A study of the readings on the gauge-pegs established at each camp, as the work progressed up stream, but all carefully connected with and referred to the initial peg near railroad bridge, shows some anomalous features, due, it is believed, to special local conditions predominating at each locality; on no gauge did synchronous readings give corresponding levels for the water surface, the differences being as small as $\frac{8}{}$ inch and as large as 5½ inches, and apparently not governed by any periodic or other continuous and distinct law or ratio, but subject to unaccountable fluctuations; these suggest the difficulty of maintaining the same continuous grade for the bottom, when, in the progress of the improvement, long stretches of river came under treatment.

To summarize: 13½ miles of river have been improved, at a round cost of $1,220 per mile; the last work—at Peak Creek Shoals—being at the obstruction which more effectually than any other, in the whole line of 19 miles up from initial point—railroad bridge—originally projected for improvement, estopped navigation in the low-water stages; the map shows this, the natural channel running for ¾ of a mile over a gravel slope underlaid by flat rock no lower than 1 foot, with the river over 400 yards wide, and most of its water in the deep pools barred by ledges on the other (easterly) bank. As was to be expected, 4 to 6 inches of water was often alone available, and no loads at all could get over; add to this a fall of 13.479 feet in the 6,661 feet of obstructions in bed (the survey of 1872 gave 14.80 feet fall, but the new leveling is believed to be the correct one), and the difficulty and importance of the section demonstrate themselves.

The freshet of September, 1878, undoubtedly went to impair much the improvement made, involving an expenditure of from $2,000 to $3,600 to do over work once completed; but with this, even, there has been a decided betterment of navigation effected. The fact, however, originally set forth must not be lost sight of—that if any marked benefit is to accrue from the improvement it must be extended up 5 miles—to make the 19 miles first projected—or to Mac's Creek, at a cost of $7,600 more. This point is in this region the down-stream boundary of an extensive and rich mineral-producing district, which is the main interest to be served by the improvement, and which alone can and would inaugurate fully use of it when once made. To utilize, then, the work already done commensurately with its cost, necessitates as immediate a completion to Mac's Creek as possible.

A review of two seasons' operations establishes certain general points, which seem to call for consideration here. The practicability of the original project has been fully proven, with the modification of abandoning the idea of selecting the present natural sluices to patch up, not only for the contemplated steam-navigation, but even for the bateau navigation and rafting. It is necessary, in my opinion, to adopt a more general and radical method to effect a permanent improvement than has heretofore been tried. With this in view, I recommend a free use of dams to collect into pools the water, which constructions should be much more elaborate than any heretofore attempted. Further application of the approved formula convinces me that 900 cubic feet per second is the maximum discharge of the river to be calculated upon in the yearly low stages. Generally, as low as 700 feet only will pass. The worst places invariably are where this constant volume discharges through a section enlarged by widening of the low-water bed. The mere rock ledges, *per se*, form a minor type of obstructions, as always they have above and below them pools more or less deep, and blasting through them readily gives a good sluice with regular grade. The velocity is certainly hereby injuriously affected; but low regulating dams or long training walls below always can be put in to better distribute, and thus rectify this induced obstacle to navigation. With the shoals and rapids the case is different. Here the simple go-ahead work of blasting down to a depth and clearing out obstructions is ineffective, as by as much nearly as the bottom is so lowered does the surface fall shortly afterwards. The supply of water must, firstly, be augmented by going up to the very head of the obstruction, probably 1, 2, or 3 miles up, and constructing the water-way by building out bodily from the banks low but solid dams, followed down stream by guide-walls. In such structures I should use largely brush in mats or bundles; for, while the river does not carry in it much sediment, and the dams would generally find rock to rest on, yet it would allow of broad bases, and would make thus not only a cheaper but a more water-tight dam than rock alone.

I should project for future work more construction of this kind, much less blasting.

