*Tabulated statement of the various rapids on the Allegheny River, between French Creek and the Kiskiminetas River.*

| Place. | Distance from mouth of French Creek. | Depth. | Length. | Fall. | Remarks. |
|---|---|---|---|---|---|
| | *Miles.* | *Feet.* | *Feet.* | *Feet.* | |
| Porter's Ripple | 0.5 | 1.6 | 1,320 | 1.6 | Easy; no trouble at this point for navigators. |
| Blue Rock Ripple | 1.1 | 2.0 | 1,200 | 0.66 | Do. |
| Petticoat Ripple | 2.2 | 1.3 | 730 | 2.39 | Narrow at upper end. A rock in channel. |
| Hoover's Island: | | | | | |
| Upper Ripple | 2.7 | 1.2 | 500 | 2.01 | Current quite rapid. No improvement suggested. |
| Lower Ripple | 3.2 | 1.2 | 500 | 1.55 | Not troublesome. No improvement suggested. |
| Porter's Island Ripple | 4.0 | 2.2 | 575 | 1.20 | Channel to right of island. Considerable water takes left chute. A rock to be removed. |
| Porter's Run Ripple | 4.9 | 2.2 | 700 | 1.00 | Several large rocks should be removed. |
| East Sandy Ripple | 5.4 | 1.0 | 3,400 | 3.25 | Three large rocks in head of ripple should be removed. |
| Foster Island Ripple | 6.8 | 1.2 | 7,000 | 7.19 | Fall in 2,000 feet 2.98 feet. This is a continuous stretch of bad river. For immediate improvement, a number of rocks should be removed from the channel. |
| Big Sandy Creek Ripple | 9.5 | 2.2 | 600 | 0.92 | Gentle ripple; a few rocks near channel apparently not dangerous. |
| Brandon Ripple | 10.4 | 1.3 | 800 | 1.88 | Easy; no improvements required. |
| Saint George's Run | 11.2 | 1.3 | 1,700 | 3.12 | A few rocks in channel not particularly dangerous. |
| Stien's Ripple | 12.3 | 3.0 | ..... | ..... | Very gentle ripple, scarcely appreciable; no trouble. |
| Charlie's Oven Ripple | 13.7 | 0.8 | 1,600 | 3.38 | A bad shoal. Wing-dam from left shore proposed. |
| Dennis Run Ripple | 15.1 | 1.8 | ..... | ..... | Very gentle ripple; no trouble. |
| Scrub Grass Ripple | 16.6 | 1.0 | 3,400 | 4.77 | Half-way down ripple in 150 feet river falls 11 inches. A wing-dam from foot of island advisable; also the removal of several rocks. |
| Sister's Bars Ripple | 18.1 | 0.7 | ..... | ..... | Widespread shoal. Wing-dams from each side to confine water in middle advisable. |
| Jacob's Bars Ripple | 18.8 | 2.0 | 600 | 1.67 | Velocity 3.4 miles per hour, channel crooked between bars; no improvement required. |
| Robert's Run Ripple | 19.2 | 2.5 | 350 | 0.71 | River confined in one body, straight; no trouble. |
| Falling Spring Rapid | 19.5 | 1.8 | 500 | 1.62 | Velocity 3 miles per hour; no trouble; no improvement required. |
| Elephant Rapid | 22.9 | 1.5 | 1,100 | 3.66 | Channel divided by gravel bars; dam from right shore suggested. |
| Shield's Run Ripple | 24.0 | 2.0 | ..... | ..... | Very gentle ripple; one bad rock in channel; no other trouble. |
| Ewalt's Island Ripple | 25.4 | 1.5 | 1,975 | 2.54 | A large rock to left of channel should be removed. No other improvement necessary. |
| —— Ripple | 27.3 | 2.5 | ..... | ..... | Current easy; one bad rock to be removed. |
| Black's Ripple | 27.9 | 1.5 | 2,100 | 4.41 | In 800 feet river falls 2.30 feet. Several rocks in channel should be removed. |
| Patterson's Falls | 29.5 | 1.0 | 850 | 3.90 | In first 200 feet fall is 1.21 feet; velocity, 3¼ miles per hour. Cannot easily be improved. |
| McGinnis Rapids or Nicholson's Eddy. | 30.8 | 0.8 | 6,900 | 11.23 | A connected series of rapids, shoalest at head. Wing-dam from left shore at head, and the removal of numerous rocks suggested. |
| Ritchie Run Ripple | 34.4 | 2.0 | 700 | 1.20 | Easy ripple; the removal of several rocks all that is required. |
| Cummings Trunk Ripple | 35.6 | 2.0 | 1,100 | 1.49 | Not troublesome; a few stones could be removed to advantage. |
| Above mouth of Clarion River. | 38.3 | 0.7 | 2,500 | 2.80 | A series of ripples, shoalest at lower end, just at mouth of Clarion. A long dam from right bank to head of island suggested. |
| Ripple below mouth of Clarion. | 38.9 | 1.5 | 700 | 1.78 | Separated from last by short and shallow pool. Dam for last ripple would aid here. A dike from foot of island would be advantageous. |



