ying broken up in the bed of the river, together with such further drilling and blasting as may be possible from the application of available funds, after setting aside a sufficient part for the work of dredging the rock. It is expected that a considerable part of the excavated rock can be utilized in the pier-work at Sturgeon Bay and Two Rivers Harbors.

A continuation of drilling, blasting, and dredging by hired labor is contemplated during the fiscal year 1880–'81, together with such repairs as may be required on the piers.

Money statement.

July 1, 1878, amount available	$9,257 14	
Amount appropriated by act approved March 3, 1879	7,000 00	
		$16,257 14
July 1, 1879, amount expended during fiscal year		7,744 13
July 1, 1879, amount available		8,513 01
Amount (estimated) required for completion of existing project		72,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1881.		40,000 00

REPORT OF MR. L. Y. SCHERMERHORN, ASSISTANT ENGINEER.

DECEMBER 20, 1878.

SIR: I have the honor of submitting the following report of operations at Ahnepee, Wis., during the season of 1878.

In accordance with the project for the improvement of the harbor, approved by the Board of Engineers, December 15, 1875, Report of Chief of Engineers, 1876, II, page 354, the plan for the season's work was a continuation of drilling and blasting to the extent of available appropriations; the broken rock to be removed by the United States dredge at a subsequent season. The most important plant to be derived from the completed work at Eagle Harbor, and the work to be carried on by hired labor.

EXTENT OF OPERATIONS.

Preparations began June 15; drilling commenced July 1 and continued to November 2.

The area of work extended from the upper limits of operations in 1876 to the bridge, and from the lower limits of 1875 and 1876 towards the mouth of the river, thereby making continuous the work of 1875, 1876, and 1878, or from the bridge downwards for a distance—measured along the center line of proposed channel—of about 460 feet, of which 200 linear feet belongs to the work of 1875 and 1876 and the rema in der to the season of 1878.

MODE OF OPERATIONS.

From the experience gained at Eagle Harbor, the advantages of drilling from a fixed platform were so manifest that, practically, the same plan was adopted at Ahnepee. The arrangement of this platform has been described in detail in reports on Eagle Harbor, Reports of Chief of Engineers, 1876 and 1877; the only modification was an increased size of platform, viz, from 33 by 33 feet to 33 by 50 feet. The engine, boiler, and steam-drill previously used at Ahnepee being too small for the proposed work, they were utilized at Two Rivers, and replaced by the larger machinery from Eagle Harbor, thereby making nearly all of the appropriation available towards working results.

The holes having been drilled in groups of about twenty, were charged with dynamite and simultaneously fired by electricity. A scow placed alongside of drilling platform carried the hoisting-engine, derrick, and boiler, furnishing steam to two No. 1 Ingersoll drills.

The general mode of operation was substantially that previously adopted at Eagle Harbor.

DETAILS OF DRILLING.

A deposit of sand, mud, gravel, and sawdust covered the limestone rock to a depth of from 1 to 6 feet; this was excluded from the drill-hole by inserting—after the withdrawal of the first steel—a piece of light wrought-iron pipe, 3 inches internal diameter, and long enough to reach from above the surface of the detritus down into the

rock about 1½ feet, or the distance penetrated by the first steel. These pipes were withdrawn after the holes were loaded. The immediately successive drill-steels, with bits reduced to 2¾ inches diameter, passed through the above pipe.

About 10 feet below water-surface a horizontal stratum was found, consisting of loose angular fragments of rock, and having a thickness of from 9 to 18 inches; the exclusion of these rock fragments from the drill-hole was necessary, and was accomplished as follows: As soon as the drill-steel—drilling a hole 2¾ inches in diameter—had passed slightly below the bed of this seam it was withdrawn, and a piece of gas-pipe, 2 feet long and 2½ inches internal diameter, was dropped into the hole and driven to the bottom, thereby scaling off the loose rock. The successive drill-steels, with bits reduced to 2 inches diameter, passed through this pipe, which was left in the hole and destroyed by the blast. This operation was not without its difficulties, and the delay connected with the successful passage of this seam added largely to the cost of drilling.