The new system, more like to a slack-water system, would probably entail a cost beyond that of the original estimate for this improvement, by reason of the greater quantities of work involved. The work, however, can be, and has been done, done at figures below that estimate. The proposed system would be unquestionably slow of execution, too slow for those requirements other than the engineering ones; the main dams, all requiring correct location, would necessitate a study of and acquaintance with, the river throughout the year—a residence on it, by the engineer in immediate charge. In this country, where to move from point to point, to transport supplies, &c., is slow work at best, it is impossible for the engineer to properly manage works spread over any considerable stretches, and yet in any extended operations, to attain

the desired execution, such spreading out is necessary, as 100 men to a locality and camp are about the advantageous working maximum On this basis, working on the present plan, not more than $18,000 can be expended in one season, so short are these. Every preparation must be completed before work actually begins, as also the essential duty of examining and locating by permanent marks the works proposed for that season; this would require the maintenance of a small permanent party making surveys, maps, &c., and a large quantum of labor and exposure for the engineer.

For the river from Hinton up to Sifford, 64 miles, the open-river system of improvement will, I think, be found to be but partially applicable; the dimensions of the river and of the main falls will necessitate the construction, at these latter, of locks and dams; with the open sluices, some system of towing up ascending boats, by cables on the bottom, the motor being steam or air, located on the banks, or better, on large floats fixed in the still upper pools, will, in my judgment, be found essential. The main feature of the present plan, that of low constructions, should in all cases be held to in practice, as far as practicable. Experience, as developed by the universal fate of the work of the late Confederate States on this river (though this now seems to have been injudiciously located and poorly built), is adverse to anything like rigid structures, such as large timbers bolted down to the bed-rock, interfering with the free discharge of the waters, in the sudden and great freshets incident to this river, and which, as the country towards its headwaters becomes stripped of its forests and gradually opened to cultivation, must be looked for more frequently and of greater size, with periods of years to elapse.

That the proposed improvement will be of real and decided local benefit, I consider now proven. It, and it alone, can and will afford an adequate outlet for a region good agriculturally; and with ascertained workable mines of the ores of lead, zinc, coal, and iron, and a considerable lumbering district all favoring the building up of local manufacturing interests, an outlet alone is needed to put in motion at once a considerable and increasing trade. Statistics on these heads, in the present condition of things, it is impossible to give, as not existing. I have the honor, sir, to remain, in conclusion,

Very respectfully, &c.,

JAS. W. CUYLER,
Captain of Engineers.

Maj. W. P. CRAIGHILL,
Corps of Engineers, U. S. A.

TABULAR STATEMENT OF WORK DONE.

Average force worked during season, men	number	102
Working days in season, on work, do	do	57
Rock excavated, moved (by boats), and built into constructions, or wasted, cubic yards		1,940
Gravel excavated, moved (by boats), and built into constructions, or wasted, cubic yards		1,092
Cost of rock work, as above specified	per cubic yard	$2 20
Lead, in boats, from 50 yards to 200 yards.		
Cost of gravel work, as ditto		$0.61
Amount of constructions	linear feet	2,325
Average base, 11 feet; height, 433 feet; slopes, 1½ B to 1 P, and 1 B to 1 P.		
Holes drilled	linear feet	8,734
Average depths of holes	do	3.75
Average depth of holes drilled per day, per drill, 10 hours	do	12.78
Blasts fired	number	2,219
Miss-fires	do	51
Holes abandoned	do	226
Ratio of miss-fires to blasts	per cent	2¼
Average charge powder, per cartridge	pounds	0.54
Average charge dynamite	do	0.33
Average rock moved per blast	cubic yards	1
Cost complete of pitch-bag cartridge (cartridge 15 inches long over all, 13 inches of powder, 1 quart tar to 2 gallons pitch-mixture; diameter, outer, 1¾ inches, full)		$0.17½
Explosives used, powder	pounds	1,275
Explosives used, dynamite	do	235
Fuse used	linear feet	13,182
Fuse length, average per cartridge = 4 minutes' time	do	5.8
Cost of commissary department per day, per man	cents	17⅛
Ration per day: 1 pound pork, 2¼ pounds cornmeal, 1.08 pounds sugar, .75 pound coffee, vegetables.		

REPORT OF MR. A. M. SCOTT, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Charleston, Kanawha County, West Virginia, May 26, 1879.

COLONEL: The following report on the improvement of New River, immediately above Hinton (mouth of the Greenbrier), from the beginning of operations in September last to date, is respectfully submitted.

In compliance with your instructions, dated Hinton, August 23, 1878, received through Lieutenant Turtle, I went at once to that place to estimate and arrange for starting the work. Your instructions were, in effect, to plan to do the least possible at any one point compatible with the navigation of the steamer then building at Hinton by the New River Steamboat Company, so that as much of the river as possible might be gone over during the low-water season.

