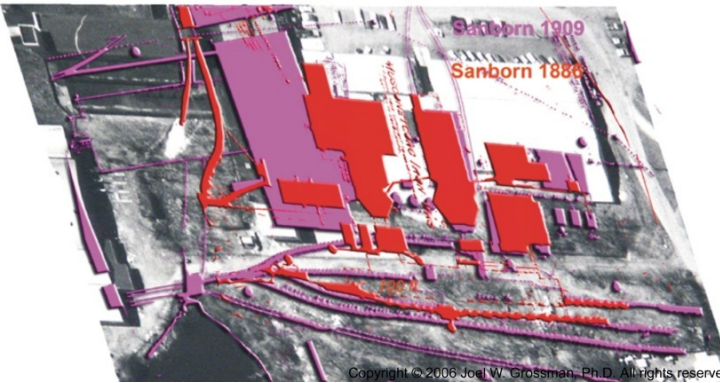


2002-STANHOPE, N.J.



Emergency Geospatial Solutions and Mitigation Through Redesign and Avoidance at Furnace Falls Dam, Stanhope, New Jersey

Joel W. Grossman, Ph.D.

In the summer of 2000, heavy flooding breached three dams in the Highlands of New Jersey causing damage to both modern infrastructure and contributing elements of the Morris Canal Historic District, bordering and within, the Musconetcong River, Stanhope/Netcong, Morris and Sussex Counties, NJ. Emergency dam repairs mandated by the New Jersey Department of Environmental Protection (NJDEP) came head to head with parallel Federal and State mandates to mitigate impacts to the 1830 Furnace Falls Dam and associated Civil War-era Musconetcong Iron foundry.

An initial evaluation by the author determined that the flood damaged dam and channel complex were "hydrologically interconnected" with, and therefore protected as contributing elements to, the Morris Canal National Historic District. The NJ DEP Office of Historic Preservation (OHP) then ordered Compact Corporation, the owner of the property, to develop a two part Mitigation Plan which would address the site's historic sensitivity and define a strategy to protect and/or document any impacted historic elements, prior to authorizing emergency dam repairs.

Design alternatives, and the urgent need to move quickly, were initially constrained by the lack of modern area-wide base-maps of the entire site, the lack of accurate maps of the historic district's boundaries, and the need to concurrently integrate the timing and logistics of any recommended archaeological field work with ongoing construction. The limitations of traditional

NJDEP - HISTORIC DAM REMEDIATION

approaches were exacerbated by the fact that the emergency dam repair work took place during the coldest winter since 1977 to protect endangered fish runs.

Completed and accepted within three months, the fast-track Mitigation Plan used both traditional archival and map sources, as well as advanced air photo image processing and geospatial software systems to reconstruct the site. Dr. Grossman worked with George Davis, a specialist, and an advanced 3D GIS and image processing system, ER Mapper, to quickly create project-wide base maps. Detailed low altitude 1950-1960-era black and white air photos were digitized and georeferenced (stretched or "rubber sheeted") to match the 3 ft. resolution and State Plane coordinate control of available NJDEP digital maps. Pre-Civil War canal design plans as well as the detailed 1927 "as-builts", made by CC. Vermeule when the canal was closed, were digitized from the collections of the New Jersey State Archives.

The historic plans were then scaled, or georeferenced, to the digital air photo base-maps to target the location of submerged and buried historic components.

Once defined, Dr.

Grossman worked in tight collaboration with Langan Engineering and Environmental Services, and the contractor, Salmon Brothers Construction, to significantly reduce impacts through redesign and avoidance. Instead of a deep, 300 ft. long temporary river bypass trench through the site, the river was diverted overland with large environmentally passive siphon pipes. Steel sheet piling across the channel was moved out of the historic area. Submerged historic wing-walls of a flood damaged 1874 stone bridge at the Falls were exposed during construction and protected in place. Only undocumented high-sensitivity areas subject to unavoidable impacts were targeted for detailed archaeological documentation.

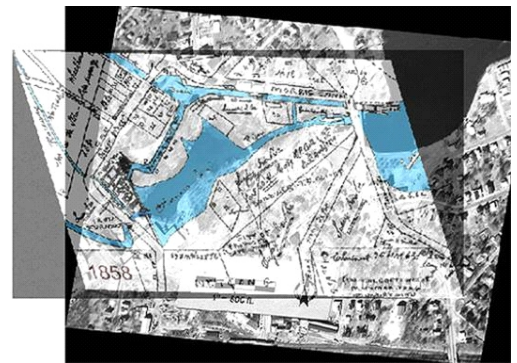
In January of 2004, a ten day, high speed, deep-winter emergency archaeological rescue effort, directed by Dr. Grossman, diverted the river overland, exposed the historic 1830 dam for six hours in sub-freezing conditions, and deployed single-camera photogrammetry and a new generation of laser-radar (LIDAR) with an integrated digital camera to produce the first true-color, mm- precise, 3D record of an archaeological site.

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2007 'Inter-Regional Studies/Archaeology of Toxic and Hazardous Environment's. In Pearsall, D(ed), **Encyclopedia of Archaeology**. Elsevier Press, London.

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**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*

By Joel W. Grossman, Ph.D.

2002

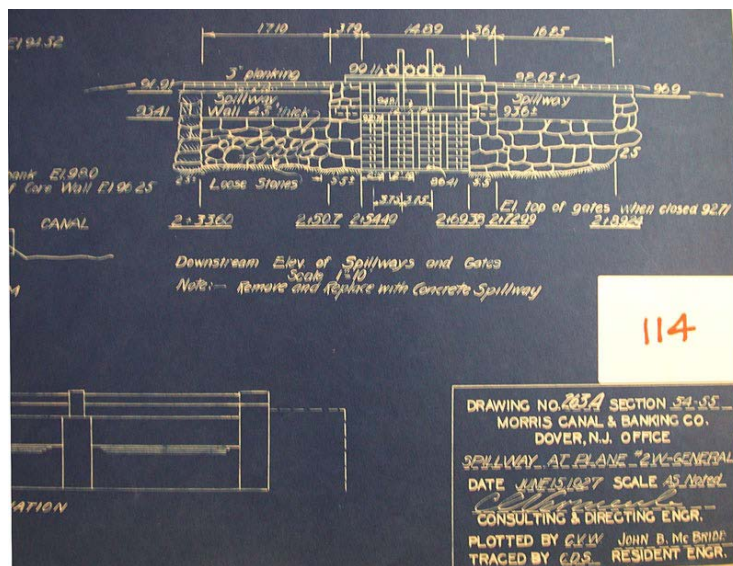


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Joint Engineering and Archaeological Mitigation Plan for the Furnace Falls Pond Dam, Weir, Spillway and Channel

**Stanhope/Netcong,
Morris and Sussex Counties, New Jersey**

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 NJSHPD.
- 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 three 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 Corporation 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 19th 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.

