18th CONGRESS,
2d SESSION.

MESSAGE

FROM THE

PRESIDENT OF THE UNITED STATES,

TRANSMITTING A REPORT OF THE

EXAMINATION WHICH HAS BEEN MADE

BY THE

Board of Engineers,

WITH A VIEW TO

Internal Improvement, &c.

FEBRUARY 14, 1825.
Read: Ordered that it lie upon the table.

WASHINGTON:
PRINTED BY GALES & SEATON.
1825.

To the House of Representatives of the United States:

I herewith transmit a report from the Secretary of War, with a report to him by the Chief Engineer, of the examination which has been made by the Board of Engineers for Internal Improvement, in obedience to their instructions, of the country between the Potomac and Ohio Rivers; between the latter and Lake Erie; between the Allegheny and Schuylkill Rivers, the Delaware and the Rariton; between Buzzard's and Barnstable Bays and the Narragansett Roads and Boston Harbor, with explanatory observations on each route. From the views which I have taken of these reports, I contemplate results of incalculable advantage to our Union, because I see in them the most satisfactory proof that certain impediments, which had a tendency to embarrass the intercourse between some of its most important sections, may be removed without serious difficulty; and that facilities may be afforded, in other quarters, which will have the happiest effect. Of the right, in Congress, to promote these great results, by the appropriation of the public money, in harmony with the states to be affected by them, having already communicated my sentiments fully, and on mature consideration, I deem it unnecessary to enlarge at this time.

JAMES MONROE.

Washington, February 14, 1825.

WAR DEPARTMENT,

February 12, 1825.

SIR: I have the honor to present, herewith, a communication from the Chief Engineer, submitting to this department the proceedings of the Board of Engineers for Internal Improvement, under the act of Congress passed the 30th of April, 1824, authorizing the Executive to cause to be procured the necessary surveys, plans, and estimates, upon the subject of roads and canals. The reports are very full, and, in detail; the Board have reported favorably as to the practicability of passing the summit level between the waters of the Potomac and the Ohio, by means of a canal, and that it may be effected at a small expense, compared with the advantages expected to result from its execution, in a national and commercial point of view.

I have the honor to be,

Very respectfully, sir,

Your obedient servant,

J. C. CALHOUN.

To the PRESIDENT *of the United States.*

ENGINEER DEPARTMENT,

Washington, February 12, 1825.

SIR: I have the honor of laying before you the proceedings of the Board of Engineers for Internal Improvement, under your instructions of the 31st of May and 29th December, 1824, of which copies numbered 1 and 2 are enclosed, directing an examination to be made of a route for a canal communication between the tide waters of the Chesapeake and the Ohio rivers, and between the Ohio and Lake Erie; also, in relation to other examinations of routes for canals under other instructions. These proceedings are contained in the joint letter of the Board to this department, dated 2d of February, 1825, a copy of which, numbered 3, is enclosed; also, in the report of Gen. Bernard and Col. Totten, and in the separate report of Mr. Sullivan, of the former of which marked A, and the latter marked C, copies are transmitted herewith.

I have the honor to be,
Very respectfully, sir,
Your obedient servant,
ALEX. MACOMB,
Maj. Gen. Chief Eng.

Hon. J. C. CALHOUN,
Secretary of War.

No. 1.

ENGINEER DEPARTMENT,

Washington, May 31, 1824.

GENTLEMEN: I am directed, by the Secretary of War to inform you, that the President has, under the authority of the act of Congress, dated the thirtieth of April, 1824, appropriating $ 30,000 for the purpose of procuring the necessary surveys, plans, and estimates, upon the subject of roads and canals, appointed you as a Board of Internal Improvement, to superintend the execution of the provisions of the said act. There will be attached to the Board for the present, Major Abertt of the Topographical Engineers, with five assistant lieutenants; Capt. M'Niell, of the same corps, with an equal number; and Mr. Shriver, who is well acquainted with the localities of the country, and who is authorized to employ, under your directions, five citizen surveyors. Captain Poussin, of the Topographical Engineers, and Lieutenants Courtenay and Dutton, of the corps of Engineers, will be immediately attached to the Board in its operations. The officers detailed for service and the citizens employed, will report to the Board for orders. The rules and regulations established in the prosecution of the survey of the coast, will apply in the disbursement of the appropriation, and the compensation to be allowed the officers of the army, who may be detailed for service under the act. The Board will observe the same rules in reporting, from time to time, the progress made in the execution of the duties assigned to them.

The Board will proceed to make an immediate reconnoissance of the country between the tide waters of the river Potomac, and the head of steam boat navigation of the Ohio, and between the Ohio and Lake Erie, for the purpose of ascertaining the practicability of a communication between those points, of designating the most suitable route for the same, and of forming plans and estimates in detail, of the expense of execution.

It is very desirable that the report should be received on this important line of communication, in time to be submitted to Congress at their next session. The Board will accordingly use every possible exertion to effect that object.

I have, &c.

ALEX. MACOMB,

Maj. Gen. Chief Engineer.

To General BERNARD, *Assistant Engineer,*
Lieut. Col. TOTTEN, *of the corps of Engineers,*
JOHN L. SULLIVAN, Esq. *Civil Engineer.*

No. 2.

ENGINEER DEPARTMENT,

Washington, Dec. 29, 1824.

GENTLEMEN: The Board of Internal Improvement will forthwith prepare a Report of their proceedings, under instructions communicated by order of the Secretary of War, by this Department, dated the 31st of May last, and subsequently, in relation to Internal Improvements. The Board will state their opinion as to the practicability of the several routes for canals which they have examined, should the examinations have been sufficient to justify the Board in forming their opinion; but, where the Board have not been able to decide definitively on any particular route, they will express their impressions of the importance of that route, or any other property or advantage which such route may have presented to the view of the Board, or other observations which the Board may deem proper to make in relation thereto. When the Board shall decide favorably in regard to any of the routes, they will, in like manner, express their opinion fully, with such observations on the advantages and benefits which may be expected to arise from the construction of the canal.

The Board will also report the operations of the Topographical Engineers and Surveyors, connected with the examinations of the Board, as far as the state of their work will permit.

The Secretary of War is desirous of receiving your report as early as practicable, in order to lay it before the present Congress.

I have, &c.

ALEX. MACOMB,

Maj. Gen. Chief Engineer.

To Brig. Gen. S. BERNARD,
Lt. Col. J. G. TOTTEN,
J. L. SULLIVAN, Esq.
Board of Internal Improvement, Georgetown, D. C.

No. 3.

WASHINGTON CITY, *Feb. 3d,* 1825.

SIR: The Board of Internal Improvement have the honor to transmit two reports on the proposed canal communication between the tide water of the Potomac and the Ohio river—between the Ohio and Lake Erie; between the Allegany and Schuylkill, or tide water of the Susquehanna; between the Delaware and the Rariton; between Buzzard's and Barnstable Bays, and between Narragansett Roads and Boston Harbor. Accompanying these reports, will be found a letter from Dr. Howard, on his reconnoissance of the country south of the Glades; a memoir on part of the Allegany river; a memoir by each of the chiefs of brigade, viz. Major Abert, Captain McNeill, and Mr. James Shriver; a letter from Lieut. John N. Dillahunty; a

copy of the records of the Board in relation to the Ohio and Lake Erie canal routes, and nineteen maps, general and particular, of the several sections of country explored and surveyed, of which the following is a list.

No. 1. Survey of part of the route of the Potomac canal, in 1824, by J. J. Abert, Major and T. E. assisted by Lieuts. Swift, Macomb, Bennett, Long. and Wilson.

No. 2. Maps of the eastern section of the summit level of the Chesapeake and Ohio canal, surveyed by Wm. Gibbs McNeill, Capt. U. S. Topographical Engineers, Lieuts. Lewis G. De Russy, Wm. Cook, Isaac Trimble, R. C. Hazzard, John N. Dillahunty, John M. Fessenden, W. G. Williams.

No 3. Profiles attached to Capt. McNeill's map of the summit level; numbered 2.

No. 4. Profiles attached to Capt. McNeill's map of the summit level; numbered 2.

No. 5. Profiles attached to Capt. McNeill's map of the summit level; numbered 2.

No. 6. Profiles attached to Capt. McNeill's map of the summit level; numbered 2:

No. 7. Profiles attached to Capt. McNeill's map of the summit level; numbered 2.

No. 8. Profiles attached to Capt. McNeill's map of the summit level; numbered 2.

No. 9. Plan of a proposed summit level of the Ohio and Chesapeake canal, between the Little Youghiogany and Crabtree creek, by Mr. Howard, assistant Civil Engineer.

No. 10. Profile of the surface of the ground over a proposed summit level of the Ohio and Chesapeake Canal, by Mr. Howard, assistant Civil Engineer.

No. 11. Map of surveys of the western section of the summit level of the Chesapeake and Ohio canal, by James Shriver, assistant Civil Engineer.

No. 12. Topography of the map of surveys, byJames Shriver, assistant Civil Engineer.

No. 13. Profiles attached to Mr. James Shriver's map, numbered 11.

No. 14. Profiles attached to Mr. James Shriver's map, numbered 11.

No. 15. Profiles attached to Mr. James Shriver's map, numbered 11.

No. 16. Map of the country between Washington and Pittsburg, shewing the proposed routes of the Chesapeake and Ohio Canal, compiled by E. H. Courteney, Lieut. corps Engineers.

No. 17. Map of the country between Pittsburg and Lake Erie, shewing the proposed routes of the Ohio and Erie canal, compiled by Mr. Howard, assistant Civil Engineer.

No. 18. Map of the country between Pittsburg and Philadelphia, shewing the route of a proposed canal from the Ohio to the Delaware, compiled by George Dutton, Lieut. corps of Engineers.

No. 19. Plan and profile of a survey and level for the proposed canal between Buzzard's and Barnstable Bay, surveyed September, 1818, by L. Baldwin—copied by Lieut. Fessenden, of the Artillery.

In execution of the orders of the Secretary of War, communicated in your letter of the 31st May last, "to make a reconnoisance of the country between the waters of the Potomac and the head of steam boat navigation of the Ohio, and between the Ohio and Lake Erie, for the purpose of ascertaining the practicability of a communication between these points; of designating the most suitable route for the same; and of forming plans and estimates, in detail, of the expense of execution:" the Board proceeded from the seat of government, through the portion of country indicated therein. Having deliberately examined every local circumstance on that part of the Allegany mountain which lies between the head waters of the Potomac and those of the Youghiogany, a branch of the Monongahela, the Board prepared instructions for the preliminary surveys and measurements to be executed by the Topographical Engineers and other officers and gentlemen attached for this service; and having now maturely considered the circumstances observed by them personally, and carefully studied the results of such of these preliminary surveys as are completed, *they are decidedly of opinion that the communication is practicable.*

The Board, on viewing the country between the Ohio and Lake Erie, along various lines indicated by public opinion, became possessed of such facts as place the practicability of canalling, from the head of steam boat navigation, in the Ohio, to Lake Erie, beyond all doubt. The information collected by the Board is not, however, of a nature to enable them to decide which of the several routes deserves a preference; and a definitive choice can only be made after the several surveys, indicated by the extract from the record of the Board, herewith, shall have been executed.

In further execution of orders, the Board repaired to the state of Massachusetts, and viewed the ground between Buzzard's and Barnstable Bays, where the isthmus of Cape Cod is not only narrow, but so low, compared with the adjacent country, as to have attracted public attention to this improvement, at an early period. Aided by the maps and reports heretofore made of this ground, at the public expense, and by maps and investigations which had been made more recently, at private expense, the Board are of opinion that this canal might be opened, at least as deep as low water, at no extraordinary cost. The tide rising from eight to ten feet on the Barnstable side, this depth of water might be carried through the canal. The locks, on the Barnstable side, to be protected by a breakwater, or pier.

The board also made a reconnoissance of the ground between Narragansett bay, and Boston harbor; likewise, with the advantage of knowing the result of previous surveys, under the authority of the

state government, whence they infer that further investigation may show this communication to be practicable.

In execution of the orders of the Secretary of War, requiring a co-operation with the canal commissioners of the state of Pennsylvania, the board examined the whole route of the proposed canal, from the Allegany to the Schuylkill. From observations made by the board along this line, and from surveys, and levellings, since made by the Pennsylvania commissioners, the board are inclined to believe in the possibility of this work; but they think that further investigations are necessary to the definitive settlement of this question.

The co-operation of the board, with the commissioners of the state of New Jersey, resulted in a strong conviction of the practicability of a canal communication between the Delaware, and the Rariton, by leading the water of the former, from about twenty-six miles abov the city of Trenton, to the summit ground between Trenton and Brunswick; and that the abundance of the water of the Delaware will supply a canal, of dimensions adapted to the vessels navigating the great rivers and bays of the seacoast. The board are, however, of opinion, that, previous to fixing the exact route of the canal, lines should be run from the vicinity of Bordentown, across the summit, to the lowest point on the Rariton, to which a canal can, with due economy, be extended, with a view to avoid as much of the difficult tide navigation of the two rivers as possible.

The board has the satisfaction to acknowledge the zeal, perseverance, and ability, with which all the officers of the two corps of engineers, and other gentlemen attached to the service, have fulfilled their duties, to the extent which the time, and the season of the year permitted. The unfinished parts of their instructions comprehend the eastern section of the Ohio, and Chesapeake canal, from Cumberland to tide, some lines on the summit, and the whole western section.

We have the honor to be,

Very respectfully,

Your obedient servants,

J. G. TOTTEN, *Maj. Eng. Bt. Lt. Col.*

S. BERNARD, *Brig. Gen.*

JNO. L. SULLIVAN.

Members of the Board of Internal Improvement.

To Bt. Maj. Gen. ALEX. MACOMB,

Col. Com. U. S. Engineers.

A.

REPORT

Of General S. Bernard, and Lieut. Col. J. G. Totten, members of the Board of Internal Improvement, on the several Canal routes examined in 1824, by orders from the War Department.

The routes for Canals which have been successively examined during the late season, by orders from the War Department, are as follows:

1st. One to unite the Chesapeake and Ohio, through the Valley of the Potomac, on the eastern, and that of the Youghiogany on the western side of the Alleghany Mountain.

2d. One to unite the Ohio with Lake Erie, through the Valley of Big Beaver Creek, on the southern side, and several directions across the country which slopes to the Lake, on the northern.

3d. One to unite the Ohio and Schuylkill, through the Valleys of the Alleghany river, Kiskimintay, great and little Conemaugh rivers, on the western side, and Juniatta and Susquehannah, on the eastern, to a point below Harrisburgh, and from thence to Philadelphia, through Lancaster county.

4th. One to unite the Delaware and Raritan, through the Valleys of Crosswick Creek, and across the Assunpich, on the western side, and the Valley of Lawrence's Brook, on the eastern.

5th. One through the isthmus of Cape Cod, from Hyannus harbor to Barnstable harbor.

6th. One to unite Buzzard's Bay and Barnstable Bay, by Monument river, and Scussett river.

7th. One to unite Narragansett Bay and Boston harbor, from Taunton river to Weymouth landing.

This report will comprise the successive examination of each of these routes; but, in the first place, it will be proper to indicate the series of operations which the Board have adopted to arrive at a definitive result, in the formation of the system intrusted to them.

The complete *project* of a canal requires great researches, and a careful investigation of its smallest details. The first operation must be to reconnoitre the ground at sight, and thus investigate, in a general manner, the main features of its hydrography and topography; this can only give general results, and approximated conjectures, more or less exact; accurate surveys must afterwards ascertain the positive facts, disengaged from all speculative ideas. Thus, 1. To reconnoitre the ground. 2. To survey accurately its topographical

features, and measure its water-courses, to ascertain their sufficiency to feed the projected canals; such are the preliminary operations which must precede the more minute details of the *project*.

The general facts established by these preparatory operations, enable to indicate approximatively the route which the canal must follow. Then, we must trace its directing line on the ground itself, and, with the level in hand, bend it to every local circumstance. The route of its feeders, the capacity of its *reservoirs*, the location of its locks, and the system to adopt in varying their lifts; the location of its dams, tunnels, and culverts, must be determined at the same time; the nature of the soil must be ascertained, and the feeding water-courses accurately guaged, when they are at the highest, and when they are at the lowest stage. This second series of operations determine the final location of the line of canal, and ascertains the several works, in earth, timber and masonry, which will be required; as well as the quantity and distribution of the waters, which the localities afford to feed the different levels, in an equal and sufficient manner.

These being ascertained, the only remaining operations are, to draw these several works, of earth, timber, and masonry; calculate their dimensions; fix their construction, and the nature and manner of employing the materials required for this purpose; and, lastly, to estimate exactly their cost, and draw up the detailed statement of it.

By following the successive series of operations which we have just analyzed, nothing is left to conjecture; every part of the work is studied and ascertained, and no chance is left for mistakes of facts, or miscalculations, to endanger the success of its completion. This regular mode of proceeding is the surest way to avoid those illusive deceptions, from whence such works have so frequently failed. The general project corresponds in its results with the details; the whole combines economy, solidity and durability, and the estimates being founded upon positive and ascertained facts, their accuracy may be depended upon.

Upon these principles the Board have divided the task which was confided to them, in the following manner.

1st. Reconnoitering and making the preparatory survey of each project.

2d. Tracing it in detail on the ground.

3d. Drawing the works, and ascertaining their estimate.

Passing to the successive examination of the several routes for canals mentioned above, we will begin by that which is destined to unite the Chesapeake and Ohio.

CHESAPEAKE AND OHIO CANAL.

This canal may be divided in three sections, eastern, middle, and western. The eastern section extends from the tide-water in the Po-

tomac, to the mouth of Savage river, in the northern branch of the Potomac. The middle section extends from the mouth of Savage river, in the Potomac, to that of Bear creek, in the Youghiogany. The western section, from the mouth of Bear creek to the Ohio, at Pittsburg.—*(See maps and profiles, from No. 1 to No. 16.)*

EASTERN SECTION.

This section ascends the valley of the Potomac; as the several ridges which that river traverses and breaks through, oblige to follow its course, without any deviation, the side on which it should ascend along the river, is the only choice left to the Engineer; we will, therefore, compare the respective facilities for receiving the bed of a canal, which exists on each of those sides.

From Georgetown to the Little Falls bridge, the northern shore of the river is flat, whilst, on the southern shore, the mountain extends closer to the stream, and is more abrupt.

From the Little Falls to the Monocacy, the northern shore is very rugged, but from the Monocacy to Harper's Ferry, it offers a succession of flats and bluffs. The southern shore on that whole extent, is very rugged; its banks of red slate hang perpendicularly over the stream in several places.

From Harper's Ferry to Shepherdstown, both shores present undulating flats, and a soil easy to work. The same nature of ground runs from Shepherdstown to Williamsport.

From Williamsport to Hancock, the northern shore presents extensive flats, whilst the mountain on the southern shore stretches closer to the bed of the river.

From Hancock to Town creek, the northern shore is flat, to the promontory formed by Sidelong hill, and from thence presents a succession of flats to Town creek. The southern shore offers no greater facilities, except in front of Sidelong hill.

From Town creek to Old Town, the flats on the northern shore are only interrupted by a precipitous bluff, on an extent of about 300 yards. The southern shore presents no advantages over it.

From Old Town to Cumberland, the northern shore is flat, except for one mile along Alumrock, and the same extent along Braddock's hill.

From Cumberland to the mouth of Savage river, the valley grows narrower, its flanks close on the bed of the river, and the northern shore is little better than the other.

This short analysis is sufficient to show, that the northern side of the valley offers the best ground for receiving the bed of a canal. Some portions of the southern bank might be more favorable than the portions of the northern shore which face them; but, in order to render this advantage available, it would be necessary to cross the river frequently by aqueducts, which would cost more than the expense required to subdue the obstacles of the northern shore. Another important consideration, which should determine our prefer-

ence of it, is its exposition to the south, by means of which, the canal will be earlier and longer navigable, and less subject to be seized by sudden frosts in spring and autumn. To extend the advantages of the canal to the inhabitants of the southern shore of the Potomac, it will be proper, in the project, to trace the works required, in order to unite with the canal the tributary streams which join it on that side. Those streams might thus contribute to feed the canal, and extend the benefits of its communication.

From the mouth of Savage river to Georgetown, the Potomac breaks through the several ridges which run parallel to the Alleghanies, and receives the tributary streams which run between them, from the north and from the south. Wherever the river breaks through these ridges, its navigation is interrupted, by falls or rapids.

The art of the engineer must avail itself of these falls, by erecting dams at those places, to raise the waters and form reservoirs, that may feed the canal. That same art must, also, make the tributary streams of that river, contribute to the same purpose, and convey into the canal the surplus of their waters, and the produce of their valleys.

In proceeding from west to east, the principal ridges, which are thus broken through by the Potomac, are, Will's mountain, Evit's mountain, Rugged mountain, Sidelong hill, North mountain, South mountain, and Cotoctin mountain. The shores are most rugged and precipitous, at the spots where the river breaks through them; the intermediate parts answer to the valleys, which run between these ridges—they are generally flat, and offer a soft and rich soil, perfectly adapted to the purposes of a canal.

The main falls of the Potomac are at Harper's ferry, where it breaks through Elk and South mountains, at the rupture of Rugged Mountain; at that of Sidelong hill, the falls of Green spring at the rupture of North mountain; the Hook falls, at the rupture of Cotoctin mountain; the Seneca falls, Great falls, and Little falls. Besides these, it presents, above Harper's ferry, several rapids, whose fall is less considerable, and does not deserve a particular notice with respect to our subject.

The tributaries, from the northern bank of the Potomac, whose waters might feed the canal, are from west to east: Savage river, George's creek, Conococheague, Antietam creek, Cotoctin creek, and the Monocacy river.

The tributaries, from its southern bank, are, the South branch, Great and Little Cacapon, and Shenandoah. The waters of the Potomac do not rise at fixed periods; they generally, however, attain their greatest elevation in the months of March and April, whilst, from June to September, they are at their lowest stage. In the dryest seasons, the higher parts of its bed, do not present above 18 inches in depth, as in all other rivers, the middle parts of its course rise more than the upper or lower parts. At Cumberland, it rises about 12 feet; at Hancock, 25 feet; at Williamsport, 30 feet. From thence,

to the Little falls, the waters rise less and less. It generally freezes in January and February.

From the surveys of Messrs. Moore & Briggs, the distances from Cumberland to the bridge of the Little Falls, have been found as follows:

From the mouth of Savage river to Cumberland, (Major Abert's survey,) - - -	27½ miles.
From Cumberland to the Great Cacapon, -	54½
From the Great Cacapon to Conococheague, -	33½
From Conococheague to Harper's Ferry, -	38¾
From Harper's Ferry to the Great Falls, -	46⅛
From the Great Falls to tide-water - -	9
	209½ miles.

The general descent of its bed is, nearly, as follows:

From the mouth of Savage river to Cumberland, (Major Abert's Survey,) - - -	327⅓ feet
From Cumberland to tide wate, - -	537
	864½ feet.

Such are the local features of the valley, through which this section of the canal, east of the Alleghany, must be directed. We will now proceed to those preparatory operations, which were necessary to determine the route through which this section must pass.

The execution of these operations and preparatory surveys, were confided to the talents of Major Abert, of the Topographical Engineers of the United States' Army. He was assisted by the Lieuts. of Artillery, Swift, Macomb, Bennet, Long, and Wilson. The Board having left Washington in the beginning of June, the necessary instructions could not be sent to Major Abert till the 30th of that month, when they had examined the ground. That officer was, meanwhile, making the necessary preparations for rendering himself. with his assistants, on the spot; and, in the first days of July, began the operations entrusted to him. But in the middle of August he was obliged to suspend them: the country had become unhealthy, and his officers were all taken sick. The result of these operations, as far as he could bring them to a conclusion, in the short time whilst he could remain on the ground, is joined to this report; and, what he performed in that time proves, that, in beginning his labors early next spring, he will be enabled to complete, during the next season, the preparatory surveys of that section of the canal.

These surveys will determine the data which must guide us in adapting its line exactly to the ground, and fix the precise position of its several works. As to the practicability of this section, there can exist no doubt. The ground offers no difficulties which may not be overcome, at a moderate expense. The tributary streams of the Potomac provide supplies beyond what the consumption of the canal re-

quires; and the Potomac itself, by erecting dams across the summits of its rapids, will afford additional aid for this purpose. In indicating the probable general route of this section, we shall report the operations and surveys made, and those which remain to be performed, before its line can be fixed in a final and definitive manner.

These preparatory surveys have given the following results, as to the portion of the canal between the mouth of Savage River and Cumberland.

From the mouth of Savage River, in descending the Potomac, its northern shore presents a perpendicular bank of a compact mass of sandstone; the canal must therefore run for half a mile along the southern shore, when stopped by a perpendicular bluff of knobly mountain, it crosses over and follows the northern shore for one mile. Here another perpendicular mass of rocks compels it to pass to the southern side, from whence it crosses over to the northern, at Westernport, at the mouth of George's Creek. From the mouth of Savage River to that of George's Creek, the canal must therefore cross the Potomac four times, in a space of two miles, unless the expense of running it along those obstacles, on an embankment supported by dry walls, should prove less than that of constructing four aqueducts.

From Westernport to W. R. Dawson's, on a space of eight miles, the canal follows the northern shore of the valley. This portion will require several deep cuts, and it will be frequently necessary to cut a shelf in the flank of the mountain, to run the canal upon.

From W. R. Dawson's to S. Cresap's, the distance is four and a half miles: A little below Dawson's, Fort Hill, a high and rocky mountain, fills up the northern shore, and compels us to run the canal across the river; and as in two other places, that hill closes the passage, we must cross the Potomac twice, between Dawson's and Cresap's, unless it be found less expensive to continue the canal on an embankment round these obstacles. It was endeavored to turn round the north of Fort Hill, along the road from Dawson's to Tenyard, but the ground was found too high, its summit being elevated 342½ feet above Dawson's.

From Cresap's to Armstrong's, the canal follows the northern shore, through a rich, alluvial, and very favorable soil. From Armstrong's, to a point four and a half miles below it, we should cross the Potomac four times, to keep in the most favorable ground. But the expense of those aqueducts must be compared with that of the deep cuttings and wallings which would be required to avoid them.

From thence to Lynn the canal follows the northern shore, on a distance of three and three quarter miles. It meets with only two obstacles; a spur of slaty rock, and a mass of calcareous stone, which hang perpendicularly, but for a short space over the river, otherwise the ground is favorable.

From Lynn the canal may turn round the north of the hill on which Fort Cumberland is built, and cross Wills Creek above the bridge, or turn round its south along the Potomac and Wills Creek,

to cross at the same place, or below the bridge; the distance by the first route would be half a mile.

Such is the general direction of that section, from Savage River to Cumberland. Its length is from 27 to 28 miles, and its fall 327½ feet. To keep on the best ground in the valley, it should cross the Potomac 12 times; but in drawing up the final project, it will be necessary to compare the expense of those aqueducts, with that which will be required to overcome the obstacles which compel to cross so often. We have every reason to believe, that a much less number of aqueducts will then be thought sufficient.

The labors of the brigade, charged to execute the surveys of the eastern section, having been suspended by sickness, as stated above, they did not proceed any further. The waters from Savage River to Cumberland have not been guaged; the extent of the reservoirs, their location, and the profile of their dams, have not been fixed. As to the location of the locks, it can only be determined upon, when all the preparatory surveys of the canal are concluded, and a general system adopted to connect them together.

The valley of the Potomac, above Cumberland, is well timbered, and fine grained and compact sandstone abounds all through it. Clay is abundant, but the highest point, where limestone is found, is one and a half miles below Westernport. Excellent building stone, a great variety of sandstone, and coal, are found in every part of the mountains, which bound the head of the valley.

In descending from Cumberland, the Canal will cross Evet's creek, and as this stream gives a constant supply, a feeder may bring its waters to it, and the minimum quantity which it may furnish, must be accurately guaged.

From thence to Braddock's hill, it will follow the left shore; but if it ran farther on that side, shelves should be cut through Braddock's hill, Alum hill, and Old Town bluff, or it should turn round them on embankments, supported by walls. At this point, the two shores should be surveyed with care, to fix the best line on which the Canal should be run. 1st. It might run, as just mentioned, in front of those three bluffs. 2d. It might turn round the north of Alum hill, and the front of the two others. 3d. It might cross the Potomac above Braddock's hill, follow the right shore, and cross over below Old Town bluff, and above South branch cape. 4th. The Potomac, from Braddock's hill, to the ledges below the South branch, might, by a dam run across those ledges, be formed into a basin, serving as a haven for the boats descending the South branch, feeding the lower parts of the Canal, and forming a part of it. Thus, the expense of the aqueducts, and of four or five miles of Canal digging, might be avoided; the post track in this case, would remain on the left shore. Surveys and levels, by giving positive data, can alone determine which is the best of these courses. Whichever is adopted, the waters of the South branch must be brought to the Canal, and the feeder connecting them be made navigable. In the first or second hypothesis, the feeder should cross the Potomac above or below the mouth of South branch;

in the third, it should fall in the Canal above the mouth of that river, as it would perhaps be shorter; in the fourth, it should enter the Potomac to the west or east of South branch cape, above the dam, or a dam and lock might be erected at the mouth of the South branch itself.

From Town creek to Sidelong hill creek, the narrow strip which runs along the left shore, offers the best ground for the Canal, which must cross Town creek and 15 mile creek, on aqueducts. As the former offers a constant supply, it should be guaged, and a feeder run to lead its water into the Canal. If Sidelong creek afford the same advantage, it should be used in the same manner. The long and perpendicular bluff of Sidelong hill compels to cross the Potomac above the mouth of this creek, and follow the right shore till you reach opposite Conoloway creek. Here the Canal may pass to the left. Indeed, from the South branch to this spot, and even to Harper's Ferry, it will be proper to examine the right shore, and ascertain whether it is not preferable to the other. Supposing the proposed directions adopted, the Canal will require three aqueducts, two over the Potomac, and one over the Great Cacapon. This river and the Conolaway may supply the Canal with their waters, and of course must be guaged, and feeders led from them.