*Tabulated statement of the various rapids on the Allegheny River, &c.*—Continued.

| Place. | Distance from mouth of French Creek. | Depth. | Length. | Fall. | Remarks. |
|---|---|---|---|---|---|
| | *Miles.* | *Feet.* | *Feet.* | *Feet.* | |
| Trout Run Ripple | 41.0 | 0.7 | 500 | 2.00? | A shoal place; could be easily improved by means of dam from right shore. (See notes.) |
| Parker's Falls | 41.3 | 1.5 | 1,350 | 4.12 | One of the swiftest rapids on the river. (See notes.) |
| Upper Rattlesnake Falls | 42.6 | 0.5 | 500 | 2.032 | Gravel bottom; wing-dam to left shore required. |
| Lower Rattlesnake Falls | 42.75 | 1.5 | 1,700 | 2.048 | Separated from last by pool 300 feet long; rock to be removed. |
| Black Fox Island Ripple | 45.8 | 2.0 | 1,400 | 2.34 | No trouble; no improvement required. |
| Eagle Island Ripple | 46.8 | 3.0 | ..... | ..... | Ripple scarcely appreciable; no improvement required. |
| Armstrong's Ripple | 49.5 | 1.5 | 1,400 | 1.7 | Dam from left shore would improve; present necessity doubtful. |
| Cat Fish Rapid | 51.0 | 1.0 | 900 | 3.88 | Important rapid. Excavation to straighten channel suggested. |
| Sugar Creek Rapid | 53.6 | 1.5 | 1,900 | 2.87 | Very swift; crossed by Brady's Bend Bridge. (See notes.) |
| Goose Bar Ripple | 56.4 | 1.0 | 300 | 0.50 | Gravel bottom. Depth could be improved by dam from left shore. |
| Frazier's Ripple | 57.8 | 2.0 | 1,800 | 2.08 | No improvement probably necessary. |
| Red Bank Ripple | 59.4 | 0.5 | 800 | 1.66 | A widespread shoal. Dam from left required. |
| Early's (Upper) Ripple | 61.1 | 1.5 | 1,200 | 1.95 | Easy, but the removal of a few rocks would improve the place. |
| Early's (Lower) Ripple | 61.6 | 1.5 | 1,200 | 3.641 | A number of rocks in channel make this place dangerous. |
| "Dixon's Chute" Ripple | 63.0 | 2.0 | 950 | 2.78 | A few rocks to be removed. Velocity 3 miles per hour. |
| "Nellie's Chute" Ripple | 64.8 | 1.5 | 2,700 | 3.762 | Three ripples at close intervals; a few rocks to be removed. |
| Upper Mahoning Ripple | 68.0 | 2.5 | 500 | 2.10 | River quite shoal just above ripple. (See notes.) Numerous rocks could be removed. |
| Lower Mahoning Ripple | 68.4 | 3.0 | 350 | 0.64 | Separated from last by pool 700 feet long; no trouble. |
| Upper Orr Hill Island Ripple | 69.7 | 2.0 | 250 | 1.16 | No special difficulty at present. Dam to right shore would be long. |
| Lower Orr Hill Island Ripple | 70.0 | 2.0 | 850 | 1.15 | No special difficulty. Little water escapes between island and shore. |
| Pine Creek Ripple | 72.5 | 2.0 | 1,800 | 2.34 | Removal of small rocks would make channel safer. |
| Cowanshannock Rapids | 74.8 | 1.0 | 500 | 1.16 | River shows disposition to change course. (See notes.) |
| Castaway Rapid | 77.5 | 2.0 | 1,200 | 2.80 | Large central bar divides channel; no rocks, but channel narrow. |
| Ripple below Kittanning | 78.9 | 1.2 | 150 | 0.63 | No trouble, but the removal of a few rocks is suggested. |
| Head Cogley's Island Ripple | 80.2 | 1.3 | 400 | 0.75 | No trouble at this place. |
| Foot Cogley's Island Ripple | 80.7 | 1.2 | 500 | 1.26 | Separated from last by half a mile of swift water. Dangerous rocks here. |
| Zuver's Island Ripple | 82.6 | 3.0 | 800 | 1.49 | Not troublesome; some rocks to right of channel. |
| Nicholson's Rapids | 85.7 | 1.0 | 5,100 | 4.87 | A bad place; dam from island to bar advisable. |
| Kelly's Ripple | 87.3 | 1.5 | 2,000 | 2.54 | Channel too narrow; dredging and dam. (See notes.) |
| Walker's Bar | 89.1 | 3.0 | ..... | ..... | Ripple scarcely appreciable; no trouble. |
| Murphy's Island Ripple | 90.0 | 1.0 | 4,400 | 2.74 | Dredging, and removal of rocks advisable. |
| Grassy Island Ripple | 91.1 | 2.5 | 700 | 1.04 | No trouble excepting at high stages. (See notes.) |
| Kiskiminetas River Ripple. | 92.7 | 1.8 | 700 | 2.18 | No special trouble; removal of old aqueduct piers, &c. |

Respectfully submitted.

