Joint Engineering and Archaeological Mitigation Plan for the Furnace Falls Pond Dam, Weir, Spillway and Channel

Stanhope/Netcong, Morris and Sussex Counties, New Jersey

Draft-Final Mitigation Plan-
Compac Corporation – Furnace Falls Dam

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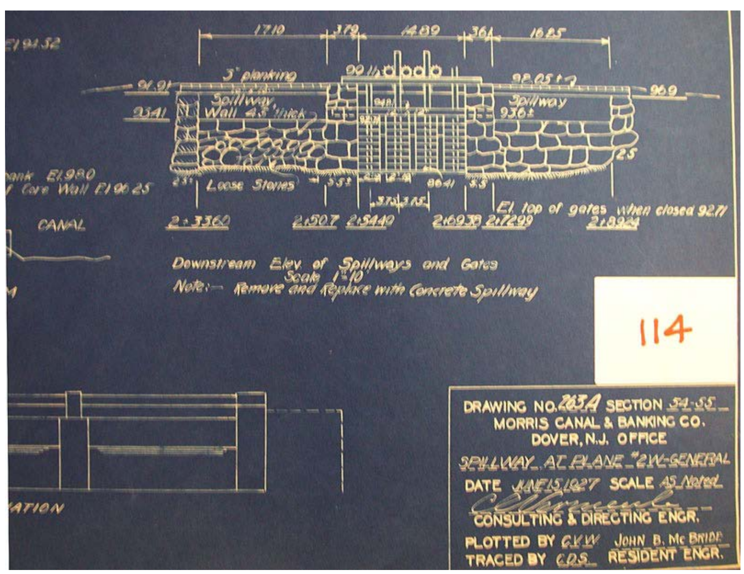

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I. Scope and Mandate

The goal of this Mitigation Plan is the development of a formal and task-specific technical mitigation program, based on a joint strategy of avoidance through redesign, followed by data recovery in the limited areas of potentially surviving resources, to mitigate any adverse impacts to elements of the Furnace Falls Dam raceway. The Mitigation Plan has been prepared in compliance with the New Jersey State Register of Historic Places, and in conformity with the New Jersey Department of Environmental Protection (NJDEP) conditions, to permit as stipulated by the April 18, 2002, e-mail memo from Mike Gregg of the New Jersey State Historic Preservation Office (NJSHPO). The primary planning goals of this Mitigation Plan are to identify, define, evaluate, and, where possible, mitigate any impacts with avoidance through redesign versus excavation or data recovery. Only when avoidance through redesign is not possible is mitigation through archaeological data recovery recommended. This Mitigation Plan includes:

- An integrated archaeological and engineering mitigation strategy to reduce impacts with redesign and avoidance through the coordinated consultations with Compac Corporation and Langan Engineering during the dam remediation design phase, consistent with the NJDEP and Department of Interior standards and guidelines for the mitigation of adverse impacts to State and National Register eligible historic properties.
- An evaluation of the scope and topical coverage of existing archives and repositories to address the land use and technological history of the immediate project area. An assessment of project critical archival and cartographic repositories, and their holdings of foundry and canal related materials.

- A Mitigation Plan for impacts that could not be avoided, including a concurrent, high speed and high definition archaeological field recording strategy to be staged and interfaced with the defined construction schedule, as defined by the project engineers and contractor, as well as a work plan that meets all of the standards and guidelines of the NJSHPO.
- A central component of this plan involves the definition of appropriate non-excavation, site definition, evaluation and mitigation strategies through the use of preservation in place and computer assisted Geographic Information Systems (GIS) based reconstructions. GIS has been used as a framework to facilitate the development of an accurate land use history for the immediate Compac Corporation facility and its associated canal features, sufficient to meet the needs of this and future preservation planning projects for the area.

The scope of this archaeological and historical mitigation strategy has been determined by NJDEP mandated cultural resource management standards and regulations, the historical sensitivity of the immediate project parcel and surrounding community, the emergency dam repair context of the investigation, and by the level of past survey and planning coverage available at the outset as the foundation for the development of an adequate mitigation plan. In response to these conditions, this mitigation plan developed between May and September of 2002 incorporates elements of a Phase IA background sensitivity evaluation, and a GIS based Phase II level of definition of the site's internal composition and diversity.

II. Past Survey Coverage

Despite the multiple areas of archaeological and historical sensitivity, this planning study was hampered by the almost complete lack of prior stage I,II or III level (Sensitivity, presence or absence testing, site definition and evaluation) cultural resource management compliance studies necessary for the development of a site-specific mitigation strategy. A review of state and local repositories highlighted the fact that, aside from a small number of regional and architectural surveys of surviving above ground structures, no area specific sensitivity or impact evaluation studies of the subsurface archaeological record existed for the town. Phase IA and Phase IB Site Specific cultural resources evaluations existed for the area to the east of the project area around Lake Hopatcong, but no comparable survey and planning studies existed for the Stanhope area (EAC 1979; MAAR Associates 1985, 1989).

Despite this lack of past area specific archaeological/ historical survey and planning studies, the immediate Compac Corporation project site is located close to and/or within three State and National Register eligible districts, that of the Morris Canal, the borough of Stanhope Historic District and the Lake Musconetcong Dam Historic District, all designated as being eligible for, or on the National and State Registers. In 1995, the New Jersey Department of Transportation (NJDOT) completed a cultural resource assessment of historic bridges and recognized the post-1926 bridge replacement, designed by Vermeule as part of his canal closing mandate, as a contributing element to the, as yet, ill-defined Lake Musconetcong Dam historic district as being potentially eligible for the State and National Registers. The district includes, but is not limited to, the bridge (NJDOT, Structure no. 1426151), the former gatehouse, the dam, the spillway, the surrounding park, and Lake Musconetcong itself (NJDOT, 1995).

A broad-based regional survey of previously recognized industrial sites highlighted twelve National and State Register eligible components of the historic canal and furnace complex, but did not include the subsurface archaeological potential and sensitivity of the area (Lefferts & Peifer, 1979, Figure 1). For the immediate area of Stanhope, three above ground surveys exist that document and plot the historic sensitivity and National and State Register eligibility of over 70 structures within the borough of Stanhope. The first of these, conducted in 1976 by the Sussex County Department of Planning, Conservation and Economic Development, identified, dated and mapped 70 historic and architectural structures within the borough, contributing elements to the State and National Register district. A 1980 study by the Borough of Stanhope Environmental Commission utilized air photo coverage as a base map to plot the locations of surviving 19th century standing structures within the borough. A reconnaissance/intensive level historic architectural survey for a proposed corridor realignment of Route 183 through Stanhope by the RBA Group under the auspices of the New Jersey Department of Transportation identified 16 historic architectural resources and sufficient information for the definition of a Stanhope historic district designation of sufficient importance to be eligible for the National and State Register (Porter & Bzdak, 1997).

All of the work to date within the immediate vicinity of historic Stanhope/Netcong areas were limited in scope to the evaluation of above-ground or well-known historic features pertaining to the iron, canal and settlement history of the area. No thematic investigation that pinpoints the location of below-ground archaeological survivals comparable to either a Phase I, II, or III level definition have been developed for the immediate project area or surrounding communities. No survey or synthesis of historic map or engineering sources has been compiled and no high definition map-based impact evaluations existed in the planning record.

Based on the background study of past survey coverage, and in order to develop an appropriate Mitigation Plan, the site definition and evaluation has focused on four major research issues pertaining to the water control, power systems and land use history of the furnace and associated canal features. Because it did not exist as a precursor to the development of a resource specific Mitigation Plan, a major portion of this effort had to start at the beginning of the compliance process and fill in with background literature survey and site definition work not available at the outset. This contextual treatment has focused on:

1. The engineering and economic history behind the various rebuilding and infrastructure upgrade additions to the facility and landscape.
2. An understanding of the original hydrology and structure of 18th and 19th century antecedents to Vermeule's 1927 modifications.
3. The role played by the Morris Canal Company in making these changes and upgrades to the Furnace Falls Dam and Spillway as part of the canal decommissioning work.
4. The reconstruction of the structural and engineering reasons behind the design of the associated blast furnaces within the retaining wall and "L-shaped canal spur" to the furnace site complex.

III. Historic Context and Significance

A. Historic Sensitivity

The historic sensitivity of the project area derives from the fact that the Stanhope region was an early 18th century center of iron production in the New Jersey highlands, and represented the high point and technological epicenter of the Morris Canal that was constructed in the 1830s to revitalize and service this industry (Goller 1994; Hanson 1961; Morrell 1980, 1983;Vermeule 1929). Pushing the limits of their technological and engineering base required the adoption of major new advances in hydrology and waterpower, materials, construction, and long distance survey and mapping.

In addition to the use of traditional land form engineering, and the use of locks to raise and lower canal boats, the builders of the Morris Canal developed highly efficient turbine systems capable of lifting cargoes in excess of 100 tons across topographic barriers of between 44 and 100 feet and upwards to 1,600 feet of overland track. The high point of the canal system was situated at Port Morris, the eastern end of Lake Musconetcong, and its reservoir provided a secure source of water for much of its distance. In his quantified evaluation of the relative efficiency of traditional locks versus turbine-powered inclined planes (one turbine powered plane was less expensive to operate than six locks in a series), Wilson (1883, Pages 2- 4) highlighted the inclined plane at Stanhope to describe the hydrology and technology of this accomplishment. As detailed below, this technological feat also transformed the topography and landscape of the canal's high point through Stanhope into an artificial landscape dedicated to the supply of water and waterpower to the canal system and the iron industry that were struggling for survival prior to its arrival.

B. Early History and Industrial Development

This overview of the developmental history of the iron operations in Stanhope used extant secondary sources and key archival and map records from local and regional repositories to focus on the engineering and land use history of the Stanhope, Sussex, and Musconetcong Iron producers as they utilized and altered the associated Furnace Falls Pond over the past two centuries.

The history of the immediate Compac property can be divided into four major periods: the earliest phase, between 1780 and 1840, was characterized by the onset of iron production in the Stanhope area, and was manifested by various corporate concerns, primarily that of the Stanhope Iron Company. A forge for the manufacture of nails and iron making was founded by the Dickerson family of Morris County on the Musconetcong River in Stanhope by the 1780s (Hanson 1961, Page 113; Morrell 1980). These earliest furnaces appear to have been up and downstream of the modern Compac property. Morrell dates the building of Furnace Falls Dam to circa 1794 as a source of power to these earliest furnaces on the river established by Silas Dickenson (Morrell 2000, Page 1). The second, between 1841 and 1855, was marked by the appearance of the Sussex Iron Company and, with it, the advent of the first furnaces on the property. [There is a discrepancy on the historic record. Morrell 1980, sets the beginning of the Sussex Iron Company at 1845. Hanson (1961) dates it beginning around 1840. This report uses 1841 to delimit the beginning of the Sussex operations at the site.] It was associated with the introduction of anthracite blast furnace technology and early experiments that attempted to produce zinc oxide and resulted in a massive explosion at the iron works, which shut down the facility, leaving it abandoned until the end of the Civil War. The third phase was marked by the incorporation of the facility as the Musconetcong Iron Works, which stayed in operation until the furnaces were taken over by the Singer Sewing Machine Company in 1901, and which continued furnace operations at the site until 1922 (Hanson 1961; Morrell 1980, 1983).

Concrete, site-specific, historic documentary and map evidence is weakest for the earliest periods, but two early 19th century maps of Stanhope depict the presence of Furnace Falls Dam in the second and third decades of the 19th century. Both depict Furnace Falls Pond with a wide dam structure, and each show two spillways out of the dam. One followed the north bank of the river channel, and the other followed the south bank.

The 1828 Morris Canal map indicates that these earliest iron making operations appear to have been located downstream about 300 to 400 feet below the dam of Furnace Falls Pond and the modern Compac Corporation property, and south of the Flanders Road crossing over the river. This map is important because it appears to be based on measured field survey data with lines and angles drawn with precision, as well as predating the addition of the circa 1840s L-shaped canal spur to the foundry. It also explicitly depicts the former presence of <u>three</u> independent millruns, or raceways, running out of the Morris Canal before the canal spur to the foundry and its supporting terrace were added to the landscape.

The other early map, a less precise and apparently impressionistic sketch, is the 1831 Map of Stanhope (not illustrated), from the holdings of the Musconetcong Foundrymen Historical Society. It also shows the locus of earliest forge operations as being located downstream by some 300 feet west of Flanders Road, the dam at Furnace Falls Pond, and the Compac Corporation property today. The lack of any apparent buildings or furnace structures as of 1831, in or near the current property limits in these two depictions suggests that the earliest iron making facilities actually established at the Compac Corporation property may not have been in place until circa 1840, contemporary with the establishment of the Sussex Iron Company.

Stanhope began as a settlement in the last two decades of the 18th century as a production center to exploit the area's ore deposits, fuel supply, and waterpower. Its earliest settlement history was summarized by Hanson's 1961 article focusing on the technological history of the Sussex Iron Company:

> The best information indicates that between 1780 and 1800 a Mr. Dickerson, either Jonathan or Silas, built the "upper forge" on the Musconetcong River at Stanhope, and in 1801 Mr. David Scaly Canfield built another. These forges seem to have followed the usual pattern of changing ownership and "off-on" operation. In 1834, Thomas F. Gordon in his *Gazetteer of the State of New Jersey* describes Stanhope as a town of 20 to 30 dwellings, 2 taverns, 3 forges and a gristmill. More to the purpose, he writes that the Musconetcong River was diverted from its bed to provide a thirty-foot waterfall, and that a plane of the newly arrived Morris-Essex Canal passed through the town (Hanson 1961, Page 113).

Prior to the opening of the Morris Canal & Banking Co. as a continuous transportation link between the ports of Newark and New York at its eastern end and the coal fields of Pennsylvania accessible via the Delaware River at its western end, the economic health of the iron industry suffered from three economic forces: the lack of adequate wood supply for fuel, the lack of sufficient water for power, and inadequacies in iron processing and manufacturing technology that resulted in substandard iron. Until the mid-19th century, iron manufacturing depended on the local availability of vast tracks of timber for fuel. However, by the decade of the 1830s these early wood fueled furnace operations were forced to close down due to the depletion and deforestation of the local fuel supplies. In this period, the New Jersey Highlands had a total of 53 forges and 3 furnaces, of which "thirty forges and nine furnaces were shut down due to the high cost of transportation and the scarcity of fuel" (Vermeule 1929, Page 49). The local iron industry of

Stanhope was no exception. It lay dormant until its revival as the Sussex Iron Works of 1841, and its initial manifestation at the sight of the modern Compac Coorporation immediately below the Furnace Falls Pond (Morrell, 2000).

The arrival of the Sussex Works in 1841 marked the advent of a major rebuilding and modernization phase for the iron industry in Stanhope. The new facility built the first blast furnaces capable of using the regionally abundant anthracite coal for fuel instead of the all but depleted charcoal and charcoal derived coke for fuel. It also corresponded with the advent of smelting and forging facilities at the Compac site adjacent to the Dam site.

The shift to these new production techniques reflected the availability of major innovations in iron processing and refinement in iron ore in the U.S. and Europe and their introduction into the local iron industry, which were codependent with the advent of long distance canal transportation and the recent ability to refine iron using heated compressed air to overcome the impurities present in anthracite coal (Boyer 1939; Chard 1995; Daumas 1979, Pages 533-555; Goller, 1994; Porter 1995).

By the mid-19th century the settlement had more than doubled in size. The 1868 Beers Atlas contained a small inset map of Stanhope that depicts the presence of over 80 structures. In addition to the Sussex Iron Company complex (Beers shows two pairs of structures at the end of the canal spur, possibly furnaces and two casting houses, but the images are schematic and small scale. What the little map does make clear is that the furnaces were described as the "Old Furnaces" of the Sussex Iron Company, and is consistent with the timing of the reported explosion and cessation of Sussex era production at the site in 1855. Like the later 19th century Weir Map No. 7 (Figure 18), which showed the extent of land holdings of the subsequent Musconetcong Iron Works spanning both banks of the river, the Beers map of 1868 clearly delimits the company holdings as straddling the river and encompassing properties to the south of the Morris Canal, also from below Furnace Falls Pond, east and upstream to the location of Musconetcong Lake. Morrell points out that this territory is consistent in extent with the size of the original 60 acre Hude Tract (Morrell 1980, Page 3). As documented by the 1887 Weir Map, this ownership pattern in land holdings over both banks of the Musconetcong River continued into the period of the Musconetcong Iron Works operations, and apparently later. Although interrupted by the imminent domain takings of property by the Canal Company sometime in the 19th century, a penciled-in notation on a NJDEP Water Resources 1925 blueprint copy of the Weir series

(Folio 7) notes that the same holdings were sold back to the Singer Sewing Manufacturing Company on September 8, 1926.

Netcong emerged as a distinct community from Stanhope at the turn of the century. What had been referred to as South Stanhope in the 19^{th} century, by 1889 began the process of being incorporated as a separate entity and was reincarnated as the Borough of Netcong as of 1894, distinguished as the western terminus of the Delaware, Lackawanna and Western railroad in Morris County (Putney 1914, Page 114).

From their inception, the Sussex furnaces were designed as blast furnaces that used forced air to increase the temperature of the fire. For the first five years, the Sussex furnaces' air supply of compressed heated "blast" was powered by water. Only in 1846 was a steam engine installed to supply compressed air (Hanson 1961, Page 114). This little anecdotal footnote may prove critical for the following reconstruction of the site's land use history because it places a chronological bracket on when the Sussex works depended upon the sufficiently large and elevated supply of water to drive the blast furnaces. This period between 1841 and 1846 also correlates with the second phase of rebuilding and enlarging the Morris Canal to accommodate larger boats and greater freight capacity. It was also during this period that the furnaces at Stanhope became inextricably linked both economically and technologically in the engineering history of the Morris Canal.

Hanson described the presence of three early furnaces, all relatively small compared to later upgrades during the post-Civil War era, measuring 30 feet in height, 10 feet in diameter, with small 3 1/2 square foot hearths. He also mentioned the presence of three "tuyeres", or blast air pipes, which provided compressed air heated to 600 degrees with a pressure of three (3) pounds per square inch. He described these three (3) early furnaces as being solely for the use of anthracite coal, which, together, produced 90 tons of cast iron per week. (Hanson 1961, Page 113).

In addition to its historical place as one of the earliest blast furnace production facilities using anthracite coal in the region, the Sussex Iron Works sought added revenue in the production of zinc oxide for commercial paint. Besides owning and using local iron deposits, the Sussex Iron Works sought to use the locally available Franklinite ore which consisted of 17 % zinc oxide, and 16 % manganese oxide with the balance made up of iron oxide. Other attempts to reduce the zinc oxide from the ore had failed when producers used traditional "pre-blast" wood burning furnaces. Edwin Post, the owner of the Sussex Iron

Works, wanted to overcome this problem using his new hotter anthracite fueled blast furnaces to refine the zinc and ore. Although no new details of his process are readily available, as he may have kept them secret, the technique generally involved heating the ore to high temperatures until the zinc evaporated as a vapor, which was then reheated and oxidized and condensed as a solid for production of commercial paint. His initial experiments appear to have been successful and, in 1853, he constructed a fourth and larger furnace, 20 feet in height, specifically designed for the collection of zinc fumes. This new facility exploded around 1855 and it was reported that the resulting fire destroyed the entire complex (Hanson 1961, Pages 115-116).

According to Hanson's brief history of the site, the complex lay abandoned and out of production from 1855 until 1864, when it was reconstituted as a new concern called the Musconetcong Iron Works. It operated apparently uninterrupted until its purchase by the Singer Sewing Machine Company in 1901 and controlled the land on both sides of the Musconetcong River between the Morris Canal reservoir upstream at Lake Musconetcong, and downstream to Flanders Road. It was during the Musconetcong period that the facility was rebuilt with the advent of two new and significantly larger furnaces measuring between 70 and 80 feet in height and 20 feet in diameter, almost twice as large as those that existed in the previous Sussex period. Depictions of these new Civil War era furnaces survived as detailed large-scale depictions by the Sanborn Insurance Map Company (Figures 19 and 41).

Morrell notes that the Musconetcong Iron Works was taken over from a group of "New York capitalists" by A. Pardee and Company in 1869, but the installation continued under the same name until the advent of the Singer Sowing Company at the turn of the 20th century (1980, Page 4). Although only limited secondary sources are available to characterize the nature and focus of production at the Musconetcong Iron Works for this period, Morrell's 1980 "Historic Stanhope Tour Guide and Documentary Overview" provided the following description:

> Iron manufactured by the Stanhope furnaces was transported via the Morris Canal and the Delaware, Lackawanna & Western Railroad to areas of northern New Jersey and various other states including New York and Pennsylvania. By 1881 annual production of the Musconetcong Iron Works had reached 40,000 tons of pig iron. Considerable quantities of this iron were shipped to Paterson to supply the extensive machine manufacturing complexes of this large New Jersey industrial center (Morrell 1980, Page 4).

During the period of the post-Civil War Musconetcong Iron Works, the dam at Furnace Falls Dam was rebuilt as an arched stone bridge of sufficient strength to serve as a train trestle. The 1874 date of the capstone to the cut stone bridge corresponds in time with a period of economic distress and with a period of transfer in ownership of the Morris Canal from the State of New Jersey to the Lehigh Valley Rail Road, which lasted until its closing and reversion to state control on March 1, 1923 (Eckhart 1975, Page 7). In 1870, the New Jersey legislature passed a law granting the Morris Canal Company authority to lease its property to private parties, and in May of 1871 it was leased to the Lehigh Valley Railroad Company for a period of ninety-nine years (Eckhart 1975, Page 13). Several years earlier, in 1868, the legislature had granted the Canal Company ability to "construct railroads of not more than 2 miles long to connect other railroads to the canal, as an aid to the business of the canal" (Eckhart 1975, Page 4). Thus, although these contractual and economic shifts brought about the interconnection of rail service to the canal and the foundry, and precipitated the rebuilding of the historic bridge into a more substantial structure capable of serving as a rail trestle, these events during the era of the Musconetcong Iron Works took place some 30 years after the landscape of the drainage was transformed with the addition of the canal spur.

C. The Furnace Complex and the Morris Canal

Furnace Falls Pond Dam represents one component of an integrated hydrological system with the Morris Canal. Historic map analysis and field observations document what appears to represent a consistent pattern of multiple functions for each element of transport, power and the regulation of water flows. The history of the foundry site is intimately intertwined with the engineering, economic, legal and technological history of the Morris Canal.

From its inception, and definitely from its initial steps at reengineering beginning in the 1840s, both the history of the Morris Canal and the evolving iron industry works in Stanhope were functionally, technologically, and economically "joined at the hip," such that the treatment of one can not be undertaken without being integrated with the other. As such, the history of the technological and land use transformations of the foundry in the 19th and 20th centuries can only be understood in the context of parallel changes in the history of the canal.

