The Building of the Schuylkill Navigation System, 1815–1828

Edward J. Gibbons
Siena College

When in 1825 Philadelphia leaders debated the kind of transportation system Pennsylvania should build to compete with New York's Erie Canal for western trade, they decided on a statewide canal system rather than a railroad. They were aware of the advantages of railroads but had no experience with them.[1] Helping to influence the decision was the successful completion of slackwater navigation on the Schuylkill River, extending from Philadelphia to the anthracite coal region in northeastern Pennsylvania.[2] It was now becoming a very profitable operation.

This article will describe the building of the Schuylkill Navigation during the years 1815-1828.[3] The Schuylkill system, one of the most successful internal improvement projects, opened the upper reaches of the Schuylkill River and contributed to the general economic development of the entire Schuylkill River valley. By making available the vast resources of anthracite coal region, it fostered the growth of eastern cities and the development of the iron and steel industry.[4] The project served as an important training ground for engineers.

In Great Britain canal building was an activity closely associated with the emergence of purely "civilian" (civil), as distinct from military, engineers in the mid-eighteenth century. Though canals interested colonists in America as a means of opening the interior of the country, no major canal building took place before the Revolution. America had few engineers. David Rittenhouse (1732-1796), astronomer, mathematician, and sometime engineer, and Christopher Colles (c.1738-1816), an Irish-born engineer who came to America in 1765, promoted and worked on canal projects. During the Revolution Americans recruited military engineers in France, but after the war most of them returned home.[5]

In the years after independence promoters urged internal improvements such as roads and canals, to help unify the nation. By 1800 over seventy companies were chartered to improve inland navigation. States had no qualms about investing in such projects, but there were limits on the amount that could be raised through taxation and not that much private capital was available, so financial resources were often inadequate. The shortage of professional engineers was another difficulty. A number of engineers would come over from Europe, but the shortage would continue.[6]

Some engineers on the canals were professionally trained in Europe, but most of the canal builders learned on the job. Many of them had other

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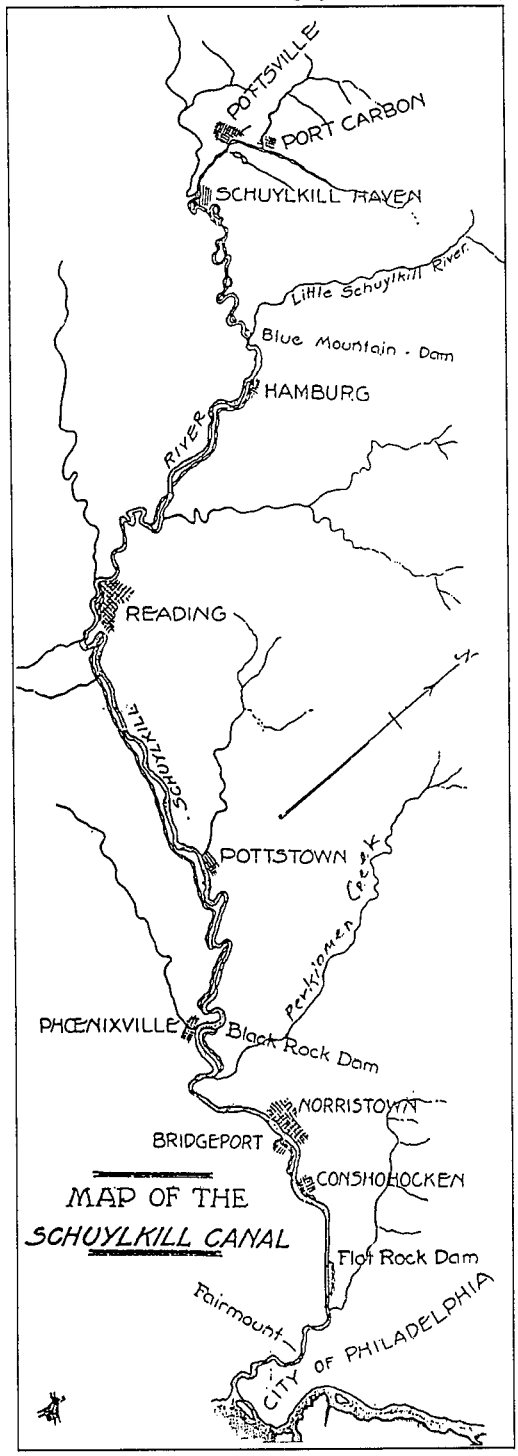

Map of the Schuylkill Canal

occupations; they were surveyors, bridge builders, builder-contractors, or architects. Two English engineers significantly aided canal building in America. William Weston (c.1752-1833), in America from 1793 to 1800, and Benjamin Latrobe (1764-1820), who settled permanently in America in 1796, served as engineer or advisor on many projects. They also trained other engineers.[7] Other European-trained engineers included Christopher Colles, John Christian Senf, a Swedish-born engineer, and Robert Fulton (1765-1815), who studied in England. Fulton was probably the best native-born American engineer, but although he did promote canals, he was mainly associated with steamboats after his return to America in 1806. Other important early canal builders were Ariel Cooley, Benjamin Prescott, Robert Brooke, Loammi Baldwin, and Benjamin Wright.[8] At the end of the War of 1812 no substantial pool of trained engineers existed; there were about thirty men who could be called engineers of a sort.[9]

A national movement for federal aid to internal improvements developed as settlement expanded westward. Recognizing their importance to the nation, Thomas Jefferson as President suggested using surplus tariff revenues for internal improvements once the national debt was paid off, although he believed a constitutional amendment was necessary. Secretary of the Treasury Albert Gallatin's *Report on Roads and Canals,* a comprehensive report on the transportation system of the country and its needs, issued in 1808, called for financing road and canal projects believed to be in the national interest. However, the coming of the crisis which then led to war in 1812 prevented implementation of a federal program of aid.[10]

Jefferson also supported creation of a professional engineering school. Congress established a military academy to train engineers at West Point in 1802. Jefferson intended it to supply the nation with civilian as well as military engineers.[11] But only after the war did West Point make an impact upon engineering.[12]

At the end of the war despite the longtime interest in canals only about one hundred miles of canal existed in America, partly because funds and engineers were in short supply, but also because most enterprises were not very successful. Navigation had been improved with short canals, locks, and other devices on a number of rivers, including the James River in Virginia, the Potomac River between Maryland and Virginia, the Susquehanna River in Pennsylvania, the Mohawk River in New York, and the Connecticut and Merrimack rivers in Massachusetts. Three longer canals had been built to link bodies of water: the Santee Canal in South Carolina, twenty two miles long, connecting the Santee River with the Cooper River; the Dismal Swamp Canal between Virginia and North Carolina, also twenty two miles, joining the Chesapeake Bay with Albemarle Sound; and the Middlesex Canal in Massachusetts, twenty seven miles, connecting the Charles River with the Merrimack River.[13]

Internal improvements in America blossomed after the War of 1812. The

years from 1815 to 1860 saw a revolution in transportation. Improved roads, canals, steamboats, and railroads drastically reduced the cost of the movement of goods and people, and made it much easier. They contributed to the settlement of the West, to the growth of manufacturing, and to the extraordinary expansion of internal trade. It made possible specialization by regions as well as an increasing division of labor. Internal improvements were especially important recipients of new investment during these years.[14]

Canals played a major role in the transportation revolution. Between 1815 and 1860 as over 4,254 miles in canal systems were completed on an investment of $188.2 million.[15] These systems improved navigation from the interior to tidewater in the eastern states, connected the eastern states with the West, and in the West connected the Great Lakes with the Ohio or Mississippi rivers. They reduced the costs of transportation drastically, much more so compared to overland transport than railroads did vis-a-vis canals. The other benefits of canals, Harvey Segal points out, include those resulting from the construction of canals: new jobs and income, new skills acquired by the labor force, new entrepreneurs—the construction contractors, activities of quarrying and lumbering, and the enhancement of banking in outlying areas by the large transfers of funds from cities; and those resulting from the completed canals, if successful: stimulation of commercial agriculture and industrial activities and the rapid growth of cities along their banks. After 1840 canal building declined, partly due to costs, partly due to the competition of the railroads, and partly because most routes had been developed.[16]

States and private sources would supply most of the funds for internal improvements. In the glow of postwar enthusiasm President James Madison put forth a nationalistic program in December, 1815, which included federal aid to internal improvements, if there was an appropriate constitutional amendment. John C. Calhoun's Bonus Bill for a federally financed national program of internal improvements passed, despite interregional differences, but Madison reluctantly vetoed the measure, March 3, 1817, since it lacked constitutional authorization. Thereafter, the federal government granted some aid from time to time, but never adopted a national program.[17]

New York state undertook to finance the construction of the Erie Canal in 1817 after hopes ended for federal aid. The success of the Erie was largely responsible for stimulating the canal building boom. The Schuylkill Navigation, the project in Pennsylvania to improve the Schuylkill River up to the anthracite coal region, with which this article deals, was authorized before the Erie Canal and was only indirectly influenced by it.[18]

FOUNDING OF THE SCHUYLKILL NAVIGATION COMPANY

Surveys of possible routes for roads and canals sponsored by the American Philosophical Society and others before the Revolution and numerous proposals

for improvements developed afterwards by such as the Society for Promoting the Improvement of Road and Inland Navigation, organized in 1789, led mainly to the building of turnpikes in Pennsylvania. Its success in building turnpikes to the West challenged New York to develop the Erie Canal. The Pittsburgh Pike ranked with the National Road as a major road to the West. Pennsylvania had completed over 1,800 miles of turnpike by 1821.[19]

Improving the navigation of the Schuylkill River and connecting the Schuylkill with the Susquehanna River in Pennsylvania had been a part of the proposals and surveys for internal improvements since the early 1760's, when the legislature investigated improving the Schuylkill River and David Rittenhouse and William Smith (1727-1803), provost of the College of Philadelphia, drew a line for a canal connecting the Schuylkill with the Susquehanna River. During the Revolution Major Manuel Eyre surveyed the Schuylkill from Reading down to Valley Forge in the winter of 1777-1778. Not until 1791-1792 did the American Philosophical Society's promotion finally lead to the chartering of two navigation companies: one to make the Schuylkill navigable from the Delaware River to Reading, some sixty miles from Philadelphia, and the other to connect the Schuylkill at Reading with the Susquehanna, a distance of about forty five miles. These companies, for whom engineer William Weston worked, completed in three years a combined total of about 15 miles of canal before they went bankrupt. On the Schuylkill River several miles of ditch were dug below Norristown.[20]

Interest in improvement of the Schuylkill revived after 1810. In 1811 the Union Canal Company, an amalgamation of the earlier companies, was chartered. Shortly thereafter in 1812 Josiah White and Erskine Hazard, partners in a wire factory at the Falls of the Schuylkill, who had experimented with anthracite, or "stone," coal and recognized its potential value, first proposed the project to improve the Schuylkill River beyond Reading up to the anthracite coal region. The proposal did not get through the legislature during the 1812-1813 and 1813-1814 sessions, partly because of doubts about the efficacy of hard coal as a fuel, but also because of the opposition of the Union Canal Company supporters, one of whom was William J. Duane in the House of Representatives. They believed that this project conflicted with their own, while their company, which was requesting aid from the state without success, made no progress.[21]

At the next session in December, 1814, Cadwalader Evans, Jr. (1762-1841), a backer of the Schuylkill project, replaced Duane as Philadelphia representative in the House. There was no reference to the Union Canal Company in either the House or the Senate discussions. Evans and Nicholas Biddle (1766-1844) of Philadelphia, then in the state Senate, with the support of Philadelphia bankers guided to passage the bill "to authorize the Governor to incorporate a Company to make Lock Navigation on the Schuylkill River" on March 2, and the Governor signed it into law on March 8, 1815. The corporation was to be capitalized at $500,000 with 10,000 shares to be sold at fifty dollars each.