Bvt. Col. Wm. E. Merrill,
*Major of Engineers, U. S. A.*

Thomas P. Roberts,
*Assistant Engineer.*

## V 9.

### EXAMINATION OF KISKIMINETAS AND CONEMAUGH RIVERS, PENNSYLVANIA.

UNITED STATES ENGINEER OFFICE,
*Cincinnati, Ohio, February* 12, 1879.

GENERAL: The examination of the Kiskiminetas and Conemaugh Rivers, in Western Pennsylvania, ordered in the last river and harbor bill, was assigned to me by your letter of July 8, 1878.

Owing to the multiplicity of my other duties I was unable to take personal charge of this survey, and I therefore secured the services of Mr. James Worrall, civil engineer, a well-known canal engineer of Pennsylvania. This selection was appropriate from the fact that Mr. Worrall, some years before, had specially called the attention of the Senate Committee on Transportation to the importance of the water-line from Pittsburgh via the Allegheny, Kiskiminetas, and Conemaugh, to the Juniata and the Susquehanna.

On learning that it was the desire of the advocates of this survey that it should not be limited to the two small streams that were named in the bill, but that they likewise wished, if time and circumstances would permit, to obtain some information as to the practicability of restoring the old Pennsylvania through freight-line that once ascended these streams, crossed the Allegheny by inclined planes and connected with the Juniata at Hollidaysburg, I authorized Mr. Worrall to gather as much material bearing on this line as time and funds would permit. The results of this examination are given in his report and maps hereto appended.

When railroads were in their infancy, and canals and turnpikes were the chief modes of cheap transportation in regions deprived of navigable rivers, the great through line between tide-water at Philadelphia and the head of the great Ohio Valley at Pittsburgh was as follows:

| | Miles. |
|---|---|
| Railroad from Philadelphia to Columbia | 90 |
| Canal from Columbia to Hollidaysburgh | 160 |
| Inclined planes, Hollidaysburgh to Johnstown | 50 |
| Canal from Johnstown to Pittsburgh | 105 |
| | 405 |

The Kiskiminetas and its tributary the Conemaugh were a part of this through line, and as such had once been improved by canal and slackwater. It was therefore unquestionable that such an improvement could again be made if circumstances called for it. The question of feasibility, therefore, had already been demonstrated. The fall of the river from Johnstown to the mouth of the Kiskiminetas was also known with certainty, having been tested by actual construction.

There is no present necessity for any improvement of the Kiskiminetas and the Conemaugh. Should a radical improvement of the Allegheny be carried into effect from Pittsburgh to Freeport, at the mouth of the Kiskiminetas, the question will then come up as to the advisability of extending navigable water up the Kiskiminetas and the Conemaugh to the city of Johnstown, a center of iron production which is second only to Pittsburgh.

These two streams will also require improvement should any effort be made to re-open the former central water-line of Pennsylvania.

In making an estimate of the cost of improving the Kiskiminetas and the Conemaugh, it was assumed that the navigation would be for boats of about 280 tons burden, and the same size of boat was used in discussing the water connection with the Juniata by tunneling the Allegheny.



The fall from Johnstown to Blairsville is 219 feet, and from Blairsville to the mouth of the Kiskiminetas 188 feet more, making a total fall from Johnstown to the Allegheny River of 407 feet. The estimates for a system of slackwater between these points (adding 10 per cent. for contingencies) amount to $3,667,000.

The work on the mountain east of Johnstown was undertaken with a view to reconnoiter the ground, and see if it were not feasible to restore and enlarge the Central Pennsylvania water-line, replacing the inclined planes by a through tunnel, and continuing the line from Columbia down the Susquehanna to the Chesapeake Bay. Neither time nor funds sufficed to do more than to decide the question of feasibility, and to make a rough estimate of cost. Should the restoration of this water-line be considered advisable, the mountain division should be re-examined with great care and in detail.

The conclusion from this summer's investigation is that the line in question is practicable, that the summit tunnel would be about $5\frac{1}{6}$ miles in length, and that the water supply is ample. The dimensions of canal assumed in this report are the same as those assumed in my previous report on the Trans-Allegheny Canal from Pittsburgh to Cumberland (Report of Chief of Engineers, 1876, part 2, page 58), being a canal prism 70 feet wide and 7 feet deep, with locks 20 feet wide and 120 feet long.

These lock dimensions are about 20 per cent. larger than those of the Erie Canal, and considerably larger than those of the existing Pennsylvania canals. They would accommodate boats of 280 tons burden. The elevation above sea-level of the proposed summit tunnel is the same as that of the proposed tunnel near White Sulphur Springs on the James River and Kanawha line, and 244 feet lower than the proposed tunnel on the Chesapeake and Ohio line.

It has been assumed that independent canal will only be built where it is impracticable to establish slackwater. The latter has the great advantage of giving greater freedom of motion for boats, and of serving both banks of the river. It is also assumed that should this water-line ever be opened it will be chiefly navigated by self-propelling vessels.