The first five years of the Morris Canal Company's existence between 1830 and 1835 were economically troubled. Short disconnected sections of the canal became available for short hauls by 1829 (Vermeule 1929, Page 53). By 1831, the canal was in full operation, providing ninety miles of water transport between Newark on the Hudson, and Dover on the Delaware Rivers (Vermeule 1929, Page 55). Like the foundry operations, the early years of the canal's operation were distinguished by economic loss and severe mechanical problems of design and construction. The first canal boats were small and of low capacity. Its profitability was also limited by the fact that goods needed to be transported over land for the last leg of the journey before reaching the ports and shipping facilities of Jersey City and New York Harbor. This limitation was redressed by an infusion of capital and the authorization from the legislature to build an eleven-mile extension to Jersey City, which was finished in 1836. This year marked a period of nation-wide financial boom and inflation. The Morris Canal and Banking Company made money as a banking institution but not as a transportation concern. Despite major redesign and engineering overhauls to increase capacity between 1835 and 1841, the company's failure to meet its loan obligations forced insolvency and it laid dormant and out of use for several years until 1844 (Vermeule 1929, Page 58).

Although finished in 1831, many of the initially implemented engineering components of the canal system did not work very well, and over the next ten years required a series of upgrades, improvements, and technological replacements (Vermeule 1929; Wilson 1883). The original dimensions of the canal were limited in depth and width, 32 feet wide at the water level, 20 feet at the base, with a depth of 4 feet. The earliest locks were built 9 feet in width and 75 feet long. The earliest boats were small and limited in capacity to 20 tons. The inclined planes were constructed with a variety of designs but were initially only 9 feet wide, consistent with the width of the water locks. These initial design parameters proved to be inadequate both financially and mechanically, and for 25 years underwent multiple design alterations to increase capacity and profits.

Table I
Summary of Cost in Round Numbers

From Delaware River to Newark	$2,000,000
Alterations of planes in 1835-36	$230,000
Extension to Jersey City in 1836	$600,000
Greenwood reservoir and feeder	$170,000
Enlarging planes and locks in 1841	$400,000
Total	$3,400,000
Enlarging canals and rebuilding planes	$1,700,000
Total cost	$5,100,000

(Wilson, 1883, Page 2)

The sequence of subsequent rebuilding and design alterations took place in three major phases. As distinguished by Wilson's 19th century financial summary (Table I), the first phase of rebuilding occurred between 1835 and 1836 at a cost of $230,000 (Wilson 1883, Page 1). The second major phase occurred between 1841 and 1848 at a cost of $400,000, exclusive of the lineal expansion of new "feeders" canal and new reservoirs. The greatest rebuilding effort took place during the second phase. Beginning in 1841, the locks were enlarged to a uniform width of 11 feet and a length of 95 feet. In 1845, the canal was enlarged to a width of 40 feet at the water line, 25 feet at the bottom, and to a depth of 5 feet. In 1845, a new design of canal boats, ones that were constructed in two sections, were introduced with an initial capacity to carry 45 tons of cargo (Wilson 1883).

Finally between 1850 and 1860, all of the inclined planes, basically water turbine powered sections of railroad tracks with wheeled dollies, were rebuilt with new designs and fitted with wire rope, versus hemp, manufactured by J.A. Roeblings & Sons of Trenton (Wilson 1883). "A long, continuous cable, operating on a drum and a series of pulleys, pulled a cradle car with the canal boat resting in it either up or down the hill. The whole mechanism was powered by a waterwheel and was capable of lifting the 70-ton boats" (Caggiano 2002). This sequence of canal redesign and expansion also helps pinpoint the time frame of the "L-shaped spur" to the furnace. As detailed in Vermeule's 1927 measured drawings, the plans for the dismantling of the canal through Stanhope document that, at its narrowest points, the spur measured 12 feet wide, with the widest sections ranging between 24 to 32 feet in width (Vermeule 1924-25, Drawing 89A, "Dam and Gates at Lake Musconetcong"; Figure 35). Assuming that it served as a transportation wing as well as waterpower supply source for the Sussex Iron Company, these measurements suggest that the spur was designed to accommodate the second generation of larger 11 foot-wide section canal boats, which went into service after 1848.

Both the first locks and boats were small and thin. "The locks measured 9 feet wide and 75 feet in length accommodating boats 8 1/2 feet in beam and 70 feet in length carrying on the average of about 25 tons… In 1840 to 1841 the canal facilities were enlarged, locks made 11 feet wide and 90 feet long, and the inclined planes widened two feet" (Eckhart 1975, Page 12). After the canal was widened, new boats were introduced that were built in two sections and hinged in the middle, measuring 10 feet wide 70 feet long and capable of transporting 70 tons of cargo (Canal Society website, Page 9). "At the commencement of service in 1846, the Canal Company owned 108 of the new section boats. These were rented to boatmen as it was considered that, by keeping down the investment of the individual boatman, this policy would lead to a greater use of the canal" (Vermeule 1929, Page 61).

The Canal Company's need for more water was addressed by building new dams, first at Greenwood and then at Stanhope, with Lake Musconetcong, as a primary canal reservoir, reopening in 1846. This major new source of water for the canal was good for the Canal Company; and it turned its first profit in 1849, but was bad for downstream water-powered iron industries at Furnace Falls Pond. This period of massive landform alterations and canal expansion appears to have been associated in time with the addition of the canal spur to the furnace.

These economic and land use changes associated with the expansion of the Morris Canal appear to suggest a chronological framework that would date the "L-shaped spur" and the massive stone retaining wall at the foundry site that supports it, at or around the mid 1840s. It is now apparent that its advent may have also been functionally associated with the introduction of blast furnace technology using anthracite coal by the Sussex Iron Company beginning in 1841.

The Sussex Iron Company sued the Canal Company over water rights and, in 1845, won the case. The Canal Company was ordered to guarantee sufficient water for the Sussex Iron Company by building a large battery dam, or reservoir, at the site of the modern Lake Musconetcong, thereby raising the water level in the canal to facilitate larger canal boats and loads. The Canal Company was also ordered by the courts to pay the foundry $12,000 for a steam engine as an alternate power source sufficient to meet the constant needs of the Foundry (Morrell 1980, Page 3; Canal Society Web site, 2002). The "L-shaped spur" was built as part of this canal expansion program specifically to meet the court ordered mandates of the 1845 lawsuit brought by the foundry against the Morris County Canal and Banking

Company. Its construction precipitated major landscape alterations to the local topography that tied the iron works to the canal, both physically and technologically.

The widening and expansion of the canal provided the large volumes of fill that would have been necessary to construct the massive stone and earthen terrace formation to support and raise this spur extension to the foundry from the main canal through Stanhope. Modern topographic coverage and field inspection suggests that the fill and structural components were both massive and deep. Outcrops of cut stone suggest the presence of large stone-reinforced terraces to the south and downhill from the "L-shaped spur." Borings taken as part of this project design phase by Langan Engineering document that even in its lower reaches near Furnace Falls Pond, the original early 19th century surface was buried under 15 to 20 feet of historic fill (Langan 2001).

The canal spur was built up behind the heavy stone retaining wall to meet the elevation of the main canal section through Stanhope. It paralleled a former mill raceway beside the region's earliest limekiln for fertilizer and flux as an additive to the smelting process (Morrell 1980; Rutsch, June 2002). The retaining wall at the furnace site raised the surface above it by 12 feet. A 10-foot high embankment was added to form the sides of the canal spur bringing it to the height of the rebuilt canal. Really a series of large cut stone terraces, this canal spur also appears to have had multiple functions critical to the operation of air blast anthracite production (Figures 4, 16, 17). The large retaining wall is massive and similar in construction and scale to the contemporary stepped hillside wall and terrace structures found at the West Point Foundry on the Hudson, excavated by the author between 1989 and 1994 (Grossman 1994, 1995).

D. The Reservoir, Water Power and Blast Furnace Technology

The historical and technological association between the need for adequate water supply, the evolution of blast furnace technology, and the timing of the building of the canal spur suggest that the water from the spur may have served for more than transport. As discussed below, it also suggests that the canal spur addition may have been an essential component of blast furnace production at the foundry as well.

The earliest available map depiction of the works, showing any detail of the furnace operation at the current site, is the 1858 *Map of Stanhope and Vicinity,* by Roome and Son, Surveyors (Figures 16 and 17). Like the later 1909 *Sanborn Insurance Map*, that labels the "L" shaped spur to the canal as the "Furnace Reservoir (fed from the canal)", the 1858 sketch map by Roome and Son clearly shows the canal spur, but unlike later views, shows the "Raceway to works" connected to the foundry by a raceway or channel with three unidentified structures aligned perpendicular to it (Figures 19 & 41). This illustration and the use of the term "Reservoir" suggest that the L-shaped spur may have served for more than ore and fuel transport to the furnaces below and adds credence to the idea that it may have supplied the water necessary for water powered air blowers as well.

The canal spur, the weir, and spillway of Furnace Falls Pond below it, and the series of overflow water level control valves along the "raceway to works" (Figures 10, 16) all exhibit multiple functions and technological interconnections between blast furnaces, anthracite coal for fuel, the advent of canal and rail transport, and the availability of adequate water supply for the foundry after the canal was opened. As illustrated by a period citation from the <u>American Cyclopedia</u> of 1873, these associations and correlations were well understood by foundry experts and owners of the period.

> In the district where it was first worked, including northern New Jersey and the adjacent parts of New York and Pennsylvania, the bloomery process has fallen into disuse since wood has become scarce and extensive workings of coal in the vicinity, with great facilities for transportation, have rendered it more profitable to treat the ores in blast furnaces than the bloomery fire (Ripley & Dana, Vol. II, 1873, Page 743).

In addition to supplying water borne access to the foundry for the delivery of coal and iron ore, the "L-shaped" water spur may have also served as a source of power to create the compressed air necessary to operate the post-1840 blast furnaces. In fact, in addition to its function as a retaining wall for the lower elevation foundry facilities, the "L-shaped" spur may have been inextricably linked to the technology of blast furnaces from the onset of their transformation from bloomery furnaces, with a water powered drop hammer in the 1830s, to blast furnace technology running on anthracite coal in the 1840s.

The 1873 account of blast furnace technology details the association between the need for an elevated waterpower source, or "reservoir", and what was then referred to as the central technological ingredient of blast furnace technology, "the water blowing machine".

> Besides the common bellows, the most efficient of these machines are the blowing cylinders, which are used to supply air to blast furnaces, and by their great size and strength are made to furnish immense bodies of air under great pressure (Ripley & Dana, Vol. II, 1873, Page 745).

> For propelling air into blast furnaces, the blowing cylinders are made of great size and strength. They are often set in pairs, upon horizontal frames of cast iron… Two such cylinders, of 5 ft. diameter and 6 ft. stroke, afford… sufficient air for a first class furnace (Ripley & Dana, Vol. II, 1873, Page 746).

The association between this water powered source for high velocity compressed air as an integral part of blast furnace technology is intriguing, but Ripley's description of a related, water and gravity, non-water wheel air blowers reads like a description of the "L-shaped" reservoir above and immediately (50 feet) to the east of the stone retaining wall. The water powered air blower:

> …is dependent upon a current of water falling from a considerable height. It consists of a large pipe, about two feet square, leading from an upper reservoir of water, be it a cistern or box, 25-30 feet below it. A few feet under the cistern, the pipe is contracted in the shape of a funnel in order to divide the water into many small streamlets. Below this narrow place are a number of holes through the pipe for the admission of air. This is taken down by water as it descends, and passes into the middle of the cistern at the bottom, where a block is placed, upon which water dashes, causing the air to separate from it…From the top of the cistern a small air pipe conveys the blast to any required point. This apparatus is used for furnishing air to cupelling and melting furnaces (Ripley & Dana, Vol. II, 1873, Page 746).

This non-water wheel driven source of compressed air for the supply of blast furnaces derives from the physics of the adhesion of gasses to liquids. "Use is made of this adhesion in the so-called water blowers, in which a stream of water falling through a wide tube carries air downward and produces a blast so strong that this principle was used for driving the drills during the boring of the Mont Cenis tunnel." (Ripley and Dana, Vol. I., 1873, Page 116). In essence, the pre-Civil War engineers were capturing the power of a waterfall to supply the furnaces with blasts of air.

The proximity and apparent historic association of the raised retaining wall, the "Access Road" embankment, the "L-shaped" canal spur, the court battles between the Foundry and the Canal Company in the 1840s, the functional interdependence between blast furnace production and the use of water, and later, steam power "air blowers" to provide the blast suggest that the historic embankment may contain subsurface structural elements of water-powered gravity and piston air blowers buried and preserved in the hill.

E. Synopsis

This overview of the site's history has been brought together to provide a chronological, economic and technological framework for the evaluation of the age and function and historic place of the immediate impact area of the Weir, Lower Spillway and cut stone channel elements of historic Furnace Falls Pond. Based on this synopsis, these elements appear to date to the time frame of the two major periods of 19th century furnace operations at the site. The cut stone channel elements appear to date to either the 1840-1855 Sussex Iron Company or to the subsequent Musconetcong Iron Works (1864-1901). The possibility exists that given the distinct style of stone workmanship evidenced between the rough cut elements of the lower channel stonework, in contrast to the finer, more symmetrical forms of the 1874 cut stone train trestle superstructure, that the lower elements derive from the earlier period, and the now-removed upper elements, to the later Musconetcong phase, but this is speculation.

What is now clear from the historical record is the fact that the massive twelve foot high stone retaining wall, and its associated land form alterations constructed to support the L-shaped spur formation and the reservoir on it, both appear to have been built in the mid to late 1840s by the earlier Sussex Iron Company. As documented below, a major insight of this background research and cartographic analysis pertains to the 20th century work by CC. Vermeule, and the fact that the latest engineering manifestations of both the Furnace Falls Weir and Lower Spillway appear to have been his doing. Accordingly, the following treatment focuses on the technological and historical context of these additions and alterations as they pertain to the changing function of the Furnace Falls Dam and channel features from the mid-19th century through to the canal decommissioning activities of CC. Vermeule, Senior and Junior, in the late 1920s.

IV. Cartographic Sources and Repositories

A major component of this joint Engineering and Archaeological Mitigation Plan involved the search for surviving data that might aid in establishing the engineering history of the subject weir and spillway at Furnace Falls Pond. What has clearly emerged from this assessment is the almost complete lack of modern and historic map control sufficient to establish the precise location of the canal elements and supporting structures, or a land use history of the evolving foundry works and the Morris Canal in this study area. Despite the availability of several popular treatments in support of cultural resource planning initiatives to protect the canal and the foundry, no detailed map-based treatment exists of the Foundry, or the Morris Canal, for this immediate region of Morris and Sussex counties (Lee 1977, 1979; Morrell 1980, 1983, 2000). An in-depth county level treatment of the Morris Canal was conducted as a formal historic preservation survey for Warren County, with funding by the Office of New Jersey Heritage and the National Park Service, but no comparable synthesis or documentation exists for the immediate project area, or for the area of Morris County (Morrell 1983; Lefferts & Peifer 1979). In essence this lack of prior work on the potential archaeological sensitivity of the area required that this Mitigation Plan needed to first develop sufficient site definition and evaluation level of data control (comparable to previously unavailable Phase I and II studies) in order to meet the cultural resource management needs of the emergency dam remediation effort in a short time period.

The most critical publication with relevant information pertaining to Stanhope remains the 1929 report to the Morris Canal Company by C.C. Vermeule on the early historical development, construction, and decommissioning of the canal. This pivotal survey also served as a critical guide and signpost for the effort to track down the scope of past coverage and the availability of pertinent archival sources and repositories. Vermeule's summary report to the Canal Commission also provided access to the long record of engineering improvements and alterations to the Canal, which, in turn, served to highlight local transformations in land use history, and facility upgrades of immediate pertinence to the land use and technological history of iron production in Stanhope.

Vermeule's 1929 report spoke in terms of construction contracts and drawings, along with cost and construction hurdles. These citations, in turn, led to a fruitful process of identification and review, which formed the backbone of this Mitigation Plan and recommendations. Current and former state officials in Dam and Water Resources divisions of the NJDEP were interviewed for leads. Dam and water supply engineers who worked for the NJDEP 15 to 30 years ago provided leads as to the nature and survival of key cartographic, legal, and engineering records. NJDEP correspondence concerning the contents and transfer of Morris Canal archives to the New Jersey State Archives (NJSA) provided references to specific contracts and design plans for the immediate Stanhope area.

The availability of a computer data base index at the NJ State Archives of all canal records, combined with specific document titles and reference numbers, then led to the uncovering of the original plans and contract records for all canal related construction and decommissioning documents for the study area in general and for land use changes in the immediate vicinity of the local iron works in Stanhope (Jones & Klett 1993). This search revealed over sixty pages of computer printouts of project specific archival records and map files.

In addition to these original plans and contract documents, this path of inquiry revealed a number of critical internal legislative, legal and canal commission studies and investigations that hold the potential for revealing important data on the development of the foundry facilities, as well as the possibility of relocating what may be the original contract documents for the weir and spillway of the Furnace Falls Pond water power system. These important sources include an often referenced to 1894 water supply study by C.C Vermeule along with three internal studies in 1903, 1912 and 1922 prepared by the Morris Canal Commission on the decommissioning of the canal as mandated by the New Jersey State Assembly (Werts, et. al., 1903).

Finally, because of the Canal Company's 1840s court ordered obligation to provide adequate water for local mill owners and the Sussex Iron Company, it is possible that these studies contain project-specific documents and records that pertain to water supply issues affecting the foundry. This untapped resource from period court records represents a particularly important research avenue because given the magnitude and immediacy of subsequent heavy building and land form changes which followed the legal decision, the possibility exists that these court records may contain surviving plans and descriptive materials of pertinence to the developmental history of the foundry (Rutsch, Personal Communication, June 17, 2002).

A key source of additional early potential map and land use evidence is contained within the Report of the Investigation Commissioner of 1903. Although only the first of many attempts to close and decommission the canal, this one is unique because it contains detailed appendices, a supplemental volume entitled Morris Canal Views, and includes a summary of litigation by and against the Morris Canal Company. This index of litigation suggests that the potential exists to find project-specific records on the water dispute of 1845 between the Sussex Iron and the Canal Companies that might throw additional light on the building and function of the "L-shaped" canal spur to the foundry (Werts, et. al., 1903).

This assessment of relevant archival holdings has highlighted the survival and availability of several archival and cartographic collections that contain previously untapped map resources regarding the reconstruction of the technological, economic, water power and land use history of the foundry complex.

Given the almost complete lack of accurate and comprehensive map control over the nature and location of former and surviving historic and archaeological resources, a key focus of the archival survey concentrated on the identification and evaluation of original map sources for the foundry site and the associated structures on the Morris Canal. The goal of this survey of repositories was to target and prioritize key repositories and holdings that held the greatest promise of yielding critical new information on the function, design, and construction of the spillway dam, the historic channel stone wing walls, and the three pronged cement weir at the head of Furnace Falls Pond.

No previous studies had appeared to focus on these resources, and at the outset of this project effort it was not clear if any historic maps for the immediate project area did survive as large scale, often hand colored, originals of sufficient detail for high resolution computer and GIS processing. A great deal of secondary literature and historical treatments did exist for the Morris Canal system in general, but there was very little in the way of detailed high resolution maps showing the location, dimensions and construction details of the canal and its supporting structures in the Stanhope area. Aside from the work of Brian Morrell on the historic sensitivity of the Stanhope/Netcong/Lake Musconetcong area and his study of the Morris Canal in Warren County to the west, no detailed historical summaries and sensitivity statements or site-specific, map based, land use histories had been undertaken for the Morris Canal related structures. The same applies to the early 19^{th} century foundry site itself and to the water control and transportation elements associated with the Furnace Falls Pond and the affected historic spillway as well as the dam and weir features. It was apparent that the potential for surviving historical records and maps existed. It was not clear what coverage might survive, where, and in what form of preservation.

The land use history developed for this mitigation plan was only viable if detailed historic maps and measured drawings did exist and could be accessible for study and digital documentation. Fortunately, the preliminary survey of primary repositories has unequivocally demonstrated that they do exist, and that such a reconstruction has proved both feasible and necessary as a first step in rectifying the gaps that currently preclude informed preservation planning for this significant national resource.

Foremost amongst these primary repositories are valuable and previously under utilized map collections of the NJDEP, the New Jersey State Archives (NJSA), the Morris Canal Society of New Jersey, Sussex and Morris County Libraries, the Musconetcong Foundrymen Historical Society, and finally, the Morris County Chancellery Court Records of historic litigation of the 1840s that precipitated the enlargement and massive landscape alteration of the foundry and Morris Canal holdings in the Stanhope/Netcong area of the Musconetcong drainage. The Morris County Library never turned over their Canal Holdings to the New Jersey State Archives. While this facility has a large collection of Morris Canal records for the county, they are not indexed or easily accessible by area or topic, and as such were beyond the scope and available resources of this study. Likewise, while the County Chancellery Records may contain case data pertinent to the Stanhope area in general and the litigation between the Canal Company and the Sussex Works in particular, a preliminary scan of these records did not reveal them.

Of these, the holdings of three repositories deserve special treatment: 1) the NJDEP Water Resources holdings, 2) the New Jersey State Archives, and 3) the Musconetcong Foundrymen Historical Society.

A. NJDEP-Water Resources Morris Canal Holdings

The survey of Morris Canal file holdings at the NJDEP yielded a limited number of maps, mostly blueprint copies of 19th century survey of canal alignment and properties acquired for its construction, but encountered a large collection of correspondence and inventories reflecting past efforts to transfer the Morris Canal archives from the NJDEP to the NJSA for permanent curation. These included lists of the original holdings, items that were transferred to the archives and listings of pertinent materials that might still be held by other divisions of the NJDEP (Wright 1979). This brief assessment of NJDEP Water Resources holdings documented the presence and survival of original survey and planning studies supervised by C.C. Vermeule in the 1920s. Additionally, it included listings of other earlier maps from the initial canal survey work in the 1830s, field books, microfilm copies of all maps, minutes of the corporations, correspondence and originals. These internal Water

Resources files, the majority dating to the 1950s and 1970s, served as a detailed road map to project-specific documents and maps which had been transferred to the New Jersey State Archives.

B. New Jersey State Archives

The NJDEP Water Resources files provided the names and, for some items, the specific plan numbers of over 500 maps from the Morris Canal and Banking Company holdings at the New Jersey State Archives. The staff of the modern and computerized facility quickly performed multiple record searches and retrievals based on the formal titles logged in the NJDEP Water Resources files.

The computerized inventory of the collection made it possible to sort and query the archival index for maps pertaining to the immediate project area. This search resulted in about 60 pages of relevant maps with coverage in four major time periods: the 1830s, the 1870s and 1880s, and Vermeule's original 1924-1929 existing conditions "as-builts " and design recommendations for the closing and decommissioning of the Morris Canal. Vermeule's original 1919-25 plans and profiles are preserved as clear, high-resolution blueprints rendered as large format plans (30 by 40 inches). They are crisp, plotted with precise angles, distances, and elevations, and are heavily laced with notations. The collection also contains the original field notes and maps of the pre-construction design work for the canal dating from 1828 to 1834.

