by drawing down the water in the pond. The site is only 2 miles above Mount Holly, which is the head of tide-water. The head of navigation is Centreton, 7.6 miles from the mouth, and the navigable depth up to this place is 4.5 feet at low water. Assanpink creek, emptying at Trenton, runs, besides a number of grist-mills, the rubber works of Whitehead Brothers, with a fall of 7 or 8 feet, and 80 horse-power during six months, by drawing down the water in the pond. At Trenton the same stream runs Wilson's woolen-mill.

Passing to the west side of the river, the tributaries from Delaware, with one exception, call for no notice. Those below Wilmington are small sand-hill streams, and their power utilized is tabulated beyond. Christiana creek, however, which empties near Wilmington, has considerable power, and its tributaries lie partly above the fall-line. The main stream, which has its sources in both Maryland and Delaware, lies entirely below the fall-line, and is essentially a sand-hill stream. It has a navigable depth of 12 feet at low water up to Wilmington, 12 miles from the mouth, above which it runs a number of small mills whose power is given in the appended table. White Clay creek, one of its tributaries, has more fall, and rises in Pennsylvania, above the fall-line. It runs a number of grist-mills, besides paper-, cotton-, and woolen-mills, and is in fact one of the best-utilized streams in the neighborhood. The Kiamensi woolen-mill, at Stanton, the head of tide-water, uses a fall of from 9 to 16 feet, and 55 to 75 horse-power, holding the water at night; just above is a site not used, formerly occupied by the "Harmony" flour-mill, with a fall of 8 feet; then a flour-mill with a small power; then a site formerly occupied by the Roseville cotton-mill, with a fall of 12 feet; and then, at Newark, Dean's woolen factory and Curtis & Brother's paper-mill, the former with a fall of 10 feet, and 50 horse-power during eight months, and the latter with a fall of 12 feet, and 75 or 80 horse-power during three months. The flow of the stream is very variable, and is said to be much less constant than in former years. Red Clay creek, a tributary of White Clay creek, is a similar stream, and runs mills of various kinds, details regarding which are not necessary. The only remaining tributary of the Christiana which is worth naming is the Brandywine, which rises in the northern part of Chester county, Pennsylvania, and flows south to join the Christiana just below Wilmington. This stream is the most important water-power stream in the vicinity. The first power is at Wilmington, where there are two dams. The lower, 200 feet long and 6 feet high, supplies the following mills: On the south side, a grist-mill, with 6 or 8 feet fall, and 30 horse-power; and on the north side, one wheel in a flour-mill run principally from the upper dam. Full capacity can be secured during only six months, because the only water available is what flows over the dam above. The upper dam is about 200 feet long and 5 feet high, and races a mile long lead the water by the first dam, supplying the following mills: On the north side, four corn- and flour-mills; and on the south side, a corn-mill, a flour-mill, a machine-shop, and the city pump-works. The fall used is 19 or 20 feet at mean tide. The total power used is uncertain. There were not long ago four other corn-mills on the south side, which were destroyed by fire. These mills can secure full capacity during only from six to nine months, and the city water-works have steam-power in reserve. The bed of the stream for some miles above tide is rock and gravel, and, like the banks, favorable for dams, but the storage obtained is small, on account of the rapid fall. This shoal or rapid is probably at the place where the stream crosses the fall-line—the head of tide-water. The drainage area being about 238 square miles, I should estimate the power at about 5 gross horse-power per foot when at its minimum, and 10 horse-power in the low season of ordinary years, the latter figure giving, therefore, a power of 200 horse-power, gross, with a fall of 20 feet. The flow of the stream is quite variable, and there are no lakes in the basin; but the rainfall is large, and favorably distributed, being as follows: Spring, 12; summer, 13; autumn,

12; winter, 10—year, 47 inches. The four mills that were burned had together eight pairs of stones, and used a fall of 20 feet. All the powers at Wilmington are owned by the owners of the mills, and the distribution of water is governed by old agreements and contracts. It appears that there are seven rights on the south side, from the upper dam, each entitled to about 155 square inches under a head of about 3 feet. The total power used on the north side is about 75 or 80 horse-power, and is all owned by one person.

For the next 5 miles above Wilmington the fall of the stream is large, amounting, it is said, to over 200 feet, while in the 8 succeeding miles, above Rockland, it is stated at only 20 or 30 feet. Between the two Wilmington dams there was once a third dam, which it was intended to raise so as to do away with the upper dam, but nothing now remains of it. The next mill above Wilmington is the Augustine paper-mill of Jessop & Moore. The dam is 160 feet long and 6 feet high, built of stone in 1868, the previously-existing timber dam having been carried away. The fall is 10½ feet, and 280 horse power is used, with, in addition, steam power to the extent of 570 horse-power, running all the time. The full capacity of the wheels can be secured during only four months of the year. The next mill is the cotton-mill of J. Riddle, Son, & Co. The dam, which is principally of stone, is 225 feet long and 8 or 9 feet high. The fall used is 15 or 16 feet, and the power is 300 horse-power, which, however, can be obtained during only about eight months, reserve steam-power being used when the water is low. The dam was partly carried away in the great freshet in October, 1877. Above this is Bancroft's cotton-mill, with a stone dam 170 feet long and 11 feet high, a race of a quarter of a mile, and 230 horse-power, with a fall of 22 feet, full capacity being secured nearly all the time. Then come the Dupont powder-mills, there being five dams in succession, the entire fall being utilized. The dams vary in length from 100 to 125 feet and in height from 6 to 12 feet, and the total fall utilized is 59 feet. The total power used is stated at about 500 horse-power, which can be secured nearly all the time. Besides supplying power to the powder-mills, these dams run a grist-mill, four cotton- and woolen-mills, a wooden-keg factory, and an iron-keg factory, all belonging to the firm of E. I. Dupont, De Nemours, & Co. It is hardly worth while to particularize further regarding the mills on the stream. It is utilized to its very head by paper-, grist-, and woolen-mills, iron-works, etc., and is in all respects an excellent stream for power. Its tributaries, too, as Buck run and Doe run, are well utilized by mills of various kinds, and, although some power still remains unused, most of the good sites are occupied. Between Rockland and Chadd's Ford there is said to be an available fall of 20 feet on the main stream not utilized; at Smith's bridge another fall of 10 or 12 feet is said to be available, where there was once a paper-mill; at North brook there is said to be 7 or 8 feet, formerly used; and there are other similar but smaller sites. There are, however, no precipitous falls, the declivity of the stream being gradual, if we may except the lower few miles. The table on pages 114 to 121 gives the utilized power on the stream.

Between Wilmington and Philadelphia there are small streams similar in character to the Brandywine, crossing the fall-line just above their mouths, and utilized to a considerable extent by mills of various kinds. Such are Cobb's, Crum, Derby, Ridley, and Chester creeks. Derby creek drains about 50 square miles, and is well utilized by grist- and saw-mills, woolen- and cotton-mills, and others. Cobb's creek, one of its tributaries, has a number of mills of various kinds. Crum creek drains about 38 square miles, and Ridley creek about the same, while Chester creek is the largest of all, draining 70 square miles. On Ridley creek and Chester creek there are numerous mills. Many of them are quite large and use principally steam-power, for in dry weather there is but little water-power available. The ponds on these streams are often large enough to hold the water during the night, even in winter and spring, so that considerable power is obtained, considering the small size of the streams. The falls are often large and the dams high. It may be said that almost the entire power of these streams is utilized, for no good sites remain unoccupied, and the mills utilize nearly the entire flow, some of them having wheels of sufficient capacity to utilize even the freshet-water.

THE SCHUYLKILL RIVER.

The Schuylkill river may be called the principal affluent of the Delaware. Rising in Schuylkill county, Pennsylvania, it pursues a southeasterly course, passing through Berks, and then forming the boundary between Montgomery on the north and Chester on the south, to flow finally through a part of Montgomery and through Philadelphia to join the Delaware river. It flows by a number of important towns, such as Pottsville, Reading, Pottstown, Phœnixville, Norristown, and Conshohocken, and is navigable for sea-going vessels only up to Fairmount, a distance of 8.4 miles from its mouth, where the first dam is built across the river. Above that point it is navigable for river boats as far as Schuylkill Haven, the navigation being controlled by the Philadelphia and Reading Railroad Company, lessees of the Schuylkill Navigation Company; and it was at one time navigable as far as Mount Carbon, the works above Schuylkill Haven having been abandoned a few years ago on account of the washing in of waste from mines, and the scarcity of water. The navigable depth at low water is 24 feet to Girard point (1 mile), 20 feet to Gibson's wharf (4.7 miles), and 12 feet to Fairmount. The mean rise and fall of the tides is 6.1 feet. The drainage area of the stream is stated differently by different authorities. Mr. H. P. M. Birkinbine gives it as 1,942 square miles, and Mr. E. F. Smith, chief engineer of canals, quotes it as 1,800 square miles. My own measurement gave 1,912 square miles, and as it is intermediate between the other two, I have assumed it correct. A table giving the drainage areas above certain points, as well as those of the most important tributaries of the stream, is given on pages 113 and 114.

The head-waters of the Schuylkill are in the mountainous coal-bearing regions of Schuylkill county, but after flowing for a distance of 25 or 30 miles, receiving large accessions, the stream enters a more highly-cultivated country and the slope becomes more gentle. The following table will show the fall of the stream:

Declivity of the Schuylkill river.

Locality.	Distance from mouth.	Elevation above tide.	Distance between points.	Fall between points.	Fall per mile between points.
	Miles.	*Feet.*	*Miles.*	*Feet.*	*Feet.*
Fairmount	8.4	0			
			21.6	66.63	3.1
Pawling's dam	30.0	66.63			
			40.0	137.89	3.4
Kissinger's dam, Reading	70.0	204.52			
			21.5	185.44	8.6
Blue Mountain dam, Port Clinton	91.5	389.96			
			8.5	81.70	9.6
Dam No. 11, Landingville	100.0	471.66			
			5.0	37.70	7.5
Dam No. 7, Schuylkill Haven	*105.0*	*509.36*			
			4.0	74.60	18.6
Dam No. 4, below Mount Carbon	109.0	583.96			
			3.0	34.80	11.6
Dam No. 1, Port Carbon	112.0	618.76			

That part of the stream above Port Carbon has a still greater slope. Although the figures in the above table, with the exception of the elevations, can not pretend to absolute accuracy, they show that the river has a very rapid fall. As already mentioned, the stream is controlled by the Reading Railroad Company, and is navigable by means of locks, dams, and canals as far as Schuylkill Haven. Between this point and the mouth there are 24 dams, and above these are six others, not now used for navigation. Statistics of these dams are given on page 103.

The rainfall over the basin of the Schuylkill is about 45 inches, of which 12 fall in spring, 14 in summer, 10 in autumn, and 9 in winter. The flow of the stream is not so variable as that of most streams of like size in this part of the country, probably on account of the favorable distribution of the rainfall, the numerous artificial reservoirs in the shape of the pools of the canal-dams, and the numberless mill-ponds on the tributary streams. There are no lakes of any consequence in the basin, but there are three artificial reservoirs, constructed for the benefit of the navigation, as follows:(*a*)

Silver Creek reservoir, on the Broad mountain, 9 miles from Pottsville, 1,500 feet above tide-water: Length of mound at top, 1,157 feet; maximum height of mound dam, 42 feet; depth of water on outlet-pipes, 37 feet; ponds, 58 acres; contents, 42,780,500 cubic feet; drainage area, 1.275 square miles.

First, or *Lower Tumbling Run, reservoir*, near Mount Carbon: Above tide, 647.54 feet; length of mound, 418 feet; maximum height of mound, 47 feet 6 inches; depth of water on pipes, 41 feet 6 inches; ponds, 25.57 acres; contents, 25,546,512 cubic feet.

Second, or *Upper Tumbling Run, reservoir:* Above tide, 694.25 feet; length of mound, 540 feet; maximum height of mound, 63 feet; depth of water on pipes, 57 feet; ponds, 31.45 acres; contents, 39,856,612 cubic feet; drainage area, 6 square miles.

These reservoirs can be filled twice each season from the rainfall on the drainage area. They are of use only to supply the upper part of the navigation, and of no use for supplying the mills near Philadelphia, the distance being about 100 miles. The Pottsville Water Company has also two storage reservoirs, the higher and larger on Eisenhuth's run, 1,700 feet above tide, with a capacity of 52,000,000 cubic feet. In regard to the actual flow of the stream no continuous measurements have been made, but the minimum flow has been estimated several times, as follows:

In 1816 measurements were made by a committee of the Schuylkill Navigation Company, at a time when the river was said to be as low as at any previous period for twenty years, giving a flow of 771 cubic feet per second. About 1825 it was estimated at 680 cubic feet per second. In 1867 it was stated at 617 cubic feet per second. In 1874 the flow was measured by Edwin F. Smith, civil engineer, now chief engineer of canals, by gauging the water used by the mills at Manayunk, and adding to the quantity so found the amount consumed in lockage and the estimated leakage. He gave the minimum flow as about 380 cubic feet per second. In the report of the chief engineer of the Philadelphia water-works for 1876 it is stated that the flow of the Schuylkill in the summer of that year, as calculated from the amount used by the wheels, pumps, and locks, averaged 230,788,838 gallons per day for a period of 45 days. In 1878, Mr. H. P. M. Birkinbine, formerly chief engineer of the Philadelphia water-works, stated that he had estimated the minimum flow at 310 cubic feet per second, by adding together the amount pumped at Fairmount, the amount used to run the wheels, the lockage, and the estimated leakage. In 1880, Mr. Charles G. Darrach, civil engineer, gave the approximate figures which we have quoted on page 10.

a For these figures, as well as many others relating to the Schuylkill river, I have to thank Mr. E. F. Smith, of Reading, chief engineer of canals, Reading Railroad Company.

The freshets on the stream, notwithstanding the considerable storage, are quite severe, and seem to have been gradually increasing in violence. Since the completion of the Fairmount dam, in 1821, the overfall of which is oblique, with a length of 1,112 feet, the water rose once to a height of 11 feet 5 inches on the dam, and it has several times reached a height of 10 feet. The increase in the violence of the freshets, and the decrease in the minimum flow which would seem to be indicated by the measurements which have just been referred to, are due, without doubt, principally to the destruction of the forests on the drainage basin.

In connection with the problem of the future water-supply of Philadelphia, the question of increasing the minimum flow of the river by the construction of artificial reservoirs has several times presented itself, and Mr. James F. Smith has proposed for the purpose "to build, in the valley of the Schuylkill, 14 new dams and 3 new reservoirs, and also to use 8 of the dams and the water of the existing navigation above the Blue mountain, as well as the waters of the present reservoirs at Tumbling run and Silver creek", affording a total storage capacity of about 614,337,000 cubic feet, or sufficient to add about 230 cubic feet per second to the flow of the stream during 30 days, supposing the reservoirs to be filled and emptied but once. The cost of this plan is not known, but it is considered that if applied to pumping water by water-power, the plan would be more expensive than pumping by steam, so that it is not favorably regarded as a means of increasing the water-supply of Philadelphia; and it seems scarcely probable that it would pay as a means of creating water-power to be used in manufacturing. The valley of the Schuylkill, however, may be said to be favorable for reservoirs, and a large amount of storage could be secured if desired. A reservoir has been proposed on Perkiomen creek (a tributary emptying 3 or 4 miles below Phœnixville) for the purpose of increasing the water-supply of Philadelphia; and it is stated that a dam 70 feet high would flood 2,000 acres, affording a storage capacity of over 20,000,000,000 gallons. This would suffice to double the minimum flow of the Schuylkill for a period of 80 days. Its cost is stated at $800,000. All plans for extensive storage must of necessity be expensive, and it is not probable that they will be resorted to as a means of increasing water-power alone.

The first power on the Schuylkill is at the Fairmount dam, where power is used by the city water-works for pumping water into the reservoirs. The dam was originally built between April 19, 1819, and July 25, 1821, by Ariel Cooley, of Chicopee, Massachusetts, and the cost of dam, locks, head-race, etc., was $150,000. The river is about 900 feet wide, and the bed, for a quarter of the width, on the east side, was rock covered with 11 feet of mud, while for the remainder of the width it was rock at a maximum depth of 30 feet, and bare at low water on the west side. From the east side a mound dam 270 feet long and 15 feet above the overfall, built of earth, quarry spawls, and stone, was carried diagonally up stream, terminating in a strong pier of timber filled with stone. At this point the bottom is mud, 30 feet below low water. From this point the overfall was carried diagonally up stream, and was 1,204 feet in length, terminated on the west by a pier and guard-locks, from which the canal extends 569 feet down stream, to two outlet-locks. The overfall was built of crib-work founded on the rock. In some places the structure of the dam is over 30 feet high, while on the west the foundation is bare at low tide and the height of the dam is less than 9 feet. The timber cribs of which this original dam was built soon became decayed above low water, and were rebuilt from that point in 1842–'43. In 1865–'66 a new crib was sunk in front of and against the old dam for a distance of 450 feet, across the deep water, to secure the foundations. This crib extended 30 feet in front of the old dam, and after being filled with stone it was decked with white-oak timber 10 inches thick. It extended only up to low water, and was finished in 1867, having cost $41,271 29. A new dam was begun June 1, 1872, immediately in front of the old one, founded on the rock at the west end, and, at the east, on the cribs sunk in 1865. Additional cribs were also sunk in front of those of 1865, to strengthen them. The length of overfall is now 1,112 feet, and the entire length of dam 1,600 feet, including overfall, mound-dam, arches of forebay (104 feet), and piers (22 feet). The race leading to the wheels is about 250 feet long, 90 feet wide, and 6 feet deep below the crest of the dam. The fall from the top of the flash-boards is 8.7 feet at high tide, 16.37 feet at low tide, and 12.53 feet at mean tide. The comb of the old dam, below which the water can not legally be drawn, is 22 inches below the flash-boards. The power is used to drive 7 turbine wheels and 1 breast-wheel, with which the pumps are connected, and the water is pumped into two reservoirs—the Fairmount reservoir, 87.58 feet above the flash-boards, and the Corinthian reservoir, 113.58 feet above the same level. The amount of power used varies greatly according to the season. The full capacity of the pumps is stated at 36,000,000 gallons per day,(*a*) which, with an average lift of 110 feet, including friction, corresponds to a power of 693 horse-power. The full capacity of the wheels is stated at 966 net or effective horse-power. This power, however, can be obtained during only a small portion of the year, the lack of power being principally due to low flow, the trouble from freshets being slight. In 1879 the average pumpage during 12 consecutive days during the low season was only 8,000,000 gallons per day, corresponding, with a lift of 110 feet, to 154 horse-power in the pumps, and about 192 in the wheels.(*b*) The pumpage by water-power in this year was less than in any year since 1865, and the daily average was only 19,950,213 gallons, while during the months of October and November it was only 9,357,842 gallons. There were but 89 days in this

a Report of the Chief Engineer, 1879. I am indebted to Mr. Charles G. Darrach, principal assistant engineer of the water department, for much valuable information, and for reports, etc.

b In the report of 1879 it is stated that to "increase this minimum to an average of 18,000,000 gallons, by building impounding reservoirs at the head-waters, will cost not less than $500,000".

year on which water flowed over the flash-boards. Some idea of the proportion of the total power used in different months will be obtained from the following statement, taken from the report for 1879, showing the average number of gallons pumped per day for each month in that year: January, 23,602,706; February, 23,311,722; March, 24,913,564; April, 25,199,519; May, 29,519,156; June, 22,919,996; July, 12,630,113; August, 18,873,656; September, 15,570,215; October, 9,198,624; November, 9,517,060; December, 24,146,228.

It is evident from the above that nearly all the available power at Fairmount is utilized. Although a considerable quantity of water flows over the flash-boards, it could not be saved except by reservoirs at the head-waters, or by increasing the capacity of the wheels and pumps, which is already much in excess of the power available in dry seasons. It is hardly worth while to attempt to make an estimate of the power available in different months, for the whole question of the power at Fairmount is intimately connected with that of the water-supply of the city and with the navigation on the stream. It is sufficient to say that into the Fairmount pool is discharged the total flow of the river, amounting to 245,000,000 gallons, or thereabout, when at its minimum, and that this flow is used for the supply of the city, for driving the water-power pumps, and for lockage. With the exception of a small amount obtained from the Delaware river, the entire water-supply of Philadelphia is drawn from the Schuylkill. Allowing nothing for contingencies, the total capacity of the pumping machinery was, in 1879, about 113,000,000 gallons per day, of which 36,000,000 were by water-power. When the consumption is greatest, however, only about 60,000,000 gallons are so available. The average maximum daily consumption in 1879, for periods of a week each, was about 60,000,000 gallons, and the daily average for the year about 48,000,000 gallons. What water remains above that necessary for the city may be applied to pumping by water-power and to lockages. The quantity required for the latter purpose is not large, the lockage and leakage being estimated by the commission of engineers appointed in 1875 at 7,000,000 gallons per day. Although at some seasons considerable additional water-power is available, yet when we remember that in 1879, during a period of seven months, water ran over the flash-boards only sixteen days, it will be evident that the additional power which could be secured would not be available during many months. It is said, however, that the present turbines are defective, and that by putting in more efficient ones the power might be considerably increased. Their efficiency is said to be but 60 per cent. The commission of engineers of 1875 recommended the improvement of the old wheels, and the construction of two new ones, one to replace the breast-wheel.

The power on the Schuylkill above Fairmount is controlled by the Reading Railroad Company, and, as has already been mentioned, there are a number of canal dams on the stream, statistics of which are given in the following table:

Lengths and dimensions of dams on the Schuylkill river.