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,

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)

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 American Cyclopedia 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 19th 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 18th or 19th 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 contemporary 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 bathymetry 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 Sheet Pile 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 sheet piling 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 19th 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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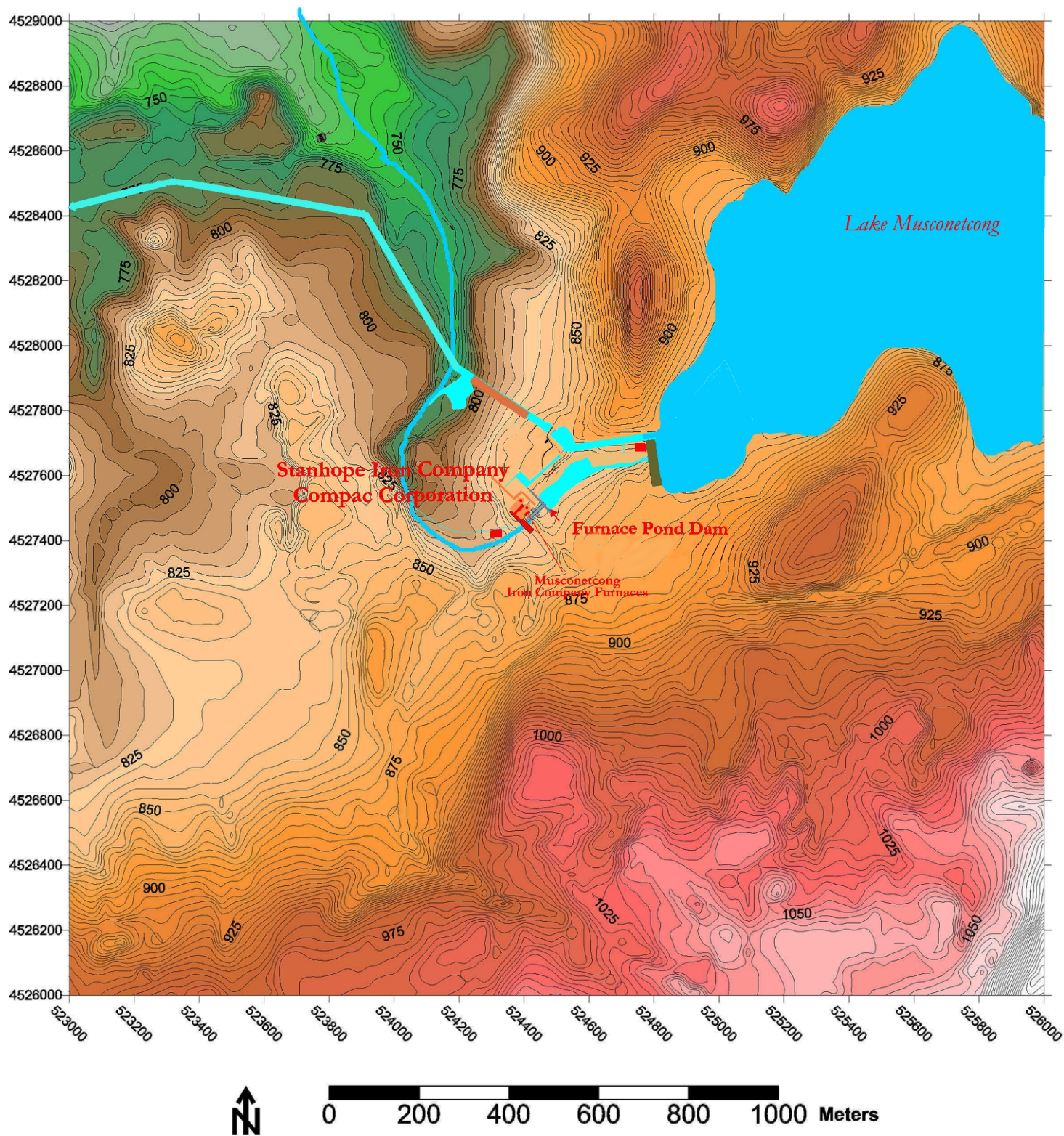
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Digital DEM Map By Joel W. Grossman, Ph.D.
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Figure 1. Topographic map of Foundry and Morris Canal in Stanhope/ Netcong project area from Digital Elevation Model (DEM) radar data.