From the Conolaway to the Conecocheague, at Williamsport, the Canal may follow the left shore, crossing the Conococheague on an aqueduct; that stream should be guaged, and a feeder led from it. From thence to the foot of Elk mountain, in front of Harper's ferry and the Shenandoah, it continues on the same side, crossing Hatictain creek. Here we may, 1st, either lead the Canal round the front of the bluff, on a shelf or embankment, or 2d, run a dam across the ledges, half a mile below Harper's ferry, forming a basin for the boats descending the Shenandoah, and a reservoir to supply the lower parts of the Canal—the upper part descending by locks, from Elk mountain, into it. In the first hypothesis, the waters of the Shenandoah should supply the Canal. It should be guaged, and a feeder, crossing the Potomac on an aqueduct, led to it; that feeder should be navigable, to favor the passage of the Shenandoah boats into the Canal.

From Elk mountain to the Monocacy, the left shore offers the best ground, though it presents two formidable obstacles—South and Cotoctin mountains. The Canal must be led along their fronts, on shelves or embankments, and dams must be erected at the South mountain falls, and Cotoctin mountain falls, or Hook's falls, where the river breaks through the ridges. They will form reservoirs for the lower portions of the Canal. It will cross the Monocacy on an aqueduct. That river must be guaged, and a feeder led from it. Griffin's falls offer a favorable position for a reservoir, by throwing a dam across them.

From the Monocacy to the Great falls, the Canal must follow the stony and perpendicular bank, which leaves a narrow strip of flats on the left shore; shelves cut in the rock, and embankments will be frequently required, especially 'twixt the Seneca and Great falls. The

level of this portion of the Canal must be kept as high as possible, in order to run it above, and to the north of the rugged banks which lie between these falls. A dam across the great falls might form a reservoir for the lower portions of the Canal: a wing dam may also be required at Seneca falls. It is desirable that the works at Great falls should not interfere with the canal which at present turns them on the right shore, as it may be useful for floating rafts and timber, when the navigation of the Potomac will be improved.

The Canal then continues along the left shore, winding round the bank which extends from the Great to the Little falls, and from thence, along the flats of the same shore, to the head of tide water in the Potomac. If, however, it be found possible to open a direct communication from Seneca falls to Washington, the obstacles which lie between the Great and Little falls, may perhaps be avoided. To ascertain this fact, a level should be run between the Seneca falls and the Rock creek which divides Georgetown from Washington. A ravine, running to the north of the Great falls, seems favorable to this line. It should be surveyed with care, and a level run on the north ridge of the height which runs from the Great falls to Washington, and on the eastern point of which is built the town of Georgetown.

MIDDLE SECTION.

This section, from the mouth of Savage river, in the north branch of the Potomac, extends to the mouth of Bear creek, in the Youghiogheny, on the west side of the Alleganies. It includes the summit level of the canal, and from the complicated topography of the ground, the height which must be overcome in a short space, and the difficulty of securing a sufficient supply of water, in dry seasons, at such an elevation, presents the greatest difficulties which occur in the whole project.

The little Back Bone Ridge divides the waters, which, in that part of the Alleganies, runs east and west; it runs parallel to the great Back Bone, through which Savage river forces its way, and the canal must, absolutely, pass through this gap. Between those two ridges run Crabtree creek, from S. W. to N. E. and Savage river from N. W. to S. E.; the former falling into Savage river four and a half miles above its mouth in the Potomac. From the west side of the little Back Bone fall Deep creek, and the little Youghiogheny, the latter runs from E. to W. and, after forcing its way successively through Hoop-Pole ridge, and Roman Nose ridge, joins the great Youghiogheny. Deep creek runs at first to the north, crossing Hoop-pole ridge, and Negro mountain; then, intercepted by Marsh mountain, it turns west, and falls into the Youghiogheny. The gap through which it forces its way across the Hoop-Pole ridge, is only sixty-six yards wide, and is called the Narrows.

The heads of the little and great Youghiogheny, to some miles above the point where they join in a single stream, run through marshy meadows, known by the name of Glades. The valleys of Deep creek,

and its tributaries, offer the same features as low down as Marsh mountain, from whence their course continues in a deep and narrow ravine, with steep, and rugged banks. The bottom of these glades, which has been sounded in several places, present the following layers: 1st. Rich loam. 2nd. Sand, colored by oxydated iron. 3d. Vegetable detritics. 4th. Alluvial clay. 5th. A horizontal bank of sand stone, four or five feet below the surface, on which the other layers all lie.

The great Youghiogheny, after receiving the little Youghiogheny, and Deep creek, receives Bear creek. The east branch of this last stream rises on the west side of Negro mountain, and runs from south to north till it forces its way through Keyser's ridge; it then turns suddenly east, and, after forcing through Winding ridge, falls into the Youghiogheny. Its west branch springs from the west side of Keyser's ridge, and joins the other at the gap where it forces its way through Winding ridge.

Savage river runs on a bed of sand stone, its course is rapid, and broad flats extend along both its banks. Crabtree creek is the chief tributary stream which joins it; it runs between the great and little Back Bone, and is formed by the junction of Crabby's arm, and Wilson's fork, which take their sources in that part of the little Back Bone which divides their ravines from the valley of the little Youghiogheny. Crabby's arm runs in a narrow vale, but which is, however, wide enough to receive a canal; its bottom is a black alluvial soil, and its banks present a gentle slope. Wilson's fork is more rapid, but runs in a wide and well wooded valley. These two streams join at Swan's mill, from whence they impetuously descend on a bed from ten to twenty yards wide; they are interrupted in two or three places by perpendicular falls, seven or eight feet high, and frequently by smaller rapids, which fall from four to five feet. From the great Back Bone, Crabtree creek receives several tributaries; they are torrents which fall into it with great impetuosity. On both sides of its valleys run flats, eight or ten yards wide, which are intersected by rugged bluffs, from 100 to 200 feet high, which divide them into isolated portions, the bluffs on one side of the stream, lying, in general, opposite to the flats on the other, and the two banks presenting an alternate succession of the same features.

Such are the main streams which, in this section, descend from the two sides of the Alleganies.

To conduct the canal across this summit ground, we must 1st. Select the best passage for it through the little Back Bone, by leading it either from the valley of Savage river, to that of Deep creek, and from that of Crabtree creek to the same, or from the valley of Crabtree creek, to that of the little Youghiogheny. 2nd. Ascertain which of these passages presents the shortest route from the mouth of Savage river, to that of Bear creek. 3d. Ascertain, as the most essential element of the whole project, whether a supply of water, sufficient for all the purposes of the canal, can be procured at this elevation.

We shall point out the several passages which lead through the

little Back Bone, beginning by those which lead from the valley of Savage river, to that of Deep creek. But, in the first place, it is necessary to state, that a base-mark has been fixed on the bridge of Deer creek, three feet above its bottom; to this have been referred all the levels taken on this section of the canal.

Monroe run, a tributary of Savage river, and Meadow mountain run, a tributary of Deep creek, offer the only ravines through which Deep creek, and Savage river, can be connected. For this purpose, it will be necessary to run a tunnel through the little Back Bone.—Supposing its bed on a level with the base-mark, and a deep cut of thirty-five feet at each extremity of it, this tunnel would extend five miles, 833⅓ yards, in length. The greatest elevation of the ridge, above the bed of the tunnel, would be 213 feet. From its eastern extremity to the mouth of Monroe run, in Savage river, the descent is 983 feet, on a length of five miles 816⅔ yards. From the mouth of Monroe run, to that of Crabtree creek, in Savage river, the descent is 109 feet, on a length of two miles, 216⅔ yards. From the mouth of Crabtree creek, to that of Savage river, itself, in the Potomac, the descent is 340 feet, on a length of five and a half miles. The level of the mouth of Savage river lies, of course, 1,432 feet below the base-mark, and at a distance of twenty-one miles 327 yards from it, ascending the ravines of Savage river, and Monroe run, and descending those of Meadow mountain run, and Deep creek.

Meadow Mountain Run flows through glades, but Monroe Run falls down a ravine, whose upper portion is very steep and narrow; it widens, however, as it descends, and presents a succession of bluffs and flats, which extends to twenty-five yards in breadth, the bluffs hang perpendicularly over the stream. At the mouth of Monroe Run, Savage river is only thirty-three yards wide, and a dam might easily be thrown across to form a reservoir.

This passage is the only one which leads from the valley of Savage river to that of Deep Creek.

We shall now examine those which connect the valley of Crabtree Creek and Deep Creek.

The first lies between the middle fork of Crabtree creek and the Meadow mountain Run, and would require a tunnel running under the Little Backbone and Hooppole Ridge. Supposing its bed on a level with the base mark, and an open cut to the depth of thirty-five feet through the height, the tunnel would extend three miles 1,333⅓ yards in length. From its eastern extremity to Crabtree Creek, in following the windings of the middle fork, the descent is 1,012 feet, on a distance of six miles 1,333⅓ yards, and from the mouth of the middle fork to the mouth of Savage River in the Potomac, the descent is 420 feet, on a distance of six miles 685 yards. The height of the ridge above the bed of the tunnel would be 210 feet; and the ravine of middle fork differs little from that of Monroe Run; its general breadth is about twenty-seven yards, and its banks are rugged. The whole distance from the base mark to the mouth of Savage River would be, by this passage, nineteen miles 915 yards.

Three passages run through the Little Backbone, from three branches of North Glade Run, a tributary stream of Deep Creek, to the valley of Crabtree Creek.

The first opens on the western branch of the middle fork, and would require a tunnel through the Hooppole Ridge. Supposing its bed on a level with the base mark, and an open cut to the depth of thirty-five feet, through the height, the tunnel would extend three miles 125⅓ yards in length, and the greatest height of the ridge above its bed would be 144 feet.

From the second branch of North Glade Run, a passage might be opened to the eastern branch of the middle fork, by a tunnel of the same nature, and on the same level as the former; it would extend three miles eighty-three yards in length, and the greatest height of the ridge above its bed would be 184 feet. But from its eastern extremity there would be a descent of 280 feet, on a distance of one mile 366 yards.

From the third branch, a passage might be opened to Rock Camp Run, by a tunnel four miles in length. The greatest height of the ridge above its bed, would be 222 feet; but from its eastern extremity to Crabtree Creek, the descent would be 728 feet, on a distance of two miles 166⅔ yards, and through a very narrow, rugged, and precipitic[illegible] ravine.

The north fork of Deep Creek rises near the summit of the Little Backbone, at Whetsall's Springs, 105 feet above the base mark. The spring of Savage Lick Run, a tributary stream of Crabtree Creek, rises opposite to it. A tunnel which would join them, with its bed on a level with the base mark, and an open cut through the height at each of its extremities to the depth of thirty-five feet, would extend two miles 1,083 yards in length. From its eastern extremity to Crabtree Creek, the descent would be 452 feet on a distance of two miles 100 yards, and the greatest height of the ridge above its bed would be 148 feet.

Three more passages have been surveyed between the tributaries of the north fork, and those of Crabtree Creek.

The first unites Hinch's arm to Glade Road Run, by a tunnel one mile 1,166 yards in length, on a level with the base mark. The distance from its eastern extremity to Crabtree Creek is 1,500 yards, and the greatest height of the ridge above its bed 205 feet.

The two others unite Dry arm and Dewickman's arm, with small ravines of Crabby's arm, a tributary stream of Crabtree Creek, which rise opposite to them. The tunnel which would be required at Dry arm, would extend one mile 916 yards in length, and the greatest height of the ridge above its bed would be 271 feet. The tunnel of Dewickman's arm would extend one mile 683⅓ yards in length, and the greatest height of the ridge above its bed would be 227 feet. These two tunnels on a level with the base mark, are the shortest of those that we have enumerated on any of the designated routes of the canal.

Two passages have been surveyed and levelled, to open a communication between Crabtree Creek and the Little Youghiogeny: the one from Crabby's Arm, and the other from Wilson's Fork to the latter stream. They would each require a tunnel. Supposing its bed on a level with the base mark, the tunnel from Crabby's Arm would extend three miles 1,538 yards, and the tunnel from Wilson's Fork four miles 300 yards, in length, with an open cut at each of their extremities, to the depth of thirty-five feet. The greatest height of the ridge, above the bed of the tunnel from Crabby's Arm, would be 444 feet, and above that of Wilson's Fork 253 feet. The distance from their eastern extremities to Swan's Mill would be two miles, with a fall of 114 feet. From Swan's Mill, to the mouth of Crabtree Creek, the descent would be 940 feet, on a distance of seven miles 966 yards; from the mouth of Crabtree Creek, to that of Savage River, in the Potomac, the distance five miles 880 yards, and the descent 378 feet. Thus, from the eastern extremity of the tunnel, to the mouth of Savage River, the total descent is 1,432 feet, on a distance of fifteen miles eighty-six yards, and of these two tunnels, the one by Crabby's Arm is the shortest.

Other passages have also been examined, to open communications between Deep Creek and the waters of the Little Youghiogeny. The bed of the tunnels required for this purpose, was fixed seventeen feet above the level of the base mark. One of these tunnels joined West-lick Run, to one of the branches of the south fork of Deep Creek; its length was two miles 583⅓ yards, and it required a deep cut, on the side of West-lick Run, of the length of one mile 600 yards, and another on the side of South Fork, of the length of two miles 50 yards. Another tunnel might join the Little Youghiogeny itself, to South Fork; it would extend one mile 1,300 yards in length, and require an open cut of one mile 1,566⅔ yards, towards the Little Youghiogany, and two miles 300 yards towards the South Fork. The height of the ridge, above the first tunnel, would be 143 feet, and above the second, 183 feet. Such are the chief passages through which a communication might be opened between the waters which descend from the eastern and western sides of the Little Backbone. In recapitulating the several routes, by which the canal my be directed through them, we will observe, that they all extend from the mouth of Savage River, either by the valley of that stream, or Crabtree Creek, to the base mark on the bridge of Deep Creek; and that the descent or fall of the canal, by all these routes, is 1,432 feet.

1st. The first ascends by Savage River, Monroe Run, Meadow Mountain Run, and Deep Creek. Its total length, from the mouth of Savage River to the base mark, is twenty-one miles 325 yards. The length of the tunnel, which it requires through the ridge, is five miles 833⅓ yards, and the height of the ridge above its bed, 213 feet.

2d. The second ascends by Savage River, Crabtree Creek, Middle Fork, Meadow Mountain Run, and Deep Creek. Its total length is nineteen miles 915 yards. The length of the tunnel which it re-

quires through the ridge, is three miles 1,333⅓ yards, and the height of the ridge, above its bed, is 210 feet.

3d. The third ascends by Savage River, Crabtree Creek, Middle Fork, the western branch of the same Fork, North Glade Run, and Deep Creek. Its total length is twenty miles 1,128 yards. The length of the tunnel which it requires through the ridge, three miles 125 yards, and the height of the ridge, above its bed, 144 feet.

4th. The fourth ascends by Savage River, Crabtree Creek, Middle Fork, the eastern branch of the same, North Glade Run, and Deep Creek. Its total length is twenty miles 1,306 yards. The length of the tunnel which it requires through the ridge, three miles eighty-three yards; the height of the ridge, above its bed, 184 feet.

5th. The fifth ascends by Savage River, Crabtree Creek, Rock Camp Run, North Glade Run, and Deep Creek. Its total length is nineteen miles 630 yards. The length of the tunnel which it requires through the ridge, four miles, and the height of the ridge, above its bed, 222 feet.

6th. The sixth ascends by Savage River, Crabtree Creek, Savagelick Run, North Fork, and Deep Creek. Its total length is twenty-one miles 435 yards. The length of the tunnel which it requires through the ridge, two miles 1,083 yards, and the height of the ridge, above its bed, 148 feet.

7th. The seventh ascends by Savage River, Crabtree Creek, Hinch's Arm, Glade Road Run, North Fork, and Deep Creek. Its total length is twenty-one miles 1,158 yards. The length of the tunnel which it requires through the ridge, one mile 1,166 yards, and the height of the ridge, above its bed, 205 feet.

8th. The eighth ascends by Savage River, Crabtree Creek, a ravine of Crabby's Arm, Dry Arm, North Fork, and Deep Creek. Its total length is twenty-one miles 1,368 yards. The length of the tunnel which it requires through the ridge, one mile 916 yards, and the height of the ridge, above its bed, 271 feet.

9th. The ninth ascends by Savage River, Crabtree Creek, a ravine of Crabby's Arm, Dewickman's Arm, North Fork, and Deep Creek. Its total length is twenty-one miles 718 yards. The length of the tunnel which it requires through the ridge, one mile 683⅓ yards, and the height of the ridge, above its bed, 227 feet.

From the base-mark, the localities of the ground leave us a choice between three routes, to the mouth of Bear Creek.

The first runs by Deep Creek, Buffalo marsh run, Rocklick run, a tributary stream to the western branch of Bear Creek, that western branch to its mouth in Bear Creek, and Bear Creek itself to the Youghiogeny. This route crosses by a tunnel, the ridge which divides the heads of the Western and Eastern branches of Bear Creek. This tunnel, beginning at McHenry's, and with an open cut of the depth of 35 feet at its southern extremity near McHenry's, and at its northern extremity, would extend about two miles in length, and the greatest height of the ridge above its bed, supposed on a level with the base-mark, would be about 170 feet. The whole ground along

this route, except where it passes through the gap of Winding ridge, is of a soft and good quality; and its whole length from the base-mark, to the mouth of Bear Creek, would be only twelve miles.

A second route might turn round the west of Marsh Mountain, and wind about Panther's Point; it would then turn successively round the heads of the ravines of Hoy's Run, Steep Run, Sang Run, Gap Run, and descend along Friend Run, a tributary of the Western branch of Bear Creek. This route is very circuitous, and in winding round Panther's Point, runs through a rocky and difficult ground. It would only be shortened by running an aqueduct 250 feet high, and above a quarter of a mile long, through the Western branch of Hoy's Run, or a tunnel half mile in length from that Western branch to the head of Steep Run. The height of the ridge above the bottom of that tunnel, would be about 250 feet. A level was also run over a bend of ground at Hoy's pine bottom, to endeavor to shorten it, and avoid the winding round of Panther's Point, but to run the canal over this line would require a deep cut of 1,431 yards in length, and of the depth of 99.06 feet at the highest point of the ridge. The total length of this route would be 24 miles.

The third route, descending the valley of Deep Creek, from the base-mark, might follow the eastern shore of the Youghiogheny to the mouth of Bear Creek, crossing successively on aqueducts, Hoy's Run, Steep Run, Sang Run, Gap Run, Bear Creek, and the smaller tributary streams of that river. The ground along this route is rocky and difficult for one mile and ⅔, from Deep Creek to Hoy's Run; then light and easy for four miles, to Gap Run; then rocky for the space of six miles, following the Western bank of Winding ridge; then for two and a quarter miles light and easy to the mouth of Bear Creek. The total length of this route would be 20 miles.

We have not mentioned a fourth route, which, from the base-mark, running by a tunnel, through Negro Mountain, might unite Deep Creek with the Eastern branch of Bear Creek, because it would require a tunnel of 8 miles in length; and that the height of the ridge above its bed, would be from 400 to 500 feet in the most elevated portion. The length of this route would also pass 20 miles.

Such are all the routes which lead from the valleys of Savage river and Crab-tree Creek, in passing by that of Deep Creek to the mouth of Bear Creek, in the Youghiogheny. We must now examine those which, departing from the head of Crab-tree Creek, reach the same point in passing by the valleys of the Little and Great Youghiogheny.

For this purpose the canal should follow the valley of Savage river, from the mouth of that stream, and ascend along Crab-tree Creek till it reaches two miles above Swan's mill, where opens the eastern extremity of the tunnel of Crabby's Arm, mentioned page 27, as the shortest of those by which Savage river can be connected with the Youghiogheny. Passing through that tunnel, it would descend the valleys of the little and great Youghiogheny, winding along their

eastern side. When it reaches the mouth of Deep Creek, it may follow one of those three directions.

1st. Ascend Deep Creek and Buffalo-marsh Run, following the first of the three routes, which we have just indicated for passing from the base-mark, to the mouth of Bear Creek. This route, as we have seen, presents a tunnel two miles in length: The total distance over which it runs, is as follows:

From the mouth of Savage river to the east extremity of the tunnel of Crabby's Arm, -	15 miles	86 yds.
From thence to the mouth of Deep Creek, -	22 miles	426 yds.
From thence to the mouth of Buffalo-marsh Run,	6 miles	
From thence to the mouth of Bear Creek, -	11 miles	440 yds.
Total distance from the mouth of Savage river to that of Bear Creek - - - -	54 miles	952 yds.

This route would present two tunnels, one three miles 1,538 yards in length at Crabby's Arm, and the other two miles in length between Buffalo-marsh Run and Rocklick Run—total nearly 6 miles of tunnelling.

2d. The canal might cross Deep Creek, and follow the 2d route indicated for passing from the base-mark to Bear Creek, by winding round Panther's Point, and the heads of the ravines of Hoy's Run, Steep Run, Sang Run, Gap Run and Friend Run, to the western branch of Bear Creek—its total length would be:

From the mouth of Savage river to that of Deep Creek, as above, - - -	37 miles	512 yds.
From thence to Bear Creek, - -	17 miles	660 yds.
Total length	54 miles	1172 yds.

This route presents only one tunnel, of the length of 3 miles 1,538 yards, or nearly 4 miles at Crabby's Arm. It may also be shortened, as mentioned above, by an aqueduct ¼ of a mile in length, and 250 feet high, or a tunnel ½ mile in length, with 250 feet of height of ridge above its bed.

3d. The canal might follow this third route indicated above, after crossing Deep Creek, by keeping along the eastern side of the valley of Youghiogeny, and crossing its tributaries on aqueducts. Its total length would be as follows:

From the mouth of Savage River to that of Deep Creek, as above - - -	37 miles	512 yds.
From thence to Bear Creek - -	13 miles	660 yds.
Total length - -	50 miles	1172 yds.

This route would require, like the preceding one, one tunnel of 3 miles 1538 yards, or nearly 4 miles in length.

From the comparison of these three routes, it is evident that the second is preferable to the first. Their length is nearly the same, but the first requires six miles of tunnelling and two tunnels, whilst the second requires only one tunnel of something less than four miles in length. The third is shorter again by four miles than the second, and passes by the same tunnel. Aqueducts must be constructed on this route to cross Hoy's Run, Steep Run, Sang Run, Gap Run, and Bear Creek; but by the successive dropping of its levels, they will require but a small elevation; and the waters of these runs, and of the Great Youghiogeny, may be raised, and used to feed the canal, an advantage which the other routes do not offer. It should also be observed, that these Runs are not above 200 or 300 feet wide at their mouths, in the Youghiogeny. The third route is therefore preferable to the two others, on the hypothesis of uniting the mouths of Savage River and Bear Creek, through the valleys of the Little and Great Youghiogeny.

We will now compare this route, which we will call the Youghiogeny route, with those which lead from Crabtree Creek to Deep Creek.

Nine routes, which all unite at the base mark, have, as we have stated before, been examined for this purpose. Their length varies only from 19 to 22 miles, but their tunnels present a much greater difference. The longest extends 5 miles 833⅓ yards, or about 5½ miles; and the shortest 1 mile 683⅓ yards, or about 1⅓ mile in length. The last should certainly be preferred; its whole length is 21 miles 718 yards; and the greatest height of the ridge, above its tunnel, is 227 feet. We shall call it Dewickman's Arm route.

We have also observed, that there are three routes from the Base mark to the mouth of Bear Creek. The first runs 12 miles by Buffalo Marsh Run, and Rock Lick Run. It is the shortest, but requires two miles of tunnelling. Were it not for this obstacle, it offers a favorable ground for digging the canal. The second, winding round Panther's Point, and the heads of Hoy's Run, Steep Run, Sang Run, Gap Run, &c. is 24 miles long, and is objectionable, not only from its length, but from the difficulties which it presents in turning Panther's Point. The third, by the valleys of Deep Creek, and of the eastern branch of the Youghiogeny is 20 miles long; it is shorter by four miles than the second, and requires no tunnelling. In this respect it is superior to the first; for two miles of tunnel costs more than eight miles of canal, which is the difference of their length. The passage of an active trade will also meet with more delay on a tunnel of two miles, unless its dimensions are very large, than on four or six miles of canal. This route possessing besides, over the two others, the advantage of feeding the canal below the mouth of Deep Creek, by raising the waters of the Great Youghiogeny and its tributaries, is preferable to them in all respects.

If we add the 20 miles of this route to the 21 miles 718 yards of Dewickman's Arm route, we shall have for the whole length of the canal, passing along Crabtree Creek, Deep Creek, and the valley

of the Youghiogeny, 41 miles 718 yards, with one tunnel 1⅓ mile in length, and the height of the ridge above it 227 feet. We shall call this route Deep Creek route, in opposition to the Youghiogeny route.

To decide between these two routes, which alone can enter in competition, we must compare their length, and the time, expense, difficulties, and trouble of their construction, viewed in a general manner.

The length of the Deep Creek route is 41 miles 718 yards; that of the Youghioegny route 50 miles 1172 yards; the former is therefore shorter by nine miles than the other.

The tunnel from Dewickman's Arm on the Deep Creek route is 1 mile 685⅓ yards in length, and the height of the ridge above its bed is 227 feet. The tunnel betwixt Crabby's Arm and the Little Youghiogeny on the Youghiogeny route, is 3 miles 1533 yards in length, and the height of the ridge above its bed is 464 feet. The former requires 2 miles 855⅔ yards less of tunnelling, and the height of the ridge above the bed of its tunnel is 237 feet less. With respect to the expense of tunnelling, the route by Deep Creek is therefore preferable to the other.

As to the deep cuts at each extremity of these tunnels, the deep cut at the western extremity of the tunnel towards the Little Youghiogeny, is 2 miles 930 yards in length. The deep cut, at its eastern extremity, towards Crabby's arm is 900 yards. The whole deep cutting on the Youghiogeny route is thus 3 miles 70 yards.

The deep cut at the western extremity of the other tunnel towards Deep Creek extends 5 miles 1096 yards. The deep cut at its eastern extremity towards Dewickman's Arm, 572 yards. Total 5 miles 1668 yards.

The Youghiogeny route will therefore require 2 miles 1598 yards less of deep cutting, than the other, at the extremities of its tunnels. But this advantage is not to be weighed with the expense of 2 miles 855 yards more of tunnelling.

In comparing the nature of the soil on each of these routes, and the obstacles which it may present, it must be remembered that their eastern portion, from Savage River to Crabby's Arm, and their western portion from the mouth of Deep Creek to that of Bear Creek are the same. In the intermediate space the ground is equally favorable and easy to work on both routes.

On the whole comparison of their respective lengths—of the time necessary to pass through the one or the other of the obstacles which they meet, and the expense and probable trouble of their construction, we believe the Deep Creek route preferable to the route by the Youghiogeny.

Our next task must be to compare the supplies of water which the canal may receive on either of these routes, and this will lead us to a detailed investigation of the resources which are offered by the water courses of the country, to feed the middle section, and summit level of the proposed canal.

Savage river and its tributary, Crabtree Creek, may feed the eastern branch of the middle section, and the great Youghiogeny its

western branch. The summit level must draw its resources from Deep Creek and the heads of the little and great Youghiogeny. These streams were all gauged in 1824, at their lowest stage. We will give, in a general manner, the result of these operations: the minimum, in cubic feet of water, that flows through each stream in a second.

Eastern Branch of the Middle Section.

	cub. ft.	100*ths.*
Savage river gave, on the 28th September, below the mouth of Crabtree Creek, in a second, - -	17	73
Savage river gave, on the 28th Sept. at its mouth - (It had, however, rained this day.)	46	09
Do. Do. 2d Sept. below Monroe Run	28	62
Monroe Run gave, on the 28th Sept. at its mouth -	00	88
Do. Do. 16th Sept. do. - -	2	28
Crabtree Creek gave, on the 14th Sept. at Swan's mill	00	97
Middle Fork gave, on the 15th Sept. at its mouth, in Crabtree Creek - - - - -	00	84
Rock-Camp Run gave, on the 2d Sept. do. do.	00	12
Savage-Lick Run gave, on the 14th Sept. do. do.	00	33
Crabby's arm gave, on the 17th August, do. do.	00	24
Wilson's Fork gave, on the 17th August, do. do.	00	35

If we consider, that the water consumed in the lockage of this branch is supplied from the summit level, these streams turned into reservoirs by dams thrown across the tributaries of Crabtree Creek and Savage river, above the mouth of that creek, will serve to supply its losses from filtrations and evaporation. Between the mouth of Crabtree Creek and the Potomac, on a distance of 5½ miles, Savage river, which gives 17.73 cubic feet, in a second, at its lowest stage, will serve for this purpose. In the remaining 9½ miles from the tunnel to the mouth of Crabtree Creek, the middle fork gives 0.84 cubic feet; Rock Camp run 0.12 cubic feet; Savage Lick Run 0.33 cubic feet; and Crabtree Creek itself, 0.97 cubic feet, at Swan's mill, at their lowest stages: total, 2.26 cubic feet. Reservoirs may, besides, be formed in the middle fork, Savage Lick Run, and Rock Camp Run. Filtrations may also be prevented, in a great degree, by a careful construction of the bed of the canal: and, from observations taken in the Summer of 1824, the loss from evaporation did not exceed the quantity received by Summer rains. It may also be observed, that any deficit will prove to be amply supplied by the waters of the summit level.

From the mouth of Savage river, the canal may be supplied from the north branch of the Potomac, which, on the 18th September, gave 106 cubic feet in a second; and a great reservoir may be formed in it above the mouth of Savage river. From this point, therefore, it needs no longer the waters of Savage river nor of its tributaries.