No.	Locality.	Height of fall.	Length of overfall.	Length of pool.	Width of pool.	Area ponded.	Remarks.
		Feet.	*Feet.*	*Feet.*	*Feet.*	*Acres.*	
1	.....	.....	.....	.....	.....	.....	Abandoned.
2	.....	.....	.....	.....	.....	.....	Abandoned.
3	Mount Carbon	.....	.....	.....	.....	.....	Not used for navigation—filled up with sand and *débris*.
4	Port Carbon	.....	.....	.....	.....	.....	
5	Second Mountain	.....	.....	.....	.....	.....	
6	Above Schuylkill Haven	.....	.....	.....	.....	.....	
7	Schuylkill Haven	10.00	351	.....	.....	.....	
8	Below Schuylkill Haven	.....	251	.....	.....	.....	
9	.....	.....	.....	.....	.....	.....	Small pools—not much larger than the canals.
10	Landingville	.....	270	.....	.....	.....	
11	....do	6.50	295	.....	.....	.....	
12	Auburn	7.30	348	.....	.....	.....	
13	....do	6.40	128	.....	.....	.....	
14	Above Port Clinton	17.52	243	12,540	203	58.438	
15	....do	15.00	265	5,280	205	14.543	
16	Blue Mountain	24.90	434	8,527	290	56.768	
17	....do	4.83	476	3,800	230	20.006	
18	Leesport	8.50	242	5,280	240	29.090	
19	Above Reading	14.81	451	19,120	280	122.900	
20	....do	8.37	425	9,240	380	80.606	
21	....do	8.71	317	6,072	300	41.818	
22	Reading	14.00	296	5,914	300	40.730	
23	Below Reading	7.02	325	13,490	430	133.166	
24	....do	18.80	423	13,041	375	112.267	
25	Limerick	6.50	342	10,348	430	102.149	
26	Phœnixville	8.40	376	18,770	425	184.445	
27	Pawling	4.30	329	9,979	430	98.507	
28	Port Kennedy	4.83	495	20,929	450	216.208	
29	Norristown	9.00	898	17,635	665	269.221	
30	Conshohocken	7.75	527	14,757	510	172.774	
31	Manayunk	16.75	523	23,100	485	257.197	
32	Fairmount (Philadelphia)	13.00	1,200	30,993	600	426.960	

It has several times been proposed to increase the water-power at Fairmount, and several methods have been advanced: First (and this method is said to be followed as far as practicable), to run the wheels during low tide, when the fall is great, drawing down the water in the pond. The storage available is a depth of 22 inches over a pond covering some 480 acres, giving nearly 40,000,000 cubic feet, or enough to store the minimum flow for over 24 hours, and thus allowing the power to be considerably increased. Second, by storage reservoirs; but this plan is so expensive that it does not find much favor. Third, by raising the Fairmount dam. It is said that the dam could be raised 4 feet, increasing the power 36 per cent.

The drainage area above Fairmount is about 1,880 square miles, according to my measurement. The rainfall is as stated on page 9. Mr. Darrach's figures regarding flow are given on page 10.

At some of these dams and along the canal at various points a certain amount of power is available, and a considerable quantity is now rented by the company, the renting of power, however, being incidental and subservient to the boating interests. The charter of the Schuylkill Navigation Company does not allow water-power to be sold or leased except out of the surplus water of the river after the navigation is fully supplied. The company, therefore, does not guarantee steady power, renting only the surplus water beyond what is needed for navigation; but the quantity leased is so regulated that a steady power can be maintained. The following table gives the statistics of power at present used on the stream:

Water-powers along the Schuylkill river.

No.	Name and kind of mill.	Location.	Number of square inches deeded or leased, under various heads.	Rental per annum.	Motive-power.	Diameter and name of wheel.	Depth of head-water in feet.	Head and fall acting on wheel, in feet.	Quantity of water discharged in cubic feet per minute.	Effective power of wheels, approximately. (*a*)	Auxiliary steam-power.
1	Heft & Ogle, Dexter cotton-mills and dye-works	Manayunk	150 10	$450 00 Free.	Overshot	18 feet 6 inches	4.329	.....	804.79	20.90	60
2	A. Campbell Manufacturing Company, cotton	....do	*b* 380 610	1,218 74 3,660 00	Turbine Overshot	48-inch Leffel 16 feet 11 inches	3.833	21.40	4,010.00 3,282.00	123.40 75.20	530
3	McDowell paper-mill	....do	100 650	313 12 4,875 00	Turbine	52-inch Jonval	.....	21.80	3,037.50	86.60	125
4	Robert Patterson & Co., cotton	....do	2,556	11,130 34	3 turbines 1 turbine	48-inch Leffel 20-inch Leffel	.....	20.80	11,918.82	354.70	.....
5	Eagle mill, cotton and woolen	....do	100	500 00	Overshot	18 feet	3.540	.....	462.52	11.10	75
6	James B. Winpenny, cotton	....do	575	3,300 00	2 overshots	18 feet	3.681	.....	2,286.36	55.09	.....
7	Wabash mills, cotton and woolen	....do	100	373 87	Overshot	18 feet	3.909	.....	488.64	11.85	60
8	Joseph Stelwagon's Sons, brown roofing-paper.	....do	142	1,050 00	....do	17 feet	4.583	.....	711.12	16.64	60
9	Thomas Schofield, woolen	....do	300	1,882 00	2 overshots	17 feet	3.384	.....	1,376.82	31.24	.....
10	John & James Dobson, carpet	....do	*c* 256.7	915 00	1 overshot	16 feet	2.704	.....	983.88	20.59	.....
11	Martin & William H. Nixon, paper	....do	1,602	8,194 00	2 turbines	40- and 48-inch Leffel	.....	19.40	6,855.17	192.09	300
12	American Wood Paper Company	....do	1,897	10,060 00	3 turbines	36-, 40-, and 48-inch Leffel.	.....	19.00	8,578.00	230.90	200
13	J. Wood & Brother, rolling-mill	Conshohocken	1,932	1,600 28	2 turbines	54-inch Leffel	.....	7.75	7,223.00	79.29	.....
14	Hamilton Maxwell, cotton	....do	1,009	630 00	.....	56-inch Leffel	.....	7.75	3,788.00	41.58	60
15	Wyoming mill, cotton (*d*)	Norristown	.....	.....	2 turbines	56- and 96-inch Leffel	.....	9.00	.....	200.00	.....
16	C. Heebner, flour-mills (*d*)	....do	.....	.....	1 turbine	30-inch Leffel	.....	9.00	.....	30.00	.....
17	Bridgeport flour-mill (*e*)	Bridgeport	.....	808 00	3 turbines	2 40- and 1 43-inch Leffel.	.....	9.00	3,174.00	40.47	.....
18	The Phœnix Iron Company	Phœnixville	400	400 00	2 turbines	48-inch Parker	.....	9.00	.....	49.00	.....
19	Krick's flour-mill (*e*)	Reading	.....	626 00	2 turbines	42-inch Parker	.....	6.00	3,686.95	31.30	.....
20	Kernsville flour-mill (*e*)	Kernsville	.....	.....	.....	.....	.....	11.00	1,282.66	19.98	.....
21	Orchard flour-mill (*d*)	Pottsville	.....	.....	1 pitchback	.....	3.000	9.00	2,010.00	25.00	.....

a Power not measured by dynamometer. *b* 810 extra. *c* 70 inches free. *d* These water-rights are owned by the mill-owners.
e These mills are owned by the Philadelphia and Reading Railroad Company. The rent includes the power.

The company leases power by the square inch of aperture under a head of 3 feet, measured from the center of the aperture to the datum surface of the canal. (The water is kept several inches above datum.)

Standard apertures are of cast iron, with edges not exceeding 1 inch in thickness, without ajutage. In computing discharge of water a coefficient of 0.70 is allowed, and a discharge per square inch of 4.05 cubic feet per minute. The prices charged for water-power are as follows: To mills using power 10 hours per day, $6 per square inch per annum; to paper-mills running full time (24 hours), $7 50 per square inch per annum.

Only one instance has occurred when there has been any lost time on account of a scarcity of water, and that was in the year 1880. The cotton-mills lost a total of 96 hours' time in July, August, September, October, and November; and the paper-mills 62 hours of day runs and 39 nights during the same period. Changes have been made since December, 1880, that will obviate any loss of time by the

mills in future. In renting power to mills using turbine wheels the gauging is done the same as at Lowell, Massachusetts, and the discharge per minute divided by 4.05 gives the number of square inches under a 36-inch head. Turbine wheels are run under the full head and fall without the intervention of an aperture and gate.(a)

Between Norristown and the mouth of Perkiomen creek there are two canal dams, but the falls are too low to be available for power, and the locations are not safe from floods. Above the Perkiomen there is surplus water enough only for the small mills, Nos. 17, 18, 19, and 20, although a small amount of water is always wasting over all the dams except the Norristown and Flat Rock dams, where flash-boards are used so as to save all the water in dry weather for the mills and navigation. Very little power is used directly from the river, *i. e.*, not from the canal or the canal dams. Below Reading there is only one mill so supplied, with a fall of about 4.5 feet and 15 horse-power, and above that place there are only a few small mills. No good sites for power were brought to my notice. Above Schuylkill Haven the six navigation dams which have been abandoned could probably be used for power, but the stream is very small; besides, the ponds are full to overflowing with coal-dirt and sand carried down by the streams on which the collieries are situated, in the Schuylkill coal regions. On the head-waters of the stream in the mountains there are large falls available, but with little water.

THE TRIBUTARIES OF THE SCHUYLKILL RIVER.

The various streams flowing into the Schuylkill are utilized to a large extent by mills of various kinds, but very little information could be collected regarding them. Mill creek, from Montgomery county, drains about 9 square miles, and is well utilized. Gulf creek drains 7.5, East Valley creek 21, Wissahickon creek 78, Plymouth creek 8, and Stony creek 16 square miles. They are all well utilized, their slopes are gradual, and their flow is quite variable. The main tributary of the Schuylkill is the Perkiomen, which drains about 345 square miles, rising in Berks county, and flowing south through Montgomery, joining the Schuylkill 3 miles below Phœnixville. The main stream, with its tributaries, runs a large number of mills. The fall does not seem to be very great, averaging only about 4 feet per mile for the lower 11 miles. The declivity is gradual, and the falls at the mills are not large. No good sites not occupied were mentioned, though there are probably many small ones. The Perkiomen has often been proposed as a source of water-supply for Philadelphia, and about 11½ miles above its mouth there is said to be an excellent site for a reservoir, where a dam 65 feet high would back up over 6 miles and flood over 15,000 acres. The stream drains principally a trap and sandstone district, and nearly one-third of the entire drainage area is wooded, and likely to continue so.

Valley creek, which enters from the south 4 miles below Phœnixville, is a smaller stream, but well utilized, though with some sites unimproved. The stream is said to be quite uniform in flow. Pickering creek, French creek, and the other creeks from the south below Reading run small grist-mills with two or three pairs of stones, which can run at full capacity only six or eight months, and are sometimes obliged to stop. French creek, however, affords power for the Phœnix Iron Company at Phœnixville, 50 horse-power in all, with three falls (from one dam) of 12, 14, and 16 feet, respectively.

Manatawny creek, entering at Pottstown from the north, has considerable fall and many mills. At the mouth is a flour-mill with a fall of 12 feet, and 75 horse-power during eight months. There are several forges and rolling-mills above, one at Glasgow, a mile above Pottstown, and one at Pine Iron Works. There are several unimproved powers on this stream, formerly used by forges; one at Spring forge, near Earlville, with a fall of 18 feet or over; the Spang forge, at Spangville, with about 15 feet; Snyder's lower forge, in Rockland township, with 20 feet; Snyder's upper forge, with also about 20 feet; and Lobach forge, near Lobachville, about 20 feet. An abandoned forge is also mentioned between Pine and Glasgow, with a fall of 10 feet or more. These forges are idle on account of lack of fuel and convenient means of transportation, the timber for making charcoal having been for the most part cut down.

Tulpehocken creek, which enters from the west, opposite Reading, is quite a large stream, draining a limestone region, and, with its tributaries, quite extensively utilized. It is followed by the Union canal for almost its entire length. Regarding its power I have no data except what is given in the table of utilized power. The same may be said regarding Maiden creek. On the Little Schuylkill there are a number of small grist-mills in the mountain region, and near its head-waters some powder-mills. The powers are all small. A mile above Port Clinton are Inness' rolling-mills, with a fall of 12.5 feet, and 110 horse-power or more during part of the year, there being no waste in dry weather, and the mill running twenty-two hours.

Generally speaking, it may be said that most of the good sites for power on the tributaries of the Schuylkill are occupied, the utilized power in the basin being very large, as the table on pages 114 to 121 shows.

TRIBUTARIES OF THE DELAWARE BETWEEN THE SCHUYLKILL AND LEHIGH RIVERS.

Proceeding up the Delaware, the most important tributaries from Pennsylvania between the Schuylkill and the Lehigh are the Neshaminy and the Tohickon, small streams like the tributaries of the Schuylkill, quite well utilized, and with no important sites not occupied. The tributaries below Easton from New Jersey, too, are,

a These quotations are from a letter from Mr. E. F. Smith, chief engineer of canals, to whom I am much indebted for valuable information and for all the data in the tables.

with one exception, almost valueless for power, being very variable in flow, and almost dry in the summer. The Musconetcong river, which takes its rise in Morris county, near the sources of the Raritan, and pursues a southwesterly course, forming the boundary line between Warren county on the north and Morris and Hunterdon counties on the south, flows by the towns of Hackettstown and Bloomsbury, and drains an area of about 150 square miles, comprising a narrow limestone valley with a shallow covering of drift. Its source is lake Hopatcong, the largest lake in New Jersey, a beautiful sheet of water on the summit of the Highlands, 914 feet above mean tide,(*a*) and covering an area of about 2,800 acres. Its original area was 1,500 acres, but it was raised 10 feet to enable it to serve as a feeder for the Morris and Essex canal, by which its area was increased by 1,300 acres. Its storage capacity is 8,700,000,000 gallons, and the canal company owns the right to control its flow, with the exception of a small portion owned by a mill near the outlet. The flow of the Musconetcong river is, on account of this lake and some other smaller lakes which are tributary to the stream, very steady, and freshets are never violent. The bed is gravel and rock, and the facilities for the utilization of the power are good. The fall of the stream is very large, its elevation at its mouth being about 126 feet,(*b*) and its length about 45 miles, so that the slope averages 15 feet or more per mile. The rainfall in this region of the state is about 48 inches—12 in spring, 14 in summer, 12 in autumn, and 10 in winter—a distribution in itself favorable for constancy of flow. No data regarding the actual flow, however, could be obtained, except such as may be inferred from the data regarding power. The first mill is at the mouth of the stream, at Riegelsville, where a fall of 22 feet is used, with a race three-quarters of a mile long and a dam 6 feet high, to drive a paper- and grist-mill, using in all about 150 horse-power, which, however, can be obtained during only about seven months, being about 100 to 120 horse-power during the rest of the time. At Finesville, a few miles above, there is a forge and knife factory, using a fall of 8.5 feet, and 65 horse-power all the year, with always a waste. At Hughesville, the paper-mill of the Warren Manufacturing Company uses a fall of 28 feet, with a dam 20 feet high, and 250 horse-power during four months. The paper-mills are run night and day, and steam is used when the water is low. At Bloomsbury several mills are run from one dam, with a fall of 9 feet, and above are a number of small mills of various kinds. The stream is no doubt the best water-power stream emptying into the Delaware from New Jersey. There are said to be no sites not occupied, except one below Penville, and 20 feet just above the dam of the Warren Manufacturing Company. If, however, the elevations given above are correct, there must be a large unimproved fall, although there may be no good locations not occupied.

The next tributary of the Delaware which it is necessary to describe is

THE LEHIGH RIVER.

This stream, one of the most important affluents of the Delaware, rises in Wayne and Lackawanna counties, Pennsylvania, and pursues a roundabout course, first in a southwesterly direction, then south, southeast, and finally east, emptying into the Delaware at Easton. It forms first the boundary line between Lackawanna and Luzerne counties on the north, and Monroe and Carbon on the south, then flows through the latter county and becomes the boundary between Lehigh and Northampton counties, finally flowing through parts of both of them before reaching its mouth. Its length, measured along the stream, is not far from 100 miles, while in a straight line it is only about 45 miles from source to mouth. The stream drains a total area of about 1,330 square miles, and in its course it passes a number of cities and towns, among which may be mentioned Easton, Glendon, Bethlehem, Allentown, Hockendauqua, Catasauqua, Slatington, Parryville, Lehighton, and Mauch Chunk. It is controlled by the Lehigh Coal and Navigation Company, and by means of locks, dams, and canals has been made navigable as far as Stoddartsville, although that part above Mauch Chunk has been abandoned for a number of years. The fall of the stream is shown by the following table:

Declivity of the Lehigh river. (*c*)

Locality.	Distance from mouth.	Elevation above tide.	Distance between points.	Fall between points.	Fall per mile between points.
	Miles.	*Feet.*	*Miles.*	*Feet.*	*Feet.*
Mouth	0	152			
			12	46	3.8
Bethlehem	12	205			
			21	145	6.9
Slatington	33	350			
			9	100	11.1
Lehighton	42	450			
			4	54	13.5
Mauch Chunk, below dam	46	504			
			8	186	23.2
Eight miles above Mauch Chunk.	54	690			
			16	415	25.9
Near White Haven	70	1,105			
			13±	352	27.1
Stoddartsville	83±	1,457			

a Cook's *Geology of New Jersey*, 1868, page 27.

b Cook's *Report of the Geological Survey of New Jersey*, 1880, page 76.

c For all but the last of these elevations I have to thank Robert H. Sayre, esq., superintendent and engineer of the Lehigh Valley Railroad Company.

It will be seen that the stream has a very large fall. Descending rapidly from the high plateau where it takes its rise, it falls at the rate of over 10 feet per mile until within 15 or 20 miles of its mouth, when it reaches the rolling farming country of Lehigh and Northampton counties, where its slope is reduced to 4 or 5 feet per mile.

Regarding the flow of the stream I could obtain no data. It is very variable, and the freshets are quite sudden and violent. The water has risen to a height of 11 feet on the dam (280 feet long) at Mauch Chunk. There are no lakes in the basin except a few very small ones on some of the upper tributaries, of no value as regulators of flow. Neither are there any artificial reservoirs except mill-ponds and the ponds of the navigation dams, but these afford little storage, and serve no purpose as regulators. The facilities for artificial reservoirs may be called good, I think, and storage reservoirs could probably be built on many of the tributaries; though on the main stream the fall is too great. The rainfall over the basin is about 43 inches—11 in spring, 14 in summer, 10 in autumn, and 8 in winter. This distribution is about the same as on the valley of the Schuylkill, but on account of the topography and the absence of reservoirs I believe the flow of the Lehigh will be found to be the more variable. The bed of the stream is rock for almost the entire distance, sometimes overlaid with a thin layer of drift, but often at the surface. The banks, especially in the upper part, are rocky and high, and the facilities for dams are of the very best. In some places, in fact, especially between Mauch Chunk and White Haven, the banks are so high and bold that the valley of the stream is simply a gorge, and there is no place for mills or villages.

There is very little power used from the Lehigh except what is taken from the canal or the canal dams on lease from the canal company. As in the case of the Schuylkill, the company controls the flow of the stream, so that mills using power directly from the stream are liable to be short of water at times. The canal company, however, leases a considerable quantity of water for power, as the table below shows. Water is leased by the square inch under a head of 3 feet, measured to the center of the orifice, the price paid varying from $1 to $4 per square inch, according to the fall, and according as the water is discharged into the river or into a lower level of the canal. The water used by mills is never gauged in any other way than by putting in an orifice of a certain size. Some mills, which discharge into lower levels of the canal, have the right to all the surplus or feed water, but the table shows that most of the mills discharge into the river. The mills can generally run at full capacity nearly all the year. There is traffic on the canal only from April 1 to December 15, and during the rest of the year water is let around the locks to supply the mills. The water is drawn off from the canal for from two to four days each year for cleaning and repairs, and except in times of extreme low water there is always enough water to supply the mills. In case of interruption of the supply on account of low water, extended repairs, etc., no abatement in the price is allowed to mills unless the interruption is for thirty days or over; but this very rarely occurs.

As regards power available, it is stated that a large quantity can still be supplied by the company, and that there are numerous points along the river, on the canal, or at the dams where power could be leased by the company.

The following tables give the statistics of power and dams:

Water-power used from the canal of the Lehigh Coal and Navigation Company.

No.	Name and kind of mill.	Location.	Number of square inches.	Head and fall.	Discharge to river or canal.	Approximate quantity of water per second.	Approximate horse-power, gross.
				Feet.		*Cubic feet.*	
1	Stewart's wire- and rolling-mills	South Easton	1,545	21	River	94	225
2	Maxwell & Palmer's grist-mill	do	100	21	do	6	15
3	McKean & Co.'s cotton-mill	do	258	21	do	16	38
4	McKean & Co.'s weaving-mill	do	587	21	do	35	84
5	Furnace and machine-shop	do	1,180	21	do	72	172
6	Glendon iron-works	Glendon	1,600	21	do	98	233
7	Cement-mill (*a*)	Whitehall	500	8	Canal	30	27
8	Foundery and machine-shop (*a*)	Bethlehem	140	8	do	8	8
9	Barrel factory	do	300	12	River	18	25
10	Grist-mill	Allentown	450	12	do	27	37
11	Grist-mill	Lower Catasauqua	450	12	do	27	37
12	Furnace and rolling-mill	Catasauqua	1,000	8	Canal	60	55
13	Grist-mill	Lowry's	450	13	River	27	40
14	Slate factory	Treichler's	180	13	do	10	16
15	Grist-mill	do	300	13	do	18	27
16	Grist-mill (*b*)	Frenchtown	450	8	Canal	27	25
17	Paint-mill	Bowman's	300	15	River	18	31
18	Paint-mill (*a*)	do	400	15	Canal	24	41
19	Grist-mill (*c*)	Laubach's	550	6	River	33	22

a Only feed-water. *b* Only eight months by water. *c* Water procured since 1881.

Dams on the Lehigh river belonging to the Lehigh Coal and Navigation Company.

No.	Locality.	Height of fall.	Length.	Approximate length of pool.	Approximate width of pool.	Approximate area of pool.
		Feet.	*Feet.*	*Feet.*	*Feet.*	*Acres.*
1	Easton	16	340	10,000	400	92
2	Glendon	12	700	15,500	800	289
3	Allentown	10	500	6,000	500	69
4	Hockendauqua	6	550	5,200	400	48
5	Lowry's	13	450	10,000	400	92
6	Above Treichler's	14	480	15,500	500	178
7	Lehigh gap	6	500	5,200	500	60
8	Parryville	12	480	4,000	500	46
9	Mauch Chunk	12	280	4,000	300	27
10	Above Mauch Chunk (*a*)	19	380	5,200	400	48
11	Hickory run (*a*)	28	190	10,000	400	92
12	Tannery (*a*)	30	306	5,200	400	48
13	Bridgeport (*a*)	22	293	4,000	450	41
14	White Haven (*a*)	23	375	4,000	450	41

a Abandoned.