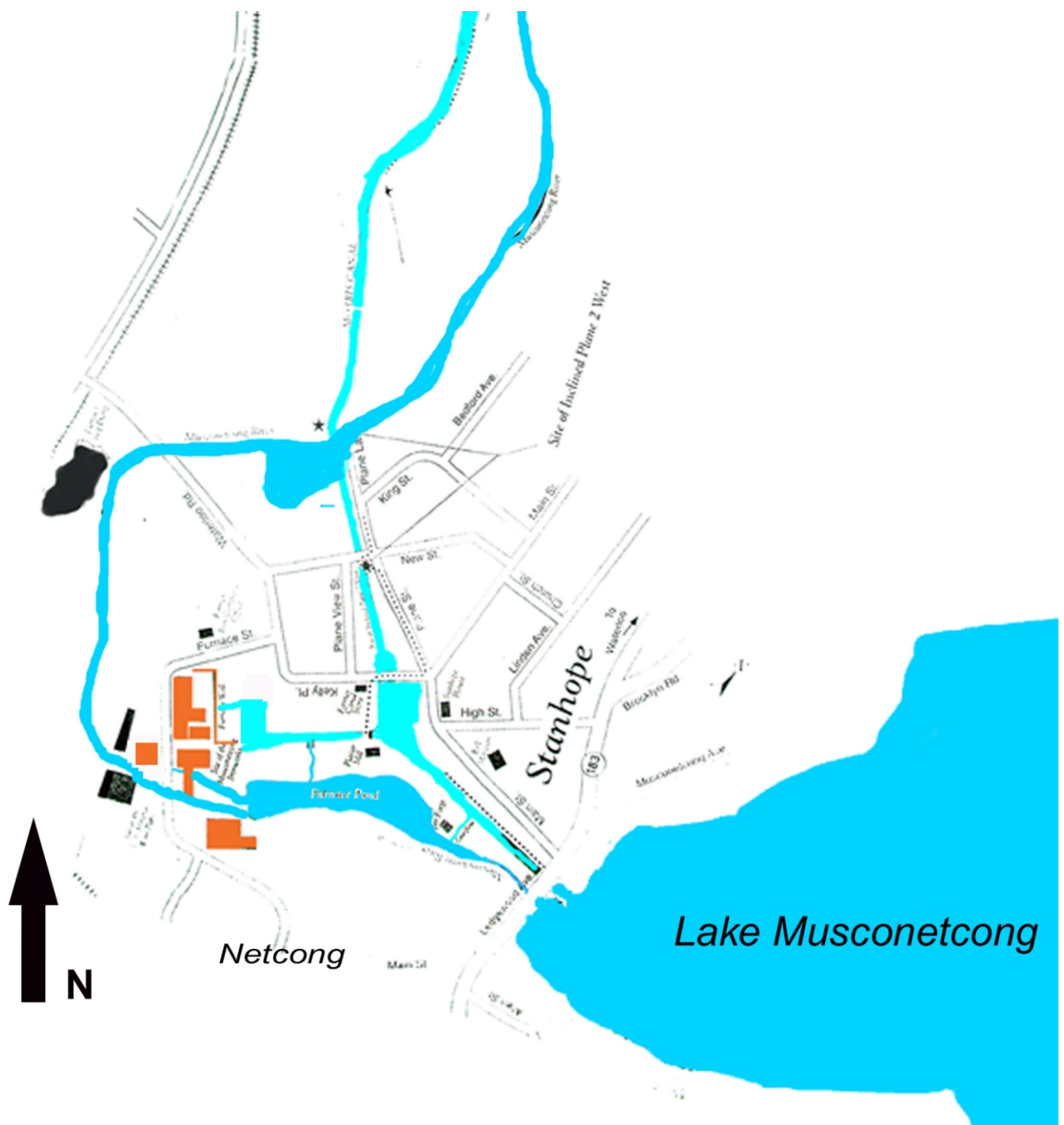
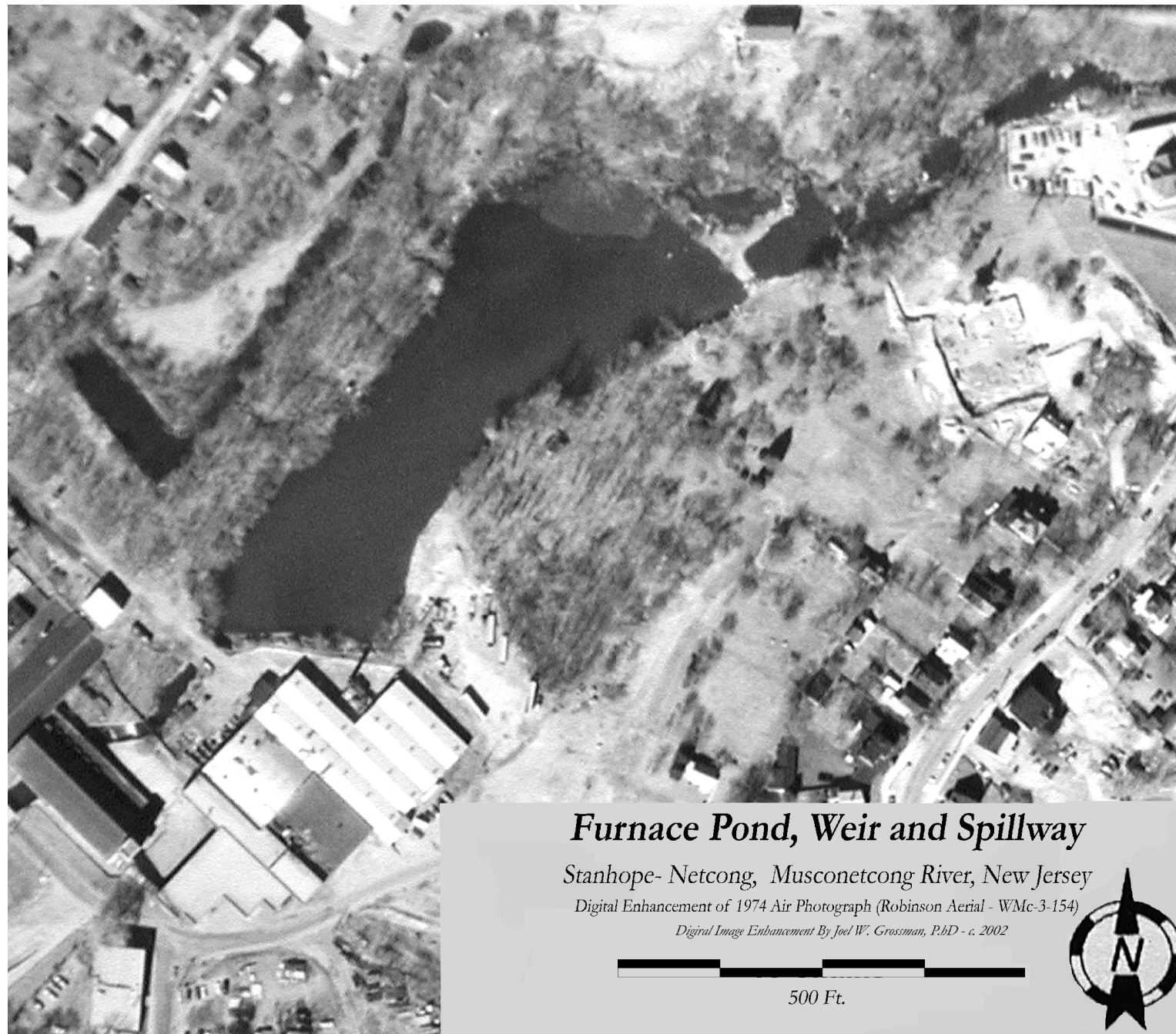


Figure 2. Schematic map illustrating the interconnected and functionally interdependent water supply and power network of the Foundry and Morris Canal system in Stanhope/Netcong (B/W base map courtesy of Canal Society of New Jersey, color and notations added by author).