And if we except the waters required for its lockage, which will be

supplied from the summit level, this branch of the middle section may be fed, in a great degree, by the streams which fall into it.

Western Branch of the Middle Section.

This portion of the canal begins in Deep creek, five miles below the Base mark, and ends at the mouth of Bear creek. The length is 14¾ miles; and, like the former branch, it will receive from the summit level the waters required for its lockage.

Hoy's Run, Steep Run, Sang Run, and Gap Run, may be employed to feed it, and repair its losses; but these streams have not been gauged. They may, nevertheless, offer some resources for reservoirs. Bear creek may also form a great reservoir, by damming its valley, and feeding the western section of the canal, but cannot feed the western branch of the middle section, from the difference of their levels.

Deep Creek is the only stream of any importance whose waters may supply the losses of this branch from filtrations and evaporation; we should, therefore, examine accurately the means which it offers for this purpose. Its usual depth under the bridge is three feet; but in its freshets it rises to twelve feet. High freshets generally occur in this stream twice or thrice a-year, and last from three to four days: when the rains last so long, it gives, during that time, from 400 to 500 cubic feet a second. During the most unfavorable season it still has freshets, less considerable, but which, nevertheless, give it a mean discharge about 100 cubic feet in a second, each time: these occur from six to eight times a year. In the dryest months it gives, under the bridge, from 10 to 5⅛ cubic feet a second: on the 27th August, 1824, it gave 5.12 cubic feet, which was the lowest quantity we ever found.

Supposing a dam erected across Deep Creek, at the head of its rapids, and five miles below the base mark, its basis would be 19½ feet below that mark; its length would be 136⅔ yards, and to raise its waters four feet above the base mark, its height should be 23½ feet. This dam would raise the waters of Deep Creek, so as to overflow an area of 948,924 square yards, from accurate surveys. The prism of this reservoir, comprised between its surface and a horizontal plane, run three feet below the base mark, would be seven feet high, and contain, in capacity, 2,214,156 cubic yards. In less than three months of the rainy season, if we allow only 9 cubic feet, or one-third of a cubic yard a second, to the average supply of Deep Creek, this reservoir would be filled. It would be filled in less than five months in Summer, if the stream yielded at the rate of five cubic feet. Thus, every year, and for nine months of navigation, from the middle of March to the middle of December, we may depend on a supply equal to twice the capacity of this basin, or 4,428,312 cubic yards. This is equivalent to 492,034 cubic yards a month, and supposes only a mean supply of 5⅛ cubic feet a second. This is the minimum of what Deep Creek can supply to repair the losses of the western branch of the middle section, from filtrations and evaporation. To

ascertain its sufficiency, we must examine next what those losses may amount to.

The length of this section is 14¾ miles—supposing it 5 feet deep, 28 feet broad at the bottom, and 44 feet at the surface of the water, the prism of its capacity, will have a base of 20 cubic yards, on a length of 14¾ miles, equal to a cubic of 519,200 cube yards. This will be filled in the first days of March, without deranging the economy of water which we have just analysed. We have already observed, that Deep Creek may supply every month a cube nearly corresponding to this or 492,034 cubic yards, at the minimum rate, and lowest state of its flow: we must now examine whether this supply will suffice every month to the filtrations and evaporations of 14¾ miles of Canal.

Without entering into minute calculations, which properly belong to the report accompanying the final project of the canal, we will state generally the most positive results which experience has given as to the joint amount of filtrations and evaporations. Having ascertained that no experiments of this nature have been tried on the Erie Canal, where the supply of water was found evidently more than sufficient, we were obliged to consult the results of those canals constructed in Europe, under a climate, which, in summer, comes nearest to our own. We have selected for this purpose, the canal of Narbonne, in the south of France. Narbonne and Baltimore, compared as to climate and rain, are as follows:

Narbonne, lat. N. 43° 11′ (from observations made during twenty years.)	mean, greatest heat, 95° mean temperature, 60° mean, greatest cold, 24°	Mean quantity of rain, $29\frac{30}{100}$ in.
Baltimore, lat. N. 39° 17′ (from observations made 1817—1822, by Mr. Lewis Brantz, of Md.	mean, greatest heat, $94\frac{54}{100}$° mean temperature, $52\frac{23}{100}$° mean, greatest cold, $0\frac{12}{100}$°	Mean quantity of rain, $38\frac{60}{100}$ in.

Of all such works, the canal of Narbonne has given most trouble to its Engineers, from its excessive filtrations and loss of water in the gravelly soil through which it is run. It is a branch from the canal of Languedoc to the City of Narbonne, three miles in length. As soon as it was opened, in 1788, it lost the value or contents of its prism in a few days, and overflowed the surrounding country; in 1789, it still lost the value of its prism in 6 days; and in 1800. it lost it in 18 days, or the value of its prism, and ⅔ every month; (16⅔ times its contents in 10 months navigation.) This evaluation is the result of careful and accurate observations; and, considering the climate and soil through which this canal runs, it may fairly be taken as a specimen of the maximum loss, which a canal can suffer, through filtrations and evaporations.

The ground through which runs the western branch of our middle section, is of a quality far superior to the country through which runs the Narbonne Canal. It is, for 6½ miles, of an excellent quality; the remaining 8½ miles run through a rugged and rocky soil, but clay

is every where at hand, to puddle the bed of the canal, if necessary. Supposing therefore, that its losses from filtrations and evaporation, equalled in one month the cube of its prism, or 519,200 cubic yards, this would certainly be their maximum, whilst the evaluation of 492,034 cubic yards of water, which we have given, as the supply from the reservoir of Deep Creek, in one month, is its minimum. For, it must be remembered, that we valued this supply from the lowest result, obtained at the lowest stage of Deep Creek, when it gave only 5¼ cubic feet in a second.

We have allowed no loss for the evaporation for the surface of the reservoir, as it will be compensated by the frequent rains which fall on the summit of the Alleghany. From observations made in July, August, September, and October, 1824, in the Valley of Deep Creek, we have ascertained that there fell,

From 19th	to 30th	July,	4 days of rain,	4.36 inch.	55°	mean temperature.
" 1	to 31	August,	8 days of rain,	2.31 "	63°	"
" 1	to 31	Sept.	12 days of rain,	3.15 "	51°	"
" 1	to 31	Oct.	9 days of rain,	3.19 "	44	"
From 19th July	to 31st Oct.		33 days of rain.	13 "	10	

During 104 days, of which 33 were rainy, there fell 13.01 inches of rain. The evaporation was 0,10 inches a day, and during the 104 days, 10.40 inches; of course the rain more than supplied the loss of evaporation.

The temperatures marked above, are the mean temperatures of the rainy days. The highest temperatures in that Valley, during these months, were at midday, in July, 76°—in August, 74°—in September, 70°—in October, 72°. The lowest were at 6 in the morning; in July, 53°—in August, 44°—in September, 32°, and in October 25°.

From these observations, it is evident, that less evaporation is to be apprehended in the Valley of Deep Creek, than in regions more to the level of the Ocean: besides, by raising the dam which forms its reservoir, we might add to it a quantity of water, sufficient to supply all the loss of its evaporation and filtration. We will conclude these remarks on the reservoir of Deep Creek, by observing, that its surface lies below the mouths of its tributaries; and that they might, therefore, at small expense, be turned into reservoirs, to preserve the waters of the Valley, when (the great reservoir of Deep Creek being full,) they would otherwise escape over the dam. For this purpose, the dams of these small streams should have sluice gates, to distibute their supplies, whenever required.

Summit Level of the Middle Section.

From these observations it is evident, that the eastern and western branches of the middle section possess sufficient supplies to repair their losses from filtrations and evaporation. The first is 15 and the second 14¾ miles in length, and both 29¾ miles. If we subtract this length from that of the whole Deep Creek route, 41 miles 718 yards,

there will remain 11 miles 1158 yards, or about 11⅔ miles. If we subtract it from the length of the Youghiogeny route, (50 miles 1172 yards,) there will remain 20 miles 1580 yards, or about 21 miles. These portions, on either of these routes, may be designated as their summit levels. On the Youghiogeny route, this portion might, perhaps, be dropped below the reservoirs of the Youghiogeny; but its length and expanse of water, which is our present object, would remain the same on either level. We should now examine, first, what means exist to feed these summit levels; second, what each of these requires to supply all its wants and losses; third, what are the respective advantages of the one and the other, and which is the most advantageous with respect to that question.

The Great and Little Youghiogeny and their upper tributaries, are the only streams of any importance which can feed either of these summit levels. Their levels, with respect to the base mark, and at different points, are as follow:

		ft.
Level of the Great Youghiogeny, at the mouth of Deep Creek, below the base mark	- - - -	250.
Do.	at the head of Swallow Falls, do. -	140.81
Do.	one mile above the mouth of Indian Run, do.	70.50
Do.	two miles do. do.	64.
Do.	at the mouth of the Little Youghiogeny, do.	53.
Do.	at the mouth of Snow Creek, two miles above the bridge, do. - - - - -	36.69
Do.	at Charles Glade's run, do. - -	28.72
Do.	at the month of Cherry tree Creek, do. -	26.18
Level of the Little Youghiogeny, where it is crossed by the state road, do.	- - - - -	44.

These levels being all below the base-mark, proved, that, whichever summit level we adopt, we must elevate the waters of the two Youghiogenies, by throwing great dams across them. The height of these dams would be lower, and a less quantity of lockage required, if we dropped the summit level of the Youghiogeny route; but the length of the tunnel from Crabby's arm, and deep cutting at each of its extremities, would then be proportionably augmented. For the sake of comparison, we have therefore supposed those two routes on a level. a passage was sought to open a communication between Deep Creek and the great Youghiogeny, through the opposite valleys of Indian run and Cranberry run. But, as the sources of these runs rise 226 feet above the base-mark, and the Youghiogheny at the Indian run lies 70.50 feet below it, a dam across the Yoghiogheny, and a tunnel through the Roman Nose ridge, would both be indispensably required to accomplish this object.

An attempt was also made to lead Muddy Creek, which, from the west, falls in the Youghiogheny, to the summit level of these routes. But to lead it to the summit level of the Deep Creek route, it would be necessary to conduct it by a long aqueduct upwards of 140 feet high, and to lead it to that of the Youghiogheny, to run a feeder upwards of 30 miles, before it reached the mouth of Indian run, and which would absorb, by filtrations and evaporation, during its course, most

of the water which it would receive. Aqueducts through the ravines which it should wind round, would shorten it: but a great number of them would be required, and their construction would be very costly.

To ascertain the relative levels of Pine Swamp (where rise the springs of Muddy Creek of Youghiogheny, and Muddy Creek of Cheat river) and Deep Creek, a level was run to the summit of the ridge, which divides the waters of the Youghiogheny and Cheat river; this ridge parallel to the Roman Nose ridge, is called Snaggy Mountain. From this level, it appeared that the point, from which rise the highest springs of the two muddy creeks, is 75 feet above Pine Swamp, and 226.77 feet above the base-mark. This result, which proved the impossibility of running the canal in this direction from the mouth of Deep Creek, proved also that a reservoir of 3 or 4 miles area might be formed in the Pine Swamp, and that being raised at least 150 feet above the base-mark, a feeder might be led from it, following the eastern ridge of Snaggy Mountain, and joining Snowy Creek, after winding round the heads of the tributaries of the Youghiogheny, from Snowy Creek to Muddy Creek. This feeder would be from 8 to 12 miles long, and to form the reservoir a dam might be thrown through Muddy Creek of the Youghiogheny, at the gap where it breaks through Snaggy Mountain. This reservoir would afford an important supply, if those of the little and great Youghioghenies should prove insufficient to feed the summit levels. We shall now enumerate and measure the capacity of these several reservoirs, and give all the necessary details of them.

Reservoir No. 1, might be formed in the main branch of the great Youghiogheny, by throwing a dam across it, above the mouth of Cherry-tree Creek. It should be 40 feet high to raise the water six feet above the summit level, and allow to the feeder a descent of six inches per mile—height of its dam 40 feet, and length of its feeder, to the dam in Deep Creek, 16 miles.

Area of the reservoir, exposed to evaporation, 2,894,333 sq. yds.
Its prism, or capacity of water, above the base mark, - - - - - - - - 5,523,370 cub. yds.

No. 2 might be formed in Cherry creek by throwing a dam across it, above its mouth; the dam should be 40 feet high, and the length of its feeder 16 miles. For this, and all the following reservoirs, we shall allow the same data, 6 feet water above the basemark, and 6 inches descent per mile for their feeders.

Area, - - - - - - - 1,752,000 sq. yds.
Prism, - - - - - - - 3,170,148 cub. yds.

No. 3 might be found in Youghiogeny, between Cherry and Snowy creek, by throwing a dam through it above the mouth of Snowy creek. Height of the dam 50 feet, length of the feeder 14 miles.

Area, - - - - - - - 1,475,444 sq. yds.
Prism, - - - - - - - 2,796,518 cub. yds.

No. 4, receiving Laurel creek and Snowy Creek, might be formed

by throwing a dam across the latter, above its mouth. Height of its dam 50 feet, length of its feeder 14 miles.

Area,	3,444,444 sq. yds.
Prism,	6,536,666 cub. yds.

No. 5 might be formed in the great Youghiogeny, between Snowy creek and the little Youghiogeny, by throwing a dam across it above the mouth of the little Youghiogeny. Height of the dam 67 feet, length of the feeder $10\frac{1}{2}$ miles.

Area,	2,833,332 sq. yds.
Prism,	5,555,555 cub. yds.

No. 6 might be formed in the little Youghiogeny by throwing a dam across its mouth. Height of the dam 67 feet, and length of the feeder 11 miles.

Area,	53,375 sq. yds.
Prism,	106,750 cub. yds.

No. 7 might be formed in Dunker's lick, by throwing a dam across it, above its mouth. Height of the dam 75 feet, and length of the feeder 9 miles.

Area,	1,055,555 sq. yds.
Prism,	1,851,851 cub. yds.

No. 8 might be formed in the great Youghiogeny, between the mouth of the little Youghiogeny, and the ledge, by throwing a dam across the ledge. Height of this dam $94\frac{2}{3}$ feet, length of the feeder, $6\frac{1}{2}$ miles.

Area,	2,770,666 sq. yds.
Prism,	5,303,555 cub. yds.

Areas of all the reservoirs,	16,279,149 sq. yds.
Prisms do.	30,844,413 cub. yds.

If we dispense with the two last reservoirs, whose dams are the highest and most expensive, the five remaining reservoirs above the mouth of the little Youghiogeny will contain—Area exposed to evaporation, 12,452,928 square yards, or $4\frac{2}{100}$ square miles, or $2,572\frac{80}{100}$ acres. Prism of their waters, 6 feet above the base mark, besides 6 inches allowed per mile of the length of the feeder of each reservoir for its descent. These are all available to supply the summit level 23,689,007 cubic yards.

These reservoirs are all independent of one another, and the higher ones may pour the surplus of their waters into the lower ones. Those numbered 3 and 5, in the great Youghiogeny, may be regarded as one, to which all the others can contribute when circumstances require it. The dam No. 3 might even be suppressed, which would reduce the number of dams to 5. But the proper location of these dams, as also their number and dimensions, will receive further investigation, which belong to the final project; their number will likely be reduced.

As to the total quantity of water which these basins might hold, if we suppose their main depth 16 yards, and a middle horizontal section run between the surface and bottom, equal in area to one half of

the upper surface, or to 6,226,464 square yards, (half of 12,452,928 square yards) it will amount to 99,623,424 cubic yards, or, in round terms, 100,000,000 cubic yards.

As to the time necessary to fill them, from observations taken with care, from 1817 to 1824, (inclusively) by Mr. Lewis Brantz, in the vicinity of Baltimore, Md. we have the following results:—In the course of eight years, from 1817 to 1824, there fell, on a mean average, yearly $39\frac{89}{100}$ inches. In 1822 there fell the smallest quantity, the summer was very dry, vegetation deficient, the crops of grain were short. The quantity of rain which fell that year was 29.20 inches. The greatest quantity which fell was in 1817, it amounted to 48.55 inches. Applying these data to the country round the summit level, and using only the results of the year 1822, the rain which fell in the three first and three last months of this year amounted to 16.70 inches, whilst that which fell in the same months of the year 1817 amounted to 18.40 inches. These 16.70 inches are equivalent to 0.465 cubic yds. Thus, during the three first and last months of each year, there will fall at least 0.46 cubic yards of rain on each square yard of the heads of the Youghiogeny, and an area of 217,391,304 square yards would be required to collect water for filling the 100,000,000 cubic yards of the reservoirs. This area amounts to $70\frac{18}{100}$ square miles; and the area of the valleys of the two Youghiogenies, above their junction, and the surface of the reservoirs amounts to much more. Besides, the heads of Cheat river could, perhaps, be brought to feed the reservoirs. These reservoirs once filled, the mass of waters which lies lower than the head of the feeders, will never alter, and the upper part, which feeds the summit level, will alone require to be renewed every year. We have seen that it contains 23,689,007 cubic yards.

The least quantity of water which the great Youghiogeny gave in 1824, under the bridge on the road from Manfield to Morganstown, was, on the 21st September, 22.58 feet in a second. The little Youghiogeny gave, on the 20th September, 1824, at German bridge, 4.30 feet. Total given by those two streams, in a second, at their lowest stage, 26.88 feet.

This is the minimum which they can give to supply the reservoirs. In one month it would amount to 2,580,480 cubic yards; and, supposing what is most unlikely, that the two Youghiogenies and their tributaries should remain in this state, and give no more for six months, from May to October, it would supply the reservoirs with 15,482,880 cubic yards; and, as during the six preceding months, they would have received much more, they would be full at the opening of navigation, and receive every month at least 2,580,480 cubic yards as regular tribute.

We do not consider in this calculation the loss by filtration and evaporation; for, by raising the dams of the reservoirs, a quantity of water would be added to them, which would overbalance it.

We must now compare those supplies, the minimum of what the heads of the two Youghiogenies can furnish, with the maximum of what either of the two summit levels will require.

They will both require the same expense of water for lockage. We know that two lockfulls is the maximum expense for raising or lowering a boat, and eight minutes are required for its passage through a lock of thirty yards in length, 5⅓ yards in breadth, and 2⅔ yards in lift. Such a lock will contain 426.64 cubic yards, without deducting from it the draught of water of the boat, and its passage (at the maximum) will thus consume 853.32 cubic yards, or 854 cubic yards at most. Now, if the canal is navigated nine months, or 270 days a year, at ten hours a day, and that the locks of the summit level be kept in constant operation all that time, they might pass, allowing eight minutes for each boat, 20,250 boats, at an expense of water equal to 17,293,500 cubic yards, for the nine months, or 1,921,500 cubic yards a month. This maximum of water for the expense of lockage, is 658,980 cubic yards less than the minimum which the reservoirs will receive during that time.

The expense of water for lockage being 17,293,500 cubic yards, and the reservoirs containing 23,689,007 cubic yards, there will remain in reserve to supply the losses of the summit level, from filtrations and evaporation, 6,395,507 cubic yards.

The summit level of Deep Creek, extending 11¾ miles in length, will require 413,600 cubic yards to fill it; and, supposing that it loses by filtrations and evaporation the value of its prism every month, or nine times in the year, it will expend 3,722,400 cubic yards. The profile of its feeder having a supposed area of 10 square yards, and a length of 10½ miles, it will consume, at the same rate, 1,663,200 cubic yards. Total consumption for nine months, 5,385,600 cubic yards. Retrenching this quantity from the surplus mass of the reservoirs, there will still remain 1,009,907 cubic yards, which, after supplying all the waste of lockage, and the losses of the summit level from filtrations and evaporation, will serve as an additional supply to repair those of the eastern and western branches of the middle section.

The Youghiogeny summit level, extending 21 miles in length, will lose from filtrations and evaporation, on the same principle, 739,200 cubic yards a month, (the value of its prism) and 6,652,800 cubic yards in nine months. It would thus absorb the whole surplus mass of the reservoirs, after the waste of lockage, and require a much greater expenditure of water than the Deep Creek summit level.

Thus the important advantage of a greater supply of water, by a length shorter by nine miles, of a tunnel shorter by two and a half miles, render the Deep Creek route, superior to the other; though the final surveys only can settle that point, yet at this stage of our operations we would recommend that route in preference. However, the analysis which we have just concluded, is a convincing proof that a canal by either of these routes over the chain of the Alleghanies, between the mouths of Savage River and Bear Creek, is perfectly practicable. The total distance from the mouth of Savage River to that of Bear Creek, will be forty-one miles at least, the rise from the mouth of Savage River to the base-mark, 1,432 feet; and the fall

from the base-mark to the mouth of Bear Creek, 956$\frac{34}{100}$ feet, total of lockage, 2,388$\frac{35}{100}$ feet.

The preparatory surveys executed on this middle section were performed by Captain M'Neill, of the United States' Topographical Engineers, and Mr. Shriver, Assistant Civil Engineer, employed by the United States. The talents and activity displayed by these gentlemen and their assistans, enabled the Board to collect the facts on which they rest their opinion of the practicability of this middle section, and of the best direction through which its route can be directed.

Capt. M'Neill was assisted in these labors by Messrs. De Russy, Cook, Trimble, Hazard, Dillahunty, Fessenden and Williams, Lieutenants of Artillery, whose scientific education, imbibed in the academy at West Point, was thus made valuable in the most efficient and useful manner, to their country and to themselves. Mr. Shriver was assisted by Messrs. Jonathan Knight, John S. Williams, Freeman Lewis and Joseph Shriver. The memoirs, surveys, and maps, of these gentleman, accompany this report.

Before we conclude the article relating to this middle section, we should give an analysis of two other routes which have been proposed for leading the canal over the Alleghany; the one by ascending Will's Creek, (a stream which falls in the Potomac at Cumberland) and descending to the Youghiogeny, by the valley of Casselman's River; the other by passing from the valley of the Potomac to that of Cheat River, and thus descending to the Monongahela.

1st. Two of the head springs of Will's Creek rise very near Flaherty Creek, which falls in Casselman's River, below Salisbury; the eastern is called Laurel Run, and the other Shock's Run. The shortest distance between Laurel Run and Flaherty Creek, is one one mile 756 yards. It was measured from Wilhelm's saw mill, on Laurel Run, to Engle's saw mill on Flaherty Creek. The first is 156 feet lower than the second. A deep cut of 333 yards long, and 35 feet deep, in the highest part of it, on the side of Engle's saw mill, a tunnel of 1,483 yards, and another deep cut, 700 yards long, and of the same depth as the former, on the side of Laurel Run, would be required to unite those two streams. The greatest height of the ridge above the bed of the tunnel, would be 156 feet. This route offers great advantages, if we only considered the shortness of the distance and tunnel, but as to the essential condition of a sufficient supply of water, it is absolutely out of the question. Flaherty Creek, at Engle's mill, gives only 0.415 cubic feet in a second, and Laurel Run, at Wilhelm's mill, 0.600 cub. ft.—(at their lowest stage in 1824.) They would only give, together, 1.015 cub. ft. per second, to feed the whole summit level. The details which we have already given in analyzing the Deep Creek route, and summit level, are sufficient to show the impracticability of receiving a canal by the route of Flaherty's Creek, with so small a supply of water.

As to the route between Shock's fork and Flaherty's creek, the season was too advanced to measure accurately its length, or the tunnel

and deep cuts which it would require. Their profile will be surveyed next season. This route would be longer than the other, and its summit level should be fed by the waters of Casselman's River above Salisbury, led by a feeder to the western extremity of the tunnel. This feeder, following the eastern sideof Casselman's valley, would receive the waters of its tributaries between Salisbury and Flaherty's Creek. At their lowest stage these tributaries gave, altogether, five feet in a second, and Casselman's River above Salisbury, 15.33 cubic feet; total 20.33 cubic feet to feed the summit level. This quantity is not considerable when we consider, that, on a length of thirty miles from the summit level to Cumberland, the canal would have to draw most of its water from Casselman's River: for Will's Creek is a torrent, which, in the greatest part of its course, gives but little water in summer.

The length of this summit level, and of the route which the canal would thus trace, are less than by Deep Creek. As to their comparative heights, no survey was made in the season of 1824, to ascertain the difference. We shall now expose the reasons why the western branch of the canal was not led through the valley of the Monongahela (before concluding this part of our report.)

We have already seen that the valley of Cheat River, through which it would be necessary to pass to the Monongahela, is divided from the Upper Youghiogeny by a ridge whose greatest depression, at the head of the two muddy creeks, is 226.77 feet above the level of the base mark. A tunnel would, therefore, be necessary to pass from the valley of the Youghiogeny to that of Cheat River.

A single inspection of the map will show that the route of the canal would be very much lengthened by running its summit level from the heads of the north branch of the Potomac to those of Cheat River, and that it should be raised to a much higher level than on the route of Deep Creek. There is every reason to believe that the bed of Cheat River has a more rapid descent than that of the Youghiogeny, and that, where it forces through the Laurel Hill, it is already nearly on a level with the Youghiogeny at Connellsville: for, at this gap, and a little above Furnace Run, it begins to be navigable. Its bed is here about 150 yards wide.

The highest floods in Cheat River do not rise above eight or ten feet at Furnace Run, and at its lowest stage in August and September, it is very low at this place, and often fordable. Indeed, Cheat River, to its junction with the Monongahela, receives no stream of any importance but the Big Sandy, whose supply is constant, but in the summer, is very trifling, even towards its mouth and in the lower part of its course. After descending along a rocky and very precipitious bed, Cheat River mingles its clear and limpid waters with the muddy stream of the Monongahela, whose bed and shores are all formed of alluvial soil.

The Monongahela has absolutely the same features as the Ohio: its shores are flat, but raised perpendicularly along both sides of the river to the height of fifteen or twenty-five feet above the line of water, form-

ed of a rich alluvial soil; they are corroded by the current, and when the river rises they crumble into it, and render its waters muddy. The floods of the Monongahela are considerable; at Brownsville it rises thirty-eight feet; whilst, at its lowest stage, its depth is only from twelve to fifteen inches on its highest bars. The two banks present all along a succession of flats and bluffs; the flats of one bank are generally opposite to the bluffs of the other, and the former are found where the river expands, whilst the latter close on its banks where it narrows. The chief tributaries of the Monongahela are on its right shore, George's Creek, below Mr. Gallatin's residence, Big Redstone, below Brownsville; and on the left, Ten Mile Creek. These streams flow constantly, but in summer give but a small quantity of water, an observation which is also applicable to many of the tributaries of the Youghiogeny.

If the western section of the Chesapeake and Ohio Canal cannot be led to the Monongahela, it will at least embranch with it at M'Kee's port, and perhaps when a denser population will render it desirable, a line of junction may be drawn between Cheat River and the valley of the Youghiogeny. It would be fed by a reservoir above the gap of Cheat river, and the constant springs which run from the western ridge of Laurel Hill.

Western Section.

This section begins at the mouth of Bear Creek, and ends at Pittsburg, descending the valleys of the Youghiogeny and Monongahela to the Ohio.

From the mouth of Bear Creek to that of Casselman's River, the Youghiogeny runs in a very winding course between a succession of flats and bluffs, the flats of one shore being generally opposed to the bluffs of the other, the banks high and rugged where they wind in, and flat where they wind out. The two banks present nearly the same difficulties, the right shore, however, seems the best. The distance between those points, following the winding of the river, is about 16½ miles.

Casselman's river is about 100 yards wide at its mouth; it is a fine river, and will give a great deal of water to the canal. At the dryest season it offers from eight inches to one foot in depth; before joining the Youghiogeny it receives Laurel Hill Creek.

From the mouth of Casselman's River till you reach two or three miles above Connellsville, the Youghiogeny forces through Briery Mountain and Laurel Hill, and its bed is very deep. The left bank is very high and rugged, the right somewhat less. In this space of about 28½ miles, the canal must be frequently cut in a shelf on the sides of the valley, or run on embankments supported by a wall. The river has a fall of about sixteen feet at Ohiopyle falls; it is here about 150 yards wide.

Connellsville is considered as the head of navigation in the Youghiogeny. In the dryest season, it has here from eight inches to one foot in depth.

From Connellsville to Robstown, the river winds during twenty-four or twenty-five miles: on all this extent, the right bank is far preferable to the other. Except in three or four places, where you meet with bluffs, it consists of flats or gentle slopes, where the canal can be run without difficulty. As to these bluffs, they consist of schistose rock, easy to work. The only stream of any importance which joins the Youghiogeny between Connellsville and Robstown, is Jacobs' creek, and it gives but little water in dry seasons. That route is also intercepted by two or three deep ravines, which the canal must cross on aqueducts.

The distance between Robstown and M'Kee's port is about sixteen miles. Along this route the right shore remains preferable to the other; it consists of a succession of flats and spurs, which, being of a schistose nature and moderate height, will offer no considerable obstructions to the canal.

From M'Kee's port to Pittsburg, the right shore of the Monongahela offers a most favorable ground, except along two spaces of about a mile each, where rugged bluffs close on the river. The first is below Judge Wallis' and the field of Braddock's defeat; the second before reaching Pittsburg. The whole distance in following the right bank of the river, is between M'Kee's port and Pittsburg, from fifteen to sixteen miles.

The highest floods of the Youghiogeny occur between Casselman's river and Connellsville—they rise to eighteen feet. At Connellsville they rise from twelve to fifteen feet. Salt wells may be dug in its valley; coal and iron are abundant; and excellent materials for building, timber, and stone, are found all along it.

The preparatory surveys of this western section were not commenced during the last season (1824). They can alone fix the general route of the canal: they will be directed on the following bases:

From Bear creek, the canal must follow the right shore of the valley, descending along the Youghiogeny; and though it is most favorable, (presenting a rugged bank only for four or five hundred yards,) when it reaches Selby's port bridge, two lines of direction may be tried, one along the right, and the other along the left bank, to the old salt works. The depth and breadth of the valleys and ravines, which it will be necessary to cross on aqueducts, will be measured, and the location of these aqueducts, and of the dams to form reservoirs will be fixed.