Subscribers could pay in monthly installments of at least five dollars per share of stock purchased.[22]

The project was to make the Schuylkill River navigable from the tidewater at Fairmount (then called Mount Morris, later "Fair Mount") starting from the Lancaster Schuylkill Bridge (Callowhill Street) up to Mill Creek on the east, or main, branch of the river in Schuylkill County. The bill originally set the terminus at Potts' forge, two and a half miles below Mill Creek, but before passage the terminus was changed to Mill Creek. The distance was estimated to be 114 miles.[23]

Work was to begin within three years of the passage of the act and to be completed within fifteen years. It would create a slackwater navigation, combining the use partly of the river and partly of canal. Dams regulated the flow of the river and create slackwater pools in order to achieve adequate depth. Locks and canals bypassed vessels around the dams or around natural falls and rapids. Locks by law, as amended February 8, 1816, were required to be not less than eighty feet long and not less than seventeen feet wide. Canals built at dams were short, often less than a mile long; longer canals were dug where conditions of the river required it.[24]

Upon certification by the state the company could collect tolls on completed locks. To insure completion of the entire navigation, the original legislation required work be done simultaneously at both ends of the river, specifying that improvements on the lower section begin "at or near the lower falls" and that those on the upper section begin "at or near the Borough of Reading." However, the amendment in 1816 permitted the company to begin improvement of each section wherever it desired, provided that the money spent be divided equally between the sections. Originally, tolls could not be collected at one end of the navigation before they could be collected at the other end, but the 1816 supplemental act allowed tolls to be collected at either end, whenever locks would be completed.[25]

The company could take land along the route for right of way, for gatehouses, and other necessary purposes in return for reasonable compensation. (It paid landowners on the site of one canal at a rate of eighteen cents per cubic yard of canal dug.) The act prohibited the company from engaging in banking activity. Involvement in transportation itself and the acquisition of coal lands were not authorized and a supplement to the law in 1821 explicitly prohibited these activities.[26]

Governor Simon Snyder granted the Schuylkill Navigation Company a charter on September 2, 1815, after a hundred or more citizens had subscribed 2,000 shares, as required by the act. A month later, the stockholders elected Cadwalader Evans, Jr., president, Clement C. Biddle, secretary-treasurer at an annual salary of eight hundred dollars, and a board of twelve managers. Biddle

was succeeded in January, 1817, by Thomas Harper. The home office was to be located in Philadelphia.[27]

At least some of the company officials had engineering knowledge or experience. Evans, a prominent political figure first in Montgomery County and then in Philadelphia, had experience as a surveyor and an engineer. Among the managers, Manuel Eyre had surveyed the Schuylkill during the Revolution. Both Lewis Wernwag (1769-1843), German-born but a citizen and a noted bridge builder, who invented nail machinery and experimented with "stone" coal at the Phoenix Works on the Schuylkill, and Daniel Dreibelbis, of a pioneer landed family on the upper Schuylkill River, undertook engineering projects for the company.[28]

The engineer was the important figure on the project. He first examined the area, taking measurements of elevations and grades ("taking the levels"), as well as distances and lines, and estimating costs. Once his report was accepted, he drew up plans. He advised on the timetable and the making of contracts. Once the work was contracted for, the engineer became a superintendent. The engineer and/or other superintendents of the company measured the amount of work done and the amount to be paid as the work progressed, and then inspected and approved the completed work.[29]

Contractors were assigned the work of building dams, canals, and locks. The company would permit its engineers and even members of the Board of Managers to become contractors, which was troublesome since the engineer or the managers were supposed to judge a contractor's work. The shortage of skilled canal builders made it necessary. Contractors were to complete their works at a specified time and to guarantee their works for a certain period, which varied with the contract. One proposed contract for the upper section called for keeping the dam repaired forever and the locks and canals for ten years; another called for guaranteeing the dam for three years. The contractors could subcontract out parts of their contract.[30]

The working season on the Schuylkill River usually extended from when the ice began to melt in late winter to when cold weather set in and iced up the river late the next fall. Contractors were principally responsible for hiring and paying the workers who dug the ditches, sawed and packed the timber, and chiseled and placed the stone from nearby quarries. In the early years the company had difficulty finding skilled workers.[31] But there seemed to be no problem getting common laborers. In 1818 the board rejected a request to hire "German or Irish passengers," suspecting the reliability of immigrant workers, because workers could be hired "in the ordinary way." A depression, beginning in 1819 and lasting through the early 1820's, made it relatively easy to attract labor. President Evans had not too favorable an opinion of workers generally. Referring to laborers in Schuylkill County, he warned, "many of the people in that country are idle, dissipated, and unprincipled. Perfect eye servants, they will

come late in the morning and go early in the afternoon and do little when they are on the ground, unless your eye is constantly upon them. . . ." With them the contractor must be "very strong handed."[32]

The company faced several persistant problems. One was finding, hiring, and then keeping an engineer. Once hired, the engineer often did not remain long, because of conflicts with the company or because of the attraction of other projects. Obtaining skilled personnel at all levels was difficult. Raising funds would remain a preoccupation, because costs always ran higher than expected. Sometimes this was due to unforeseen circumstances of terrain or weather, but also because the contractors often cost more than they should and did their work poorly. The requirement of simultaneous construction on both sections of the river made it difficult to appropriately supervise widely separated projects.[33]

PHILADELPHIA TO PERKIOMEN CREEK; POTTS' FORGE TO HAMBURG

To initiate the project in 1815 the company first sought information on improvements in progress elsewhere. It received an account of the work done on the Mohawk River in New York from Thomas Eddy, a director of the company involved in those improvements and a member of the commission promoting the Erie Canal. Members of the Board of Managers went to investigate the works on the Connecticut River in Massachusetts.[34]

Ariel Cooley advised the company officials about the Connecticut River improvements. Cooley, who had constructed locks on the Connecticut River as well as on the James River in Virginia, now had contracted to keep the canal at South Hadley Falls in repair and to take tolls in return for a quarter of the tolls for fifty years. He had just completed another dam across the Connecticut River.[35]

At the company's request Cooley came down to survey the lower part of the Schuylkill in the autumn of 1815 and then examined its entire length in April, 1816. He found the greatest obstructions to navigation to be at the lower end between Spring Mill and the tidewater and at the upper end below Mill Creek. The rest of the river was relatively free of obstructions and, he believed, could be improved by wing dams and sluices rather than dams and canals, except where it would be useful to produce water power.[36]

The company wanted to hire Cooley immediately to superintend the works, along with Thomas Gould, who seems to have worked on the Mohawk River improvements, but sufficient funds were not yet available. The Board of Managers offered Gould $1,200 per year. Cooley offered to do improvements at Flat Rock at the lower end of the Schuylkill for $90,000 (including $15,000 in stock), but the company could not yet afford such a large scale operation.[37]

The company undertook smaller projects during 1816. On the lower end of the Navigation it contracted in August with Josiah White, who was a stockholder, to build a dam, canal, and locks at the Falls of the Schuylkill in return for

the water power for his mill. At the upper end the company contracted with Lewis Wernwag to build improvements at the John Potts' forge, the terminus stated in the original draft of the enabling legislation, where Pottsville was laid out in 1816. By the end of the year White had completed his works and Wernwag almost so.[38]

The Schuylkill Navigation Company and other internal improvement companies requested state aid in advancing their projects. After the failure of the federal aid movement, the Pennsylvania legislature on March 24, 1817, agreed to purchase stock in the companies. The State purchased 1,000 shares of the Schuylkill Navigation Company stock at par, or $50,000 worth. Although only half the amount requested, it enabled the company to begin full-scale operations.[39]

Expecting the state aid, the company had hired Ariel Cooley as its engineer in January, 1817. He served in that capacity until March, 1819, and continued to do contracting work with the company into 1821. A number of assistants helped superintend projects. Charles Carey, Jr., assisted Cooley in superintending work on the upper section during 1818.[40]

Lewis Wernwag contracted to do improvements from John Potts' forge down some five or six miles to below Schuylkill Haven, where the west branch of the Schuylkill flowed into the main or east branch of the river. The company also contracted for dams just below Wernwag's contract. Cooley himself contracted to improve the lower section at Flat Rock Bridge for $82,500. The contracts were to be completed by the end of 1818.[41]

To raise funds and stimulate support, the company widely publicized the enterprise, by such means as giving broad distribution to Evans' address to the stockholders in May, 1817, describing the advantages to be gained from the improvements. He touted the many resources of its upper reaches: clay for bricks, marble and limestone for building, wheat and other grains, flaxseed, "stone" coal for heating, and the potential water power for industries and communities. By the end of 1817 only a little over half of a subscription of 3,545 shares, some $94,000, had yet been paid. The state itself had made only partial payment.[42]

In the summer of 1818 Cooley and a committee of the board, including Wernwag, considered other projects to be undertaken when funds were available. The board decided on improvements at Lewis's Falls, several miles below Reading on the lower section, and on the upper section at and below the southern foot of Blue Mountain at the mouth of the Little Schuylkill, about sixteen miles below Potts' forge. They projected the remainder of the lower section to be improved with only partial, or wing dams, and sluices, but strenuous objection to the impermanence of such improvements led the company ultimately to construct full dams with locks and canals. They also considered improvements below the Falls of the Schuylkill.[43]

During the year the company began offering conditional subscriptions, which meant that full payment would be dependent upon completion of the system. Its financial report to the legislature in December 1818 showed that almost all its stock (9,872 shares) had been purchased, but only 41 percent of the value, some $200,000, had yet been paid to the company.[44]

White's improvements at the Falls of the Schuylkill produced the first tolls during 1818, amounting to $233. Meanwhile, White had become dissatisfied with the company management and, believing he could get coal more cheaply by way of the Lehigh River, he departed. He launched another ultimately successful navigation project, the Lehigh Navigation Company, chartered in March, 1818. Early in 1819 White sold the dam and water power rights at the Falls of the Schuylkill to the City of Philadelphia.[45]

Cooley's Flat Rock improvements, a dam, five locks, and a two-mile canal, were completed on schedule and on November 7, 1818, Cooley entered into a new contract for $100,000 to do the improvements at the Little Schuylkill and at Lewis's Falls, together with those at Matson's Ford, several miles above Flat Rock.[46]