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



Furnace Pond, Weir and Spillway

Stanhope- Netcong, Musconetcong River, New Jersey

Digital Enhancement of 1974 Air Photograph (Robinson Aerial - WMc-3-154)

Digital Image Enhancement By Joel W. Grassman, P.bD - c. 2002

500 Ft.



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

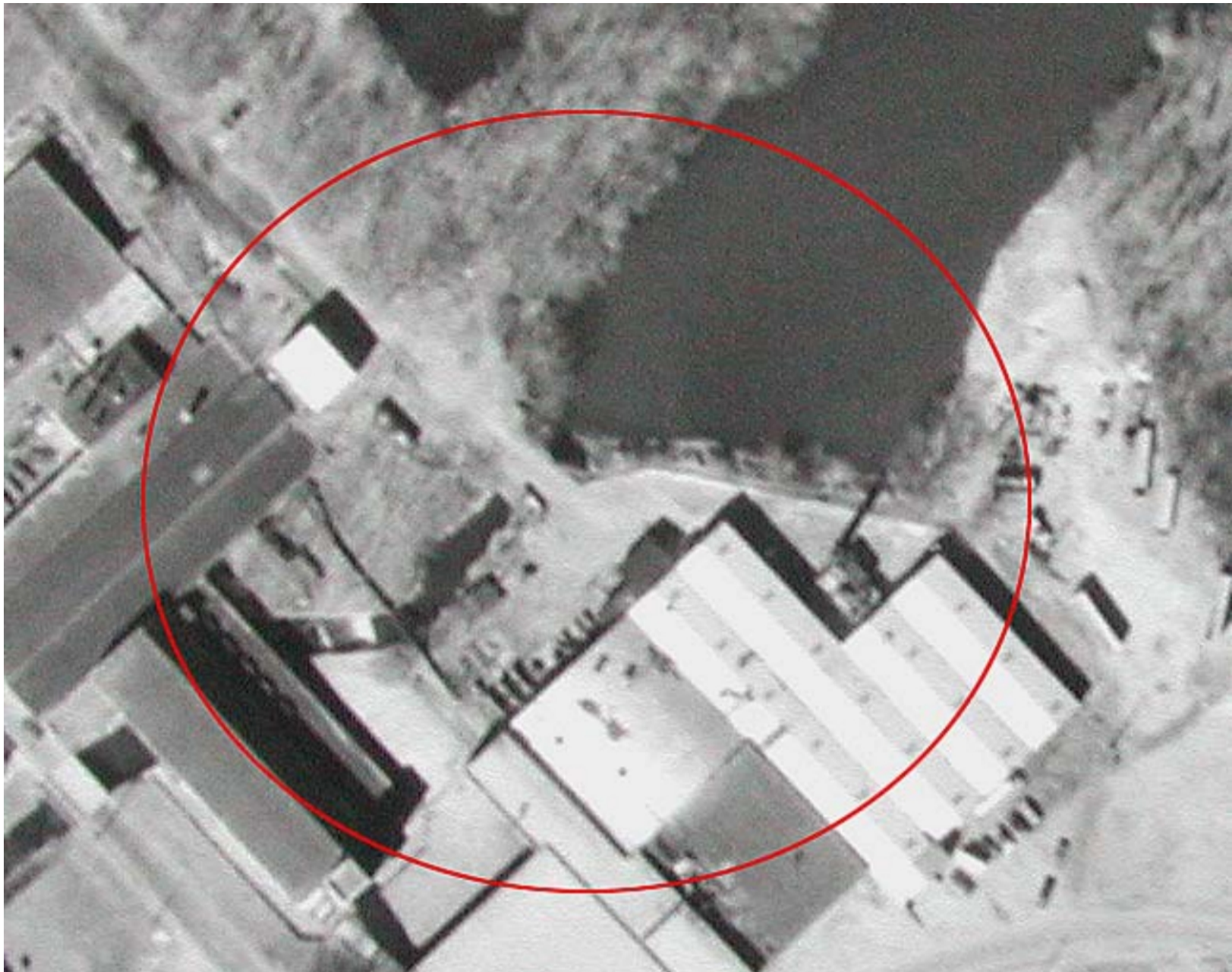


Figure 5 . Detail of 1974 air photo of project area (X 1500%) (Robinson Aerial).

Compac Corporation Archeological Mitigation Furnace Pond Site

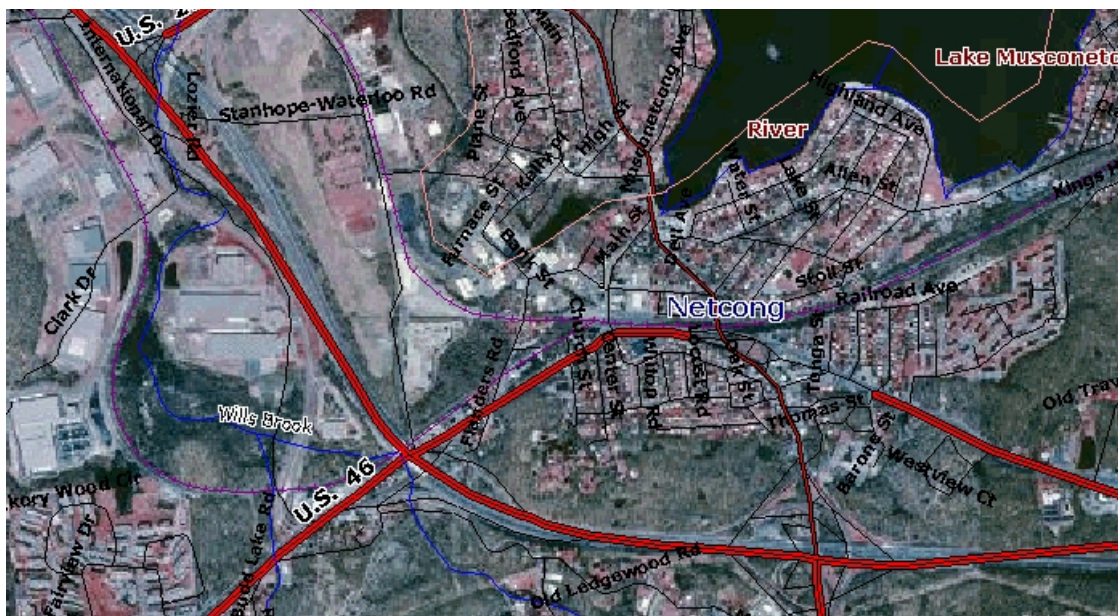


Figure 6 . Computer generated 2D and 3D terrain models derived from radar D.E.M data, draped and surface mapped with the NJDEP infrared orthophotos of the project area (3D GIS surface mapping courtesy of Davis Associates, Inc. 2002) .