These dams are all substantial structures of crib-work filled in with stone. They are generally 60 feet wide up and down stream, on rock foundation, and to build them now would cost from $20,000 to $35,000 apiece. Those above Mauch Chunk are built with a partly-sloping face. The canal is 60 feet wide at top, 40 feet at bottom, and 6 feet deep.

Below Mauch Chunk there are only a few small mills using power directly from the river, with wing-dams. Details regarding them are unnecessary. Above Mauch Chunk the navigation works have been abandoned, but the dams are still in existence and in quite good condition. Between Mauch Chunk and White Haven the river flows through a narrow gorge, closely followed by the Lehigh Valley and the New Jersey Central railroads; and although the fall is very large, and the theoretical power also, but little is practically available, on account of the contracted situation and the lack of building-room. There are a few places, however, where dams might be located and power obtained, and at the already existing dams belonging to the company a considerably greater amount of power could be used than is used at present. Packer's dam, the first above Mauch Chunk, is entirely unemployed; and the same is true of Hickory Run dam. The Tannery dam is used by one saw-mill, the Bridgeport dam by a saw-mill, and the White Haven dam by two saw-mills and a foundery. All the mills below White Haven, as well as those below Mauch Chunk, pay rent to the company for their power. Above White Haven, although the stream offers considerable available power, there are only a few small saw-mills and a tannery.

THE TRIBUTARIES OF THE LEHIGH RIVER.

The table on page 113 gives the drainage areas of the principal tributaries of the Lehigh. They are all small streams, and I learned of no peculiarities regarding their power. They have a large fall, a gradual descent, and are utilized to a considerable extent. Their flow is variable, but not more nor less than that of other streams in eastern Pennsylvania. The valley of the Lehigh is the seat of considerable manufacturing, the principal industry being that of iron-working, but considerable steam-power is used in preference to water-power.

The tributaries above White Haven are utilized only by saw-mills and tanneries. Bear creek, which enters 8 miles above that place, is said to have a very rapid fall and some cataracts; but it is now utilized only for driving logs. Tobyhanna creek is a similar stream with several falls. On several of the small streams in this vicinity there are "splash-dams", such as have been noticed on the West branch of the Susquehanna, but none of the ponds are very extensive. The tributaries between White Haven and Mauch Chunk are small streams, little utilized, but with large falls. The powers are small and the facilities for building are often poor. In view of the cheapness of steam-power in this coal-producing region, and its convenience, they will scarcely be soon utilized.

The tributaries below Mauch Chunk are more important and better utilized, although on all of them there are numerous sites not occupied. The most important of these streams is the Little Lehigh, which enters at Allentown. It drains a limestone region, and its flow is said to be quite constant. Its basin is hilly, its banks high, and on the stream and its tributaries there are grist-mills, as well as mills of other kinds. It is an excellent stream for power, and, although the best sites are probably occupied, there are numerous others which could be developed. The grist-mills have generally 2 to 4 pairs of stones and run at full capacity during eight or nine months. The city of Allentown pumps its water-supply, which is obtained from a spring, by means of water-power obtained from the Little Lehigh, with a fall of 6 or 8 feet. Monocacy creek, which enters the Lehigh at Bethlehem, is a similar stream, but not so constant. It runs a number of grist-mills.

Ascending the Delaware from the mouth of the Lehigh, the first stream we meet is Bushkill creek, emptying less than a mile above the Lehigh. It is a small stream rising in Northampton county, but it descends from the Blue mountains with a very rapid fall over a rocky bed, and is in all respects an excellent stream for power. It is utilized extensively for grist- and paint-mills, all the best sites being occupied. Martin's creek is another small stream from Northampton county, somewhat similar in character. At its mouth is a cotton-mill, not now running, with a fall of 28 feet. Its flow, however, is said to be very variable.

The most important of the tributaries from New Jersey, above Easton, is the Pequest creek, which rises in Sussex county, New Jersey, and pursues a southwesterly course through Sussex and Warren, emptying into the Delaware at Belvidere, after draining an area of about 160 square miles, according to my measurements. Its length is about 30 miles along its general course, and its drainage basin, lying in the highlands of New Jersey, comprises a hilly country, quite well wooded. The stream is fed by a number of small lakes and ponds, the principal of which are Green's, Glover's, Rice, Alamuchc, Panther, Long, and Sickles' ponds. They are all small sheets of water, but by their number may make up for their small size, and may serve to regulate the flow to a considerable extent. Until a few years ago the stream, like the Passaic above Little Falls, was bordered by swamp-lands from Danville, in Warren county, up to the Sussex line and beyond, a distance of over 6 miles in a straight line; and although the fall of the stream within this distance was considerable, its course was so tortuous and so obstructed by fallen timber that its slope was very small. Within a few years these lands, known as the Great meadows, and covering 5,500 acres or more, have been drained, with much benefit to the health and agriculture of the region. The fall of the stream probably averages, from source to mouth, about 8 or 10 feet per mile, or more. Regarding its flow, or that of any of the tributaries from New Jersey, no data are at hand. It may be estimated by comparing the tables on pages 9 and 10. The bed of the stream is sometimes rock, but more often drift, which covers the valley in some places to a considerable depth. The power of the stream is utilized to run a number of small grist- and saw-mills, the most important power being at the mouth, where, within a distance of a mile, there is a very considerable fall. The first power is a saw-mill with about 12 horse-power, and a flour-mill with about 95 horse-power, both from the same dam, the falls being 14 and 16 feet, respectively. Just above is a second dam, supplying two flour-mills, with together 50 horse-power, the fall being 6 or 7 feet. Half a mile above is a third dam, supplying three mills, viz, a flour-mill with 30 horse-power, a wheel and wagon factory with about 40 horse-power, and a furniture factory with 60 horse-power, the fall being 18 feet at all the mills. Full capacity can not be obtained all the year. The dams were built over 40 years ago. Above Belvidere there are no powers worth describing. The fall of the stream is not all utilized, but with the exception of a fall of 13 feet just above Belvidere, which is said to be unimproved, no other sites were brought to my notice.

Similar to the Pequest are the other tributaries of the Delaware from New Jersey. An important feature of this region is the presence of a large number of small ponds, as in the valley of the Pequest, by which the flow of the streams is rendered much more constant than it otherwise would be, and the freshets much less destructive and violent. The facilities for the construction of artificial reservoirs are also very good; and if it were desired to utilize these streams extensively, their flow could be regulated to a considerable extent. These streams, however, are not very easy of access, at least those above the water-gap, there being no railroad along the Delaware between that point and Port Jervis. I have no details regarding their power, but the only mills they run are grist- and saw-mills, the former with two or three pairs of stones, which they can run only part of the time. The principal of these streams are Paulin's kill and Flat brook, which drain valleys nearly parallel with the Delaware. On the former, which drains a long anticlinal limestone valley, there are a number of ponds, several of them covering nearly a square mile each. Its utilized power is insignificant, but its fall is probably not much less than that of the Pequest. It is bordered at one place, near Newton, by swamps covering over 1,800 acres.

The tributaries of the Delaware from the west, between the water-gap and Port Jervis, have generally a very rapid fall, descending from the same elevated plateau which gives rise to the Lehigh, and flowing nearly south or southeast, through deep and narrow channels, in which occur innumerable cascades. They seem to be excellent streams for power, by reason of the great fall and of the numerous lakes which are tributary to them, their chief disadvantage being their inaccessibility. Being small streams, they afford, of course, no very remarkable powers. They are utilized, like the New Jersey tributaries, by saw- and grist-mills, running generally only for part of the year, although the flow of the streams is not remarkably variable. The first and largest of these streams, above the water-gap, is the Analomink (or Brodhead's) creek, which drains an area of nearly 300 square miles, taking its rise in Pike county, very near the border of Monroe, and flowing nearly south, past the town of Stroudsburg, emptying into the Delaware just above the water-gap. It has only a few small lakes tributary to it, and its flow is therefore probably more variable than that of the streams north of it; but being followed for some distance by the Delaware and Lackawanna railroad, it is more accessible than any of the others. Its bed is rocky, and the facilities for power seem to be of the best. It is utilized only by a few small grist- and saw-mills, a foundery, etc., and there are numerous sites not occupied; in fact, only a small part of the available power of the stream is yet turned to account. The stream has several tributaries which also afford good power. Marshall's creek, which joins it just above its mouth, has a large fall but a very variable flow. A few miles from Stroudsburg it has a fine

cascade. Pocono creek, which flows through Stroudsburg, just below which place it joins the main stream, runs, with its tributaries, a number of mills, including at Stroudsburg a grist-mill, a saw-mill, and a woolen-mill, all from one dam, using a fall of about 14 feet, and together about 125 or 150 horse-power, which, however can be obtained during only about six months.

Bushkill creek, which enters the Delaware at Bushkill, is similar to the Analomink, but is fed by five or six lakes of small size. Five miles from its mouth there is a fall of 30 feet. On Raymond's kill, near Milford, there is a cataract, and on the Saw kill, which flows through the town, there is a beautiful cascade a mile above the town, the stream falling over a hundred feet into a winding chasm.

The tributaries of the Delaware above the northern boundary of New Jersey, both those from New York and those from Pennsylvania, partake of the general character of those just described. In both states there are innumerable lakes and ponds scattered over their drainage basins, and their fall is generally quite large, though as the Delaware is ascended the fall of the tributaries becomes probably less. Regarding their power, details could be obtained in only a few instances. From what I could learn, I should judge the power to be in all respects excellent, and the reason why they are not utilized to a greater extent is that they are generally not very accessible, and that the region is sparsely settled and not much developed. With the exception of a few mills on the tributaries of the Lackawaxen, there is no manufacturing on any of these streams. The lumber interest has always been the most important one, and the mills are generally saw-mills; but, as the timber is being cut down, these are gradually being abandoned.

Considering, first, the tributaries from New York, the Neversink is the first of importance. Taking its rise in the western part of Ulster county, it pursues a nearly southerly course, entering the Delaware about a mile below Port Jervis, and draining a narrow valley measuring nearly 350 square miles, comprising a wild and broken country, very little developed. Its fall is large, its bed very rocky, and its flow very variable, the freshets being, it is said, very severe, although it is fed by 15 or 20 small ponds. Its power is almost all unimproved, there being only a few small saw-mills and tanneries in operation. Its tributaries, however, are better utilized.

The next important tributary of the Delaware is the Mongaup, a small stream draining only about 230 square miles, rising in Sullivan county, through which it flows in a direction nearly due south, entering the Delaware at Mongaup after forming the boundary between Orange and Sullivan counties. It is fed by over twenty lakes and ponds, some of which are of considerable size, so that its flow is probably more regular than that of the Neversink, although no accurate data regarding this point are at hand. Its basin is characterized as a wilderness, and although its fall is rapid and its available power very large, it is utilized only to a very small extent. In former times it was quite well utilized by saw-mills, tanneries, etc., but the lumber and bark have become scarce, and many of the mills have been abandoned. It offers numerous sites for power, and is said to have some very large falls. Six miles from the mouth is a fall known as Little falls, and 4 miles above are Big falls, formerly utilized by a saw-mill. Its bed is very rocky and the facilities for dams are excellent. As in the case of many of these streams, however, the valley is narrow, and not much storage can be obtained. It is on the smaller tributary streams that the lakes and ponds are generally situated. The upper part of the stream is said to be better utilized than the lower, but it is not very accessible. Monticello is probably the nearest railroad point.

Passing a number of small streams, we come to the Callicoon, a stream similar to the Mongaup. It formerly was the seat of an immense lumber business, but is now little used. It is fed by a number of lakes, and it may be mentioned that many of the lakes in the vicinity have been raised by dams at their outlets, affording good constant power to small mills.

The East branch of the Delaware will be described after the remaining tributaries of the main stream from Pennsylvania have been considered. The first of these above Port Jervis is Shohola creek, a stream similar to those just described, but regarding whose power I have no data. The next important one, and the largest affluent the river receives in this part of its course, is the Lackawaxen river. It is formed by the union of two branches, both of which rise, not far apart, in the northern part of Wayne county, and flow nearly south, uniting at Honesdale, from which point the river flows southeast, and then east, passing into Pike county, and joining the Delaware at Lackawaxen. The drainage area measures about 600 square miles, and comprises a hilly and broken country, forming part of the high plateau which contains the sources of the Lehigh and the Lackawanna. The basin is dotted with numerous lakes and ponds, of which thirty or more may be counted on the map, and the facilities for storage are excellent. The stream is followed from its mouth as far as Honesdale by the Honesdale branch of the Erie railroad, and also by the Delaware and Hudson canal, and the canal company has already constructed, as feeders for the canal, ten large reservoirs on the tributaries of the West branch, and one on the East branch, above Honesdale, statistics regarding which are given in the following table:

Reservoirs of the Delaware and Hudson Canal Company on the tributaries of the Lackawaxen.

No.	Name.	Height of dam.	AREA.				Capacity.
			High water.		Low water.		
		Feet.	*Square feet.*	*Acres.*	*Square feet.*	*Acres.*	*Cubic feet.*
1	Stanton pond	19	11,625,000	266.87	2,392,500	54.92	135,643,750
2	Keen's pond	18.5	4,682,500	107.49	1,452,500	33.34	61,145,000
3	Elk pond	14	7,972,500	183.02	5,432,500	124.71	92,707,500
4	White Oak pond	26	15,577,500	367.61	2,585,000	59.34	248,788,750
5	Swamp pond	20	2,417,500	55.49	732,500	16.81	33,637,500
6	Long pond	20	6,685,000	153.41	2,782,500	63.87	93,783,750
7	Stevenson's pond	22	4,305,000	98.82	1,085,000	24.90	69,407,500
8	Miller's pond	24.5	4,230,000	97.10	527,500	12.11	73,834,750
9	Beaver Meadow pond	25	9,347,500	214.58	1,100,000	25.25	137,995,750
10	Lower Woods pond	18.5	4,177,000	95.56	1,810,000	41.55	61,758,750
11	Cajaw pond	14	4,055,000	93.09	1,175,000	26.98	36,412,500

NOTE.—All but No. 10 are on the West branch; No. 10 is on the East branch.

These reservoirs, aggregating a capacity of over 1,045,000,000 cubic feet, are emptied during the summer for the supply of the canal, which is fed by means of dams across the stream, there being one at Honesdale and three between Honesdale and Lackawaxen, besides the one across the Delaware at the latter place. Their effect is, of course, favorable on the water-power of the mills above Honesdale.

The stream has a rapid fall, its elevation at Honesdale, 24 miles from the mouth, being about 965 feet, while that of the Delaware at Lackawaxen is about 600 feet, so that the fall of the Lackawaxen below Honesdale is at the rate of 15 feet per mile, while above Honesdale it is probably greater. These figures will serve to give some idea of the fall of the tributaries to the Delaware above the water-gap, for they are all rapid streams, similar to the Lackawaxen.

Regarding the flow of the stream no data are at hand. The rainfall over the basin and all the adjacent territory is about 42 inches—11 in spring, 13 in summer, 10 in autumn, and 8 in winter.

On account of the fact that the main stream below Honesdale is controlled by the canal company, which has the right to use all the water for the canal, if necessary, and also that in dry weather almost all the flow is in fact so used, the water-power of the stream is of little importance, there being, according to the census statistics, only one small mill below the junction of the two branches. Although there is no power used from the canal in this part of its course, it is said that some power could be used at the locks by using the flume-water which flows around through the waste-sluices; but it is probable that the amount of power which could be so used is small, and that none would be available at times. But although the main stream offers no power, its tributaries afford a large amount. The first one which we meet as we ascend the creek is Blooming Grove creek, flowing nearly north from Pike county. It is a small stream, but has a rapid fall and is fed by several lakes. At its mouth a saw-mill and furniture factory use a fall of 15 feet, and within a distance of a little over a mile above there is said to be a fall of over 100 feet not utilized, but which could be easily developed. The stream is said to be very constant in flow.

The next tributary of the Lackawaxen is Paupack creek, a much larger stream than the Blooming Grove, taking its rise in the very corner of Wayne, Pike, and Monroe counties, near the sources of the Lehigh, and flowing nearly north, forming the boundary between Wayne and Pike. It joins the Lackawaxen at Hawley, and drains a total area of about 233 square miles, its length along its general course being about 25 miles. Like the Blooming Grove, it is fed by a number of small ponds, but its flow is probably more variable than that of the latter stream. Rising in the southern part of the high plateau of Pike county, the stream has little power in the upper part of its course, or until within less than 2 miles of its mouth, flowing for a long distance in a bed of gravel and sand, and with only a few small mills. Above the dam at Wilsonville, less than 2 miles from the mouth, there is said to be a number of miles of slack-water, the next power being at Ledgedale, 14 miles above, and the fall between the two points being very small. There is one dam, used only for running logs, within this distance, and the stream often overflows its banks, spreading out from its natural width of about 75 feet to many hundred. Above Ledgedale the fall of the stream is greater, and there are numerous sites for power. On the East branch of the stream there is said to be one fall of 90 feet just below the outlet of a small lake; but all the powers above Wilsonville are unimportant. At that place three saw-mills and a grist-mill are run from one dam, the fall being 22 feet. The dam is a zigzag dam, about 6 feet high, the height being varied 3 feet by means of flash-boards. The natural fall is about 25 feet, so that it is not all utilized. From this point to the mouth, a distance of about 1½ mile, the stream falls very rapidly, its bed being solid rock. It is, in fact, a continuous cataract, and the total fall is said to be over 300 feet. Of this fall only a portion, at Hawley, is utilized. The first mill below Wilsonville is a carriage factory and planing-mill, with a dam about 2 feet high, composed of timbers bolted to the rock, with a fall of 25 feet and a race 250 feet long. The power used is only about 25 horse-power, according to the census statistics of manufactures. Just below the mill a large silk factory has just been built by Mr. C. Lambert, of Paterson, New Jersey, to use

several hundred horse-power, with a fall of 56 feet. The dam, which was built in June, 1880, at a cost of $1,000, is 125 feet long and 8 feet high, built of timber and stone. A few hundred feet below is a third dam, about 2 feet high, from which lead two races, one on each side, one running a tannery with a fall of 32 feet (over 40 being available), and the other a spoke factory with a fall of 16 feet, and a grist-mill with 20 feet, the power used being small.

The power offered by the Paupack river below Wilsonville is probably the finest in the valley of the Lackawaxen, and perhaps as good as any in the whole valley of the upper Delaware. No gaugings of the stream are on record, except some observations made while the dam was being built, according to which the discharge was 125 cubic feet per second. It is probable, however, that the flow is at times much smaller than this, and I should estimate the minimum at not over 50 cubic feet per second and the flow during the low season of ordinary years as perhaps 75 cubic feet per second. This would afford 8.5 horse-power per foot fall, and with the large fall available the power which could be developed is quite large. It could no doubt be very much increased by artificial storage.

Middle creek, which joins the Lackawaxen at Hawley, is a small stream, but has considerable available power. No details are at hand.

The West or main branch of the Lackawaxen affords considerable power. At Honesdale there are three dams, the lower one, 9 or 10 feet high, supplying a planing-mill, the next being the canal feeder-dam, and the next running a grist-mill, with a fall of 7 feet. At Seelyville, a mile above, there is quite an important power. There are two dams, about 300 feet apart, the upper one 16 or 18 feet high, built of stone in hydraulic cement, and the lower one, 2 feet high, of timber. The upper dam runs a stick factory with a fall of 16 feet, and a saw-mill and woolen-mill with a fall of 28 or 30 feet, discharging below the lower dam. The lower dam, below which is a natural fall of 12 or 14 feet, runs a machine shop and sash-and-blind factory with a fall of 14 feet. The total power used can not be stated with accuracy. There are other smaller establishments of various kinds on the stream above this point.

The East branch of the Lackawaxen, known as the Dyberry, has a fall of 30 feet at Tanner's falls, 7 miles above Honesdale, used by a tannery and some saw-mills; but no further details regarding the power of the stream are at hand.

The other tributaries of the Delaware below the junction of the two branches are utilized by small saw-mills, but their power, although considerable, does not merit a special description, as they closely resemble the tributaries already considered.

It remains to describe the two branches of the Delaware which unite at Hancock. The East branch, or Pepacton, takes its rise in the eastern part of Delaware county, through which it flows in a southwesterly direction for a distance of about 50 miles in a straight line. It drains an area of about 919 square miles, comprising a region as yet but little developed, passing no large towns, and with few mills except small grist- and saw-mills. Its fall is considerable, but gradual, there being no cataracts or even remarkable rapids, so far as I could learn. Its bed is mostly gravel and sand, and its flow subject to large variations. There are a few lakes in the basin, but they are small in comparison with the size of the stream, and do little to regulate its flow; though the facilities for artificial storage are said to be good. The drainage basin is quite well wooded, and is the seat of considerable lumbering. Formerly many rafts were sent down the East branch, but now the lumbering is more confined to the Pepacton. Details regarding the power of the stream could not be obtained with the time at disposal. That which is utilized is tabulated below, and in regard to that which is available, it may safely be said that it is very large, though no specially good sites can be indicated.

Of the tributaries of the Pepacton many have been utilized to a considerable extent to run saw-mills, but a large proportion of these mills have been abandoned in late years on account of the want of timber, so that the streams are now utilized only to a very small extent. The principal of these streams is the Beaver kill, which rises in the western part of Ulster county, near the sources of the Neversink, and flows nearly west, draining about 320 square miles. Its fall is large, but probably not so large as that of the Mongaup and the Neversink, its neighbors. It offers an abundance of fine power, but little of which is utilized, for saw-mills and tanneries. Trout brook, one of its affluents, takes its rise in a lake known as Long pond, about 2 miles long by three-eighths of a mile wide. The level of this lake is raised 6 feet by a dam, and just below the outlet is a natural fall of 25 feet, utilized by a saw-mill, and there are other saw-mills lower down. There are other lakes in the vicinity whose outlets are dammed and the fall utilized for power.