During 1817 and 1818 Wernwag measured levels for the company and participated in the planning for future projects, but his own project by the summer of 1818 was not progressing well.[47] In July, 1818, criticism had surfaced: "... [the board] observe with mortification and regret ... the backwardness of your work...." and "wish you to comply with your instructions...." A committee found the work "not in good order" in early December. Wernwag then made Daniel Dreibelbis his agent to finish the contract.[48]

Wernwag last attended a meeting of the board in March, 1819. He moved to Conowingo, Maryland, to build a bridge. When his contract had not been completed by April, 1819, the board accused him of negligence in getting the work done and of ignoring the criticisms of his work: "... you obstinately persevered in a course, intended to promote your interest, although at the expence [sic] of your reputation as an engineer and a mechanic." Evans later referred to "the unfaithfulness of the workmanship." Wernwag eventually would be thought of more favorably; in 1825 he had a new canal boat named after him on the Schuylkill Navigation. His successful career as a bridge builder continued until his death in 1843.[49]

Meanwhile, the company contracted for other improvements on the upper section from below Schuylkill Haven down to the Little Schuylkill River. It accepted a proposal to tunnel a canal through a low hill on the western side of the river, some three miles from Orwigsberg. This was the company's most ambitious undertaking. Jay Hare states that, but for the interest in building the first tunnel for transportation purposes in America, tunneling could have been made unnecessary by laying out the canal some one hundred feet farther westward. The tunnel project, entailing a 450-foot long tunnel, through which

flowed a canal with three locks, about a mile in length, which George Duncan planned and supervised, would be completed by the end of 1821.[50]

Fifteen locks were completed by early 1819.[51] The tolls set for the outlet of the Flat Rock Canal and at the Falls of the Schuylkill were twenty cents per ton on coal and stone, forty four cents per ton on all other classes of freight, and six and a quarter cents per lock on pleasure boats. Lockkeepers were hired to tend the locks and sometimes to collect tolls, though usually someone else collected tolls.[52]

Ariel Cooley gave up his position as the company's engineer at the end of March, 1819. Thomas Oakes (?-1823), who offered his services at $2,000 a year, replaced him. From Staffordshire, England, and at the time residing in Bloomfield, New Jersey, Oakes had a good reputation as an engineer and surveyor. He continued with the company until his death in 1823. When Oakes assumed his position in April, Cooley helped him examine the works on the Navigation.[53]

Expecting to deal mostly with the work being done on the upper section of the river, Oakes had his office, and a clerk, in Reading. Evans advised, "As these works are very distant from the residence of the Managers, much discretionary power as to the superintendence, the necessary contracts, and the execution of the work must be vested in you."[54]

Oakes was instructed to begin by inspecting the works on the upper section, especially the works of Wernwag, which had been assigned to Dreibelbis. He was to get Dreibelbis to complete Wernwag's contract immediately, or Oakes was to do it himself. Oakes took it over in May and finished it. The works covered a distance of about five miles, including four dams, locks, and about three miles of canal, overcoming a fall of about a hundred feet.[55]

On the lower section the company in June agreed that the City of Philadelphia could build a dam at Fairmount below the Falls of the Schuylkill (which would be submerged by the new dam) in return for the water power for its new water works. Cooley agreed to build it for $150,000. In July Daniel Thomas contracted to build improvements at Norristown; the company engaged Thomas George at fifty dollars per month to superintend the works. Completion of the entire Navigation was envisioned by the end of 1820, at least by the end of 1821.[56]

The Matson's Ford dam was finished in September, 1819, creating a slackwater pool of about three miles up to the Swedes' Ford at Norristown and a three-quarter-mile canal with three locks was completed sufficiently in December so that boats could pass through the locks. The Norristown dam, completed by December 1, created a slackwater pool extending over four miles upriver to Catfish Island.[57]

Toward the end of the 1819 season, Cooley's relations with the company deteriorated. The board believed construction was not being carried out according to contract. Harper, the secretary treasurer, referred to a "shameful deception which was attempted ... at Lewis's Falls...." The Flat Rock works were

considered defective. We do not have Cooley's response to these allegations except that Cooley argued that some parts of the contract just could not be completed according to the original plans. When the company and Cooley signed a new agreement, December 15, 1819, it provided for closer supervision.[58]

The Swedes' Ford Canal opposite Norristown, nearly three quarters of a mile long with three locks, was finished by February, 1820, the opening of the season, and navigation was now complete from Philadelphia to Norristown. Unfortunately, severe flooding occurred in February, destroying part of the Norristown dam and damaging dams at Matson's Ford, Flat Rock, and the Falls of the Schuylkill. Throughout the course of construction of the Navigation flooding repeatedly damaged or destroyed the works. Once construction was completed, the company found it necessary continually to repair and rebuild the works. As Walter Sanderlin has remarked, "In a sense the Schuylkill Navigation was never completed." Repairs in 1820 took much of the summer.[59]

The board hired Luther Thustin, an engineer from New York, in April, 1820, at $1,850 per year to do repairs on the Norristown dam and to plan the next portion of the Navigation above Norristown, the improvements at Catfish Island and probably at Pawling's Bridge near Perkiomen Creek.[60]

Cooley's projects at Lewis's Falls and at Blue Mountain above the mouth of the Little Schuylkill, supposed to be completed by the spring, were not. Believing Cooley was extravagant, the company ordered Oakes to make monthly reports on the "value of the work done" at Lewis's Falls, and at Blue Mountain. Oakes was told to ensure that superintendents knew what was expected in the contracts for fear "that Mr. Cooley would take advantage of their ignorance."[61]

At the end of 1820, though, Oakes approved Cooley's work at Blue Mountain. The two dams at Lewis's Falls were completed and the four locks there nearly done. The canal tunnel was still in progress on the upper section. On the lower section the works at Matson's Ford and Norristown and the dam at Pawling's Bridge with two locks were completed. The works at Catfish Island were in progress. Overall, the company reported twenty three dams, eighteen canals, and sixty seven locks were finished, overcoming a fall of about 340 feet. The river was fully open to traffic from Philadelphia to beyond Norristown, close to twenty miles.[62]

In his report to the stockholders Evans sought to explain why the Navigation was not yet complete, citing the lack of skilled personnel, the inefficiency and wastefulness of the contractors, and the difficulty of supervising construction at both ends of the river. He believed that with the hiring of Oakes, the company had corrected the deficiencies and was more efficiently carrying out projects. "[T]he skill of the Engineer now employed leave no ground to apprehend further difficulties on that account."[63]

Costs were higher for other reasons. The fall of the river was one-fifth more than had been calculated; the fall that was originally believed to be about 480

feet, was determined to be about 580 feet. (That was from Potts' forge; from Mill Creek it was actually almost 620 feet.) Also, the company had to build the more costly dams, canals, and locks rather than sluices over some stretches. A total of $425,680 had been spent, $390,889 on construction of the works and $34,791 on the purchase of real estate; $443,442 had been received in cash from stock purchases. Only $803 was collected in tolls during 1820, down from the previous year when tolls amounted to $1,202, no doubt a consequence of the damage from flooding.[64]

Nevertheless, the outlook remained favorable to investors. When the company offered an additional $200,000 in stock in early 1821, it was immediately taken up. One person, probably Stephen Girard, subscribed $60,000. During these years the nationwide enthusiasm for internal improvements grew rapidly. The Erie Canal proved to be so successful as parts of it were being completed that it was already influencing the willingness of people to invest despite the depressed times.[65]

The company sought to stimulate traffic in 1821. It offered a premium of two hundred dollars to anyone who would start a steamboat passenger service to Norristown. Steamboat passenger service from Philadelphia was carried on during 1821, but the banks of the canals could not withstand the churning of the water by the paddles and steamboat transportation was abandoned. The company offered premiums of one hundred dollars and fifty dollars to persons bringing the two highest amounts of coal down the river to Philadelphia.[66]

The sale of water power from the dams provided the company with one source of revenue. In late 1821 it laid out a town called Manayunk on land it owned at Flat Rock. Manayunk was built up by grants of water power. Soon an important factory town, it was one of the many towns to emerge with the building of the Navigation.[67]

On the lower section from the Perkiomen Creek up to Lewis's Falls two canals were begun during the 1821 season: one, three and a half miles long, to extend from just above Perkiomen Creek opposite the Phoenix Works up to a dam at Black Rock just above French Creek; the other, five miles long, upriver from the pool to be formed by the Black Rock dam. For the 1822 season the company approved Oakes' plan for construction of a canal to extend from Lewis's Falls dam twenty-two miles downriver to within a mile of the five-mile canal.[68]

The dispute with Cooley carried into 1821. The company constantly complained about his works at Flat Rock, at Matson's Ford, and at Lewis's Falls. Totally frustrated, Cooley declared he would never touch the works again. Finally, in June a settlement was reached, the company assuming responsibility for his works, and the last payment was made to Cooley on September 22, 1821.[69]

Cooley finished the Fairmount dam for the city in June, 1821, and by the end of the year the city considered the works completed, but the company

refused to give its necessary approval. It was still not satisfied with the canal and locks at the end of 1822. Not until 1824 did the company report the locks completed. Cooley had died sometime before that. His prestige remained high in western Massachusetts canal circles, but not so on the Schuylkill Navigation.[70]

At the end of 1821 Evans reported the works at Catfish Island between Norristown and Pawling's Bridge completed, probably by Thustin. The tunnel project on the upper section was also completed.[71] The Schuylkill was now navigable from Philadelphia to the Perkiomen Creek beyond Norristown, almost twenty-five miles, on the lower section and the upper section was now navigable from Potts' forge down to near Hamburg, about twenty miles. There remained a substantial portion of the river to be improved. Business on the Navigation increased but not significantly during 1821; tolls amounted to $1,793, twice the amount received the previous year, but still an unimpressive return.[72]

By the end of the 1821 season the company had hired another engineer, Henry King, to assist Oakes. He probably replaced Thustin. In early 1822 the company's offer of another subscription of stock of $250,000 was entirely subscribed within three weeks; this showed investors' continued optimism.[73]

The Union Canal Company, which had remained inactive because of insufficient funds during the first years of the Schuylkill Navigation, finally became active in 1821. The state guaranteed to subscribers of stock in the company the payment of the six percent interest which the state had authorized in 1819. Loammi Baldwin, the Younger (1780-1839), was hired as their engineer in 1821 and work began.[74] Since the Schuylkill Navigation Company had already made the Schuylkill River navigable to Perkiomen Creek beyond Norristown, as well as making improvements below Reading at Lewis's Falls, the Union Canal Company project would build the canal between the Schuylkill at Reading and the Susquehanna at Middletown.[75]

But Baldwin got involved in disputes with the company concerning routes and the size of the canal and locks to be built. The company decided on narrower locks, eight and a half feet wide, than Baldwin wanted. It followed the advice of Thomas Oakes, whom the Union management consulted, accepting his concern about the water supply and the cost over that terrain. At the end of 1822 Baldwin resigned. Canvass White (1790-1834), formerly a principal engineer on the Erie Canal, succeeded him as chief engineer.[76]

PERKIOMEN TO READING; HAMBURG TO READING

During 1821 construction of canal works had been slowed by "an uncommon degree of mortality" among workers, who faced the constant threat of illness on the works. The interruption of the currents, the residual puddles, and especially the quantities of vegetable matter and other debris left in the dams and along the shores were blamed.[77]