The rough estimate on the whole line from Havre de Grace to Pittsburgh is as follows:

| | |
|---|---|
| Havre de Grace to Frankstown | $10,720,000 |
| Frankstown to Johnstown | 15,607,000 |
| Johnstown to Pittsburgh | 4,518,700 |
| Approximate cost | 30,845,700 |

If to this we add $5,400,000 for doubling the locks, and then add 10 per cent. for contingencies, we obtain $40,000,000 as the total approximate cost of the through water-line from Havre de Grace to Pittsburgh.

It must be borne in mind that no examinations were made except between Frankstown and Johnstown, the estimates on the remainder of the line being made on the basis of former surveys and examinations on file at Harrisburg.

Further details may be found in Mr. Worrall's report.

Respectfully submitted.

WM. E. MERRILL,
*Major of Engineers.*

Brig. Gen. A. A. HUMPHREYS,
*Chief of Engineers, U. S. A.*

## REPORT OF A RECONNAISSANCE OF THE KISKIMINETAS AND CONEMAUGH RIVERS, PENNSYLVANIA, MADE IN THE AUTUMN OF 1878, WITH A VIEW TO THE SAID STREAMS BEING MADE NAVIGABLE. PROPOSING ALSO A CONNECTION OF THE OHIO RIVER AT PITTSBURGH, PA., WITH THE HEAD OF THE CHESAPEAKE BAY AT HAVRE DE GRACE, MD., BY WAY OF THE VALLEYS OF THE SAID STREAMS AND THOSE OF THE JUNIATA AND SUSQUEHANNA ON THE EASTERN SLOPE OF THE ALLEGHENY MOUNTAINS. MADE UNDER THE DIRECTION OF MAJ. WM. E. MERRILL, CORPS OF ENGINEERS, BY MR. JAMES WORRALL, ASSISTANT ENGINEER.

HARRISBURG, PA., *January* 28, 1879.

SIR: * * * * * * * *

From the foot of the Allegheny Mountains at Johnstown, on the Conemaugh, down to the Kiskiminetas, of which the Conemaugh is a constituent, and again down to the mouth of that stream at Freeport, on the Allegheny River, and thence by that river to Pittsburgh, formerly existed the western division of the main line of the Pennsylvania Canal, forming a continuous water communication something over 100 miles in length. This being the fact, there was not much surveying needed in order to ascertain whether the Kiskiminetas and Conemaugh were capable of being improved, at least to the capacity of a 60 or 70 ton boat, for they had been improved to that extent, and along their banks many millions of tons of our great country's productions had been transported through a period of more than a quarter of a century. These streams had in fact helped to form Pennsylvania's great canal system.

This system was carried east over the Allegheny Mountain by means of a portage railroad some 40 or 50 miles long, attaching at Hollidaysburg the eastern foot of the Allegheny Mountain with another canal, which conducted the products along the valley of the Juniata to the Susquehanna and to tide-water. The whole line, commencing at the east, consisted of about 90 miles of railway from Philadelphia to Columbia, 160 miles of canal from Columbia to the foot of the Allegheny Mountain, say 50 miles of portage railway across the Allegheny Mountain, and about 105 miles of canal and slackwater from Johnstown to Pittsburgh via the Conemaugh, the Kiskiminetas, and the Allegheny Rivers. The series was called the main line of Pennsylvania's public works, and was about 405 miles in length, perhaps a little longer.

This work was commenced in the very infancy of engineering in this country, and that a great work like this could have originated and been carried out to successful completion at such a time does high credit to the brains and hands of the day in which the work was begun.

* * * * * * *

We had but a small amount of money at our disposal to help to make this examination; we knew, however, that canals had existed from Pittsburgh to Johnstown, and from Hollidaysburg to Havre de Grace. We hoped to be able, by ransacking the archives of Pennsylvania, to obtain as much knowledge of the canal practicability of the canalled spaces mentioned as we could by a survey in the field, and we believe we have attained that knowledge, after a good deal of searching.

### CROSSING THE MOUNTAIN.

The passage of the mountain was left for us to ascertain in the field, and here we did our field-work. We knew that the first board of Pennsylvania canal commissioners had pronounced it practicable. It was left for us to verify the *dictum*. To do that, we took a section of the Allegheny Mountain summit, bounded north by the crossing of the Pennsylvania Railroad, and south by that of the old Johnstown turnpike, and between these two crossings we ran a contour or girt line at an elevation of 1,700 feet above the level of the sea. We knew that the old tunnel was some 200 feet higher in elevation, and that it was 4 miles and 2,095 feet in length. We would rather, in these late days, have a few extra rods of tunnel to bore than some 400 feet of lockage extra, up and down, so we adopted 1,700 feet, that being, as we knew, less than the highest elevation of the Chesapeake and Ohio Canal, and exactly the proposed elevation of the James River and Kanawha.

Our girt line gave us 105 square miles of water-shed at about 200 feet less elevation (or 400 feet less lockage) than the Clarke tunnel, for which we incurred in exchange about three-fourths of a mile more tunneling—a good exchange.