The drill-holes were carried to a depth of 17 feet below the plane of low-water, or 5 feet below the bottom of intended excavation. This rather excessive depth was adopted for the following reasons: On account of the detritus covering the rock, and the difficulty of passing the stratum of loose rock, the first 10 feet in depth below the water-surface cost nearly three times as much to drill as the last 7 feet. Hence, by giving the holes this increased depth, it was possible to push them further apart, thereby reducing to a minimum the number of times that these difficulties were encountered.

At first the drill-holes were placed about 7½ feet apart each way; this distance was increased to 9½ feet; a greater increase seemed to result in breaking the rock into masses too large to be economically handled by the dredge.

For further drilling details, reference is made to the "results of season's work."

BLASTING.

Giant powder of Nos. 1 and 2 was chiefly used as the explosive.

The drill-holes were usually charged with the following proportions and arrangement of Nos. 1 and 2, viz: 1 pound of the former to 4 pounds of the latter; one-half of the No. 1 was placed in the bottom of the hole, the No. 2 was then superposed, upon the top of which was placed the remaining No. 1, the last cartridge of which contained the exploding cap and wires; generally the holes were loaded to within less than 2 feet of the surface of the rock, and averaging one-fourth of a pound of No. 1 and one pound of No. 2 per linear foot of drill-hole. Experiments were made in which the proportion of No. 1 was in excess of the above, the results of which cannot yet be determined.

I believe that the dynamites, or high explosives, have a value as disruptive agents directly proportional to their inherent nitro-glycerine, and that black powder, salts of potassa or soda, or anything else added to or constituting the absorbent for the nitro-glycerine, have no value as assistant disruptive agents, but are only useful as absorbents or diluents. But to have alone employed the nitro-glycerine contained in the charges used would have reduced their volume about one-half, thereby placing the top of the charge about 8 feet below the surface of the rock, concentrating the disruptive effort near the bottom of the hole, and breaking the lower part of the rock into unnecessarily small fragments, leaving the upper part in large masses. The use of Nos. 1 and 2 dynamite permits of the distribution of the disruptive energy of the minimum amount of nitro-glycerine along the entire section of fracture, producing a nearly uniform breakage. In shallow holes, or where the necessity of breaking the rock into small masses does not exist, undiluted nitro-glycerine would be more economical.

In placing the cartridges in the drill-holes they should not be subjected to more ramming than just sufficient to bring them into close contact; experience indicating that the breaking up of the cartridges and their admixture with water resulted in a loss of disruptive energy.

Twelve hundred pounds of Hercules powder was used; in this, carbonate of magnesia seems to largely constitute the absorbent. Generally, force had to be expended on the cartridges in getting them into the drill-holes, and as the Hercules powder was very soft and plastic, the cartridges were easily pushed to pieces, allowing the water to exert its solvent effect on the absorbent, and resulting in a separation of the nitro-glycerine from the mass.

When a number of symmetrically-arranged and equally-charged holes were simultaneously fired, a piling up of the broken rock around the central area of the blast resulted; and this tendency seemed to equally obtain both where the rock had been broken by previous blasts on two sides of a new group of holes or where the rock on all sides of the group was solid. It was found that this central upheaval could be prevented by making the charges in the outside holes of a group in excess over the charges for central holes, and about in the proportion of 4:3.

The effect of explosions on adjacent buildings is of interest. The largest blast fired contained 25 holes, charged with an amount of dynamite carrying 330 pounds of nitro-glycerine. Not the slightest injury resulted to buildings but 50 feet from the blast. At another time the explosion in the open air of a small amount of dynamite, carrying less than 10 pounds of nitro-glycerine, broke the glass in windows, and the supposition was that a very heavy blast had been fired. This seems to indicate that as long as the energy of the nitro-glycerine is usefully applied towards overcoming the resistances of the rock, that the residual effect will be too small to produce destructive detonation, even in close proximity to the blast.

Many of the blasts were covered with less than 4 feet of water. From these very large quantities of rock fragments were thrown into the air, while with a covering depth of 10 feet no rock appeared above the water-surface.

The vertical elevation was carefully measured, to which the water was thrown from a blast of 20 holes charged with about 275 pounds of nitro-glycerine, and covering an area of 33 by 50 feet. Over the entire area the water attained an elevation of 40 feet; from this mass ascended a column whose base covered about one-half the area of the blast, to an additional height of 155 feet; while from the center of this column was thrown a spire-like jet to a further height of 20 feet, or a total of 215 feet.