It grew worse during 1822. As a consequence of disease ravaging the

workforce and flooding in 1822, little more of the Schuylkill works were completed. Only $1,055 in tolls were received during 1822.[78]

Although the company reported at the end of 1822 that the improvements were "chiefly done or under contract," excepting about five and a half miles near Reading, "under contract" meant that much more work remained to be completed. On the lower section the canals between the Perkiomen and Reading were unfinished. Contracts had just been let on two canals between Hamburg and Reading on the upper section: one extending from just above Hamburg ten miles downriver; the other from about a mile above Maiden Creek three miles downriver. Over forty miles of canals, together with dams and locks, remained to be done.[79]

In order to finance the remaining work, the company in December 1822 authorized issuance of another $200,000 in stock. But then the Board of Managers negotiated a mortgage of the Navigation with Stephen Girard for a loan of $230,850 in February, 1823. The board thereupon resolved that "the funds necessary for the completion of the improvement of the Navigation of the River Schuylkill having been obtained. . ., it is ordered that the subscription books be closed."[80]

This eased the financial situation considerably and now the company expected rapid progress on the work. In March Oakes began a canal through Reading. The dams and canals other than the Reading Canal were expected to be completed by November 1.[81]

The company continued to be well pleased with Oakes, even though there had been little progress the previous year. In March, 1823, the Board of Managers raised his salary five hundred dollars for the previous year and set his future salary at $2,500 per year. He had assistants or superintendents supervising various portions of the improvements: William Jones, hired as superintendent in early 1823 on the lower section, and on the upper section John Roush as an assistant and Benjamin Hamilton as supervisor of toll collections. Their main responsibility was to supervise the works rather than to do planning. The planning was left to Oakes or King.[82]

The year 1823 was another bad one for the company due to sickness among the workers, especially in Reading. Oakes himself suddenly became ill and died in Reading on August 14, 1823. Henry King, who succeeded him, died also a month and a half later. The death of Oakes, "this enterprising, able and intelligent officer," followed by King's, was a heavy blow to the company and set back the work.[83]

To find a new principal engineer, the company contacted Canvass White, who would act as a consulting engineer for the Schuylkill Navigation Company until the Navigation was completed. After a rapid survey of the Schuylkill works and the plans, White looked to the Erie system, which by then was producing quite a few engineers. He first recommended Nathan S. Roberts, who declined,

and then Ephraim Beach. Beach was at the time making a survey for the Morris Canal in New Jersey. In November the Board of Managers appointed Beach, at a salary of $2,000 a year, because he was known and acceptable to the contractors. He served for a year.[84]

By the end of the 1823 season little more had been finished and the company clearly needed still more funds (only $1,964 in tolls were received in 1823). So, the company took out a second mortgage for $250,000 in November and obtained an extension on Girard's loan. They assured the lenders that the improvements would be completed by the end of the following season.[85]

Beach's immediate task was to examine the twenty two-mile canal, whose completion was delayed, the company believed, by "the dilatory manner in which the contractors have carried on their work." Two new assistant engineers, Ira Dodd of Bloomfield, New Jersey, and Edward H. Gill, worked on the construction of the Reading Canal. On the upper section the board assigned Roush to superintend the ten-mile and three-mile canals, while Jones oversaw both the twenty-two-mile and the five-mile canals on the lower section. Caleb Baldwin, a clerk for Oakes since 1822, handled most of the administrative details at the Reading office.[86]

The completion of the twenty-two-mile canal with nine locks occasioned an Independence Day celebration on July 5, 1824. The board named it the Girard Canal after their benefactor. At the same time they named the three and one-half-mile canal at Black Rock dam, the Oakes Canal, after their late engineer. Two boats were named the *Stephen Girard* and the *Thomas Oakes*, and a third boat after the projector of the Erie Canal, the *DeWitt Clinton*. The boats transported dignitaries down the Girard Canal, but a number of defects were discovered.[87]

Then came extremely heavy rainfall on July 29, creating "one of the greatest floods ever known in this country" and necessitating extensive repairs along the entire system. It forced the company to borrow another $180,000 from banks.[88]

At the end of August all remaining improvements were finished except for the Reading Canal: on the lower section the five-mile canal with four locks, named the Vincent Canal; on the upper section the ten-mile canal with a dam and seventeen locks, named the Hamburg Canal, and the three-mile canal opposite Maiden Creek with its dam and six locks, called the Duncan Canal after George Duncan who constructed it. The issue of the Fairmount works was resolved with the company giving the City permission to raise the dam and then signing an agreement with it in June, 1824. The Navigation from Reading to Philadelphia, 64 miles, was now open.[89]

The improvements at Reading consisted of a dam and a seven-mile canal with eight locks running through the town and necessitating bridges over six streets. The board scheduled the opening of the entire length of the Navigation for September 20, inviting many dignitaries to witness it. To the embarrassment

of the company, the Reading Canal leaked through its limestone base when water was let into it. Attempts to repair the Reading Canal failed.[90]

The failures at the Girard and Reading canals no doubt added to the company's increasing irritation with Beach. In May the board had discovered an apparent error in measurement of the levels of the Vincent Canal. At the same time the board had begun asking for more detailed reports from Beach. The board accused him of failing to supply specifics on requests for money and to submit other information asked for. Complaining about the "backwardness" of the work, Harper wrote that "The board have been mortified and disappointed," when the Reading Canal was not ready. In early November the board said with regard to his latest call for money that "The information conveyed is in such general and loose language" that "They cannot gather from you ... anything satisfactory as to the state of the work. ..."[91]

Finally, the board in a terse resolution on November 11, 1824, voted "That the services of Ephraim Beach are not required" and that "He is therefore discharged." Beach was not long without a position, because he soon became chief engineer on the Morris Canal (1825-1831), and later chief engineer of the Morris and Essex Railroad. Still later he joined the Canojoharie and Catskill Railroad.[92]

To carry out the engineering responsibilities with regard to the Reading Canal, the company appointed Ira Dodd, formerly an assistant engineer. He served through the 1825 season. Hired as superintendent, he received a salary of only $1,250 a year, apparently because he only superintended part of the works and perhaps because the engineering tasks were less extensive. He shared superintendence responsibilities with Jones who had authority over the lower section of the works up to the outlet of the Vincent Canal and Hamilton whose authority seems to have covered the Navigation above the Duncan Canal.[93]

The company could not open the Navigation to the new town of Mount Carbon before the end of the season. Just below Pottsville, Mount Carbon would be the terminus for a time. Some thirty eight miles of improvements were completed in 1824, but the construction difficulties and bad flooding reduced toll revenue to only $635, lower than any year since 1818.[94]

With the season ended, the company began building towpaths along the pools of the dams, as well as along the canals. Duncan was assigned the task of planning and carrying out the project. He was to make channels in the pools, if necessary. To accomplish its work in 1825, the company borrowed $100,000 in January and another $100,000 in July.[95]

The company consulted Frederick Graff, who had built the new water works at Fairmount, and William Strickland, another prominent Philadelphia engineer, about the problems with the Reading Canal. Although their suggestion of a "planked bottom and sides of puddled earth" was followed, the canal still

leaked on May 20, the day the company announced the works were to be opened the entire length. More planking was laid.[96]

At long last, in the middle of June, 1825, regular traffic moved along the system from Philadelphia to Mount Carbon. There remained about two and one-half miles of river to be improved from Mount Carbon up to Mill Creek, the terminus stated in the act of incorporation. Tolls, which amounted to less than $2,000 in any year previously, increased to $15,776 for 1825, over twice the total amount of tolls collected since 1818. Coal quickly became principal product carried on the Navigation, accounting for 61 percent of the amount of toll collected. In 1825 the rate of toll for coal from Mount Carbon was $1.68 per ton.[97]

The navigation system from Philadelphia to Mount Carbon extended 106.34 miles.[98] Thirty dams, built of timber cribs filled with stones, created 45.09 miles of slackwater. The length of the dams naturally varied with the width of the river. The height of the dams varied according to the needs of the particular part of the river and the size of the slackwater pool desired, ranging from three feet high to one twenty six feet high at the Little Schuylkill River. 120 locks, eighty feet long by seventeen feet wide, overcame the fall of 583.96 feet from Mount Carbon. It took four to five minutes to pass through each lock. Twenty three canals varied in length from very short ones to the Girard Canal, twenty two miles long, all of which covered 61.25 miles. Canals were from thirty two to forty feet wide at the top and about twenty two feet at the bottom with a depth of from three to four feet. They had a capacity for at least thirty-ton, perhaps forty-ton, boats. A boat could travel from the coal mines to Philadelphia in four days.[99]

Construction of the Navigation cost $2.2 million, over four times the original capitalization.[100] According to this figure the average cost of construction was almost $21,000 per mile, which was well within the range of cost of canal construction in America at that time.[101]

With the Navigation to the coal mines complete, Cadwalader Evans, president since the company's inception, submitted his resignation on August 25, 1825. A month later, Joseph S. Lewis (1773-1836) was elected president, a position he would hold until January, 1836. Lewis had some familiarity with the Schuylkill Navigation, having chaired the Watering Committee for the City of Philadelphia which had supervised the building of the water works and the Fairmount improvements.[102]

At the end of the year Ira Dodd resigned his position. His departure was amicable and communication continued with him after he went on to other projects. Samuel Griscom replaced him at the same salary. Griscom was one of several superintendents, including Jones (who would resign by the end of June, 1826), John Place, and Hamilton. These men were managers, concerned with

running, maintaining, and repairing an existing system. Caleb Baldwin, chief clerk at Reading, left in early 1826.[103]

EXTENSION TO MILL CREEK

The opening of the Navigation to Mount Carbon dramatically improved the company's fortunes. Revenue from tolls now made quantum leaps, to $43,109 in 1826, to $58,150 in 1827, and to $87,112 in 1828, even though tolls were lowered for coal from $1.68 per ton in 1825 to $1.59 per ton in 1826 and to $1.48 per ton in 1827 and 1828.[104]

The Union Canal Company and the Schuylkill Navigation Company appear to have cooperated, with Oakes and White each advising the other company and with Samuel Mifflin, president of the Union Canal Company, being a member of the Board of Managers of the Schuylkill Navigation Company from 1819 till 1826.[105] By the end of 1825 the Union Canal Company had finished forty miles of its canal. Following an agreement between the two companies the state legislature on Feb. 20, 1826, authorized the Union Canal to connect with the Schuylkill Navigation at Poplar Neck (just below Reading). George Duncan completed the building of a dam and lock there in 1826.[106]

The Union Canal, eighty-one miles long with ninety-one locks overcoming a rise of 505.54 feet, was finished at the end of December, 1827. Having a capacity for boats of no more than twenty-five tons and not more than eight feet wide, it was too small for boats of larger capacities which could use the Schuylkill Navigation and the projected state works, so that often transshipment was required. It would always suffer from a shortage of water and the heavy lockage limited the success of the Union Canal.[107]