The size of our tunnel we took from your report on the Chesapeake and Ohio Canal, a work crossing the mountain some 40 miles south of us, accepting your reasoning in its favor as correct, except that we added to the tunnel height, or, rather, depth, 2 feet, which does two things for us, viz, gives us a reservoir 2 feet deep, 42 feet wide, and 5.17 miles long, and affords a space, in the early use of the tunnel, to hold fragments of rock dropping from its roof, which might otherwise impede navigation, giving us time,



as it were, to clear them out of the way. To be sure, this costs more than other reservoirs, but its conveniences are very manifest, and it will be found to be fully worth its cost. The sizes of our canal prism and lock-chamber are copied from the Chesapeake and Ohio Canal also, being some 20 per cent. larger in the lock—not in the prism—than the Erie Canal, and affording navigation for boats of, say, 280 tons burthen, the lock-chamber being 120 by 20 feet, and the canal prism being 70 feet wide on the bottom and 7 feet deep, the slope being 2: 1.

Of our approaches to the tunnel, that on the west is convenient and does not interfere with any competing interest. On the east the approach is easy, and at the same time grand and magnificent. The line leaves the tunnel going east in a cultivated field of Costello's farm on the mountain side, continuing down the valley of Poplar Run, which is for the most part cultivated. From the western end the line passing under the grade of the Pennsylvania Railroad near the mouth of Ben's Creek soon sinks to the bed of the Conemaugh, which it leaves only twice to reach Johnstown, in order not in any case to inconvenience the road or the Cambria Iron Company. The first withdrawal occurs in passing the mouth of the South Fork of the Conemaugh where the space, though somewhat contracted, is sufficient. The line returns to the stream bed very soon and follows it to Conemaugh, where it is proposed to leave the stream again and re-enter it below the confluence of Stony Creek at Johnstown.

On the east, the lines progressing east from the tunnel on approaching the village of Marion, popularly named Puzzletown, in the valley of Popular Run, may turn to the left, and, tracing the depression opposite Newry, seek the old basin of Hollidaysburg, whence Frankstown will be reached by the old canal line, or it may continue along Poplar Run Valley, reaching the main Juniata above the old reservoir, and so along to Frankstown, the east end of our Summit Division.

The above describes the Summit Division, extending from Frankstown, on the Juniata, to Johnstown, on the Conemaugh, evidently the heart of this grand enterprise.

### WATER.

We will now say a few words about water. The rainfall of the Allegheny summit is 38 inches on the average. This would give on the area above our tunnel, every foot of which, continuing on the surface of the ground, can be led to the tunnel, 9,270,000,000 of cubic feet of water.

Cases are of record in which, where there was storage-room, one-half of the rainfall and more has actually been utilized. Supposing we had storage-room, then, we could use out of the above quantity 4,635,000,000 of cubic feet of water. But we have not that storage-room, while we have storage-room for 2,500,000,000 of cubic feet, although for the present we have only provided storage-room for 1,257,000,000; but by an additional expenditure of $2,500,000 we could store the 2,500,000,000, an amount ample for the utmost possibilities.

The maximum possibilities of the canal may be set down at 288 lockages (10 feet lift) per day of 24 hours, including the business of both ends of the tunnel, and the season may be calculated as 244 days long, say from the 1st of April to the 30th of November, both days inclusive. This would require 1,686,000,000 of cubic feet, which, out of our 2,500,000,000 would leave 814,000,000, not quite 50 per cent., for contingencies and probable losses.

[NOTE.—It may be mentioned here that the losses of the canal, if properly built, may be reduced to a very small minimum. For, 1. The tunnel will lose no water, judging from the tunnels already bored through this mountain. 2. The reaches of the canal, formed of the detritus soil of the Allegheny Mountains, ought not to lose any water, and if they did it would be from bad engineering, which, it is to be presumed, need not be anticipated. 3. The losses will be at the gate and admission valves, which, if properly constructed and attentively worked, can be made very nearly water-tight. But, besides, an extra stop-gate can be put at the upper end of each head-lock, almost entirely water-tight, relieving the valves of pressure during slack times and throwing pressure upon the valves only for the nonce. The 814,000,000 reserve, then, is a generous calculation.]

But we calculate now on but 150 lockages in the 24 hours, which would be a very satisfactory business, and this number requires 878,500,000, which deducted from our stored 1,257,000,000, leaves for a reserve and for loss 378,500,000. Again a proportion between 40 and 50 per cent., which will cover all contingencies, will cover indeed the contingency of a rainfall diminished consider ably below the recorded average, a contingency which, of course, must be met. The water question, then, is at rest. The exigent parts of our water-way exist only between Johnstown and Frankstown. After that the canal may be said to be at the bottom of the country, where, as a matter of course, all the water flows. There may be indeed some independent canal on the main Susquehanna, but there, there can be no question of water.*

*We calculate, of course, that the reservoirs and the canal will be always full at the opening of navigation, as the *whole rainfall* of the winter can be led to our summit level, save soakage and evaporation.