I found, by conferring with the directors of the company, that they were anxious to have improvements made as soon as possible that would enable them to run their boat up to the mouth of Lick Creek, about 22 miles above Hinton. This would open to navigation considerable fine farming country, and practically connect with the important Tazewell County road. As the small appropriation could not possibly be applied to advantage over a greater distance, I limited my investigations to that point, and it was finally thought best, owing to the lateness of the season and the need of economy in applying the money, not to attempt anything last fall above the foot of Bull's Falls, and a project and estimate for opening a preliminary channel up to that place (11 miles above Hinton) were submitted as soon as possible, and approved by you in letter dated September 5.

As to a description of New River above the mouth of the Greenbrier, the susceptibility to improvement for steam navigation, the characteristics of the beautiful and promising country through which it runs, I can add nothing to your quite full reports of December, 1872, and January, 1873, printed as Appendix T 29, of the Chief of Engineer's Report for 1873.

The work, as planned and partly carried out last season, consisted principally of blasting a channel 50 feet wide and about 2 feet deep at low-water, through the solid ledges of which the shoals are mainly composed. There were also many large detached pieces and bowlders to be removed either by a craneboat or blasting, or both, and more or less smaller stone and gravel, best managed by hand.

The following is an abstract of the project and estimate approved by your letter of September 5:

For a craneboat	$600 00
For 1 batteau	75 00
For 3 skiffs	75 00
For tools and blasting material	450 00
For labor, including foreman, to be expended in blasting and removing by hand solid rock and loose stone at the different shoals, viz:	
Between the landing at Hinton and head of Greenbrier Shoals (mostly solid rock)	1,375 00
Pack's Ferry Shoals (bowlders)	85 00
Deer Lick and Blue Stone Shoals (bowlders and solid rock)	530 00
Land Crafts Ford and Shoal (solid rock)	900 00
Buffalo Shoal (bowlders and solid rock)	165 00
Gardner's Ledges (solid rock)	490 00
Ellis Shoal (bowlder and solid rock)	245 00
To operate craneboat 35 days, with a force of 11 men, including foreman, at $18 per day	630 00
For blacksmithing	125 00
For superintendence and contingencies	800 00
Amount of estimate	6,545 00

Arrangements for beginning work, the procuring of tools, boats, blasting materials, &c., were made at once, and a force of hands got to work on the shoals between the landing and the foot of Greenbrier Shoal on September 7.

Operations were a good deal delayed by the unprecedented rise in the river, which on September 13 reached 20.20 feet above low-water at Hinton. At the mouth of Blue Stone River, 5 miles above, its highest point was 23.7 feet above low-water. This was from 5 to 6 feet higher than ever known before. It did much damage in the valley. At Upper or Old Hinton, 16 buildings, several of them good frame houses, were carried away. The sawmill of Mills and Company, the only one then in operation in the place, was also seriously damaged.

The damage to the mill delayed us considerably about the building of the craneboat, and we did not succeed in getting it ready for work till October 12. The boat, as built, overran the estimate, costing, complete, $730. It is 48 by 17 feet, rigged with a good double-geared crab, capstan, spuds, and a strong four-pronged grapple of 5 feet reach. It proved to be well adapted to the work. Both it and the smaller crane sent down from the upper river did good service, and will be indispensable in future operations.

The boats, tools, camp equipage, &c., that had been in use by Captain Cuyler on the upper part of the river were received at Hinton October 13. As stated, the most of the work consisted in blasting. This was all under water, generally in a current so swift that breakwater-dams were necessary and could only be carried on to advantage in low, clear stages. The season was very unfavorable; besides the big flood of September, the work was frequently stopped by small rises and bad storms. Owing principally to so much of the work being *in* the water a good deal of trouble was had in getting hands, particularly after the weather turned cool, and we were finally obliged to send a number from Kanawha to keep up the force. From 40 to 75 men, distributed at different points, were kept employed whenever the weather and water would permit, till November 27, when we were obliged to suspend for the season. Nothing has been done in the river since, except to place three additional ring-bolts and remove a few particularly troublesome stones at Greenbrier Shoals.