In total, this preliminary survey identified some 17 boxes of maps for the Stanhope/Netcong study area, and contained 51 folios of individual and group map sets for the Stanhope/Netcong/Lake Musconetcong area. Each folio contained one or more large-scale plans and profile sections covering existing conditions, and proposed alterations for the demobilization of the canal between Bridges 517 and 523. In his 1929 report, Vermeule noted the final creation and transfer to state repositories of hundreds of drawings, stating, "The drawings prepared totaled 575, nearly 400 of which were standard contract drawings or surveys of permanent record" (Vermeule Jr.1929, 1922).

This survey of map holdings suggested that 75 to 150 maps, or about one quarter of the collection, pertain to the Stanhope portions of the canal system. The archive includes an inventory of the Morris Canal Company archives on microfilm, of which no less than 17 and possibly up to 28 rolls contained legal, cartographic, and contractual records regarding the are area. It also identifies a number of large-scale measured plans of the two locks, Lock 1 west and Lock 2 west constructed at either end of the Stanhope section of the Morris Canal. Both depict detailed renditions of existing conditions and proposed changes as well as secondary structures and landscape features associated with each of these locks (NJSA, Morris Canal Collection Box 30 item 1, Box 25 item 11, Box 48 item 46).

The archive collection also holds the large format, 42 x 111 1/2 inch, ink on paper original of Weir's 1887 Map No. 7 of the canal through Stanhope (at 1"=400 ft.) as well as measures and survey dimensions and locations of the canal features (NJSA, Box C Item 21-MC Col.). This detailed map served as the planning base map for the state as the "Amended Official Weir Map" until 1969 (Figure 18).

In addition, the archives hold the Henry Kummel Collection of historic photographs of the Morris Canal taken between 1923 and 1937. Kummel was the Director of the New Jersey Department of Conservation and Development as well as the State Geologist. He had served as Secretary for the Morris Canal Commission of 1923 and subsequently as the General Manager of the Morris Canal Company throughout the period of its decommissioning and closing by the State. His tenure overlapped that of Cornelius C Vermeule and then of C.C. Vermeule Jr., who took over the design and engineering work on the canal dismantling upon his father's retirement in 1928. Kummel's photographs documented existing conditions as of 1923 and various views of stages of dismantlement and repair of bridges and associated water control features. Of the total collection of 93 prints and negatives (some by CC. Vermeule, Jr.), 31 pertain to work in the immediate Stanhope area. His photographic record included a number of views of Lock 1 West at the Musconetcong Dam, the gatekeeper's house next to it, and several photographs of the lock and associated bridge across the canal. Given this time frame, it is probable that the historic views of the stone arched bridge (Figure 12) and the historic Lower Spillway (Figure 13) may have been taken by Kummel in, or around, 1923.

Based on survey of the collection, it appears that the scope of Vermeule's survey and planning maps stopped short of the immediate modern Compac Corporation project boundaries. While no maps or plans were identified covering the current property limits, Vermeule's work did produce detailed measured drawings for the "L" shaped spur off of the canal alignment through Stanhope. His map archive also yielded what appears to be plans and profile sections of a cement weir structure similar, if not identical, to that at Furnace Falls Dam.

In his final 1929 report to the Canal Commission, Vermeule specifically included these dam and raceway structures at Furnace Falls Pond as components of the Contracts for Sections 56 and 57. In his final 1929 report to the Canal Commission he reported that plans for this work were approved in July 1925, and the contract awarded for Sections 55 and 66 through Stanhope by John W. Heller Co. in August of 1926, for a final estimate of $115,262.33. Also, Vermeule specifically wrote, "This contract included the Musconetcong Dam, the Singer Level Spillway, and the improvement of the Lake by removal of stumps," (Vermeule, Jr.1929, Page 31). This quote strongly implies that the Compac Corporation/Singer Company dam and weir were redesigned and replaced by C.C. Vermeule as Consulting and Directing Engineer, with C.C. Vermeule Jr. signing the plans as Assistant Engineer in the summer of 1927 (Figure 36).

Although no specific plans or blueprints for foundry parcels have been identified to date, records in the next adjacent block of contract documents (to the west) contained what appeared to be generic plans for the three pronged, cast cement weir with vertical board slots for wooden splash gates like the one at the Compac weir (Figure 34). Several contained detailed elevations and profiles of similar spillway and weir structures that were marked as "GENERAL" (Drawing No. 263A, Section 54-55; Figure 33). This explicit notation in the blueprint title block argues strongly that the current Compac spillway and weir structures were, in fact, plotted by C.C. Vermeule on June 15, 1927.

Vermeule's design of the three-pod cement Weir structure parallels similar forms used to raise and control water levels in his the final, post-1926, additions to Stanhope Reservoir upstream from Furnace Falls Pond. Musconetcong Lake was initially enlarged to supply more water to the canal around 1845-46, coterminous with the building of the "L-shaped" canal spur to the iron works (Vermeule 1929). Vermeule rebuilt the Lake around 1926 with a more permanent cement dam structure as part of his dismantling operations. In the 1930s the top of the 1926 concrete dam was raised by two feet with the addition of slotted structures to accommodate removable splashboards, similar to those used in the cement weir at Furnace Falls Pond. According to Vermeule, this engineering supplement served as a mechanism for the control weeds through periodic inundation (Vermeule 1925).

It is not unreasonable to speculate that his design of the cement Weir at Furnace Falls Pond may have been implemented for the same purpose, as a weed control mechanism.

The Canal collection included a detailed measured drawing of the "L-shaped" canal spur to the Furnace. It is labeled as Plan 89A, one of 11 drawings for Contract sections 56-57, labeled "Drawing No. 89A, Section: 56-57...Dam and Gates at Lake Musconetcong, Nov. 21, 1924, June 17, 1925, Scale 1" = 20 & 40 ft." (Frame 207, NJSA Morris Canal Map Collection, Box/Folio 30, Item 1, Figure 35). The 1"=40 ft. scale plan of the canal spur documents cross section profiles, as well as angles, distances and dimensions of the spur's length and width. The interior dimensions of the Reservoir measured 210 by 65 ft at water line, with a surface area of at least 13,650 square feet, as of 1925. Assuming a minimum depth of five feet below water line, these dimensions indicate that the reservoir held in excess of 510,000 gallon of diverted canal water.

The Vermeule Drawing No. 89A also shows the canal spur labeled as the "Singer Feeder" and the rectangular basin labeled as the "Singer Reservoir". It also clearly depicts the presence of five "Gate Box" features along the western edge of the basin or reservoir, facing the Access Road and the Compac Corporation property. Finally, underscoring the use of Vermeule's and Weir's original plans to maintain records of additions and alterations to the canal into the 1960s, the blueprint copy of Vermeule's plan of the spur has the notation in red pencil of the addition of a 36" pipe installation within the southern towpath of the main canal in 1966 (Figure 35).

Vermeule's contract drawing for the canal in the Stanhope and Waterloo (to the west and downstream of Stanhope) contract areas (Sections 54- 57) also showed both existing conditions and structural details of similar dam and weir structures before they were replaced after 1927 (Figure 34). The Vermeule "existing conditions" plans clearly show that the original dam and spillway at Plane 2W, to the west of the project area, was made of a massive, 4 1/2 foot thick masonry wall-dam and structure, shown apparently built into grade (Figure 33). His specifications mandated that the contractor "Remove and replace with Concrete Spillway" (NJSA, Folio 114, "Drawing Nos. 263A&B-Spillway at Plane #2W-General", Figure 36). In addition, two early 19th century maps dated 1831 and 1858, show the original pre-1927 Furnace Falls Pond dam structures as being several hundred feet long and apparently extending from each side of the original sloping grade on each side of the

Musconetcong valley before it was re-sculpted for the new canal spur and furnaces in the 1840s (Figures 16&17).

Finally, these map sources together with the recent geotechnical boring provide several clues on the structure size and orientation of the earlier 19th century dam structure at Furnace Falls Pond. The preliminary snap shots of Vermeule's contract drawing for the canal in the Stanhope and Waterloo (to the west and downstream of Stanhope) contract areas (Sections 54- 57) showed both existing conditions and structural details of similar dam and weir structures before they were replaced after 1927 (Figure 34). The Vermeule "existing conditions" drawings clearly show that the original dam and spillway at Plane 2W, to the west of the project area, was made of a massive, 4 1/2 foot thick masonry wall-dam and structure, shown apparently built into grade (Figure 33). His specifications mandated that the contractor "Remove and replace with Concrete Spillway" (NJSA, Folio 114, "Drawing Nos. 263A&B-Spillway at Plane #2W-General", Figure 36). In addition, two early 19th century maps dated 1831 and 1858, show the original pre-1927 Furnace Falls Pond dam structures as being several hundred feet long and apparently extending from each side of the original sloping grade on each side of the Musconetcong valley before it was re-sculpted for the new canal spur and furnaces in the 1840s (Figures 16 & 17).

Taken together, these multiple lines of cartographic and geotechnical information suggest that this earlier dam structure appears to have been constructed of a massive matrix of stone and wooden grillage elements (Vermeule, 1927; Figure 33). It spanned over 300 feet in length and tied into the original historic topography of the northern slopes of the Musconetcong Valley prior to the addition of the retaining wall and fill for the post-1840 spur of the canal. The scaled GIS correlation between the 1858 map and the scaled orthophoto enlargement of Furnace Pond suggests that this early furnace dam structure was originally oriented some 35 degrees northeast of the subsequent late 19th century rail trestle into the foundry as far as the southwest corner of the "L" shaped spur (Figures 16 & 17).

Recent boring logs taken by Langan Engineering (2001), documented presence of wood and brick structural elements at a depth below 16 feet of historic fill. Boring No. 1 identified the presence of wood at 17 feet. Boring No. 3 recovered brick fragments and "fill" at a depth of 16 feet below grade. Both borings were taken at an approximate elevation of 840 feet, at a contour range comparable to the previously existing surface of the cut stone train trestle bridge before it was removed, suggesting that historic structures and the original pre-fill surface lay at between 820 to 825 feet in elevation, about five feet below the current water level of Furnace Falls Pond (Langan 2001). This subsurface evidence in turn suggests that elements of the historic early 19th century dam and spillway structures of Furnace Falls Pond could still survive as archaeological features on either side of the spillway.

C. The Musconetcong Foundrymen Historical Society Holdings

This survey of repositories and project critical archival and map sources also highlights the fact that aside from the late 19th and early 20th century original color-coded Sanborn Insurance maps (1886, 1901, 1909, 1920), the only identified, site-specific, historic maps of the immediate Compac Corporation property has so far been limited to those contained within the collections of the local Musconetcong Foundrymen's Historical Society collection. Mr. Morrell graciously provided both a personal tour of historic Stanhope, and copious amounts of critical past studies and maps. He also opened the Society's archive to show me their collection of maps of the former foundry site within the property lines of the modern Compac Corporation.

In 1974, Morrell rescued the original historic maps across Flanders Road, 200 feet north of the modern Compac Company property from a demolition contractor's dumpster when the former Musconetcong office was being gutted (Morrell, personal communication June 23, 2002). These large format plans and drawings may hold the key to any cartographic reconstruction of the land use and technological history of the foundry site for the as yet uncontrolled Sussex Iron Company period of the site's occupation (1840-1855).

Each of these large format original maps is currently protected in sealed plastic envelopes that preclude accurate photographic documentation in their present condition. It is suggested that a concerted effort be undertaken to document these critical map sources (with high resolution, six mega pixel macro, or flat field, digital photography) in order to transform them into scaled and georeferenced composite maps which accurately document the location of former and surviving historic structures relative to modern facilities and conditions. Given their current condition and encapsulation, this procedure would require that the maps be unsealed, photo documented, and resealed in a new, acid free storage medium under proper curatorial supervision. This recommended procedure would be performed on-site in conformity with current conservation and archival guidelines without flash or heat producing light sources.

V. Non-Excavation Mitigation Strategies

A. GIS Land Use History of the Project Site

The survey of regional repositories and archival sources has revealed a vast wealth of surviving historic maps for the Stanhope/ Netcong region. However, this documented record exists in a cartographic vacuum. All exist as unrelated fragments of special data, at different scales and sizes. No scaled or georeferenced map studies correlating the location of primary or secondary Morris Canal or foundry facilities, relative to modern conditions, exist in sufficient detail to meet the level of precision and definition necessary to address current planning needs of the project site or area surrounding it. This vacuum of cartographic data control presented an obvious and immediate priority for the resolution of key gaps in the historical record for the study area.

Accordingly, one of the primary tasks of this joint mitigation program utilized the graphic synthesis of this disconnected historic map record into a unified series of scaled and georeferenced planning maps for the project area. As a critical component of the contextual land use and technological history of the Furnace Falls Pond and sluiceway study area, this study employed the computer assisted GIS technology as the primary methodological framework to capture, scale, and compare through time the shifting land use patterns of the immediate project area and to bring together these diverse maps segments into a unified map based reconstruction of the site's land use history from the 1860s to the present.

This priority is not one of convenience, but reflects the fact that the primary archaeological and historical evidence is necessary to reconstruct the land use history of the furnace site, and its facilities consist of map or photo derived information. As such, GIS emerges as a crucial unifying tool to correlate, compare, and evaluate these primary sources. This plan used modern high speed computer technology to scan, "rubber sheet" and georeference selected site-specific diagnostic maps into a series of scaled overlays which would document the land use and engineering history of the foundry, Furnace Falls Pond, raceway, dam, retaining wall, and associated Morris Canal facilities bordering the project site. In essence, this effort used GIS and scaled comparison through time of historic maps to provide a non-intrusive and non-excavation Phase II level of definition of the location, extent and internal distributions of the former furnace and support structures at and within the site.

1. GIS Map Reconstruction: A Planning Tool for Archaeology

Geographic Information Systems (GIS) has been defined as a "computerized 'layer cake' of spatial information" (Figure 37). GIS software systems are distinguished from simple enlargements produced by copy machines, or simple photographic enlargements, by three primary capabilities.

- The ability to register and precisely correlate a number of surviving map renditions, all at different scales and sizes, into a single uniform grid system.
- The ability to accurately stretch or shrink sub-areas of formally unaligned or out of scale historic maps, so that they accurately overlay modern surveys or orthophotos.
- The ability to assign and extract real world coordinates to the adjusted, or georeferenced, digital images of historic maps.

This process of enlarging, shrinking, or stretching one layer to match another is called "rubber sheeting." Each level of the "layer cake" is adjusted to be consistent in scale with each other layer, regardless of the size or scale of the original data set. Only after being rectified, georeferenced, and reworked as scaled overlays do they emerge as useful planning tools to locate and evaluate the now buried resources. Once georeferenced, in this case to the modern New Jersey State Plane Coordinate system, and "asymmetrically stretched" to precisely match the modern orthophotos or project base maps, one can then extract the coordinates of historic features, enter them into a computer "Total Station" electronic transit, and then "shoot" and relocate the 18^{th} or 19^{th} century structures on the ground, and modern survey plans, with a precision in feet and inches.

As often commercially applied today, GIS is most commonly used for the comparative analysis of different sets of mostly <u>contemporary</u> data. In business contexts, economic analysts may use GIS to identify modes of population concentration of different age, socioeconomic, or ethnic origin. Likewise, the scaled GIS analysis of various "multi-band" airborne or satellite images of agricultural or drought areas through time is commonly used as a tool for estimating crop yields for the future and commodity markets. Marketing firms employ GIS to identify target populations by city or borough or the age range and family composition of different cities (i.e. percentage of families with teenage children) for the definition of regional sales strategies. For the archaeologist and preservation planner, the utility and benefit of GIS derive from the ability to scale, or "rubber sheet", modern, historic, and environmental map data as spatially rectified renditions to the same size and scale. Instead of the comparison of contemporary data sets, the primary goal of this approach of historic GIS is the use of scaled map comparisons through time.

As illustrated in Figure 38, this time-based approach to GIS takes place in two general steps, the first additive and the second subtractive. The first phase compiles and scales "positive" data, the accumulation of prehistoric and historic site locations, environmental and topographic information. The second phase involves the subtraction of "negative" past impacts to the study area from man-made and natural causes, such as modern trenches, foundations, buildings, construction, or landfills, a process the writer has come to call Historic Impact Analysis (Grossman 1997). The computer comparison of scaled historic maps provides a chronological framework to control the nature and extent of additions and subtractions to the landscape to focus preservation planning and project resources only on high integrity and undisturbed portions of a study area.

The use of computer based environmental reconstruction through the digital computer integration of scaled 18th, 19th and 20th century maps provides a critical tool for reconstructing and pinpointing the location of currently unrecognized subsurface structural remains, despite subsequent alterations and impacts to the site. Scaled GIS processed overlays document the location of historic features relative to current conditions systems (property lines, building locations, and historic land use patterns), as well as to modern State Plane Coordinates. When combined with the historic map and recent air-photo coverage, these maps can then be rendered to provide a clear and cartographically accurate series of baseline archaeological sensitivity maps of changing site conditions and land use patterns.

The GIS framework can provide the planner and archaeologist with two general categories of information, control over what is already known about the study area, and the ability to address what has happened to the area to affect the projected location and survival of as yet unidentified cultural resources. This may vary from the documentation of the shifts in river or stream courses, landscape alterations as scaled, two dimensional historic maps overlays, to the more refined, 3D reconstructions of historic topography prior to being covered by land fill or rising sea and lake levels. GIS also provides a tool for incorporating the analysis of recent and otherwise unmapped data from air photo sources. Low altitude digital air photo image capture represents a cost effective and critical source of current information on recent impacts and landform changes (Figure 32).

In archaeology, this approach has been successfully applied at a number of investigations of historic military and urban sites to reconstruct the location of surviving buried structures and activity areas, and to delimit the extent of past impacts to the project area. It has been used by the author to correlate Civil War maps of the depth of mud in the New Jersey Meadowlands with modern naval bathometry surveys to reconstruct a 3D model of the drainage prior to being landfilled and inundated by rising sea levels (Grossman 1992, 1994, 1997). At Drew University, the digital capture of 19th century landscape plans were georeferenced and scaled to match modern property surveys to locate Gibbons' 1830s greenhouse, which lay buried and lost, adjacent the surviving mansion (Grossman 1992). In New York City, scaled historic maps helped pinpoint the location of buried walls and cobble floors of the 17th century Dutch West Indian Company warehouse and homes twelve feet below the modern streets of Lower Manhattan (Grossman 1985). As is illustrated by Figure 38, for this and other cases deployed by the author, GIS served as a primary archaeological definition and planning tool, comparable in importance to remote sensing and subsurface testing, and as the overall framework to integrate and correlate spatial data from other sources (Grossman 1997).

2. A GIS Land Use Reconstruction of the Project Site

This GIS-based study has used map sources derived from the files of the New Jersey Historic Preservation Office of the NJDEP, the NJSA, the Musconetcong Foundrymen Historical Society and the map holdings of the New York Public Library to reconstruct the land use history of the site as far back as the 1860s, or the period of its development controlled by the Musconetcong Iron Company. Any earlier reconstructions dating back to the furnace site's beginnings in 1840 must await the availability and incorporation of as yet uncontrolled historic map sources, if they do indeed exist with sufficiently resolved coverage.

A formal (i.e. georeferenced) GIS map reconstruction requires a "base map" against which digitized and georeferenced versions of pertinent historic maps can be correlated. As an interim solution, a 1"=300 ft. scale enlargement of a 1959 panchromatic air photo has been used to compile and compare initially identified historic map coverage. As a point of departure, and pending the availability of higher resolution air photo coverage, the NJDEP one-meter resolution, orthophoto coverage has been used by George Davis, of Davis Associates, Inc. to georeference the high resolution (600 Mb) digital scan of the 1959 air photo, provided by Robinson Aerial of Morristown, New Jersey, as an interim base map.

To date, three sets of historic map sources were utilized:

- The 1858 Roome Map (Figures 16 –17) made available by the Musconetcong Foundrymen's Historical Society
- High resolution digital captures of late 19th and early 20th century Sanborn Insurance maps from 1886 to 1920.
- Vermeule's and Weir's original measured drawings and existing condition plans of the Stanhope/Netcong area at the NJSA to correlate site-specific components with adjacent landforms and the "L-shaped" Morris Canal spur to the iron works.

The transformation of these digital images into georeferenced scaled overlays, specifically of the 1858 Roome map of Stanhope (Figures 16 & 17), was done as a critical planning tool for the development of this mitigation plan by Davis Associates, Inc. The historic map data was captured with a high-resolution digital camera, digitally "cleaned" and computer enhanced, transferred to the GIS system, rendered as a scaled overlay onto the selected orthophoto base map, georeferenced to the New Jersey State Plane coordinate system, and produced as both hard copy and web based output. For the purposes of meeting the needs of the Land Use Permit process, this current level of effort has been limited to the collection and post processing of historic map data as two-dimensional GIS depictions of the site's current and past setting. The high-speed data processing capabilities of 3D GIS will be used to integrate the 3D Laser Radar (LIDAR) scans of the dewatered cut stone channel into existing engineering surveys and plans of the site.

B. Mitigation Through Redesign and Avoidance

As initially conceived, the scope of the repair work would involve the use of sheeting to stabilize the cement weir at the head of the pond, the lowering of the height of the Lower

Spillway, and canalization of the spillway channel between them, with grading and stabilization utilizing crushed stone riprap. Between May and September of 2002, the project archaeologist and engineers worked in a concerted and coordinated effort to mitigate the extent of potential adverse impacts through redesign and avoidance of areas identified as archaeologically sensitive. This collaborative design effort has resulted in the significant reduction of impacts in four major areas of proposed dam repair and remediation

1. The Dewatering Bypass System

The initial design recommendations for the dam and channel remediation work called for the excavation and construction of a single, large bypass channel and conduit through the northern embankment of the project area. The bypass channel was to be cut so as to divert the flow of outflow from Furnace Falls Pond, to provide the contractor access to the now submerged Lower Spillway, upper weir and channel. Given its depth and extent, this option posed the threat of cutting into and impacting historic structures and deposits belonging to the era of foundry operations and, as such, constituted a demonstrable potential negative impact to the site. This level of physical intrusion, if left as is, would have required a major and concerted subsurface archaeological testing and possible excavation effort to evaluate and then document any encountered historic structural or stratigraphic deposits.

Instead, the collaborative redesign was initiated at the request of Compac Corporation, which mitigated this potential impact through avoidance. In response, Langan Engineering devised a non-impacting dewatering strategy based on the use of above ground pipes and pumps between Furnace Falls Pond and the cement lined downstream spillway channel under the Compac facility.

As currently designed, the new bypass and dewatering system will avoid the potential for impacts to the northern historic embankment. No further archaeological procedures are herein recommended for this task area of the dam repair protocol.

2. Relocated Sheeting Operations

The cement weir at the outlet of Furnace Falls Pond has apparently lost structural integrity and either has a hole in it or a break in the juncture between the weir and the historic cut stone, former bridge abutment and raceway. As initially proposed, the dam remediation plan was to sink a line of heavy sheeting across the channel into the embankment on either side. This approach would have cut into both the channel as well as the cut stone raceway and bridge abutment, causing direct and immediate impacts to the cut stone channel wall and to potential historic subsurface structural elements in either side. Present or not, the extent of the proposed sheeting would have required a formal subsurface testing strategy prior to permitting and construction.