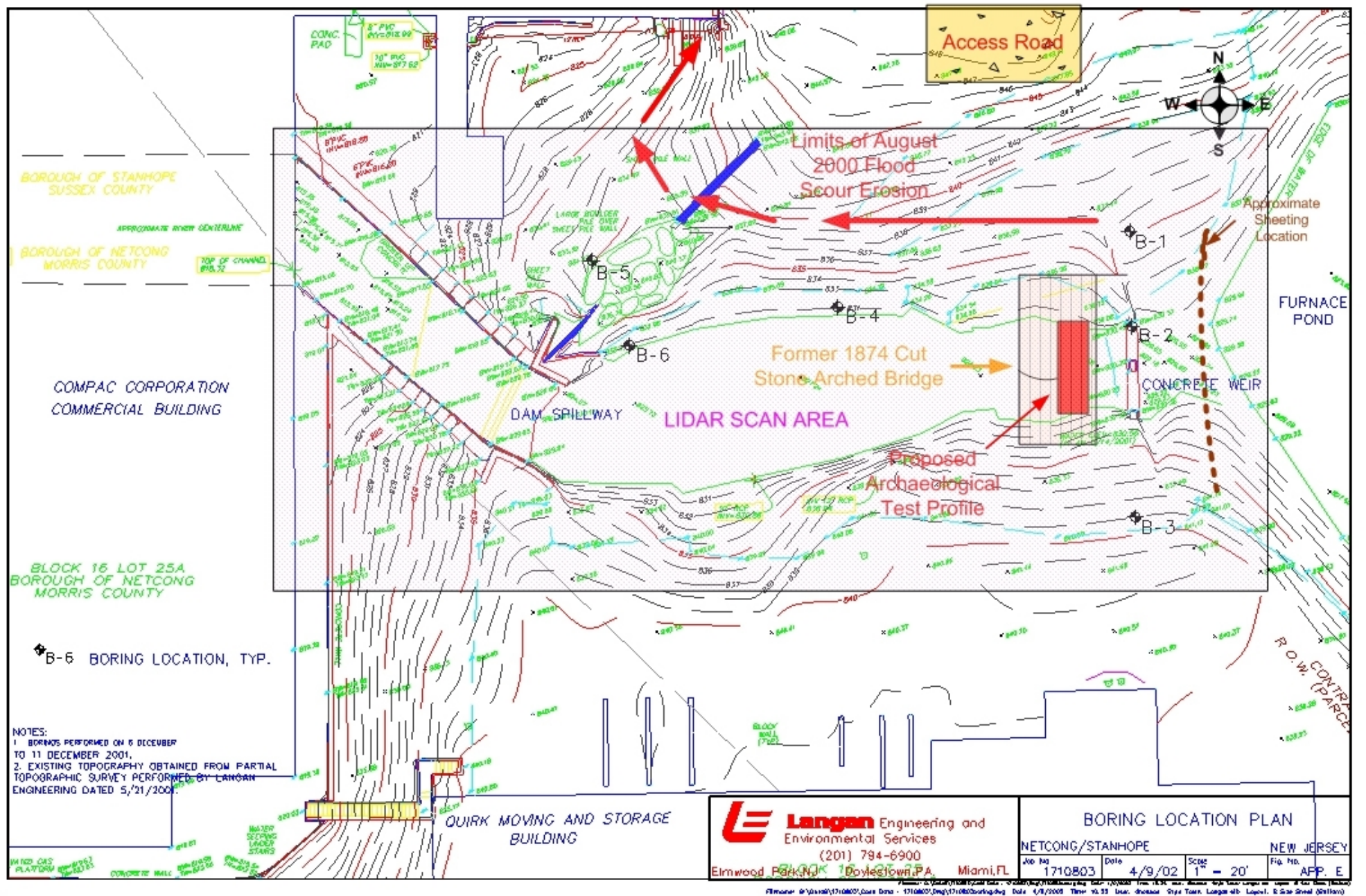


Figure 7. Project Plan of Furnace Pond Falls showing topography, zone of deep flood scour damage, locations of Langan test borings, proposed LIDAR 3D scan area, relocated sheeting plan, proposed N-S archaeological profile cut and former 1874 stone bridge.



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).