The work was carried out substantially as planned, but at a greater proportional cost, up to the head of Blue Stone, and a considerable amount was done on Land Crafts, the next shoal above. We were unable to do anything above that point.

The following is a statement of the rock removed at the different *shoals measured in piles, side walls, &c., after excavation:*

	Cubic yards.
Between Hinton Landing and foot of Greenbrier Shoal (estimated)	43
On Greenbrier Shoals	1,754
On Pack's Ferry Shoal (estimated)	12
On Deer Lick Shoal	227
On Blue Stone Shoal	221
On Land Crafts Shoal	437
Total	2,694

As appears, the greater part of the work was done on Greenbrier Shoals. This is a bad place, consisting of a series of solid ledges, beginning at the mouth of Greenbrier River and extending up 3,600 feet. The fall in this distance, Hinton gauge reading 3.30 feet per levels by Mr. Schoonmaker, was 7.20 feet.

The work on this shoal exceeded my estimate a good deal, and there is still considerable work to be done on some of the ledges at straightening and widening the channel. The average cost not including outfit, boats, tools, &c., of all the excavation, measured in the pile, was a little over $2 per cubic yard. On Greenbrier Shoal, where the work was heavier and more connected, the cost was about $1.40 per yard.

Dynamite or giant powder was used almost exclusively, with very satisfactory results. It proved to be much better for the work than common powder.

The width of channel adopted, 50 feet, has been found by trial to be too narrow in places for the new steamer, and it will be necessary to increase it to about 75 feet at some points where the current is very swift or somewhat indirect. As a rule, though, it is thought 50 feet will answer present purposes.

As to slopes, depths, &c., but little was attempted at grading the chutes; and at several places it was found impracticable, under the plan pursued, to reduce the slope to less than about 1 in 130, and on a few of the ledges and falls it will be even steeper than this. With such grades, a depth of not more than about 2 feet (equal to an *available* low-water depth of about 18 inches) could be made; and this was finally adopted and worked for throughout.

By extending the side-walls somewhat, and the occasional use of short wing-dams (the rock excavated for channels was used for these purposes as far as it went), it is thought an available ordinary low-water depth, of from 20 to 22 inches, can be made at very reasonable expense.

Steamers will be obliged to "wind" through some of the chutes, and must be provided with steam capstans for this purpose. To facilitate the ascent of boats, the channel at the shoals was located next the shore as far as practicable; and at other points, where the current was too strong to be stemmed, ring-bolts were placed.

The steamboat company got their new boat, the Cecilia Miller, ready to run by the middle of December, and have since made several trips, during rather high stages of water, to the foot of Bull's Falls. They are unable, though, when the Hinton gauge reads less than 3½ feet (corresponding to 2.60 feet above low water), to get above Land Crafts, the point reached by our work last fall.

The boat is a well-built stern-wheeler, 100 by 20 feet, provided with a steel boiler, 8 by 30 inch cylinders, a steam capstan, and good machinery throughout. She draws, when light and under way, less than 12 inches. She is thought to be rather too large

for the navigation intended, but is considered as having fully demonstrated the practicability of making this part of the river navigable for small light-draft steamers.

The benefit afforded to the lumbering interest, which is considerable and increasing, should also be noticed. Many of the old batteau channels and "notches" are so narrow and crooked that rafting is attended with a good deal of risk; our channels being wide enough for the rafts, will render the passage of the shoals comparatively safe.

The desirability of continuing the improvement up to the mouth of Lick Creek as soon as possible, has been referred to. This, as stated, would benefit quite an extent of good farming country, notably the rich Crump's Bottom and Indian Creek districts, and connect with the Tazewell, Mercer, and Monroe County wagon-road. Between Land Crafts and the mouth of Lick, the principal points to be improved, mentioned in order going up, are Gardner's Ledges, Bull's Falls, War Ford Shoal, Crump's Ledges, and McDaniel's Falls. War Ford, which has a fall of about 8 feet in 1,000, is the most serious. It is thought a permanent winding-line or wire-rope will be advisable at this shoal, and some arrangement of this kind is likely to be found expedient at other points.

The additional expenditure necessary to complete the improvement, as begun, to the mouth of Lick Creek, I have estimated roughly at from $18,000 to $24,000.