THE AVERAGE LABOR FORCE EMPLOYED.

One master driller, repairing drills and sharpening steels.
One machinist, tending boiler and engine.
Two drill-runners, operating drills.
Two drill-helpers, operating drills.
Two jobbers, sharpening steels, and miscellaneous work.
One watchman, night duty.

RESULTS OF SEASON'S WORK, WITH DRILLING AND BLASTING DETAILS.

Steam-drills employed	No..	2
Hole drilled and blasted	linear feet..	4,466.2
Hole drilled and abandoned	do....	357.1
Holes drilled and blasted	No..	328
Holes drilled and abandoned	do..	51
Average depth of holes drilled and blasted	linear feet..	13.61
Average depth of holes drilled and abandoned	do....	7.0
Depth of blast-holes below low-water	feet..	17.0
Depth of blasted holes below proposed bottom	do..	5.0
Drills sharpened	No..	241
Depth drilled per sharpening	feet..	20
Loss of steel by sharpening and wear	pounds..	73
Gross time during which drilling was in operation, reduced to time of one drill	hours..	1,344
Net time drills were running, reduced to time of one drill	do..	680
Rate of drilling per hour, gross time	linear feet..	3.6
Rate of drilling per hour, net time	do....	7.1
Dynamite used, No. 1	pounds..	1,888
Dynamite used, No. 2	do..	4,574
Area drilled and blasted	square feet..	25,979
Average depth of rock to be removed	feet..	9.3
Average depth of water before blasting, reduced to low-water	do..	3.7
Amount of rock blasted in place and above a plane of 13 feet below low-water	cubic yards..	8,921
Average area covered by each hole blasted	square feet..	79.1
Supposed amount of nitro-glycerine contained in dynamite used	pounds..	3,062
Supposed amount of nitro-glycerine used per cubic yard of rock to be removed	pounds..	0.34

COST OF WORK.

The expenditure for the working season of 1878 was applied as follows:

Machinery and tools	$767 35
Supplies, including dynamite used	3,635 66
Scow-rent and boats	68 00
Freight, storage, and transportation	188 66
Labor, pay-rolls	2,069 40
Superintendence	600 00
	7,329 07

The cost of work is properly divided between two items, viz, drilling and blasting, and in detail was as follows:

DRILLING.

Labor, including all minor details	$1,738 29
Supplies	238 07
Machinery and tools	646 03
Scow-rent and boats	57 12
Freight, storage, and transportation	158 47
Superintendence	504 00
	3,341 98

A cost of 69.3 cents per linear foot of hole drilled, or a cost of 37½ cents per cubic yard of rock in place, to be removed.

BLASTING.

Labor, including all minor details	$331 11
Supplies, including dynamite	3,397 59
Machinery and tools	121 32
Scow-rent and boats	10 88
Freight, storage, and transportation	30 19
Superintendence	96 00
	3,987 09

A cost of 89$\frac{3}{10}$ cents per linear foot of drill-hole blasted, or a cost of 44$\frac{7}{10}$ cents per cubic yard of rock broken; making the aggregate cost of drilling and blasting 82$\frac{3}{10}$ cents per cubic yard, measured in place, or exclusive of superintendence 75$\frac{6}{10}$ cents per cubic yard.

In the the foregoing statements of costs the expenditure for machinery and tools are charged as though these items were no longer available, whereas a large part of such expenditure is applicable towards continuing the work next season. The items of machinery and tools are small on account of the utilization of the Eagle Harbor plant; had this not been available an extra expenditure of about $3,800 would have been required for carrying on the work.

PREVIOUS OPERATIONS.

The extent of previous operations under the superintendence of Assistant Engineer Mr. E. P. North is as follows:

Experimental drilling and blasting of 1875, 5,100 square feet; drilling and blasting of 1876, 15,400 square feet. The dredging of 1877 developed the fact that the rock had not been broken to the required depth, and subsequent soundings indicated that the depth obtainable, reduced to low-water, will not be more than 9 feet, or 3 feet less than the proposed and expected depth. The dredging was mainly directed towards determining the extent to which the rock had been broken, and the cost of its removal, and was not carried to the removal of all broken rock.