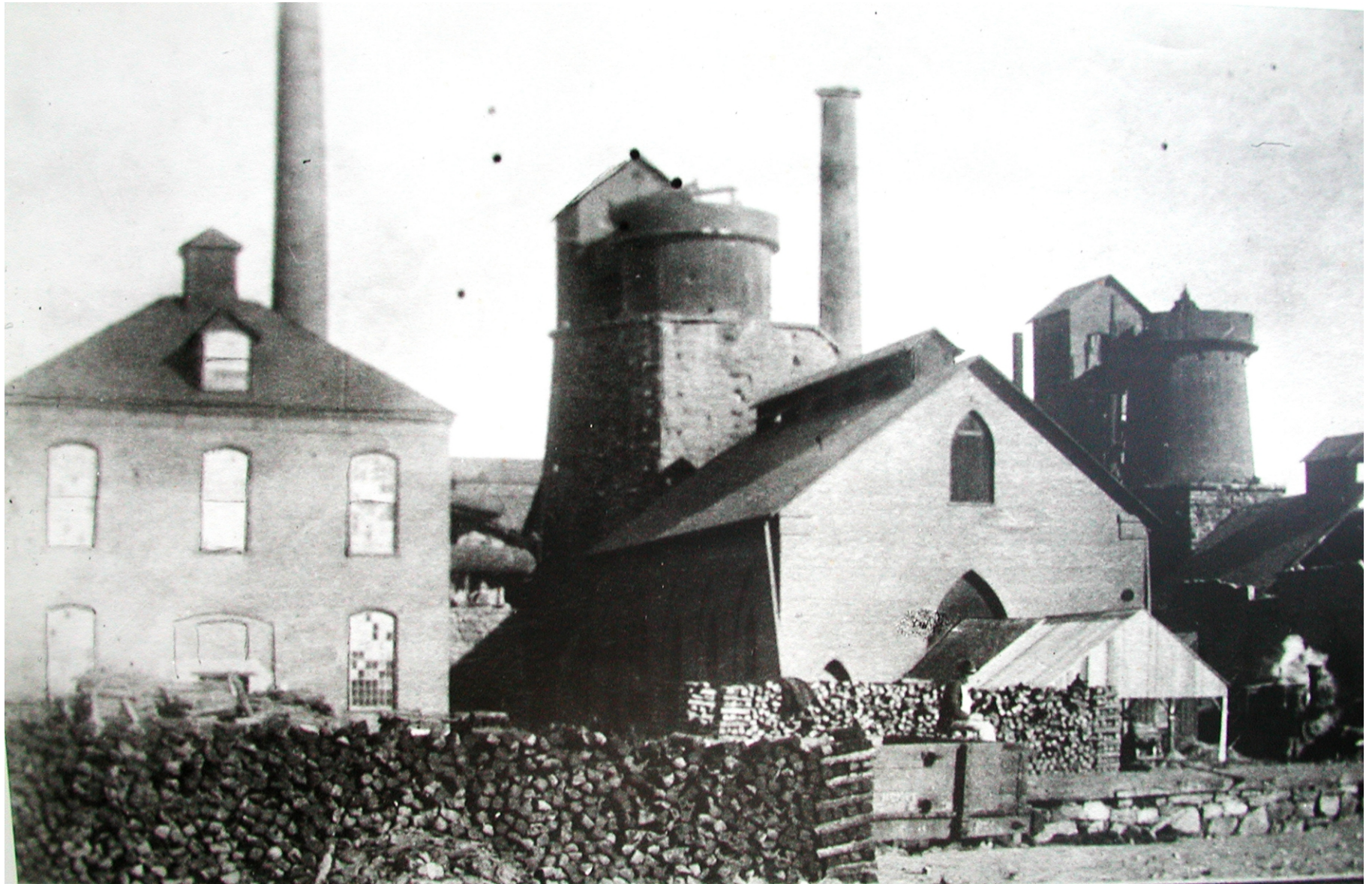


Figure 11. Late 19th to early 20th historic photo of Musconetcong Iron Co., Stanhope, New Jersey, looking south-east from Flanders Road at stands of fuel logs, two casting houses with furnaces and 50 ft. high brick smoke stacks in the rear(*Photo courtesy of the Musconetcong Foundrymen Historical Society*).

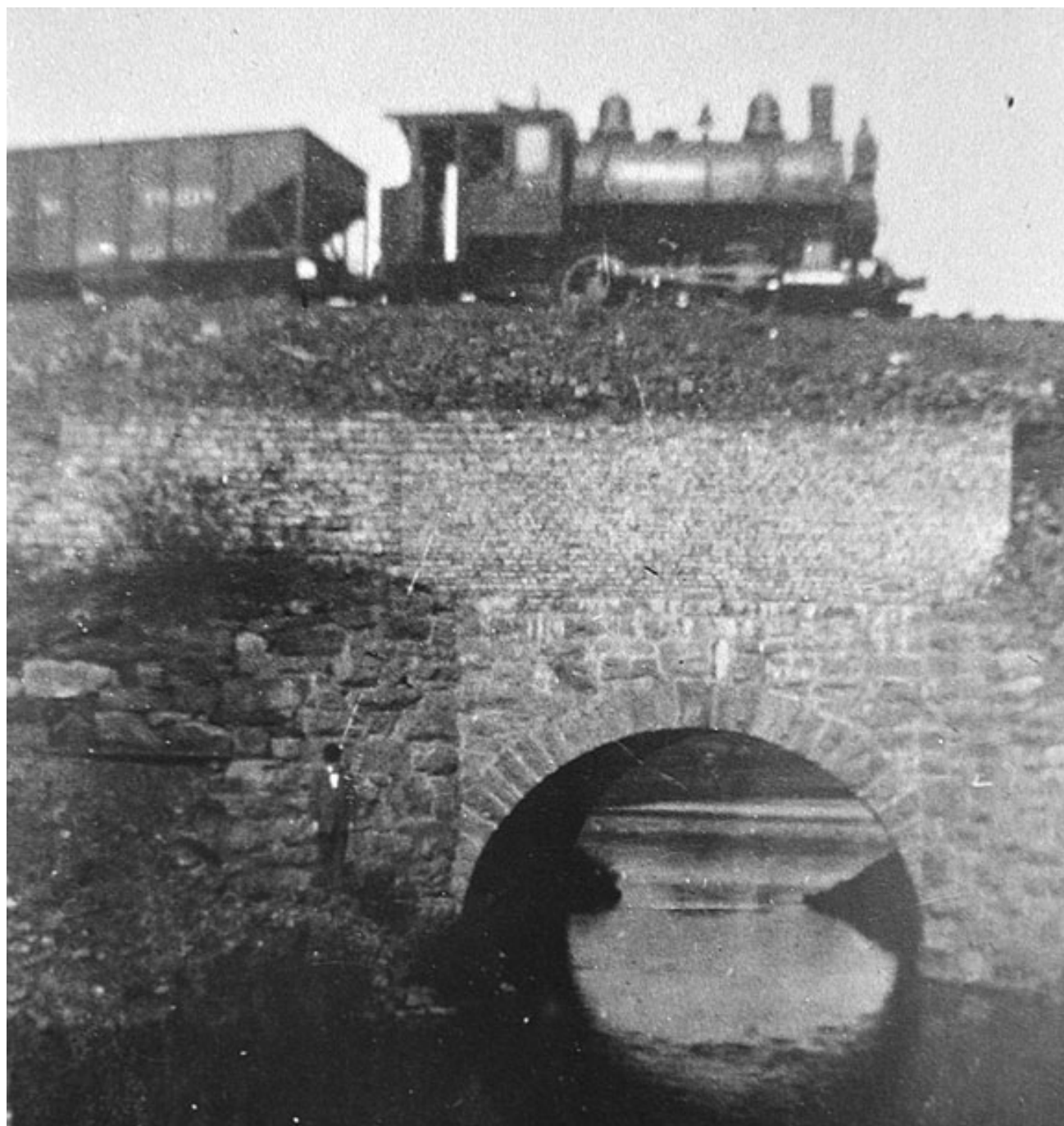


Figure 12. Undated (pre-1927) historic photograph of the former cut stone arched bridge and train trestle at Furnace Pond (*Photo courtesy of Musconetcong Foundrymen Historical Society*)