There remained to be completed on the Schuylkill Navigation only the two and a half-mile distance between Mount Carbon and Mill Creek. During the last phase of the building of the Navigation, George Duncan was the principal engineer. Duncan had early been associated with the system, building the canal tunnel and the Duncan Canal. He continued making the towpaths and channels during 1826, while he finished building the works at Poplar Neck. When problems arose regarding repairs at the Fairmount and Flat Rock pools, President Lewis called on Duncan to survey the work and comment regarding their completion. A major problem, still, was the leaking in the Reading Canal. Another loan was necessary in April, 1826.[108]

In the spring of 1826 Duncan offered to do the section between Mount Carbon and Mill Creek, advancing the capital necessary for it and collecting tolls in lieu of interest until he was paid. The company appeared to be in no particular hurry to complete the work, perhaps because it was more interested in the going concern than in this unimportant addition. Finally, in order to satisfy the requirement of the act of incorporation within the time limit, the company

contracted with Duncan in mid-March, 1827, to have it built for a specific price, $28,000.[109]

Duncan had his works ready for navigation by the end of August, 1828. The extension overcame a fall of 34.80 feet and consisted of 0.82 mile of canal, five locks, and 1.43 miles of slackwater created by two dams. The dimensions of the locks were eighty feet long and thirteen and one-half feet wide. The canal dimensions were thirty-two feet wide at the top, twenty-three feet wide at the bottom, and three feet deep. On October 14, 1828, the Governor was formally notified. The new terminus of the Navigation at Mill Creek was called Port Carbon.[110]

The company declared that the extension of the Navigation to Mill Creek "does great credit to the Engineer and Contractor, Mr. George Duncan." Duncan would continue to do engineering work for the company, later building a new Reading Canal and a reservoir at Mount Carbon, although he would resign over a misunderstanding in 1833.[111]

Thirteen years after the act of incorporation which had given the company fifteen years to complete its work, the Schuylkill River was navigable from the tidewater to Mill Creek. The Navigation extended 108.59 miles, consisting of 62.07 miles of canal and 46.52 miles of slackwater, and overcame a total fall of 618.76 feet. Primarily responsible for the building of the Navigation were Ariel Cooley, Thomas Oakes, Ephraim Beach, and George Duncan. Others contributed, Josiah White, Lewis Wernwag, Luther Thustin, Henry King, Ira Dodd, and Edward H. Gill. Oakes, Dodd, and Duncan were most appreciated for their work. The company was critical of Wernwag, Cooley and Beach. Total cost of construction was over $2.3 million. Besides the financial cost, it cost the lives of many workers, including those of Oakes and King.[112]

The Schuylkill Navigation Company now entered a period of prosperity, paying its first dividend in 1829. Prosperity was shared by the existing communities along the river and by the towns founded as a consequence of the Navigation, such as Manayunk, Mount Carbon, Pottsville, Port Carbon, and others. In 1842 a period of competition set in with a new carrier along the Schuylkill River, the Philadelphia and Reading Rail Road Company. The Philadelphia and Reading took over the Schuylkill Navigation Company in 1870.[113]

Appendix A
Salaries and Wages Mentioned in SNC Materials (Annual Unless Otherwise Noted)[114]

	1816	1817	1818	1819	1820	1821	1822	1823	1824	1825	1826
Secretary-Treasurer of Board of Managers											
Clement Biddle	$800										
Principal Engineers											
Thomas Oakes											
(a)				$2,000							
(a)								$2,500			
Ephraim Beach								$2,000			
Engineers, Superintendents, Part of Works											
Thomas Gould	$1,200										
Luther Thustin (b)					$1,850						
Ira Dodd										$1,250	
Samuel Griscom											$1,250
Assistants to Engineers $3 dy											
John Rousch											
(c)							$2 dy				
(c)								$2.50 dy			
Superintendents of Workers											
Charles Carey (d)	$125 qtr										
Thomas George (e)				$50 mo							
Clerks											
						$300					
Caleb Baldwin (f)										$600	
Collectors											
At Flat Rock (g)											$25 mo
At Reading (e)											$400
Lockkeepers											
At Hamburg (h)										$10 mo	
At Flat Rock											
(g)										$12 mo	
(g)										$15 mo	
At Reading										$200	
Skilled											
Woodchoppers (i)	$18 mo										
Journeymen											
carpenters (i)	$25 mo										

(a) Oakes' salary raised from $2,000 to $2,500 per year.
(b) Thustin had to pay his clerk out of his salary.
(c) Roush's daily wage raised from $2 to $2.50.
(d) $10 for lodgings was deducted.
(e) The person was an agent.
(f) Baldwin was then chief clerk or agent.
(g) The lockkeeper's salary raised from $12 to $15 per month; the same person then became a collector.
(h) Salary included board.
(i) The maximum they were to be paid.

Appendix B
Capital Stock, Loans, Tolls Based on Amounts Found in SNC and Other Materials[115]

	Capital Stock	Loans	Tolls
1815			
Original Legislation	$500,000		
1816			
1817			
1818			$ 233
1819			1,202
1820			803
1821	200,000		1,793
1822			1,055
January	250,000		
December	(a)		
1823			1,964
Girard Mortgage		$ 230,850	
Second Mortgage		250,000	
1824		180,000	635
1825			15,776
January (b)		97,323.60	
July (b)		97,100	
1826 (c)		87,800	43,109
1827			58,150
1828			87,112
Totals	$950,000 (a)	$1,030,873.60	$211,832

(a) The company authorized issuance of stock in the amount of $200,000, according to Jay V. Hare, and/or $60,000, according to a newspaper report, but then closed its books upon receipt of the loan from Girard. The total includes neither of these amounts.[116]

(b) The amount shown is discounted from $100,000.

(c) Minutes of the Board of Managers indicate that $50,000 was borrowed in April, 1826, but a listing of loans by Harper in October, 1826, indicates of loan of $87,800 in April, 1826. The latter amount has been used because other loans listed are correct.[117]

Notes

1. Legislation was passed in February, 1826. For the debate over the transportation system, see Julius Rubin, "Canal or Railroad? Imitation and Innovation in the Response to the Erie Canal in Philadelphia, Baltimore, and Boston," American Philosophical Society *Transactions,* LI, part 7 (1961), 5-106.

2. Slackwater navigation combines use of both the river and canals (see below).

3. This article relies primarily upon the Records of the Schuylkill Navigation Company (hereafter referred to as SNC Records) in the Pennsylvania State Archives, Harrisburg, Pennsylvania, and the Collection of the Reading Company (RC) in the Hagley Museum and Library, Wilmington, Delaware, as well as the *Norristown Herald and Weekly Advertiser,* later the *Norristown Herald* (*NH*), Norristown, Pennsylvania. Jay V. Hare wrote the most detailed account of the SNC in a series of articles, part of a much longer series on the Philadelphia and Reading Railroad, which absorbed the SNC. The SNC articles appeared in the following issues of *The Pilot:* "History of the Reading: The Schuylkill Navigation Company," XIII (September, 1912), 289-295; XIV (February, 1913), 33-37; (March, 1913), 73-80; (April, 1913), 105-113; and (May, 1913), 137-144, to be cited hereafter as Hare, I, II, III, IV, and V. Hare's articles on the Reading Railroad were published in book form by John Henry Strock as *The History of the Reading* (Phila., 1966). Another substantial account is by Chester L. Jones in his study of the anthracite tidewater canals, *The Economic History of the Anthracite Tidewater Canals* (Phila., 1908), pp. 126-158. A more recent account is Walter S. Sanderlin, "The Expanding Horizons of the Schuylkill Navigation Company, 1815-1870," *Pennsylvania History,* XXXVI (April, 1969), 174-191. The latter two accounts do not in trace the actual building of the Schuylkill navigation.

4. Harvey H. Segal, "Canals and Economic Development," in *Canals and American Economic Development* (NY, 1961), ed. by Carter Goodrich, p. 234.

5. Among the first persons to be considered "civilian" engineers were James Brindley (1716-1772) and John Smeaton (1724-1792), both associated with canal building. Henry T. Wood, "Brindley, James (1716-1772)," *DNB,* II, 1253; Thomas H. Beare, "Smeaton, John (1724-1792)," *DNB,* XVIII, 393-394; Anthony Burton, *The Canal Builders,* 2nd ed. (North Pomfret, Vt., 1981); Charles Hadfield, *The Canal Age,* 2nd ed. (North Pomfret, Vt., 1981); Robert Payne, *The Canal Builders* (NY, 1959); Henry S. Drago, *Canal Days in America* (NY, 1972); Daniel H. Calhoun, *The American Civil Engineers: Origins and Conflict* (Cambridge, MA, 1960); J. Elfreth Watkins, "The Beginnings of Engineering," in *The Civil Engineer: His Origins,* ed. by American Society of Civil Engineers (NY, 1970), pp. 9-87; Hare, I, 289; W. Carl Rufus, "Rittenhouse, David," *DAB,* XV, 630-632; Harry J. Carman, "Colles, Christopher," *DAB,* IV, 301; and Elizabeth S. Kite, *Brigadier-General Louis Lebeque Duportail: Commandant of Engineers in the Continental Army, 1777-1783* (Baltimore, 1933), pp. 2-3, 247.

6. George Rogers Taylor, *The Transportation Revolution, 1815-1860* (NY, 1951), p. 32; Goodrich, "Conclusion," in Goodrich, *Canals,* p. 252; Ronald E. Shaw, *Erie Water West: A History of the Erie Canal, 1794-1854* (Lexington, KY, 1966), p. 11; and Ralph D. Gray, *The National Waterway: A History of the Chesapeake and Delaware Canal, 1769-1965* (Urbana, IL, 1967), pp. 8-9.

7. When the Erie Canal was later projected, Weston was offered but declined the position of chief engineer. Latrobe achieved a greater fame as an architect, being appointed by President Thomas Jefferson as surveyor of public buildings in the new capital city of Washington in 1803. Richard S. Kirby, "Weston, William," *DAB,* XX, 21; Fiske Kimball, "Latrobe, Benjamin Henry," *DAB,* XI, pp. 20-25; and Calhoun, pp. 10ff.

8. Brooke, Baldwin, and Wright assisted Weston on various canal projects. Calhoun, pp. 9ff; Carman, p. 301; Payne, p. 141; and Carl

W. Mitman, "Fulton, Robert," *DAB,* VII, 69-71.

9. Calhoun, p. 22.

10. Carter Goodrich, *Government Promotion of Canals and Railroads, 1800-1890* (NY, 1960), chapter 2; Gray, pp. 25-28; Julius Rubin, "An Innovating Public Improvement: The Erie Canal," in Goodrich, *Canals,* pp. 34-38, 43-46; and George Dangerfield, *The Awakening of American Nationalism, 1815-1828* (NY, 1965), p. 7.

11. Forest G. Hill, *Roads, Rails, and Waterways: The Army Engineers and Early Transportation* (Norman, OK, 1957), pp. 12-13; and Dumas Malone, *Jefferson the President: Second Term, 1805-1809* (Boston, 1974), p. 510. At the end of the Revolutionary War Louis Duportail, commander of engineers, had proposed a peacetime military school to train engineers. One was established in 1794 at West Point but suspended operations due to a fire in 1796. Hill, pp. 11-12; and Kite, pp. 125-144, 216. Duportail resided in America along the Schuylkill River from 1795 to 1802, but devoted himself to farming, Kite, pp. 282-284.