My duties on the Kanawha Improvement made it necessary for you to employ a local superintendent, and I take pleasure in acknowledging the efficient services of Mr. T. Schoonmaker, assistant engineer, who acted in this capacity during the working season. From notes and sketches made by Mr. Schoonmaker, maps (five in number) of the shoals where work was done were made on a scale of 1 inch to 100 feet.

During the progress of the work, temporary gauges, referred to approximate low-water, were kept at various points on the shoals; these were finally connected with permanent bench-marks.

Agreeably with your instructions, and by permission of Lieutenant Turtle, I went to Hinton on the 19th instant and turned the records, property, and work generally, over to Col. William Proctor Smith, assistant engineer.

Very respectfully, your obedient servant,

A. M. SCOTT,
Assistant Engineer.

Maj. WM. P. CRAIGHILL,
Corps of Engineers, U. S. A.

SURVEY OF NEW RIVER, FROM LEAD MINES, IN WYTHE COUNTY, TO THE MOUTH OF WILSON CREEK, IN GRAYSON COUNTY, VIRGINIA.

UNITED STATES ENGINEER OFFICE,
Baltimore, Md., January 10, 1879.

GENERAL: In the river and harbor bill of June 18, 1878, was a requirement for an examination or survey of New River, Virginia, from the Lead Mines, in Wythe County, to the mouth of Wilson Creek, in Grayson County. A survey had been previously made (in 1872) of the portion of the river from the Lead Mines down to the mouth of the Greenbrier, at Hinton in West Virginia, and in 1874, in connection with the surveys of the central water-line, a survey had been made of the part of the river from Hinton to the mouth of the Gauley, where the New and Gauley unite and form the Great Kanawha. The whole of the river, therefore, from the mouth of Wilson Creek to its mouth has been surveyed and mapped.

The New River rises in North Carolina and crosses the line between that State and Virginia nearly at the mouth of Wilson Creek, the initial point of the survey of 1878. After flowing in a general easterly direction from the mouth of Wilson Creek, it turns down again into Alleghany County, of North Carolina, whence it soon re-crosses into Virginia. The point of its junction with the Gauley, in West Virginia, is almost due north of the place of its crossing from North Carolina into Virginia.

The survey of this year was made in September by Col. W. Proctor Smith, lately of the Corps of United States Topographical Engineers.

His report, dated January 10, 1879, and maps, prepared in this office, are forwarded; the report by mail, and the maps by express.

The portion of the river surveyed by him has a length of 62 miles. The survey was as complete as the money available allowed. Colonel Smith's report is quite full, and, together with the maps, gives much valuable information concerning the river, and the country through which it passes.

It appears, from a study of the regimen of the river, that there is an "abundance of water for any system of navigation that may be inaugurated."

Three estimates are presented for the improvement, as follows:

1. For a two-foot navigation for keelboats, with a channel not less than 30 feet wide, with tracking or towing paths at the falls and rapids	$115,000
2. For a steamboat navigation, with a channel 90 feet wide and not less than 3 feet deep, with a grade always less than 1 in 400, including 28 locks and dams	1,200,000
3. For a five-foot steam navigation	1,600,000

Very respectfully, your obedient servant,

WM. P. CRAIGHILL,
Major of Engineers.

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

REPORT OF COL. WM. PROCTOR SMITH, ASSISTANT ENGINEER.

BALTIMORE, *January* 10, 1879.

COLONEL: I have the honor to submit the following report of a survey of New River, made last fall, under your directions, and with it the following maps, viz: Seven sheets of map of New River, scale 1 inch to 800 feet; one tracing of map of New River, scale 1 inch to 5 miles; eleven sheets of profile of New River, scale 1 inch to 400 feet; one sheet of profile of New River, scale 1 inch to 4,000 feet.

The first maps exhibit the meanderings of the stream, its width and depth, as well as position of ledges, shoals, and falls, also topography. The second gives the outlines of the stream, on a smaller and more convenient scale. The third indicate the slope of the water surface, from the mouth of Wilson to the Lead Mines, on an exaggerated scale. The fourth, the same slope on one sheet, for greater convenience.

The maps are of such a scale, and the whole report written in such a manner, as to make the survey an extension of the one made, under your directions, by N. H. Hutton, in 1872, from the Lead Mines to the mouth of the Greenbrier.