The West or main branch of the Delaware is similar in general character to the East branch, but it drains a more open, cultivated, and better-developed country. Its basin is not so well wooded, and it is fed by but a few small lakes, so that, as would be expected, its flow is said to be more variable than that of the East branch. Its fall is gradual and its utilized power very small. Less than a mile above the forks is a saw-mill with a fall of 7 feet; at Hale's eddy there is a second one with a fall of 5 feet; at Deposit is a third with a fall of 6 feet. At Stiles' settlement, a mile and a half above, a fall of 5 feet supplies power to several mills of different kinds, and above are other small mills. At Delhi a woolen-mill uses a fall of 10 feet, but, with the exception of this and a few other small woolen-mills, the mills are grist- and saw-mills. The available power is doubtless large, but as the slope is gradual I learned of no particular sites.

The tributaries of the West branch do not require detailed description, as none of them are large or important. They have considerable fall, though not so much by any means as the tributaries between Port Jervis and Hancock, and they are sometimes fed by small lakes, which serve to regulate the flow, some of which are dammed. Like the other streams in the vicinity, they are not utilized now as much as they were formerly, on account of the thinning out of the timber.

The following tables have already been referred to. They contain what additional information is needed to give an idea of the power of the Delaware:

Table of drainage areas of the Delaware river and tributaries.

Name of stream.	Tributary to what.	Locality.	Drainage area.
			Square miles.
Delaware river	Delaware bay	Below junction of East and West branches	1,604
Do	do	Long eddy	1,733
Do	do	Pond eddy	2,946
Do	do	Port Jervis	3,252
Do	do	Below mouth of Neversink	3,600
Do	do	Belvidere (without Pequest creek)	4,550
Do	do	Wycott	4,790
Do	do	Easton (without Lehigh river)	4,880
Do	do	Bull's falls	6,750
Do	do	Lambertville	6,820
Do	do	Scudder's falls	6,894
Do	do	Trenton (without Assanpink creek)	6,916
Do	do	Philadelphia (without Schuylkill river)	8,186
Do	do	Philadelphia (including Schuylkill river)	10,100
West branch	Delaware river	Walton	348
Do	do	Deposit (without Oquaga creek)	519
Do	do	Hale's eddy	634
Do	do	Mouth	685
East branch	do	Above mouth of Beaver kill	520
Do	do	Mouth	919
Little Delaware creek	West branch	do	53
Oquaga creek	do	do	82
Beaver kill	East branch	do	322
Callicoon creek	Delaware river	do	123
Mongaup creek	do	do	231
Neversink river	do	do	546
Basha's kill	Neversink river	do	67
Lackawaxen river	Delaware river	Honesdale	161
Do	do	Mouth	597
Paupack creek	Lackawaxen river	do	233
Blooming Grove creek	do	do	29
Shohola creek	Delaware river	do	91
Bushkill creek	do	do	158
Analomink creek	do	do	289
Bushkill creek (Easton)	do	do	75
Lehigh river	do	Gouldsborough	75
Do	do	White Haven	290
Do	do	Tannery	300
Do	do	Mauch Chunk	581
Do	do	Perryville	727
Do	do	Lehigh gap	870
Do	do	Lowry's	940
Do	do	Hokendoqua	985
Do	do	Allentown (without Little Lehigh)	1,009
Do	do	Glendon	1,328
Do	do	Mouth	1,352
Tobyhanna creek	Lehigh river	do	121
Bear creek	do	do	50
Little Lehigh creek	do	do	177
Schuylkill river	Delaware river	Schuylkill Haven	134
Do	do	Above mouth of Little Schuylkill	260
Do	do	Reading	889
Do	do	Limerick dam	1,142
Do	do	Phœnixville	1,323
Do	do	Pawling	1,707
Do	do	Norristown	1,752
Do	do	Conshohocken	1,787
Do	do	Manayunk	1,817
Do	do	Fairmount	1,880
Do	do	Mouth	1,912

Table of drainage areas of the Delaware river and tributaries—Continued.

Name of stream.	Tributary to what.	Locality.	Drainage area.
			Square miles.
Little Schuylkill river	Schuylkill river	Mouth	134
Tulpehocken creek	do	do	219
Maiden creek	do	do	205
Manatawny creek	do	do	97
Perkiomen creek	do	do	345
Flat brook	Delaware river	do	58
Little Flat brook	Flat brook	do	14
Pequest creek	Delaware river	Vienna	89
Do	do	Townsbury	94
Do	do	Butzville	118
Do	do	Mouth	161
Musconetcong creek	do	Asbury	122
Do	do	Bloomsbury	138
Do	do	Mouth	150
Paulin's kill	do	do	*a* 170
Pohatcong creek	do	do	*a* 50
Assanpink creek	do	do	*a* 105
Crosswick's creek	do	do	*a* 115
Rancocas creek	do	do	346
Rancocas creek, South branch	Rancocas creek	do	142
Rancocas creek, North branch	do	Pemberton	136
Do	do	Smithville	154
Do	do	Mouth	*a* 164
Cooper's creek	Delaware river	do	*a* 56
Big Timber creek	do	do	*a* 50
Mantua creek	do	do	*a* 51
Raccoon creek	do	do	*a* 58
Oldman's creek	do	do	*a* 43
Salem creek	do	do	*a* 109
Alloway's creek	do	do	*a* 285
Cohansey creek	Delaware bay	do	*a* 100
Do	do	Bridgeton	52
Maurice river	do	Millville	217
Do	do	Mouth	360
Christiana creek	do	do	465
Do	do	Above mouth of White Clay creek	46
White Clay creek	Christiana creek	Mouth	98
Red Clay creek	White Clay creek	do	52
Brandywine creek	Christiana creek	Contesville	25
Do	do	Wilmington	238

a These figures are taken from Professor Cook's report on the *Geology of New Jersey*. My own measurements did not agree with his very well, giving the areas always considerably larger, generally by from 10 to 20 per cent. Thus, Professor Cook gives the following as the drainage areas of some of the streams named above, and for which the above table gives my results: Pequest, 140; Musconetcong, 124; Rancocas, 320; Maurice, 360.

Table of utilized power on the Delaware river and tributaries.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
Delaware river	Delaware bay	Pennsylvania	Bucks	Flouring and grist	(?)6	35	263
Do	do	do	do	Flouring and grist	1	*a* 10½	8
Do	do	do	do	Paper (*b*)	1	9	165
Do	do	New Jersey	Mercer	Wood-turning (*c*)	1	7	25
Do	do	do	do	Machinery (*c*)	2	25	40
Do	do	do	do	Planing (*c*)	2	28	85
Do	do	do	do	Hardware (*c*)	1	16	20
Do	do	do	do	Plaster (*c*)	1	14	97
Do	do	do	do	Carpentering (*c*)	1	18	12
Do	do	do	do	Flouring and grist (*c*)	5	73	170
Do	do	do	do	Rolling-mill (*c*)	1	11	100
Do	do	do	do	Woolen (*c*)	4	52	160
Do	do	do	do	Flouring and grist	4	*d* 91	130
Do	do	do	Hunterdon	Cotton (*e*)	1	8½	65

a From Delaware Division canal. *b* Being built. *c* At Trenton. *d* From canal to river. *e* At Lambertville.

Table of utilized power on the Delaware river and tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
Delaware river	Delaware bay	New Jersey	Hunterdon	Machinery (*a*)	1	19	100
Do	do	do	do	Paper (*a*)	3	35	196
Do	do	do	do	Twine (*a*)	1	9	69
Do	do	do	do	Flouring and grist (*a*)	2	37	95
Do	do	do	do	Saw (*a*)	1	17	25
Do	do	do	do	do	1	2	18
Do	do	do	do	Flouring and grist	1	8	22
Do	do	Pennsylvania	Monroe	do	(*b*)1	8	16
Do	do	do	Wayne	do	(*b*)	(*b*)	(*b*)
Tributaries of	Delaware bay	Delaware	Sussex	Woolen	1		5
Do	do	do	do	Flouring and grist	10	61	157
Do	do	do	do	Saw	12	81	249
Do	do	do	Kent	Woolen	1	8	30
Do	do	do	do	Dye-woods, etc	1	6	40
Do	do	do	do	Upholstering materials	1	6	18
Do	do	do	do	Foundery	1	8	12
Do	do	do	do	Saw	3	31	60
Do	do	do	do	Flouring and grist	24	210	699
Christiana creek	Delaware river	do	New Castle	Agricultural implements	1	12	15
Do	do	do	do	Flouring and grist	5	76	147
Brandywine creek	Christiana creek	do	do	Gunpowder		59	500
Do	do	do	do	Cooperage	1	8	10
Do	do	do	do	Flouring and grist	(*b*)2	27	155
Do	do	do	do	Paper	3	50	500
Do	do	do	do	Cotton	5	64	470
Do	do	Pennsylvania	Chester	Flouring and grist	16	222	342
Do	do	do	do	Saw	7	101	126
Do	do	do	do	Machinery	1	6	20
Do	do	do	do	Paper	4	34	111
Do	do	do	Delaware	Flouring and grist	1	4	56
Do	do	do	Chester	Iron and steel	2	36	120
Other tributaries of	Delaware river	Delaware	New Castle	Woolen	5	50±	189
Do	do	do	do	Rolling	2	30	189
Do	do	do	do	Paper	1	12	84
Do	do	do	do	Carriage materials	1	13	8
Do	do	do	do	Saw	6	90	122
Do	do	do	do	Flouring and grist	25	435	621
Do	do	Pennsylvania	Chester	Fertilizers	1	8	25
Do	do	do	do	Butter and cheese	2	36	10
Do	do	do	do	Flouring and grist	76	1,852	1,183
Do	do	do	do	Saw	24	410	331
Do	do	do	do	Leather	1	14	8
Do	do	do	do	Plaster	1	12	40
Do	do	do	do	Machinery	2	26	29
Do	do	do	do	Paper	13	225	454
Do	do	do	do	Wood-turning	1	21	10
Do	do	do	do	Woolen	9	150	230
Do	do	do	do	Iron	1	12	
Do	do	do	Delaware	Flouring and grist	27	488	549
Do	do	do	do	Saw	9	159	129
Do	do	do	do	Cutlery, etc	1	20	40
Do	do	do	do	Paper	6	119	215
Do	do	do	do	Cotton	9		816
Do	do	do	do	Woolen	13	187	555
Maurice river	Delaware bay	New Jersey	Gloucester	Flouring and grist	1	7	30
Do	do	do	Cumberland	Water-works	1	24	40
Do	do	do	do	Foundery	1	24	60
Do	do	do	do	Flouring and grist	1	24	40
Do	do	do	do	Cotton	1	24	400
Do	do	do	do	Blacking	1	24	50
Do	do	do	do	Bleachery	1	24	100
Do	do	do	do	Saw	1	11	70
Cohansey creek	do	do	do	Flouring and grist	7	108	141
Do	do	do	do	Saw	2	20	30
Do	do	do	do	Rolling	1	14	150

a At Lambertville.

Table of utilized power on the Delaware river and tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
Rancocas creek	Delaware river	New Jersey	Burlington	Flouring and grist	6	47	275
Do	do	do	do	Saw	6	53	142
Do	do	do	do	Cotton	1	6	15
Do	do	do	do	Machinery	1	8	100
Other tributaries of	Delaware bay	do	Cape May	Flouring and grist	3	14	26
Do	do	do	Cumberland	do	10	36	142
Do	do	do	do	Saw	7	68	133
Do	Delaware river	do	Salem	Flouring and grist	15	185	396
Do	do	do	do	Saw	13	130	242
Do	do	do	do	Wood-turning	1	8	7
Do	do	do	Gloucester	Woolen	1	13	40
Do	do	do	do	Flouring and grist	17	261	378
Do	do	do	do	Saw	8	85	107
Do	do	do	Camden	Agricultural implements	1	12	25
Do	do	do	do	Flouring and grist	6	70	154
Do	do	do	do	Saw	2	21	75
Do	do	do	do	Paint	1	15	20
Do	do	do	Burlington	Flouring and grist	17	170	443
Do	do	do	do	Saw	8	75	144
Do	do	do	Mercer	Woolen	1	18	.....
Do	do	do	do	Cotton	1	7½	80
Do	do	do	do	Flouring and grist	9	88	265
Do	do	do	do	Saw	2	22	100
Do	do	do	do	Rubber	2	16	115
Do	do	do	do	Plaster	1	8	25
Do	do	do	do	Wood-turning	1	6	20
Do	do	do	Ocean	Flouring and grist	2	24	50
Do	do	do	do	Saw	2	15	28
Do	do	do	Monmouth	Flouring and grist	10	103	254
Musconetcong creek	do	do	Morris	do	1	10	55
Do	do	do	Warren	Woolen	1	7½	15
Do	do	do	do	Flouring and grist	6	.....	240
Do	do	do	do	Paper	1	22	145
Do	do	do	do	Agricultural implements	1	6	8
Do	do	do	do	Foundery	1	9	18
Do	do	do	Hunterdon	Cutlery	1	8	65
Do	do	do	do	Paper	1	28	250
Do	do	do	do	Saw	2	20	30
Do	do	do	do	Flouring and grist	4	36	150
Do	do	do	Sussex	do	1	.....	18
Pequest creek	do	do	Warren	do	8	77	280
Do	do	do	do	Saw	1	14	12
Do	do	do	do	Carriage	1	16	20
Do	do	do	do	Carriage materials	1	16	20
Do	do	do	do	Furniture	1	16	60
Do	do	do	Sussex	Flouring and grist	4	51	100
Do	do	do	do	Saw	2	24	44
Other tributaries of	do	do	Hunterdon	Woolen	1	24	8
Do	do	do	do	Sashes, doors, and blinds	1	24	20
Do	do	do	do	Wood-turning	1	.....	10
Do	do	do	do	Saw	8	176	193
Do	do	do	do	Flouring and grist	16	322	342
Do	do	do	Warren	do	39	723	1,146
Do	do	do	do	Sashes, doors, and blinds	1	9	10
Do	do	do	do	Wheelwrighting	1	12	20
Do	do	do	do	Saw	14	.....	286
Do	do	do	do	Agricultural implements	1	20	9
Do	do	do	do	Furniture	1	.....	3
Do	do	do	Sussex	Flouring and grist	18	305	448
Do	do	do	do	Brooms, etc	1	9	20
Do	do	do	do	Foundries	2	16	16
Do	do	do	do	Saw	5	75	83
Do	do	do	do	Leather	2	20	23
Do	do	do	do	Woolen	1	.....	35
Schuylkill river	do	Pennsylvania	Philadelphia	Water-works	1	12±	700
Do	do	do	do	Cotton	4	84	630
Do	do	do	do	Cotton and woolen	2	40	26

Table of utilized power on the Delaware river and tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
Schuylkill river	Delaware river	Pennsylvania	Philadelphia	Paper	4	82	525
Do	do	do	do	Flouring	1	19	21
Do	do	do	do	Woolen	1	20	31
Do	do	do	Montgomery	Rolling	1	8	80
Do	do	do	do	Cotton	2	17	242
Do	do	do	do	Flouring	1	9	30
Do	do	do	Chester	Flouring and grist	2	14	55
Do	do	do	do	Rolling	1	9	49
Do	do	do	Berks	Flouring and grist	2	14	56
Do	do	do	Schuylkill	do	2	20	46
Do	do	do	do	Saw	1	16	24
Do	do	do	do	Gunpowder	1	.....	20
Tributaries of	Schuylkill river	do	Philadelphia	Paper	1	16	80
Do	do	do	do	Cotton	1	40	12
Do	do	do	Delaware	Flouring and grist	2	37	55
Do	do	do	do	Saw	1	28	35
Do	do	do	Chester	Agricultural implements	2	29	20
Do	do	do	do	Fertilizers	1	8	25
Do	do	do	do	Hardware	1	7	10
Do	do	do	do	Flouring and grist	41	657	700
Do	do	do	do	Saw	14	195	208
Do	do	do	do	Planing	1	28	20
Do	do	do	do	Machinery	1	5	10
Do	do	do	do	Paper	3	68	67
Do	do	do	do	Rolling	2	40	80
Do	do	do	do	Woolen	2	16	30
Perkiomen creek	do	do	Berks	Flouring and grist	8	124	131
Do	do	do	do	Leather	2	18	26
Do	do	do	Montgomery	Oil	3	47	64
Do	do	do	do	Paper	1	15	20
Do	do	do	do	Sashes, doors, and blinds	1	7	12
Do	do	do	do	Leather	1	6	20
Do	do	do	do	Flouring and grist	23	208	647
Do	do	do	do	Saw	3	33	87
Manatawny creek	do	do	Berks	Iron-forging	1	14	75
Do	do	do	do	Flouring and grist	10	99	188
Do	do	do	do	Saw	3	19	43
Do	do	do	do	Paper	1	14	25
Do	do	do	do	Rolling	1	14	110
Do	do	do	Montgomery	Flouring and grist	1	12	75
Do	do	do	do	Rolling	1	13	100
Tulpehocken creek	do	do	Lebanon	Flouring and grist	2	13	50
Do	do	do	Berks	do	12	68	218
Do	do	do	do	Saw	1	7	17
Do	do	do	do	Rolling	1	8	25
Maiden creek	do	do	do	Flouring and grist	7	43	141
Do	do	do	do	Saw	3	19	72
Other tributaries of	do	do	Montgomery	Woolen	4	59	110
Do	do	do	do	Cotton	1	12½	20
Do	do	do	do	Agricultural implements	1	8	6
Do	do	do	do	Brass foundery	1	26	40
Do	do	do	do	Cutlery	1	6	8
Do	do	do	do	Gunpowder	2	23	33
Do	do	do	do	Paper	2	26	40
Do	do	do	do	Shoddy	1	17	30
Do	do	do	do	Wheelwrighting	1	12	10
Do	do	do	do	Leather	2	11	30
Do	do	do	do	Flouring and grist	71	1,019	1,402
Do	do	do	do	Saw	11	126	195
Do	do	do	Bucks	do	1	.....	15
Do	do	do	do	Flouring and grist	14	267	240
Do	do	do	Lebanon	Blacksmithing	1	.....	5
Do	do	do	do	Flouring and grist	5	85	73
Do	do	do	Lehigh	Agricultural implements	1	18	8
Do	do	do	do	Foundery	1	18	8
Do	do	do	do	Flouring and grist	4	69	55

Table of utilized power on the Delaware river and tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
Other tributaries of	Schuylkill river	Pennsylvania	Lehigh	Saw	1	15	20
Do	do	do	do	Woolen	1	8	20
Do	do	do	Berks	Woolen	4	.....	87
Do	do	do	do	Rolling	2	47	165
Do	do	do	do	Forges and blomaries	8	25	66
Do	do	do	do	Blast-furnaces	5	95	120
Do	do	do	do	File	2	21	18
Do	do	do	do	Carriage materials	1	13	8
Do	do	do	do	Agricultural implements	2	19	15
Do	do	do	do	Foundories	3	37	72
Do	do	do	do	Flouring and grist	97	1,616	1,837
Do	do	do	do	Saw	25	303	396
Do	do	do	do	Locksmithing	2	29	28
Do	do	do	do	Paper	1	13	24
Do	do	do	do	Tinware, etc	1	15	20
Do	do	do	do	Wheelwrighting	1	10	10
Do	do	do	Schuylkill	Rolling	1	12	110
Do	do	do	do	Blomaries and forges	1	25	.....
Do	do	do	do	Cigar-boxes	1	250	4
Do	do	do	do	Fertilizers	1	10	8
Do	do	do	do	Gunpowder	.....	.....	276
Do	do	do	do	Machinery	1	24	30
Do	do	do	do	Printing	1	.....	3
Do	do	do	do	Saw	3	32	32
Do	do	do	do	Flouring and grist	15	232	334
Do	Delaware river	do	Philadelphia	Cotton	4	.....	73
Do	do	do	do	Agricultural implements	2	42	112
Do	do	do	do	Cutlery	1	13	30
Do	do	do	do	Flouring and grist	6	77	195
Do	do	do	do	Saw	3	34	62
Do	do	do	Montgomery	Agricultural implements	1	20	20
Do	do	do	do	Cutlery	1	14	12
Do	do	do	do	Hardware	1	14	40
Do	do	do	do	Flouring and grist	17	266	365
Do	do	do	do	Saw	2	22	35
Do	do	do	Bucks	Flax	1	16	30
Do	do	do	do	Fertilizers	1	.....	6
Do	do	do	do	Wooden handles	1	10	4
Do	do	do	do	Paper	1	28	35
Do	do	do	do	Plaster	1	10	15
Do	do	do	do	Cotton	1	9	45
Do	do	do	do	Sashes, doors, and blinds	2	49	50
Do	do	do	do	Saw	38	493+	816
Do	do	do	do	Flouring and grist	89	1,350	2,069
Lehigh river	do	do	Northampton	Cotton	1	21	(†)70
Do	do	do	do	Blast-furnace	1	21	180±
Do	do	do	do	Rolling	1	21	120
Do	do	do	do	Machinery	1	21	125
Do	do	do	do	Flouring and grist	3	38	60
Do	do	do	do	Foundery	1	8	6
Do	do	do	do	Paint	1	9	30
Do	do	do	do	Slate	1	13	13
Do	do	do	do	Saw	1	4½	25
Do	do	do	Lehigh	Barrels	1	12	18
Do	do	do	do	Cement	1	8	.....
Do	do	do	do	Rolling and furnace	1	8	.....
Do	do	do	do	Slate	2	8	40
Do	do	do	do	Flouring and grist	3	37	.....
Do	do	do	Carbon		1	8	.....
Do	do	do	do	Paint	2	30	.....
Do	do	do	Luzerne	Saw	4	86	200
Do	do	do	do	Foundery	1	21	80
Do	do	do	Lackawanna	Leather	1	17	60
Do	do	do	do	Saw	1	12	20
Tributaries of	Lehigh river	do	Monroe	Flouring and grist	4	66	118
Do	do	do	do	Saw	4	70	270
Do	do	do	Carbon	Blast-furnace	1	4	15