The rock seems removable down to the horizontal stratum of loose rock—referred to in a previous part of this report—and it seems possible that the bottom of drill-holes was too near this seam to obtain much breakage below it, but resulted in a dissipation of the explosion along the seam.

It seems probable that the entire area above referred to will require redrilling and blasting, to which further reference is made under "future operations."

FUTURE OPERATIONS.

The total area covered by rock to be removed, under project submitted by Board of Engineers, was 75,000 square feet, of which the operations of 1875 and '76 covered 20,521 square feet, and the operations of 1878, 25.979 square feet, leaving an area of 28,500 square feet upon which no work has been done; over this area the rock to be removed has an average depth of about 4 feet, and if the drill-holes are carried to a depth of 5 feet below proposed bottom, there will be required about 340 holes, aggregating a depth of 3,060 linear feet, requiring about 80 working days, or, with time required to start the work, about 3½ months.

In redrilling and blasting the area of 20,521 square feet, covered by operations in 1875 and 1876, there will be difficulties foreign to those already encountered, and introducing an element of uncertainty in an estimate of time required, viz: it is almost impossible to thoroughly remove the broken rock by dredging, and this loose rock will be an annoying obstacle in starting the drill-holes. Again, the rock to be removed is

more or less shaken or slightly loosened by the superposed blasts, adding further difficulties to the drilling.

In redrilling this area, about 240 holes will be required, aggregating a depth of 2,000 linear feet; adding one-fourth for the above-named difficulties, then this amount of work will require 3 months.

The foregoing estimates of time are based on the employment of 2 drills and the labor force of the past season.

The amount of rock to be removed by the United States dredge is as follows:

	Cubic yds.
Estimate submitted by Board of Engineers	16,000
Additional, by lowering low-water plane 0.7	2,000
Total amount	18,000
Removed by United States dredge in 1877	1,000
Amount yet to be removed	17,000

During the experimental dredging at Ahnepee in 1877 the United States dredge handled in 14 days 3,551 cubic yards of rock, scow measurment; allowing this to be equal to 2,000 cubic yards in place, the dredge handled at the rate of 3,500 cubic yards per working month, which would require $4\frac{8}{10}$ months for the removal of 17,000 cubic yards, or, adding $\frac{1}{4}$ for delays and breakages, say 6 months.

ESTIMATES OF COST.

For drilling and blasting the remaining 28,500 square feet, $3\frac{1}{2}$ months' labor, at $450	$1,575
1,200 pounds dynamite, No. 1, at 75 cents	900
3,600 pounds dynamite, No. 2, at 45 cents	1,600
350 exploders, at 30 cents	105
Scow-rent, repairs, and miscellaneous supplies	1,125
	5,305
For redrilling and blasting the area of 1875 and 1876—20,521 square feet:	
3 months' labor, at $450	$1,350
800 pounds dynamite, No. 1, at 75 cents	600
2,400 pounds dynamite, No. 2, at 45 cents	1,080
260 exploders, at 30 cents	78
Scow-rent, repairs, and miscellaneous supplies	900
	4,008
For dredging 17,000 cubic yards rock in place:	
6 months' dredge-labor and tug-hire, at $650	$3,900
6 months' ordinary repairs and fuel, at $500	3,000
Extraordinary repairs, supplies, and contingencies	2,000
	8,900