If, between Selby's port and the old salt works, the left shore presents any advantages over the other, deserving the expense and trouble of crossing twice the Youghiogeny, the location and dimensions of two aqueducts, one at Selby's port, and one above the old salt works, will be determined, and a feeder led from Casselman's river to the latter.

From the old salt works to the Ohiopyle falls, the canal must follow the right shore, which is most favorable, and then crossing Indian creek, on an aqueduct, continue along the same bank to the paper mill four or five miles south of Connellsville. It will be pro-

per to ascertain whether its line should not leave the valley of the Youghiogeny, above the Ohiopyle falls, and running east, gain the southern branch of Indian creek, to rejoin the Youghiogeny by descending Indian Creek valley.

From the paper mill, the canal should be run at a sufficient elevation above the river, to leave the shore, and gain, if possible, the high level which lies east of Connellsville, in order to turn round the rugged bluff below that place. From thence, following the right shore, it will reach Robstown, after crossing on aqueducts Mount's creek and Jacob's creek. The localities and dimensions of these aqueducts must be determined, as well as the resources which these streams may afford to supply the canal, by turning them into reservoirs.

From Robbstown to M'Kee's port, keeping along the right shore, it must cross Sewickly creek over an aqueduct, whose dimensions and location must be determined. As this creek has two considerable branches, they must be examined, to determine whether reservoirs cannot be made in them.

From M'Kee's port to Pittsburg, the canal will follow the right shore of the valley of the Monongahela, crossing, in succession, Crooked Run, Turtle Creek, and Nine Miles Run, on aqueducts.

To ascertain whether from Paper Mill the right shores of the Youghiogeny and Monongahela are certainly the best, a level should be run along their valleys on the left shore, and the locations and dimensions of the dams or aqueducts which it would be necessary to run through the Youghiogeny at M'Kee's port, and through the Monongahela near its confluence with the Youghiogeny, in case this route was adopted, should be fixed and calculated.

It will also be essential to try whether the canal might not turn to the west of that narrow and rugged portion of the valley of the Youghiogeny, where it forces its way through Briery Mount and Laurel hill. For this purpose, a level should be run from Selby's port, and some point of a proper elevation, and cross the Briery Mount at the depression which it offers between the heads of Buffalo Marsh Run and the eastern branch of Sandy Creek. This level should then wind round the ravines of the head of the western branch of Sandy Creek, till it met the Laurel Hill at the spot where it might be crossed by the shortest tunnel. When it reached its western slope, it should run northwardly along its foot, to descend by one of its ravines to the Youghiogeny, opposite the paper mills.

On the whole, the western section of the canal, from the mouth of Bear Creek to that of the Monongahela, at Pittsburg, offers no obstacles which may not be surmounted at a reasonable expense; and the waters of the Youghiogeny, Bear Creek, and Cassellman's river, are amply sufficient to feed it. Large reservoirs may be formed in Bear creek and Cassellman's river, by throwing dams across them, and on the route from Cassellman's to the Paper mills, and at the mouth of the Youghiogeny in the Monongahela. The practicability of this section is out of question.

Its length will be about 100 miles, and its descent from Bear creek

to Pittsburg 584½ feet, as Pittsburg is 756 feet above the level of the ocean.

The investigation of the topography and water courses of the country, through which the Chesapeake and Ohio canal should run, and the results of our preparatory surveys, obtained up to the present moment, demonstrate that this noble enterprise is practicable; and although we have not yet sufficient data to calculate the expense of the work, there is every probability that it will not bear any comparison with the political, commercial, and military advantages which it will procure to the Union.

The total result of the length, rise, and fall of the canal, is as follows:

TOTAL LENGTH.

From the tide water in the Potomac to Cumberland, (from Messrs. Moore and Briggs's survey,) -	182	miles.
From Cumberland to the mouth of Savage river, (from Major Abert, U. States Topographical Engineer's survey,) - - - - -	27½	
From the mouth of Savage river to that of Bear creek, by the Deep creek route, from the surveys of Capt. M'Niell, United States' Topographical Engineer, and Mr. Shriver, United States' Assistant Civil Engineer - - - - - -	41	
From the mouth of Bear creek to Pittsburg, (from Mr. Shriver's computation,) - - -	100	
	350½	miles.

TOTAL RISE.

From tide water, in the Potomac, to Cumberland, (from the profile of Cumberland road,) - -	537	feet.
From Cumberland to the mouth of Savage river, (from Major Abert's survey,) - - - -	327½	
From the mouth of Savage river to the Base mark, on the Deep creek summit level, (from Capt. M'Niell's survey,) - - - - -	1,432	
	2,296½	feet.

TOTAL DESCENT.

From the Base mark to the mouth of Bear creek -	956	
From thence to the Ohio, at Pittsburg - -	584½	
	1,540½	
Total lockage for rise and descent - -	3,837	feet.

OHIO AND ERIE CANAL.

[*See Map, No.* 17.]

This canal may be divided in two sections: 1st. The Southern, beginning at Pittsburg, and terminating at the summit level which divide those waters that pay their tribute to the Ohio from those which pay it to Lake Erie. 2d, The Northern, beginning at that summit level and ending in Lake Erie.

Southern Section.

It should follow the right shore of the Ohio, from Pittsburg to the mouth of the Big Beaver, ascending the valleys of that river, and one of its heads, till it reaches the summit level.

From Pittsburg to the mouth of Big Beaver, the river winds for about thirty miles. Its right shore is formed of successive bluffs and bottoms; the latter generally form two beds parallel to the river, and rising one above the other, as if the bed of the river had formerly been higher than it is at present. The upper bottom is never overflowed, and both are formed of an alluvial soil, most favorable for digging a canal. The bluffs consist of a schistose and clayey soil, which is easy to excavate; nor do they offer any considerable steep ground, except four miles below Pittsburg, on a length of four miles. The left shore possesses no advantages over the other, and offers the same features, the bottom of one shore generally lying opposite to the bluffs of the other. No stream of any importance joins the Ohio, from Pittsburg to the Big Beaver; but the river presents, in that interval, eighteen bars, which have but 10 or twelve inches of water in the dry season. At Pittsburg, its floods rise from 22 to 24 feet.

The Big Beaver, from its mouth in the Ohio, to the forks of Mahoning and Shenango, presents, like the Ohio, two flat bottoms on each of its shores; they both consist of a succession of bottoms and bluffs; the former offering a most favorable ground, and the latter consisting of a schistose and clayey soil, presenting no serious obstacle to the digging of a canal, except on the left shore at the spot where it joins the Ohio. This bluff is almost perpendicular, and consists of a mixture of clay and gravel.

The floods of the Big Beaver rise from eight to nine feet; and sometimes those of the Ohio back its course; it then rises and presents a level surface from the foot of the falls. These begin five or six miles from its mouth; their total descent is fifty one feet. From the mouth of the river to the forks of Mahoning and Shenango, its course winds about twenty miles. It receives no tributary of any importance, nor presents any ravine considerable enough to require an aqueduct for the canal in all this space.

The Mahoning and Shenango are the two upper forks of the Big Beaver. The first descends from the neighborhood of Warren, and rises west of this place, on the east side of a ridge which divides

its waters and those of Grand river, from those of the Cuyahoga. The Mahoning as well as the Shenango, has but a small current in the summer season, their beds are seldom more than 40 or 50 yards wide, and their depth at that time seldom passes 5 or 6 inches.

The Mahoning receives no stream of any importance; Musquito Creek, which joins it on the left shore, below Warren, is often dried up in Summer. The Shenango receives on its right shore the Pymatuning, which is not entirely dried up at its lowest stage. The two forks of the Shenango join at Greenville, the western fork is called Shenango Creek, and the eastern, Little Shenango, the latter receives on its right bank, Crooked Creek. Musquito Creek, the Pymatuning, Shenango Creek, and Crooked Creek, all rise in the swampy ground which here divides the waters which fall into the Ohio, from those which join Lake Erie. The head of Shenango Creek, and Crooked Creek, cross also, the Pymatuning swamp to the W. of Conneaught lake. At Greenville, the floods of the Shenango rise from 8 to 10 feet.

From the mouth of Mahoning to Warren, the distance is about 26 miles, in following its windings. As to the nature of its valley, its banks are generally flat, and favorable for digging a canal, as well as those of the Shenango, and of its tributary the Pymatuning.

In following from W. to E. the ground which divides the heads of the Big Beaver from the tributary streams of Lake Erie, it descends from Cuyahoga to Champion township, and ascends towards French Creek. Champion Swamp is thus the lowest part of this level; its elevation above Lake Erie, from a survey of Mr. Geddes, is 342 feet, and from the report of Messrs. the Ohio Canal Commissioners, 214 feet above the mouth of Big Beaver in the Ohio; that mouth is, therefore, 127½ feet above the level of Lake Erie. The rapids of Cuyahoga are from 97 to 100 feet above the Champion Swamp, and from 439 to 442 feet above Lake Erie. Conneaught Lake, E. of the head of Crooked Creek, is, from the level of Messrs. the Pennsylvania Canal Commissioners, 470 feet above Lake Erie.

Supposing the summit level of the canal in the Champion Swamp, it might be fed by the waters of the Cuyahoga from the rapids. Supposing it at Conneaught Lake or Pymatuning Swamp, it might be fed by the waters of French Creek, derived from Meadville, as we shall see below.

The Cuyahoga, below the rapids, cannot be turned into the Champion Swamp; its valley, until it reaches nearest to the basin of the Muskingum, is divided from Mahoning fork by a ridge, whose greatest elevation is 208 feet above the Champion. The pond which is on the portage from Cuyahoga to the Muskingum is — feet above the Champion Swamp, — feet above Nelson's township, and about — feet above the bridge at Warren.

The quantities of water given by these streams at their lowest stage in 1824, are as follows:

Big Beaver, at the Falls, and in that part only which runs through the races of the Falls, gave, from instructions received, - - - - -	88.888 ft. in a sec.
Shenango, above Greenville, 16th August, -	28.650

Mahoning, at Warren, 6th August, (*) -	46.000
Silver Creek, a fork of Mahoning, 7th August, (E. Branch Kempt Creek at Stephens' mill, 0.664—Main Branch at Garrett's mill, 5.406,)	6.070
Cuyahoga, at its rapids, 8th August, -	56.148
Outlet of Conneaught Lake, 16th August, -	6.293
French Creek at Meadville, 17th August, -	221.008
Do. do. 23d August, -	229.972

Northern Sections,

The water courses which correspond with the heads of the Big Beaver, and fall into Lake Erie, are from west to east; Grand River, Ashtabula, and Conneaut Creek of the Lakes.

Grand River has dug for itself a bed, whose bottom is considerably lower than the general surface of the country to its east. At Bloomfield it is already 92 feet below the level of the turnpike. Its valley is deep, and its banks are very rugged, and formed of clay, without any tenacity. It offers some flats at the bends of the river, but in the intervals the banks are often perpendicular, on a height of 100 or 150 feet. At its lowest stage it has but little water—its tributaries on the right bank are almost dried up in Summer, but on the left bank, descending from a higher country, they are more permanent. When it reaches the natural dyke which borders on the Lake, Grand River, near Austinburg, runs suddenly to the west to join Lake Erie, at Fairport. Its greatest floods rise from 15 to 16 feet; in the lower part of its course they do not rise above 8 or 10 feet, and at its mouth are insignificant. By sinking two rows of piles in continuation of that mouth, a passage has been opened for the river through a sand-bar, which formerly obstructed it, and on which there was only 10 or 12 inches of water. But the piles are not closed, and an interval of 1 or 1½ feet has been left between them; it would be proper to sink more piles in these intervals, especially to the W. as the reigning winds are from the S.W. and the neighborhood is subject to squalls from the N.W. This would secure an important port on this part of the Lake. The bottom is sand and gravel, the length of the passage between the piles is from 270 to 330 yards, its breadth 138 yards. A new bar is formed at the mouth of the channel, but has 8 or 10 feet above it.

The Ashtabula offers precisely the same feature as Grand River, as to the depth of its valley, below the general surface of the country, and the rugged and perpendicular character of its banks. Conneaut creek of the Lakes offers the same features, and, as well as Grand River, has but a small provision of water in the summer months, at least if compared to the Big Beaver, or Cuyahoga.

To the east of Conneaut creek, of the Lakes, Crooked creek, Elk creek, and Walnut creek, run successively into Lake Erie. The val-

(*) N. B. As it was not at its lowest stage, we give only ½ of the result.

leys of these streams are broad, but their banks are high, and perpendicular in the lower part of their course; they are of soft slate in layers, which, worn by the water, present a perpendicular surface. The floods of these streames rise from 7 to 8 feet.

The soil of the country between these steams, consists, in general, of a clay, very favorable for digging a canal, except at Austinburg, where we meet a ridge, which would require a deep cut; there exist no obstacles any where to its excavation, and the preparatory surveys will determine whether we ought not to prefer it to the valleys which run throught it.

Conneaut lake belongs to the valley of French creek, its surface is valued at 1600 acres or thereabouts; its outlet is called Conneaut creek, and falls in French creek, 6 or 7 miles below Meadville. Its inlet rises opposite the head of Conneaut creek of the Lakes. From the surveys of the Pennsylvania Canal Commissioners, a cut 14 or 15 feet deep, and 60 or 70 yards long, would join the waters of Conneaut creek, and Conneaut of the lakes. From the head of the inlet to that of the latter stream, the distance does not pass 2 miles. The same commissioners have ascertained that a feeder, beginning at French creek, above Meadville, might, by following the western side of its valley, and then the ravine of Conneaut creek, feed Conneaut lake, if we considered it as the reservoir of a summit level. By erecting a dam wherever required, round that lake, we might obtain a vast reservoir to feed both sections of the canal.

The description which we have given of the water courses and ground on both sections of this canal, proves that we have the choice of several summit levels; Champion swamp and Conneaut Lake are the chief.

The summit ground of Champion swamp, being 342 feet, and Conneaut lake 470 feet above Lake Erie, the former has over the latter the advantage of 128 feet less in height, and of course 256 feet less of lockage. But the resources in water of the Champion swamp summit level, as we have seen above, are only 56 feet in a second, from the Cuyahoga, and 6 feet from Silver creek, total 62 feet per second.

The resources of the Conneaut summit level amount to 221 cubic feet per second from French creek, which gives it a superiority of 159 cubic feet per second over the other. Reservoirs may and ought also to be found in the Cuyahoga and French creek, and a much greater depth of water can be collected, at little expense, in Conneaut lake, by running dams in certain parts of its border. Its mean depth has not been sounded.

Preparatory and comparative surveys must determine our choice between these two summit levels, and combine their several advantages with those of the several routes which may lead to them. The slender means of the Board did not allow them to begin those surveys in 1824; of course, they cannot recommend either in preference to the other, as they do not possess those exact documents, which alone can give, in a certain and positive manner, the local circumstances and details required to weigh their respective advantages and inconve-

niences. But the Board have already formed the conclusion, that a canal from Pittsburg to Lake Erie is not only practicable, but offers no difficulties from the nature of the soil, and will be amply provided with water for its navigation. As to the materials for its construction, stone and lime must be brought from a distance; but may be conveyed by water, by the Ohio or Lake. Brick of the best quality will be amply supplied on the spot.

We will now give a rapid review of the several routes which the canal might follow, and of the operations to perform on the ground, to determine which of them we should adopt.

First route. It may follow the right bank of the Ohio, from Pittsburg to the mouth of Big Beaver, ascend the valleys of Big Beaver, Shenango, and Pymatuning, and descend to Lake Erie at the mouth of the Ashtabula. The summit level of this route would run to the E of Pymatuning Swamp, and be supplied by a feeder led from French creek through Conneaut Lake. Its northern section would descend from the lowest spot between the sources of the Pymatuning and Ashtabula, following the most favorable ground, to the mouth of that latter stream. When it reaches Ashtabula, surveys must determine whether the canal should follow either bank of the river, or run entirely outside of the valley. In either case, all the facts relative to the establishment of a port at the mouths of the Ashtabula, in Lake Erie, must be determined. A feeder must be led from Conneaut Lake to the summit level.

The southern section of the canal, on this route, would descend, successively, the valleys of Pymatuning, Shenango, and Big Beaver, to the Ohio. Levels on both sides of these valleys must determine which is most favorable. The location of the locks and dimensions of the aqueducts must be fixed, as well as those of the dams to four reservoirs, the streams destined to supply it gauged at the points where they are dammed: and the same labor must be performed on all the other routes which we shall designate.

When this route reaches the falls of Big Beaver, surveys must determine whether the directing line of the canal can be run on a height sufficient to turn round the bluff which lies to the east of its confluence in the Ohio, or even to reach Pittsburg at the close of its descent. But if the bluff opposes too many difficulties, and if it be impossible to quit the valley at a height sufficient to reach Pittsburg by successive descent of levels, instead of a section of canal descending from the Big Beaver falls to Pittsburg, we should run one descending from Pittsburg to the mouth of Big Beaver. For this purpose, running from Pittsburg up the valley of Alleghany river a line of 6 inches ascent per mile, to the first spot where a dam might be thrown across that valley, we would form a reservoir. This line would trace the feeder which should supply the canal from Pittsburg to the mouth of the Big Beaver, and this canal run till it met the other, crossing on the right side of the Big Beaver, to avoid the bluff on its left. This arrangement would increase the total lockage of the canal as much as would be required in the descent from Pittsburg to the mouth of Big Beaver.

Second route. It might follow the same route as the former, from Pittsburg to the forks of the Mahoning and Shenango; ascend the Mahoning to Champion Swamp, where its summit level would be traced; then descend to Lake Erie, either by following the valley of Grand river, or turning to the mouth of the Ashtabula, through the townships of Bloomfield and Austenburg. The summit level of this route would be fed by the waters of the Cuyahoga and Silver creek. Its feeder, from the rapids of Cuyahoga, (two miles and a half N. W. from Judge Harman's, where a dam might be conveniently thrown across to form a reservoir) might run to the head of Silver creek, and follow its valley to Garret's mill dam; thence, from a point five feet above this dam be led through the most favorable ground to the summit level. If this route ended, however, in a level lower than the Champion Swamp, we should lead the feeder from a point higher than the rapids, and conduct it through the most favorable ground. The feeder should have a slope of six inches per mile.

The southern section of the canal on this route should cross the Mahoning, near Warren, and drop its level to receive the waters of that river. A dam should be thrown across the valley at Warren, or above, to form a reservoir for the canal. Descending then the right shore of Mahoning valley to the mouth of the Shenango, means should be brought to feed it also with the waters of Musquito creek.

The northern section, if traced by the valley of Grand river, should be run above its highest floods, but kept as low as possible consistently with this rule, to receive the waters of its tributaries. As the valley is excessively steep at the bend of Austenburg, every care must be taken to avoid its rugged banks without crossing the river too frequently on aqueducts. At the mouth of Grand river, the localities must be examined with attention to determine what can be done to form a good port on Lake Erie at Fairport.

If this section is to be traced, running to the Ashtabula, it must pass successively through the townships of Champion, Bristol, Bloomfield, Leffingwell, Rome, Morgan, Austinburg, and Ashtabula. An experimental line may also be run from the east of Bloomfield Swamp, and another from Rome, through Jefferson, to Ashtabula. Their object will be—1st. To discover the best location for a summit level, which may be fed both by the Cuyahoga and French creek, through Conneaut lake. 2d. To fix the most favorable spot for crossing the ridge which runs from Ashtabula to Wrightsburg, parallel to Lake Erie. To complete our investigations relative to the first of these objects, an experimental line should be run from Conneaut lake to the summit level which we have just mentioned; it should, probably, run by the head of the Shenango, Pymatuning, and Musquito creek.

Third route. It might follow the same course as the former, to the fork of the Mahoning and Shenango, ascend the Shenango to Greenville, then Shenango creek, or Crooked creek, to reach the summit level of Conneaut lake; thence, descend to Lake Erie, directing itself on the mouth of Elk creek. Its summit level would be fed by the waters of French creek and reservoir of Conneaut lake. The sur-

veys should begin at a base mark, six inches above the bottom of the outlet of that lake, at its bridge. The summit level line should run north as far as possible, towards the ridge which divides Conneaut lake from Conneaut creek of the lake, and south to the point, where it will be necessary to drop it. By this level we will measure and calculate the deep cuts which will be required through the ridges which bound north or south the basin of the lake, and judge whether the level of that line should be raised to diminish the depth of these cuts, or lowered, in order that Conneaut lake may be high enough for a reservoir; in short, it will shew relatively to its southern section whether the summit level should be separated from the lake.

Having fixed the summit level line, we should run it as far north as possible toward the valley of Conneaut creek of the lakes, and descend the right shore of that valley, on levels as long as possible, to reach Lake Erie at the mouth of Elk creek. All the localities of this spot must be examined with care, to determine what work will be necessary to form a port in the Lake.

To the south of the summit level, two routes may be tried to descend to Greenville: the one through Shenango creek, and the other through Crooked creek. From Greenville, the canal will descend Shenango Creek to the mouth of the Pymatuning, from whence it follows the same route as the first which we have analyzed. At this spot bench marks should be established to compare the levels of these two routes.

A feeder, with a slope of six inches per mile, should be traced from Conneaut lake to French creek, following the left shore of Conneaut creek and the right shore of French creek, directing itself towards Meadville. The surface of Conneaut lake, at its usual level, should be measured, and, in the supposition that its bed should be raised three, six, or nine feet higher, the level of the surrounding ground should be taken on each of these hypothesis, in order to calculate the height, length, and dimensions of the dams, which would be required, in order to confine this reservoir within the bounds, which would be necessary. The elevation of the dam required to keep the waters of French creek at the elevation of the summit level, and its location below Conneaut creek, or below Little Sugar creek, will then be fixed. If this elevation below Sugar creek was moderate, it would procure on the summit level an open passage, through which the trade of Big Sugar creek and the Alleghany above Franklin might pass to the canal, and form, moreover, a vast reservoir to supply all its wants.

Lastly, we should examine whether a branch might not be run from the northern extremity of the canal to Erie, (Presqu' isle) either by following the banks of the Lake, or crossing Elk creek and Walnut creek.

Fourth route. From Pittsburg, it might ascend the valley of the Alleghany to Franklin, and then ascend French creek and Conneaut creek, to the summit level of the abovementioned route, following the same directions in its subsequent position.

The summit level and northern section of this route would be the same as those of the former. Its southern section, after descending

the valley of French creek to Franklin, would follow that of the Alleghany to Pittsburg. The two shores of both these valleys are equally favorable for digging a canal, but, as their chief tributaries join them on the left shore, it should be preferred. On each shore there are about ten miles of rugged banks, which leave little or no room for a canal; it will be necessary, at the most difficult spots, either to run it on artificial embankments, or, in the most rugged spots; to pass over from these banks to the other on aqueducts; three miles along the left shore, and four and a half along the other, present the greatest difficulties.

It will be necessary to trace a route along each bank, above the highest floods of the river, to compare them. The Big Sugar creek, the Alleghany above Franklin, Toby's creek and the Kiskimanitas, may be formed into reservoirs to feed the canal, and these may be considered as the lowest levels of canals descending through their valleys. The feeder from these streams should be traced in the preparatory surveys, and the dams which would be required across the valley of the Alleghany should have locks, in order to leave the navigation of that river open. In these surveys, we should take in all the experimental lines for tracing the course of the canal, and those relative to its details, locks, dams, and aqueducts. The waters should every where be measured with care at their lowest stage.

The branches which this canal might receive from the East, give it in our opinion an importance, which, though its route is longer than the other which we have analysed, justifies the expense of a preparatory survey. The whole valley of the Alleghany above Franklin and those of Toby's creek, Mahoning, Kiskiminatas, by which the basin of the Susquehannah may one day be united with that of the Ohio, will thus become tributary to it.

Such are the four routes which may connect the Ohio from Pittsburgh, by the shortest distance and least elevation of summit level with Lake Erie. They may all be regarded as a prolongation of the Chesapeake and Ohio canal, and as forming part of that noble line of artificial communication, which will join the vast regions of our northern Lakes with the Capital of the Republic.

Exact surveys can alone give the true length of these several routes, and the accurate height of their summit levels; the following sketch may, however, give an approximative result to compare them.

1st Route—length, 104 miles; elevation of the summit level at Lake Erie, 450 ft. total lockage 773 ft.

2d Route, by Grand River—length, 115 miles; height of the summit level above Lake Erie, - - 342 ft do. 557 ft.

by Ashtabula—length, 104 miles; height of the summit level above Lake Erie, - - - do. do. do.

3d. Route—length, 113 miles; height of the summit level above Lake Erie, 470 ft do. 803

4th Route—length, 140 miles; height of the summit level above Lake Erie. 470 ft total lockage, 749 ft.

And in case a section of canal should descend from Pittsburgh to the north of Big Beaver on the first, second, and third routes we should add about 64 feet to their lockage.

Before concluding this part of our report, we should give some details on other terminations proposed for the Ohio and Erie canal in Lake Erie. One is to the west, and the other to the east of those which we have analysed.

The first joins the Lake at Cleveland. For this purpose, after reaching a proper height to the north of Warren, the route ascends from Garret's mill up Silver creek, and from thence directs itself to the rapids of Cuyahoga. From thence it descends from N. E. to S. W. the valley of Cuyahoga, and directs itself N. N. W. thro' the same valley to Cleaveland. But besides the difficulties which it would meet in winding along this rugged valley and its rapids to Cleveland, the total route of the canal would thus be lengthened from 24 to 30 miles, beyond what would be required if it ended at Ashtabula: and, as the rapids of Cuyahoga are from 97 to 100 feet higher than the Champion swamp, this section would require 194 or 200 feet more of lockage than the former, without the resource of more water at its summit level.

Another direction has been suggested for this route, by embracing the northern section of the Ohio, and Erie Canal, with the canal contemplated by the state of Ohio, to unite the Cuyahoga, and the basin of the Muskingum. The summit level of this route would be in the swamps of the southern line of Portage county, which afford the least elevated, passing between the valley of Cuyahoga, and the southern branch of Mahoning Creek. It is in township No. 1. X range. These swamps, from Mr. Benjamin Tappan, are 553 feet higher than Lake Erie, and 41 feet higher than the rapids of Cuyahoga.

To fulfil this object, the line of the Ohio and Erie canal should, from Warren, be directed through one of the southern branches of the Mahoning creek, to the swamps in Portage county, considered as a summit level. This, however, cannot be supplied, except from the upper Cuyahoga, whence a feeder of 35 to 40 miles in length, and requiring much extra embankments, should be traced from a point, elevated 41 feet at least above the rapids.

By this direction, the northern section of the Ohio and Erie canal would be no more lengthened than in the preceding supposition, when its summit level was at the rapids; but its summit level would be 41 feet higher, and its lockage from 276 to 282 more than by the Champion swamp route. And its feeder being obliged to ascend 41 feet higher than the rapids, it is unlikely that the Cuyahoga, at such a level, would give water enough to feed the canal, on one side to Warren, and on the other to the valley of Cuyahoga, below the falls, and also to supply the lockage on the summit level.

A third direction has been suggested, with a summit level at the rapids of Cuyahoga, from thence, the line would follow the right side of the valley of Cuyahoga, to a point 5 or 6 miles below, from whence it would turn to Cleveland, leaving to its west the ravine of

Tinker's creek. The practicability of this route, and its length, depend on the form and height of the soil between the Cuyahoga, below the rapids, and the head of Tinker's creek. But whatever they may be, the length of this line would be at least as great as that of the Champion Swamp route, and it would require from 194 to 200 feet more of lockage. The only advantage of terminating the canal at Cleveland, rather than any more eastern point, would be, that its port is sooner freed from ice at the close of winter. But admitting it opened a whole month before Buffalo, and ten days before Erie, there could only be a few days difference, between the opening of Cleveland and Fairport, or the mouths of the Ashtabula, or Elk creek. The Board is of opinion, that this advantage would not compensate for the augmentation of length and lockage which it would require, and did not in consequence deem it necessary to reconnoitre those sections which led the canal to terminate at Cleveland.

As to the direction by which it would terminate in Lake Erie to the east of the four routes mentioned above, it begins at Franklin, on the Alleghany river, and ends at Port Erie. This section was explored and levelled by Gen. Marks, Col. Foster, and Col. Brown, Pennsylvania Canal Commissioners. From Franklin to Meadville, it follows the eastern side of the Alleghany valley, and ascends it to Lebœuf creek; it then follows Lebœuf creek valley to the Beaver dam swamp, where rise Lebœuf creek and Walnut creek, a tributary of Lake Erie, and which forms its summit level. From Beaver dam swamp it descends to Port Erie. The distance from Franklin to Port Erie by this section of the canal, is 73 miles, of which 15 run from Beaver dam swamp to Erie. The summit level is 630 feet above Lake Erie, and would be fed by the waters of French creek, drawn from Fork point, 21 feet higher than that level. French creek, on the 23d August, 1824, gave, at this place, 43 feet 30 per second; Lebœuf creek at Waterford, 64 feet 9 inches below the Beaver dam swamp; and at its mouth in French creek, 92 feet 9 inches below it. French creek at Franklin, is feet below the same level.

If we adopted this course, in continuation of the fourth route mentioned above, it would augment its length, and as Beaver dam swamp is 160 feet higher than Conneaut Lake, its total lockage would be increased 320 feet. If to this we add, that the summit level of Beaver dam swamp, would be fed by 48 cubic feet per second, whilst Conneaut Lake, in its level, could receive 221, we may conclude to reject this route for the continuation of Ohio and Erie Canal, and prefer the route by Conneaut Lake, which has equally been indicated for the canal, by Messrs. the Pennsylvania Canal Commissioners.