In the flights of locks and their reaches, either west of Frankstown or east of Johnstown, should a want be experienced, subsidiary reservoirs, lower than our main gatherers, are practicable and sufficient, but, as I do not think they will be needed, I do not estimate for them.

PLAN OF RESERVOIRS.

The general plan of our reservoirs is as follows: A bank is thrown across the mouth of a gorge or ravine; it will, in general, be not more than 50 feet high plus the guard height, say 6 feet, but for the sake of a large gathering it may be raised even to 100 feet. It will be 20 feet wide on the top, and slope on the water side 3:1, on the outlet side 2:1. It will be made impervious by puddling, and will be saved by proper paving or riprap from being washed. The outlets will be carried through drifts in the hill itself; the integrity of the holding bank must never be disturbed. We calculate our outlets to cost $12,500 on the average; we also calculate on a flood-weir, or by-wash, which is to carry off the waters of sudden showers if they should reach toward the top of our reservoir. These will be, say, 200 feet wide, and will be at the exact level of the reservoirs when full. The retaining bank will be at least 6 feet higher, so that a stream approaching 6 feet deep and 200 feet wide will be relieving the reservoir of the extra flood as that flood rises to the level of the holding bank. Now, unless the Allegheny Mountain itself is unretentive, our losses will be small. But of course there will be probing and all other precautionary measures before a reservoir bank shall be located. These reservoirs are all to be connected with iron pipes, and the whole series will discharge their waters finally into the tunnel at either end, as the case may be.

Large spurs of the mountain in front of our reservoirs we intend to drain toward us by the means of catchment races. But we shall not go to that expense unless something worth while in the way of supply will be the result.

INCLINED PLANES.

I do not go into the subject of inclined planes, for we can have a wet canal. If, however, inclined planes should be adopted on great canals, they can be very easily applied on our eastern slope; not so easily, for several reasons, on the western slope. But we need not discuss the subject at present. It is for us to present the project of a great water-way upon the route proposed as practicable, which we do without hesitation. Inclined planes or not, let those who may be called upon to build the work settle the point. The whole work is eminently practicable; the water question is at rest.

* * * * * * *

It remains now for me to try to give an idea of the style of the work, and we will commence at the east.

STYLE OF THE WORK.

The better opinion among hydraulic engineers leans of late unquestionably to the side of slackwater (lock and dam) navigation where that system can be adopted, and this work, then, will be a slackwater navigation, with the exception of the mountain division from a point on the Conemaugh east to Frankstown or Hollidaysburg. There are, as has been seen, two short deviations on the Conemaugh between Johnstown and the point where the navigation arrives at that stream from the tunnel. There is, however, another very large exception, and that is the whole of the first and second sections of the eastern division, or, say, from the mouth of the Susquehanna to the mouth of the Juniata.

In a very few words I will give some of the prominent reasons in favor of slackwater. The first is that the expanse of water in the lock and dam system through which the vessels pass is indefinite and is as large as possible, thereby easing traction, a matter of very great importance on several accounts. The second is that in the case of slackwater the navigated water is at the lowest surface of the country, so there cannot be any leakage except at the mechanical structures, and this latter can be reduced to a very small percentage, for of late years skill in construction almost abolishes danger from this source.

The objection to slackwater is that in times of freshet it is dangerous and difficult of navigation against the stream. In a system like ours, however, the danger is ameliorated by the number of reservoirs near our summit level, which will unquestionably reduce the freshets to some extent and regulate and shorten their duration. This, however, always remains an objection to slackwater, but it seems to be less feared of late years than formerly. Its casual interruptions are perhaps more than made up by the additional facility of navigation which the large expanses of water afford during the quiet, medium, and low-water stages.

EASTERN DIVISION.

But on a portion of the eastern division of this work the state of things is somewhat unusual. The stream to be navigated is very wide, and there is a great fall in it. From Havre de Grace to Columbia the rise is over 226 feet, the distance being 45 miles.



Now, dams in such a stream as the Susquehanna, in width from half a mile to a mile and over, ought not to be more than, say, from 15 to 20 feet high; and of such dams, to make a navigation between these points, there would be required at least 20. These, with their locks, would be costly, averaging nearly half a million each. Besides, the Susquehanna is subject occasionally to ice-freshets, and when it is stated that one of these is known to have formed a dam of ice actually backing the water so as to float away a bridge which was placed at an elevation not less than 40 feet, according to my recollection, above low-water, some idea of their magnitude may be formed. * Yet, notwithstanding this, if as many dams as were required for this work were constructed, they themselves might prevent the recurrence of these gorges. But the subject requires more consideration than on such an examination as this I have been able to give to it, nor need these considerations be brought forward until the work is nearer construction than it is.

There are many very important arguments on both sides, and all engineers know that great hydrographic questions cannot be decided without a study of the subject on the spot. Abstract science cannot settle such questions, so I will not now undertake to decide.

But this I do know, namely, that an independent canal can be made between the points in question, with one short interval of slackwater from Chicques (Chicquesalonga) Gap to the foot of the Kanawaga Falls, and for the present I shall return an estimate of the cost of such a work, premising that the slackwater system throughout, on account of the unusual width of the Susquehanna, would cost about 25 per cent. more.