Table of utilized power on the Delaware river and tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
Tributaries of	Lehigh river	Pennsylvania	Carbon	Fertilizers	3	45	39
Do	do	do	do	Saw	16	221	299
Do	do	do	do	Flouring and grist	10	143	167
Do	do	do	Schuylkill	Saw	4	59	45
Do	do	do	do	Leather	1	15	5
Do	do	do	do	Flouring and grist	6	.....	64
Do	do	do	Northampton	Agricultural implements	4	58	42
Do	do	do	do	Hardware	1	6	8
Do	do	do	do	Machinery	1	14	15
Do	do	do	do	Slate	2	24	22
Do	do	do	do	Flouring and grist	43	676	1,004
Do	do	do	do	Saw	6	63	81
Do	do	do	Berks	Flouring and grist	4	76	82
Do	do	do	do	Leather	1	5	9
Do	do	do	Lehigh	Agricultural implements	1	6	8
Do	do	do	do	Carriage materials	4	57	57
Do	do	do	do	Fertilizers	1	12	18
Do	do	do	do	Foundery	1	10	16
Do	do	do	do	Flouring and grist	63	974	1,232
Do	do	do	do	Cooperage	1	19	16
Do	do	do	do	Leather	2	21	20
Do	do	do	do	Saw	12	165	170
Do	do	do	do	Machinery	1	7	10
Do	do	do	do	Mantels, slates, etc	2	13	22
Do	do	do	do	Water-works	1	6	.....
Other tributaries of	Delaware river	do	Northampton	Agricultural implements	2	22	28
Do	do	do	do	Fire-arms	1	16	32
Do	do	do	do	Planing	1	11	40
Do	do	do	do	Marble and stone work	2	23	62
Do	do	do	do	Paint	1	7	40
Do	do	do	do	Slate	6	47+	72
Do	do	do	do	Wheelwrighting	1	.....	2
Do	do	do	do	Flouring and grist	28	432	961
Do	do	do	do	Leather	1	12	12
Do	do	do	do	Saw	10	101	236
Analomink creek	do	do	Monroe	Fertilizers	1	8	12
Do	do	do	do	Machinery	1	4½	10
Do	do	do	do	Leather	1	15	15
Do	do	do	do	Flouring and grist	3	33	83
Do	do	do	do	Saw	4	82	155
Other tributaries of	do	do	do	Woolen	2	.....	55
Do	do	do	do	Agricultural implements	2	32	30
Do	do	do	do	Blacksmithing	1	10	22
Do	do	do	do	Carriage materials	1	13	30
Do	do	do	do	Emery-wheels	1	23½	130
Do	do	do	do	Foundery	1	14	20
Do	do	do	do	Sporting goods	1	9	2
Do	do	do	do	Slate	2	24	35
Do	do	do	do	Sashes, doors, and blinds	1	14	75
Do	do	do	do	Leather	2	.....	32
Do	do	do	do	Flouring and grist	23	344	679
Do	do	do	do	Saw	5	72	79
Paupack creek	Lackawaxen river	do	Pike	Leather	1	40	40
Do	do	do	Wayne	Agricultural implements	1	9	5
Do	do	do	do	Carriage materials	1	26	25
Do	do	do	do	Wooden handles	1	16	25
Do	do	do	do	Saw	9	152	(b) 344
Do	do	do	do	Leather	1	15	75
Do	do	do	do	Silk	1	56	.....
Do	do	do	do	Flouring and grist	2	52	140
Do	do	do	do	Woolen	1	10	10
Other tributaries of	do	do	Pike	Furniture	1	9	20
Do	do	do	do	Flouring and grist	2	14	25
Do	do	do	do	Leather	1	16	40
Do	do	do	do	Saw	6	92	165
Do	do	do	Wayne	Woolen	2	38	72

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Table of utilized power on the Delaware river and tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
Other tributaries of	Lackawaxen river	Pennsylvania	Wayne	Wheelwrighting	2	29	60
Do	do	do	do	Cutlery	1	20	50
Do	do	do	do	Saw	27	325+	700
Do	do	do	do	Leather	4	70	118
Do	do	do	do	Flouring and grist	16	275	672
Do	do	do	Lackawanna	Saw	3	40	185
Do	Delaware river	do	Pike	Agricultural implements	1	13	18
Do	do	do	do	Carriage materials	2	38	20
Do	do	do	do	Flouring and grist	5	109	113
Do	do	do	do	Leather	2	36	29
Do	do	do	do	Saw	11	.....	157
Do	do	do	Wayne	Drugs and chemicals	1	10	8
Do	do	do	do	Furniture	1	10	7
Do	do	do	do	Wooden handles	1	14	35
Do	do	do	do	Toys	1	14	35
Do	do	do	do	Saw	32	605	1,038
Do	do	do	do	Leather	3	.....	68
Do	do	do	do	Flouring and grist	4	73	83
Neversink river	do	New York	Ulster	Saw	6	72	155
Do	do	do	do	Leather	1	15	30
Do	do	do	do	Wooden ware	3	40	120
Do	do	do	do	Furniture	1	16	8
Do	do	do	Sullivan	Saw	4	33	100
Do	do	do	do	Leather	1	16	50
Mongaup creek	do	do	do	Saw	10	125	182
Do	do	do	do	Leather	1	17	8
Do	do	do	do	Wooden ware	1	14	20
Do	do	do	do	Woolen	1	10	10
Do	do	do	do	Flouring and grist	4	56	123
Callicoon creek	do	do	do	Saw	3	51	60
Pepacton river, or East branch of	do	do	Delaware	Woolen	1	4	7
Do	do	do	do	Cooperage	1	3½	4
Do	do	do	do	Foundery	1	4	10
Do	do	do	do	Flouring and grist	3	34	60
Do	do	do	do	Saw	4	38	(b)105
Do	do	do	Greene	do	2	20	64
Beaver kill	Pepacton river	do	Sullivan	do	4	30	80
Do	do	do	do	Leather	2	18	124
Do	do	do	do	Wooden ware	1	10	30
Do	do	do	do	Flouring and grist	1	9	32
Do	do	do	Ulster	Saw	1	20	50
Do	do	do	do	Wooden ware	1	20	30
Other tributaries of	do	do	Sullivan	Saw	7	64	251
Do	do	do	do	Leather	2	28	116
Do	do	do	do	Wood-turning	a 1	11	24
Do	do	do	do	Wooden ware	1	27	30
Do	do	do	do	Flouring and grist	1	18	25
Do	do	do	Delaware	Woolen	1	14	6
Do	do	do	do	Agricultural implements	1	18	6
Do	do	do	do	Drugs and chemicals	1	.....	8
Do	do	do	do	Flouring and grist	8	126	190
Do	do	do	do	Saw	46	650	1,200
Do	do	do	do	Leather	4	.....	67
Do	do	do	do	Planing	1	21	10
Do	do	do	do	Machinery	3	40	24
Do	do	do	do	Sashes, doors, and blinds	2	18	14
Do	Delaware river	do	Orange	Planing	1	28	20
Do	do	do	do	Plaster	1	18	25
Do	do	do	do	Sashes, doors, and blinds	1	20	40
Do	do	do	do	Carriage materials	1	18	30
Do	do	do	do	Flouring and grist	4	78	110
Do	do	do	do	Furniture	1	.....	19
Do	do	do	do	Saw	1	14	25
Do	do	do	Sullivan	do	98	574	708
Do	do	do	do	Leather	2	26	40
Do	do	do	do	Wheelbarrows	1	22	40
Do	do	do	do	Wood-turning	2	26	43

Table of utilized power on the Delaware river and tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
Other tributaries of	Delaware river	New York	Sullivan	Cooperage	1	9	16
Do	do	do	do	Excelsior	2	41	80
Do	do	do	do	Furniture	1	10	16
Do	do	do	do	Paper	1	18	15
Do	do	do	do	Flouring and grist	18	351	503
Do	do	do	Delaware	Saw	3	34+	72
West branch of	do	do	do	Woolen	3	28	34
Do	do	do	do	Agricultural implements	1	11	5
Do	do	do	do	Cooperage	2	17	7
Do	do	do	do	Cutlery	1	5	8
Do	do	do	do	Furniture	1	11	3
Do	do	do	do	Hardware	1	3	8
Do	do	do	do	Flouring and grist	6	72	188
Do	do	do	do	Saw	9	84	117
Do	do	do	do	Leather	2	26	25
Do	do	do	do	Machinery	1	19	11
Do	do	do	do	Wooden ware	1	5	6
Tributaries of	do	do	do	Woolen	1	20	26
Do	do	do	do	Carriage	1	18	20
Do	do	do	do	Cooperage	2	17	13
Do	do	do	do	Drugs and chemicals	1	2	8
Do	do	do	do	Furniture	2	.....	(?)22
Do	do	do	do	Flouring and grist	11	198	336
Do	do	do	do	Saw	20	312	431
Do	do	do	do	Leather	2	.....	35
Do	do	do	Broome	Flouring and grist	1	9	45

VIII.—THE COAST STREAMS OF NEW JERSEY.

Under this head will be considered the remaining streams in the district assigned to me, comprising all those flowing into the Atlantic ocean from the state of New Jersey, or between cape May and the Hudson river. Of these streams, those draining the southern part of the state differ considerably in character from those draining the northern part; and to understand clearly the cause and the nature of this difference, it will be necessary to consider for a moment the general features of the topography and geology of the state. In the introduction to this report attention has already been called to the fact that the system of the Alleghanies approaches very near the coast in northern New Jersey, so that the Atlantic plain, which bounds that system on the east, lying between it and the ocean, although some 50 miles wide in New England, and very much wider south of the state of Pennsylvania, almost vanishes near the mouth of the Hudson. Of the three divisions into which the Atlantic water-shed may be divided, namely, the mountainous or western, the middle, and the eastern, and which are so well marked in the southern states, the eastern almost disappears in the northern part of New Jersey, and the middle one is reduced to a narrow strip, averaging only 20 miles in width through the state, from the Hudson to the Delaware, so that the mountain region, although not so high or so broken as toward the south or the north, borders almost on the coast. Extending across the state from northeast to southwest, and including all the northern and northwestern part of the state, it is separated from the coast by the narrow middle region just referred to, and, beyond the fall-line, by a plain belonging to the eastern division, varying in width from nothing at the north to 50 or 60 miles at the south, and including all the southern and southeastern part of the state. But, as has already been remarked in the introduction, this eastern division is not by any means so low and flat as the eastern division in the southern states. On the contrary, the divide which lies in that division, and forms the water-shed between the streams flowing directly to the ocean, and those tributary to the Delaware river, has an average elevation of from 160 to 190 feet, and lies at a distance from the sea of from 20 to 40 miles only, so that the slope toward the ocean is between 4 and 7 or 8 feet per mile. As we cross the state from south to north, then, we encounter first a comparatively level or gently sloping plain, covering the entire southern part of the state; then we cross the fall-line, and after passing over the middle region we come to the Appalachian chain, with its broad belt or series of ridges, which cross the state from southwest to northeast, and occupy all its northern and northwestern parts. The boundaries of these three divisions may be indicated approximately as follows: The fall-line, which forms the boundary between the eastern and the middle division, lies almost in a straight line between Trenton and Jersey City, while the boundary between

the middle and western divisions is the first range of hills which we may consider to belong to the latter, namely, that formed by Mine mountain, Trowbridge mountain, Stony Brook mountain, and Ramapo mountain. Geologically, the eastern division belongs to the Tertiary and Cretaceous formations, and the soil is sand, gravel, clay, and marl; the middle division is Triassic, the rocks being red sandstone, but intercepted by numerous trap ridges, whose general direction is nearly northeast and southwest; and the western division belongs to the Azoic and Paleozoic formations. The difference between the northern and the southern streams is now easily understood. The former have considerable fall, and although their declivities are often uniform on account of the large masses of drift through which their courses lie, yet, where they cross the trap ridges, and the outcrop of other hard rocks, they sometimes show concentrated falls of considerable magnitude. The southern streams, on the contrary, belong, to a certain extent, to the class of sand-hill streams; they have no precipitous falls, they flow with uniform declivities in beds of sand and gravel, and in general they flow directly down hill by the line of steepest descent, nearly at right angles to the coast, their courses being independent of geological configuration, and their beds being simply channels scooped out in the movable deposits in which they lie. As the characteristics of the sand-hill streams will be fully explained when speaking of some tributaries of the Cape Fear, it is unnecessary to refer to them here in detail; but the most important facts are that their flow is very constant, and that the topography of the region which they drain is favorable to storage, so that large reservoirs can be formed, and the power available very largely increased in that way.

In order to understand clearly the character of the more northern streams, the topography of the western and middle divisions must be described rather more at length. That part of the Appalachian chain which lies in New Jersey consists of two principal ranges, the Blue or Kittatinny Mountain and the Highland range. The former, known in New York as the Shawangunk, and in Pennsylvania as the Kittatinny Mountain, extends in an almost unbroken ridge from the New York state line to the Delaware water-gap, and is the highest land in the state, varying from about 900 to 1,800 feet in height. The Highland range, on the contrary, "is composed of a great number of mountain ridges, and while it occupies a belt of country 22 miles wide on the New York state line, and 10 miles wide on the Delaware, it really includes no long, unbroken ridges, except the Green Pond mountain range; and the subordinate ridges of which it is composed are not really in line with each other, nor are their axes parallel to the direction of the main range, but are somewhat oblique to it, so that if the direction of the range is northeast, that of these ridges would be about north-northeast. The effect of this peculiar arrangement is to make it possible to cross from one side of the range to the other in a north-northeast direction without surmounting any considerable elevation, while it is impossible to cross it from southeast to northwest without rising over a succession of steep and high mountain ridges". The range is lowest at the Delaware, and gradually rises toward the New York state line, its highest point being 1,488 feet above the sea. The ranges vary greatly in surface, but are much smoother and more rounded in outline than the Kittatinny Mountain; and while many are deeply covered with earth, others are of loose stone or bare rock. The existence of these ridges, parallel but not continuous, serves in many cases to explain the courses of the rivers, often very crooked.

The middle region, or red-sandstone district, "like that of Massachusetts and Connecticut, as well as those of New York and Pennsylvania, is traversed by various and irregularly-distributed ridges of trap-rock. These rough, rocky, and wooded ridges are remarkable from their occurrence in the midst of a rich, highly cultivated, and productive agricultural district. The principal of these ridges are, Sourland mountain, in Hunterdon and Somerset counties; Rocky Hill, in Somerset; Round Valley mountain, in Hunterdon; Bergen hill and Palisade mountain, in Hudson and Bergen counties, and the First, Second, and Third mountains, which form the long, narrow, and parallel ridges that rise in Somerset and run across Union, Essex, Morris, Passaic, and Bergen counties. They are rough in outline, very abrupt in their descent toward the southeast, and gentle in their slope toward the northwest".(a) Being composed of hard and durable rock, occurring in the midst of the soft red sandstone, they are of great importance as regards the water-power of the streams which cross them, and many of the large falls are due to them.

In the southern half of the state, below the fall-line, there are no rocky eminences, and the rounded hills are all of earth.

The valleys between the ranges of mountains in the northern half of the state are covered, and in some places to a considerable depth, with beds of drift, through which the rivers have cut out their channels, reaching, in places, the rock. The valleys offer in many places sites for the construction of storage reservoirs, although the topography is not particularly favorable in this respect; but the flow of the streams is to a certain extent regulated by the numerous lakes and ponds already existing.

These remarks and quotations will serve to give a general idea of the topography of the country; and we now proceed to consider in detail the various streams flowing into the Atlantic, beginning at the south. Regarding those lying below the fall-line, there is little to be said except to refer to the powers utilized. These declivities being uniform as a rule, there are no falls of note, and no sites can be specially mentioned, except a few which have at some time been utilized, and where it is therefore known that power can be obtained. Dams are always necessary, of course, and, generally, only small falls can be utilized.

a The quotations above are from Professor Cook's *Report on the Geology of New Jersey*, to which I am greatly indebted.

The first important stream is the Great Egg Harbor river, which takes its rise in the southern part of Camden county, flows in a southeasterly direction, forming for a short distance the boundary between Camden and Gloucester counties, and afterward flowing through Atlantic county into Egg harbor, an inlet of the ocean. Its length is 41 miles, and it drains a total area of 425 square miles, lying entirely below the fall-line. It is tidal and navigable as far as the town of May's Landing, about 15 miles from the ocean, at which place occurs the first power on the river. Above this point the stream is utilized to a considerable extent, the bed is sand and gravel, the banks are generally low but seldom overflowed, the declivity is gradual, and the ponds are large. No data regarding its flow or declivity could be obtained, except such as follow from the data obtained regarding power utilized.

The power at May's Landing is obtained by damming the stream to a height of about 11 feet, by which the water is ponded over an area of about 1,000 acres to an average depth of 10 or 11 feet, so that considerable storage is afforded. The dam is of earth, about 12 or 13 feet high, and crosses the stream in a broken line, with a total length of about 1,000 feet. Near the center is a stone overfall, about 125 feet long (not included in length of dam) and 11 feet high. The dam was first built many years ago, but was gradually increased in height in order to obtain a larger pond. Although the stream is not subject to very heavy freshets, nevertheless there was one on September 15, 1878, of such violence as to wash out the dam almost completely, carrying away two-thirds of the earthen dam and the entire stone dam, and causing an amount of damage estimated at $13,000. The mills were not injured. In 1879 the dam was rebuilt more solidly than before, but the effect of the freshet in washing out the old dam was to fill up the bed of the river below, so that vessels of 6 or 7 feet draught, which could previously come up almost to the railroad bridge, were obliged to land half a mile or so farther down. The race leading to the wheels is about 500 feet long, 40 feet wide, and 10 feet deep, and the fall used is about 11½ feet, with a power of 120 horse-power utilized. This power can be obtained all the time, the mill being run sixty-four hours a week and no steam-power being used. In fact, there is always a little waste in summer at night. The power is owned by the May's Landing Water Power Company, but at present no power is leased to other parties, all that is used being for the cotton-mill of the company. In regard to the dam, it should further be mentioned that the stone overfall is founded on piles, and that the bed of the stream in front of it is protected by an apron.(*a*)

The drainage area above May's Landing is about 190 square miles. If we take the gross power utilized as 180 horse-power, with a fall of 11½ feet, we find the flow to be about 140 cubic feet per second, or about three-quarters of a cubic foot per second per square mile. As this can be obtained all the time and with always some little waste in the dry season during the night, it is reasonable to conclude that the low-season flow is in the neighborhood of half a cubic foot per second per square mile; so that we may perhaps take the flow of the sand-hill streams of New Jersey as varying between half a cubic foot and one cubic foot per second per square mile, or the same as in the case of the sand-hill streams in the southern states (see pages 61, 62, 84, 85, 97, and 132 of the report on the southern Atlantic water-shed).

The next power, as the river is ascended, is at Weymouth, 5 miles above May's Landing, measured in a straight line, at which place there is a paper-mill, using about 80 horse-power, with a fall of 10 feet, together with a saw-mill, all from one dam. Details regarding the power could not be obtained.

Above this point there is said to be no utilized power of much consequence on the stream, although there are a few small mills scattered about on the various tributaries. The table on pages 137 to 140 gives the statistics of power utilized.

It would doubtless be possible to develop power at some points of the stream and on the tributaries, but no particularly good sites were heard of. On Babcock's creek, a small tributary entering at May's Landing, there is a site near the mouth, formerly in use by a grist- and saw-mill, but now idle; and there are no doubt other similar ones, but to locate and judge of them more extended surveys would of course be required.

The mills in this neighborhood are troubled little with ice or freshets, and the supply of water is comparatively constant.

The next stream requiring special mention is Little Egg Harbor or Mullicas river, which is formed on the line between Atlantic and Burlington counties by the union of several smaller streams, whence it pursues a southeasterly course, emptying into Great Harbor river. It drains a total area of 476 square miles, and its length, measured from its mouth to its sources (not to the junction of the streams just referred to), is about 42 miles. There is no power on the main stream, but on nearly all of the tributaries there are mills, and the power is considered good. Although small, these streams are capable of affording large amounts of power on account of the large storage-room obtained, but only a few scattered notes could be gathered regarding them with the time at disposal. Wading river, the first important tributary, enters from the north, is about 28 miles long, and drains a total area of 140 or more square miles. Its most important power is at Harrisville, on the East branch, where there is a paper-mill using a fall of about 12 feet and about 140 horse-power. A large pond is formed, so that considerable storage is obtained. It is also said that the West branch of the stream, which naturally flows into the river below the dam, is brought in above, being intercepted by a canal. The stream is navigable up to within a few miles of this place.

a The abstracts of power used in cotton-mills, complied from the census returns, give the fall at this place as 9 feet, and the power as 170 horse-power.

A few miles above Harrisville, on the East branch, there is a site, now unoccupied, where there was formerly a furnace and a saw-mill, said to have used a fall of 8 feet. Above this no sites were heard of, although it is probable that power could be obtained there. On the West branch there are several mills and some sites not used, one at Speedwell, where there was formerly an iron furnace, with a fall of 7 feet or so, and some others below that place. It is said that all the mills in this vicinity can run at full capacity all the year.

The two principal streams which go to form the Little Egg Harbor river are the Batsto and the Atsion river, which unite about 6 miles north of Egg Harbor city. Batsto river, the more northerly of the two, has a length of about 18 miles and drains an area of some 70 square miles. The first power is at Batsto, now not in use, but formerly used by iron-works, and a saw- and grist-mill. The fall is stated at about 10 feet and the power is considered the best in the vicinity. Farther up the stream, at the Lower Forge, is another site not in use, and still farther up others can be developed. All the dams on these streams are of earth, and they are seldom disturbed by freshets. The Atsion river, which rises in Camden and Burlington counties and forms for its entire length the boundary line between Camden and Atlantic on the south and Burlington on the north, is considerably larger than the Batsto river, draining somewhere about 150 square miles. The first power is said to be about 2 miles below the town of Atsion, where there was once a mill using a fall of 7 feet. At Atsion we come to the first utilized power—the Atsion cotton-mill. The dam, which is of earth, 600 or 700 feet long and 10 or 12 feet high, ponds the water over a hundred or more acres, and the fall used is 11 feet. The power is stated at 130 horse-power, but this can be obtained during only eleven months, even by drawing down the water in the pond during the day-time, the capacity during the remaining month being about 100 horse-power. In addition to the factory a small grist-mill and a saw-mill are run occasionally. No steam is used for power, and in very dry weather the mill is sometimes obliged to stop. It is said that the pond is connected by a canal with the Mechesatauxen river, a stream flowing nearly parallel with the Atsion, and joining it at a distance of 8 or 10 miles below, so that an additional supply of water is obtained in this way. Above this place there are only very small powers on the stream.