OHIO AND SCHUYLKILL CANAL.

(See Map No. 18.)

It is proposed to run this communication from the valley of Alleghany river above Pittsburg, through those of the Kiskimanitas, Great

and Little Connemaugh, to the west of the ridge, and Juniatti and Susquehannah to its east, to a point above Harrisburg, and from thence to Philadelphia, through the county of Lancaster.

The Board has examined this route in co-operation with Messrs. Col. Jacob Holgate, James Clarke, and Charles Tresingburg, Pennsylvania Canal Commissioners. It would unite the Western waters with the Atlantic. The Board began by reconnitering the general features of the country through which it would pass; and the Commissioners then executed, as far as the advaneed season would allow it, the levels and surveys required to ascertain the total heights of lockage and the length of its several sections.

From Pittsburg to the mouth of the Kiskimanitas, the valley of the Alleghany offers no difficulties in the way of a canal; the river has from 9 inches to 1 foot of water at its lowest stage, and rises from 20 to 22 feet in its greatest floods at Freeport.

From the mouth of the Kiskimanitas to the forks of the Loyalhana and Connemaugh, the river presents the same depth as the Alleghany at its lowest stage, but its greatest floods do not rise above 16 or 18 feet.

The banks of the valley offer a succession of flats and bluffs; the first affording a most favorable ground for the canal, and the latter sloping so gently as to oppose no serious obstacles to it.

The Connemaugh to Blairsville, where it is joined on its right shore, by Blacklick creek, offers precisely the same features as the Kiskimanitas, of which it is only a continuation. In descending from Johnstown to Blairsville, it flows with a more rapid course than below Blairsville, and forces its passage successively through Laurel Hill and the Chesnut ridge. The banks of these gaps offer no serious obstacles to a canal.

The gap of Laurel Hill is about 2½ miles in length, its right bank is rugged and perpendicular, but the left has a slope of 20 or 30 degrees. Some rapids are found above the gap, but on its whole length the water is deep and the current slow. The gap in Chesnut ridge is about 2 miles long, and is very narrow in some places; it offers two or three rapids, of which the most considerable is Richards' falls; its banks do not slope beyond them 30 or 35 degrees. The floods of the Connemaugh at Laurel Hill gap, rise to 7 or 8 feet. Stony creek and the Little Connemaugh join at Johnstown, an may be considered as the upper forks of the Connemaugh; the canal should proceed up the valley of the Little Connemaugh, to the point where it receives Bear Rock run. Its valley in all that space offering no serious obstacle to it. From Pittsburg to this point, the bottom of all these valleys is stony, and offers a firm and easy ground for the works which may be run through them. Their banks are formed of sandstone, stratified, or in heavy blocks. Coal is abundant; and salt wells have been bored with success through the whole valley of the Connemaugh. These salt works are now in operation, and their number is multiplying very fast at the present moment.

This section from Pittsburg to the forks of the Little Connemaugh and Bear rock Run, may be considered as the western section of the

contemplated canal. It will be supplied with water by the rivers whose valleys it ascends and their tributaries. The results of the measurements which were taken in this view in the middle of September, 1824, are as follows:

The Little Connemaugh below Bear Rock Run, two miles below Selby's mill, yielded	14.43 ft. per sec.
The Little Connemaugh at Selby's mill	7.09
Do. at the mouth of South fork	40.21
Do. above Johnstown	110.73
Stoney creek above Johnstown	239.25

Reservoirs might also be found in the valley above Selby's mill, and the head waters of South Fork and Mountain Run led to that spot by feeders.

At this point of the Little Connemaugh the line of canal is stopped by the Alleghany Mountain, which it must cross by a tunnel, to join the water courses which fall to the east. The Beaver Dam, a branch of the Juniatta, offers the best route. This branch is joined by Burgoon's Creek and Blair's Run; whose springs are constant, and whose waters might be led by feeders to the point where the tunnel opens on the eastern side of the Alleghany Mountain; the waters, which on both sides of that chain might be led to that tunnel and supply the summit level of this canal, can give altogether, by actual measurements, 40 cubic feet in a second.

The eastern section of the canal should descend the Beaver Dam, and then follow successively the Frankstown branch of the Juniatta, and the Juniatta itself, to its mouth in the Susquehannah, above Petersburg; from thence it should descend along the Susquehannah to Middletown, to direct itself afterwards, through the most favorable ground, either to the Schuylkill above Philadelphia, or to Philadelphia itself.

The Beaver Dam joins the Frankstown branch at Frankstown; its valley, from Blair's Run, is open and bordered by a large flat bottom. From Frankstown to Williamsburg, the valley offers no serious obstacle; the route then traverses Lock Mountain at Canoe Gap. From Williamsburg to Alexandria, the right shore of the river is rugged, but the left easy. The river breaks through Tussey's Mountain. At this Gap its banks are alternately flat and rugged; the flats of one side lying opposite to the bluffs of the other. Its flood seldom rises above seven or eight feet.

From Alexandria to Millerstown, the valley still offers no serious obstacle to a canal. Its banks consist of a succession of flats and bluffs, whose slope is, in general, so gentle towards the river, as to oppose no difficulties in the way of the works. In this space the Juniatta receives the Raystown branch below Huntingdon and Standing Stone Creek, which, at all seasons, affords an ample supply of water. From Blair's Run to Millerstown, the left shore of this valley is, in general, most favorable; but lower down, and to its confluence in the Susquehannah, this shore of the Juniatta offers several perpendicular

bluffs on the river. Seven or eight miles above Clark's Ferry, its bed begins to be crossed by banks of slaty and schistose rock, which obstruct its course. At the Great Falls, three miles above Clark's Ferry, these obstructions rise from four to fifteen feet above the bottom of the stream. The bed of the Susquehannah to Harrisburg, is embarrassed by these schistose banks, which cross it, and belong to the ridge of Peter's Mountain, through which the river forces its passage.

All the valleys which we have just mentioned, have a strong solid bottom, favorable for works of this nature; the floods of their rivers do not rise so high as in those which fall from the western side of the Alleghany, but they flow all the year, and are never dried up in the warmest seasons.

From Harrisburg, the route of the canal might proceed to Middletown, at the mouth of the Swetarra. But from thence to the Chesapeake, the banks of the Susquehannah become difficult and rugged; this consideration has led to such a passage to the Atlantic, towards the east by the Schuylkill.

To promise a sufficient supply of water for this section, and shorten its distance, it is necessary to keep as much as possible to the south of the road from Middletown to Philadelphia, by Lancaster and Downingtown; thus the line of the canal will intersect the chief tributaries of the Susquehannah below Middletown, and those of the Delaware below Philadelphia; nevertheless, as it crosses them near their heads, it is doubtful whether in the dry season they will supply water enough for an active navigation, especially if we consider that they run over a stratum of calcareous soil, which will frequently occasion considerable filtration. Particular attention should be paid, in tracing this section, to measure the springs which must feed it, and its line must be kept as low as possible, to admit as many streams as the localities will allow. In any case, one tunnel will be indispensable at Gap Tavern, through the Mine Ridge, which divides Octorara creek from Peguea creek; for the lowest depression of this ridge is 587 feet above the ocean, and 290 above the Susquehannah at Harrisburg.

This gap will thus be the summit level of the section of canal from Harrisburg to the Schuylkill, and its tunnel must be kept low enough to receive a sufficient supply of water to allow the level which descends on the one side, to Middletown, and on the other to the Schuylkill, to receive also their supplies; and to avoid more summit levels in this section of the route, these requisite conditions will compel to open two other tunnels on this route; the one east of the first between the heads of the Octorara and Buck run, the other west, through the ridge which divides the little Conestago, from the Big Chickisalengo. The total length of the three tunnels which will probably be required on this section will be about two miles.

These important facts, relative to this section, results from the levels, performed under the direction of the Pennsylvania Commissioners, after concluding the reconnoitering tour, which we made together. We will now examine the results of the surveys, which the advanced

state of the season allowed them to make on the other section of the canal; beginning by the summit level on the ridge of the Alleghany.

A profile of the Alleghany mountain has been taken, running from Selby's mill; the line of section making an angle of 81° 45′ with the meridian. By that means a point was fixed in Blair's Gap Run, a branch of the Beaver-dam, on a level with Selby's mill. The horizontal distance between them, was found to be four miles 698 yards; If a tunnel was run in this direction and on this level, with deep cuts at both extremities, and to the depth of 35 feet, it would have nearly four miles in length, its bed would be 754 feet below the summit of the mountain, 1,831 feet above the ocean, and 1,075 feet above the Ohio at Pittsburg. By raising the level of this tunnel, its length would be diminished, but it would augment the lockage and be supplied with less water. By lowering it, it would have more water and less lockage, but its length would be augmented. Accurate and detailed estimates can alone enable us to compare the expense of a foot of tunnelling with that of a foot of lockage. &c. But for our present object, we will merely state that a tunnel of four miles in length is the shortest which in this part of the Alleghany can unite its eastern and western waters; and that, by lowering it 70 feet, which would diminish its lockage 140 feet, and augment its length about one mile, it is probable that the summit level might be abundantly supplied by the constant flowing springs of its eastern and western streams, formed into reservoirs. We will add that the summit of the Alleghany is, from the preceding data, 2,585 feet high at the spot where the profile was taken.

As to the other sections of the canal, the surveys and levels gave the following results for the total amount of their lengths and lockage:

From Pittsburg to the western extremity of its summit level, tunnel length, - - - -	112	miles, ascent	1,075 feet
Length of summit level tunnel - - -	4	do	
From its eastern extremity to Middletown - -	153	do descent	1,608 do
From Middletown to the Schuylkill - - -	110	do as. & des.	675 do
	379		3,358

We have not examined the line of canal which might lead from Harrisburg to the mouth of the Susquehannah; it did not enter into the plan of those operations which we performed in co-operation with the Pennsylvania Canal Commissioners. From the levels run in 1823, for the state of Maryland, by Capt. Hartman Bache, United States' Topographical Engineer, and Lieuts. Eakin, Graham, and Boyce, of the United States' Artillery, and the surveys directed by Mr. Geddes, a canal, descending from York Haven to Havre-de-Grace, at the mouth of the Susquehannah, would require 272 feet lockage, on 55¾ miles in length. If led to Harrisburg, its total length would be 62 miles, and its lockage 297 feet at most, as Harrisburg is 297 feet above tide water. This line would have over that from Middletown to the Schuylkill, the following advantages: 48 miles less in length to reach tide water; about 378 feet less of lockage; a more plentiful supply of water, and the saving of about two miles of tunnelling. But to these

advantages are opposed the difficulties and obstacles which the ground opposes to the construction of a canal in the valley of the Susquehannah, from Middletown to Havre-de-Grace: surveys, accurate gauging of the waters, and regular estimates, can only afford elements necessary to decide this question.

In any case, overlooking the consideration of expense, in an object so important as that of uniting the waters of the West with the Atlantic, we see that nature, on the route we have just described, has probably given the means or possibility of joining the Ohio to the Ocean. Reservoirs judiciously formed in the heads of the Conemaugh and Juniatta, might secure a sufficient supply of water to the summit level, and a section of the canal, descending the valley of the Susquehannah, from Middletown to Havre-de-Grace, might be substituted to that which runs from Middletown to the Schuylkill, if the latter was found more expensive, insufficiently supplied with water, and longer. The comparison of these two routes, and the examination of the summit level, at the heads of the Conemaugh, are the parts of this work which require to be studied with the most scrupulous exactness, before coming to any conclusion.

DELAWARE AND RARITAN CANAL.

This interesting route was examined by the Board, in co-operation with Messrs. the Hon. G. Holcombe, L. Z. C. Elmer, and Peter Kean, New Jersey Canal Commissioners. A level was run on the ground, in 1816, by Mr. John Randal, jun. under the direction of Messrs John Rutherford, John W. Simpson, and G. Holcombe, then Canal Commissioners of New Jersey. This is the line which we reconnoitred.

Commencing above Lamberton, it directs itself, deviating little from a straight line, to the Raritan, between New Brunswick and Washington. Its length is about 29 miles. Supposing the canal 8 feet deep, and its bottom $60\frac{91}{100}$ feet above the medium of high and low water in the Raritan, and $58\frac{86}{100}$ feet above the medium of high and low water in the Delaware, its line of water would not deviate much from the actual surface of the soil in the greatest part of its length. In some spots, however, embankments would be necessary to raise it; in others, cutting through the undulations of the ground; but the former would seldom exceed from one to 12 feet in length; the others from five to 20 in depth, and would only be required for short distances. Many of them may be avoided in finally locating the route of the canal.

This work will thus run on one level, offering at each extremity a series of locks to descend, on one side, into the Raritan, and on the other into the Delaware. But, before examining its terminations, we should trace the intermediate route between those extreme points.

Crossing, successively, the Assunpick and Millstone, it descends the

valley of Lawrence brook. From the Assunpick to Millstone river, it crosses the ground which divides the waters of the Raritan from those of the Delaware. Although it is lower than the ground between Millstone river and the head of Lawrence brook, at Longbridge farm it joins the valley of that brook and descends it, turning round the foot of Sandyhill, and crossing from its right to its left shore, follows it nearly to the spot, where it is crossed by the road from Washington to New Brunswick.

The terminations of this canal were not yet fixed upon at the period of our co-operation with the Commissioners. If it is to be eight feet deep, and navigable for sea vessels, its eastern termination should join the Raritan, if possible, below the obstructions which, at low water, impede its navigation for ships drawing more than 8 feet: for this purpose it should run eastwardly, and by the most favorable ground, to reach a spot on the right shore of the Raritan, below which it may present, through its whole channel, from eight to nine feet of water at low tide. It will, perhaps, be necessary to depart, in consequence, from the line which we have indicated, south of the head of Lawrence brook, and turn, more eastwardly, towards South river.

As to the termination of the canal in the Delaware, that river is obstructed below Trenton, by shifting banks, which are covered by only 2½ feet at low water. These obstacles extend to Bordentown, and are formed by the deposite of the waters at the meeting of the rising tide and descending course of the Delaware. It is not probable that they can be remedied by any work performed in the bed of the river. This circumstance will compel to descend from the heights of Lamberton into the valley of Conwick's creek, to join the Delaware at Bordentown; and, as this creek presents a bar at its mouth, it will require a dredging machine to keep its channel open. From the point where the canal joins Conwick's creek, to Bordentown, the right side of its valley is perpendicular, and 60 or 70 feet high. Its left shore is a meadow, whose surface is higher than the waters of the Delaware, and is never flooded by the ice which the Delaware drives down in the winter. The canal might be run along this prairie, during this part of its course; and the widening of the creek at its mouth, would afford, in every season, a safe harbor for the boats and vessels navigating the canal. As to the nature of the soil, it consists, generally, of a mixture of light sand and stony gravel, and will compel, not only to give a great slope to the sides of the canal, but to puddle both them and the bottom, in order to diminish its leakage and filtration, especially where the line of the canal will require it to be raised above the natural soil. Independently of the water required for its lockage, on a route so frequented as that between the Delaware and Raritan, this soil will also render a large supply necessary, to provide for losses from filtration and evaporation.

The heads of the Assunpick, Millstone, and Lawrence brooks, will certainly furnish a great deal, amounting, from the measurement taken in 1816, by Mr. M. J. Randal, jr. to 8,234,444 cubic yards a

month; but it is not stated if they were taken at the lowest stage of those streams. If so, this quantity would be sufficient for a canal 60 feet wide at its upper surface, 30 at bottom, and 8 feet deep, on 30 or 40 miles of length. But, to ascertain, so as to leave no doubt on the subject, the exact quantity which those streams can supply, is an indispensable preliminary operation to decide whether it will not be necessary to have recourse to the waters of the Delaware in order to feed the canal—and supposing it was not found necessary, we should still compare, *on the other side*, the expense of purchasing the mill sites of these rivers, and the loss which their suppression would occasion; and, *on the other side*, the cost of a navigable feeder descending from the Delaware, balanced with the advantages which it would add to the revenue of the canal.

If this feeder began at the rapids of the Delaware, above Tumbling dam, that river might supply the canal with all the water which it required. This spot is 90 feet above the level of the stream at Trenton from Judge Gordon's levels, and 28 or 29 feet above the line of water of the canal; the localities are favorable for the construction of a wing dam, and the navigable feeder would run for 25 or 30 miles in length, through a ground which would oppose no serious obstacle to its course. Supposing the canal terminated in the valley of Conwick's creek, this feeder might supply a branch, opening a communication between Trenton and the canal. It is needless to add, that, as it would enter the canal at its western extremity, it would be necessary to give to the bottom of that canal a slope from west to east, sufficient to make its waters flow freely at the end opposite to that which receives the feeder.

As to the dimensions of the canal, we have supposed that its depth would be at least 8 feet and that it should be navigable for bay vessels—otherwise, the noble line of interior navigation running parallel to the coast, and which is contemplated from Georgia to Massachusetts, would here be interrupted. In a national point of view, it is therefore very desirable, that the Delaware and Raritan Canal, which, besides, communicates between two such cities as New York and Philadelphia, should receive the same profile adopted for the Chesapeake and Delaware Canal, by the high spirited gentleman engaged now in that great work (1.)

BARNSTABLE AND HYANNIS HARBOR CANAL.

The northern termination of this canal opens in Barnstable harbor, and its southern termination in Hyannis harbor. Its object is to provide a passage through the isthmus of Cape Cod, in order that the coasting trade may avoid doubling that cape.

(1.) This canal will be 60 feet wide at the water's line, 36 at the bottom, 8 feet deep, 14 miles long, and is lined with stone.

The two issues of this canal are the only favorable points about it; the intermediate ground is entirely unfit for such a work. The harbor of Barnstable is well sheltered: its channel near the entry of the port, is intercepted by a bar, which has at the ebb of the tide, but five or six feet water; but in the interior of the port it offers an excellent anchorage. The tide rises here about ten feet. Hyannis' harbor is an open road, with two or three fathoms of water at low tides, but has an anchorage where vessels can be secured against any wind. In winter it is easily disencumbered from ice.

The line of canal which should join these two ports, would be only five or six miles long, but there is no valley in that space to receive it, and it should be one deep cut from one end to the other. The lowest part of the ridge which it should cross, is at sight 80 feet at least above low tide. It is true, that between the hills which form this ridge, lie a chain of ponds in the direction which the canal should follow; which might suggest the idea of uniting them by deep cuts, and making them a part of the canal. But they would not give the water required for its navigation; they appear to be filled by rains and snows rather than by springs; and what confirms this hypothesis, is, that a cut having been made from one of them, to establish a mill at this artificial outlet, its surface immediately sunk to the level of its bottom, and never rose since. And, as besides, each of them only receives the waters of a small surface of gound, they cannot be considered as reservoirs sufficient for the object in view; the highest of them could never feed a summit level.

From these motives, and from the evident inferiority of this line to a more western one, which we are going to describe, we are of opinion that it ought to be given up.

BUZZARD'S BAY AND BARNSTABLE CANAL.

A canal to communicate between Buzzard's and Barnstable Bay, should follow successively from W. to E. the valleys of Monument and Scusset rivers. That route was surveyed in 1818, by Mr. L. Baldwin, at the individual expense of Messrs. Israel Thorndyke, Thomas Perkins, and other gentlemen of Boston. Its total length is about eight miles. (See map No. 19.)

At its western extremity, the tide rises in Buzzard's bay, from five feet to five feet three inches. At its eastern extremity, it rises in Barnstable bay, from ten feet to ten feet four inches, and three hours and a half later than in the other. Thus the medium of tide water in Barnstable bay, is probably about on a level with high tide water in Buzzard's bay; the level of low water in the latter, was, on the 11th of September, 1818, $8\frac{6}{10}$ inches higher than in Barnstable bay.

As the tide ascends three or four miles in Monument river, and about two miles in Scusset river, this route extends only two or three miles from the head of one tide to the head of the other. The highest

point of the intervening ground is 33½ feet above low water in Barnstable bay, and 23½ above high tide. Thus nature has left little to do to unite the two bays. We shall trace, in a general manner, the route which the canal might follow.

Departing from Back river harbor at the mouth of Back river, in Buzzard's bay, it might run through the most favorable ground to Monument river, and enter its valley about three-quarters of a mile above its mouth. Then following that valley to the mouth of Herring pond brook, it might cross the ground which divides the heads of the Monument from those of the Scusset, to descend the valley of the latter to Swift's mill. From thence it might either follow the left shore of the Scusset river, and enter Barnstable bay by prolonging, in a northern direction, the foot of a bank which lies to the west of the Salt marshes, through which the Scusset winds, before it falls into the bay. Or it might follow the right shore of the Scusset river and cross the Plymouth neck at its lowest point, and, turning to the east, round it, enter the Bay in a N. N. E. direction. This second route would be shortest, but the other would be susceptible of better defence in time of war; be more protected at its south against the N. W. winds, and lead to a part of the bay of a more convenient and adequate depth for shipping.

The ground, through which runs this route, offers, on its surface, a sandy soil, embedding rocks, loose stones, and gravel; it is probable that, in digging it to the depth required for the bottom of the canal, we would meet with no great difficulties, but this point can only be decided with certainty by sinking shafts in it.

As to the harbors where the canal would end in both bays, its western extremities would join Back river harbor. Sea vessels, drawing no more than eight feet can enter this port. Crossing, at low tide, between Bird's island and Wing's neck, they might run to the east of this neck into a channel from 20 to 22 feet deep, then, directing themselves upon Back river, they would pass a shoal which offers above eight feet water, and as they approach Back river, deepens from 13 to 20 feet. Back river harbor might be easily defended in time of war, by batteries raised in Hog's and Marshner's islands, which are near enough for this purpose, to one another and to the main. At low water the pass between Hog's island and the main, is three fathoms deep; that between Hog's and Marshner's islands is fordable, and that between Marshner's island and the main, has about eight fathoms in depth. These islands form, with the main, a road exposed to the N. W. winds, as the coast to its west is too low and distant to shelter it. Besides the outer harbor of Back river, an inner harbor might easily be formed in the river itself, in laying out and constructing the works of the canal.

At the eastern extremity of the canal, the harbor of Barnstable bay offers three fathoms of water at a short distance from the shore. The bank to its west, of which we have spoken above, shields it from N. W. winds, but it remains much exposed to those from the north to east round by the west; for the isthmus of Cape Cod is too low and

distant to shelter it. A jetee would be required to fulfil this object, and the materials to erect it, would be found on the shore itself. An inner harbor could easily be dug in the salt marshes through which the canal runs before its termination.

We have only now to determine whether this canal should be built with a summit and inferior levels, or be all constructed on one level, and fed by the tide.

The only stream which could feed its summit level, would be the outlet of Herring pond, 32 feet above high tide in Buzzard's bay. It yielded, on the 30th of October, 1824, 9½ cubic feet per second, and it had rained during the preceding days. This quantity would not suffice even for one half of the minimum of its lockage if the locks admit sea vessels. Of course we have no choice. The canal must extend on one level from one bay to the other, be fed by the tide of Barnstable bay, and provided with a tide-lock and port at each of its extremities. Its bottom will be at least 8½ feet below the neap tides or 9½ below the common tides in this bay. It is needless to add, that its dimensions should be adapted to sea vessels.

This short analysis proves that the practicability of the Buzzard's bay and Barnstable canal does not admit of a doubt, and that its construction will meet with no serious obstacle. The expense will not be great, if we compare it with that of the Delaware and Chesapeake canal, which extends fourteen miles in length, and requires a deep cut of three miles, through a ridge which rises 84 feet above tide water, and 76 feet above its summit level. The maximum cost of this last canal has been valued at $1,354,364.

The Board have not examined the navigable character of Buzzard's bay, as the season was too advanced to perform this task in a satisfactory manner. The following information has, however, been procured with respect to it.

The Northwest winds, which reign chiefly during the winter and autumn, are favorable to ascend the bay, as well as the Southwest winds, which reign chiefly during the summer. Its shores offer several anchorages; and the rocks which are found amongst them, may be marked, in order that the coasters may avoid them. They may pilot themselves into the bay. It is not affected by fogs more than the Vineyard sound. In its lower parts the tide rises 2½ knots in an hour—on the shoals, 4 knots. In the winter, the ice formed on the northern shore, when thawed by the southwest winds, is driven to the opposite shore, when the northwest blows. In consequence, this bay is therefore longer obstructed by floating ice than the Vineyard sound.

As to the canal itself, it would freeze during 2½ months, at most, and six weeks, at least; but this inconvenience is in some measure diminished, as the port of Boston is frequently inaccessible during two or three weeks in the winter from the same cause.

Buzzard's and Barnstable canal is the eastern link of the great line of internal communication along our Atlantic frontier, which is destined to connect all its ports from Georgia to Massachusetts.

But it cannot be denied, that, in time of war, the passage from Long Island Sound to Buzzard's Bay, is much exposed to be annoyed, or even totally intercepted, by cruisers stationed in the anchorage of Gardiner's Bay. This section of our maritime frontier will thus require, at such a period, a constant naval force for its protection. A naval force will also be required in Barnstable Bay, to secure the communication between the mouth of the canal and Boston Bay.

TAUNTON AND WEYMOUTH CANAL.

This canal will open to the south in Mt. Hope Bay, a branch of Narragansett Bay; and to the north in Boston Bay. Beginning at Weymouth landing, its route would meet the Taunton at Williams' landing place, passing through the township of Abington, Bridgewater, and Raynham. Its total length will be 26 miles, and its summit ground, at Howard's meadow, in Bridgewater town, is 132 feet 10 inches above the highest tides.

This route was explored and surveyed by a committee appointed in March, 1806, by a resolution of the Legislature of Massachusetts, consisting of Messrs. Williams, Taylor, and Eliphalet. The Board received also, on the ground itself, exact documents on the contemplated canal, from Mr. Minot Thayer.

Weymouth Great pond, in Weymouth town, and Cranberry pond, (in Braintree) are considered as reservoirs, destined to feed the summit level of this canal. Weymouth Great pond has an area of 507 $\frac{1}{10}$ acres; its depth varies from 10 to 18 feet; its surface is 147 feet 5 inches above high tides, and 14 feet 7 inches above the summit level. Cranberry pond is 160 feet 9 inches above tide water, 27 feet 11 inches above the summit level, and 13 feet 4 inches above Weymouth Great pond.

The outlet of the former gave, on the 5th of November, 1824, 2 $\frac{2}{3}$ cubic feet per second, and Cranberry pond gave 1 $\frac{1}{2}$ feet—total 3 $\frac{5}{6}$ cubic feet per second. These two ponds cannot, between them, feed a summit level. Of course, its line of water cannot be raised to the level of the lowest, and it will be necessary to drop it sufficiently to receive some other supplies of water.

Braintree town offers two other ponds on a lower level. They are called Great and Little pond. The former has an area of about 500 acres; its surface is 109 feet 5 inches above tide water, and thus, 23 feet 5 inches below the summit ground. It gave, on the 1st of November, 25 $\frac{1}{3}$ cubic feet. This quantity, added to 3 $\frac{5}{6}$ cubic feet, would amount to 29 $\frac{1}{6}$ cubic feet, and prove barely sufficient for the expense of lockage, which a canal of ordinary dimensions would require, leaving no supply to repair its losses from filtration and evaporation. In the winter, the water of the ponds might indeed be preserved and accumulated by dams, and provide a supply for the open-

ing of navigation. But further investigation can alone decide to what height they might be raised above their actual level, and thus ascertain whether the canal is practicable. The importance of such a work, and particularly of this route, deserves the expense of such researches.

Another pond lies partly in Bridgewater, partly in Raynham town; it is the largest of all those which are found in this route. Its area is valued at about 1000 acres, and its surface is 49 feet 1 inch above tide water. It is thus, 83 feet 9 inches below the summit ground. To drop the level of the line of water on this summit, to a level with the pond, a deep cut of 7 or 8 miles would perhaps be required. Elias pond, as well as those of Furnace and Forge, cannot, therefore, supply the summit level, but may be made use of for feeding the lower levels of the canal.

The depth is 12 feet at Weymouth landing, in high tides, and 4 feet in low tides; the canal should open at a sufficient distance below this place, to reach a depth, which, at low water, may equal its own. By sea, the distance between Weymouth and Boston, is only 12 miles. As to its termination in the Taunton, that river is navigable at high water to one mile above Taunton; but at low water it ceases to be navigable 6 miles below the town. At Taunton the tide rises 8 feet, and the river has there from 6 to 7 feet in depth. The termination of the canal must be directed in consequence, and a tide lock provided at each of its extremities.

As in following this route, the streams which we meet have all a general direction to the east; another route more to the eastward has been surveyed and levelled by commissioners above mentioned. It begins at Weymouth back landing, and directs itself on Titicut bridge, on the principal branch of the Taunton. Its length would be only $23\frac{1}{4}$ miles to the spot where it would begin, to descend the valley of the Taunton. Its summit ground at Curtis' meadow is 131 feet 10 inches above tide water. Weymouth Great pond and Cranberry pond might supply this summit level with their waters; the former is only $8\frac{1}{2}$ miles distant from it. These other ponds might also feed the canal along this route: Whitman's pond, in Weymouth town, three-fourths of a mile from Back river landing; it's surface is 54 feet 10 inches above tide water. Barret's mill pond, to the north of the summit ground; its surface is ninety feet two inches above tide water.—Nark's mill pond, to the north of the summit ground; its surface is eighty-two feet five inches above tide water. By a deep cut of forty-nine feet five inches, independent of the inclination of the feeders, and depth of the canal, all these ponds, except Whitman's pond, might convey their waters to the summit level. We should add that in Middleborough, there are three ponds which communicate together, and whose waters may be led to the north in the chief branch of the Taunton; these are Assumset, Long Pond, and Kinticuts.