Only so much of the river was surveyed as lies between the mouth of Wilson, in Grayson County, Virginia, and the Union Lead Mines, in Wythe County, Virginia, a distance by the course of the river of 62 miles.

An examination of this section was made, in 1874, by S. T. Abert, United States civil engineer, who described the country and river and reported thoroughly on its mineral and agricultural resources to the Chief of Engineers of the United States Army, January 7, 1875.

The party was organized and equipped on the 26th of August, at Wytheville, the county-seat of Wythe County, Virginia, 47 miles from the mouth of Wilson via Independence, the county-seat of Grayson County, Virginia. On the 28th of August it was in camp at Fox Creek, a few miles from the mouth of Wilson, ready for work, but owing to a rise in the river of 8 feet, operations were not commenced until the 2d of September, and finished October 1, at the Lead Mines.

Level and transit lines were run throughout the entire distance, determining the meanderings of the river, the slope of the water-surface, and the form and character of the obstructions. Numerous soundings were made, and sufficient topography taken for the purposes of the survey.

September the 12th, at the 18th mile, a sudden and unprecedented rise of the river took place; 18½ feet above ordinary low-water, and 7½ feet higher than the great flood of May, 1840. At Samuel Cox's mill, below Peachbottom Creek, the rise was 22 feet.

New River is formed by two tributary streams, which rise in the mountains of North Carolina and unite on the border of Virginia. The North Fork rises in Ashe County, the South Fork in Watauga County, and they flow together 4 miles above the mouth of

Wilson, the initial point of this survey. From the latter point the river runs between the different ranges of the Blue Ridge and the Alleghany Mountains, in an easterly direction for 22 miles, and thence northeasterly to the terminus of the survey. The headwaters are 2,500 feet above tide-water; the country mountainous, the roads rough and sometimes impassable.

Throughout this distance, except where the river flows through the mountains, the valleys present some bottom-lands in places from one-half to three-quarters of a mile wide. The hills bordering on the river, however, are cultivated to their very summits.

Beginning at the mouth of Wilson, with a width of 300 feet and an average depth in the pools of 4 feet, the river gradually widens to 1,000 and 1,100 feet, and contracts again to the width of 450 feet, and an average depth in the pools of 5 feet at the Lead Mines.

Between the mouth of Wilson and the Lead Mines, several streams of no inconsiderable size empty into New River; among them, from the south and east, are Potato, Carolina-Elk, Meadow, Chestnut, and Crooked Creeks, and Little River; from the north and west, Fox, Saddle, Bridle, Peachbottom, Elk, Eaglebottom, Surgener, Brush, Snowhill, and Cripple Creeks, and Bull Run. All of these are mountain streams, furnishing from 25 to 200 cubic feet of water per second, at ordinary stages.

The drainage area of the river, within the limits of the survey, amounts to 900 square miles.

The river during a portion of the time of this survey was down to what the inhabitants call summer water, but they had known it 3 or 4 inches lower. The stream, however, was sufficiently low for the results of observation for velocity and quantity of water to be relied upon. The discharge indicated 2 miles below the mouth of Wilson was 1,200 cubic feet per second; and 1,800 cubic feet per second at a point 4 miles above the Lead Mines. These results show that the stream affords abundance of water for any system of navigation that may be inaugurated.

As is usual with mountain streams, this river presents pools of comparatively deep and still water, separated by rapids, shoals, and falls. The water flows in the pools at about the rate of 1 mile per hour; over the rapids at about the rate of 3 miles per hour, and over the falls at about the rate of 5 miles per hour. The depth usually, over the falls, is from 9 to 12 inches; frequently, however, obstructions are formed below, by bowlders, which increase this depth to 2 feet.

Throughout this survey the pools are very short, whole miles being composed of ledges of gray and blue granite or slate, a few hundred feet apart, with very short pools between. Only five pools of a mile in length in this portion of the river.

The total fall in the river from the mouth of Wilson to the Lead Mines is 507 feet, or about $8\frac{1}{8}$ feet per mile; a grade, although very heavy, that, if distributed equally throughout the entire distance, would not present an insuperable obstacle to the navigation of the stream.

The obstructions to navigation consist of solid flat rock on the bottom of the river, loose rock, gravel, and sand; ledges over which the water flows, those which scarcely disturb the surface, and collections of bowlders, showing many feet above the surface.