Some of the tributaries of Atsion river have small mills, but none are large enough to merit special description.

The next stream above Little Egg Harbor river is Cedar creek, which is 20 miles long and drains 70 square miles. The next is Tom's river, a larger stream, about 30 miles long and draining about 150 square miles above the village of Tom's River, and with some power utilized and probably some undeveloped. The next is the Metedeconk river, about 22 miles long, and draining about 100 square miles. This stream has two branches which join about 3 miles below Bricksburg, and below the junction there is no power worth mentioning, the tide coming up to within a mile or so of that point; but there was once a forge just above the head of tide-water, with a fall of about 9 feet, it is said. On the North branch there are a few small grist- and saw-mills, but the stream is said to be not so constant as the South branch. On the latter there are several powers. About 2 miles below Bricksburg there was once a saw-mill, now not in use, and at Bricksburg is the best site on the stream. It was used until within a few years by a machine-shop, foundery, blacksmith-shop, and saw-mill, and the dam is still in good condition. It is of earth, about a quarter of a mile long and 10 feet high, serving at the same time as a wagon-road. The overfall is about 20 feet long, and the pond covers probably 20 acres. The fall was about 9 feet, and it was stated that the flow is remarkably constant. There is some power on the stream above this, but it is not important. In fact, the drainage area above Lakewood is in the neighborhood of only 25 square miles; so that the power at that place would presumably not exceed 3 or 4 horse-power per foot fall in very dry seasons, even if the water were stored during the night.

There are no other streams worth mentioning south of the Raritan, so that those just described, together with the lower tributaries of the Delaware, comprise all the streams in the eastern division in the state. The rainfall over all this region is about 48 or 50 inches, of which about 12 inches fall in each season.

We now come to the streams which lie principally in the middle and western divisions, not belonging to the class of sand-hill streams.

THE RARITAN RIVER.

This stream, the largest in the state, is formed by the union of two branches, the North branch and the South branch, which unite in Somerset county, whence the stream pursues a general easterly course, passing into Middlesex county, flowing past the city of New Brunswick, the most important city on the stream, and emptying into Raritan bay at the southern extremity of Staten island. The only important towns by which it flows, above New Brunswick, are Bound Brook, Somerville, and Raritan. The length of the river from the junction of its forks to its mouth at Perth Amboy is about 22 miles in a straight line. The total length of the stream (probably from its headwaters) is given by Professor Cook as 80 miles. Its total drainage area is between 1,000 and 1,100 square miles, distributed nearly as follows among its principal tributaries:

	Square miles.
North branch (length, 30 miles)	180
South branch (length, 50 miles)	280
Millstone river, from the south (length, 35 miles)	250
Green brook, from the north (length, 15 miles)	63
South river, from the south (length, 30 miles)	122

The total drainage area above New Brunswick, which is at the head of navigation and of tide-water, and one terminus of the Delaware and Raritan canal, is about 850 square miles.

The sources of the Raritan lie in what we have called the western division. The South branch takes its rise in Budd's lake, a beautiful and nearly circular sheet of water lying in the highest part of the Highlands, at a height above the sea of somewhere about 900 feet and measuring about 3½ miles in circumference. From this source the South branch pursues a circuitous course, flowing first toward the southwest, but gradually bending to the east; it has a rapid fall and drains a hilly and broken country. The North branch rises on the Succasunny plains, at an elevation above the sea of about 725 feet, and is more sluggish than the South branch, draining a more level country. From the junction of the two to the sea the course of the Raritan lies through the middle division, and its fall is not great, as the following table shows:

Table of declivity of the Raritan river.

Locality.	Distance from mouth.	Elevation above tide.	Distance between points.	Fall between points.	Fall per mile between points.
	Miles.	*Feet.*	*Miles.*	*Feet.*	*Feet.*
Mouth	0	0			
			14	0	0.0
New Brunswick	14	0			
			5	21	4.2
Bound Brook, crossing of Lehigh Valley railroad.	19	21			
			5	18	3.6
Near Somerville	24	39			
			6	16	2.7
Junction of two branches	30	55±			

The stream crosses the fall-line a few miles above New Brunswick, but the fall thereby occasioned is not large. The first canal-dam of the Delaware and Raritan canal, which affords inland water communication between New Brunswick and Bordentown, on the Delaware, is located at this point, and will be referred to together with the power obtained from it at New Brunswick. As in the case of the streams as far south as the James, the fall-line is only a little above the head of tide-water. The eastern part of the Atlantic plain, at the place where the river crosses it, is very narrow, and it gradually disappears toward the north, while toward the south it widens; so that some of the southern tributaries of the Raritan belong to a certain extent to the class of sand-hill streams, and are used to a considerable extent for power. Such are South river, Lawrence brook, and the Millstone river, the two former emptying below New Brunswick, and the latter, although emptying some miles above that place, with its headwaters in the eastern division. The topography of the state in and around the basin of the Raritan is rather curious. Between Perth Amboy, on Raritan bay, and Trenton, on the Delaware, the width of the state is smaller than anywhere else—between 30 and 35 miles—yet from Trenton all the way up to the Musconetcong valley the ridge or water-shed between the Raritan and the Delaware is at a distance of only about 9 miles from the latter stream, and its direction is nearly northwest and southeast, or parallel to the Delaware river, instead of northeast and southwest, the general direction of the water-shed between the Delaware and the Atlantic, in the state, both north and south of the Raritan. North of the Raritan there are few, if any, real sand-hill streams, either in New Jersey or in the New England states, and the fall-line borders almost on the coast in this whole region.

The general shape and dimensions of the basin of the Raritan, and the courses of the streams referred to, may be seen from the accompanying map. It will be noticed that the course of the Raritan is tolerably crooked, and although the distance between the source in Budd's lake and Perth Amboy is 80 miles by the course of the stream, it is only 36 miles in a straight line.

With the exception of Budd's lake, the source of the South branch, there are no lakes in the basin of the Raritan, and in this respect the stream contrasts strongly with the streams in the northern and northwestern parts of the state, whose drainage basins are dotted with ponds. It is perhaps a fair conclusion that the facilities for storage are not so great in the basin of the Raritan as in those of the latter streams; and if it were not for the fact of the existence of the southern sand-hill tributaries of the river, we should certainly be entitled to conclude that its flow is more variable and its freshets more severe than in the case of the streams referred to. Only one gauging, however, is at hand on which to base a conclusion in this respect. It is to be remarked, moreover, that the topography of the basin is not such as to facilitate a very rapid discharge of storm-waters; so that, although there are no lakes to regulate the flow, it is not probable that it is so variable as in the case of streams like the upper Potomac or James, which drain narrow and parallel valleys very favorable to a sudden discharge of the rain-water. Nevertheless, as regards those streams tributary to the Raritan which do not lie in the eastern division, though not so variable in flow as the more southerly streams just referred to, I think their flow will be found more variable than that of the more northerly streams of New Jersey. It is further to be noticed that the rainfall over the basin of the Raritan is about 48 inches, distributed as follows: Spring, 12 inches; summer, 14 inches; autumn, 12 inches; winter, 10 inches. This distribution, according to the discussion in the introduction to the report on the southern

Atlantic water-shed, is very favorable for constancy of flow; and although, on account of the comparatively sma size of the drainage basin, the absolute minimum flow may reach a tolerably low figure, it is hardly to be expecte that the average flow during the driest season should do so. These facts have been borne in mind in estimatin the power.

The bed of the stream is in places rock, but generally it is a deposit of gravel and sand. The drift deposit however, do not seem to be so extensive as on the Passaic and its tributaries. The facilities for dams are no doub good, especially in the upper part of the basin. Although there are some bottoms subject to overflow, they do no seem to be extensive, and on the upper part of the North and South branches they are few in number.

The stream is very favorably situated as regards accessibility, it being comparatively easy to reach almost an part of its basin. Below the junction of the two forks the stream is within easy reach from several railroads, an up to the mouth of the Millstone it is closely followed by the canal. The portion of the basin drained by the Nort branch is the least accessible of any, but it will be seen that the water-power of this stream is not of very grea importance.

As the river is ascended, the first dam we meet is that of the Delaware and Raritan canal, situated about miles above New Brunswick, and supplying the lower level of the canal with water. This dam, and that at Bull falls on the Delaware, at the head of the feeder-canal, are the only dams by which the canal is supplied, so tha the water from the Delaware river literally flows through the canal over the water-shed between that river and th Raritan, the highest point of the canal being only 57 feet above tide, this being the lowest point in the water-she separating the Delaware from the ocean. South of the summit of the canal the height of the water-shed increase to 200 feet, and preserves this elevation along the center line of the state as far south as Cumberland county. Th dam above New Brunswick is of crib-work, pointed up stream, and is about 800 feet long and 10 feet high. I was built between the years 1832 and 1834, and backs the water a mile or more, with an average width of 600 feet From the New Brunswick level, fed from this dam, a race leads to the two mills of the New Brunswick Manufacturing Company, which use a fall of 12 feet, discharging the water to the lower level or basin, which is about 1½ foot above high tide. These mills manufacture hosiery, but the power used is uncertain. The method by which water is leased by the canal company has been described in speaking of the power at Lambertville on the Delaware (page 96). Although the mills receive only the surplus water, it is stated that those at New Brunswick are seldom shut off, except when the water is drawn from the canal, which is the case every year for a longer or shorter time, during which period these mills use steam-power. The quantity of water they use is stated at about 450 square inches at one mill and 540 at the other, under a head of 3 feet. No additional power is available at this place, either at the dam or at New Brunswick, for the mills above described are sometimes short of water, and it is stated that at low water there is no waste over the dam, the entire flow of the stream, except leakage, being diverted into the canal. The mean rise and fall of the tides at New Brunswick is about 5 feet.

The drainage area above the dam being about 825 square miles and the rainfall as given on page 125, I have estimated the flow and the power for a fall of 12 feet as in the following table:

State of flow (see pages 8 to 11).	Drainage area.	Fall.	Flow per second.	Horse-power available, gross.	
	Sq. miles.	*Feet.*	*Cubic feet.*	*1 foot fall.*	*12 feet fall.*
Minimum	825	12+	165	18.8	225
Minimum low season			210	23.9	287
Maximum with storage			825	93.8	1,125
Low season, dry years			250	28.4	340

These figures have little practical value, because all the power available without storage is now practically utilized. It may, however, enable some who are acquainted with the river to form an idea of the degree of approximation of my estimates.(*a*)

The next power met with as the stream is ascended is at the town of Raritan, above the mouth of the Millstone river and only a few miles below the junction of the North and South branches. The stream is dammed at a point about 2¾ miles above the town, the dam being of crib-work, about 175 feet long and 3½ feet high, built in a curve, founded on a bed of sand and gravel, and backing the water only a short distance. It was built about the year 1839, at a cost of $1,200 or thereabout, and is 36 feet in breadth, up and down stream, embracing 20 feet back of the crest and 16 feet in front of the same, part of which is the apron. The race leading to the town where the mills are located is said to be about 30 feet wide at the bottom and 4½ feet deep, and the total fall at the lower end is about 16 feet. The power is owned by the Raritan Water Power Company, and water is nominally leased by the

a Since writing the above, Ashbel Welch, esq., of Lambertville, president of the American Society of Civil Engineers, has given me the results of a gauging of the Raritan made by him near this point many years ago, when the river was unusually low. Mr. Welch found the flow to be 180 cubic feet per second; and, he adds: "Probably it sometimes now gets a little lower; I suppose the usual (not extreme) low-water discharge may be 250 cubic feet per second." The close agreement between this result and the figures in the table is very satisfactory.

square inch under a head of 30 inches, though in the case of the mills now in operation there seems to be no regular rate for water, the rents being determined by special agreement. The price per square foot of opening is from $300 to $400 per annum. The following mills are being supplied at present:

1. Reed & Company's *grist-mill; fall, about 14 feet;* uses about 50 horse-power.
2. Kenyon Brothers' foundery and machine-shop; fall, about 14 feet; uses about 10 or 15 horse-power.
3. New Jersey enamel-paint works; fall, about 14 feet; uses about 15 horse-power.
4. Adair & Company's grist-mill; fall, 14 feet; uses about 30 horse-power.

In addition to these mills a woolen-mill uses about 50 square inches, but only for washing, and not for power.

These mills can run at full capacity almost all the time. There is always a waste of water, but it is said that the canal is in poor condition, being filled up at the upper end, and that this is the cause of any lack of full supply which may and sometimes does occur. There is trouble with backwater during about a week in the year.

The drainage area above Raritan is about 450 square miles. I have, therefore, estimated the power as in the following table:

State of flow (see pages 8 to 11).	Drainage area.	Fall.	Flow per second.	Horse-power available, gross.	
	Sq. miles.	*Feet.*	*Cubic feet.*	*1 foot fall.*	*14 feet fall.*
Minimum	450	14	88	10.0	140
Minimum low season			112	12.7	178
Maximum with storage			450	51.1	715
Low season, dry years			135	15.4	216

I am not able to state whether there are favorable sites in the upper valleys for storage reservoirs of sufficient capacity to render the maximum with storage available, but it is probable that there are none. The facilities for the utilization of the power are good in all respects as regards location and transportation, and the site is perhaps the best on the river. Above it there are no powers except on the two branches, which will be described below.

THE TRIBUTARIES OF THE RARITAN RIVER.

South river, the first of these, enters below New Brunswick and drains about 122 square miles. It belongs to the class of sand-hill streams, and I have no details regarding its power. That which is utilized will be found tabulated on page 137. The same remarks are true regarding Laurence brook. The table of utilized power shows that the power of this stream is quite extensively utilized by small mills, among which are grist-mills, saw-mills, a tobacco factory, and a rubber factory, the last using considerable steam-power all the time. Green brook is an unimportant stream entering from the north near Bound Brook and with only a small amount of power. The Millstone river, from the south, is the most important tributary of the Raritan below the forks, and drains an area of some 190 square miles, the length of the stream being about 35 miles. Taking its rise in the western part of Monmouth county it flows in a northwesterly direction into Middlesex, forms for some distance the boundary between that county and Mercer, and finally flows nearly north through Somerset county, emptying into the Raritan 2 or 3 miles above Bound Brook. It is followed for a distance of 20 miles or over from its mouth by the Delaware and Raritan canal, and its fall in that distance is not over 35 feet, so that the stream is not very rapid, but rather sluggish. Its elevation at the railroad-crossing near Plainsborough is 54 feet above tide. Its drainage basin is flat compared with those of the northern tributaries of the Raritan, and the stream belongs in fact more to the class of sand-hill streams than to any other. Its bed is sand and clay, its flow quite constant, and it has no falls or lakes. Its power is of not much importance, though it runs a number of small mills, with falls averaging about 5 feet, and dams of about the same height. These mills are tabulated on page 137, and further particulars are not at hand.

The North branch of the Raritan takes its rise on the Succasunny plains, in Morris county, and flows nearly south, joining the South branch in Somerset. It drains a total area of about 180 square miles, and receives as its principal tributary the Lamington river. Its sources lie at an elevation of about 725 feet,(*a*) while that of its confluence with the South branch is about 55 feet, so that its fall is 20 feet or more to the mile. But the greater part of the fall of 670 feet occurs where the stream is too small to be used for power, and for a number of miles above its junction with the South branch it is said to be rather sluggish, and to have, in fact, no greater fall than the Raritan below the junction. The elevation at the crossing of the Central Railroad of New Jersey, about 3 miles above the junction, is 66 feet above tide. The power of the stream is not very great, according to all that could be learned, and no unimproved sites of any importance were brought to notice. The amount of utilized power can be seen by referring to the table on page 137.

The South branch of the Raritan is a stream of rather different character and much better suited for power. Rising in Budd's lake, in Morris county, it flows in a southwesterly direction through the Highland region into Hunterdon county, and gradually bending to the east flows into Somerset county, where its course is nearly north

(*a*) *Geology of New Jersey*, p. 22.

to its confluence with the North branch. While the distance of that point from Budd's lake, measured in a straight line, is only slightly over 20 miles, the length of the stream is 50 miles.(a) The total drainage area is about 280 square miles, lying mostly in the Highland region. The fall of the stream is much greater than that of the North branch, as will be seen from the following table:

Table of declivity of the South branch of the Raritan river.

Locality.	Distance from mouth.	Elevation above tide.	Distance between points.	Fall between points.	Fall per mile between points.
	Miles.	*Feet.*	*Miles.*	*Feet.*	*Feet.*
Mouth	0	55±	5	4±	0.8
Crossing of Lehigh Valley railroad at Neshanic	5	*a* 59	3	43	(?)14.3
Crossing of Lehigh Valley railroad at Three Bridges	8	*a* 102	7	17	2.4
Crossing of Lehigh Valley railroad at Stanton	15	*a* 119	11	116	10.5
Crossing of Central Railroad of New Jersey at High Bridge	26	235	10	273	27.3
Crossing of proposed railroad from Morristown to Easton, German Valley	36±	*b* 508	14	400±	28.6
Budd's lake, source of river	50	900±			

a I am indebted for these figures to Mr. Robert H. Sayre, superintendent and chief engineer of the Lehigh Valley railroad.
b *Geology of New Jersey*, p. 841.

By virtue of its larger fall the stream has much more power than the North branch, and its flow is probably more constant on account of the lake at its head. The declivity is generally gradual, there being no precipitous falls. The power of the stream is utilized at a number of places for mills of various descriptions, as will be seen by referring to the table of utilized power on pages 137 and 138. In Somerset county there are four mills, with an average fall of about 7 feet; in Hunterdon county we first come to six or seven flour- and grist-mills, with falls of about 6 feet each, but the falls soon become greater, and in the upper part of the county, both on the main stream and on many of its tributaries, large falls are obtained. Some of the tributaries flowing with large falls from the highland ranges, between which the South branch pursues its course, offer considerable power in comparison with their size and drainage area. Although Budd's lake is not sufficient to render uniform the flow of a large stream, such as the Raritan, or even the South branch in its lower parts, yet it is sufficient to render the upper parts of the stream much more valuable for power than they otherwise would be, and to make it possible to utilize with good effect a considerable part of the large fall which the stream possesses in its upper parts. By referring to the table it will be seen that in Morris county alone there are 22 mills on the stream, using a total fall of 322 feet, or a large part of the total fall which the stream possesses in the county. Perhaps the most important power on the stream is at High Bridge, where the Central Railroad of New Jersey crosses the stream. At this place are located the Taylor Iron Works, using power from two dams to run their forge and foundery. The upper dam, which is partly of earth and partly of crib-work, is about 20 feet high and ponds the water over 20 (?) acres. A race of 500 feet leads to the forge, where the fall is 32 feet. Statements differ in regard to the power used. The lower dam is about 4 feet high, and the fall at the foundery, which it supplies, is 12 feet. A considerable amount of power is used, and it is stated that full capacity can be secured all the time.

It is probable that there are sites for power on the river still unimproved, but I can not mention any particular ones. The facilities for dams, races, and buildings are generally good, and from what has been said it will be seen that the stream is an excellent one for power. It is, moreover, very accessible throughout its whole length, and the advantages for transportation are quite good. The powers, however, are of course all comparatively small.

I have estimated in the following table the flow and power of the two branches of the Raritan at their confluence. The figures are of course not exact, in the total absence of gaugings, but may serve as a means of comparison between this stream and others.

Estimated flow and power of branches of the Raritan river at their junction.

State of flow (see pages 8 to 11).	SOUTH BRANCH.			NORTH BRANCH.			RAINFALL.				
	Drainage area.	Flow per second.	Gross horse-power.	Drainage area.	Flow per second.	Gross horse-power.	Spring.	Summer.	Autumn.	Winter.	Year.
	Sq. miles.	*Cu. feet.*	*1 foot fall.*	*Sq. miles.*	*Cu. feet.*	*1 foot fall.*	*In.*	*In.*	*In.*	*In.*	*In.*
Minimum	280	50	5.7	180	30	3.4	12	14	12	10	48
Minimum low season		62	7.0		40	4.5					
Maximum with storage		300	34.1		195	22.2					
Low season, dry years		70	8.0		43	5.5					

a *Geology of New Jersey*, p. 26.

THE PASSAIC RIVER.

This important stream has its sources in Morris county, not far from the sources of the North branch of the Raritan, and its course to the sea is very crooked. Flowing first in a nearly southerly direction, and forming for some distance the boundary-line between Morris and Somerset counties, it bends quite abruptly toward the east, and pursues its course in a northeasterly and northerly direction, forming the boundary between Morris county on the west, and Union and Essex on the east, until, at the northern extremity of the latter county, it bends again abruptly and flows toward the east, between Essex county on the south and Morris and Passaic counties on the north, passing into the latter county. Bending once more near Paterson it flows nearly south between Essex county on the west and Bergen and Hudson on the east, emptying into Newark bay below the city of Newark. Although the source of the stream is distant from its mouth only 25 miles in a straight line, the course of the stream measures over 80 miles. The stream flows by the cities of Newark and Paterson and the town of Passaic, but with these exceptions there are no large towns along its course. Its crossing with the fall-line affords no fall, unless it be that at Passaic, which is at the head of tide-water and of navigation, there being a navigable depth at mean low water of 6 feet up to this place, a distance of about 29 miles.

The total area drained by the stream is about 960 square miles, according to my measurements. It is stated differently by others, and is sometimes called in round numbers 1,000 square miles. The sources of the stream lie in the western district, as do those of its principal tributaries, the Rockaway, Pequannock, and Ramapo rivers, and topographically the drainage basins of these streams are broken and rocky in their upper parts. The drainage area of the Passaic comprises a central basin with an area of about 200 square miles and a general elevation of 120 to 180 feet above tide, inclosed by the Highlands on the west and several high ridges of trap-rock on the east, through which the river breaks at Paterson and Little Falls. The tributaries named above come down from the Highland region and their basins are more broken and hilly than that of the main stream, whose course lies for some distance through the central basin just alluded to. In their courses through what we have called the middle division the streams cross a number of ridges of trap-rock, and in those places their beds and banks are rock, and generally there is a fall available for power; at other places the bed is sand and gravel, the whole valley of the stream being thickly covered with glacial drift, sometimes to a considerable depth.