12. The first civil engineer graduated from West Point in 1818. West Point became firmly established when Sylvanus Thayer, an 1808 graduate of West Point who was sent to France after the war to study engineering, became superintendent at West Point in 1817 and organized the study after the Ecole Polytechnique. Hill, pp. 13-16; and Calhoun, p. 42.

13. The first notable navigation project to be completed in America was a canal around the falls of the James River at Richmond in 1789, improving the river for seven miles. Christopher T. Baer, et al., *Canals and Railroads of the Mid-Atlantic States, 1800-1860* (Greenville, DE, 1981), p. [54]; William W. Hay, *An Introduction to Transportation Engineering* (NY, 1961), p. 27; Hadfield; Drago; Calhoun, pp. 10-12; Elizabeth Kytle, *Home on the Canal* (Washington, 1983), p. 10; Payne, pp. 141-142; Shaw, pp. 12ff; W. DeLoss Love, "The Navigation of the Connecticut River," *Proceedings,* American Antiquarian Society, n.s. XV (April, 1903), 406-409; Josiah G. Holland, *History of Western Massachusetts* (Springfield, MA, 1855), I, 306-309; Henry S. Tanner, *A Brief Description of the Canals and Railroads of the United States. . . .* (Phila., 1834), pp. 6-7; Kimball, p. 21; and Taylor, p. 32.

14. See Taylor.

15. Harvey H. Segal, "Cycles of Canal Construction," in Goodrich, *Canals,* p. 172.

16. Wagon transport was at least thirty cents per ton-mile, 1800-1819, and about fifteen cents per ton-mile in the 1850s. Canal transport was less than two cents per ton-mile in the 1850s. Segal, "Economic Development," pp. 224-228. For more on the economic impact of canals see also the rest of Goodrich, *Canals;* H. Jerome Cranmer, "Canal Investment, 1815-1860," in *Trends in the American Economy in the Nineteenth Century,* Studies in Income and Wealth, XXIV, National Bureau of Economic Research, (Princeton, NJ, 1960), pp. 547-564; Goodrich, *Government Promotion;* Harry N. Scheiber, *Ohio Canal Era: A Case Study of Government and the Economy, 1820-1861* (Athens, OH, 1969); and Taylor, pp. 32-55.

17. C.M. Wiltse, *John C. Calhoun: Nationalist, 1789-1828* (Indianapolis, IN, 1944), pp. 134-136; Dangerfield, pp. 5-8, 17-20; and Taylor, p. 19.

18. Taylor, pp. 33-36. On the Erie Canal see Shaw; and Rubin, "The Erie Canal."

19. Gray, pp. 6-7; Rubin, "The Erie Canal, p. 57, and Rubin, "An Imitative Public Improvement: The Pennsylvania Mainline," in Goodrich, *Canals,* pp. 67-68; Goodrich, *Government Promotion,* pp. 61-62; and Taylor, p. 23.

20. Weston served four Pennsylvania companies, three navigation companies and a turnpike company, Conference, January 16, 1793, Minutes of Conference Committee, Union Canal Company Box (UCC), RC. Remarks of William Duane (Duane, Remarks) in *Journal of the House of Representatives,* Commonwealth of Pennsylvania (*JHR*), March 19, 1813; Hare, I, 289-290; Drago, pp. 25, 27; J. Bennett Nolan, *The Schuylkill* (New Brunswick, NJ, 1951), pp. 276-280; Harris E. Starr, "Smith, William," *DAB,* XVII, 353-357; William J. Buck, *History of Montgomery County Within the Schuylkill Valley* (Norristown, PA, 1859), p. 12; Rubin, "Canal or Railroad," p. 37; Kirby, p. 21; and Calhoun, pp. 15-16.

21. William J. Duane, *Letters . . . Respecting the Internal Improvement [of Pennsylvania]. . .* (Phila., 1811); Duane, Remarks; *JHR,* December 10, 1812, *et passim; NH,* December 29, 1813; Nolan, p. 168; Hare, I, 290-291; Chester Jones, p. 126n; B.H. Meyer, dir., *History of Transportation in the United States Before 1860* (Washington, 1917), p. 214; and Jules I. Bogen, *The Anthracite Railroads* (NY, 1927), p. 8. For a very brief introduction to the anthracite coal region, see *ibid.,* pp. 1-7.

22. *JHR,* December 20, 1814, *et passim; Journal of the Senate,* Commonwealth of Pennsylvania (*JS*), January 18, 1815, *et passim;* Acts of the Legislature (AL), SNC Records, pp. 3-20; Nolan, p. 280; and Thomas P. Govan, *Nicholas Biddle: Nationalist and Public Banker, 1786-1844* (Chicago, 1959), pp. 45, 52.

23. Upon completion the Navigation was actually 108.59 miles of river and canal. *JHR,* January 13, 1815; AL, p. 9; Stockholder, "Navigation on the Schuylkill, August 9, 1819," *NH,* August 18, 1819 (Stockholder, Report, 1819); Hare, I, 292; Baer, p. [54]; and Nolan, pp. 16, 166.

24. The original minimum dimensions required of the locks were 120 feet long and 20 feet wide. AL, pp. 15, 19, 21. See also Tanner, *A Brief Description,* pp. 29-31; and Henry V. Poor, *History of Railroads and Canals of the United States of America* (NY, 1860), pp. 540-543.

25. AL, pp. 9, 13-14, 20-22.

26. *Ibid.,* pp. 11, 16, 25-26; and Minutes of the Board of Managers of the SNC (BM), SNC Records, Pennsylvania Archives, Harrisburg, PA, July 3, 1819.

27. AL, p. 5; Cadwalader Evans, Jr., "Address of the President and Board of Managers of the Schuylkill Navigation Company, May 29, 1817," *NH,* June 18, 1817 (Evans, "Address, 1817"); Stockholders meetings, October 5, 1815, and January 6, 1817, Stockholders Minute Books (SMB); SNC Journal A (January, 1816-March, 1830) (JA), RC, p. 38; and Hare, I, 293.

28. Hare, III, 76; and Burr A. Robinson, "Wernwag, Lewis," *DAB,* XX, 2.

29. Probably the most difficult mechanical problem the engineer faced was designing the lock, a rectangular chamber with a moveable gate at each end and filled and emptied by drains controlled by valves, which overcame the elevation in the canal or in the river at dams. Hay, pp. 149-154; Calhoun, pp. 55-60; Evans to Lewis Wernwag, December 31, 1817, to Thomas Oakes, May 17, 1819, and to John L. Sullivan, November 24, 1823, and Thomas Harper to Ephraim Beach, November 24, 1823, Letter Books (LB), SNC Records; and BM, November 30, 1820.

30. BM, May 4, 1816, and March 31, 1817.

31. At times the company paid the travel expenses of skilled workers brought in from elsewhere, such as those Cooley brought down from Massachusetts. When Cooley was authorized to hire in 1817, "good Ax men" were to receive not more than eighteen dollars per month and journeymen carpenters not more than twenty five dollars per month. Report of the President and Managers to the Stockholders of the SNC, December 1, 1820, SMB (Evans, RepSt, 1820); and BM, February 3 and July 29, 1817.

32. Harper to Wernwag, July 13, 1818, and Evans to Oakes, May 17, 1819, LB; and Edgar P. Richardson, "The Athens of America, 1800-1825," in *Philadelphia: A 300-Year History,* ed. by Russell F. Weigley (NY, 1982), pp. 239, 256. SNC Records indicate only lump sums issued for payment to workers, not daily wages. In 1829 Matthew Carey, writing about the Philadelphia area, reported that canal workers received between sixty two and a half and eighty seven and a half cents per day, but they paid one dollar and fifty cents to two dollars a week for board. Workers on the Erie Canal earned eight to twelve dollars per month or fifty cents a day. As Walter S. Sanderlin states, because the Schuylkill Navigation was one of the earliest to begin after the War of 1812, it avoided the competition for workers which set in the 1830's. At the end of the 1820's, according to Carey, there was still no shortage of workers. Matthew Carey, *Public Charities of Philadelphia,* quoted in Gustavus Myers, *History of Great American Fortunes* (NY, 1937), p. 81; Sanderlin, pp. 180-181; and Shaw, p. 91.

33. Evans, RepSt, 1820.

34. Thomas Eddy to SNC, December 26, 1815, in BM, February 6, 1816; BM, October 7, 1815; Rubin, "The Erie Canal," pp. 39-40, 53; and Evans, Address, 1817.

35. Evans, Address, 1817; and Holland, I, 307.

36. BM, November 20, 1815 and February 5, 1816; and Evans, Address, 1817.

37. BM, March 12, April 22, and May 21, 1816; and Calhoun, pp. 21, 205. Gould was a stone mason from New York. The board also considered hiring Marshall Lewis of New York (who later became an important engineer on the Erie Canal). One of these may have been the person Thomas Eddy referred to in his letter describing the Mohawk River improvements in New York: "a man who resides at Little Falls ... is an excellent workman who was employed in building stone locks in Wales, and erected ours at the Little Falls...." Eddy to SNC, December 26, 1815, in BM, February 5, 1816.

38. According to Baer, p. [56], 1.79 miles were completed in 1816. Evans, Address, 1817; AL, p. 3; Samuel Baird to Governor Simon Snyder, November 28, 1816, in *JHR,* December 5, 1816. BM, December 18, 1816; Cadwalader Evans, Jr., "Address of President and Managers of the Schuylkill Navigation Company, May 9, 1818," *NH,* May 20, 1818 (Evans, Address, 1818); Hare, I, 293; and Nolan, p. 28.

39. *JHR,* December 31, 1816, February 24 and March 24, 1817.

40. Assistants received three dollars per day. Charles Carey was employed in 1816 to superintend workers at $125 quarterly (less ten dollars for lodgings). BM, January 10, and February 3, 1817, and March 25, 1818; and JA, pp. 53-153.

41. BM, December 18, 1816, and March 21, 26, and 31, 1817; Evans, Address, 1817; and Nolan, p. 43.

42. The company tried and failed to get the state legislature during its 1817-1818 session to enact a duty on auction sales to aid it. Evans, Address, 1817; and Statement of Funds, SNC, in *JHR,* December 15, 1817; *ibid.,* January 5 and March 9, 1818, and January 12, 1819; *JS,* March 18, 1818.

43. Evans, Address, 1818; BM, June 27, and July 25, 1818; *NH,* August 12, 1818; Chester Jones, p. 127; Harper to Wernwag et al., June 26, 1818, LB; and Cadwalader Evans, Jr., Report of the President and Managers of the SNC, December 21, 1819, in *JHR,* January 5, 1820 (Evans, Report, 1819). Distances between different points on parts or all of the Navigation are listed in a number of places, the earliest being S. Alspach, *Schuylkill Canal Navigator,* (Phila., 1827), p. 2; here see Tanner, *A Brief Description,* p. 31; and Table of Distances on Schuylkill Navigation, 1845 (TD), in Broadsides, SNC Records.