As an alternative, sheeting will be installed approximately 15 ft. upstream of the weir, within the State controlled limits of Furnace Pond. This alternative will provide a secure barrier for dewatering and construction, as a viable mitigation strategy to avoid impacts to potential subsurface buried remains that may exist within the banks adjacent to the location of the former cut stone bridge.

Although the redesign of the sheeting placement avoids cutting into the cut stone channel and historic embankments on either side, access to this historic data will be lost once the existing channel is graded and lined with a bedding of riprap. As detailed below, this area-specific impact will be mitigated with the use of a single archaeological profile trench, over a one-week recording period in coordination with the contractor subsequent to dewatering (Figure 7). This single archeological field procedure is being recommended for two reasons: first, the subsurface structure of the early 19th century cut stone channel is not otherwise documented; and second, archival map evidence suggests the potential presence of buried wooden cribbing and stone masonry structures associated with earlier 19th century dam and spillway features. Likewise, previous archeological work suggests the potential presence of wooden coffer or support structures beneath and behind the cut stone elements visible on the surface today. In essence, this single profile exposure is aimed at documenting the subsurface structure, metrics, or dimensions, of the raceway and how it was built.

3. The Non-Intrusive Temporary Pumping Platform

A platform to support the multiple pumps was redesigned to rest on the surface, instead of cutting into the northern embankment with a 10 by 20 foot shelf. To avoid possible subsurface impacts, the project engineers will use an above ground, gravel platform built out from the embankment with a temporary retaining wall. The redesign effort also stipulated the laying of a protective bedding of riprap stone as an extension of the access road (Figure 7) to buffer the exposed surface from potential impacts. The use of riprap in conjunction with filter fabric as a protective buffer was initially established as part of Langan

Engineering construction specifications (Langan Permitting Plan, 5 Aug., 2002, Drawing no. 27.04).

4. Reduced Channel Grading Plan

Finally this collaborative engineering and preservation process resulted in a fourth design change to the proposed canalization of the historic Furnace Pond Dam cut stone channel and raceway. As initially proposed, the dam remediation process stipulated that the redesigned channel would be 20 feet wide and thus would perhaps cut into or impact the historic cut stone siding of the channel as part of the grading process. As an additional mitigation measure, Langan Engineering has redesigned the proposed channel work to encompass a reduced width of 15 feet instead of 20 feet to minimize the impacts to the historic cut stone channel structures.

VI. Mitigation of Unavoidable Impacts

The map-based historic impact analysis significantly reduced the location and extent of construction related impacts through the evaluation of four variables: 1) the subtraction of the horizontal and vertical photo documented scour damage from the flood of August 2000, 2) the removal of the historic arched stone bridge superstructure (Pursuant to the July 23, 2001 Emergency Removal Permit issued by the NJDEP Land Use Regulation Program; File No. 0000-00-0027.3), 3) the map and air photo derived definition of fluctuating meander pattern that shifted the channel north and south by twenty feet over the last century, and 4) the avoidance and mitigation through redesign of initially proposed construction impacts. Three surviving features, or areas, have been identified that will require mitigation through archaeological documentation and protective buffering, or burial, during the construction process. A fourth category of possible sedimentological /environmental data recovery was initially considered. However, it was dropped as a category of potential data loss following consultation with Dr. Scott Stanford, Supervising Geologist of the New Jersey Geological Society (2002). Three areas remain: the access road; the historic bridge footer, raceway and weir; and the Lower Spillway.

The field and photo records of the August 2000 flood and dam breach documented the extent and depth of the flood breach zone west of the former 1874 stone arched bridge and train trestle. Once "subtracted" from the overall project zone, the level of potential archaeological impacts was reduced to the immediate weir, channel, and cement spillway of the damaged dam and raceway system.

Accordingly, in addition to LIDAR metric documentation of the structure and form of each, the field mitigation activities will focus on the immediate area of the former bridge abutment and the cement weir. Specifically, the recommended field exposure and documentation with high resolution LIDAR and photographic documentation will be limited to a single 5-10 foot wide by 20 foot long profile cut across the stone raceway immediately to the west and down river from Vermeule's 1927 cement weir (Figure 7).

A. The Access Road

The modern access road into the Furnace Falls Pond site off of Furnace Road is not only the elevated fill behind the circa 1840s stone retaining wall, but it may also contain buried structural remains. Based on the map evidence and the technology of blast furnace production, these structures are suspected to include water powered piston driven air blowers for the blast furnaces, which cut into the hill through the retaining wall (Figure 19).

Field inspection and interviews with local experts and historic maps document that the access road currently overlies buried and exposed elements of the foundry and canal spur waterpower, freight delivery, and blast furnace structures (Figure 41). Late 19th and early 20th century Sanborn Insurance maps depict brick and cement structural elements in the locale of surface elements protruding above the compacted dirt access road. At the surface, these include the rectangular cement wall and building elements, along with mortared semi-circular brick features, apparently representing the lower portions of one of several foundry related smoke stacks.

The 1858 map of Stanhope shows the northern tip or western side of the "L-shaped" canal spur with channel or conduits as either surface or subterranean water control features flowing from the canal spur to the foundry (Figures 16-17, 41).

1. Site Preservation and Protection Through Burial-in-Place

The proposed dam remediation construction activities will involve the transit of heavy equipment over the access road and the exposed structural remains. Identified subsurface historic foundry and canal related resources include brick smoke stack, cement and brick wall elements, and the potential for near-surface and buried water control and possible "air blower" structures or machinery, both in and under the road. It is recommended that construction related impacts to these buried, near surface remains be mitigated with *in situ* burial through the application of a buffer of protective bedding to protect against direct contact, crushing, chipping, and compression from heavy machinery.

"Burial as a Method of Archaeological Site Protection" (Mathewson, et. al, 1992) is not new to archaeology and provides a cost effective, non-intrusive mitigation strategy as an alternative to field-testing excavation and data recovery. The U.S. Army Engineer Waterways Experiment Station in Vicksburg, Mississippi has provided controlled studies on the effect of compression and the protective measures to mitigate against it, as well as some preliminary guidelines for this non-excavation approach to site protection. In soft or friable soil, these studies have shown that buried artifacts and structures can be impacted up to depths of four feet. For archaeological sites in friable soil matrixes, solid wooden structures over the surface may be required. For already compacted soils, only buffers of chemically compatible sand, gravel, or clay have been found to provide adequate protection. In more compacted soil, such as those of the Compac Corporation access road, breakage from compression diminishes after a foot in depth (Mathewson et. al 1992; Thorne 1989, 1991; U.S. Army Engineer Waterways Experiment Station, ASPN II-5, 1989).

This approach to preservation in place, in lieu of mitigation data recovery through excavation, has been successfully used by the author to protect exposed historic and ancient burial sites in Ohio, at several federally funded project sites on the Hudson River, and to protect near surface prehistoric cemetery sites in the sandy soils of the South Fork of East Hampton, N.Y. Protection through burial was used as a primary alternative to excavation as part of the NYSHPO and U.S. Federal Energy Regulatory Commission program for the preservation of exposed, or near surface, archaeological resources with the proposed path of the Iroquois Gas Transmission System across New York State in the 1990s.

As coordinated with the project engineers, and as an alternative to recommending labor intensive field investigation, this plan proposes the use of site burial and protection through the application of a layer of preferably un-compacted fine-grained sand or dirt, or clean gravel/crushed stone, over a layer of geotechnical cloth to mitigate against construction related damage from heavy equipment and vibration.

This mitigation measure is restricted in scope and timeframe to address the short term potential for impacts from heavy construction equipment only for the duration of this project construction phase.

2. Pre-Interment Field Documentation

Two pre-burial procedures need to precede this approach: 1) prior to burial, exposed surface features need to be surveyed and plotted on project maps, and 2) the interface beneath the geotechnical cloth needs to be demarcated in time from the overlying fill. The author has consistently used several hundred modern pennies over the surface to date and distinguish the time frame of the protective fill from the original soil matrix (Grossman, et. al., 1980; 1990).

B. Surviving Arched Stone Bridge Abutments and Raceway Wall

The 120-foot long historic spillway between the cement weir at the outlet of Furnace Falls Pond, and the Lower Spillway downstream can be divided, in terms of relative sensitivity, into two segments. The upper or eastern half of the channel, for a distance of approximately 40 feet downstream from the weir, is lined with heavy cut stone footer or wall elements. The lower, or western half of the channel is unlined and consists of unstructured earthen embankment, newly filled in with blue stone and riprap following the scour damage from the August 2000 flood. A relatively recent cement outfall pipe protrudes from housing on the southern embankment into the spillway ten feet off the Lower Spillway.

At the outset of this study, it was thought that it would be necessary to recommend as many three subsurface, back-hoe assisted, profile cuts, spaced across the center and ends of the channel to determine the presence of potentially sensitive subsurface remains. However, the analysis of channel impacts from flood waters and the identification of natural meanders, or fluctuations in the western, unlined, section of the channel has reduced the need for testing to a single profile cut in the vicinity of the former bridge abutment and cement weir.

Two lines of evidence were used to achieve this reduction in potential field effort. First, analyses of modern NJDEP and Compac Corporation digital photo records were used to plot the lateral and vertical extent and depth of flood scour damage (Figures 7, 20-23). Views from the north, east and west served to plot the extent and depth of flood scour damage into the former northern embankment of the channel. Second, comparison through time of modern air photo, computer enlarged and image enhanced by the author from 1”=1,500 ft, to a resolution of about 1”=60 feet (or by a factor of 25, or 2500%), relative to historic map coverage was utilized to document lateral shifts in the channel alignment and position between 1959 and 1986 (Figure 32). This photographic series was compared to earlier, late 19th century, Sanborn Insurance maps of the same section of the spillway channel to identify changes over the last century (Figure 19).

The section of the channel to the west of the stone raceway without stone coursing appears to have shifted in its course through meander channels and ox-bow fluctuations back and forth, or north and south, at least ten feet, between the late 19th century and the present. These historic fluctuations, combined with the documented flood scour damage from the August 2000 flood and dam breach, suggest that the western portion of the channel has little potential for containing any surviving historic elements with integrity. No field procedures of subsurface testing are recommended for this previously impacted section of the project area. No comparable fluctuations are apparent for the eastern, or upstream, half of the raceway in the vicinity of the former stone arched bridge. Although the superstructure of the bridge is now gone, the underlying stone support and cut stone channel structure remains intact.

The flood of August 2000 first clogged the spillway under the bridge with heavy debris, backed up to the level of the former surface of the bridge (about 642 feet in elevation) and then breached and eroded deep channels across the roadway at either end of the bridge (Figures 26-29). These deep triangular erosion channels washed out the loose earth rubble and slag fill of the bridge and collapsed portions of the interior stone arch roofs on both sides of the channel. This symmetrical pattern of collapse on both sides, in turn, destabilized the two side arches supporting each face of the bridge, posing the threat of imminent collapse (Figures 28-29). Following photographic documentation, the remaining elements of the bridge were removed in January 2001 down to the water level along with the cut stone wing wall bordering the eastern 40 feet of the channel (Lent 2001; Figures 30-31).

This stone liner served both as the footer and wing wall for the 1874-arched stone bridge and as a strong stone raceway, or channel, for the outflow from Furnace Falls Pond. The 1828 Sykes map (Figure 15) indicates that a Dam and spillway predates the 1874 date of the bridge capstone by 40 years. Morrell's initial date for Furnace Pond of 1794, suggests that the earliest dam may have been in place eighty years before the cut stone train trestle was constructed (Morrell 2000, Page 1).

The potential exists to encounter otherwise undocumented subsurface remains of the original cut stone channel and bridge structure dating to the first quarter of 19th century. No details are yet available to pinpoint the precise date and form of these original structures, but it is apparent that the lowest course of large cut stone elements, forming the base or footing of the bridge, suggest a different form and style of stonework and may in fact date to this earlier period of construction. These earlier elements hold the potential for revealing currently undocumented information on the engineering history of the Furnace Falls Pond sluiceway.

Finally, the analysis of the earliest 19th century Sanborn Insurance maps, coverage 1886 and 1896, together with digital photography by Compac Corporation, Langan Engineering, and NJDEP Dam Safety Division suggest that the dewatering process may also expose surviving elements of a mid 19th century water intake structure somewhere on the north side of the channel. The 1886 and 1896 Sanborn Insurance maps show that the little building and connecting room located due north of the Lower Spillway appears to represent the rebuilding over a preexisting 10 by 20 foot structure that was then incorporated into the post 1901-2 cement-clad Singer Company building. Both the 1886 and 1896 Sanborn Insurance maps show a "flume" or conduit connecting to the structure with its outlet or intake point terminating at a bulging ox-bowl or inlet formation immediately west of the cut stone channel lining (Figure 19).

The potential archaeological survival of this small feature is suggested by the digital photographic records of flood conditions captured by NJDEP Dam Safety, and the Langan Engineering and Compac Corporation personnel between August 13th and 21st of 2000. As a field view looking due west downstream from the edge of the flood scoured northern bank documents, a line of vertical wooden elements in what appears to represent one or more cut stone elements extends south out of the eroded embankment, in the same location as the "flume" depicted in the 1886 and 1896 Sanborn Insurance maps (Figure 22). These vertical wooden elements may represent 19th century construction or wooden sheeting associated with this apparent water intake feature. While no field measurements exist to establish its depth, the emergency flood photographic record suggests that this potentially surviving element was built at or below the 829 foot elevation, and beneath of the top of the lower cement spillway. Although no historic archival evidence has been identified to establish the function or date of this feature, it appears to predate the 1901 arrival of the Singer Sewing Machine Company and therefore may represent a water supply mechanism of the post 1860 Musconetcong Iron Works tenure at the site. If the case, its presence may explain one possible reason that the Lower Spillway was originally constructed as a continuously renewed water supply basin, prior to being connected to a centrally administered municipal water supply.

If this feature survived the initial emergency dam repair and bridge removal process, it will be cleaned off and documented at the same time the remainder of the cut stone channel is recorded with LIDAR and high definition digital photography.

1. Archaeological Investigation and Documentation

To address the potential presence of undocumented historic structural remains within this eastern end of the channel, this mitigation plan recommends the use of a single backhoe profile across the channel between the surviving cut stonewall sections, immediately adjacent to, and west, and downstream of the cement weir. The testing will be conducted as a coordinated field effort with the contractor at the outset of construction following the introduction of the cofferdam and dewatering bypass pumps. It is projected that this single, subsurface exposure will require no more than five days to open, clean, and record, once the water level is lowered in Furnace Falls Pond and the channel. Any identified structural remains will be cleaned and prepared for photographic and LIDAR documentation and then immediately cleared for the continuation of scheduled construction activities contingent on authorization and concurrence by the client and the NJSHPO.

This strategy will be coordinated with the contractor to begin once dewatering systems are in place, and prior to the onset of sheeting. Assuming that the dewatering efforts are indeed successful, and the water level can be dropped to expose the now submerged channel, an initial attempt to achieve visual access will be attempted prior to the proposed sheeting installation. If the subsurface flow of water is too great, an alternative strategy will attempt to gain profile control by cutting a cross section behind or to the east of the sheeting after installation and prior to the onset of channel grading. The location of the proposed sumps will be adjusted in coordination with the supervising engineer and the contractor.

2. Strategy and Staging

Archaeological procedures will be followed in compliance with eligible resources of the NJDEP State and National Register. The backhoe equipment will be fitted with a flat blade over the normal cutting teeth to minimize the potential for damage or disturbance of any deposits or structural elements. This limited data recovery task has been structured to be completed within a one week, or five day, window of archaeological field access, beginning immediately following the successful dewatering of the channel by the project contractor. Archeological procedures will be conducted in tandem, and overlapping with, data control and recording activities of the LIDAR team. Under the direction of the principal investigator, a staff of two archaeologists and at least two support construction workers will expend three days working with the contractors' heavy equipment operator to cut, stabilize, and clean to prepare the proposed profile section across the interior of the cut stone channel for recordation. On the third day, the LIDAR team will arrive to begin a one-day survey and provenience control activities, followed by two days of scanning and recordation. This restricted one week time frame assumes the coordinated availability of contractor support services and the pre-field completion of site stabilization and dewatering activities.

3. Data Recovery Goals

The goals of the recommended field investigation will be to address gaps in the surviving archival and cartographic record based on the available sources identified to date.

- What is the subsurface structure and depth of the cut stone raceway?
- What is the structure relationship of the 1927 cement weir to any potentially surviving 19^{th} century dam structures?
- A volumetric record of this hydrological chokepoint of the Musconetcong River. Access to this historic data will be lost once the existing channel is graded and lined with a bedding of riprap.

C. The Lower Cement Spillway

The initial date of construction of the Lower Spillway is yet to be established with assurance, but it is clear from surviving historic photographs that the spillway was in place prior to 1927. Also, the historic photo of the spillway suggests that it served as a bridge or roadway over the millrace at this time (Figure 13). Its use as a river crossing may post-date, and correlate with, the secondary transformation of the upper stone arch bridge into an elevated, earthen-banked train trestle sometime after 1874. After that date, the installation of the rail trestle would have rendered the upstream crossing at the weir impassable for foot traffic. The likelihood exists that the historic footbridge depicted in the photo was installed as an alternative after the cut stone arched train trestle was built in 1874, but this is only a supposition. A bridge is at the location of the spillway on the 1886 Sanborn Insurance map, but not on the later 1901, 1909, or 1920 maps. But this could be a cartographic oversight, or simply mean that the spillway was not in danger of catching fire, and therefore not worthy of depiction on the insurance maps. At the very least, it is clear that the spillway was in place prior to 1927. C.C. Vermeule referred to it as "Singer's Lower Spillway" in his 1929 report when he described the local contract work which went to bid in 1927 (Vermeule 1929, Page 31).

Interviews with current workers of long standing at Compac Corporation also suggest that elements of the cement wing wall replacement of the earlier earth filled stone bridge abutment on either side of the Spillway bridge may have been altered or added as late as the 1960s. The historic photo documents that the original wing wall of the spillway was made of cut stone elements that predated the more modern cement wing walls that border the spillway and line the lower raceway down stream.

Because of the introduction of later structural cement wing wall elements and the loss of earlier historic components, no subsurface testing or investigation is recommended for the Lower Spillway. Pending the discovery of original design plans and specifications, and given the lack of information on its form and structure, field procedures will be limited to the capture of its shape and dimensions with the LIDAR scanner and photo documentation. Once dewatered, these two recording procedures will facilitate the rapid documentation of the as yet otherwise undocumented dimensions and form of the now submerged spillway.

VII. Recommended Field and Recording Procedures

Given the logistical scheduling challenges brought by the need to apply archaeological procedures after dewatering and concurrent construction is underway, traditional manual recording procedures will be augmented with new capabilities of non-contact, high resolution, 3D LIDAR measurement and documentation technology to enhance the speed, precision, and safety of the documentation process. In addition to providing increased accuracy and speed, these recording procedures have resulted in increased levels of data control, which, in turn, open new avenues for the 3D evaluation of flood and flow levels, historic dam design, and historic waterpower systems.

A. Basic Field Tasks

Archaeological field procedures will be limited to a single, north-south profile cut across the channel between the former footing stones bordering each side of the channel. Within a ten foot working zone downstream from the cement weir, the lateral position of the cut will be partly determined by the success of the dewatering procedures, the effectiveness of the sump pump and hole in the channel, and the stability and safety of the exposed channel sediments. The position of the cut will be finalized in the field in conjunction with the contractor and project engineers to assure the feasibility and safety of the proposed procedure. The purpose of this machine assisted profile cut will be to define and record a stratigraphic profile to document the now submerged lower section of the cut stone channel and bridge abutment.

Once exposed and cleaned for documentation, a combination of standard field and applied technology procedures will be utilized to record the exposed features quickly, precisely, and remotely. Based on the field conditions and the concurrent construction data recording field schedule, it is recommended that high-speed, ground based LIDAR be deployed to produce a high-resolution metric record of any historic features or structural details exposed in the test cut and to rapidly record the structure and 3D shape of historic features in dewatered channel without delay to ongoing construction activity.

B. High Speed Concurrent Data Recording: LIDAR

This new technology facilitates the recording of almost unlimited "point clouds" of xyz data points of structures, features, and land forms at a resolution order of magnitude higher than is possible with traditional manual or single transit station survey instruments. Once collected, the parallel scan lines of millimeter precise LIDAR transects are "seamed" together into a uniform georeferenced data set of millions of points in one coordinate system. Then, the cloud of points is either processed into CAD compatible files for further rendering and data processing, or into any number of commercial surface modeling or animation programs for later data extraction or multi-media productions. The LIDAR software permits the viewer to pick any point or object and extract its precise coordinates, dimensions, and/or volume. It is faster and inherently safer than traditional techniques, and, because of its speed, can permit the rapid archaeological recording of sensitive features in a fraction of the traditional archaeological time frame. Field tasks can be reduced to days, concurrent with ongoing construction and site preparation tasks, instead of weeks and months (See Appendix II).

The Cyra Corporation of Oakland, California, developed 3D scanning with Laser-Radar (LIDAR) with funding for Chevron Oil and the U.S. Government, for civilian applications in 1998. Over the next year, LIDAR was successfully applied to create realistic landscapes and animation sequences for the science fiction film *Starship Troopers,* and by the oil industry to create accurate "as-builts" for undocumented offshore oil platforms as an effective, flexible and initially cost effective alternative to traditional EDM transit and stereo-photogrammetric systems. Looking like a large box-shaped transit on a tripod, this new portable ground based laser radar scanner is capable of capturing details of a 3D structure with an accuracy of millimeters over a distance of six hundred feet. When rendered in a portable on-site computer, the resultant "point cloud", or record of almost infinite data points, produces a 3D model of the subject, be it a building, industrial plant, oil platform, movie set or, as was implemented in Albany, New York for the first time, a complex archaeological site.

Captured as a series of parallel scan lines, the raw LIDAR transects yield a series of point clouds, which must be seamed together into a single data set within a uniform, coordinate system by the Cyra system software. The point clouds are "seamed" together by the software using the presence of overlapping targets that serve to register, correlate and georeference each of the field scans into a single data set. These reflective reference hubs or reflective targets, each sequentially numbered and visible to the LIDAR beam and the captured point cloud. Once "seamed" together into precise joint data sets, the software can export the raw data as a CAD compatible file of dxf or dwg line elements for incorporation into project engineering plans.

In essence, LIDAR produces a millimeter precise framework, or "skeleton", of the site. The high-resolution digital camera system provides high resolution and undistorted color images of the surface details, or "skin", of the site. Together, the two technologies provide the ability to rapidly document and reconstruct a photo-realistic and precise, scientifically accurate, 3D, Virtual Reality simulation of a complex archaeological site. This technology provides a long-term 3D record of the impact area for high-resolution volume, structural and façade damage assessment and documentation. The density of data recorded provides, in turn, the ability to meet standards or data requirements for any later purpose, including the precise location, volume or the extraction of dimensions and size of features or structures.