A dam at Chicques will easily supply a canal to Havre de Grace, though the distance is some 48 miles, one or two side streams being available as subsidiary supplies, and the same dam will make a slackwater to Kanawaga Falls. Thence an independent canal is practicable to the mouth of the Juniata, where may come in another feeder from Clark's Ferry Dam, which I have presumed in the estimate will still be standing when this work comes to be further considered. From this point to the foot of the mountain about Hollidaysburg the Juniata will be slackwatered, and this completes what we call the eastern division; its first and second sections extending from Havre de Grace to the mouth of the Juniata, its third embracing the Juniata to the mountain's foot.

MOUNTAIN DIVISION.

Then comes the mountain division, commencing at Frankstown and ending at Johnstown. This may be called independent canal for the whole way, except some pieces of slackwater on the Conemaugh before mentioned. In this division occurs the tunnel, very many locks, and some 18 reservoirs, all shown on the map and estimates. The lockage divided by 10 will, in general, give the number of the locks, though that number may be a little exceeded where a change in the proportion cannot be avoided. This is is the life and soul of the work. The tunnel has been described. It is believed that it will mostly stand without arching, but arching is estimated for about one-fifth of the tunnel's length. There is enough water, aided of course by the reservoirs at the summit level (the tunnel); but if help is wanted on the slopes east and west, it can be had from the main Juniata and from branches of the Conemaugh outside of our chosen rainfall area. For this help I did not consider an estimate necessary. In the nature of a necessity it may be considered *paulo post futurum*.

Both east and west of the mountain division, as the navigation is along the bottom of the country toward which all the water of the region tends, there can be no leakage, and if the mountain division wants no more water, how can these valley divisions want it, receiving, as they do, all the water saved in the mountain reservoirs, and all the waters of the valley occupied and its tributary watersheds?

WESTERN DIVISION.

The western division extends from Johnstown to Pittsburgh along the Conemaugh and the Kiskiminetas to the mouth of the latter stream. The width of the slackwatered streams will be from, say, 200 feet at Johnstown to from 500 to 600 feet toward the mouth of the Kiskiminetas, and in the Allegheny from 800 to 1,100 feet.

We have calculated on slackwatering the Allegheny River on the scale necessary for this work. If that river is to be improved *per se*, might not this circumstance be borne in mind, and would it not be better to calculate on the possibility of our waterway being finally constructed?

I conclude this report with the estimates, which are as follows, in the tables, and the divisions are distinctly marked on the map and the profile; a map and profile on a large scale and a sketch and profile on a small scale being returned with this report.

* Burr's celebrated bridge near McCall's Ferry, carried off in 1818.

The summit or mountain division was actually surveyed. We ran a line with the compass and chain, inclosing the 105 square miles heretofore mentioned. We ran a girt line of levels with the aneroid barometer, and, having frequent means of testing our levels upon points the elevations of which were actually known, we may state with confidence that our aneroid's errors may be all found within a zone of 10 feet vertical thickness, quite near enough for a reconnaissance. The rest of our work was among the archives of Pennsylvania, and, as one or other of the corps had traced every foot of ground between Pittsburgh and Havre de Grace, we think we have been able to submit a practicable plan and a reliable estimate. The special works of the great line we have enumerated and estimated, but not located with precision, except vertically. It would take a very careful location survey to say exactly where each of the works should be placed. Had it not been for the archives, we could have only pronounced on the possibility of this grand enterprise. With their aid we can not only say that it is practicable, but we believe it could be let to-morrow and built at our estimate. Whether it would be worth the money is for the consideration of the people. Its capacity to transport would nearly reach, if not exceed, 10,000,000 tons per annum. Put it at 5,000,000 tons through trade, and one-quarter of a cent per ton per mile would pay 6 per cent. on a cost of $40,000,000 and leave $2,000,000 to pay for keeping up the work and its management, which would appear ample.*

And ought any work to pay more profit than that and do justice to the people in the matter of their transportation? A quarter of a cent per ton per mile, let that be called the inevitable first cost of transportation, leaving the other three-fourths of a cent to reward the transporters. To this complexion must we come at last. Our farmers, producers, merchants, ought all to be able to make their bargains when transportation was an element of the transaction, estimating transportation at the rate of one cent per ton per mile for everything; but as there must be exceptions to all rules, let there be exceptions here, slightly favoring, say, the heavy minerals, coal, iron, fire-clay, salt, stone, &c.

* * * * * * *

Attached to the estimate will be found a table of the reservoirs and their capacities. It will be seen that these are located on well-known water-courses; no dry ravines, but drains made in the mountain itself by nature, and of such a character in size as to have acquired a regular designation as a water-course of the country. These streams are never entirely dry; there is, in the greatest droughts, an appreciable amount of water in them. There can be no doubt on the subject of water in the minds of those who are aware of what has already been done in this way, and who know the wants of a canal, not perhaps in this country, but in Europe, particularly on the continent, where, for water-ways and for great manufacturing establishments, water has been studied and practiced with to an extent far beyond anything of the kind that has been even thought of among ourselves.