Exact surveys can alone decide which of these routes affords the most favorable ground; but as to the practicability of either, it rests entirely on the sufficiency of their supply of water, and on the elevation which might be given to them, so as not to require too considerable

deep cut. The exact gauging of the waters, supplied by several ponds at their lowest stage, a survey of their area, and an investigation into the causes which form and feed them, can alone direct us to come to an accurate conclusion on the practicability of the canal.

If this communication is found practicable, it will procure great advantages. It will shorten, by two or three days, the navigation from New York to Boston; and, when the N. W. winds are reigning, will give a great advantage to vessels which may run into Narragansett Bay, rather than Buzzard's Bay: for, on issuing from the eastern termination of the canal projected from the latter Bay to Barnstable Harbor, they could not reach Boston by a N. W. wind. In winter Narragansett Bay does not offer the same difficulties from floating ice as Buzzard's Bay, and its navigation is shorter and safer. In time of war, vessels will be better protected upon this route, and the canal itself better covered against any attack. If, to these considerations, we add the great advantage of a prompt and easy communication between two such harbors as Boston and Narragansett Bay, and of securing, in time of war, the safe and prompt arrival of naval supplies from the southern states to the naval depot of Boston; we will readily conclude that a work so important and useful as the canal from Taunton to Weymouth, deserves that every care and attention should be bestowed in investigating to what degree it is practicable.

Such are the general views and particular details, already ascertained, on the several lines of canals which the Board have explored and examined during the last season. These details may, perhaps, be found, on many points, too minute; but we have deemed them all essential to the object to which they relate. The result of such researches, whether they prove important or otherwise, should, besides, be recorded, to avoid, hereafter, a repetition of the expense which the nation has incurred to procure them.

As to the general results obtained by this expedition, they are as favorable as possible to the great object in contemplation; opening a system of communication to unite all the sections of the Republic by the bonds of commercial intercourse, and rapid mutual aid in time of danger. This system will contribute essentially to the great end of rendering the means of our Government more efficient; for, by reducing the time necessary for communication, it will reduce, in fact, the great distances which divide the sections of our vast empire from each other, and will enable us easily and promptly to transfer the means and produce of one climate to another; it will give a new value to the agricultural and mineral riches of our soil, and a new life and activity to our manufacturing industry, by facilitating their circulation. Without a free and constant circulation, the political, as well as the human body becomes paralyzed and benumbed in its operations.

The results, at the present stage of the operations, are as follow:

1st. A canal from the Potomac to the Ohio, and one from the Ohio to Lake Erie, are perfectly practicable; the difficulties to be encountered in their executions, are, in no respect, greater than those which have been overcome before now in works of the same nature.

2d. A continued line of interior navigation from Chesapeake Bay to Barnstable Bay, Mass. may be opened or rather completed at a reasonable expense for coasting vessels. One branch of it, the Delaware and Chesapeake Canal, is now constructing. The Delaware and Raritan Canal may, at a moderate expense, be built on the same dimensions, (for coasting vessels.) The Buzzard's Bay and Barnstable Canal, at no great expense, may receive a still greater depth of water than the former.

3d. A canal joining Narragansett Bay and Boston Bay, would make a part of this line, and procure great advantages to the interior trade and national defence of the Union, if subsequent surveys demonstrate its practicability. But the canal across the isthmus of Cape Cod, from Hyannis Harbor to Barnstable Bay, from the great expense which its construction would require to procure a sufficiency of water to feed it, is impracticable; and its vicinity to the proposed canal between Barnstable Bay and Buzzard's Bay, renders it an object of less importance.

4th. Lastly, it is probable that a communication may be opened between the Ocean and Ohio, through the Conemaugh and Juniatta.

We should not conclude this report without paying to the gentlemen who have assisted the Board during their labors, the just tribute which we owe to their zeal and talents. Captain Poussin, of the United States' topographical engineers, has continued those efficient and scientific services which rendered him so useful as an assistant in the planning of our system of fortifications for the defence of our frontiers. In this circumstance he has shown himself equally fitted for military and civil engineering.

Lieuts. Courtnay and Dutton, of the military engineer corps, and distinguished pupils of our Military Academy, have shown, by their acquirements, how highly beneficial that institution will become to diffuse through our country that theory of mathematics so useful in civil engineering.

Mr. Wm. Howard, United States' assistant civil engineer, has reconnoitered, along with the Board, the line of the canal from the Potomac to Lake Erie. His advice and services were highly important, and principally in the investigation relative to the summit level of the Ohio and Chesapeake Canal: conversant with every branch of science, he was of great help in our operations.

Major Douglass, Professor of Engineering at the Military Academy, West Point, attended the operations of the Board, whilst they were reconnoitring the route of the Ohio and Erie Canal.

S. BERNARD, *Brig. Gen.*
JOS. G. TOTTEN, *Maj. Eng.*
Brevet Lt. Col.

Washington City, February 2, 1825.

B.

ILLUSTRATION

OF THE

Report of the Board of Internal Improvement.

By J. L. SULLIVAN, *Member, &c. &c.*

On the reconnoissance from the Potomac to the Ohio.

On the reconnoissance from the Ohio to Lake Erie.

On the co-operative reconnoissance through Pennsylvania.

Analysis of the reconnoissance in Massachusetts.

The reconnoissance in Massachusetts.

Washington, February 3, 1825.,

Analysis of the First Part.

Preliminary remarks.
Division of sections.
Potomac section.
Summit section.
Mountain ground, objects of surveys.
Valley of the Youghiogeny described.
Monongahela, Cheat Run, Sandy Creek.
Intermediate route.
Results of lines of level.
Measurement of water.
Comparison of lines and tunnels.
Expense of water.
Calculations applying experience.
Evaporation.
Reservoirs.
Feeders.
Dams.
Shortest line considered.
Shortest tunnel line considered.
A tunnel the gauge of a canal's power.
Consideration on the descent from the summit.
Reservoirs for the western section.
Preferable route, probable.
Conclusion and view of general and state canal policy.

Illustration of the report of the Board of Internal Improvement: by J. L. Sullivan.

To Major General ALEXANDER MACOMB,
Chief Engineer, Department of War.

SIR: The Board of Internal Improvement, in their letter, at this time, report on the *practicability* of communications by canal between the tide waters of the Potomac and the head of steam boat navigation on the Ohio; between the Ohio and Lake Erie; between the Ohio and the Schuylkill; between the Delaware and the Rariton; between Buzzard's and Barnstable Bays; and between Narragansett bay and Boston harbor, and intimate their intention to submit their respective views of the means of accomplishing those objects. I have the honor to submit, therefore, the following illustrations of the practicability of these works.

1st. To elucidate and explain the grounds of the opinion which, as a member of the Board, I have expressed, that *it is practicable* to make a canal communication between the tide waters of the Potomac and the Ohio, it will be necessary to have recourse to a few facts founded on the experience of other countries, and in climates most like our own, and to apply the discoveries of experimental philosophy in Europe to a scene of operation under somewhat different circumstances, yet, in this incipient stage of the investigation, in a degree hypothetically.

A canal may be primarily practicable in difficult ground, yet not effectual to its object. It may be constructed in the usual manner, without securing the convenience of a continuity of passage. And as a canal fails of its purpose, unless it affords an expeditious, sure, and cheap route, whatever its elevation of ground, or its length of way, the question is not only whether the work can be done, but whether, in operation, it will be such as the country requires for its accommodation. Our country generally, and, in particular, this elevated part of it, demands a style of civil engineering adapted to the climate and the extraordinary roughness of the ground—a bolder method than has heretofore been usual in the more level communications of Europe, where the surrounding ocean, or the melting Alps, afford a more regular supply of water. Indeed, the prevailing character of the American people, remarkable for activity and energy in travel and business, demands correspondent plans in our canal communications. A glance over the whole ground at this time, in anticipation of the period when the whole plan would have naturally come forward in a mature

report on the line of location, together with an estimate of expense, may yet be made, under existing circumstances, without impropriety.

The whole line naturally divides itself into two sections:

The first extends from the tide to the foot of the Alleghany, where the Savage, a branch of the Potomac, breaks through the Great Back Bone, as this mountain is called to distinguish it from another range more west. This section is computed to be 210 miles.

The second section extends from the mouth of Savage to the mouth of Bear creek, a distance, varying according to the line which may be finally adopted, of from 34 to 62 miles.

The third section extends from the mouth of Bear creek to the city of Pittsburg, 326 to 350 miles, according to the line which may be found most suitable.

The canal between the Ohio and the Lake naturally divides into two sections—the southern and northern—the first about 70, the latter about 30 miles.

The most remarkable features of the eastern or first section may be thus briefly described:

The Potomac passes through the Blue Ridge, near Harper's Ferry, at an elevation of about two hundred feet above tide. This height gives a command of the ground eastward, and may enable the engineer to choose the ground most convenient to pass the *whole* of the Great Falls.

Immediately below the junction of the Shenandoah, which is above the Blue Ridge, the river is contracted by the hills, which will confine the works to a narrow compass. Ledges in the stream transverse to its course, appear well situated to support a dam necessary to form a basin, at once to accommodate the village with a good landing, the trade of the Shenandoah with access to the canal, and for the purpose of supplying water to the eastern levels; but no place on this level presents more complicated circumstances, or requires more to be studied.

The valley of the Potomac, as we ascend it to Cumberland, exhibits favorable ground—generally extensive intervales and gentle acclivities, with few exceptions of abrupt hills. A few aqueducts will be required, and above Cumberland they must be frequent; for 28 miles, it will be often a question of expediency and calculation, whether to cross or recross, or rather carry the canal some distance through rock. It is not, however, improbable that a modern improvement in aqueducts will diminish their expense, so as to make that method less objectionable.

The Potomac, in June, was found to deliver 220 cubic feet per second above Savage, and the Savage 76 cubic feet; on the 17th of September, $100\frac{537}{1000}$, and the Savage 35.613. The survey executed as far down as Cumberland, has ascertained the descent to that place to be 327 feet 6 inches, the distance 28 miles.

The *second* or *summit* section follows up the Savage through the Alleghany mountain, and at the distance of five and a half miles, reaches the Crabtree branch, coming in from the southwest. Thus far, although the hills rise high and steep, there are narrow bottoms

along the stream, on one side or the other, wide enough for a canal; but on ascending the Crabtree, whether it be one mile to Middle Fork, or up to Swan's old mill, seven and a half miles, such is the steepness of the shores and the height of the hills, that it is believed the canal must occupy the bed of the stream.

From Swan's mill we ascend the Dividing Ridge or Little Back Bone mountain gradually a mile, when the descent is very gentle to the glades of Deep Creek. These glades the most favorable ground for the summit level of the canal, are enclosed by hills of moderate elevation, and the creek passes westward through Hoop-pole Ridge *narrows*, when it falls a few feet, passing on the right, *previously*, North Glade—subsequently Meadow mountain Glade, then Cherry hill high glade run, and then Buffaloe valley. Its course then continues westward through wet ground for six miles, to the head of the *rapids*, which in a mile terminates at the Youghiogeny River, having Bear Point on the left, and Panther Point on the right, which there will be occasion again to mention.

The junction of the creek with the river is at the foot of the Great Falls. Tracing up its course, we reach, at the distance of nine miles, the Little Youghiogeny coming in from the east, having its source in the Dividing Ridge; but the river being traced further southward, is found to divide into the Cherry tree branch, Snowy branch, and Duncard Lick. Retracing our steps, Pearl Run comes in from the west, in the Great Falls not far above, and opposite to Deep Creek. The river continuing its course northward, passes through Winding Ridge mountain, and, at the distance of fifteen miles, reaches the mouth of Bear Creek, the western end of the second section. Ascending Bear Creek Middle Branch in about a southeastern course, we come over a low ridge of ground to Buffaloe valley, before mentioned, which leads directly, or nearly so, to Deep Creek bridge, two and a half miles below the narrows.

This general view of the topography of the mountain section, explains the occasion and the object of the lines of level, which were run by the brigades attached to the Board for these operations, as well as to make an accurate and skilful delineation of the ground, to enable the government at once to see the relative situation of the places named in the reports.

On making this part of the reconnoissance, it was perceived that if a line up the *Meadow Mountain Valley* should be found practicable and preferable, it would permit of excavation above the usual surface of Deep creek, free from the incumbrance of much water, and, finally, when done, allow of filling the summit level by means of a dam on the creek near the rapids, empounding a large body of water, to convert the summit into a reservoir; arranging the gates of the locks so as to permit of some variation of the surface. The base line thus fixed, a *central* point, to which all distances should refer, was also established at the bridge.

The survey of the eastern section of the summit ground was assigned to Capt. M'Neill's brigade and the western section to Capt. Shriver's and the civil surveyors of his party.

The instructions from the Board to them were definitively directed to the determination of points of immediate and primary consequence, viz: The comparative elevation of the streams and intermediate grounds. Consequently, the elevation of the dams necessary on the Youghiogeny, to raise the water high enough to be led into the Deep creek summit. By what line it would be preferable to descend towards the west. By what line to pass with most convenience through the Dividing Ridge. The length of tunnel required on each line. The command of water, both in its natural flow, and capable of being held in reserve against the dry season of the year.

While preparations were making for these investigations, the Board continued the reconnoisance of the country throughout the western section.

Following the course of the Youghiogeny it was found to flow always rapidly between bottom lands and high hills, till within eight or ten miles of Ohiopyle falls, when the bottom lands discontinue, and the shores become rocky and steep. We crossed the Laurel mountain, and returning to the river at Connelsville, ascended the ravine to view the places considered by the inhabitants the most rapid and narrow. This mountain passage of the stream was by them computed to be *eighteen* miles through. Below Laurel mountain the valley exhibits more easy ground; and the river winds its way among extensive meadows and comparatively gentle hills for forty miles, to its junction with the Monongahela, whence the ground is favorable along the right bank to Pittsburg,

We next ascended along the fertile shores of the Monongahela to Geneva, where George's creek comes in from the southeast, perhaps the means, one day, of connecting this productive district with the canal.

The immediate object of this part of our reconnoissance was to view the south ravine of Laurel mountain, through which Cheat river flows, and then to ascend the high ground between it and the Youghiogney, to examine Pine swamp, the source of Pearl Run, which had been conjectured to be low enough to allow of a canal route in this direction, but it was ascertained to be 222 feet above Deep creek. It is, however, found that Pearl Run may be made to flow a large extent of ground in Pine swamp.

Having, in our way, made some observations on the southern part of *Big Sandy Creek*, which joins Cheat river just above the ravine, we directed our course to the inspection of those branches which occupy the space between the Laurel ridge and Youghiogeny river; and so far as the ground was seen, the aspect of the country was not unfavorable. But whether it would be accessible to a line of canal commencing at the Forks of Bear creek, led along the slope of the eastern side of the Youghiogeny 'till opposite Selby Port, crossing the river to gain Coddington's valley, at a sufficient elevation to be carried into the Valley of the northeast branch of Sandy creek, and by the line which may be found preferable, reach the eastern base of the Laurel range, to pass it by a tunnel, and emerge not far from the village of Monroe, in the county of Fayette, is not yet ascertained.

This line is a part of the unexecuted instructions of the Board. Elevated aqueducts and long tunnels, are now of so common occurrence in modern canalling as to be no material obstacle, especially since the application of the steam engine. But lines or routes of canals are compared, not only in point of expense, but of ultimate practical economy, command of water, preservation of the works, accommodation to the inhabitants of the adjacent country, &c. In this instance, however reluctantly a majority of the Board consented to the investigation of this line, from its forbidding aspect, which it is but justice to them to remark; yet the reasons for it appear to me sufficient, when recollecting that on Erie Canal, from Little Falls twelve miles down along the Mohawk, four times as much water is consumed, as the middle section uses per mile per minute; and knowing how difficult it is to make a canal tight, which is sustained along the rough shore of a river high enough to be out of reach of freshets. Nor is it any easy thing to supply from a river having the characteristics of a torrent, by means of dams; and considering too the length of the ravine, there seemed to be reason for a comparison of a line which might possibly result in an escape from any serious difficulty. The boldness of the plan of crossing the Youghiogeny at the elevation of perhaps one hundred feet, to gain the valley of Sandy Creek, may be readily countenanced by the experience of England in like cases. The writer of these pages stood on the Aqueduct Pontcysylte, over the river Dee, in North Wales, (130 feet high) while building, and a year afterwards saw it in full operation. Its arches and trunk are of cast iron. *(See plate* 415, *New Edinburg Ency.)* The place of the tunnel in this instance will demand, no doubt, the best judgment. In the want of a preference of this line, the canal would descend from about one-third the western elevation of the Laurel, and regain the valley of the Youghiogeny not far from Connelsville. The distance is computed, from Bear creek to the mountain, 14 miles; and the saving in the length of the western section about twenty miles. And it is presumed the saving of expense will not be inconsiderable.—There are three great points to be kept in view in deciding upon the line of the western section: *directness*, *management*, as well as command of water, cost of the work, and uninterrupted operation.

While the Board were fulfilling the orders of the Hon. Secretary of War, in examining the country between the Ohio and the Lake, their instructions had been so far executed on the summit ground, as to determine some of the most material points. I return, therefore, to the inquiry depending thereon.

It was found that the Youghiogheny, at a certain ledge above the great falls designated by the Board, is below the base line 74.50 ft.

The fork of the Little Youghiogheny - - -	57.
The mouth of Snowy creek - - - - -	40.69
The fork of Cherry Tree creek - - - -	30.18
Armstrong's, on Little Youghiogheny - - -	46.
The mouth of Nest Lick run, on the Little Youghiogheny	16.28

A point four miles above Armstrong's, on the Nest Lick, and four-fifths of a mile above this last place, level with Deep Creek.

The *measurement* of the *water* was made after three or four weeks of dry weather, and computed according to methods established by the philosophical experiments of Du Berat, confirmed by those of Dr. Robinson, professor of natural philosophy in the University of Edinburg, detailed and discussed in his work on mechanical philosophy. And the correctness of them was ingeniously tested by a method of mechanical measurement, contrived by Mr. Shriver, and the gentlemen of his brigade to prove his calculations. It resulted, from the mean of all these operations, that Deep Creek at that period delivered, per second, $5\frac{540}{1000}$ cubic feet; and Buffalo Run, coming in below the bridge, $1.703 = 7.247$; and, corroborative of it, Captain McNeill measured the same in his section, and found 5.402 feet.

All the head waters of the Youghiogheny were, at this period, also measured.

The Little Youghiogheny was found to discharge	12.036
The Main Youghiogheny - - - - -	13.126
Cherry Tree fork - - - - - -	4.300
Snowy creek - - - - - . -	11.476
Feet	41.038

The developement of these facts, suggested the expediency of trying a *lower line* for the summit level, and a survey was directed to be made up the valley of the *Little* Youghiogheny, to investigate the practicability of a communication with the *Crabtree*. This line of level was run *twenty-four feet* below Deep creek, and was found to strike the ground seven and a half miles above Armstrong's, near the mouth of Block Run, and that a tunnel of nearly four miles would effect a communication with Crabby's arm, a branch of the Crabtree.

The several lines ascertained by the surveys have their peculiar advantages and disadvantages. It is necessary briefly to describe and enumerate them, in order to explain the reasons of preference, and to account for the manner of applying the principles upon which practicability depends.

These lines may be all considered as starting westward from the *mouth of Crabtree Creek*, because, thus far, the successive levels must depend on the same source of supply. From that point down we have the waters of the Savage.

Line.		Distance. m. yds.	Summit. m. yds.
1st.	By Savage River, Monroe Run, Meadow Mountain Valley, to Deep Creek bridge,	15.255	5.0833
2d.	By Crabtree, Middle Fork, west branch Meadow Mountain,	15.0035	3.1333
3d.	" North Glade, - - - -	15.0248	3.0125

4th.	" East, - - - - -	15.0436	3.0083
5th.	" Rock Camp, north fork Deep Creek, -	13.1522	4.0000
6th.	" Savage Lick Run, - - -	15.1315	2.1083
7th.	" Hink's Arm, - - - -	16.0272	1.1116
8th.	" Dry Arm, - - - -	16.0488	1.0916
9th.	" Dewickman's Arm, - - -	16.0735	1.0683
10th.	" Wilson's Fork, Little Youghiogheny,	36.0732	4.0300
11th.	" Crabby's Arm, - - -	36.0894	3.1538

The several lines thus converging to a point excepting the two last, which are, however, brought to a parallel position and equidistant, nearly from their object, *the mouth of Bear Creek*, the continuation of them, in comparison, may be thus pursued:

The 10th and 11th have *two alternatives*. 1st. To cross Deep Creek over the falls by an aqueduct to Panther Point, then turn that point in high rocky excavation, and descend 150 feet to the river shore, near Hoy's Run, and continue down along the Ginsing Bottoms to the ravine of *Winding Ridge*, pass through it five miles, and in about fifteen miles from the point, reach Bear Creek. Or, 2dly, ascend along Deep Creek, cross it at the rapid by an aqueduct, pass through Panther Ridge by a tunnel of half a mile; then, either cross Hoy's Valley by an embankment and aqueduct, or turn it by a circuitous line, and gaining the west branch of Bear, descend to the mouth of the creek, about 24 miles. These distances added to the former, make by one route, 51½ miles.

By the other, 60¼ miles.

The Glade lines having converged to the *centre at the bridge*, the comparison may next be made between that which has the *shortest tunnel* and that which has the *least distance*: these are the 2d and the 9th.

The second line has to the centre point the length of, miles 15.0085 yards. If we continue the line up *Buffalo Valley* till the digging becomes 35 feet deep to a tunnel, not exceeding two miles, under a ridge of 170 feet, the distance is, miles 14.0000, which, added to the preceding, is miles 29.0035 yards. Or, if we take the length of the 9th line, with the shortest tunnel, it is 30 miles 732 yards.

This would evidently be the lesat expensive route, through at a higher level; and the question of supply of water comes next in order.

Canals in England being in a very different climate, do not, in regard to water, afford data on which fully to rely. Our own experience is not conclusive, since the Santee has required to be deepened, and Middlesex was not made originally with that precaution which might have allowed it to be a guide in this estimate, nor has Erie Canal been long enough in operation to exhibit the minimum of its consumption of water by filtration. The canals of France, whose climate most resembles that of the middle states, differ greatly from

each other. But to take the mean of these and the best section of Erie together, is perhaps a near approximation to the truth, viz:

	wide,	deep,		cubic ft.	lockage,	evaporation filtration.
The canal de Briare, (6 miles,)	40 ft.	4 ft.	sect. 128 uses	62.60	5.80	56.80
The canal of Languedoc, (69 miles,)	64 ft.	7½	sect. 375 "	35.90	17.00	18 90
The canal du Centre, (69 miles,)	47 ft.	5¼	sect. 215 "	55.60	9.74	45.86
The canal of St. Quintin, (32 miles,)	54 ft.	5⅓	sect. 232 "	70.70	10.52	60.58
The Erie canal (141 miles,)	40 ft.	4	sect. 136 "	121.00	6.16	114.84
				414		348.78

The whole expense of water per mile per minute, 69
The whole expense of water for evaporation and filtration per miuute, 58.13

The above is for the *summit* levels, and the estimate of lockage is assumed proportionately for all, from the average of Languedoc, for six years, which was found to be 1920 boats a year. If, therefore, the locks on this canal are 100 feet by 20 feet, and 8 feet deep,

$$16.000 \times 1920 = \frac{30{,}720{,}000}{365}$$

is 841,644 cubic feet per day of 12 hours, or 1169 cubic feet per minute; which, divided by the number of miles 69, gives 17 feet per mile per minute; then, assuming that the others have *proportionate lockage*, and that these locks are of a size proportionate to their section, and the above deductions will be in accordance with Languedoc, leaving for evaporation and filtration above 58.13 per mile per minute.

This average is much more favorable than the experience of Erie canal alone would have been, as it has been stated in the Ohio Commissioners' report, as the answer of one of the Engineers to their inquiry, viz:

That 61 miles of this canal,	Rochester to Senaca,	uses	6000 ft.
11	the Camillus level,	- -	2000 ft.
69	the Rome summit,	- -	9000 ft.
141			ft. 17000
	Per mile per miuute,		120.57

If the preceding calculation of the mean of the expense of water per mile per minute, is *a near* approximation to the truth, the application of it may be made to the lines of canal by considering, not only the summit level, but those levels which are successively, or alike dependent on the same source as one of the data of the estimate, and the *lockage* from the summit level as another.

It is proper to take the longest line, in the first instance, sixty miles; especially as the passage of the Winding Ridge Ravine (not yet surveyed) is considered very difficult: 60 × 58.13 = ft. 3,487.800.

The lockage may, on so great a communication, be nearly equal to the possible operation of the canal; and if we suppose a boat to enter at each end every twelve minutes, or five per hour, and the descending boats passed at the same time, there would be ten falls per hour.

The locks 90 × 15 × 8 =	10,800	
Plus ¼th, for waste, =	2,700	
	13,500	
Per hour, -	135,000	
Per minute, - - - -		2250.00
Per minute, total cubic feet, - -		5737.80
Per second, - - - -		ft. 95.63
The flowing water at command, as before stated, -		48.28
The requisite artificial supply per second, - -		47.35

The next point in the investigation is, what body of water would afford this supply; what opportunities of forming reservoirs exist; and on what principles both such, and the feeders from them, are constructed?

That they would be filled, may be shewn from the known operations of nature on these high grounds.

The ratio of evaporation is a preliminary and indispensable inquiry. From a very extensive collection of facts, by philosophical observers in Europe, it appears that the ratio of evaporation from the *surface* of *water*, in the summer season, is greater than the *rain;* but from *land*, somewhat less. To exemplify the first, it is found that, by observations at Salem, in the United States, the rain is 35 inches, the evaporation 56 inches: at Baltimore, (by Mr. Brantz,) 39.83 inches: evaporation not observed in an open field.

In England, the average of six years,	21.00 on the plane.	
	25.00 on an eminence.	
Idem, another series, -	23.83 evaporation	36.44
Idem, in winter months, -	11.48	10.27
Idem, in summer, - -	12.43	26.17
In Scotland, in winter, - -	14.19	12.89
In summer, - -	19.36	31.51

The well-known experiments of Dalton and of Hoyle, resulted in shewing the loss to be 1-5th of an inch in 12 hours.

There is a resemblance, in some respects, between the summer weather of England, and of the Allegany, in the temperature, and the frequency of showers.

The rain and evaporation *in summer* belong more especially to our computation. The following results, for the several months of the year, are from long observation in England.

		Inches evaporation from Ground.		Inches from Water.
In January, the rain	2.46	1.01		1.50
February do	1.80	.53		2.00
March do	.90	.62		3.50
April do	1.72	1.49		4.50
May do	4.18	2.69		4.96
June do	2.48	2.18		6.49
July do	4.15	4.06		5.63
August do	3.55	3.38		6.06
September do	3.28	2.95		8.90
October do	2.90	2.67		2.35
November do	2.93	2.08		2.04
December do	3.20	1.48		1.50
	33.55	25.14		44.48
The six summer months,	19.36	16.73		31.54

The difference, 12.18, or at least one foot more evaporation than rain. But these experiments must necessarily have been tried on a small and great surface; but the surface of a reservoir is exposed to the wind: This exposure to the cause of evaporation is increased by the agitation of the surface of the water in waves, and even by its mechanical force to take up and carry off the broken, air-commingled particles, facilitating the chemical union of the water with air, according to the received theory; of its solution by means of caloric; the one fluid combining with the other through its agency. But against this excessive evaporation by the wind, we may set the reduced temperature of this lofty region. The water being held in the air by means of caloric, the presence of comparatively cooler strata of the air is often evinced in the sudden production of clouds and rain. Moisture, copiously exhaled in the warm latitudes of the Gulf of Mexico, and throughout the vast valleys of the Mississippi, the Ohio, the Cumberland, the Tennessee, the Alabama, is borne by the prevailing winds of spring and summer *in contact* with the Appallachian range, and there meeting with the winds of the north and the east, unite and precipitate those copious and genial showers which supply every river and fertilize every state.

While natural philosophy and experience permit no doubt of the existence of those regular causes of an ample supply of rain in the spring of the year, to fill great reservoirs, we must not omit an interesting experiment in Scotland, which establishes another law, corroborative of those, but applicable to the summer season, to prove that it rains more, even on moderate eminences than on the plains. Two rain gauges were employed, one upon a hill 600 feet above the

sea, the other on the low ground, 20 feet only above the sea. The series of observations extended through the course of five years, 1814 to 1818; when it resulted that there fell, in a year, upon the plain, 25.66, upon the hill, 41.49 inches, nearly as 5 to 8.

The past summer, in the month of June, there was, on the Allegheny, a copious fall of rain, which raised Deep Creek nine feet. But, from the 4th July to 17th August, there was little, and then quite a freshet; but it was again a dry time in September.

We return, therefore, to the extent or capacity of reservoirs requisite to the quantity of water deficient for the longest line, sixty miles:

Deficiency 47.35 cubic feet, $\times 60 \times 60 \times 24 \times 60$ days = 245,462,400 cubic feet.

To provide for this quantity, under the supposition of its being requisite for 60 days, we have the following places, which, if flowed to the depth of six feet above the level required for feeders, whose slope shall be sufficient to carry the water to the canal, with an allowance above that of one foot, for evaporation, and two feet for filtration, will contain *available quantities* as follows, according to the report of the surveys, viz.

1st. On the Youghiogeny, above the mouth of Cherry tree branch, by a dam, which, measured from the surface of the stream to the surface of the reservoir, will be, besides the submerged part and the foundation	19 ft.	149,131,000
2d. On Cherry tree Creek,	19 ft.	85,494,000
3d. On the Youghiogany, from Cherry tree to Snowy Creek	29 ft.	75,506,000
4th. On Snowy Creek, including Laurel,	29 ft.	176,490,000
5th. On Youghiogeny, from Snowy Creek dam to Little Youghiogeny,	44 ft.	150,000,000
6th. On the Little Youghiogeny,	44 ft.	200,000,000
Cubic feet,		836,721,000

This quantity appears to be treble that required, nor have we included those reserves which might be formed on the Deep Creek and Glades; nor that of which the Pine Swamp, west of the Youghiogeny, may be capable; nor one which might possibly be formed by a dam 90 feet high, above the Great Falls.