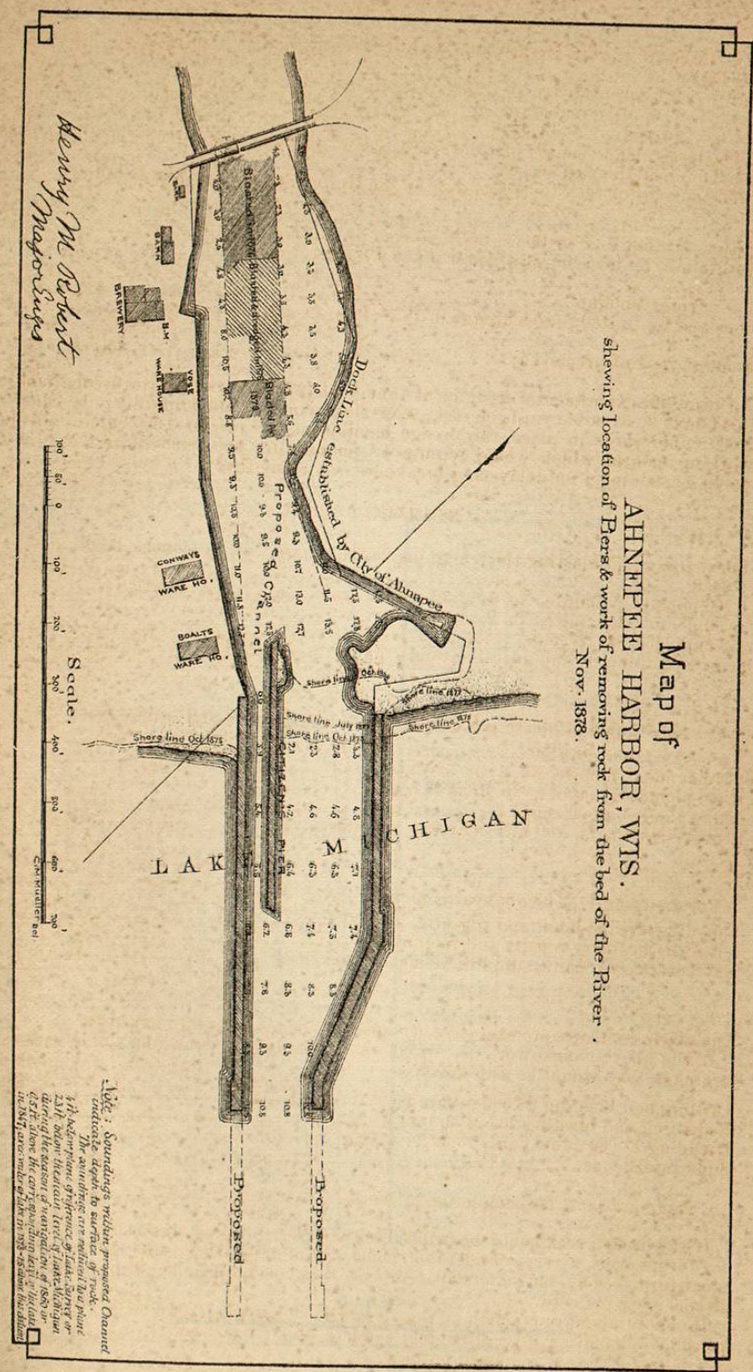
The above estimates are exclusive of superintendence and office expenses.

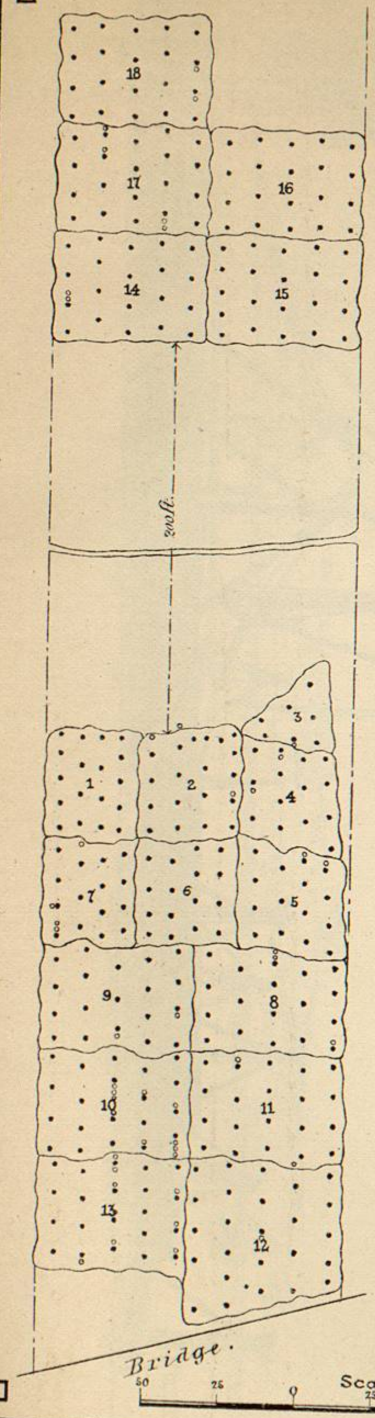
If the above-named work is carried on conjointly and done in a single season the aggregate cost would be as follows:

Drilling and blasting 28,500 square feet	$5,305
Redrilling and blasting 20,521 square feet	4,008
Dredging 17,000 cubic yards rock	8,900
Superintendence	800
Aggregate cost for completion of work	19,013

If the broken rock could be utilized, either as crib-filling, extension or foundation for future cribs, a very considerable economy would result, or a saving from the cost of stone furnished by contractors, if at Ahnepee, of $3 per cord, and at Sturgeon Bay or Two Rivers of $2 per cord.