1. The Albany Excavation Prescient

This high resolution laser-radar recording technology was deployed and implemented for the first time in archaeology in July and August of 1999 by the author to document the unexpected discovery of the bastion elements of 17th Century Dutch Colonial Albany and the bulkheads and docks of this historic inland port site. The two block matrix of thousands of carved log structures was discovered at the end of a three-month excavation of more recent historical levels, and deemed by the State Historic Preservation Officer to be too complex to be "adequately" documented with traditional archaeological recording procedures within the remaining period of days before the onset of construction.

Because preservation in place proved impossible in this case, the author was retained to deploy an alternative solution. Over a six-day field period, a precise 3D record of the site that met the highest scientific standards was provided and contained the essential elements for the creation of a photo realistic, virtual reality reconstruction of the site. The project began construction on schedule and finished on budget without undue delays and costs. Since the initial archaeological use of this new technology in 1999, LIDAR has been used to document complex excavations in China, Japan and Europe. Following the events of 9/11 it has also been deployed by the Department of Interior to create precise 3D records of the Statue of Liberty and other potentially vulnerable national monuments.

2. Logistical Considerations and Deployment

- Second generation ground based LIDAR scan hardware can capture the form and precise metrics of structures, buildings, and topography up to 600 feet.
- Because of the limited mobilization and work pad footprint, the LIDAR can be deployed on the ground to provide rapid scanning from all directions with no interference to ongoing recovery operations.

- Data control for later point coordinate or dimension extraction is established with multiple "targets" shot in with a standard EDM "total station" that are visible to both the metric camera and LIDAR for later correlation and rectification.
- The LIDAR system requires a two-person field team, one to operate the hardware, the other for recording tasks
- The LIDAR output yields AutoCAD or Micro Station compatible CAD data sets for the creation of 2D plans and profiles, 3D vector mesh models, or surface mapped solid model reconstructions.
- Because the utility of LIDAR is restricted to line of sight, it will be necessary that the current ground cover of tall weeds and bushes be cleared prior to survey.

C. Environmental Considerations: Historic Sedimentology

In addition to these surviving, contributing, structural elements to the State and National Register eligible site complex, it was initially thought that the channel itself might yield information of relevance to historic Sedimentology and the history of flood and flow levels of the Musconetcong River beyond what survives in the historic record. In 1894 and 1925, C.C. Vermeule submitted two studies based on measurements of recorded water flow and lake levels for the Musconetcong drainage between 1892 and 1922. He augmented these flow records with annual measurements of lake levels between 1887 and 1924 maintained by the gate tender at Lake Hopatcong, Mr. Messenger. Vermeule used these quantified records to recommend optimum lake and water flow levels to meet the recreational needs of the summer residents, sufficient flow volumes for downstream mill owners and sufficient flows to keep the canal filled where legal agreements mandated (Vermeule 1925).

Because the original Furnace Falls Pond spillway and bridge may date back to the late 18th century, the possibility was explored that historic sediments within the channel could contain physical evidence for the relative intensity of flow and flood episodes which predate Vermeule's late 19th and early 20th century records.

The archaeological and environmental utility of the sediment sequence of the channel derives from the fact that it is possible to use vertical sequence of sediment samples from core samples to document historic changes in particle size, water velocity, flood episodes and channel meander patterns for episodes not otherwise recorded in the archival record (Selley 1988, 159-168).

However, pursuant to consultations with Dr. Scott Stanford, Supervising Geologist of the New Jersey Geological Survey, the potential for recovering useable data from the use of core or controlled vertical samples from the Furnace Falls Pond Spillway is low. Not only would such an effort be logistically questionable and potentially costly with no guarantee of success, but the nature of the deposits and the flow patterns of the drainage in particular indicate that the likelihood of recovering undisturbed deposits is problematic. Dr. Stanford indicated that given the predominantly gravel and boulder makeup of Musconetcong channel deposits, "I wouldn't expect much of a sedimentary record of flooding in the Stanhope area because the Musconetcong is a 'bed load' river and there's little over bank deposition," (2002).

Accordingly, given the nature of sedimentary record for the drainage, and given the low probability of encountering intact sediments that predate Vermeule's documented historical record of late 19th and 20th century flood and flow levels, no subsurface column or "vibra-core" field or laboratory studies are recommended as part of this mitigation plan.

VIII. The Final Report Deliverables

The final report will be prepared to include the following information in accordance with Department of Interior and New Jersey standards and guidelines for the mitigation of impacts to a National and State Register resource and will include:

A. Map Reconstruction and Land Use History of the Furnace Complex.

1. As presented in Figure 41, a key element of the contextual history of the water control systems at the site has used a select sample of historic maps to develop a detailed land use history of the foundry context and its associated water control and transportation facilities.
2. Consistent with the scope of the now localized impacts (the immediate channel area), the scope of this GIS based land use history has been explicitly limited to encompass only the immediate setting of the historic channel structures and associated historic furnace elements within the

modern property limits of Compac Corporation. For the purposes of this Dam Safety Land Use permit remediation effort, the archaeological mitigation scope and historical background map and land use reconstruction will be limited to the immediate Compac Corporation property limits.

3. As depicted in the graphic land use history in Figure 41, the background work performed to date has garnered sufficient information to reconstruct the changing footprint of the historic furnace facilities from the onset of the Musconetcong Iron Works in 1864. However, with the exception of the cut stone retaining wall, the raised canal spur terrace formation, which re-sculpted the northern slopes of the valley, and the man-made Furnace Falls Pond, the schematic, pre-GIS map reconstruction does not include the location or outlines of any furnace facilities belonging to the initial phase of the earlier Stanhope and Sussex Iron Companies belonging to the 1840 to 1855 period of the site's history.

B. Baseline Fieldwork Report Requirements and Inclusions

For the purposes of this Land Use permit application, the final report on the archaeological mitigation of adverse impacts to the State and National Register eligible contributing elements of the Furnace Pond channel and sub-grade bridge features will comply with the NJDEP and US Department of Interior standards and guidelines as follows:

1. Description of the study area;
2. Relevant historical documentation/background research;
3. The research design;
4. The field studies as actually implemented, including any deviation from the research design and the reason for the changes;
5. All field observations;
6. Analyses and results, illustrated as appropriate with tables, charts, and graphs;

7. Evaluation of the investigation in terms of the goals and objectives of the investigation, including discussion of how well the needs dictated by the planning process were served;

8. Recommendations for updating the relevant historic contexts, planning goals and priorities, and generation of new or revised information needs;

9. Reference to related on-going or proposed treatment activities, such as structural documentation, stabilization, etc.;

10. Information on the location of original data in the form of field notes, photographs, and other materials.

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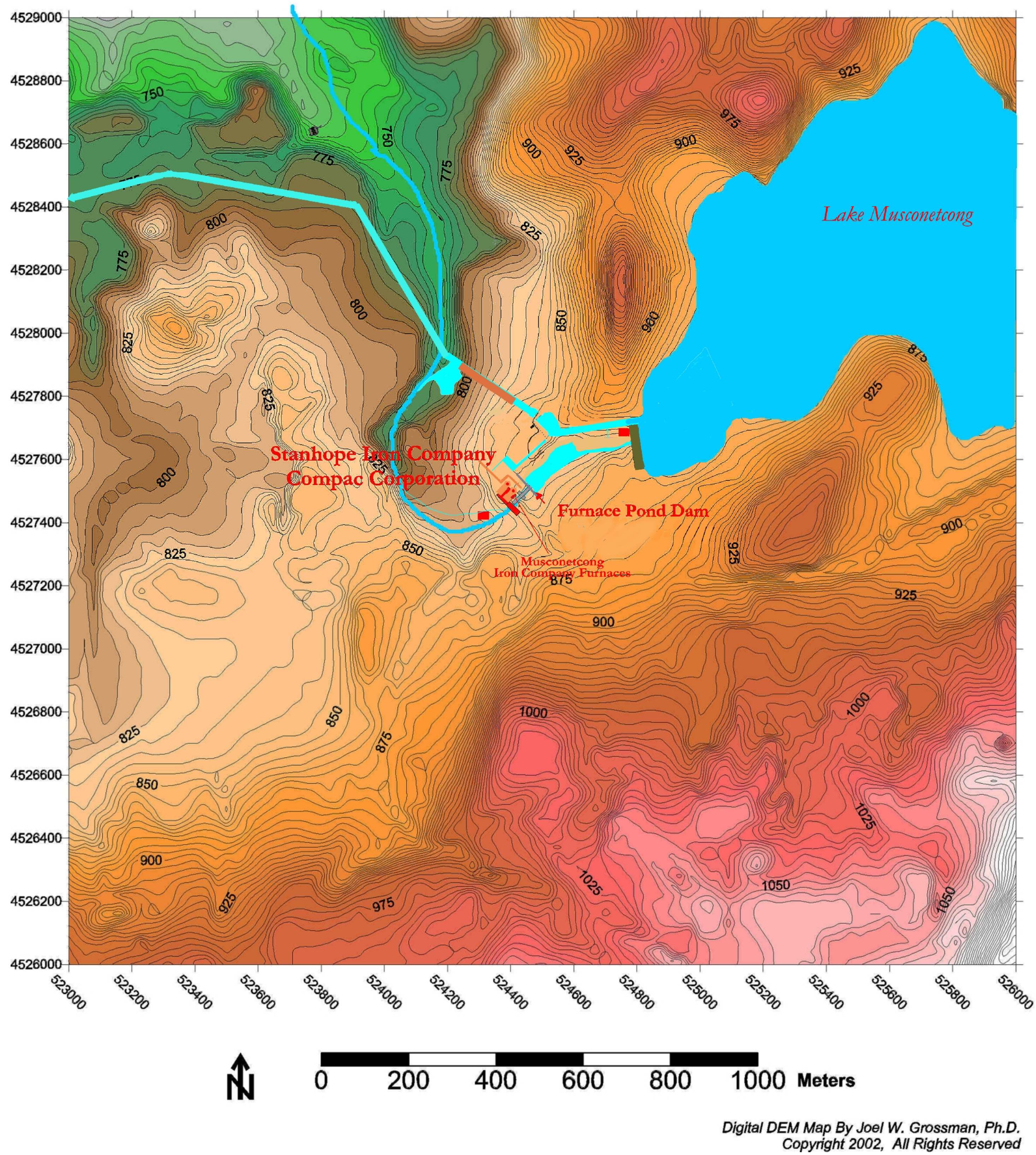


Figure 1. Topographic map of Foundry and Morris Canal in Stanhope/ Netcong project area from Digital Elevation Model (DEM) radar data.

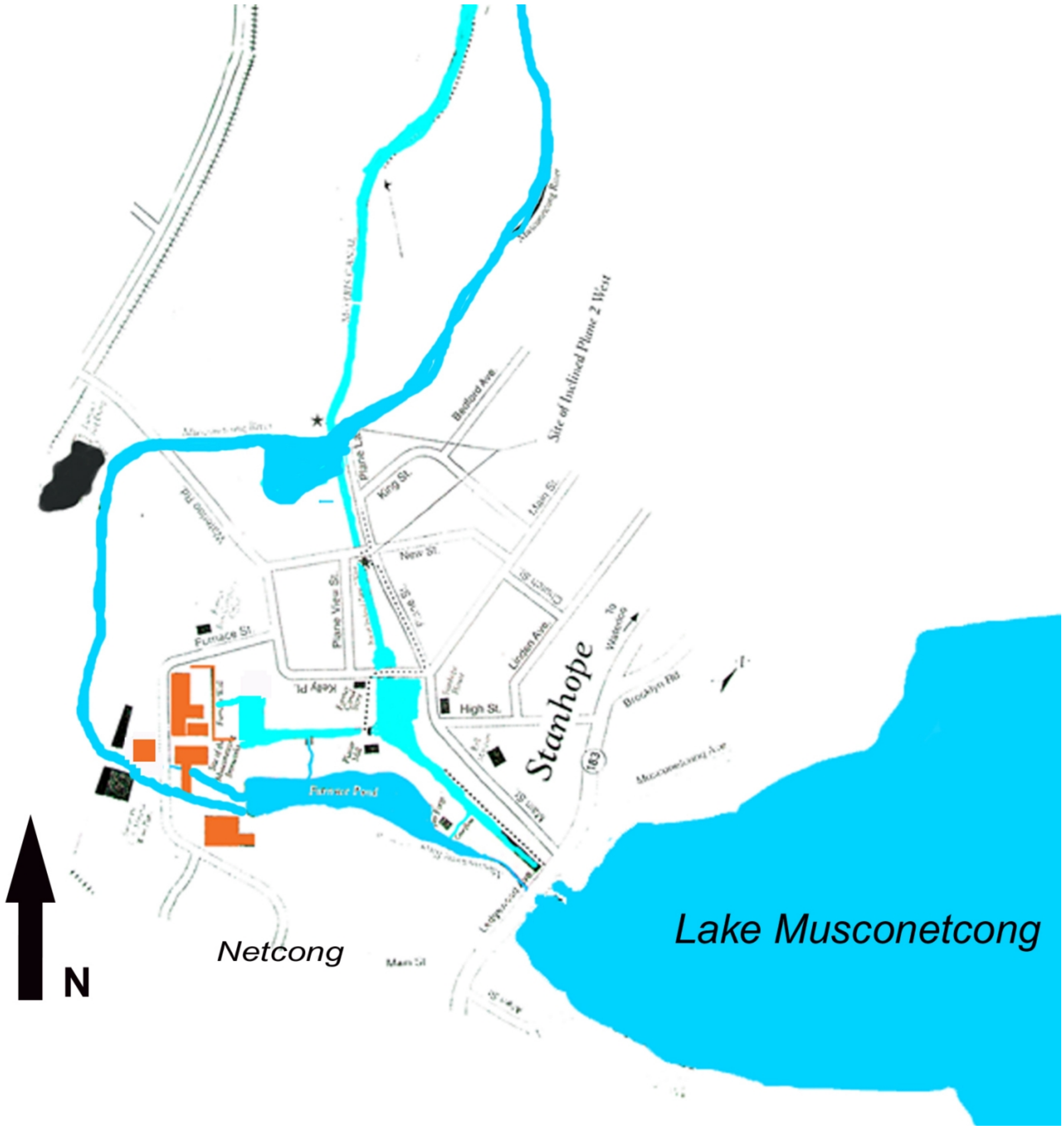


Figure 2. Schematic map illustrating the interconnected and functionally interdependent water supply and power network of the Foundry and Morris Canal system in Stanhope/Netcong *(B/W base map courtesy of Canal Society of New Jersey, color and notations added by author).*

Figure 3. Digital image of 1974 air photo of project area (Robinson Aerial).

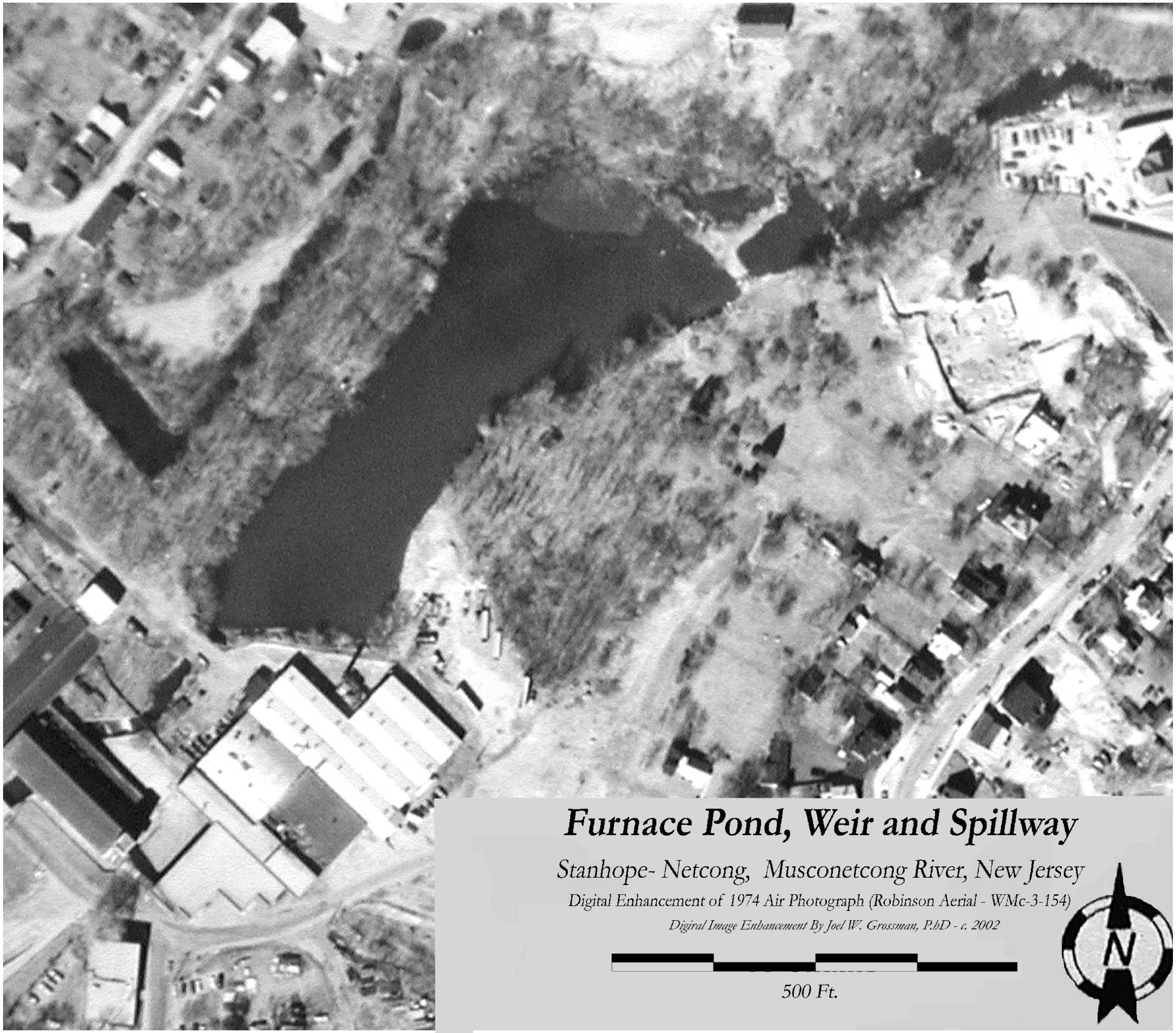


Figure 4 . Digital image enlargement of 1974 air photo of project area .(Robinson Aerial).

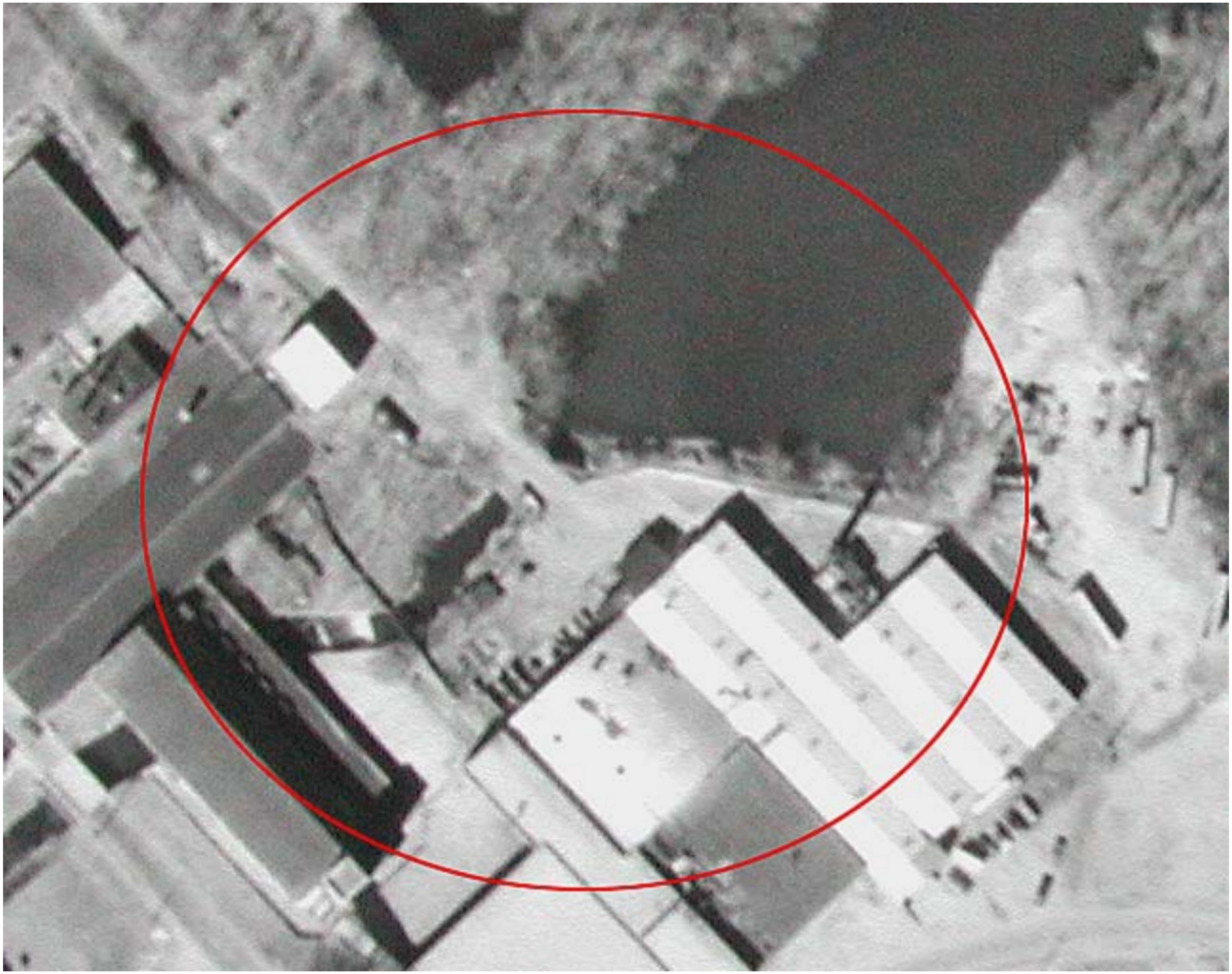
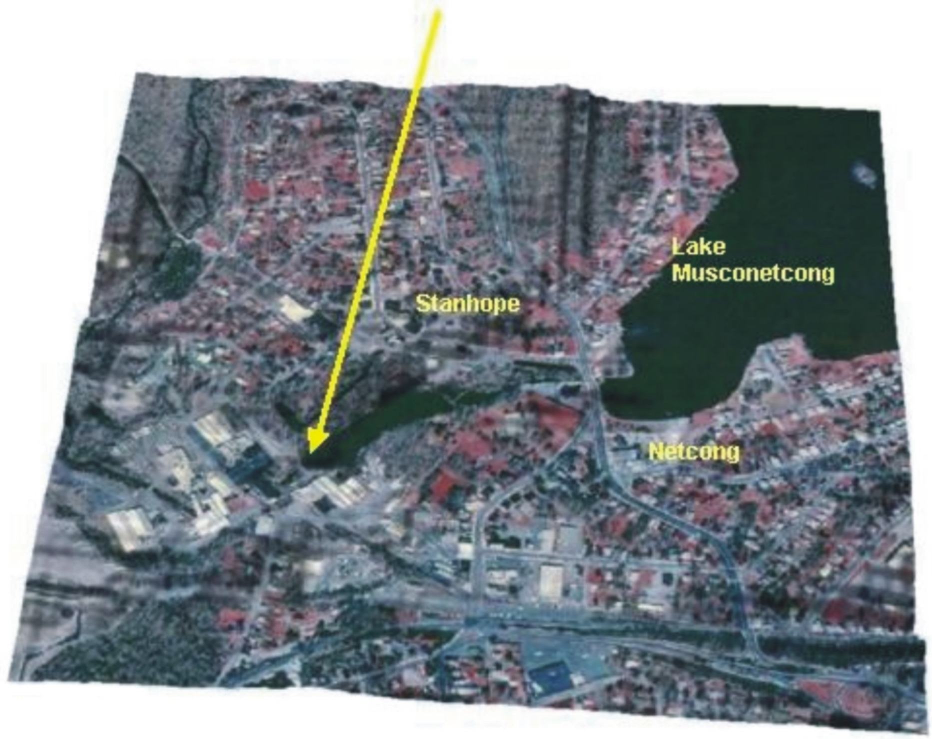


Figure 5 . Detail of 1974 air photo of project area (X 1500%) (Robinson Aerial).