The four first are the most practicable, and they would have a feeder of about 16 miles in length.

It is not to be denied, in practice, that the principles which should govern the construction of *feeders* are in some obscurity: with the utmost precaution they have sometimes disappointed expectation. That of St. Prive, on the canal De Briare, is eleven miles in length, and it lost three fourths of the water that entered it, although the feeder was rebuilt with every possible precaution, *except covering* it. The usual section of the stream at the entrance gate was 5 feet broad and

2 feet deep; the gate where the feeder discharged into the summit level, is 3 feet 4, and the water 7 inches deep. The slope of this feeder was 5½ inches per mile. The quantity of water received into the feeders of Languedoc canal, is 72,000,000 metres; of which 37,256,000 is discharged into the canal, and 35,344,000 is lost by filtration and evaporation. Without attempting either to account for this loss, or for the fact that feeders, of comparatively small dimensions, appear to lose as much as canals, the conjecture may be hazarded that the shallowness of the water permits its temperature to be raised—its velocity increases exposure to the air, and the more so if the wind is against the current: the absence of hydrostatic pressure on the banks, as the volume diminishes, allows them to become more dry and absorbent. These concurrent causes may account for the disappearance of this large proportion, and may suggest, besides the expedient of covering them from the sun, others by which they may be adapted to our climate.

The construction of dams of great elevation, though by no means impracticable, are not only attended with expense and difficulty, but with some uncertainty. That of the St. Ferreol reservoir of Languedoc, is 110 feet in height; in masonry, parallel walls of great thickness, filled between with earth. But it is stated, as the result of experience in dams of masonry, that they are found too often to require repairs. In Scotland, preference is given to building a puddle wall in the centre of an embankment. There is one of this kind, 90 feet high, at Glencorreburn, near Edinburg. In building them, the course of the stream must be diverted. Puddle is any tenacious earth, compacted under water, by which the air is excluded from it—the particles of the mass are afterwards kept in contact by the weight of the atmosphere.

The uncertainty of success arises principally from the hydrostatic pressure, in any deep artificial water, which sometimes occasions small leaks secretly to spring out, perhaps through fissures of the rock, if on lime stone; or, by the porosity of the earth, discharging much water by small and imperceptible openings. Reservoirs are, of course, experimental, in proportion to their magnitude; but most likely to succeed where the ground has been occasionally or annually flowed.

We have shown that the loss by evaporation more than rain, may, in summer, be one foot. Du Cros, (a writer on these subjects,) states the absorption on canals to be one and an half times the evaporation. In this ratio, we must allow for a reservoir, were it of the same depth only; according to the tables for the summer season, 31.45 inches, plus 15.77, but as a drought for sixty days would be so extraordinary as to preclude the navigation of the western rivers—we may safely assume the results of Dalton's experiments which were 12 inches for sixty days, and allow the filtration to be 2 feet. This addition has been therefore made on the elevations of the dams.

It has been shown, that, by these means and methods, there may be water enough for the *longest*, but *lowest*, line.

The next inquiry is, whether there is water enough at command for the shortest line, 29 miles, described page 15.

This line is higher than the former by 34 feet, viz: 10 feet above the base line of Deep creek, occasioned by ascending to the Bench mark near the mouth of Meadow Mountain Run, and which increased elevation is necessary to be out of reach of the freshets of Deep creek, which rise at the bridge, at least 9 feet.

As the canal must be kept out of reach of floods, it may be supposed to be led along the foot of Meadow mountain, across Cherry-tree Glade Run, and along the declivity of Negro mountain, and up the Buffaloe valley to the *tunnel* leading into Bear creek valley, which on this plan may be shortened, and by somewhat deeper digging at both ends, reduced to about *one* mile.

The quantity required, in. $29 \times 58.13 =$	1,685.77
Lockage as before. - -	2,250.00
per minute,	3,935.77
per second,	65.59
To supply this demand, we have Deep creek in its lowest state. -	7,247

Quantity to be provided for. feet, $58,343 \times 60 \times 60 \times 24 \times 60$ days, = 309,346,560 cubic feet.

To provide for it we have,

1st. The summit level capable of a variation of three feet. Its length measured from the eastern extremity of the east tunnel to the western extremity of the west tunnel is 10 ms. 1,663 yds. of which 4 ms. 1,333 yds. may be 15 feet wide, 376,785

5 ms. 1,100 yds. may be 40 feet wide, 188,000

feet, 1,564,785

Multiplied by 3, 3

4,692,355

The Glade reservoir may be formed by a dam at the narrows, 200 feet wide, 12 feet high, plus foundation. This would flow the water to Elk Lick, on the foot of the Dividing ridge which is, feet, 26.194 above base and

	m.	d.	p.
	4	42	32
Because *less* to Meadow mountain, feet 14,344 - distance,	2	13	37
Shows the dam to be 11,750 the distance,	2	28	95

The area would be about $2\frac{1}{4}$ miles plus 1 mile up South fork, plus $\frac{3}{4}$ up North glade or $4 \times \frac{1}{4}$ is 27,878,400, 6 feet deep available. - - - . 167,270,400

To this we may add a reservoir higher on the South fork; another higher on the North glade, another on Meadow Mountain Run about the entrance to the tunnel, and on the high glade of Cherrytree; these require no extent of feeders, and a moderate extent and elevation of dam. These may be considered as at least equal to one square mile 6 feet deep, or, 167,270,400, which added to the preceding sums, is 339,233,155.

Recollecting that we are providing for a *droughth of sixty days*, which has never been known on these mountains, this may be admitted as sufficient—but, in truth, we have assumed large size locks, and *constant* operation of them. But it may appear inexpedient that they should be *so large*, and still there are two other sources of supply, attended with some expense. These are—First, To bring into the glade reservoir the waters of the upper branches of the Little Youghiogeny, Nest Lick, and Wolf Runs, (the minimum delivery of which, appears to have been, feet 8,746,) by means of a duct through the intervening hill, the distance through, being three *miles*, and connected with this, might be a feeder to the Cherrytree fork, which affords 11,503, these added 1,728,000, and reach the best situation for reservoirs on all the upper branches of the Youghiogeny.

To these may be added the Pearl Run and Pine swamp reservoir, which may, (according to Mr. Shriver's Memoir and survey,) be of several square miles extent, confined by a dam of small dimensions. But this must be attained by means of an aqueduct feeder, and the use of some extent of iron pipe. This is not difficult, but the ground has not been examined with this view; the elevation is, however, considerably above the base line, and the line under discussion. But we may leave the resources of the west side of the river in reserve for the western section.

It remains to elucidate the circumstances of the line with the *shortest tunnel*, viz: the 9th line. This line passing from Dry Arm to Deep creek, it is probable the tunnel may be shortened to *one mile*—passing down the glade to the narrows, it thence will follow, as before described, the course to Bear creek valley. The glade was examined and found to have a soil of about four feet deep, based on rock, probably like that of the adjacent ridges sandstone in strata. If excavation were to commence 4 feet deep at North glade, which was found to be 17.794, then minus 4, is 13,794. The mouth of Elk Lick opposite Dry Arm 26.194 above base, also, minus 4 = 22.194 less 13.794 = feet 8.400, the depth of digging in rock diminishing westward to 0. In forming a canal through the glade, it will, no doubt, be necessary to employ considerable force in pumping; perhaps the cheapest power is the steam engine, where fuel is cheap.

The summit level would occupy the place of one of the glade reservoirs before described, and must be made to have the properties of one. The others will be conditionally adequate.

This line is one mile longer than the shortest; but besides that, the tunnel is but about one mile. Should increase of business on the canal render it expedient, a second tunnel of the same length might be made,

not far from the first, into Dewickman's arm; and two, or a *wide one*, will be necessary. The inconvenience of *narrow tunnels* in causing delay, is thus exemplified: If it be one mile through, and boats can pass in half an hour, and are entering half an hour, others wait *an hour* for their turn, which is six hours a day, and which diminishes the power of the canal, considered as a machine, one half. In an active trade the tunnel may as well be the gauge of all the rest of the canal, and a great saving of cost take place. In this country, where so many are doing business on their own account, delay and hindrance ill accords with the industrious, persevering genius of the people: hindrance also occurs where a canal, being led through rock, is made narrow; or where aqueducts are of single width, or the abutments of bridges are allowed to contract the trunk of the canal. It may be said, without hesitation, that a work like this in contemplation of the National Government, should be capable of *two processions of boats*, in opposite directions, from end to end; but the size of them should be adapted to the trade, and to the natural navigation which the canal connects together.

It thus appearing that the communication is practicable by the ordinary methods of supply, the natural flow and reserved bodies of water; the practical inquiry next occurs, whether the descent from the summit level each way, so much in so short a distance, affords room for the locks? From the east end of the tunnel to the mouth of *Crabtree*, will be eight miles, the descent being 1,054 feet; it is 40 in length for one descent. A lock of 100 feet, eight feet lift, with its entrances, occupies 120 feet. Therefore, a succession of locks with intermediate basins of 200 feet, will occupy the whole ground. On the west side the descent is 960 feet in six miles, or 33 feet for one foot. It would indeed be very difficult to keep a canal in operation thus constructed; the reason is, that, in these successive basins, their depth, in relation to the entrances of the locks, is easily deranged. If a boat is going up, she checks the supply, and, at the same time, another draws from the source thus failing of supply: throughout one hundred and five locks, and as many basins, there would be an incessant fluctuation of this kind of trouble. To remedy it by a feeder along the whole way, parallel to the work, would involve the waste of water, did the ground permit; or, if the descent were made by a set of connected locks, four or six together, in order to extend the basins in this case to 1,000 feet, then occurs delay in passing, unless there are *parallel* series; and, for this, I fear our ravine of 40 feet will hardly afford room.

There are indeed other methods of passing from one level of a canal to another; but it too often occurs that ingenuity is disappointed of fortunate results, from a want of that practical philosophy which would have enabled them to calculate the strength of materials, and the resistance of friction in the movement of heavy bodies, and whenever improvements of this kind come from the hands of those who are known to be versed in mechanical science, such is the natural fondness of inventive genius for its own offspring, that machines for a

public object must be subjected to the coolest test of principle, the most thorough investigation, and the judgment of practical minds.

The western section may have an interest, or depend in a degree on the reservoirs or the head branches of the Youhgiogeny: we have not only to guard against the violence of floods, but the extreme of the opposite condition; and the utility of them is at once perceived in reviewing the circumstances of the two lines of this part of the route, for which the water must almost all go from the mountains, one hundred miles.

Besides those, there may be one by means of a dam at the head of the ravine of Winding Ridge. From hence, or from some lower point in this passage, a feeder may be led to the canal at the elevation required for the Laurel tunnel route; or if the line should be preferable down the course of the river, then others on Cassellman's and North Branches. Indeed, these may, in either case, be wanted, as the two lines unite below the Laurel Mountain, and the supply must then be had from the Youghiogeny.

Finally. Having explained the whole subject, so far as the present state of information permits, my impression is, that, notwithstanding the (9th) line of the shortest tunnel is not the shortest canal, and the Deep Creek summit will be *thirty-four feet higher* than the circuitous line; notwithstanding the route by *Bear Creek* will require a second tunnel, and the line away from the river a third tunnel, and a magnificent aqueduct, yet I give a decided preference to this whole route, as that which embraces the great points, directness, control and command of water, economy of expense, and continuity of operation, with most certainty. Both lines should be investigated thoroughly, as it is for posterity and perpetuity that this great work is to be accomplished.

In conclusion, a few general remarks may be offered, arising from the occasion and the position of the Board. No difficulty has been diminished or magnified. The obstacle to a communication by the Potomac route with the Western states, lessens to a point, compared with the magnitude of the object, whether in a commercial or political relation to the prosperity of the country. In Europe, their canals, even those of Governments, have all some definite limited object of utility. But here it is not alone the distance—the elevation —the vast natural navigation to be connected, which constitutes the grandeur of the design; but the immense interests it combines into an harmonious national whole.

Whoever visits the Western states for the first time, is astonished that so few years have elapsed, since this fertile and populous part of our country was a vast wilderness; but the surprise ceases with the recollection, that, at the establishment of the constitution, the United States became the owners of these lands, ceded and pledged by the states to each other, jointly and severally, as a basis of public credit, so broad and safe as to be an effectual guarantee against the oppression of an accumulating national debt, and therefore, the real wealth with which every thing for the common good may be accom-

plished. The immediate offer to sale of this fine body of land, in a mild climate, intersected by great and by small rivers, could not but induce the emigration of a youthful, brave, and resolute population, from every Atlantic state.

The provisions of the constitution were thus fulfilled: and in time, young states became partners with their old parents in the advantages of civil liberty. Money paid into the common treasury purchased a title to their farms; but they carried with them, or inherited a title to equal prosperity under that compact, which establishes power to provide for the general welfare.

This prosperity, it is clear, can be attained only when the geographical isolation of a large portion of the country shall cease, and avenues be opened to a participation, on equal terms, in the commerce of the world. From the Alleghany mountain to the Wabash; from the Tennessee to the Lakes, there is a great and valuable portion of the interior remote from every seaport, and intercepted by nearer, but not more fertile regions from the accessible markets, especially in the early spring. Industry is indeed so depressed, that, notwithstanding the modern mode of navigation prevails largely, produce is so low as to bear land carriage (by the National road) three hundred miles.

This section of our country comprehends one sixth of Virginia, one fourth of Pennsylvania, with the states of Ohio, Indiana, and Kentucky, containing eighty-five millions of acres, and at least one million six hundred thousand inhabitants. But not these only—all beyond them are interested in an ultimate system of internal communications, and all, too, on this side, since our internal prosperity is the support of our external commerce—our navigation, which cherishes our best means of preserving peace, by efficiency in war. The eight Western states contain two hundred and forty-eight millions of acres, and at least two million five hundred thousand inhabitants. If the land may average five dollars an acre, its value is twelve hundred and forty millions of dollars, and to this may be superadded, the four territories, containing seven hundred and eighty-six millions of acres, much of which is already likewise valuable. How small a percentage on this value would amount to the cost of all the internal improvements! How certainly good communications must double that value!

That these and other great results in contemplation of government, cannot be produced and secured by any single canal in execution or contemplation by the states which extend beyond the mountains, is demonstrable. Constructed by their citizens for themselves, if equal, when accomplished, to their accommodation only, they would surely have the best right. No compact, no duty prescribes that they should make and maintain commercial means of intercourse for the general welfare, or keep open such as they may have made, beyond the limits of their own interest. The states may take care of themselves; but the United States, of all. Hitherto, the business of the West had been thought essential to an income proportionate to the cost of public works of this kind; but this apprehension is dissipated by the suc-

cess of Erie, thronged with navigation even before it has reached the Lake. And although the capacity of that canal for business may be increased by parallel locks, and other means, there are limitations to its power, set by the command of water it possesses. Ever since the commencement of that work, the western counties of New York have been increasing greatly in population, and there will be no *necessity* for business from Ohio and Michigan to ensure a competent revenue from Erie canal. The very facts which shew the wisdom of that undertaking, prove that the Western states may find it pre-occupied. The nearest customers must always have the preference. They are in possession. Nor would a canal through Pennsylvania be less occupied. This state, besides being equally fertile, possesses iron and coal. She is favored by nature with great rivers, whose courses converge to the canal route, and must, when effectuated, pour into it a great accession of transport.

It is evident, therefore, that the General Government has an interest in the success of the state Governments—in the effectual and extensive influence of their public works, with which its own co-operates to the same great end. To each it must be best that they should yield a fair income. The revenue isnot all in the public good produced; those who use canals can well afford to pay tolls; they are benefitted in a much higher ratio than that charge upon the increased value of the property transported; nor would it be just, in good policy, not to make the income, in time, not only secure the perpetuity of the way, but the interest on the investment, which it would most certainly do, at very moderate rates. If as many boats were to enter as has been assumed in the calculation of the water, it would be $5 \times 12 \times 2 = 120$. If twenty-five tons, then $120 \times 25 = 3000$ per day. If 200 days, 600, 000 tons, at two cents a ton a mile, is 3,900,000 dollars, the canal being at least 326 miles.

Finally: in reviewing the whole ground, the Alleghany mountain stretching through the centre of the Union, so far from being a barrier to the most economical form of communication, is, in fact, to be rather considered the great laboratory of that element, which is essential to this branch of the internal improvements in contemplation of the General Government.

The next division of this communication is in relation to the route of canal between the Ohio and Lake Erie, also respectfully submitted.

JOHN L. SULLIVAN,
Member Bd. Inter. Improvements,

Washington, February 3, 1825.

Reconnoissance of the country between the Ohio and the Lake.

While the investigations were proceeding on the summit ground, the Board made the reconnoisance of the country between the Ohio and Lake Erie, in order to designate the most suitable route for a communication between these waters.

The course of the Ohio river, from Pittsburg to the mouth of Big Beaver, is in a direction which approaches the Lake, and that point is found to be the most proximate. With the guidance of a gentleman well acquainted with the district, the Board, after examining the falls, ascended the valleys, diverging for some distance up the Shenango, which was subsequently visited along its upper branches. From Warren, at the head of the Big Beaver, where the branches called the Mahoning, and Silver creek, come in, excursions were made to all the points of essential interest to which our attention was drawn, either by the known topography of the country, or by facts ascertained under the authority of the adjoining states, or by gentlemen actuated by motives of public spirit.

The adjoining township of Champion being the highest ground between the Beaver and Grand river, had been ascertained to be *three hundred and forty-two feet* above Lake Erie, and *two hundred and eighteen feet* above the Ohio. It became, therefore, as this line has the lowest known summit, a very interesting inquiry, whether a sufficient command of water could be had to make this "the most suitable route," especially, as the gentle slope of the country through Rome, Austinburg, and Ashtabula, appeared to be favorable ground, and the valley of Grand river, for some distance, afford advantages. An important fact had been ascertained by an engineer employed by the state of Ohio, viz. that the Cuyahoga could be led eastward, to the summit of Champion. The distance and elevation of that point, and the quantity of water at command, would therefore decide the practicability of a canal by this route.

We proceeded, therefore, to the Cuyahoga, and ascended to the rapids. At this time there had been no rain for three or four weeks. The opportunity was favorable to determine nearly the mimimum quantity of flowing water. The section and velocity of the stream were taken at several places, and the mean of these operations and calculations was $56\frac{148}{1000}$.

We returned by the track which Mr. Geddes levelled, to the head of Silver Creek, where the greatest depth of cutting was ascertained to be seventeen feet, and the distance between one and two miles. We visited Garret's mill, on this stream, where it was found, that 6.070, was the quantity, per second, of flowing water; and at Parkman, a small stream, also, at command, measured $1\frac{388}{1000}$ ft. together $63\frac{6}{10}$ being the whole of the natural supply at command above Champion; and it was the opinion of some of the inhabitants, that the Cuyahoga was, at times, a quarter to a third lower than at present.

The length of feeder required would be eighteen miles; the length of canal to be supplied from these sources, would be some distance down the Beaver, aided by the Mahoning, and fifty miles to the Lake; in the course of which it would cross some feeble streams from Bloomfield Swamp, perhaps low enough to receive them. Or, if the line were to descend into Grand river valley, it would be circuitous, and from Austinburg to Paynesville, under peculiar disadvantages, from the washed banks, or high bluffs, of earth, along the foot of which

this stream alternates by sweeps. The line could not leave the valley to attain a termination at Ashtabula.

When the question presented itself, Whether the canal route might not rather ascend to the Cuyahoga, and descend that valley to Cleaveland, the first inquiry naturally was as to the elevation of the ground. Mr. Geddes had not levelled up the rapids, and we were left to infer its elevation from the other elevations which he measured, and partly from the conjectures of the inhabitants.

He began on the side of the small lake between the Muskingum and the bend of the Cuyahoga, 404 feet above Lake Erie. His line was run eastward beyond Ravenna, and the ground west of the Mahoning was found to be 149.20 feet above the starting point at the little lake. It was found that the narrow falls of Cuyahoga is forty-nine feet above that point, from whence to the rapids, (the place we visited,) the ascent is estimated at 120 feet, distance fifteen miles. Mr. Geddes continued his line of level from the high ground to Garret's mill. on Silver creek, found to be 58.80 feet below the starting point: continuing on, he found the swamp in Nelson to be 37.80

and Champion below that - 21.

58.80

As Champion is 58.80 below the point of departure, and the Narrow Falls 47 above it, and the fifteen miles ascent 120, as conjectured, Cuyahoga Rapid is 225.80 above Champion, and Champion is 342 above Lake Erie; therefore, 567.80 is the elevation of this line.

This is corroborated thus:

The starting point	-	404
To the Narrow Falls	-	47
To the Rapids	-	120
		571

It is true, the number 120 is conjectural; but as the people estimated the fall to be 150, it is set down at 120. To this discouragement might have been superadded the difficult nature of the ground down the Cuyahoga Valley, according to Mr. Geddes' report in print.

It is not our duty at this time to dwell on the advantages which Ohio may ultimately derive from local relations and elevations of the Cuyahoga. It may surely be the means of forming a useful canal eastward, if it cannot adequately supply a canal of the dimensions this communication, prospectively considered, will require.

Subsequently to these observations, the Board followed the line from Warren to Austinburg; thence to Paynesville and the mouth of Grand River.

Returning to Austinburg, we pursued the line proposed to Ashtabula, and viewed its harbor also; the next object was to view the summit ground between the head of the Ashtabula and the head of the Pymatuning, a branch of the Shenango; thence, to the head of that river, and down its valley, southward, to the junction of *Crooked Creek* branch, which

was followed up, northward, to *Conneauti Lake*, which is separated from its head waters by rather low ground; thence, to Lake Erie, descending 470 feet. From the north end Conneauti, the waters running into Erie are separated by a ridge of 15 feet for a short distance. To the lake is 25 miles. To Erie Harbor nearly 40 miles. The nearest point on the Lake shore is at Elk Creek mouth, about 16 miles west of Erie Harbor. An artificial harbor might be securely built here; the bottom is rock, gradually declining from the shore.

To view the line near Waterford, the Board, after visiting Erie, ascended to the sources of supply on French Creek. The elevation of this summit would be 670 feet near La Bœuf Lake.

Arrived at Meadville, we availed immediately of the long period of dry weather, to ascertain the minimum of flowing water in *French Creek*, which the Conneauti Lake route is capable of receiving. The operation of measuring it was repeated several times, and the mean of these measurements found to be 230 cubic feet per second, which is considered to be abundant, especially as the plan of the work will probably include the waters of Conneauti Lake; and, if necessary at any future time, it may be raised, and make a reservoir of five miles in length, and nearly one in breadth, if found, on investigation, that it would fill.

This source of supply being the only one amply sufficient, would seem, of course, to prescribe the route nearest to it, as *most suitable;* and we saw no difficulty in making a canal from the mouth of Beaver to the mouth of Elk, in the distance of a little more than one hundred miles.

Having thus accomplished the reconnoissance, we divided our party, and Col. Totten descended the Alleghany to make a chart of that river, the distance from Franklin to Pittsburg being 109 miles, and there are 45 rapids in its course. On re-assembling at Pittsburg, it was deemed expedient to preserve the information thus acquired for future usefulness, embodied in the form of instructions for surveys, and to place them on the records of our transactions as a Board; but not, (on my part,) as expressive of the opinion that it would be of essential importance to execute them all. The line of communication depends upon the command of water, and it is evident there is but one route where it is found in sufficient quantity.

The next division of this illustration of the general subject, is on the co-operation with the Pennsylvania Commissioners, also respectfully submitted.

JNO. L. SULLIVAN,
Member Board Int. Improvement.

Pennsylvania Reconnoissance.

In conformity with the orders of the Secretary of War, the Board of Internal Improvement, in their way to the Eastern states, met and co-operated with the canal commissioners of Pennsylvania in making a reconnoissance of the country from the Ohio to the Schuylkill.

To convey a general idea of this route, it is necessary to recal to mind the great features of the country.

At the distance of thirty miles, by the course of the Alleghany, from Pittsburg, the Kiskimanitas, whose upper eastern branch is called the Conemaugh, comes in from the east, that branch heads opposite the Juniatta (itself a branch of the Susquehannah): and, both to the east and west of the Alleghany mountain, are seen others, ranging transversely to these rivers—the Chesnut and Laurel on the west, and many on the east, which divide Pennsylvania into fertile valleys; while farther beyond the Susquehannah, Dauphin, Lancaster, and Chester counties exhibit a milder aspect of country.

This route naturally divides itself into four sections: 1st, from Pittsburg to the mouth of the Little Conemaugh, computed to be 128 miles; 2d, thence, to the forks of the Juniatta, 40 miles; 3d, thence, to the Susquehannah, 110 miles; 4th, thence, to the Schuylkill, 125 miles. The whole 403 miles.

The first section has favorable ground along the river, on alternate sides, for a large proportion of the distance, presuming the substratum will be found tenacious ground. The principal exceptions are the ravines of Chesnut and Laurel mountains, one five, the other seven miles through. It will often be a question of expediency for skill and calculation, to decide whether to carry the line along the declivity of steep shores, or to cross by an aqueduct to a more favorable ground for a distance, when the same alternative will again present. For this section, which, from its elevation at the eastern end, gives to the stream the characteristic of a torrent, and precludes improvement of the natural navigation, there will be water in abundance for a canal.

Beside the tributary streams, which are considerable, Stony brook was found to discharge, at Johnstown, at this time, not indeed the lowest state of the river, 239 cubic feet per second, and the Little Conemaugh, near its mouth, 100 cubic feet per second.

The second section includes the Alleghany mountain; and here the question of how much water is in its natural flow at command, or may be had in reserve in the dryest season, becomes an inquiry of the greatest moment: our view was indeed cursory; but so far as the investigation was carried, may be considered essentially accurate.

One of the Board, Mr. Sullivan, had been accidentally detained half a day at Pittsburg, and crossing the country to fall in with the party, had reached this place before them, and preceded the rest of the company, attended by Mr. Livergood, one of the most respectable of the inhabitants of Johnstown. At three miles from this place, up the Little Conemaugh, Hildebrand's mill is situated. The owner, Judge Hildebrand, was asked how the present state of the water compared with

its lowest state. His reply was, that in a dry season, such as we had lately had, there was just enough to carry his two grist mills. The measure of his flumes, compared with the result of a measurement of the water as now flowing, would give the minimum and the medium quantities. Each gate was found to be 33 inches wide, its hoist $4\frac{1}{4}$ inches, head of water 3 feet. According to the formula of Du Berat and Dr. Robinson, the quantity discharged is thus found: depth to the centre of gate 3.188 feet; the square root of which being 1.785, which multiplied by $\frac{8.02 \times (\text{by area})\ 1.03 \times 82 (\text{vena contracta})}{1{,}000{,}000{,}000}$, gives cubic feet 12.093 per second.

12.093 the same for the other gate.

24.186 feet is therefore the minimum quantity.

The race was found to measure at its entrance 7 feet in width, and 2 feet deep, the velocity 100 feet in 80 seconds, which, according to Prony, is 14 feet.

According to Du Berat, 13.56

27.56

2

The mean of which is 13.78 per second.

The discharge over the dam was at this time three inches deep, 180 feet in length, which according to the formula given in Robinson's Mechanical Philosophy, is $2.226 \times 180 \times 12 = 61.$ =80.136 feet.

Or by another formula, 5.19, the square root of the cube of the depth, $\times 180 \times 12 \times 11.50$ =74.600

154.736

2

The mean is 77.368, and plus 13.78, gives present medium quantity 91.148 feet at Hildebrand's mill, which is almost four times the minimum delivery.

The next day the gentlemen who were ascending the river reached Johnstown, and, proceeding up the Little Conemaugh, measured the stream at the forks, about six miles as the stream runs above the mill.

The south fork was found to contain 43.87 feet

The north fork 59.02

102.89

The evaporation in the course of that six miles very well accounting for the difference.

The whole party having joined at Ebensburg, excepting Colonel Totten, whose military duties had called him away, we proceeded to measure those streams which are nearest the top of the mountain, or those of them which were most immediately relied on.

Ben's Creek comes in one mile below Lilly's mill, and the Little Conemaugh was found to deliver immediately below the junction 11.640 feet—at Lilly's mill, 7.098

On the east side of the mountain, Blair's Gap Run, 3.370
North Brook, 1.873
5.243

Together 16.883 f. per second

The Commissioners had not yet had time and opportunity to investigate the value and local relations of the other streams in this vicinity, as they did at a later period. They state in a letter to the Board, of the 16th November last, that the Beaver Dam branch of the Juniatta, being surveyed, would afford the head waters of Burgoon's Creek, dividing into Kitanning Run, Old Gap Run, Sugar Run, and Blair's Creek, draining the eastern side of the Alleghany for ten or twelve miles. On the west side, the heads of the Little Conemaugh, composed of Trout Run, Laurel Run, Ben's Creek, Limestone Run, Beard Rock Run, M'Closky's Run, and Laurel Deep Run, derivable by feeders from the distance of fourteen miles, all of which the commissioners state to be more than *forty* cubic feet per second; they also describe favorable situations for reservoirs.

Perhaps no branch of practical civil engineering is involved in more difficulty than the calculation and construction of reservoirs and feeders. We have not, on this occasion, that intimate knowledge of the local circumstances ourselves necessary to appreciate or to doubt the persuasion which the commissioners express. While our respect for them, as men of sound judgment, on the one hand, inclines us to believe much may be done on this part of the section; on the other hand, our recollection of the practical difficulties, occasions a degree of doubt and hesitation to concur in the confidence they express.