The banks are in many places low and swampy and overflowed in freshets, especially on the main river in the central basin, while at others, in the upper part of the basin and where the trap ridges are cut through, they are rocky and sometimes precipitous. In all places where fall is practically available the bed and banks may be said to be favorable for the development of power.

The freshets on the Passaic and its tributaries are restrained to a considerable extent by a number of lakes and swamps which serve to regulate the flow. These lakes and swamps will be referred to more in detail when the tributaries on which they lie are considered, so that it will suffice here to state that the total area covered by lakes in the Passaic basin is about 8 square miles, while the area of swamp- or "wet" meadow-land is about 26 square miles.(*a*) The level of many of the lakes could be raised several feet without much additional flowage, and the reservoir area could in this way be increased to about 10 square miles;(*b*) many of the lakes are in fact partly artificial, and if we should calculate the area of all the mill-ponds in the basin, which are equally storage reservoirs, the above figures would be considerably increased. Were it desired to utilize as much power, and hence to obtain as much storage as possible, the most convenient way would perhaps be to raise the levels of some of these lakes; but, in addition, other storage reservoirs could be made artificially, there being several sites where they could be located. The utilization of the maximum power obtainable with storage, however, would be very expensive, as is always the case with all but very small drainage areas.

The declivity of the stream may be seen from the following table, which, however, is not very accurate:

Table of declivity of the Passaic river.

Locality.	Distance from mouth.	Elevation above tide.	Distance between points.	Fall between points.	Fall per mile between points.
	Miles.	*Feet.*	*Miles.*	*Feet.*	*Feet.*
Mouth	0.0	0	29.00	0.0	0.00
Passaic	29.0	0	0.50	22.0	.....
Crest of Dundee dam	29.5	22	11.50	17.0	1.50
Paterson, below falls	41.0±	39	1.00	76.0	76.00
Crest of Paterson dam	42.0±	115	5.00±	47.0	9.40
Crest of Little Falls dam	47.0±	162	21.75	6.0	0.29
Lower Chatham bridge	69.0±	168	17.00±	72.0	4.24
Near Madisonville	86.0±	240			

a Annual Report of the State Geologist, 1876, p. 44. *b Geology of New Jersey*, 1868, p. 14.

The mean annual rainfall over the basin of the Passaic is about 47 inches, distributed as follows: Spring, 11 inches; summer, 14 inches; autumn, 12 inches; winter, 10 inches—a distribution very favorable to constancy of flow in the streams. A few gaugings of flow are at hand and will be referred to in the proper place.

Beginning at the headwaters of the stream near Mendham, in the southern part of the central basin of the drainage area, we find a few small mills scattered along the stream and its tributaries as far down as Chatham. The facilities for power, however, are not very good, the fall of the streams being small and the banks frequently low and swampy. At Millington mills the stream cuts through Long hill, a trap ridge, flowing through a deep and narrow gorge, and offering some power, part of which, and perhaps all, is utilized. The drainage area above this place is only 51 square miles. From Chatham, above which the drainage area is 99 square miles, the stream flows for a distance of nearly 25 miles, down to Little Falls, with a very sluggish current through the central basin referred to, and offers no power whatever. It is bordered by low and swampy lands, all subject to overflow in times of freshet, and, as the table of declivity shows, its fall is but a little over 3 inches to the mile. On the Passaic and its branches, the Whippany and Rockaway, above Little Falls, there is in fact an area of 11,000 acres subject to overflow. Its course is quite tortuous and its bed sand and gravel. The whole valley of the upper Passaic, in fact, is filled with a thick deposit of drift, and down almost as far as Pompton, rock is never seen in the deepest excavations—some borings have been driven 300 feet without reaching it. The cause of the slight fall of the stream between Little Falls and Chatham is to be found in the dam at the former place, where the stream falls over a ledge of trap-rock known as the Second mountain, the effect of the natural dam formed by the ledge being increased by the artificial dam, which will be referred to again. For a distance of 20 miles above this dam the stream overflows its banks in times of freshet, and lays thousands of acres under water; and although attempts have been made to have this area drained, nothing has yet been accomplished.

At Little Falls we meet the first power of importance on the stream, and as the river receives the Rockaway and Pompton rivers not far above, the volume of water is very much greater than at Chatham, the drainage area above this place being about 790 square miles according to my measurements.(*a*) The total fall at Little Falls is stated by Professor Cook as 34 feet, and by Messrs. Croes & Howell as 32 feet, but of this only about 16 are used. The dam is stone, 280 feet long and 8 feet high, rebuilt in 1869 at a cost of $15,000; and a race 80 feet long gives a fall of 16 feet at the large carpet- and felt-mills of Mr. Robert Beattie. The power used is stated at 250 horse-power, with always a waste of water, although it is also stated that full capacity can be obtained during only eleven months, averaging two-thirds during the rest of the time. No steam-power is used. By comparing with some measurements of flow, which will be referred to again, I have estimated the power as follows:

Estimate of flow and power at Little Falls.

State of flow (see pages 8 to 11).	Drainage area.	Fall.	Flow, per second.	Horse-power available, gross.		
	Sq. miles.	*Feet.*	*Cubic feet.*	*1 foot fall.*	*16 feet fall.*	*34 feet fall.*
Minimum	790	34	176	20.0	320	680
Minimum low season			220	25.0	400	850
Maximum with storage			780	88.6	1,418	3,012
Low season, dry years			260	29.5	472	1,000

I am not able to say whether the entire fall of 34 feet, as stated by Professor Cook, is easily available or not, but the power is evidently a very fine one.

The next power of importance on the stream, and the most important one in the state of New Jersey, is at Paterson, about 4 miles below Little Falls. Between the two places there is some fall not used, but none of importance except that already referred to, which forms part of the fall at Little Falls. At Paterson the river crosses a second trap ridge, known as First mountain, falling a perpendicular distance of 50 feet or more, the total fall in a mile being about 75 feet. Some 200 feet above the falls a dam extends entirely across the stream, ponding the water about 2 miles with a width of about 400 feet. The dam is of stone, 350 feet long and 8 feet high. For about one-third of its length its upper part consists of flash-boards, which are washed out in high water. The dam was built to a height of 4½ feet in 1837, and was raised to 8 feet in 1864, the upper part being flash-boards until the summer of 1881, when two-thirds of its length was built up in stone; it is said to have cost $13,000. The bed of the stream is rock and the banks are rather low. The total fall utilized at Paterson is about 66 feet, from three levels, the fall from each being 22 feet. The total length of canals is about 4,500 feet, and they are rectangular in section, 3 feet deep and 20 feet wide. The following is a list of the mills supplied:

	Square feet leased.
I. From upper canal, 1,200 feet long:	
1. Ivanhoe Manufacturing Company (paper); fall, 22 feet	13
2. Rogers Locomotive Works; fall, 22 feet	8
3. Barbour Flax Spinning Company (flax thread); fall, 22 feet	6
4. Dolphin Manufacturing Company (flax and jute); fall, 22 feet	9
Total square feet leased from first level	36

a 750 square miles according to Professor Cook, and 832.75 according to Messrs. Croes & Howell (*Report on Additional Water Supply for Newark*).

	Square feet leased.
II. From second level, 1,600 feet long:	
1. J. H. Booth & Co. (silk); fall, 22 feet	4
2. Grant Locomotive Works; fall, 22 feet	3
3. Danforth Locomotive Works; fall, 22 feet	8
4. Hamil & Booth (silk); fall, 22 feet	7
5. Hopper & Scott (silk); fall, 22 feet	3
6. Robert Adams (silk); fall, 22 feet	2
7. Franklin Manufacturing Company (machinery); fall, 22 feet	1½
8. R. & H. Adams (mosquito-netting); fall, 22 feet	8
9. John Ryle (silk); fall, 22 feet	2
Total square feet leased from second level	38½
III. From third level, 1,300 feet long:	
1. Franklin Manufacturing Company (calico-printing); fall, 22 feet	7
2. Todd & Rafferty Manufacturing Company (machinery); fall, 22 feet	3
3. James Mussey (machinery); fall, 22 feet	2
4. Phœnix Manufacturing Company (silk); fall, 22 feet	5½
5. R. & H. Adams (mosquito-nets and silk); fall, 22 feet	14
6. Globe Mill Company (silk); fall, 22 feet	3
7. Machinists' Association (machinery); fall, 22 feet	2
Total square feet leased from third level	36½
IV. On overflow from lower level, 400 feet long:	
1. Paterson grist-mill; fall, 12 feet	1

The total gross power utilized at these mills is about 2,350 horse-power. In dry weather there is no waste over the dam, even at night, and most of the mills run during only the day-time, or about ten hours. In dry weather the company shuts off the water from the mills from 7 p. m. till 6 a. m. The mills can obtain their full capacity during only about nine months of the year, and almost all of them have supplementary steam-power for the rest of the time, while a few use some steam-power continuously. During about three months the mills can obtain only about three-quarters of their full capacity; while during about eight months there is a waste over the dam in the day-time. It must be remarked, however, that some water is allowed to pass the dam to supply the pump-works below, so that not quite the entire flow is available for power.

The power at Paterson is owned and controlled by the "Society for Establishing Useful Manufactures", an association incorporated in 1791; and it was one of the earliest of the large powers in this country which was developed and utilized for manufacturing to any considerable extent. Water is leased by the company at the rate of $750 per square foot under a head of 3 feet, delivered through a sharp-edged orifice 6 inches high, at the bottom of the canal. This amounts to about 8.5 cubic feet per second, equal to 21¼ gross horse-power with a fall of 22 feet; so that the price per annum per gross horse-power is nearly $36, or $88 per cubic foot per second, a very high rate compared with that at other places where large amounts of power are leased. No detailed measurements, however, are made to determine the exact quantity of water used by each mill, except when a new wheel is put in, or when the company has reason to suspect that an excess of power is being used. The water is gauged for overshot wheels by orifices in the flume; while for turbine wheels the apertures in the wheel are used in determining the quantity, the aperture corresponding to a square foot under a 3-foot head being taken for the turbines as 53.18 square inches, this bearing the same ratio to 144 that the square root of 3 does to the square root of 22. No deduction is made from the price on account of a lack of water at times; and, in fine, the power is only roughly controlled compared with the care which is exercised in Lowell, Lawrence, and other places.

Below the dam, which has already been described, at the head of the principal fall, and extending in a zigzag line across the stream, is a second dam, averaging perhaps 5 feet in height, and used simply for the purpose of supplying power and storing the water for the city pumping station, which is situated on the left bank of the river just above the fall. The dam is of stone, with 23 inches of flash-boards on top. It was originally built many years ago, but was raised in 1881 to increase the storage. At present it ponds the water up to the upper dam, which is provided with gates, through which water is let down for the supply of the city, and is pumped by water-power during from seven to nine months, steam being used partly or wholly during the rest of the time. The wheel-pit is a chasm in the natural rock, the fall is 30 feet, and the power 120 horse-power. The amount of water pumped is in dry weather about 7,000,000 gallons in twenty-four hours, or 14 cubic feet per second.

The minimum flow of the Passaic river at Paterson is stated by Messrs. Croes & Howell at 195 cubic feet per second, and the maximum at Passaic at 17,913 cubic feet per second. I have estimated the following table from these data:

Estimated flow and power at Paterson.

State of flow (see pages 8 to 11).	Drainage area.	Fall used.	Flow per second.	Horse-power available, gross.		
	Sq. miles.	*Feet.*	*Cubic feet.*	*1 foot fall.*	*22 feet fall.*	*66 feet fall.*
Minimum	813	66	195	22.2	488	1,465
Minimum low season			246	28.0	616	1,848
Maximum with storage			800	90.9	2,000	6,000
Low season, dry years			287	32.6	717	2,150

These figures are estimated, of course, like all the others in this report, for the natural flow of the stream, taking the average for twenty-four hours. If the water is stored during the night the power could be much increased. The entire fall of 22 feet from the lower level, however, is not entirely used, and some deduction must be made for the water used by the city. Still it is difficult to understand how, if the above figures are at all correct and the mills are using only a gross power of 2,350 horse-power, they should run short at all. It is to be regretted that more reliable and detailed information regarding the flow of the stream, and the power utilized, by which these discrepancies could be reconciled, is not at hand.

The power at Paterson, as regards commercial facilities of all kinds, can not be excelled, and to it the prosperity of the city is no doubt chiefly due.

As the Passaic river is further descended, the last important power on the stream, situated at the head of tide and navigation, is at Passaic. The dam, 2 miles above the town, is of stone, stepped in front, and extends across the stream in an arc of a circle, the chord being 450 feet and the center ordinate 7 feet. It is 14 feet high, and was originally built in 1858, at a cost, it is said, of $250,000, but was extensively repaired in 1880. It is founded on a sandstone ledge, and has never been much injured by freshets or ice. It ponds the water for about 4 miles, with an average width of about 500 feet. The tide is felt up to within half a mile of the dam. The race is nearly 2 miles long and 80 feet wide. The power is owned and controlled by the Dundee Water Power and Land Company, and the following mills are supplied: The Passaic print-works, Basch & Co.'s woolen-mill, Reid & Barry's print-works, the Rittenhouse Manufacturing Company, the New York steam-engine works (not running at present), an oil-cloth works, Waterhouse Brothers' woolen-mill, and the city water-works. The fall varies with the tide from 20 to 24 feet, averaging 22 feet. Power is leased by the "mill-power", which is defined as 8½ cubic feet per second under a fall of 22 feet during twelve hours in the day, the regular price being $700 per mill-power per annum, or about $33 33 per gross horse-power, a rate nearly as high as that at Paterson. The whole number of mill-powers leased is at present 62, including 20 mill-powers leased to a large rubber factory now being built. As a mill-power is equal to about 21 gross horse-power, the power leased is about 1,300 horse-power, that used being about 882 horse-power. Full capacity has generally been secured all the time, though there has sometimes been a slight scarcity for a few weeks. In very dry weather there is no waste at night, but generally there is some waste at all seasons. No steam-power is used to supplement the water-power, but some of the mills use steam all the time. The city water-works takes its water-supply, consisting of one mill-power, from the canal, pumping it by steam. The amount of water taken by the mills is not controlled accurately, no attempt at measurement being made, and the amounts paid for being based on measurements made some years ago by Mr. William E. Worthen. It is thought probable that more water is used than is paid for, but on account of there being an excess of power, no trouble has occurred. The company does not lease water except during the day-time, but most of the mills run somewhat at night, though the company can prevent their doing so if it so choose. I have estimated the power at Passaic as follows:

Estimated flow and power at Passaic.

State of flow (see pages 8 to 11).	Drainage area.	Fall.	Flow per second.	Horse-power available, gross.	
	Sq. miles.	*Feet.*	*Cubic feet.*	*1 foot fall.*	*22 feet fall.*
Minimum	908	22	211	24.0	528
Minimum low season			264	30.0	660
Maximum with storage			900	102.3	2,250
Low season, dry years			320	36.4	800

This power, though small, is an excellent one in every respect.

THE TRIBUTARIES OF THE PASSAIC RIVER.

The first tributary we meet in ascending the stream is *Saddle river*, a small stream, but utilized very extensively for mills of various kinds, as the table of power shows. The next tributary is the *Pompton river*, which enters at Two Bridges just above Little Falls. This stream is formed by the union of the Pequannock, Ringwood, and

Ramapo, and is only about 5 miles long. It offers no power at all, and it is only on its tributaries that any is available. The *Ramapo river* takes its rise in Orange and Rockland counties, New York, and flows in a general southerly direction through Bergen county, draining about 172 square miles comprising a very broken and rugged country. "At the headwaters of the stream, near Turner's, there is a small limestone region of about 8 square miles area; the base rock of the rest of the water-shed is gneiss, except the eastern slope of the lower 15 miles of the stream, which is red sandstone."(*a*) The river is fed by the following-named lakes and ponds:(*b*)

1. Franklin lake, New Jersey: area, 94 acres; drainage area, 1,000 acres; perhaps connected with Crooked lake, which covers 30 or 40 acres, and The Ponds, by subterranean channels.
2. Rotten pond, New Jersey: area, 20 acres; drainage area, 1,200 acres.
3. Negro pond, New Jersey and New York: area, 100 acres; drainage area, 900 acres.
4. Truxedo pond, Little Long pond, Mount Bashon pond, Island pond, Slaughter pond, Cranberry pond, and Round pond, all in New York, are small sheets of water, regarding which no data are at hand.

Of these ponds some are dammed, but it is not probable that they exercise much influence on the flow of the river. The power used on the stream is tabulated beyond. The most important site is that at Pompton, where the steel-works are located, the fall being 20 and 24 feet. It is said that 250 horse-power are utilized during six months. At Ramapo, New York, there were formerly iron- and nail-works, using a fall of 18 feet, but no mill is there now; this is the only important unimproved power on the stream which was brought to my notice.

The *Ringwood river* rises in Orange county, New York, and flows through Passaic county, New Jersey, draining about 108 square miles. It is fed by the following-named lakes and ponds:

1. Mud pond, New Jersey: area, 50 acres; drainage area, 1,600 acres.
2. Tice's pond, New Jersey: area, 40 acres; drainage area, 800 acres.
3. Shepherd's pond, New Jersey: area, 90 acres; drainage area, 1,000 acres.
4. Greenwood lake, New Jersey and New York: area, about 4 square miles; drainage area, 32 square miles. This lake is one of the feeders of the Morris canal, and is dammed to a height of 13 feet.
5. Besides Sterling pond, New York, regarding which no data are at hand, there were several large ponds on the Ringwood river itself, between Boardman and Winokee, mostly artificial, but the dams are said to be going to ruin. The power was used for blast-furnaces and forges, some of which are not now in operation. Other than the data given in the table of utilized power I have no information regarding the power of the stream. As Greenwood lake is not heavily drawn upon to supply the canal, it would seem probable that the flow of this stream might be made comparatively uniform, and its water-power of considerable value.

The *Pequannock river* rises in Morris, Passaic, and Sussex counties, New Jersey, and forms for its entire length the boundary between Morris and Passaic. It drains, above the mouth of the Ringwood, some 90 square miles. The basin resembles that of the Ramapo, and the stream is fed by the following-named lakes and ponds:

1. Macopin pond, or Echo lake: area, 363 acres; drainage area, 1,700 acres; dammed, and can be drawn down 4 feet; drainage area could easily be increased to 3,200 acres.
2. Hank's pond: 80 acres; drains 4 square miles.
3. Cedar pond: 96 acres; drains 800 acres.
4. Duck Mountain pond, Dunker pond, Canistear pond, Pine Hammock pond, Timber Brook pond, and Stickle's pond are small sheets of water, some of them partially or wholly artificial, and serving a useful purpose as regulators.

The stream offers considerable power, a portion only of which is utilized. The fall is rapid, the banks are high, and the flow is quite uniform. As few data regarding elevation are at hand, I can give no figures regarding the power available; but as the head-waters of the stream in the swamp near Snufftown lie at an elevation of 1,025 feet, while at Bloomingdale the elevation of the stream is only 258 feet, the fall is evidently very large. There must also be considerable power available between Bloomingdale and Little Falls. That utilized is tabulated on page 138. At Bloomingdale the Rubber Comb and Jewelry Company uses a power of 100 horse-power all the time, and 300 horse-power during five months, with a fall of 32 feet, and the figures, which agree well with those given by other manufacturers, give the average low-season flow as about 30 cubic feet per second during working hours, or about fifteen as the natural flow of the stream.

The *Rockaway river* rises in the eastern corner of Sussex county, flows first in a southwesterly direction as far as Port Oram, where it bends to the east, and flows nearly east, passing the towns of Dover and Boonton. Its drainage basin is broken and rocky and its fall rapid, so that a large amount of power is available. The stream is fed by a few lakes, but they are not large enough to do very much to regulate its flow. They are as follows:

1. Split Rock pond covers 237 acres and drains 6¼ square miles. It is already dammed. Its height above tide is 815 feet.
2. Durham pond covers 65 acres, drains 1,000 acres, and is also dammed.
3. Green pond covers 560 acres and drains 2½ or 3 square miles. Its height above the sea is 1,069 feet.
4. Denmark pond covers 175 acres and drains 2½ or 3 square miles.

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a Newark Aqueduct Board. *Report on Additional Water Supply*, p. 16.
b *Annual Report of the State Geologist*, 1876.

5. Middle Forge pond covers 70 acres.

6. Dixon's Forge pond covers 60 or 75 acres and drains 1½ or 2 square miles.

7. Shongum pond covers 125 acres and drains 2½ or 3 square miles. Some of these ponds besides the two already specified are dammed and used as reservoirs.

The power utilized on the Rockaway is tabulated beyond. A considerable amount, however, is still unimproved and all along the Green Pond valley there were once forges, many run by water-power, but most of them not now in operation. At Dover, the Dover Iron Company has a dam 10 feet high and uses a fall of 11 feet, with 100 horse-power during five months, and about 70 all the time by drawing down the pond; at Rockaway a fall of 11 feet and 70 horse-power are used by a rolling-mill; and at Powerville a fall of 10 feet is used for a rolling-mill, forge, and grist-mill, with some 125 horse-power. The principal power on the stream, however, is at Boonton, the total fall in a little over half a mile being about 110 feet. A stone dam at the head of the falls, 150 feet long and 12 feet high, built in 1830, and backing the water only a few hundred feet with an average width of 25 feet, turns the water into a canal on the left bank, from which it was used in four falls; the first was of 25 feet, and was used by a nail factory, with 200 horse-power; the second was of 25 feet, used by a blast-furnace, with 200 horse-power; the third was of 30 feet, used by a rolling-mill, with 500 horse-power; the fourth was of 30 feet, used by a nail factory and saw-mill, with from 60 to 100 horse-power. The Morris and Essex canal, which crosses the river in the pool of the dam, overcomes a difference of level of 80 feet by an inclined plane (No. 7), and uses from the upper canal a fall of perhaps 45 feet and several hundred horse-power to run the machinery for moving the boats, discharging the water so used between the second and third falls. This splendid power was not utilized at the time of my visit, only one steam blast-furnace being in operation. When all the mills were running there was no waste over the dam in the summer, except at night, and steam was used part of the time on the third fall. Full capacity was obtained during about eight or ten months, sometimes falling as low as one-half. The drainage area above this place being about 120 square miles, and the rainfall the same as on the Passaic (see p. 130), I should estimate the minimum flow at about 20 cubic feet per second, and the ordinary low-season flow at about 35 cubic feet per second, corresponding, with a fall of 25 feet, to a gross power of 57 and 100 horse-power, respectively, during twenty-four hours.