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.*)

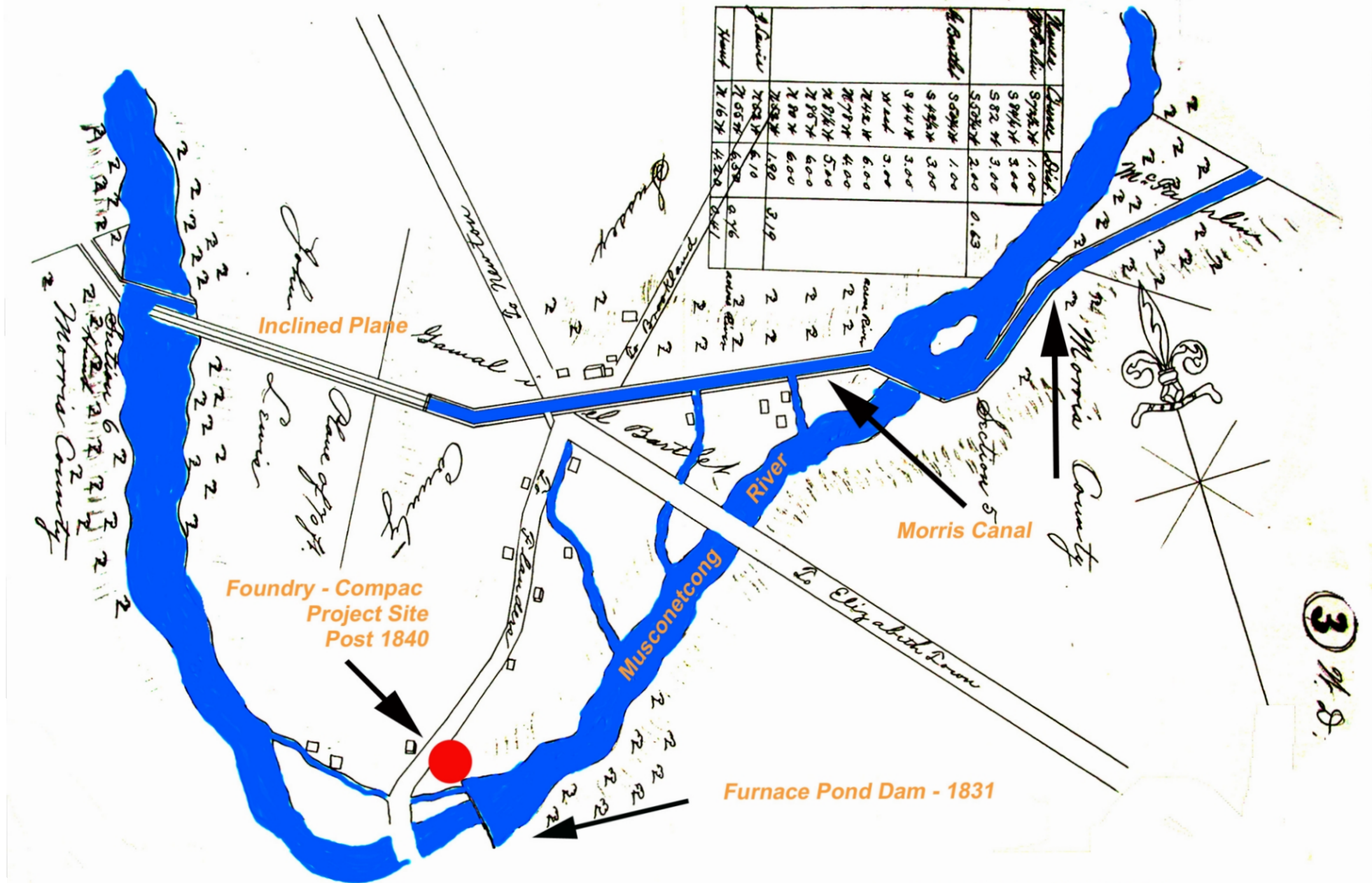


Figure 15. Digital copy of apparently surveyed and scaled 1828 map of the Morris Canal through Stanhope, New Jersey, by Lorenzo A. Sykes, Engineer, titled "Map and Field Notes of the Morris Canal and Banking Co., Stanhope-Western Division", showing Morris Canal and pre-1840's Lower Forge downstream of 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.)