The length of the tunnel requisite, and the elevation of the ground above the tide are sufficiently well ascertained; if the summit level, or tunnel, be below the level of Lilly's mill, (and it will be of consequence as to the supply of water to place it low) its length will be 1407 perches, and the line, it is found, will be above Frankstown 910 feet.

Frankstown, above Harrisburgh, - - -	576 feet.
Harrisburgh, below the summit level, between Lancaster and Chester, - - - - -	209
Thence to the side, - - - - -	519
	2214
The commissioners also state that the descent to the fork of Conemaugh, is - - - - -	349
And thence to Pittsburg, (759 above tide,) - -	688
	3251 feet.

The inquiry, how much water a canal requires in situations and seasons exposed to those causes of evaporation and soakage which are active, and, in a degree, uncertain, is answered with no little difficulty, even from experience. Take, for example, the five most complete and noble canals in France, the country whose climate most resembles our own; and take, also, Erie canal, in its middle and most unexceptionable portion, we find they differ from each other, probably being through a rough country, in some instances, and constructed with more or less precaution. We know of no better rule than the average of these canals, viz.

De Briare,	6 m.	40ft.	wide,	4 ft.	deep,	see 128 ft.	uses 62.60	pr. m.	pr. min.		
									lockage	5.80	56.80
Languedoc,	69	64	"	7½	"	375	"	35.90	lockage	17	18.90
Du Centre,	69	47	"	5¼	"	215	"	55.60	"	"	9.74	45.86
St. Quintin	32	54	"	5⅓	"	232	"	70.70	"	"	10.52	60.58
Narbonne	61	64	"	7½	"	375	"	68.80	"	"	17	51.80
Erie,	141	40	"	4	"	136	"	121	"	"	6.16	114.84
								414				6)348.78
								69				
								6	pr m. pr min.	58. 13	} evap. or soakage	

For evaporation, soakage and lockage, 69 feet.

But we do not know how much was used in the locks [illegible] except in the instance of Languedoc, on which the average of [illegible]'s was 1920 boats, its locks being 100 f. 20 f. wide. 8 feet deep 3000 f × 1920 = 30,720,000 cubic feet ÷ 365 = 841 644 per day, hours is 1169 per minute ÷ 69 miles = 17 feet per mile per minute nearly. Now, assuming that the others have proportional lockage, and that the size of their locks are in proportion to their size, or section, the deduction must be made as above for their lockage, respectively, leaving the nett expense of water for evaporation and filtration; the average of which is seen to be 58.13 per mile per minute; this average is more favorable than the experience of Erie alone, as it has been stated by one of the Engineers on that work, we do not know from what data, or with what correctness, not having had yet an opportunity of personal verification thereof.

That 61	miles	from Rochester to Seneca	receives	6000	feet.
11	"	the Camillus Level,	"	2000	"
69	"	the Rome Summit	"	9000	"
141				17000	

Or per mile per minute 120

.57

Applying this experience to the second section and the size of the locks in contemplation there, and assuming the summit and adjoining levels to be from the forks of the Conemaugh to the forks of the Juniatta 28 miles, the calculation would stand thus: 28 × 58.82 = 1627. 64 per minute per mile, for evaporation and filtration, the locks 80

by 11 by 8 feet+20 (waste) 8448.10 per hour, 84480 per minute 1408 feet.

Consequently, 1647 per minute × 60 × 24 × 90 days = 210,942,144
1408 " × 60 × 16 × 90 " = 121,651,200

Cubic feet, - 332,593,344

Admitting that the branches of the
Little Conemaugh - 102.89
And the stream near Lilley's mill 17 could be brought in,

We must reduce them to the minimum of ¼ or 30 feet.
30 × 60 × 60 × 24 × 90 amounts to 233,280,000

Shewing the quantity by reservoir to be 99,313,344 feet.

One mile square 8 feet deep, with due allowance for evaporation, the feeder being short, would probably be sufficient.

It should not be expected that evaporation will cease during night in tunnels, as the air draws through them, nor that they will be exempt from soakage. The hydrostatic pressure which they are liable to produce on the fissures of rocks, may possibly occasion as much loss of water as they gain by the percolation from above their level; and as the Alleghany falls off very steep towards the east, compared to the declivity of the country west, it will be prudent rather to make their tunnel low than high; though at the expense of its greater length. The commissioners state, that the mountain, in many places, exhibited strata of rock in a horizontal position, mixt with clay, which are not unfavorable indications.

Section 3. The country down the valley of the Juniatta continued generally to wear a favorable appearance, unless it be where the mountains range transversely to the course of the river, when the shores rise steep and high, covered with a vast aggregation of the fragments of rock. These, however formidable to the eye, are to be considered rather as masses of rough materials broken up to hand, in readiness for the high and strong walls with which the canal will have to be supported, above reach of the freshets. In this place it would seem an omission not to notice the improvement of the Susquehannah down to the Chesapeake Bay (in progress by the joint exertions of Maryland and Pennsylvania.) The commissioners, in their report to the Secretary of the Commonwealth of Pennsylvania, express great satisfaction that the commissioners of both states, "are unanimously of opinion that an ascending navigation is practicable, although there may be some difference of opinion as to the ulterior measures that may be most expedient, and the expense required to accomplish it." The commissioners have taken considerable pains to form an opinion upon the best ground within their power, of the probable expense of the ascending navigation, at the same time they would have been highly gratified to have had the opinion of a skilful engineer. They have, however, come to the conclusion, that a less

sum than two hundred thousand dollars will be sufficient. While it must be a gratification to see the strong probability exhibited in the report of the ultimate success of the improvement of the Susquehannah, giving access from the north to Baltimore, it will be still kept in view that the western trade will be necessarily by canals, in bottoms not adapted to the Chesapeake, and that access to that market from the west, must be more convenient by the Potomac route.

Section 4. The Susquehannah, at the junction of the Juniatta, appears to be about half a mile wide, and is full of ledges; the current must, here, at times, be extremely rough, but the only danger to which an aqueduct would be exposed is the same to which bridges on this river are subject, viz: the lodgment and accumulation of ice, and the consequent rise of the water.

The ground from Clark's Ferry to Harrisburg, 14 miles, appeared to be generally level; thence, to Middletown, also favorable. To view the line which the commissioners had been exploring through Lancaster county, we accompanied them to the villages of Elizabeth, and Manheim, taking the gauge of the branches of the Chickisalengo, three feet, and our opinion was, that the plan of running one or more feeders to the head branches of the Conestago, of a navigable size, would be both useful and essential.

On this part of the line two alternatives seem to offer in the direct course, either to rise and descend a ridge of land between the Chickisalengo and the Conestago, or pass under it by a tunnel of about one mile. A tunnel is now of such common occurrence in civil engineering, as to oppose no obstacle, if the expense of it is none in comparison with the object of the work; and even the expense and time may be essentially diminished by the employment of steam engine power to raise the earth through shafts opened perpendicularly at different distances for this purpose.

We regretted the wetness of the season had not permitted the commissioners to remark the lowest state of the water that ever occurs, through this part of the county of Lancaster; we could not at the time we saw the streams, form a decisive opinion. We crossed the Conestago, near the city of Lancaster, where it runs, as it does in fact, for a long way in a deep bed. The line then led over into the valley of Mill Creek, and afterwards gains the valley of the Pequa; and reaches the ascent to the passage into the county of Chester, in about 14 miles from the city. The ground ascends gradually, for one mile, till it reaches the proposed level of a tunnel under the gap of the mountain about 72 feet below the surface, in conformity with the ground on the south side thereof, and 150 feet above the general level of Lancaster. The supply of water relied on for this part of the canal, is principally that of Buck Run, and the west branch of the Brandywine, with the head waters of the Octorara. The head waters of Pequa, also, on the north side. These streams were all so much more abundant at this time than they are at midsummer, that we did not think their measurement conclusive, though made in some instances. The west branch of the Brandywine was found to deliver

(with some allowance for the forge above the spot) 30 feet per second. The east branch of the Brandywine crosses Chester valley, a few miles more to the east, in a deep bed. That valley being well known to extend to the Schuylkill, with very little interruption of ridges of no considerable elevation, had drawn attention at a very early period, as favorable to canal communication. But the commissioners, in accordance with our own judgment, were decided to reconnoitre a more southern route; as the former necessarily falls in with the line of the Schuylkill navigation, without a legal right to supply from that river, it being already appropriated, we don't know with what limitation, to the works of that incorporation. It would be necessary, perhaps, to cross the Schuylkill to gain near Morristown the old line, began by the late Robert Morris, which entered Philadelphia at the elevation of the highest street in the city. On the other, more southern line, it was thought that a canal might reach the city of Philadelphia at about the same elevation, crossing the Schuylkill by an aqueduct near Gray's Ferry, or more southerly coming into the city, not far from the Navy Yard.

We therefore proceeded down the valley of the West Brandywine to its junction with the main branch near Jeffriesford, where we took the gauge of the stream (53.43) and crossed the ridge of land dividing this river from the west branch of Chester river, which runs generally eastward till it unites with that stream; the line afterwards crosses *Ridleys*, *Crum*, and *Darby* Creeks.

The practicability of this line will depend on leading water from the Brandywine, and our impression of this route was so favorable, as to induce us to suggest to the Commissioners in a letter, the investigations necessary to decide the most material points. Thus the fourth section, except so far as the Susquehannah water may be made use of, appears to depend on streams already much occupied by mills and manufactories. This obstacle is not, however, insurmountable. The vast importance of Canals to the whole community, is generally acknowledged. But mills are of great utility: to extinguish them, would be a loss to the community of equal value, and be attended by great inconveniences. Could these great interests be reconciled, which is not improbable, by a method of passing from level to level of a Canal, without using near so much water as locks require—and by reserving water for the canal, when, otherwise, the superabundance on the stream would run to waste, Pennsylvania might have the benefits of canal communications without disturbing the mills near their course; but, on the contrary, affording them the facilities and savings attendant on water carriage for the raw material, and from greater distances, and permitting of a greater profit on the manufactured article, a system of peculiar importance to Pennsylvania. On reviewing the whole ground, so far as the facts have been developed, there is scarcely sufficient reason to believe, that the summit level of the Alleghany mountain, and the Lancaster and Chester line, can command water enough for a canal of great capacity.

But it is evident, Pennsylvania has great means and resources for inland navigation, with or without the aid of the General Government; and it is hoped that their co-operation with the Commissioners, though so limited in time and extent, will have been of some little use in promoting the public works, in contemplation of the state government.

The next division of this communication is on the New Jersey route—also respectfully submitted.

JNO. L. SULLIVAN,
Member of the Board of Internal Improvements.

Analysis of the preceding pages.

1st. Or western section up the Kiskiminitas.
2d. Section across the Alleghany mountain.
Calculations of water.
Length of tunnel.
Elevation of ground.
Application of the principle of computation of expense of water on canals.
3d. Section down the valley of the Juniatti.
The Susquehannah improved.
4th Section The Dauphin, Lancaster, and Chester line to Philadelphia.

Reconnoissance in New Jersey.

In pursuance of the orders of the Honorable the Secretary of War, the Board proceeded to meet the canal Commissioners of the state of New Jersey, and viewed the ground contemplated as the route of a canal between the Delaware and the Raritan.

The Board proceeded with them to the examination of the depth of water in the creek at Bordentown, and then to a point on the Delaware, twenty-six miles above Trenton, ascertained to be at an elevation correspondent with the summit level of the canal as proposed to be located to Brunswick.

The length of this feeder must, however, be considerably greater than that distance, as it must several times recede from the river, pass around the valley, and return to be carried along the spurs, which rise steep and rocky, not far from the shore.

The Board, on gauging the mill streams which cross the canal line, were satisfied that a feeder, from the Delaware, would be indispensable to a lock navigation, and to a canal of dimensions correspondent to those which are in process of execution to connect the bays of Delaware and Chesapeake, and the latter with the Albemarle Sound.

The tide of the Raritan is rapid—its channel is crooked: vessels navigating the tide waters will generally be impelled by the wind. To give them access and avoid delay, this canal, if a national work, should be extended as far as possible, and with as low a summit level as may be possible, that the difficulty and extent of the feeder may be less.

In passing through New Jersey, at a later period, it seemed probable that a direct line between Amboy and Bordentown, might be found practicable, with a deeper excavation of the summit; requiring, consequently, a less expensive feeder from the Delaware.

This route might not interfere with the existing project under the authority of the state Legislature, and an opportunity be found of making a canal of the width and depth of the others parallel to the seacoast.

The Board have already agreed in expressing an opinion that a survey would be useful to determine how far the canal may be extended down along the Raritan. It is further my own conviction, that the ground between South River and the creek at Bordentown, should be investigated, as the shortness of the feeder and favorable ground towards the east, may warrant the reduction of the summit.

The following division of this communication is on the canal routes examined in Massachusetts, also submitted by

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ANALYSIS

OF

THE FOLLOWING ILLUSTRATIONS

OF THE

Massachusetts Reconnoissance,

The notoriety of the route.
Description.
Tides.
Plan and execution.
Back River harbor.
Herring Pond.
Former estimate.
Winter.
Sands.
Harbors.
Commercial consideration.
Objects of further investigation.
Barnstable, Hyannis, and Yarmouth.
Narragansett Bay and Boston Harbor communication.
Description.
Considerations on commerce and defence.

The Massachusetts Reconnoissance.

In pursuance of the orders of the Secretary of War to the Board of Internal Improvement, they proceeded to Massachusetts, to make an examination of the grounds between Barnstable and Buzzard's Bays, in accordance with the memorial of the delegates of that state, addressed to the President on the 4th May, 1824, in compliance with a resolve of the Legislature of the 21st January, 1824, strongly representing the national importance of a communication between those waters, and clearly elucidating the valuable effects thereof, both in regard to domestic and foreign commerce and naval operations.

The public attention had been drawn, at an early period, and with greater interest, as the coasting trade increased, both to the narrowness of the Isthmus and the favorable circumstances of the ground. Accurate surveys of it had been made both at public and private expense; and provided with the maps and reports from the archives of the state, and with the use of others, politely loaned by the proprietors for the occasion, the Board went upon the ground with a knowledge of the most essential facts, and aided with the judgment of all who had preceded them: but it not being within the scope of their commission, at this time, to form a definitive plan of the works, and to make an estimate of the cost, but rather to form a decisive opinion of the practicability of the canal, and to acquire a knowledge of the route requisite to direct the execution of surveys necessary to the final plan, a brief description of the intervening country will make the subsequent remarks more intelligible.

At this place, the Rocky Ridge, which appears to occupy the nearer portion of Plymouth county, and extend eastward along the middle of the Isthmus, discontinues for about one-fourth of a mile, and a long narrow valley exists, which, including the marshes on the north, measures eight miles. The highest ground in the route is a plain of nearly one mile in extent, 33 feet above low water mark on the Barnstable Bay side. Two small rivers flow in opposite directions in this valley. The Scussit rises on the north side of the plain, in a bog of some extent, and, in its course, has fall enough to carry a mill situate thereon. The Monument has its source in Herring Pond, a large expanse of water, situated on the west side of the valley, and 40 feet above it. This stream enters about the middle of the valley, and flows to Buzzard's Bay.

The summit ground has not, to our knowledge, been bored or searched by sinking shafts. How much it may partake of the nature of the adjacent country, remains to be ascertained.

The tide is three hours *latest* in Barnstable Bay, and rises eight feet in neap tides, nine feet in common tides, and twelve to thirteen in Spring tides. Low water mark is eight inches *lowest* on this side; on the south side of the Isthmus it rises three to five feet, or, more accu-

rately, full tide is four feet three inches six-tenths higher, relatively, than high water in Buzzard's Bay.

A canal may, therefore, be excavated and drained to the low water mark, and carry eight to nine feet, and sometimes twelve feet, filled. continually, by the tide. and kept full by the gates of the locks which must occupy its entrances. The northern entrance, from the Bay, must be protected by a break-water, or pier, forming, to some extent, an artificial harbor.

Examples of this kind of construction are numerous in Europe; and, in this Bay, we have one to the extent of several hundred feet at Cape Ann. The bottom off Sandwich is found to be good anchorage—three and a half fathoms are found at one-third of a mile, or three fathoms are found 250 fathoms from the shore. Immediately within the beach it would be easy to excavate, in the Salt Marsh, a basin, for shipping to wait a favorable wind, and, by means of a dam near the mouth of Scusset creek, to include a body of water so extensive as to supply the lockage without materially affecting the level or depth of the canal.

To render this passage at all times useful, it will be necessary to enter and leave it at all times of tide. This can only be provided for by carrying the lock out beyond low water mark, placing it in depth sufficient to float a vessel into it at *low water*. This lock must, therefore, be of double the usual depth, or there must be two of them in succession. The construction of locks, in a situation thus exposed to the action of the sea, is no doubt attended with some difficulty. The usual resource of the Coffer dam is impracticable here. In two similar situations in Scotland, (except in exposure to the open sea) they projected a mass of earth, and excavated for the lock therein. But here the very nature of the adjacent country forbids this method as well as the waves of the ocean. In one of the reports which had been made, it was contemplated, as most expedient, to line the lock with plank, and make it tight by caulking; but, although this might answer, and be easily executed, if the lock is placed wholly above water at low tide, and consequently operative *only at the moment of high tide*, it would not be conveniently and securely done for a deep lock. Cemented walls cannot be built under water. Perhaps there remains, therefore, but one method, which is to build the lock above water *wholly* and place it between the strong rough wall, which should be previously built to receive, sustain, and protect it.

If this were to be the mode of construction, and *wood the material*, the next question would be, both how it should be made durable, strong, and perfectly tight: the answer would be, that this structure should be built *over* the situation prepared for it, and lowered into it complete, when the previous arrangements being made, it might be permanently secured, or it might be built like a vessel on shore, and launched, &c. The manner of constructing it for tightness and durability would be, in preference, the *new method* of ship building in England, by successive layers, transverse to each other, interposing tarred canvass or paper, the materials then become posited in their greatest strength, perpendicular to the fibre, while the resinous substances exclude the

air as well as water, being drawn together by as many trenailings or nailings as there are layers, except one, and as many thicknesses may be given to the bottom or to the sides, it is necessarily strong and durable.

There is still another method, however, which was resorted to at Venice in the construction of naval docks. That of building a caisson, and then, by the erection of the walls within it, cause it to settle, and finally to sink, thus loaded, into its place. This method would, in our case, be attended with more expense, but is not impracticable. The caisson might, on that occasion, be built of lamina as described for the lock chamber.

In a communication of this importance, one lock or entrance of the large dimensions necessary, would scarcely be a sufficient accommodation, and two would be a guard against interruption from any temporary accident.

The adjacent shores furnish an abundance of rocks for the construction of piers The shore is bold, and at the distance of 250 fathoms, is deep enough to float any ship that could pass through.

The engineers heretofore employed on the survey of this route, traced a line of canal to Back River Harbor, half a mile west of the mouth of Monument River. The harbor is found to have 11 to 17 feet at low water, the inner harbor eight feet; but there is a sand bar between the former and the bay, extending from Toby's Creek to Marshner's Island, which has eight feet at low water. If a channel were to be cut through this bar, vessels might, of course, enter at all times; but vessels drawing fifteen feet would be the largest that could enter at high water safely, and then would ground at low water.

Perhaps the depth of this harbor is the best rate for the depth of the canal, unless the locks should be carried beyond the inner shoal and the outer shoal removed, when there would be 17 to 20 feet at the entrance.

The water from Herring Pond appears to have been relied on in some measure to supply the canal. It is supposed to have an area of four square miles; at this time the outlet afforded but $10\frac{164}{1000}$ cubic feet per second This pond, however, as a reservoir, may be occasionally very valuable. If it could be raised, or if the outlet (of which there is less doubt) were deepened, four square miles four feet deep, reduced by evaporation to three feet, would amount to 334,570,200 cubic feet. Should the canal be 80 feet wide and eight miles long, its area is 3,379,200 square feet; that quantity would raise the surface of the canal four feet 24 four times, six feet 16 times. The section of such a canal would be 650 feet, the prism 22,256,000. The reservoir would hold 15 times the prism. The upper section of the Languedoc canal for the whole year uses eleven prisms of its contents.

Applying the rule of estimate we have, in the early part of this report, shown to be according to experience, viz: 58.13 per mile, per

minute, for evaporation and soakage, and allowing this canal to be double width, and usual depth above tide

58.13 × 16 × 60 × 12 hours = 669 600 per day.

Lockage three locks per hour, cubic feet, 30,000 2,160,000

Cubic feet per day 2.829,600

The reservoir would, therefore, provide for 111 days an additional depth of five feet.

These calculations are intended to show the importance of an accurate survey of Herring Pond, and an investigation of its capacity and *capability* of being converted and improved into a reservoir.

Although not charged with the duty of making an estimate of the expense of this work, it may be acceptable to the Department to learn what estimates have been made on former occasions. These appear to be respectively as follows: 427,000 dollars, 417,000 dollars, 492,000 dollars, 400,000 dollars: the latter including three steam boats for towing the vessels and breaking the ice. Their plan did not probably include the breakwater and some other particulars referred to; nor a canal of those noble dimensions we have been supposing.

The winter, if very severe, may close the canal for a short time. It is very rare that Boston harbor is closed, *even for a short time.* At such times the active exertions of steam boats, equipt with ice-breakers as suggested by Mr. Jones, for the Delaware, would keep Back River Harbor clear, and one which should break up the ice in the canal, would also be useful in assisting vessels through against the wind.

Some apprehension has been entertained that sand might accumulate at the entrance of Barnstable Bay. It appears, on inquiry, that there is a constant progress of some sand from west to east from Monument Point: and from southeast to northwest; also from the same towards Plymouth, and by this course, Scusset Creek had been gradually gaining east. In twenty-two years it was said its mouth had shifted 300 yards; but there can be nothing to apprehend from this cause, since, by allowing the canal to drain off occasionally, its entrance would be cleared, but the operation of the lock would alone keep it so.

Some few general remarks upon the navigation may not be misplaced.

The harbors on Barnstable Bay are Province-town and Wellfleet for large vessels; Barnstable is accessible at all times for coasting vessels; Plymouth is accessible also for large vessels on the west side.

In coming up Buzzard's Bay there are three or four good ship harbors. It is well known that the prevailing winds of the spring are easterly, of the autumn westerly. In going over the shoals or in doubling Cape Cod, there must be a shift of wind to gain any port from Plymouth to Portland. Vessels bound to them make some of the harbors of the Vineyard sound, and are sometimes, after sailing

with a fair wind, met by an adverse gale before they reach their port, and after being driven around Nantucket Shoals regain the sound to make a new effort. But the same wind that would carry a vessel into the Vineyard, would carry her up Buzzard's Bay and through the canal to Boston Light, and all the other eastern harbors would be under the lee bow, with a northwest wind running from the canal.

The importance of this canal communication is illustrated by reference to the number of vessels which pass Cape Cod in a year. It was on a former occasion ascertained that, in the year 1791, six hundred passed. It appears now, in the memorial of the delegates of Massachusetts referred to, that, in 1823, there were 5000 and it is stated that 2,500, averaging 100 tons, would pass the canal in a year, immediately after this passage should be opened. Indeed the saving of insurance would be such as to induce freighters to stipulate with masters of vessels that they should use the canal, or the preference given to those who did so would render it necessary that all should, for the saving in distance would be 200 miles between New York and Boston, and still more *in time*, as one is a circuitous and the other a direct passage. Indeed, the masters of vessels would have other interests in it, the saving in *pilotage*, in *wages*, in wear and tear of their vessels. Mercantile men of the first intelligence calculate that 50,000 dollars would be annually saved in wages only. The saving in premiums of insurance would be a very great sum, as few coasters load between Boston and New York with less value than 10,000 dollars, and often with cargoes of 100,000 dollars. 2,500 vessels of the average value of 20,000 dollars would be fifty millions of dollars, upon which a saving of one half per cent, would be 250,000 dollars. It is evident, therefore, that owners could well afford to pay a toll for this facility and safety of passage.

It is scarcely necessary to remark, after the exposition of the commercial advantages of the passage described in the memorial, that the increasing intercourse between the northern and southern and western states, as their respective resources of wealth are developed, has given a consequence to this more immediate communication that it never before had attained; but which is equally appreciated by Connecticut, New York, the middle and southern states, as by Massachusetts.

It remains, therefore, to designate the investigations, essential to be made, to form an estimate of the expense of this improvement.

1. The external or visible circumstances being known already, to ascertain the nature of the ground to the depth of the proposed excavation.
2. The nature and extent of the bar at the entrance of Back River.
3. The nature of the ground or bottom of Monument River, whereby, possibly, much excavation may be saved, compared with the route to Back River.
4. The proprietary of the soil; the mill-sites, and the pond; and all

other property affected by the proposed work, and the dispositions of the owners.

5. A survey of Herring Pond and its outlet, with all the local circumstances connected with it, and its value, or history of its state within the memory of the neighbouring people.
6. An inquiry whether any other sources of supply exist in this vicinity, and if so, lines of level run, to determine the practicability of their accession.

Remarks on Barnstable Harbor Route.

The inquiry whether Barnstable Harbor, and Hiannis' roads, might not afford a preferable route of communication, having heretofore received some share of attention, the Board conceived it would be in accordance with the spirit of their commission to view this line. They accordingly visited Barnstable. and, accompanied by several gentlemen of that place, crossed the Dividing Ridge, about eighty feet above tide, and found the plain to the south beyond it, four miles to Hiannis' Harbor, apparently thirty feet above tide; returning by the line of ponds. which occupy a considerable part of the distance, they were not found to have any visible outlet, and would afford no supply or lockage; the circumstance of the existance of such high ground, and the more eastward situation of these places, considering the object of the two Governments, were conclusive. But while at Hiannis' some improvement in it as an anchorage, was pointed out, and may be worthy the attention of the Government at some future day.

It was suggested that the ground was low and favorable between Barnstable Harbor and Yarmouth Harbor; but the circumstance of the former being at the bottom of the bay, and it being, therefore, subject to the inconvenience of vessels having to beat out against a northwest wind, precluded further investigation, under the discretionary orders. and the limited time in our power to command, at the season of these remarks.

Massachusetts second route between Narragansett Bay and Boston Harbor.

The general import of the order of the Secretary of War, in regard to other routes than that of the bays already described. was understood to refer to the one which had received the sanction of the Legislature, so far as a survey, at public expense could designate it. Public opinion had, indeed, long held in view the connection of Boston Harbor with Narragansett Bay.

Since the establishment of a Navy Yard at Charlestown as one of the principal depots, it has begun to be thought of national interest to connect it with Newport Harbour, which is the only one on the coast accessible with a northwest wind. Its approach being so safe, its entrance so immediate from the open sea, its position so defensible, that a communication with the harbor of Boston would, in time of war, be in effect to give extension to the power of that establishment. It would have two entrances far apart by sea, but be practically one, by this canal. The history of the late war has proved that it is no easy operation to blockade for any length of time either of these ports. American frigates sailed from them while squadrons were off; an obvious reason is, that an easterly gale compels them to haul off to sea, and a change to the west *puts them at a distance* and to *leeward*. A navy must, therefore, be far more efficient equipt at these ports than at any others. A ship entering Newport to refit would be supplied from the navy yard with every thing required in a short time; and instead of a passage round Nantucket Shoals, she would be equipt for sea again in almost as little time as it might have required to get well into port if she had made the coast in the latitude of Newport.

In a commercial point of view this communication will be also of value in time of war. The less vulnerable a nation makes herself in her domestic resources, the more powerful and independent in relation to other powers. The continued prosperity of the people at home will be felt in their strength to carry on war abroad. It is thought that Long Island Sound, as well as Chesapeake Bay, may be protected by active steam batteries. The Bay and Sound being kept free and open, this communication becomes a part of the chain extending from the seat of government in New Hampshire to the southern states, and ultimately to the western states.

The States contiguous to Massachusetts have an immediate interest in this improvement; by it their intercourse with the city of Boston would be by water carriage, and Connecticut would have the choice of the two great markets for all produce. Indeed the interior of the state of New York is not without an interest in this facility, of communication, with a place already supplied circuitously with flour in some measure from thence.

The manufactories of iron and cotton in Rhode Island, and between that state and Boston, supply, at this time, a transportation estimated at forty thousand tons.

The description of this route may be briefly made. The entrance of a canal in this place would be *twelve miles* from the navy yard; thence to the tide on Taunton River, *twenty four miles*; thence, by sloop navigation to Newport, *forty miles*; the whole 76 *miles*.

Ascending the valley of Weymouth river, the summit ground at the distance of about ten miles, is found to be in Howard's meadow, 133 feet above high tide; from thence the country declines gently to the tide near the course of Taunton River. The supply of the canal will depend upon streams which issue from certain large ponds. Im-

mediately on the proposed line we have Braintree Great Pond, but it is twenty-three feet five inches below the summit. It will be necessary to reduce the summit level to a conformity with this source of supply. It discharges, per second 25.14

Weymouth Great Pond, 507 *areas*, had, at this time, been drawn down by mills, and discharged only - -	2.50
Cranberry Brook - - - - -	2.50
Trout Brook on the south, estimated - - -	5.00
Feet, -	35.14

But there are other ponds in this part of the country which are probably at such elevation as to co-operate with these. Those already mentioned are capable of being raised and made reservoirs. It is always safe and of certain effect to raise the surface of *natural* reservoirs. There is a rational probability than an increased pressure will not cause escapes to appear.

The general aspect of the ground was strikingly favorable to a canal, and the terminations of it may be easily made in *deep water*, so as to avoid waiting for tides.

The cursory view which the Board had only an opportunity of taking, left an impression of the great utility of this work, if it can be effectuated.

A general and thorough survey appears to be wanting, before this canal can be considered practicable on a scale commensurate with the national purpose.

All which elucidations and explanations are most respectfully submitted, by

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