The ledges encountered for the first 20 miles of this survey are composed of gray granite almost entirely; for the next 30 miles this same rock, called by the inhabitants gray river rock, largely predominates, interspersed with blue granite or slate, soap and sandstone, and some gneiss and ferruginous rock; for the last 5 miles the ledges are almost exclusively limestone. In a great many instances these deposits are distorted and upheaved in such a manner as to make their removal easy by blasting.

The following statement of the obstructions met with in each mile will give a good idea of the work necessary for the improvement of the river. The stream elsewhere than where these obstructions prevail affords a good navigation of 4 feet at low stages.

Commencing at the mouth of the Wilson, with an elevation above tide-water of 2450.9 feet, four shoals, over gray granite ledges, are to be found in the—

First mile.—One at ford, 300 feet long, fall 3 feet; one 100 feet long, no fall; one 800 feet long, loose rock, fall 1.8 feet; and one 300 feet long at ford, fall 1.1 feet. Fall in the mile 7.74 feet.

Second mile.—Elevation 2443.16 feet, one shoal 100 feet long, no fall; slight rapids, flat rock bottom for 2,450 feet, fall 3.6 feet. Fall in the mile, 6.47 feet.

Third mile.—Elevation 2436.69 feet; Fox Falls, 2.55 feet in 150 feet, over 2 ledges of solid rock; one fall .6 foot in 75 feet; and rocky shoal 400 feet long, fall 1 foot. Fall per mile 5.76 feet.

Fourth mile.—Elevation 2430.93 feet; one slight shoal 2000 feet long; fall 1.4 feet. Fall in the mile $3\frac{1}{4}$ feet.

Fifth mile.—Elevation 2427.43 feet; one shoal full of bowlders, 1550 feet long, 2.2 feet fall; one shoal 300 feet long, no fall; one fall .7 foot in 100 feet. Total fall 4.53 feet.

Sixth mile.—Elevation 2422.90 feet; one shoal 2000 feet long, bowlders at Cedar Island, flat-rock bottom, fall 6.88 feet; one shoal 300 feet long, fall 1.2 feet. Total fall 10.57 feet.

Seventh mile.—Elevation 2412.33 feet; one shoal 250 feet long, full of bowlders, fall .4 foot; slightly shoal for 2600 feet, bowlders, fall 3.9 feet. Total 6.91 feet.

Eighth mile.—Elevation 2405.42 feet; good water; one ledge, 1 foot high, extends $\frac{3}{4}$ way across the stream. Fall in the mile 2.83 feet.

Ninth mile.—Elevation 2402.59 feet; fall of 1 foot in 50 feet, good soundings over it, and there smooth water; one shoal 300 feet long, no fall. Total fall 2.83 feet.

Tenth mile.—Elevation 2399.76 feet; Osborne's Falls consisting of a succession of ledges, from 6 inches to 18 inches, over which the water falls nearly vertical; 1st fall 8 feet in 1200 feet, then pool 1100 feet long; 2d fall, $7\frac{1}{2}$ feet in 600 feet, then rapids, with deep water, but full of bowlders, fall $1\frac{1}{2}$ feet; 3d fall, $3\frac{1}{4}$ feet in 200 feet. Fall in the mile $20\frac{3}{4}$ feet.

Eleventh mile.—Elevation 2379.01 feet; good water for 600 feet; balance wide and shoal; shoal between island and mainland; gravel and loose rock. Total fall 7.36 feet.

Twelfth mile.—Elevation 2371.65 feet; one ledge 50 feet long; fall $\frac{1}{4}$ foot; one shoal 500 feet long, full of bowlders; 2 ledges; fall 2 feet; shallow between island and mainland; one fall .8 foot in 50 feet; one shoal 800 feet long, full of bowlders, at Elk Creek Ford; fall $3\frac{1}{4}$ feet. Fall in the mile 9.44 feet.

Thirteenth mile.—Elevation 2362.62 feet; bowlders at island; one 500-foot shoal at Horse Ford, flint rock and flat bottom; .6 foot fall; fall of $2\frac{1}{2}$ feet in 250 feet; one shoal 450 long; fall .4 foot. Total fall per mile, 7.84 feet.

Fourteenth mile.—Elevation 2354.37 feet; one shoal 500 feet long; fall .6 foot; one slight shoal 800 feet long; fall 3 feet; one shoal 400 feet long; fall 1 foot. Fall per mile 6.8 feet.