Probably about one-fourth of the rock will be too finely broken to justify the expense of rehandling after dredging, leaving about 4,000 cords (crib measurement) available for the above-named purpose.





Sketch

shewing blasts in bed of the River at

AHNEPEE HARBOR, WIS.

during the working season of

1878.

• Holes drilled & blasted.

○ " " & abandoned.

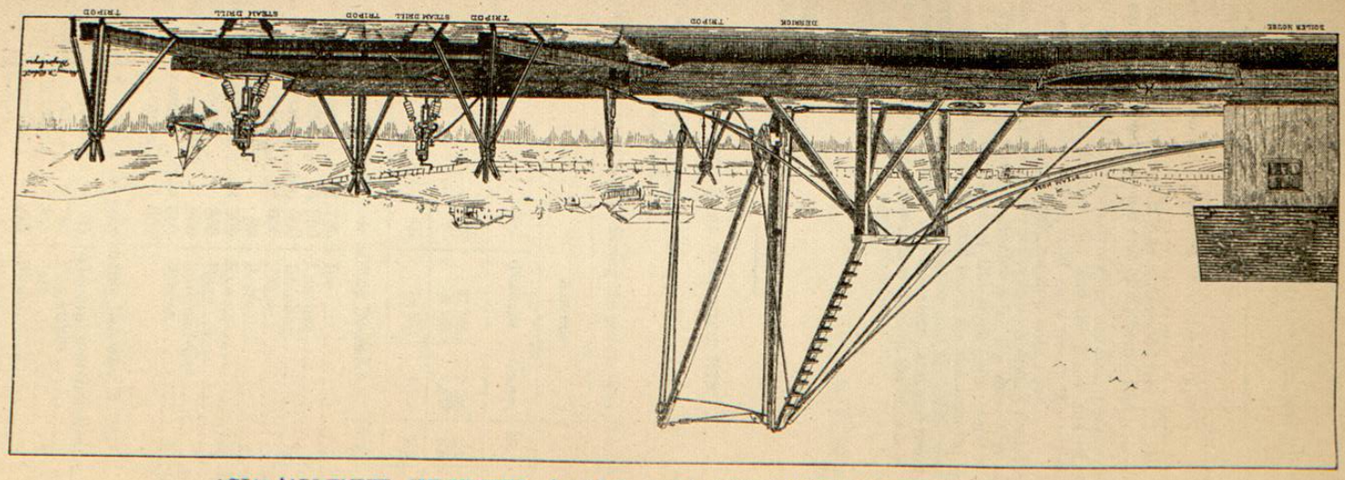
Summary.