The elevation of the top of the canal-plane at Boonton above tide is 480 feet; that of the junction of the Rockaway and the Passaic, some 8 miles below, about 165 feet; so that the fall of the stream in this distance is 315 feet, or at the rate of nearly 40 feet per mile. Of this fall, 110 feet occurs at Boonton, leaving say 200 feet between Boonton and the mouth of the river. There is, no doubt, a very large amount of power available here, very little of which is utilized. At Old Boonton there is a paper-mill, with a fall of 28 feet, the dam having been built in 1880. The power used is stated at 514 horse-power, which can be obtained about seven (?) months. Below Old Boonton the stream is more sluggish and does not afford so much power. When we consider the fact that the facilities for storage are excellent in the valley of the Rockaway, and the large fall available, it would seem that the advantages for power must be excellent, and that the stream is worthy of a careful examination by those seeking good powers. Of the tributaries of the Rockaway, the most important is the Whippany, which affords power for several paper-mills, besides mills of other kinds.

THE WATER-POWER ON THE MORRIS AND ESSEX CANAL.

Before leaving the Passaic river and its tributaries, a few words must be said about the power which is utilized from the Morris and Essex canal, although the amount of power so used is small. The canal, which was completed in August, 1831, and connects the city of Newark with the Delaware river at Phillipsburg, follows the Passaic and Rockaway rivers, rising, by means of 12 inclined planes (with a total rise of 758 feet) and 16 lift-locks (with a total lift of 156 feet), to its summit, near lake Hopatcong, 914 feet above mean tide. West of the summit it follows the Musconetcong valley, descending by 11 planes (with a total fall of 691 feet) and 7 lift-locks (with a total fall of 69 feet) to the Delaware, where it is 154 feet above tide. The canal is fed entirely from lake Hopatcong and from Greenwood lake. The former lake, which originally covered 1,500 acres, is raised 10 feet by a dam, and now covers, when full, 2,800 acres. Its drainage area is 27 square miles. A mill at the outlet owns the right to the original water-power there, so that not all the flow can be used for feeding the canal. As already mentioned, Greenwood lake is raised 13 feet by a dam. There are a number of canal-dams on the rivers which it follows on either side of the summit; none of them are used for feeders, however, but simply in order to enable the canal to cross the river, and the company sees to it that more water is locked into the river than out of it. A number of mills, however, whose works are in some degree interfered with by the canal, receive their regular power from the canal, paying no rent for it. Other mills rent power from the canal, carrying the water around the inclined planes and discharging into the canal below; and finally, the machinery for hauling the boats up the inclined planes is driven by water-power. In cases where the company rents water no special quantity is guaranteed, but the mills have the right to the surplus water only; neither is there any fixed price, and water is sometimes rented in this way for washing and other purposes, instead of for power. In fact, the power available is very limited, and the interests of navigation generally conflict with those of manufacturing. No power is used at the canal-locks. The mills using power are tabulated on page 139, and it is only to be remarked that most of them can obtain their full capacity during only about nine months of the year, and in some cases less.

From the foregoing it is clear that the Passaic river and tributaries offer a large amount of power. The available power, however, could be largely increased by increasing the storage-room, which in many cases could best be done by raising the levels of some of the lakes with which the basin is dotted. Professor Cook gives the following table relating to the ponds and storage:

Reservoirs of the Passaic river.(a)

Name of pond.	Tributary to what.	Depth controlled at present.	Area at present.	Pond could be raised—	Area corresponding to pond if raised.	Drainage area.
		Feet.	*Acres.*	*Feet.*	*Acres.*	*Acres.*
Franklin lake	Ramapo river	5	94	0	94	1,000
Rotten pond	do	6	20	4	100	1,200
Negro pond	do	5	100	4	125	900
Truxedo pond, etc	do					
Mud pond	Ringwood river	4	50	11	120	1,600
Tice's pond	do	5	40	3	125	800
Shepherd's pond	do	4	90	6	90	1,000
Greenwood lake	do	13	2,560			20,480
Stirling pond	do					
Macopin pond	Pequannock river	4	362	5	412	3,200
Hank's pond	do	6	80	5	120	2,500
Cedar pond	do	4	96	3	140	800
Duck Mountain pond	do	0	75	12	120	1,600
Dunker pond	do	5	125	5	800	3,200
Canistear pond	do	15	70	5	120	2,000
Timber Brook pond	do	5	72	3	100	800
Stickle's pond	do	10	101	5	161	1,800
Split Rock pond	Rockaway river	10	237	10		4,000
Durham pond	do	4	65	6	110	1,000
Green pond	do	0	560	3		1,920
Denmark pond	do	5	175	3	300	1,800
Middle Forge pond	do	5	70	10	100	4,000
Dixon's Forge pond	do	5	75	5		1,200
Shongum pond	do	5	125	5	165	1,800

a In addition to these reservoirs, there are the numerous and extensive meadows or swamps, which have already been referred to, and which, although evaporating largely, do something toward regulating the flow.

Professor Cook also gives the following table regarding some sites for artificial reservoirs which could be created:(a)

Location.	Tributary to what stream.	Depth which could be rendered available.	Area.	Drainage area.
		Feet.	*Acres.*	*Acres.*
Mouth of Mud pond	Ringwood river	10	100 to 125	3,000
On the Ringwood river	do	20	570	55,680
Near Hewitt furnace	do	10	75 to 80	1,300
West of Boardville	do	10	100 to 150	1,000
Mouth of Stickle's pond	Pequannock river	8	80 to 100	3,000
Mount Pleasant	Rockaway river	10	800	8,320
Pompton Furnace	Ramapo river	6	292	94,720

Besides these, there are various other sites where reservoirs could be created, and there seems to be little doubt that a rainfall of 12 inches, and perhaps more, could be rendered available for almost the whole basin. The upper part of the main Passaic valley, by reason of the flatness of its slope, is unfitted for storage, there being, according to Mr. Croes, only one available site for a reservoir, at Chatham, where a dam 14 feet high above the bed of the stream would flood an area of 2,000 acres, of which 2,600 would be less than 6 feet deep, and nearly all of which is good farming-land. On the Rockaway there is a site for a reservoir 3 miles below Boonton, and others above, so that on this stream the maximum with storage could probably be rendered available.

The only river remaining to be described on the Atlantic coast of New Jersey is the Hackensack. This stream takes its rise in Rockland county, New York, and pursues a southerly course, emptying into Newark bay just above the Passaic. Its fall is small and its flow variable, so that its water-power is of not much importance. It flows for the most part through meadow-lands, and offers no natural falls of any note, so far as could be learned. The power utilized is tabulated beyond.

a Annual Report of the State Geologist, 1876.

Drainage areas of the coast streams of New Jersey.

Stream.	Tributary to what.	Locality.	Drainage area.	Remarks.
			Sq. miles.	
Great Egg Harbor river	Atlantic ocean	Mouth	321	Above Great Egg Harbor.
Do	do	May's Landing	190	
Tuckahoe river	Great Egg Harbor	Mouth	100	According to Professor Cook.
Little Egg Harbor river	Great bay	do	476	Do.
Wading river	Little Egg Harbor river	do	179	140 according to Professor Cook.
Do	do	Harrisville	144	
Batsto river	do	Mouth	95	70 according to Professor Cook.
Atsion river	do	Mouth of Batsto river	158	
Cedar creek	Atlantic ocean	Mouth	70	According to Professor Cook.
Tom's river	do	Tom's River	150	
Metedeconk river	do	Lakewood	24	
Manasquan river	do	Mouth	60	Do.
Shrewsbury river	do	do	20	Do.
Navesink river	do	do	88	Do.
Rahway river	do	do	62	
Raritan river	do	do	1,098	1,000 according to Professor Cook.
Do	do	New Brunswick	852	
Do	do	Raritan	456	
North branch of Raritan river	Raritan river	Mouth	184	
South branch of Raritan river	do	do	270	280 according to Professor Cook.
Do	do	Clinton	109	
Do	do	High Bridge	69	
South river	do	Mouth	122	According to Professor Cook.
Green brook	do	do	63	Do.
Stony brook	do	do	55	Do.
Millstone river	do	do	190	Do.
Lamington river	North branch of Raritan river	do	100	
Passaic river	Newark bay	do	902	981 according to Messrs. Croes & Howell.
Do	do	Passaic	908	
Do	do	Paterson	813	855.49 according to Messrs. Croes & Howell.
Do	do	Little Falls	790	750 according to Professor Cook. 832.75 according to Messrs. Croes & Howell.
Do	do	Mouth of Pompton river	370	
Do	do	Chatham Bridge	99	105.96 according to Messrs. Croes & Howell.
Do	do	Millington	51	
Hackensack river	do	Mouth	199	
Do	do	Hackensack	130	
Do	do	Mouth of Pascack creek	56	
Pascack creek	Hackensack river	Mouth	35	
Saddle river	Passaic river	do	61	
Pompton river	do	Two Bridges	401	
Pequannock river	do	Mouth of Ramapo river	204	
Do	do	Bloomingdale	89.94	According to Messrs. Croes & Howell.
Ramapo river	Pompton river	Mouth	172	168.5 according to Messrs. Croes & Howell. 148 according to Professor Cook.
Do	do	Pompton Furnace	170	
Do	do	Ramapo	100	
Ringwood river	do	Mouth	108	According to Professor Cook. 118.42 according to Messrs. Croes & Howell.
Rockaway river	Passaic river	do	210	165 according to Professor Cook.
Do	do	Mouth of Whippany river	138	
Do	do	Old Boonton	121	
Do	do	Boonton	120	126.65 according to Messrs. Croes & Howell.
Do	do	Powerville	118	
Do	do	Denville	100	According to Professor Cook.
Do	do	Baker's Forge	30	Do.
Whippany river	Rockaway river	Mouth	71	59 according to Professor Cook.

Table of utilized power on the coast streams of New Jersey.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
Great Egg Harbor river	Atlantic ocean	New Jersey	Atlantic	Paper	1	10	80
Do	do	do	do	Cotton	1	11	120
Do	do	do	do	Saw	1	10	42
Tributaries of	Great Egg Harbor river	do	Gloucester	do	1	.....	10
Do	do	do	Atlantic	do	1	8	12
Do	Little Egg Harbor river	do	do	do	1	7	24
Do	do	do	Burlington	Flouring and grist	3	24	70
Do	do	do	do	Saw	6	43	101
Do	do	do	do	Paper	1	12	140
Do	do	do	do	Cotton	1	11	130
Do	do	do	Atlantic	Paper	1	11	101
Other tributaries of	Atlantic ocean	do	Cape May	Flouring and grist	4	18	42
Do	do	do	Atlantic	do	4	30	62
Do	do	do	do	Saw	2	12	55
Do	do	do	Ocean	do	13	97	149
Do	do	do	do	Flouring and grist	5	38	90
Do	do	do	do	Box	2	18	27
Do	do	do	do	Flax, hemp, and jute	1	13	32
Raritan river	do	do	Middlesex	Hosiery	1	12	(1)
Do	do	do	Somerset	Flouring and grist	2	28	80
Do	do	do	do	Paint	1	14	15
Do	do	do	do	Machinery	1	14	15
South river and tributaries	Raritan river	do	Middlesex	Flouring and grist	4	38	154
Do	do	do	do	Drugs and chemicals	1	7	90
Do	do	do	do	Shirts	1	16	15
Do	do	do	do	Tobacco	3	39	81
Do	do	do	Monmouth	Flouring and grist	5	56	185
Do	do	do	do	Saw	4	48	49
Lawrence brook	do	do	Middlesex	Flouring and grist	3	37	73
Do	do	do	do	Rubber	1	7	35
Do	do	do	do	Saw	3	32	42
Do	do	do	do	Tobacco	1	7	15
Millstone river	do	do	Mercer	Flouring and grist	1	5	35
Do	do	do	Middlesex	do	2	12	52
Do	do	do	Somerset	do	4	19	258
Tributaries of	Millstone river	do	Mercer	Saw	2	.....	20
Do	do	do	do	Flouring and grist	5	42	114
Do	do	do	Monmouth	do	1	16	20
Do	do	do	do	Saw	3	25	51
Do	do	do	Somerset	Flouring and grist	3	23	75
Do	do	do	do	Saw	1	10	10
North branch of	Raritan river	do	Morris	Flouring and grist	2	18	58
Do	do	do	do	Saw	3	45	53
Do	do	do	Somerset	Flouring and grist	7	72	206
Do	do	do	do	Carriage materials	1	11	12
Do	do	do	do	Saw	2	23	50
Tributaries of	North branch Raritan	do	do	Flouring and grist	6	116	249
Do	do	do	do	Coffins	1	3½	2
Do	do	do	Morris	Flouring and grist	5	87	154
Do	do	do	do	Woolen	1	9	15
Do	do	do	Hunterdon	Agricultural implements	1	14	10
Do	do	do	do	Leather	1	16	10
Do	do	do	do	Saw	2	17	28
Do	do	do	do	Flouring and grist	12	171	221
Do	do	do	Somerset	Saw	1	25	40
South branch of	Raritan river	do	do	Plaster	1	7	15
Do	do	do	do	Saw	3	20	26
Do	do	do	Hunterdon	Looking-glass and picture frames.	1	22	30
Do	do	do	do	Iron castings	1	32	253
Do	do	do	do	Forge	1	12	66
Do	do	do	do	Saw	5	37+	66
Do	do	do	do	Flouring and grist	11	99	365
Do	do	do	Morris	Agricultural implements	1	9	15
Do	do	do	do	Flouring and grist	10	133	341
Do	do	do	do	Saw	10	175	187

Table of utilized power on the coast streams of New Jersey—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
South branch of	Raritan river	New Jersey	Morris	Wheelwrighting	1	14	12
Tributaries of	South branch Raritan	do	Somerset	Flouring and grist	4	20	181
Do	do	do	Hunterdon	Flax	1	5	8
Do	do	do	do	Linseed oil	1	23	20
Do	do	do	do	Saw	3	25+	68
Do	do	do	do	Flouring and grist	15	283	334
Other tributaries of	Raritan river	do	Middlesex	do	4	52+	120
Do	do	do	do	Saw	1	6	16
Do	do	do	do	Shirts	1	11	16
Do	do	do	do	Marble and stone work	1	.....	3
Do	do	do	do	Printing and publishing	1	.....	2
Do	do	do	do	Slaughtering	2	.....	10
Do	do	do	Union	Flouring and grist	2	28	65
Do	do	do	do	Paper	1	38	44
Do	do	do	Somerset	Flouring and grist	3	44	54
Do	do	do	do	Fur-dressing	1	22	53
Do	do	do	do	Saw	1	8	15
Do	Atlantic ocean	do	Monmouth	Flouring and grist	10	209	474
Do	do	do	do	Carriages	1	8	16
Do	do	do	do	Saw	13	120	198
Do	do	do	Middlesex	Flouring and grist	1	9	30
Passaic river	Newark bay	do	Somerset	do	1	20	30
Do	do	do	do	Saw	1	8	24
Do	do	do	Union	Wheelwrighting	1	9	20
Do	do	do	Morris	Flouring and grist	2	16	216
Do	do	do	do	Saw	3	37	64
Do	do	do	do	Paper	1	7½	110
Do	do	do	Passaic	Flouring and grist	2	21	62
Do	do	do	do	Bagging, flax, hemp, and jute	1	21	125
Do	do	do	do	Machinery	8	128+	508
Do	do	do	do	Paper	1	22	250
Do	do	do	do	Printers' fixtures	1	3½	12
Do	do	do	do	Printing and publishing	1	.....	2
Do	do	do	do	Shoddy	1	3	40
Do	do	do	do	Thread linen	1	.....	180
Do	do	do	do	Vulcanized rubber	1	22	148
Do	do	do		Wire	1	.....	6
Do	do	do	do	Wood-turning	1	.....	6
Do	do	do	do	Woolen	3	62	430
Do	do	do	do	Cotton	3	.....	660
Do	do	do	do	Carpet and felt	1	16	250
Do	do	do	do	Silk	8	176	619
Saddle river	Passaic river	do	Bergen	Flouring and grist	6	41	81
Do	do	do	do	Saw	4	27	127
Do	do	do	do	Agricultural implements	1	6	8
Do	do	do	do	Bleaching and dyeing	1	7½	30
Do	do	do	do	Edge-tools	1	6	8
Do	do	do	do	Hosiery	1	8	12
Ramapo river	Pompton river	do	Passaic	Steel-works	1	20-24	200
Do	do	do	Bergen	Flouring and grist	1	6	16
Do	do	do	do	Saw	4	24	47
Do	do	do	do	Electrotyping	1	5	20
Do	do	do	do	Bronze foundery	1	4	12
Do	do	New York	Orange	Flouring and grist	4	61	102
Do	do	do	do	Blast-furnace	1	12	150
Do	do	do	Rockland	Shoddy	1	12	32
Ringwood river and tributaries	do	New Jersey	Passaic	Bobbins	1	3½	13
Do	do	do	do	Blast-furnace	1	14	75
Do	do	do	do	Flouring and grist	4	42	63
Pequannock river	do	do	Morris	Bark	1	9	12
Do	do	do	do	Flouring and grist	1	7	10
Do	do	do	do	Saw	2	23	23
Do	do	do	do	Rubber	2	44	340
Do	do	do	do	Paper	2	30	207
Do	do	do	Passaic	Flouring and grist	3	26	59
Do	do	do	do	Blomary and forge	1	15	30

Table of utilized power on the coast streams of New Jersey—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse power used, net.
						Feet.	
Rockaway river	Passaic river	New Jersey	Morris	Cutlery	1	8	*a* 8
Do	do	do	do	Flouring and grist	6	63	110
Do	do	do	do	Saw	1	14	*a* 20
Do	do	do	do	Rubber	1	18	*a* 45
Do	do	do	do	Rolling-mills	2	20	195
Do	do	do	do	Rolling-mill, etc	1	110	*b* 1,000
Do	do	do	do	Blast-furnace	1	24	250
Do	do	do	do	Blomaries and forges	3	31	151
Other tributaries of	do	do	do	Baskets, etc	1	30	6
Do	do	do	do	Foundery facings	1	11	15
Do	do	do	do	Flouring and grist	11	201	332
Do	do	do	do	Saw	3	45	40
Do	do	do	do	Paper	4	80	165
Do	do	do	do	Blomary and forge	1	30	45
Do	do	do	do	Cotton	1	.....	50
Do	do	do	do	Woolen	1	24	15
Do	do	do	Passaic	*Flouring and grist*	*1*	*19*	*40*
Do	do	do	do	Paper	1	18	50
Do	do	do	do	Carriage and wagon materials.	1	12	20
Do	do	do	do	Screws	1	7	6
Do	do	do	do	Toys and games	1	7	3
Do	do	do	do	Wood-turning	1	8	18
Do	do	do	Somerset	Carriage and wagon materials.	1	14	6
Do	do	do	Sussex	Leather	1	8	8
Do	do	do	Essex	Carpentering	1	.....	2
Do	do	do	do	Jewelry	1	.....	1
Do	do	do	do	Printing and publishing	1	.....	1
Do	do	do	do	Sewing-machines	1	13	*a* 25
Do	do	do	do	Paper boxes	1	10	16
Do	do	do	do	Bronze-powder	2	55	55
Do	do	do	do	*Carriage and wagon materials*	*1*	*20*	*30*
Do	do	do	do	Copper-rolling	1	18	100
Do	do	do	do	Foundery facings	1	18	18
Do	do	do	do	Flouring and grist	2	49	*a* 125
Do	do	do	do	do	5	109	115
Do	do	do	do	Machine-shop	1	20	*a* 30
Do	do	do	do	Cotton	1	16	15
Do	do	do	do	Woolen	3	31	119
Do	do	do	do	Saw	4	75	65
Do	do	do	do	Paper	1	32	*a* 130
Do	do	do	do	do	1	11	60
Do	do	do	do	Wire	1	15	60
Do	do	do	do	Wood-turning	1	18	7
Do	do	do	Bergen	Woolen	2	28	40
Do	do	do	do	Cotton	3	64	125
Do	do	do	do	Flouring and grist	9	125	97
Do	do	do	do	Saw	6	65	70
Do	do	do	do	Bark	1	10	25
Do	do	do	do	Wood-turning	1	14	30
Do	do	do	do	Paper	1	13	50
Do	do	do	do	Vulcanized rubber	1	14	25
Do	do	New York	Orange	Flouring and grist	1	24	25
Do	do	do	Rockland	Agricultural implements	1	9	5
Do	do	do	do	*Flouring and grist*	*6*	*59+*	110
Do	do	do	do	Saw	3	42	129
Do	do	do	do	Leather	1	11	4
Do	do	do	do	Foundery	1	20	15
Hackensack river	Newark bay	New Jersey	Bergen	Flouring and grist	2	16	35
Do	do	do	do	Saw	1	5	40
Do	do	do	do	Furniture	1	6	20
Do	do	New York	Rockland	Flouring and grist	1	15	80
Tributaries of	Hackensack river	New Jersey	Bergen	do	*6*	*63*	*98*
Do	do	do	do	Saw	5	47	108

a From Morris and Essex canal.

b Not in operation since July 1, 1876.

Table of utilized power on the coast streams of New Jersey—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse-power used, net.
						Feet.	
Tributaries of	Hackensack river	New Jersey	Bergen	Furniture	1	6	7
Do	do	do	do	Wood-bending	1	10	10
Do	do	do	do	Leather	1	6	25
Do	do	New York	Rockland	Flouring and grist	8	113	192
Do	do	do	do	Saw	4	45	47
Do	do	do	do	Woolen	1	.....	10
Other tributaries of	Atlantic ocean	New Jersey	Marion	Flouring and grist	7	75+	183
Do	do	do	do	Paper	2	32	80
Do	do	do	do	Printing and publishing	1	.....	3
Do	do	do	Essex	Flouring and grist	2	35	70
Do	do	do	do	Paper	6	130	230

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