Fifteenth mile.—Elevation 2347.57 feet; slight shoal 1700 feet long; fall 3 feet; river broad, shoal and rapids for 1450 feet; 3 feet fall. Fall per mile 7.41 feet.

Sixteenth mile.—Elevation 2340.16 feet; rapids and fall at beginning over blue granite or slate; fall 3 feet, balance good water, gravel bottom, some sand islands. Total fall per mile 5.68 feet.

Seventeenth mile.—Elevation 2334.48 feet; commences with good water; then shoal 1600 feet long at Doughton's and Middle Ford. Total fall 4.38 foot.

Eighteenth mile.—Elevation 2330.10 feet; at beginning shoal for 400 feet, at Taliaferro's Ford; fall 1 foot; then pool, and at end shoal 750 feet long; fall 3.3 feet. Fall per mile, 7.03 feet.

Nineteenth mile.—Elevation 2323.07 feet; good navigation. Fall per mile 2.71 feet.

Twentieth mile.—Elevation 2320.36 feet; good water. Fall per mile 6.82 feet.

Twenty-first mile.—Elevation 2313.54 feet; one shoal 1700 feet long; fall 4 feet; one shoal 1600 feet long; fall 3 feet. Fall per mile 7.55 per feet.

Twenty-second mile.—Elevation 2305.99 feet; rapids for 300 feet; 1.8 feet fall; 2 slight shoals, 400 feet long each; balance pool. Fall per mile 5.79 feet.

Twenty-third mile.—Elevation 2300.20 feet; shoal 175 feet long; fall 2 feet; at Peachbottom Creek and Cox's Ford, slightly shoal for 2400 feet, water smooth and still. Fall per mile 4.94 feet.

Twenty-fourth mile.—Elevation 2295.26 feet; rapids for 250 feet, good water, however; balance pool. Total fall 6.2 feet.

Twenty-fifth mile.—Elevation 2289.6 feet; rapids for 100 feet; fall .4 foot; rapids and falls for 700 feet; 2.7 feet fall; balance good water. Total fall 5.19 feet.

Twenty-sixth mile.—Elevation 2283.87 feet; mouth of Little River, shoal for 800 feet. Total fall 2.61 feet.

Twenty-seventh mile.—Elevation 2281.26 feet; pool 2200 feet long; one shoal 300 feet long; $\frac{1}{2}$ foot fall; pool 1200 feet long; balance flows rapidly. Total fall 5.16 feet.

Twenty-eighth mile.—Elevation 2276.10 feet; 900 feet shoal at Collins's old ford; fall 1.8 feet; balance good water. Fall per mile 4.17 feet.

Twenty-ninth mile.—Elevation 2271.93 feet; pool for 3300 feet; shoal for 2000 feet. Total fall 4.97 feet.

Thirtieth mile.—Elevation 2266.96 feet; shoals and pools about equal. Fall in the mile 6.44 feet.

Thirty-first mile.—Elevation 2260.52 feet; one shoal for 200 feet and another for 800 feet; fall 8 feet. Fall in the mile 3.24 feet.

Thirty-second mile.—Elevation 2257.28 feet; Island Ford, rapids for 700 feet; 2.3 feet fall; one small vertical fall and then rapids for 400 feet. Total fall $5\frac{3}{4}$ feet.

Thirty-third mile.—Elevation 2251.53 feet; rapids for 800 feet, then succession of short rrpids and pools, and a fall of $1\frac{1}{2}$ feet in 200 feet. Total fall 8.05 feet.

Thirty-fourth mile.—Elevation 2243.48 feet; one shoal 1000 feet long; fall 2 feet; one shoal 600 feet long; fall 1 foot. Fall per mile 4.31 feet.

Thirty-fifth mile.—Elevation 2239.17 feet; one shoal 200 feet in length; one shoal 1000 feet long and rocky. Fall per mile 3.35 feet.

Thirty-sixth mile.—Elevation 2235.82 feet; for 800 feet rocky and rough, but good water; one shoal 500 feet long. Fall in the mile 3.86 feet.

Thirty-seventh mile.—Elevation 2231.96 feet; good water. At end very wide; some sand islands. Total fall 3.37 feet.