Compac Corporation Archeological Mitigation
Furnace Pond Site



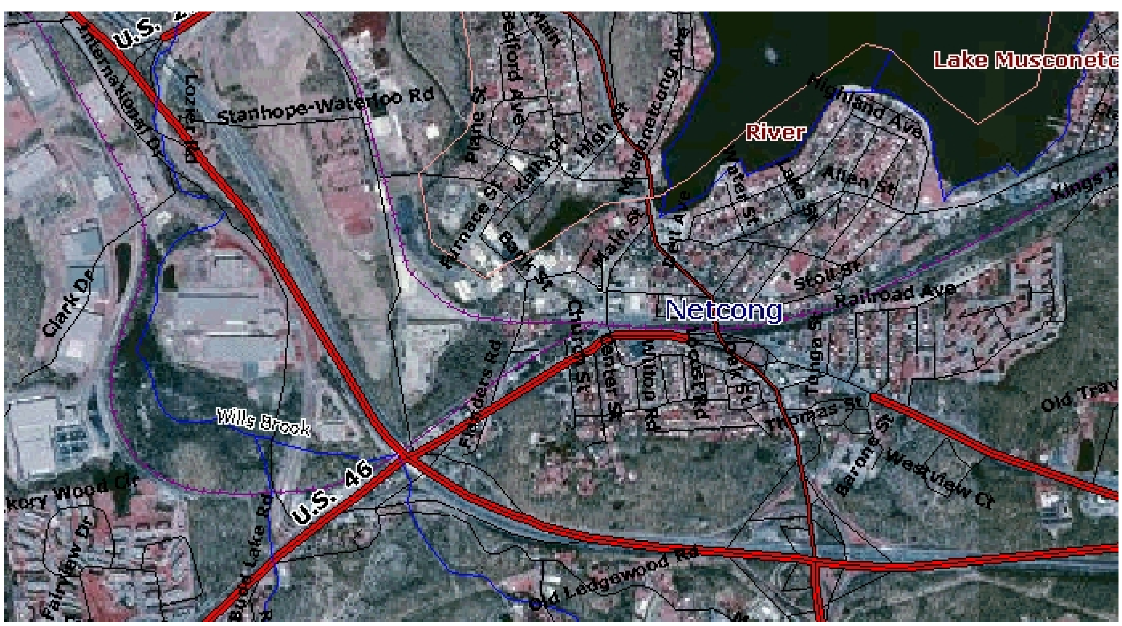


Figure 6 . Computer generated 2D and 3D terrain models derived from radar D.E.M data, draped and surface mapped with the NJDEP infrared orthophotos of the project area *(3D GIS surface mapping courtesy of Davis Associates, Inc. 2002)* .

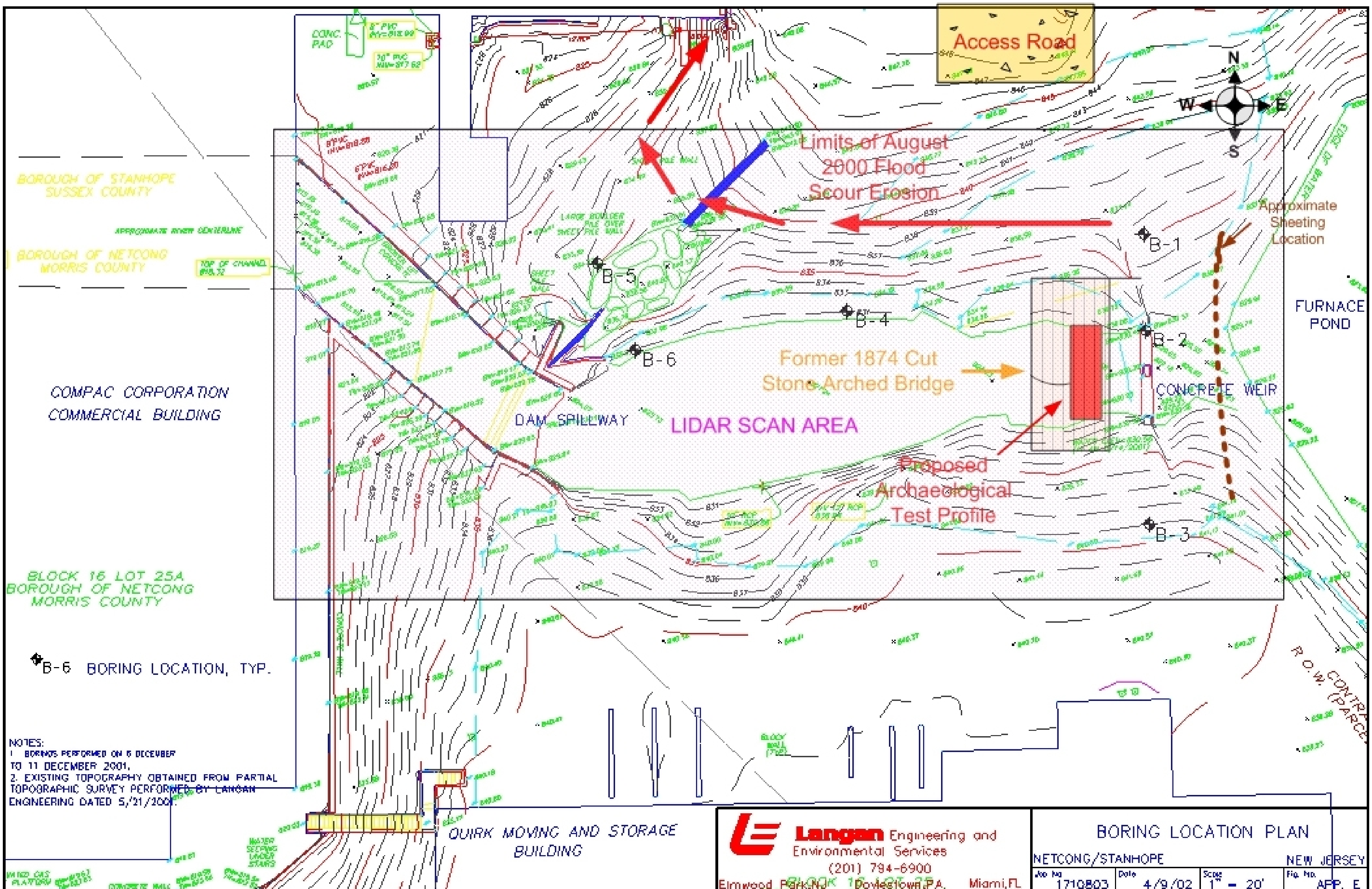


Figure 7. Project Plan of Furnace Pond Falls showing topography, zone of deep flood scour damage, locations of Langan test borings, proposed LIDAR 3D scan area, relocated sheeting plan, proposed N-S archaeological profile cut and former 1874 stone bridge.

Figure 8. Modern view looking west, towards the foundry, along the L-shaped Morris Canal Spur, or "Raceway to the Works". Note cut stone lined channel like the foundry retaining wall below. *Photo By Joel W. Grossman, Ph.D., June 23, 2002.*

Figure 9. Modern view looking north along 16 ft. high, post-1840 stone retaining wall supporting interior blast furnaces and "L" shaped Morris Canal spur to the Foundry. Note fire reddened stones from former furnaces. (*Photo By Joel W. Grossman, Ph.D., April 19, 2002).*

Figure 10. Contemporary field views of "Foot" of 1840's L-shaped Spur, or "*Raceway to the Works"*, above the Foundry, looking south in the direction of Furnace Pond *(Top);* Detail looking north, towards south bank of the L-Shaped Spur, at mid-19th century cut stone and iron Sluice Gate, which regulated water discharge to both the Foundry and Furnace Pond below *(Bottom) (Photos by Joel W. Grossman, Ph.D., June 23,2002).*

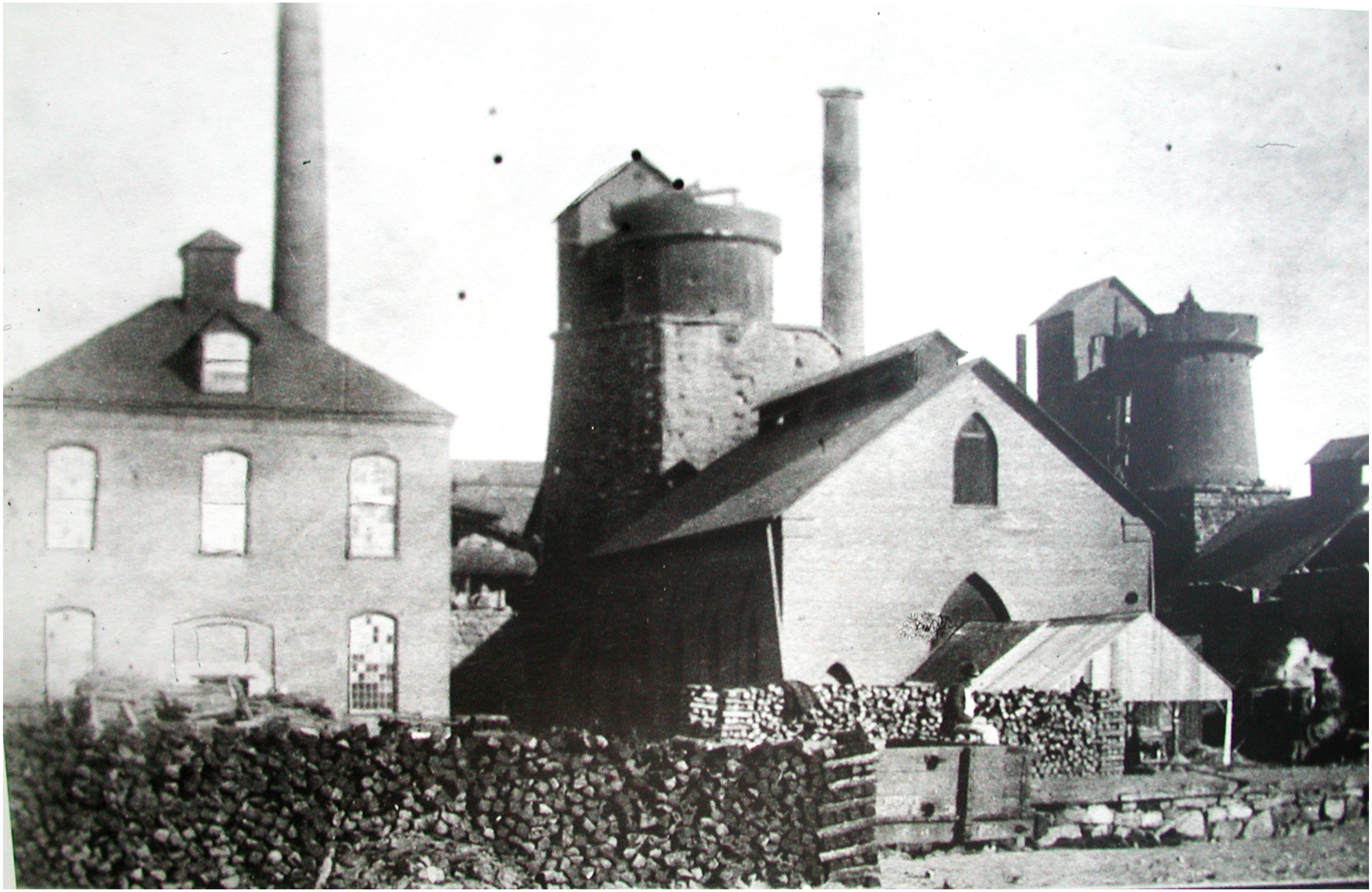


Figure 11. Late 19th to early 20th historic photo of Musconetcong Iron Co., Stanhope, New Jersey, looking south-east from Flanders Road at stands of fuel logs, two casting houses with furnaces and 50 ft. high brick smoke stacks in the rear*(Photo courtesy of the Musconetcong Foundrymen Historical Society).*

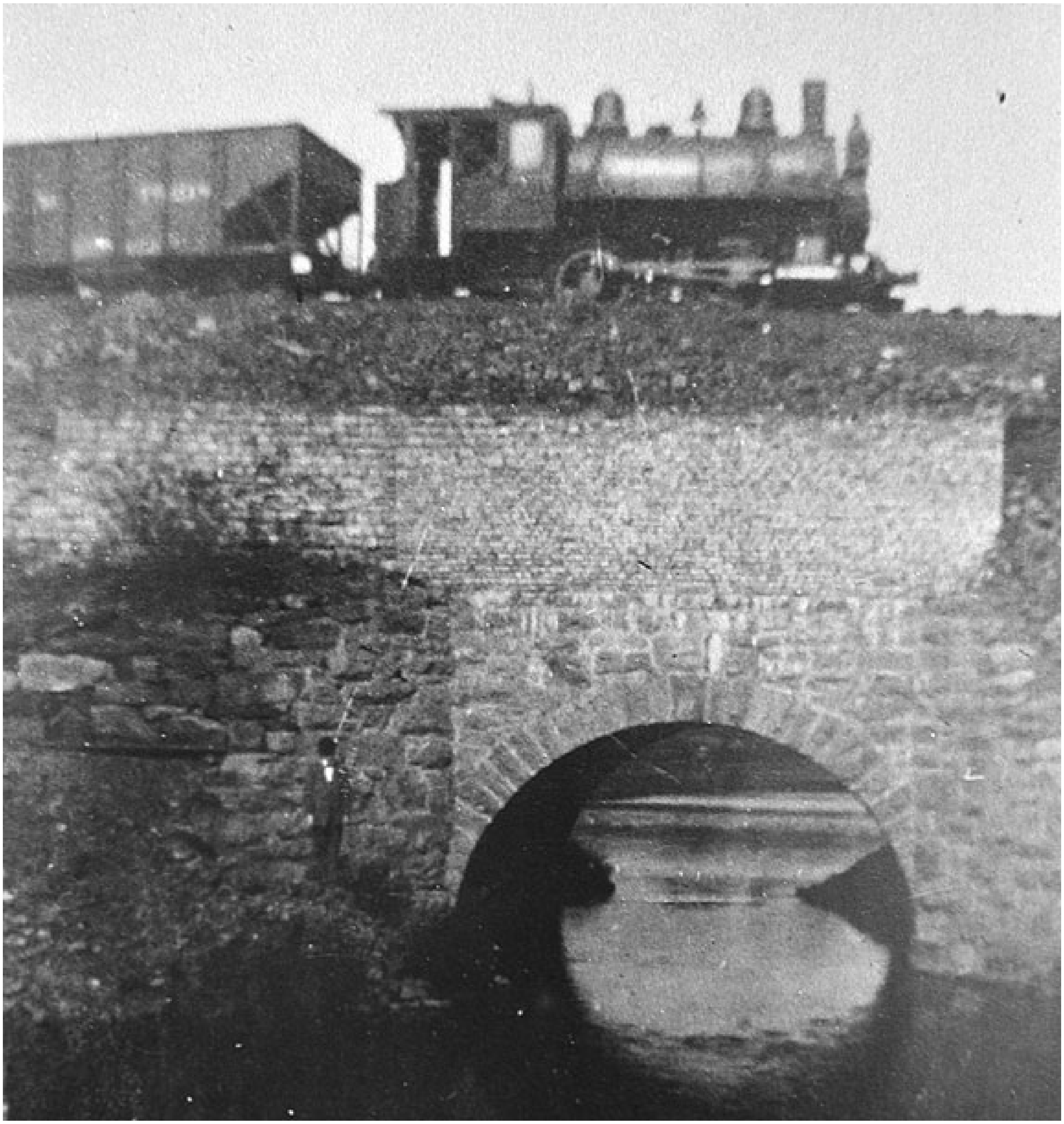


Figure 12. Undated (pre-1927) historic photograph of the former cut stone arched bridge and train trestle at Furnace Pond *(Photo courtesy of Musconetcong Foundrymen Historical Society)*

Figure 13. Undated (pre 1927) historic photograph of the "Singer Lower Spillway" showing 19th century motored stone abutment and wing wall supporting former footbridge (*Photo courtesy of Musconetcong Foundrymen Historical Society)*

Figure 14. View looking east, up stream, at modern Lower Spillway Dam of Furnace Pond Falls, Stanhope/Netcong, New Jersey, June 23, 2002 *(Photo by Joel W. Grossman, Ph.D.)*

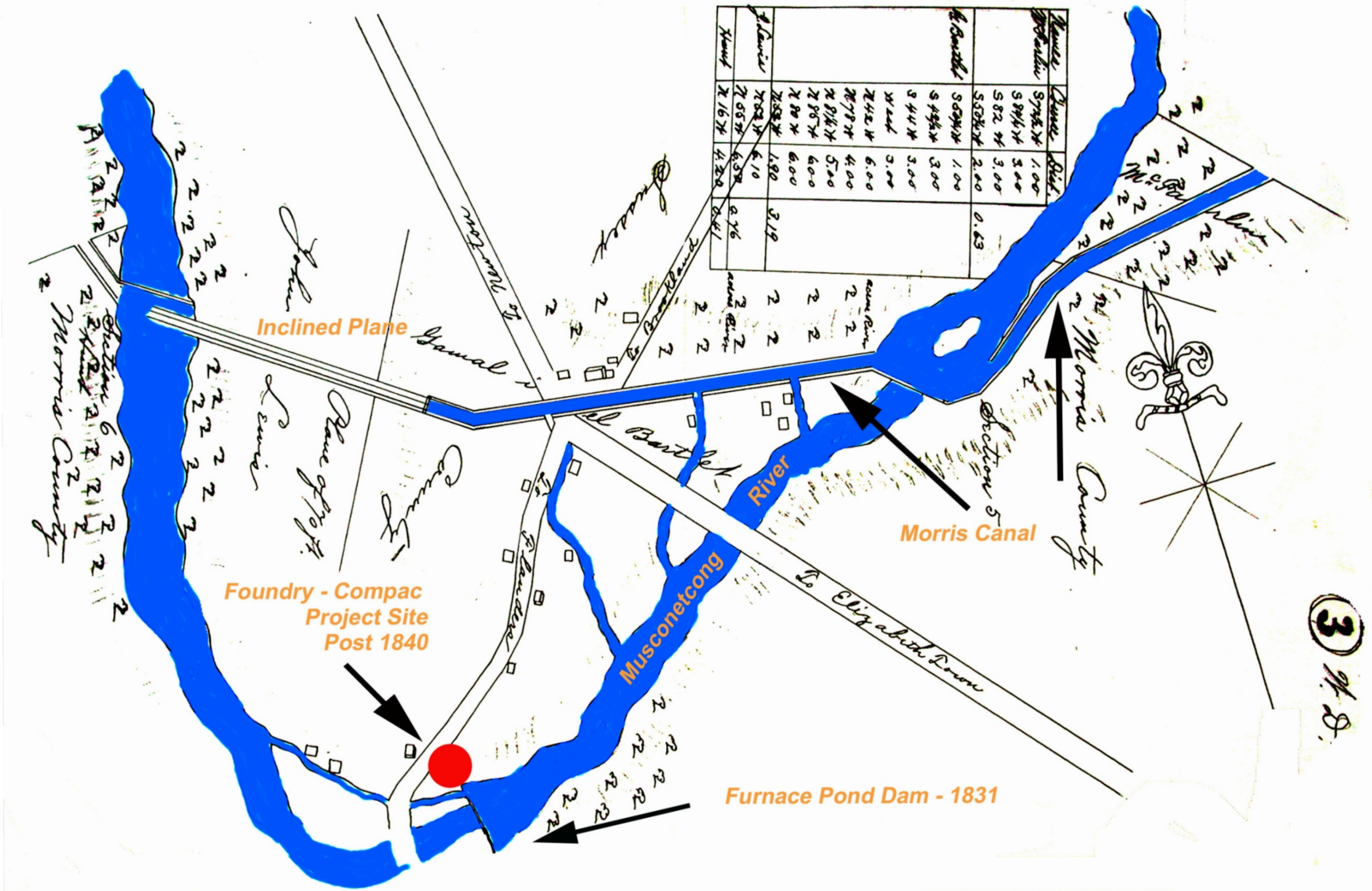


Figure 15. Digital copy of apparently surveyed and scaled 1828 map of the Morris Canal through Stanhope, New Jersey, by Lorenzo A. Sykes, Engineer, titled *"Map and Field Notes of the Morris Canal and Banking Co., Stanhope-Western Division"*, showing Morris Canal and pre-1840's Lower Forge downstream of Furnace Pond, before the Foundry operations moved to present site, before the 1807 Turnpike and Flanders Road were realigned, and before the post-1840's construction of the "L"-Shaped spur, or "Raceway to the Works", was built to the Foundry. Notice the three pre-1840's mill runs, or raceways, flowing out of the south bank of the Morris Canal into Furnace Pond *(Photo courtesy of NJDEP, Division of Water Resources. Date and provenance courtesy of Brian Morrell, Musconetcong Foundrymen Historical Society, color and notations added by author.)*