44. Evans, Address, 1818; Nolan, p. 285; JA, pp. 19-37; and *JHR,* January 12, 1819.

45. *JHR,* January 12, 1819; Articles of Agreement Between Ariel Cooley and the City of Philadelphia, Report of the Watering Committee (RWC), pp. 43-44, in Reports to Stockholders (RS), SNC Records; Richardson, pp. 238-239; H. Benjamin Powell, "Coal and Pennsylvania's Transportation Policy, 1825-1828," *Pennsylvania History,* XXXVIII (April, 1971), 141; and Chester Jones, pp. 8, [155]. See *ibid.,* pp. 7-13, for the Lehigh Navigation Company.

46. TD; and BM, July 25, August 12, and November 7, 1818, and November 30, 1819.

47. Evans to Wernwag, December 31, 1817; BM, June 27, 1818; and Harper to Wernwag et al., June 26, 1818, LB.

48. Evans, Address, 1818; BM, July 11, November 7, and December 21, 1818, and February 17, 1827; and Harper to Wernwag, July 13 and 20, 1818, LB.

49. Evans, Address, 1818; BM, March 21, 1819, and February 17, 1827; Harper to Wernwag, April 8, 1819, LB; Evans, Report, 1819; Robinson, p. 3; and *NH,* September 28, 1825.

50. According to Hare, the tunnel was begun in 1818, but the first reference to proposed contracts is January 22, 1819, when Evans responded to a Dreibelbis proposal regarding that area. Hare, IV, 35, 106; Evans to Daniel Dreibelbis, January 22, 1819, and to Oakes, May 17, 1819, LB; BM, March 25, 1818; January 13 and 16, 1819; JA, pp. 133, 139; Evans, RepSt, 1820; Cadwalader Evans, "Schuylkill Navigation," *NH,* January 17, 1821 (Evans, Report to Legislature, December 25, 1820, cited as Evans, RepLg, 1820); Evans, Report,

1822; "Schuylkill Canal Works," *NH*, June 30, 1824 (Schuylkill Works, 1824); and Nolan, p. 48.

51. Baer, p. [56], states that 11.53 miles of the Navigation were completed by the end of 1818.

52. Lockkeepers, locktenders, or gatekeepers, as they were variously called, were paid from ten to fifteen dollars per month in 1825, except the one at Reading who was paid two hundred dollars per year. At Flat Rock the lockkeeper became a collector in 1826 at twenty five dollars per month and employed a lockkeeper. The collector or agent in Reading in 1826 was to be paid four hundred per year. Evans to Governor William Findley (no date, but probably between January 25 and February 3, 1819), Harper to Daniel Dreibelbis et al., March 1, 1819, to Lewis Reese et al., March 22 and 24, 1819, to John Curry, February 23, 1825, and to Dodd, August 8, 1825, LB; BM, September 17, 1825, April 15 and September 9, 1826; and Hare, II, 34.

53. Evans to Daniel Dreibelbis, March 24, 1819, and Harper to Oakes, March 30, April 8, 12, and 20, 1819, LB; Nolan, p. 82; Hare, II, 34; BM, March 30, 1819; and Calhoun, p. 97. On the Erie Canal principal engineers made $1,500 to $2,000 a year, Shaw, p. 91.

54. Evans to Oakes, May 17, 1819, LB; and BM, May 20, 1819. A clerk appointed in 1821 was paid three hundred dollars per year, Harper to Oakes, July 13, 1821, LB.

55. Evans to Oakes, May 17, 1819, LB; and BM, February 17, 1827.

56. BM, July 19, November 11 and 30, 1819, and February 17, 1827; Evans, Report, 1819; JA, p. 158; RWC, p. 44; Stockholder, Report, 1819; Hare, I, 294; and Calhoun, p. 34.

57. Baer, p. [56], says 15.89 miles of the Navigation were completed by the end of 1819. Evans, Report, 1819; Stockholder, Report, 1819; and *NH*, September 22 and December 1, 1819.

58. Stockholder, Report, 1819; BM, November 30, December 13 and 15, 1819; and Harper to Oakes, July 26 and August 7, 1820.

59. *NH*, February 23, March 1, and June 18, 1820; "Neighborhood News and Notices from the Southern Tier of Townships," *Bulletin*, Historical Society of Montgomery County, Pennsylvania, VIII (April, 1952), 132; BM, March 2, and July 8, 1820; Sanderlin, p. 180; and Nolan, p. 283.

60. He had to pay his clerk out of his salary. BM, April 14, and August 11, 1820; Harper to Thustin, June 30, 1820, LB; and *NH*, February 7, 1821.

61. Evans, Report, 1819; BM, May 20, 1820; Harper to Cooley, July 13, 1820, and to Oakes, July 26 and August 7, 1820, LB.

62. Evans reported the river navigable for about 54 miles, but he exaggerated here, since there remained interruptions and work still in progress. According to Baer, p. [56], 36.97 miles of the Navigation were completed by the end of 1820. Evans, RepLg, 1820; Evans, RepSt, 1820; and BM, November 30, 1820.

63. The use of contractor-engineers came in for much criticism. Loammi Baldwin, the Younger, who became chief engineer on the Union Canal, ascribed many of the SNC difficulties to the contractor-engineers, the wastefully extravagant "quack" engineers. Evans, RepSt, 1820; BM, May 20, 1820; Harper to Oakes, August 17, 1820, LB; and Calhoun, pp. 97-98, 104.

64. Evans RepSt, 1820; Evans, Address, 1817; Baer, p. [54]; and Chester Jones, p. [155].

65. Nolan, p. 290, says Girard helped at this time. Evans, RepSt, 1820; *NH*, February 21, 1821; and Taylor, p. 34. By 1821 the Erie Canal was completed from Little Falls to the head of Cayuga Lake at the Seneca River, Shaw, facing p. 130.

66. Evans, RepSt, 1820; "Neighborhood News," VIII, 132-133; *NH*, February 21, May 9, and August 8, 1821; and Edward Pinkowski, *History of Bridgeport, Pa.* (Bridgeport, PA, 1951), p. 10.

67. Hare, II, 36.

68. BM, March 12, May 29, and October 25, 1821, and June 3, 1822; *NH*, December 5, 1821; Cadwalader Evans, Jr., Report, January 7, 1822, quoted in Hare, II, 36 (Evans, Report, 1822); and Tanner, *A Brief Description*, p. 30.

69. BM, January 5 and 19, June 18, and September 22, 1821; and Harper to Cooley, February 12, 1821, LB.

70. Sometime between 1821, when the company records last refer to him, and 1824 Cooley died. A boat was named after him on the Connecticut River; nothing received his name on the Schuylkill. Holland, I, 307; Love, p. 429; *NH,* July 4, 1821; BM, December 13, 1821, June 6, 1822, and October 21, 1822, and Evans to Governor J. Andrew Shulze, October 8, 1824, LB.

71. Not only the contractor-engineers caused the company problems. Thustin disappeared at the end of December, 1820, with a payroll of $1,000 for the workers at Pawling's Bridge (having become "completely bewildered and deranged"). After a short time, however, he returned with the money. He continued in service until November, 1821, probably to complete the works by Catfish Island. Harper to Thustin, February 13, 1821, LB; BM, January 2, 1821; *NH,* January 3 and February 7, 1821; and Evans, Report, 1822. The last payment to Thustin was on November 22, 1821, BM.

72. Baer, p. [56], says that 58.52 miles of the Navigation were completed by the end of 1821, which must include the improvements around Lewis's Falls. The company charged no toll on the upper section during 1821. Evans, Report, 1822; Tanner, *A Brief Description,* p. 31; and Chester Jones, p. [155].

73. Board minutes first record a payment to King, December 29, 1821. Harper to Oakes, April 4, 1823, LB; and *NH,* January 23, and February 6, 1822.

74. Apparently, the potential profitability of the anthracite region had attracted investment away from the Union Canal, Powell, p. 140n. "Baldwin, Loammi, [the Younger]," *DAB,* I, 540-541; Meyer, p. 215; Calhoun, p. 94; and Hare, II, 34.

75. Poor, p. 550, states that the UCC decided to devote its attention to Schuylkill-Susquehanna connection once the SNC was chartered in 1815. Yet the UCC continued to protect its rights on the Schuylkill, protesting in 1819 the effort of the SNC to build a canal on the Norristown side of the river on the site of the earlier unfinished sixteen-mile canal to Philadelphia, Harper to Levi Pawling and John Henderson, June 10, 1819, LB.

76. Baer, p. [54]; Calhoun, pp. 36, 96-97, 104; and Charles B. Stuart, *Lives and Works of Civil and Military Engineers of America* (NY, 1871), pp. 74-90.

77. *NH,* August 8, 1821; *JHR,* January 8, 1823; Nolan, p. 82; and William Whitehead, *Directory of Norristown and Bridgeport. . ., 1860-61* (West Chester, Pa., 1860), p. 81. Matthew Carey reported that hundreds died annually on canal projects. He estimated that five percent of canal workers came down with "fevers and agues" and that half of these died. Many of the thousand who came down with fever on the Erie Canal in 1819 died. See Carey in Myers, p. 81; Benjamin W. McCready, *On the Influence of . . . Occupations in the United States on the Production of Disease* (Albany, NY, 1837), p. 96 [microfiche]; and Taylor, p. 289.

78. No further mileage of the Navigation was improved during 1822, according to Baer, p. [56]. *NH,* February 27, 1822; *JHR,* January 8, 1823; and Chester Jones, p. [155].

79. *NH,* January 22, 1823; BM, November 29, December 9 and 20, 1822.

80. In the newspapers it was reported in January that the company had resolved to raise $60,000 by additional subscriptions. It is not known whether any addition stock was sold before the books were closed. Hare, III, 73; *NH,* January 22, 1823; and BM, February 4, and 18, 1823.

81. *NH,* January 22, 1823; BM, February 4 and 18, 1823; Harper to Oakes, March 7 and July 9, 1823, LB; and Hare, III, 73.

82. BM, March 27, 1823; and Harper to William Jones, February 14, 1823, to Oakes, August 1, 1823, to John Curry, February 13, 1824, to Roush, March 8, 1824, and to Beach, May 12, 1824, and Evans to Thomas Firth and John G. Hoskins, October 6, 1823, LB. Jones worked for the company on the Matson's Ford works in late 1819-early 1920, JA, pp. 167, 170, 185. Roush was on the company payroll as early as March 15, 1822, Harper to Beach, January 12, 1824, LB. Hamilton was hired in 1822 to supervise the toll collection on the locks above Hamburg, BM, September 20, 1822; and Harper to Hamilton, September 13, 1824, LB. By 1826 he had become a superintendent, Harper to

Benjamin Hamilton, March 7, 1825, and to Hamilton et al., June 12, 1826, LB. Roush, as an assistant, earned two dollars and fifty cents per day, which was raised from two dollars per day in 1822. Roush's lower wage in 1822 and 1823 may reflect the depressed times of the early twenties, Richardson, pp. 239, 256. Shaw, p. 91, says assistants on the Erie Canal made four dollars per day.

83. Harper to Margaretta Farmer, October 13, 1823, LB; BM, August 14, 1823; and Hare, III, 73-74.

84. Evans to Roberts, November 12, 1823, and to Sullivan, November 24, 1823, Harper to Sullivan, November 12, 1823, and to Beach, November 24, 1823, LB; Stuart, pp. 83-86; Shaw, facing p. 130; and Calhoun, pp. 29, 36, 62, 71.