Blasts	Total depth drilled in rock	Average depth drilled in rock	Holes blasted	Holes lost	Aggt. depth of drilled holes lost	Average depth of hole from water surf.	Depth of water reduced to gauge	Area blasted	Height of rock blasted in place and above a plane 13 ft below low water	Amount of rock blasted in place & above a plane 13 ft. below low water
№	Ft.	Ft.	№	№	Ft.	Ft.	Ft.	Sq.ft.	Ft.	Cub.yds.
1	279.2	15.51	18	0	0.0	16.9	1.4	1089	11.6	467.8
2	267.1	14.27	19	3	19.0	16.7	2.4	1089	10.6	427.5
3	97.4	13.91	7	1	5.5	16.6	2.7	495	10.3	188.8
4	202.9	14.50	14	2	14.0	17.1	2.6	1089	10.4	419.5
5	200.8	14.34	14	2	16.0	17.0	2.7	1089	10.3	415.4
6	234.8	14.63	16	4	27.8	16.9	2.3	1089	10.7	431.5
7	227.4	15.16	15	4	35.0	17.1	2.0	1089	11.0	443.7
8	267.1	14.06	19	3	18.0	16.7	2.7	1650	10.3	630.0
9	287.2	15.11	19	2	10.2	17.5	2.4	1650	10.6	636.6
10	292.2	14.61	20	10	59.4	16.9	2.3	1650	10.7	650.2
11	284.0	14.20	20	2	12.0	17.0	2.8	1650	10.2	625.0
12	330.2	13.21	25	1	12.0	17.2	4.0	2450	9.0	816.0
13	307.9	14.66	21	9	67.7	17.2	2.6	1650	10.4	632.0
14	280.0	14.00	20	2	12.0	17.5	3.5	1650	9.5	522.5
15	211.8	10.10	21	0	0.0	17.5	7.4	1650	5.6	342.0
16	203.4	10.17	20	0	0.0	17.3	7.2	1650	5.8	348.0
17	246.9	12.34	20	4	27.0	17.7	5.4	1650	7.6	465.0
18	245.9	12.25	20	2	21.5	17.7	5.5	1650	7.5	460.0
	4466.2	13.73	328	51	357.1	17.1	3.43	25979	9.6	8921.5

O. M. Mueller, del.

Henry M. Robert
Major Engrs.

Scale.
50 25 0 25 50' 75 100'



VIEW OF DRILLING PLATFORM AND SCOW, AHNEPEE HARBOR, WIS.

PRESENT CONDITION OF HARBOR.

The present channel depth of water between the piers is as follows:

	Feet.
At entrance	12
100 feet from entrance	10
200 feet from entrance	9.5
300 feet from entrance (opposite lower end of Citizens' Pier)	7.0
400 feet from entrance	6.5
500 feet from entrance (opposite middle of Citizens' Pier)	6.0
700 feet from entrance (opposite upper end of Citizens' Pier)	8.0

indicating that the results of previous dredging are nearly obliterated.

The sandspit between the Citizens' Pier and the inner end of north pier has been removed by the action of the waves, and as a result the bayou, which had been dredged to a depth of 14 feet, has nearly refilled with sand.

The city authorities of Ahnepee have recently established dock-lines along both sides of the river. These lines generally coincide with the shore-line and existing docks, and are placed so far from the limits of the work being done by the United States that the expense which individuals would incur for the removal of the large quantities of rock lying between the work in progress and the established dock-lines would involve an investment with doubtful remuneration, and as a result nothing will probably be done by private enterprise towards widening the channel.

All of which is most respectfully submitted by

Your obedient servant,

L. Y. SCHERMERHORN,
Assistant Engineer.

Maj. H. M. ROBERT,
Corps of Engineers, U. S. A.

COMMERCIAL STATISTICS, 1878.

Ahnepee Harbor is in the collection-district of Milwaukee, Wis. The nearest lighthouse is at Twin River Point, Wis.

Arrivals and departures of vessels during the year ending December 31, 1878.

	Arrivals.			Departures.		
	No.	Tonnage.	Crews.	No.	Tonnage.	Crews.
Steamers	127	37,611	2,205	127	37,611	2,205
Sailing-vessels	285	36,041	2,629	285	36,041	2,629
Total	412	73,652	4,834	412	73,642	4,834

Exports during the year ending December 31, 1878.

Bark	cords..	1,785	Ice	tons..	3,000
Barley	bushels..	15,000	Leather	sides..	2,000
Barrel-hoops	number..	100,000	Lumber	feet, b. m..	200,000
Brick	do....	20,000	Pease	bushels..	5,000
Butter	tons..	80	Posts	number..	125,000
Eggs	dozens..	4,500	Rye	bushels..	500
Fish	packages..	800	Rags	bales..	400
General merchandise	tons..	800	Railroad-ties	number..	375,000
Shingles	number..	150,000	Wheat	bushels..	125,000
Wood	cords..	5,000			

Imports during the year ending December 31, 1878.

Beef	barrels..	95	General merchandise	tons..	2,500
Flour	do....	2,750	Hay-rakes	number..	75
Plows	number..	350	Salt	barrels..	2,000
Pork	pounds..	275	Whisky	do....	150
Reapers	number..	50	Sugar	do....	600
Seeders	do....	95			

The above information was obtained from Mr. H. D. Wing.