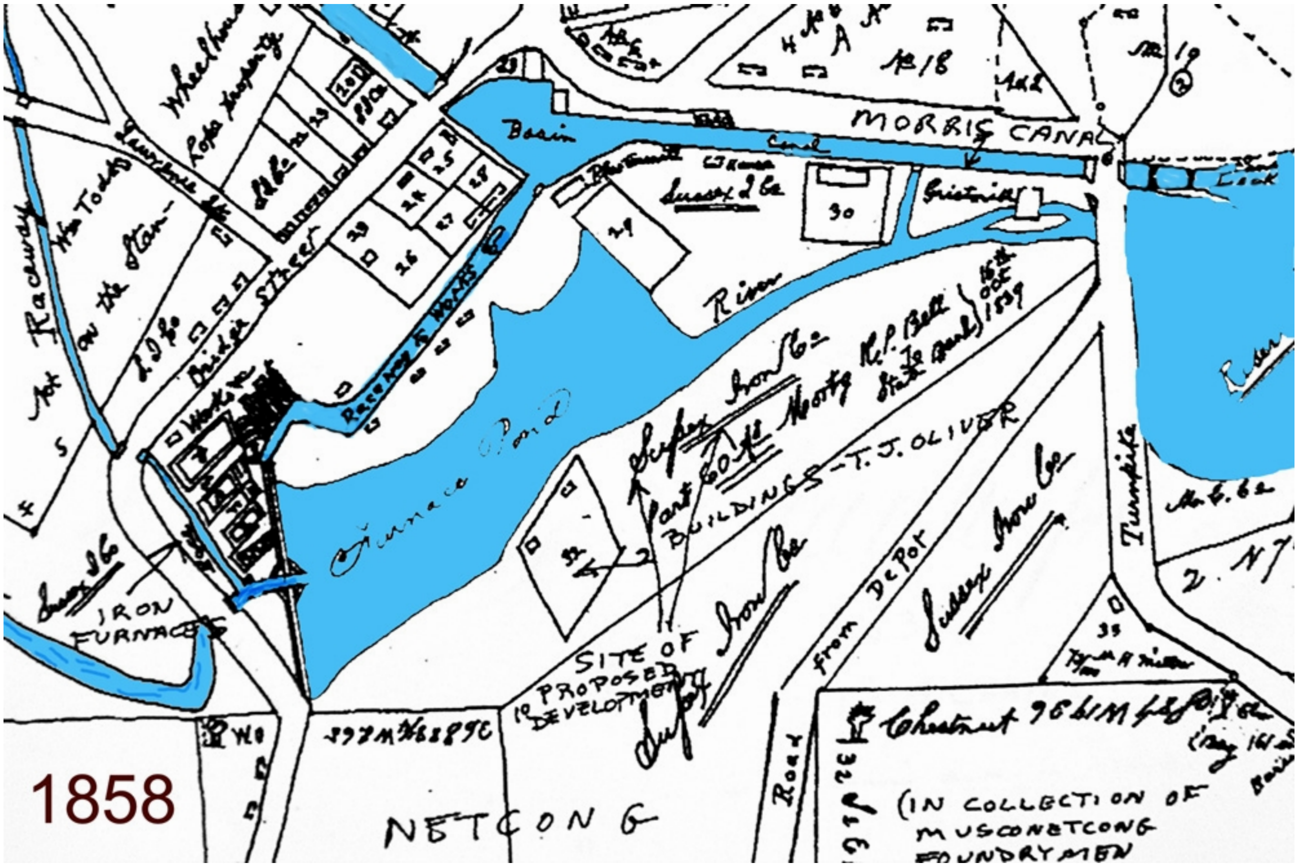


Figure 16. 1858 "Map of Lands Lying in Stanhope, New Jersey and Vicinity" by Benjerman Roome and Son, Surveyors. *Showing ca. 400 ft. Dam at Furnace Pond and sluice, or channel, connecting "L" shaped canal spur , or "Raceway to Works", to blast furnace area of Foundry (Color added by author. Photo courtesy of Musconetcong Foundrymen Historical Society).*

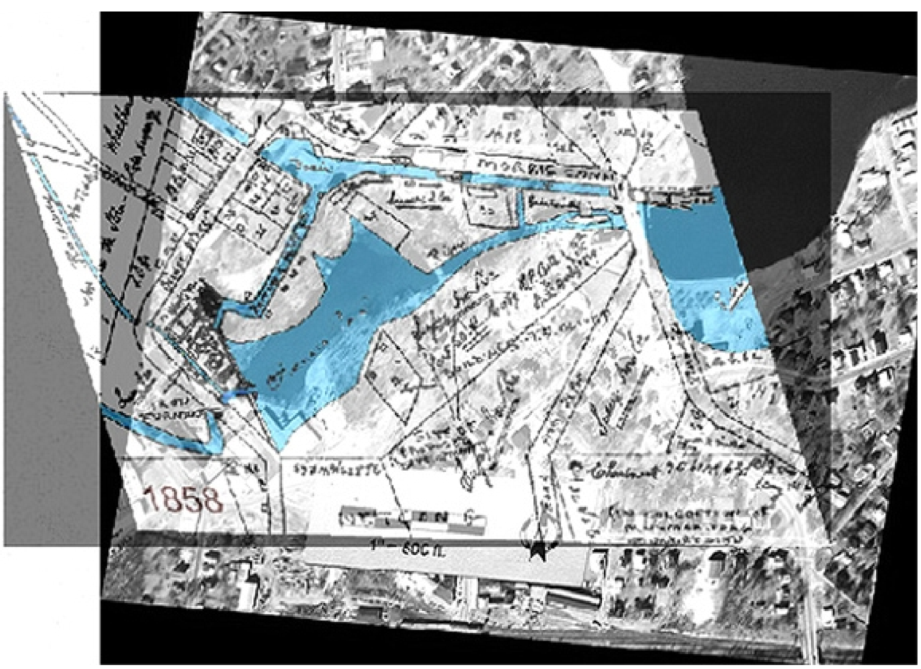


Figure 17. 1858 "Map of Lands Lying in Stanhope, New Jersey and Vicinity" .after being georeferenced and overlaid to scale over modern orth photo of project area. Screen shot of variable transparency GIS image off of Web. *(Image courtesy of Davis Associates, July 2002).*

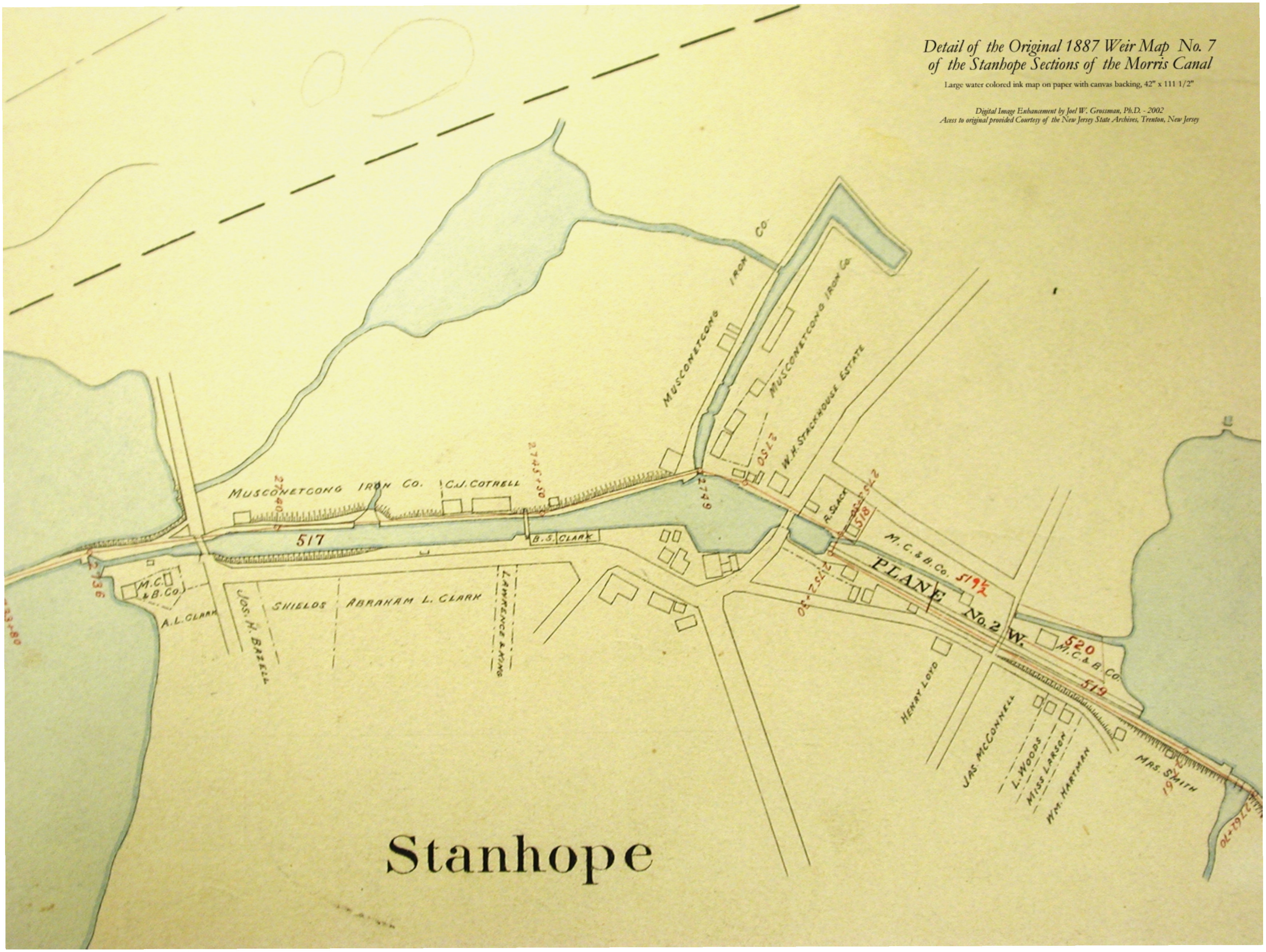


Figure 18. Digital image detail of Weir's Original 1886 Map of the Morris Canal through Stanhope, New Jersey *(New Jersey State Archives, Folio/Box C, Item 21)*

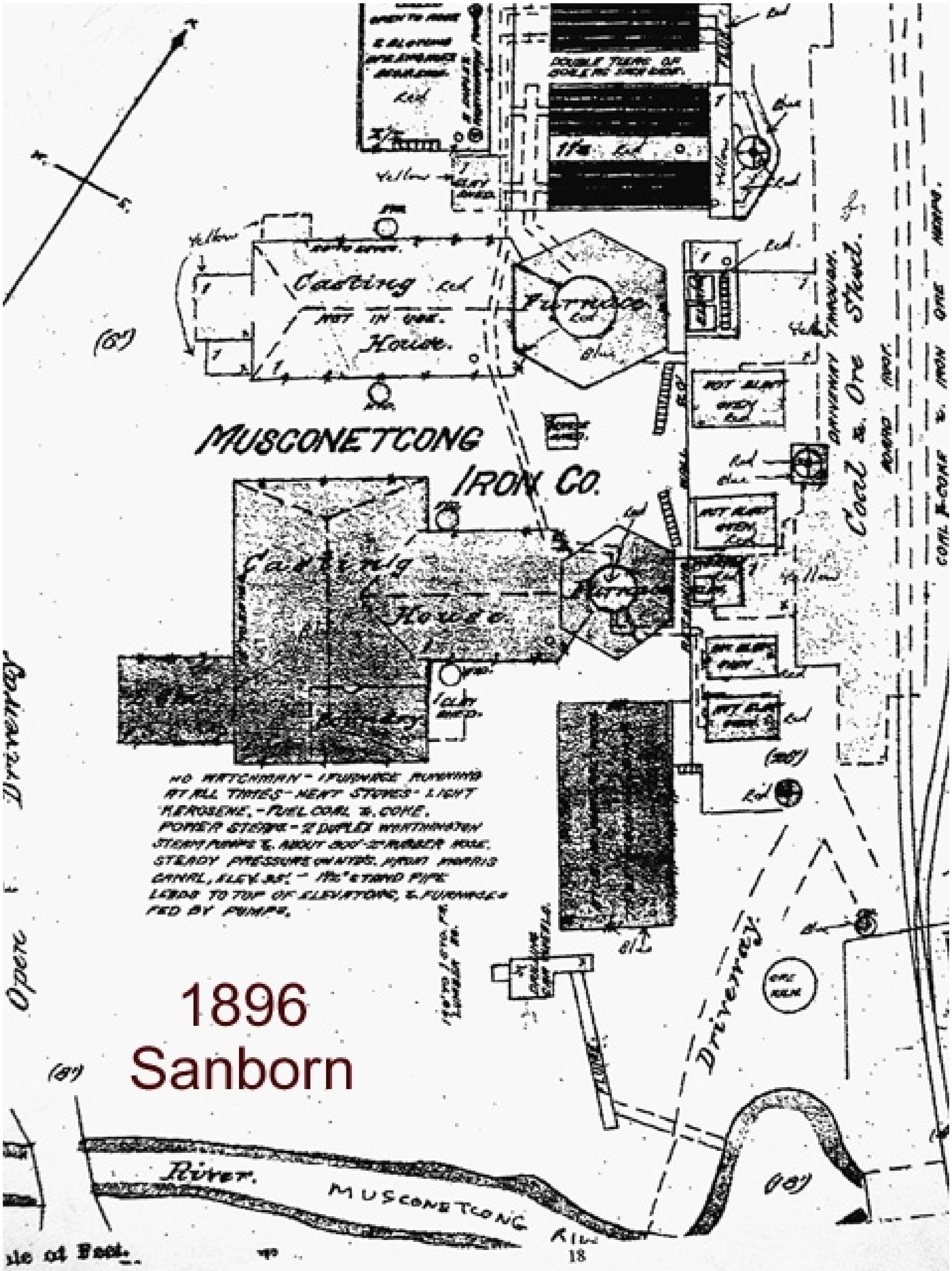


Figure 19. Black and white digital copy of one of a series of late 19th and early 20th century color coded Sanborn Insurance maps of the Musconetcong Ironworks in Stanhope/Netcong showing oxbow in raceway channel west of cut stone bridge and three blast furnaces built into post-1840 stone retaining wall (*Map courtesy of the Musconetcong Foundrymen Historical Society).*

Figure 20. Field shot looking south-east towards Lower Spillway during August 2000 dam breach and flood at the Compact Corporation site in Stanhope/Netcong, New Jersey *(Photo courtesy of Compac Corporation)*.

Figure 21. Field shot looking due south at Lower Spillway documenting extent and depth of scour erosion during August 2000 dam breach and flood at the Compact Corporation site in Stanhope/Netcong, New Jersey *(Photo courtesy of Compac Corporation)*.

Figure 22. Field shot looking west, downstream, at Lower Spillway showing north-south extent and depth of scour erosion during 2000 Musconetcong flood at the Compact Corporation site in Stanhope/Netcong, New Jersey *(Photo courtesy of NJDEP).*

Figure 23. Field shot looking west, downstream, at Lower Spillway showing depth of scour erosion in Stanhope/Netcong, New Jersey *(Photo courtesy of Compac Corporation).*

Figure 24. Field shot looking east, upstream, through arch of cut stone bridge showing collapsed earth filled core on right interior at the Compact Corporation site in Stanhope/Netcong, New Jersey *(Photo courtesy of NJDEP).*

Figure 25. Detail of 1874 capstone in former cut stone arched bridge at Furnace Pond *(Photo courtesy of NJDEP)*

Figure 26. View looking south, across 1927 cement weir pods,into interior arch of former cut stone bridge at Furnace Pond showing partial collapse from flooding of central core of earth filled structure *(Photo courtesy of NJDEP).*

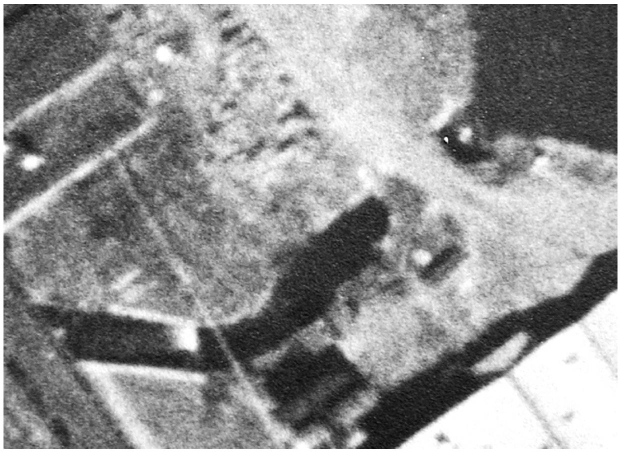
Figure 27. View looking south at deep scour channel through northern half of earth filled cut stone clad arched bridge at Furnace Pond *(Photo courtesy of NJDEP)*

Figure 28. View looking north-west at deep erosion induced collapse of southern half of earth filled and cut stone clad 1874 arched bridge at Furnace Pond Dam(*Photo courtesy of NJDEP)*

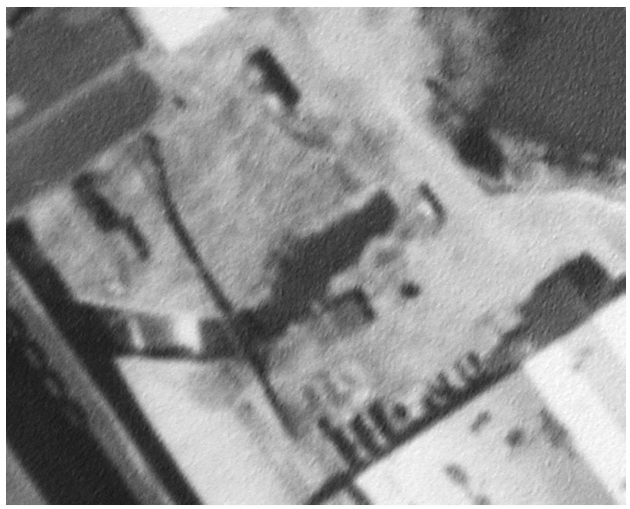
Figure 28. View looking north-west at deep erosion induced collapse of northern half of earth filled and cut stone clad 1874 arched bridge at Furnace Pond Dam(*Photo courtesy of NJDEP)*

Figure 30. View looking south-east, towards Furnace Pond, along mid-19th century cut stone lined raceway of historic channel*(Photo by Joel W, Grossman, Ph,D.).*

Figure 31. View looking, downstream, south-west across protruding and slotted post-1927 cement pods immediately upstream from former stone arched bridge *(Photo by Joel W, Grossman, Ph,D.).*



1959



1974

1986

Figure 32. Air photo record of changes in channel alignment and condition between 1958 and 1986. (*Photos by Robinson Aerial, image enhancement by Joel W. Grossman, Ph.D.*).

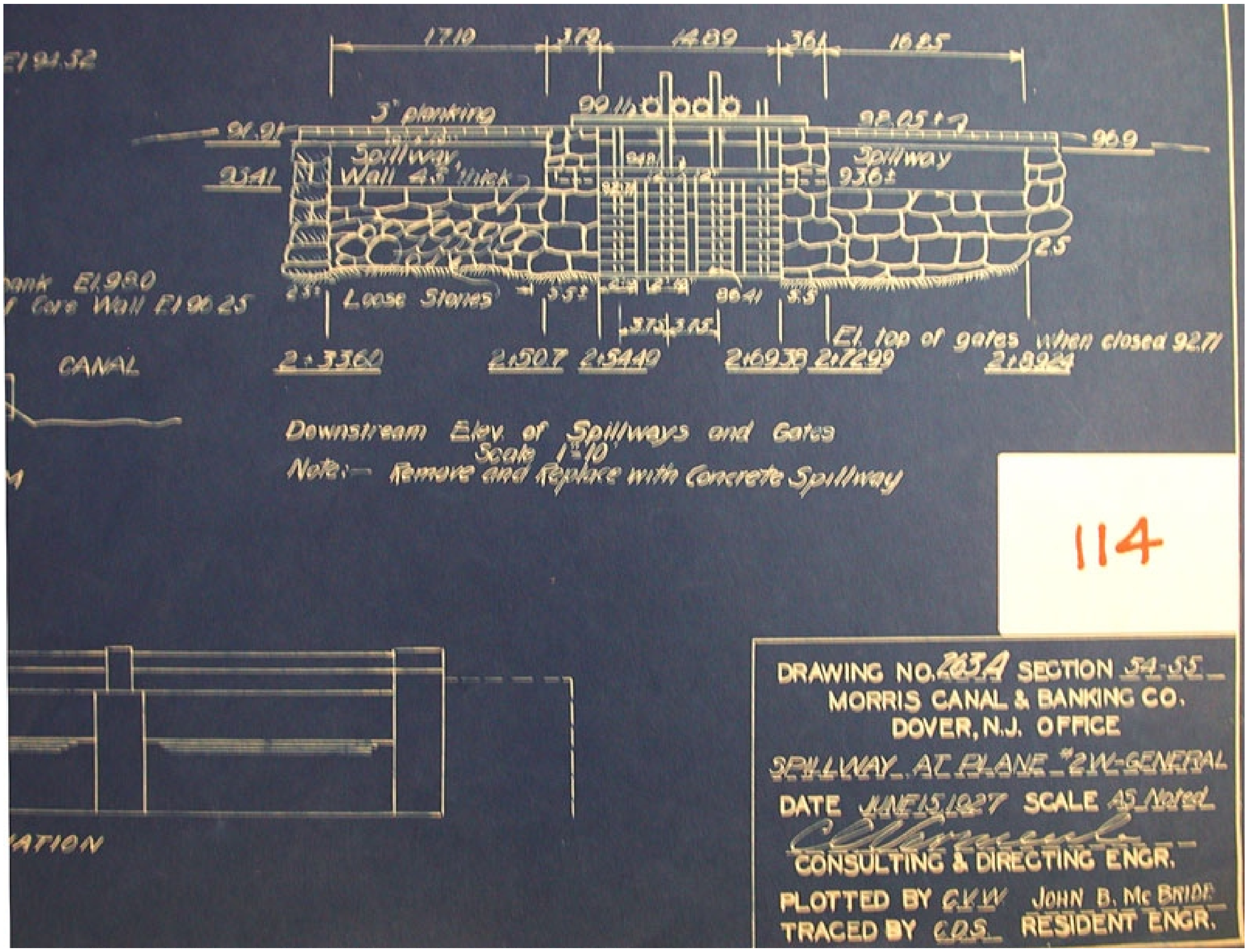


Figure 33. Detail of Vermeule's original 1927 plan for a cement spillway similar to weir at Furnace Pond, showing exiting conditions with mid-19th century heavy wooden and masonry dam structure that preceded it *(Digital photo by author, courtesy of NJ State Archives, Box 37, item Number 1, Plans for work on Section 54-55).*