85. Again, according to Baer, p. [56], during 1823 no further mileage of the Navigation was improved. Girard would grant many such extensions on the loan. Evans to various banks, October 20, 1823, LB; BM, November 29, 1823, and March 1 and 9, 1824; and Chester Jones, p. [155].

86. As chief clerk in 1825, Baldwin earned $600 a year, Harper to Baldwin, December 19, 1825, LB. Evans to Firth and Hoskins, October 6, 1823, Harper to Beach, November 24, 1823, January 19, and April 9, 1824, to William Jones, December 1, 1823, and to Dodd, March 3, 1824, LB; and BM, July 13 and September 20, 1822.

87. BM, June 29, 1824; Harper to Beach, July 9, 1824, LB; Schuylkill Works, 1824; and Hare, III, 73-74.

88. Harper to Beach, August 4, 1824, to J.G. Coster, August 9, 1824, and to various banks, August 5, 1824, LB; and BM, August 9, 1824, and January 15, 1825.

89. BM, June 14, 1824; Harper to Joseph S. Lewis, March 5, 1824, and to Beach, May 7 and 12, 1824, and Evans to Shulze, October 8, 1824, LB; Schuylkill Works, 1824; *NH,* August 18, 1824; and Hare, IV, 105.

90. Harper to Beach and to Hamilton, September 13, 1824, to Shulze, September 13, 1824, to Officers of the State Government, September 13, 1824, to Lenders to SNC, September 17, 1824, and Evans to Shulze, October 8, 1824, LB; Schuylkill Works, 1824; *NH,* November 3 and 24, and December 8 and 22, 1824; Hare, II, 34 (Map) and III, 75; and Nolan, p. 81.

91. Harper to Beach, May 12 and 24, August 4, 6, 23, and 27, October 8, and November 3, 1824, LB.

92. BM, November 11, 1824; and Calhoun, pp. 36, 71.

93. Harper to Caspar W. Morris and Thomas Firth, November 12, 1824, to Dodd, December 3, 1824, and April 1, 1825, to William Jones, January 28, 1825, and to Samuel Griscom, February 20, 1826, LB; and Hare, III, 77.

94. According to Baer, p. [56], 96.68 miles of the Navigation was improved by the end of 1824. Harper to J.G. Coster, August 9, 1824, LB; and *NH,* June 30 and September 15 and 29, 1824; TD; Nolan, p. 32; and Chester Jones, p. [155].

95. Both loans were discounted several thousand dollars, $97,323.60 and $97,100, respectively, Harper to J. Roberts, October 19, 1826, LB, which lists all loans up through date of letter. *NH,* January 26, 1825 (Schuylkill Report, 1824); Harper to Duncan, December 31, 1824, and to William Jones, January 28 and December 22, 1825, LB; and BM, January 3 and 18, and July 13 and 26, 1825.

96. *NH,* November 3 and 24, December 8 and 22, 1824, and June 8, 1825; BM, January 12, 1825; Harper to Dodd, May 23, 1825, LB; Joseph S. Lewis, Report of the President and Board of Managers of the Schuylkill Navigation Company, January 2, 1826, RS (Lewis, Report, 1826); Ray P. Baker, "Graff, Frederick," *DAB,* VII, 467; and Hare, III, 78.

97. *NH,* June 15, 1825; Lewis, Report, 1826; Schuylkill Report, 1824; and Chester Jones, pp. 128, 135, [155].

98. When the Navigation was opened in June the company gave no statement of the dimensions of the works. I have used descriptions by the company in 1824 and earlier and have drawn from later accounts what seems to be most correct. Baer, et al., of the Regional Economic History Research Center at the Hagley Foundation have made the most recent calculation of the measurements in their work,

p. [54], which separates the Navigation completed to Mount Carbon and the extension from Mount Carbon to Mill Creek. Contemporary descriptions include Samuel A. Mitchell, *Mitchell's Compendium of the Internal Improvements of the United States...* (Phila., 1835), pp. 36-37; and Tanner, *A Brief Description,* p. 31, published in 1834, which may include some of the enlargement begun in 1830. See also Poor, p. 540, published in 1860. Other later descriptions are in Hare, published in 1912-13, and S.H. Sword, "The Schuylkill Canal: An Episode in the History of Pennsylvania," *Pennsylvania Forests and Waters,* II (1950), 31. These descriptions are somewhat at odds with one another.

99. BM, November 30, 1819, and October 31, 1825; Evans to Oakes, May 17, 1819, and Harper to Beach, November 24, 1823, LB; Stockholder, Report, 1819; Schuylkill Report, 1824; Lewis, Report, 1826; Hare, I, 292; Baer, p. [54]; Poor, p. 540; and Sword, p. 31. The number of dams and locks includes those at Fairmount. Schuylkill Report, 1824, says there were 28 dams at the end of 1824. The company decided to build a second dam at Catfish Island in July, 1825, BM, July 8, 1825. Baer, p. [54], states there were ninety two lift locks and gives canal dimensions of thirty-two feet wide at the top, twenty-two feet wide at the bottom, and three feet deep. The company reported the capacity to be forty tons, Schuylkill Report, 1824, but Baer, p. [54], states it to be thirty tons, as does Poor, p. 540.

100. The total original cost in October, 1825, was $2,200,000, according to Charles Ellet, Jr., a civil engineer and later president of the SNC (1846-1847), *Position and Prospects of the Schuylkill Navigation Company,* 1845, reported in Chester Jones, p. 128. The Schuylkill Report, 1824, set the cost of construction as of December 31, 1824, at $1,800,000.

101. Calculation based on 106.34 miles comes to $20,688.36 per mile. Using the Schuylkill Report, 1824, and based on Baer's calculation of 96.68 miles completed, Baer, p. [56] (the Schuylkill Report incorrectly states that 110 miles were completed), the per-mile cost to the end of 1824 would be $18,618.12. Matthew Carey in the winter of 1824-1825 listed the average cost per-mile of the Schuylkill Navigation to be $20,000, while listing the completed portion of the Union Canal at $13,000, the Erie and Champlain Canals at $22,500 and the Merrimack also at $22,500; another report at the time placed the cost of the Erie at $20,000, the cost of the Middlesex Canal $17,000 to $18,000, Rubin, "Canal or Railroad?" pp. 36, 86. Taylor, p. 53, states that most canals cost from $20,000 to $30,000 per mile, though the Chesapeake and Ohio cost $60,000 and the Susquehanna and Tidewater cost $80,000. Scheiber, pp. 43, 53, indicates the cost of the Miami Canal and the Ohio Canal to have been about $13,000 per mile, more or less.

102. BM, August 22 and September 26, 1825; and Hare, IV, 108.

103. Dodd had resigned by January 28, 1826. Joseph S. Lewis to Dodd, January 28, 1826, and Harper to Griscom, February 20, 1826, to Place, April 10 and June 24, 1826, to Hamilton et al., June 12, 1826, and to Dodd, October 16, 1828, LB. The last reference to Jones is in the letter, Harper to Place, June 24, 1826, LB.

104. Chester Jones, p. [155]; *NH,* January 26, 1825; and Rates of Toll for 1826-1828 in Broadsides, SNC Records.

105. However, the Norristown newspaper reported rumors even after the completion of the Schuylkill Navigation to Reading in 1825, that the UCC was considering building another canal along the left bank from Reading to Philadelphia. BM; Calhoun, pp. 97-98; and *NH,* July 6 and 13, 1825.

106. Rubin, "Canal or Railroad," p. 36; Memorandum of Agreement, Schuylkill Navigation Company and Union Canal Company, January 12, 1826, UCC; Joseph S. Lewis to Duncan, November 16, 1826, LB; and Hare, IV, 105.

107. The direct distance between Reading and Middletown was only about forty five miles. Baer, p. [54]; Hadfield, pp. 197-198; Rubin, "Canal or Railroad," pp. 36-37; and Taylor, p. 41.

108. $50,000 was borrowed, according to BM, April 14, 1826; but Harper to J. Roberts, October 19, 1826, LB, lists a loan on April 3, 1826, of $87,800. Joseph S. Lewis to Duncan, April 29 and November 16, 1826, and Harper to Dun-

can, February 20, 1826, LB; BM, November 16, 1826; Hare, IV, 105; and SNC Construction Accounts Register (CA), February, 1827, RC. The original canal through Reading was later abandoned for a new canal, Hare, II, 34, III, 78.

109. No mileage of the Navigation was completed during 1826 and 1827, according to Baer, p. [56]. Joseph S. Lewis to Duncan, May 29 and October 9, 1826, LB; BM, March 15, 1827; and Report to the Stockholders, January 5, 1829, RS (Report, 1829).

110. Duncan took advantage of an amendment in 1827 allowing the reduction in size of the locks, AL, p. 36. Joseph S. Lewis to David Lewis, July 12, 1827, and to Duncan, August 25, 1828, and to Shulze, October 14, 1828; Harper to David Lewis, July 25 and December 31, 1827, and February 28, 1828, and to Duncan, February 28, 1828, LB; Baer, p. [54]; and *NH,* November 12, 1828.

111. BM, December 25, 1828; Report, 1829; and Hare, III, 78, and IV, 106.

112. In 1828 the company gave no statement of the dimensions of the works and, since the company began an enlargement of the system as early as 1830, it is difficult to give an accurate description or an accurate statement of cost as of 1828. I have accepted Baer's measurements, p. [54]. See also Mitchell, pp. 36-37, and Tanner, *A Brief Description,* p. 31, both of which include some of the enlargement; Poor, p. 540; Sword, p. 31; and Hare. Mitchell, p. 37, says that as of January 1, 1830, the cost of construction was $2,336,380, which based on 108.59 miles, would be an average cost-per-mile of $21,515.61; Tanner, *A Brief Description,* says the cost was $2,500,176, which would be $23,024.00 cost-per-mile; and Sword, p. 43, says it was completed in 1828 at a cost of nearly $3 million.

113. See Hare, Chester Jones, and Sanderlin.

114. BM, April 22, 1816, February 3, 1817, April 14, 1820, March 27, 1823, September 17, 1825, and April 13 and September 9, 1826; Harper to Oakes, March 30, 1819, and July 13, 1821, to Beach, November 24, 1823, and January 12, 1824, to Dodd, April 1 and August 8, 1825, to Baldwin, December 19, 1825, to Griscom, February 20, 1826, and to John Curry, February 23, 1826, LB; and JA, pp. 38, 53, 158.

115. AL, p. 3-5; Evans, RepSt, 1820; *NH,* January 23, 1822; BM, February 4 and 18, 1823, November 29, 1823, August 9, 1824, January 3 and 18, 1825, July 13 and 26, 1825, and April 14, 1826; Evans to various banks, October 20, 1823, and Harper to various banks, August 5, 1824, and to J. Roberts, October 19, 1826, LB; and Chester Jones, p. [155].

116. Hare, III, 73; *NH,* January 22, 1823, and BM, February 4, 1823.

117. BM, April 14, 1826; and Harper to J. Roberts, October 19, 1826, LB.