Before closing I must allude to my assistants in the field, Mr. W. H. Snyder, of Centre County, in command, and Mr. Charles A. Young, of Philadelphia, in charge of the levels and the aneroid. They both of them performed their parts well. Mr. H. Alricks, jr., of Harrisburgh, has assisted Mr. Snyder in the mapping, and, bearing in mind that they were obliged to derive much of their data from musty archives, they deserve credit for their research.

To gentlemen in Cambria and Blair Counties I am very much indebted for local topographical information; to Mr. Hutchinson, of Altoona; to Messrs. Fulton, Peeler, and Brawley, of the Cambria Iron Company; to Mr. Antes Snyder, of the Pennsylvania Railroad engineer corps; and to Captain Kelly, of Apollo, on the Kiskiminetas; also to Mr. Gibboney and Mr. Irvine, of Duncansville, Blair County; also to gentlemen of Hollidaysburg, namely, Judge Caldwell, Mr. Jack, and Mr. Gardner, and to Lawyer Hewit; but especially to Mr. D. K. Reamey, who was indefatigable in serving the little corps in every way that he could, both by his local knowledge, which is quite extensive, and acting as a guide in several cases to the mountain passes. I trust that the hopes of these gentlemen may at last be fulfilled, and that they may repossess one of our great lines of communication.

* * * * * * *

I am, very respectfully, your obedient servant,

JAMES WORRALL, C. E.,
*Assistant.*

Bvt. Col. W. E. MERRILL,
*Corps of Engineers, U. S. A.*

*The Erie Canal transported over 5,000,000 tons last year and did not cost $1,000,000 to keep up—scarcely more than three-fourths of a million.



*Estimate showing the cost of a water-line through Pennsylvania and part of Maryland, by way of the Allegheny, the Kiskiminetas, the Conemaugh, the Juniata Rivers, and the river Susquehanna, to Chesapeake Bay, at Havre de Grace, Maryland, the result of a reconnaissance made in the year 1878–'79, under the charge of Bvt. Col. W. E. Merrill, U. S. Engineers, by James Worrall, assistant.*

EASTERN DIVISION.

*First section.*—Havre de Grace to foot of Kanewago Falls:

| | |
|---|---|
| 237,600 linear feet enlarged canal, at $8 | $1,900,800 |
| 10,560 linear feet independent canal, at $10 | 105,600 |
| Dam and guard-lock at Chicques | 300,000 |
| 60,440 linear feet towing-path, at $2 | 120,880 |
| 261 vertical feet lockage, at $2,500 per foot | 652,500 |
| Contingent works, bridges, &c | 154,220 |
| Amount | 3,234,000 |

*Second section.*—Kanewago Falls to mouth of the Juniata:

| | |
|---|---|
| 154,100 linear feet independent canal, at $10 | 1,541,000 |
| 82 vertical feet lockage, at $2,500 | 205,000 |
| Dam, with guard-lock and feeder, at mouth Juniata | 150,000 |
| Contingent works, bridges, &c | 95,000 |
| Amount | 1,991,000 |

*Third section.*—Mouth of Juniata to Frankstown:

| | |
|---|---|
| Slackwater navigation, 57 dams, at $43,650 each | 2,488,050 |
| 661,700 linear feet towing-path, at $2 per foot | 1,323,400 |
| 569 vertical feet lockage, at $2,500 per foot | 1,422,500 |
| Contingent works, bridges, &c | 261,050 |
| Amount | 5,495,000 |

*Summary.*

| | |
|---|---|
| First section | 3,234,000 |
| Second section | 1,991,000 |
| Third section | 5,495,000 |
| Total | 10,720,000 |

MOUNTAIN DIVISION.

*First section.*—Frankstown to east end of tunnel:

| | |
|---|---|
| 64,000 linear feet independent canal, at $10 | 640,000 |
| 788 feet vertical lockage, at $2,500 | 1,970,000 |
| Contingent expenses, bridges, &c | 150,000 |
| Amount | 2,760,000 |

*Second section.*—Tunnel, reservoirs, &c.:

| | |
|---|---|
| 1,215,650 cubic yards tunneling, at $5 | 6,078,250 |
| Excavation, approaches | 91,600 |
| 28,100 cubic yards brick arching, at $10 | 281,000 |
| One shaft, 10 feet diameter, 850 feet depth, at $30 | 25,500 |
| Contingent expenses | 323,650 |
| Amount | 6,800,000 |

RESERVOIRS.

| | |
|---|---|
| Yellow Creek: 451,000 cubic yards bank, at 35 cents; outlet, $12,500; by-wash, $2,500; clearing 40 acres, at $150 | $178,850 |
| South Fork: 498,000 cubic yards bank, at 35 cents; outlet, $12,500; by-wash, $2,500; clearing 130 acres, at $150 | 208,800 |
| Laurel Run: 590,000 cubic yards bank, at 35 cents; outlet, $12,500; by-wash, $2,500; clearing 250 acres, at $150 | 259,000 |