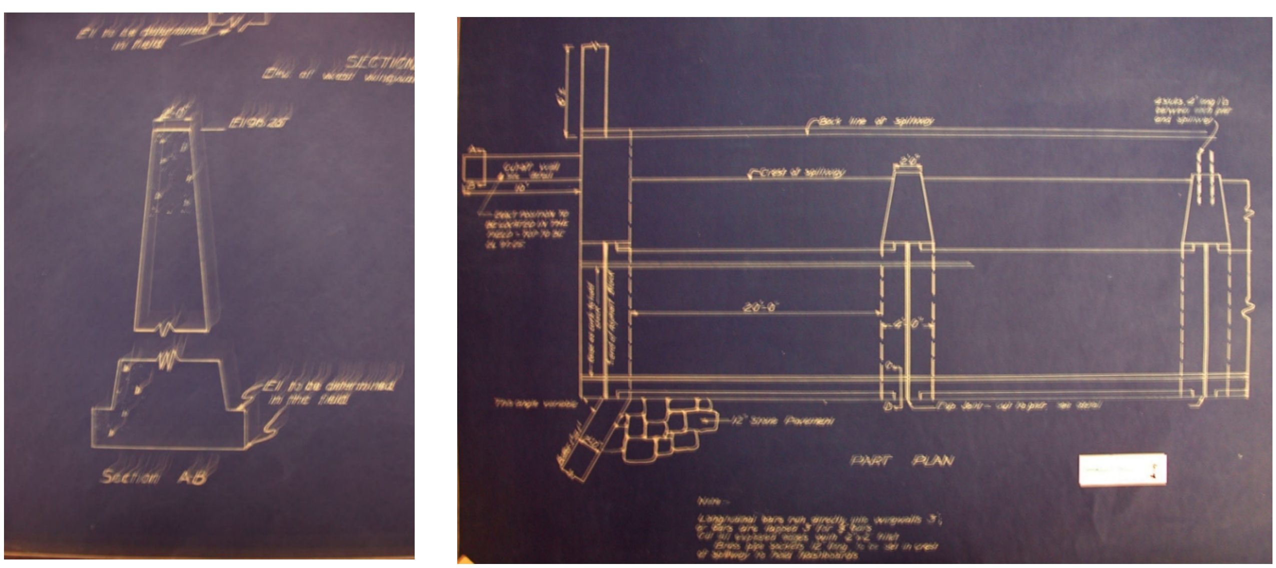


Figure 34. Detail of Vermeule's original 1927 plan for a cement spillway similar to three-pronged weir at Furnace Pond, in plan and profile *(Digital photo by author, courtesy of NJ State Archives, Box 37, item Number 1, Plans for work on Section 54-55).*

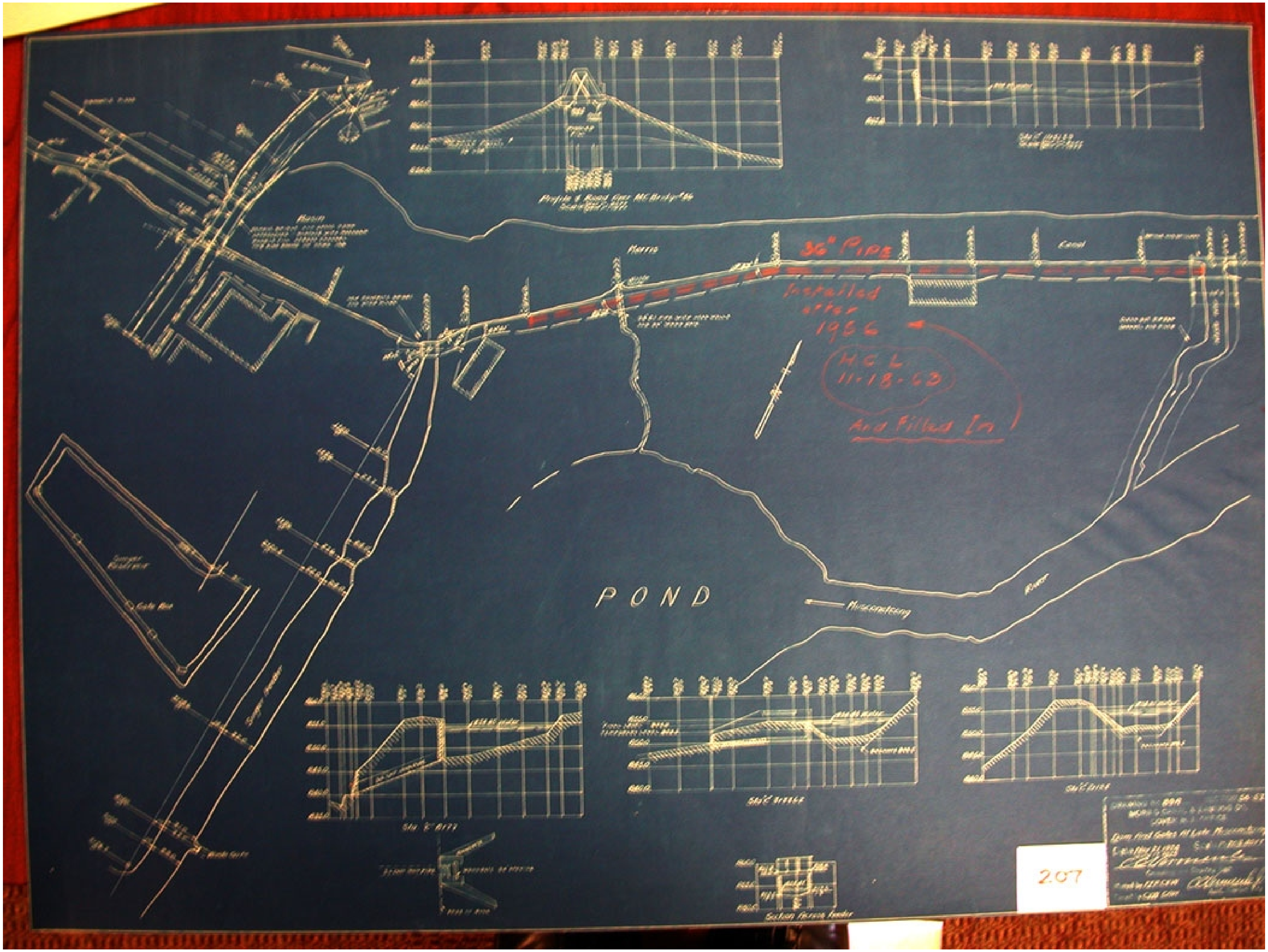


Figure 35. Digital copy of C.C. Vermeule's original 1927 plan of the "L" shaped canal spur, or "Raceway to the Works" supplying the Musconetcong Ironworks *(Digital photo by author, NJ State Archives, Box 30, Item No. 1, Plans for work on Section 56-57, June 15, 1927).*

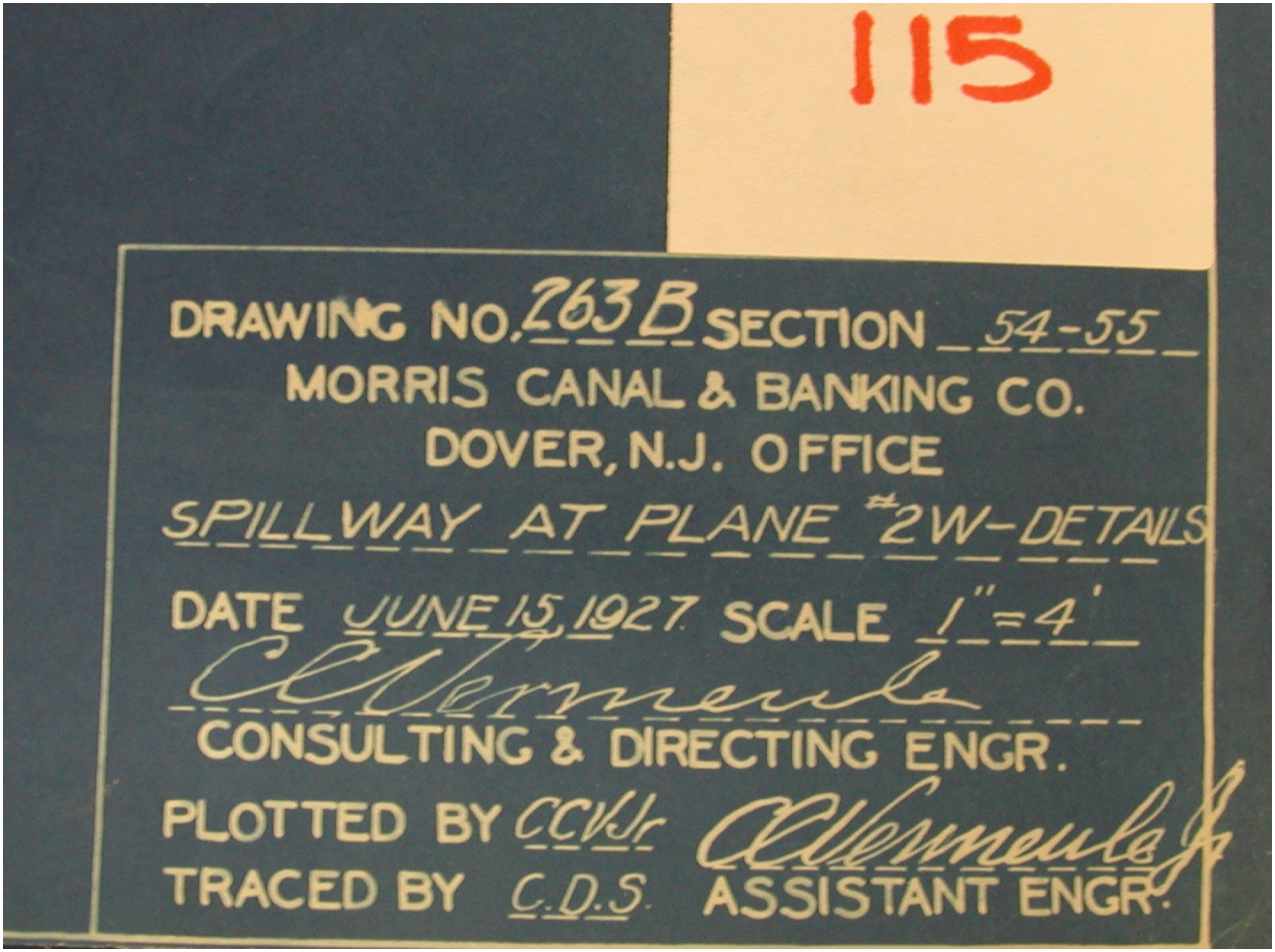


Figure 36. Detail of C.C. Vermule's blueprint key to Drawing Number 263B of Spillway plan and profile similar to the weir at Furnace Pond Falls on the Compac Corporation property *(Digital image enhancement by Joel W. Grossman, Ph.D., New Jersey State Archives, Folio/Box 37, Item 1 Plan).*

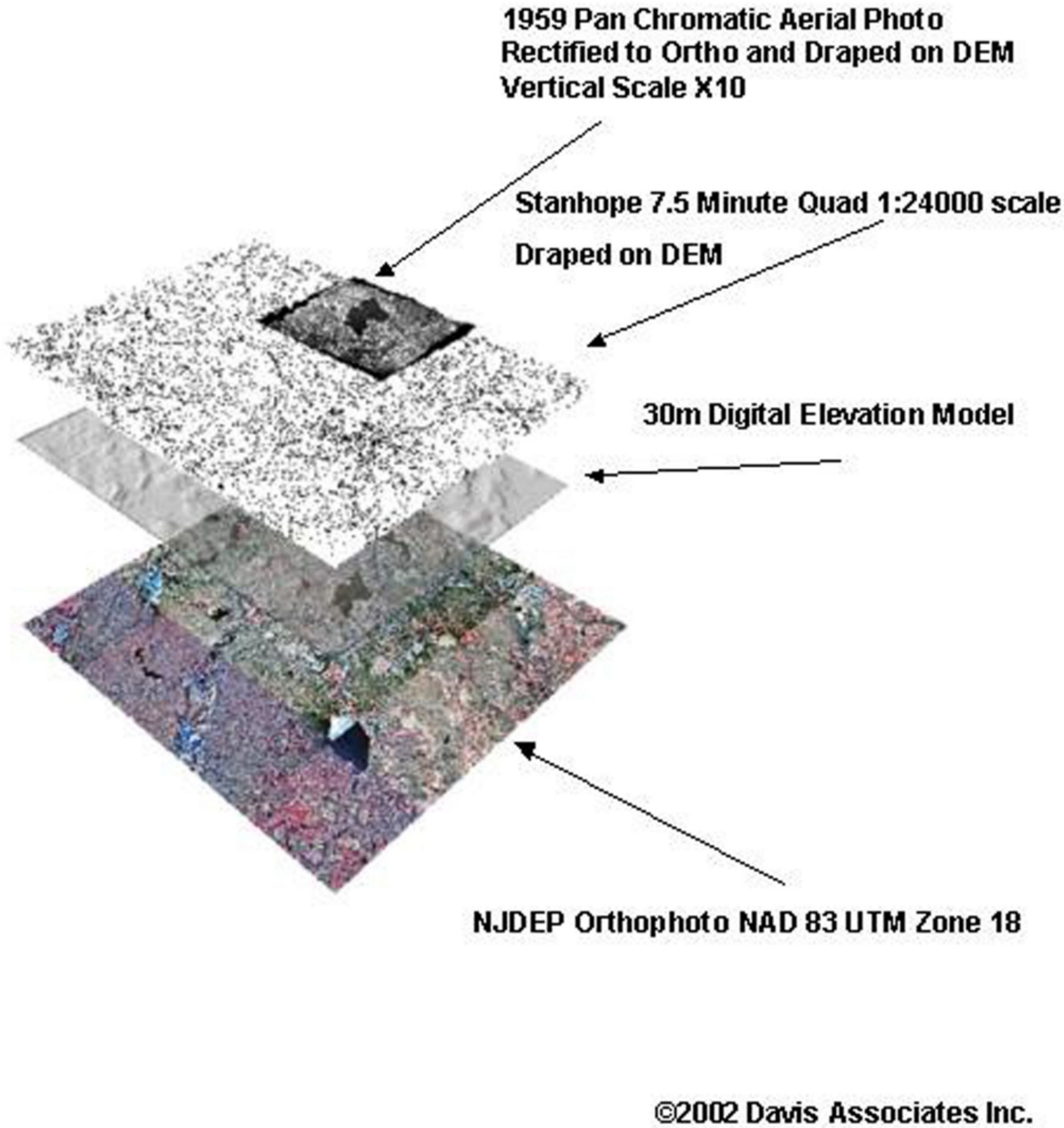


Figure 37. Computer generated GIS "layer cake" of scaled and georeferenced map and air photo coverage of project terrain registered to NJDEP infrared orthophoto of Stanhope area as base map *(Davis Associates Inc. 2002).*

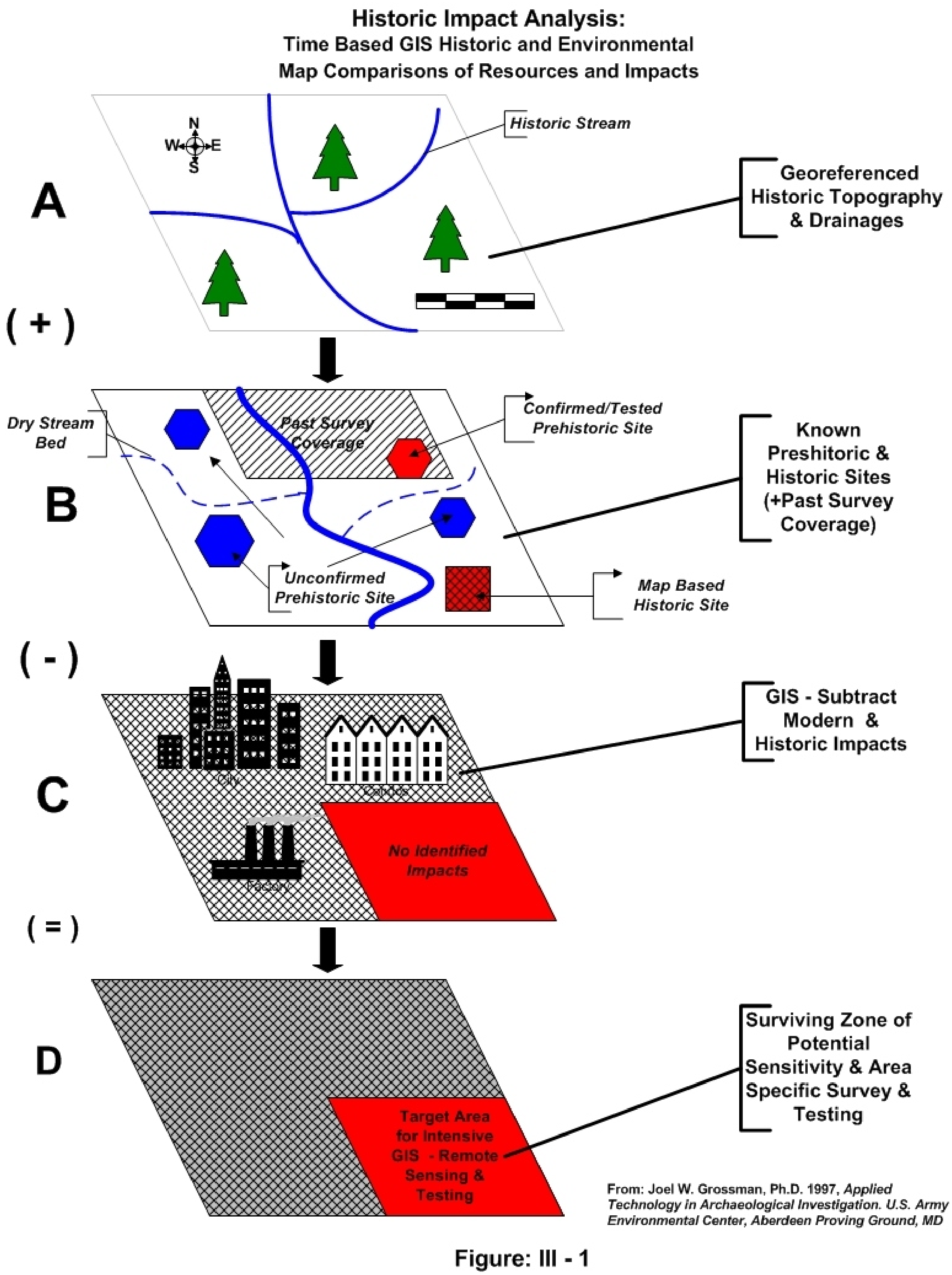
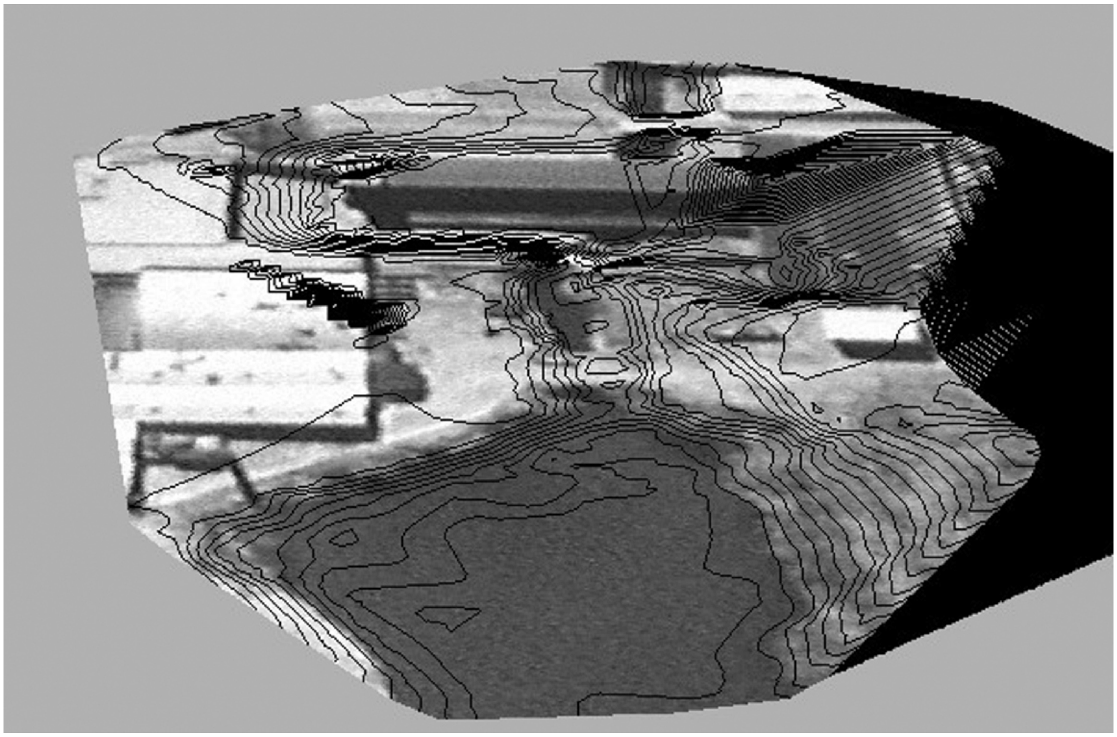


Figure 38. Schematic process chart illustrating diachronic, or time-based, use of Geographic Information Systems (GIS) technology to reconstruct the history of past impacts and potential archeological survivals as recommended for the Compac project, from 1997 U.S. Army study by author.



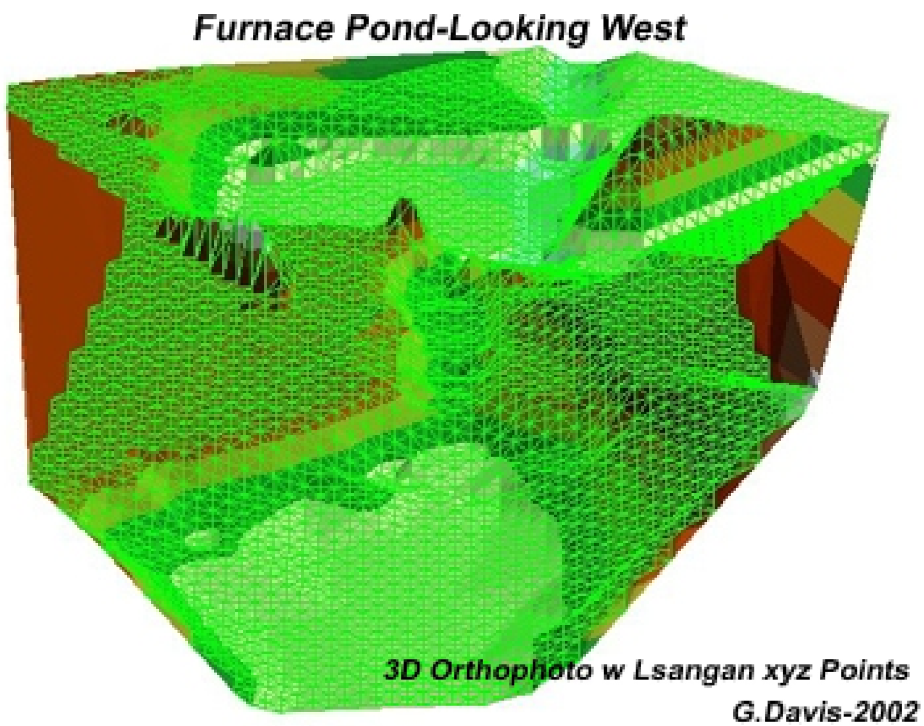


Figure 39. 3D GIS terrain models of Furnace Pond spillway showing survey points from Langan Engineering rendered as surface mesh model with georeferenced orthophoto of project site draped over topography (top), and with the raw points (bottom) *(GIS by Davis Associates, Inc., 2002).*