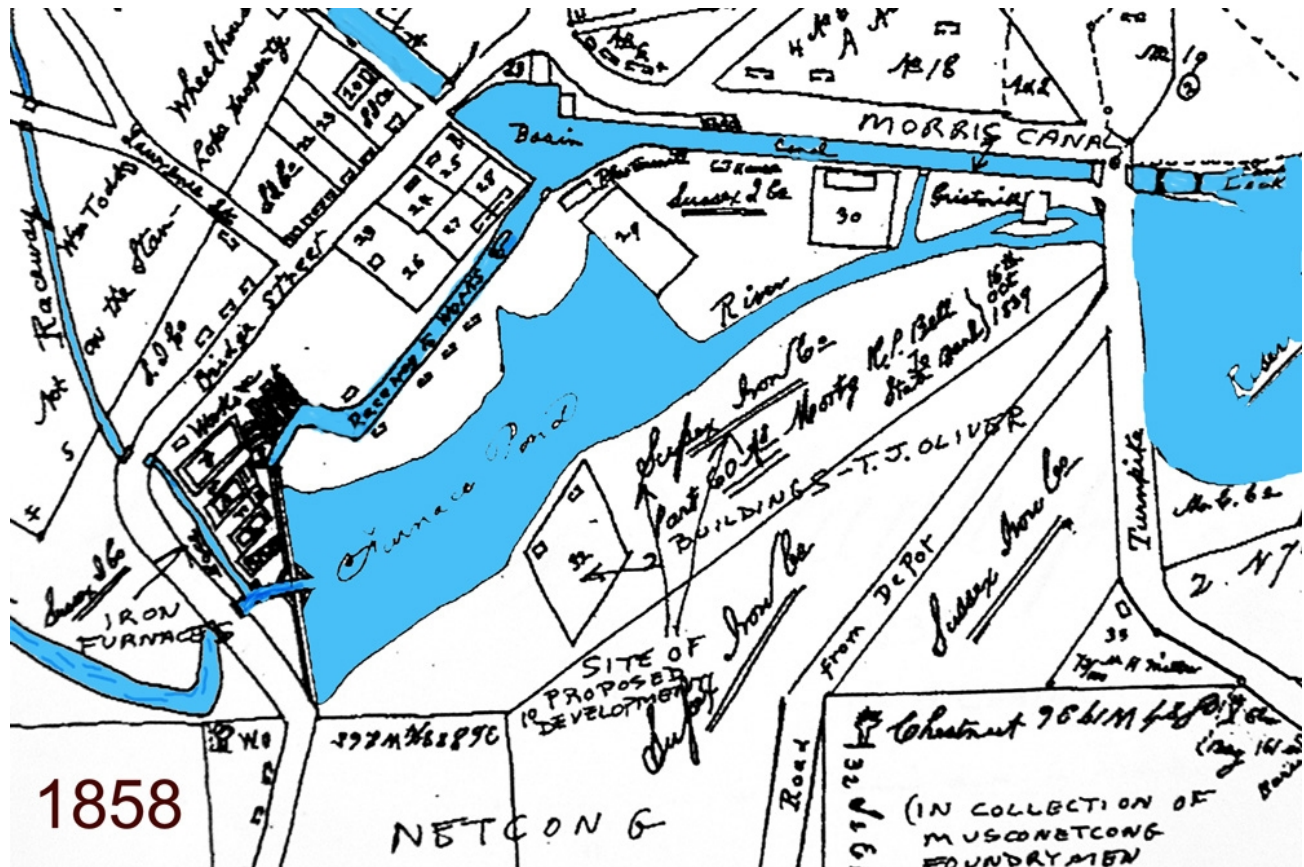


Figure 16. 1858 “Map of Lands Lying in Stanhope, New Jersey and Vicinity” by Benjerman Roome and Son, Surveyors. Showing ca. 400 ft. Dam at Furnace Pond and sluice, or channel, connecting “L” shaped canal spur , or “Raceway to Works”, to blast furnace area of Foundry (Color added by author. Photo courtesy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

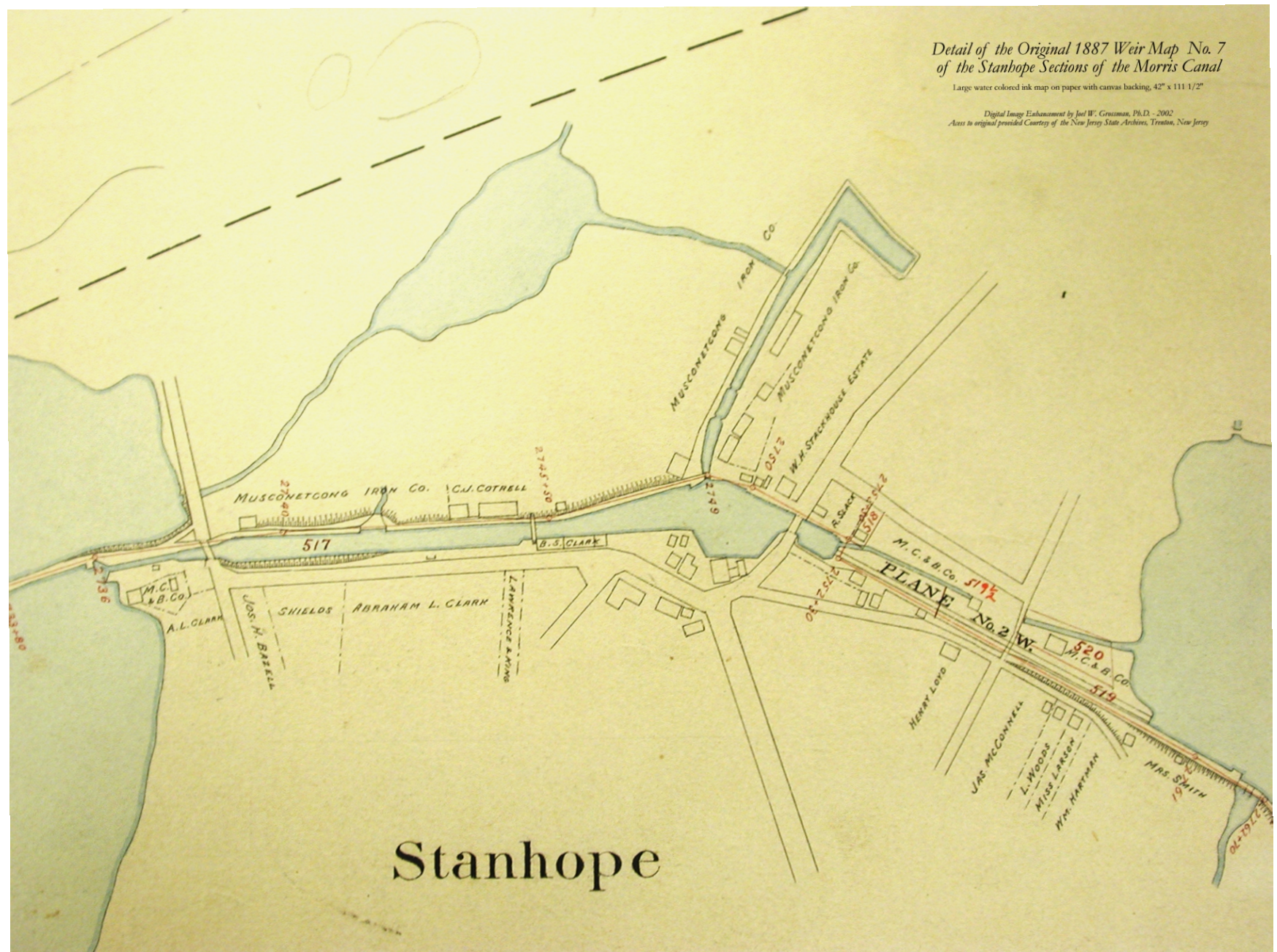


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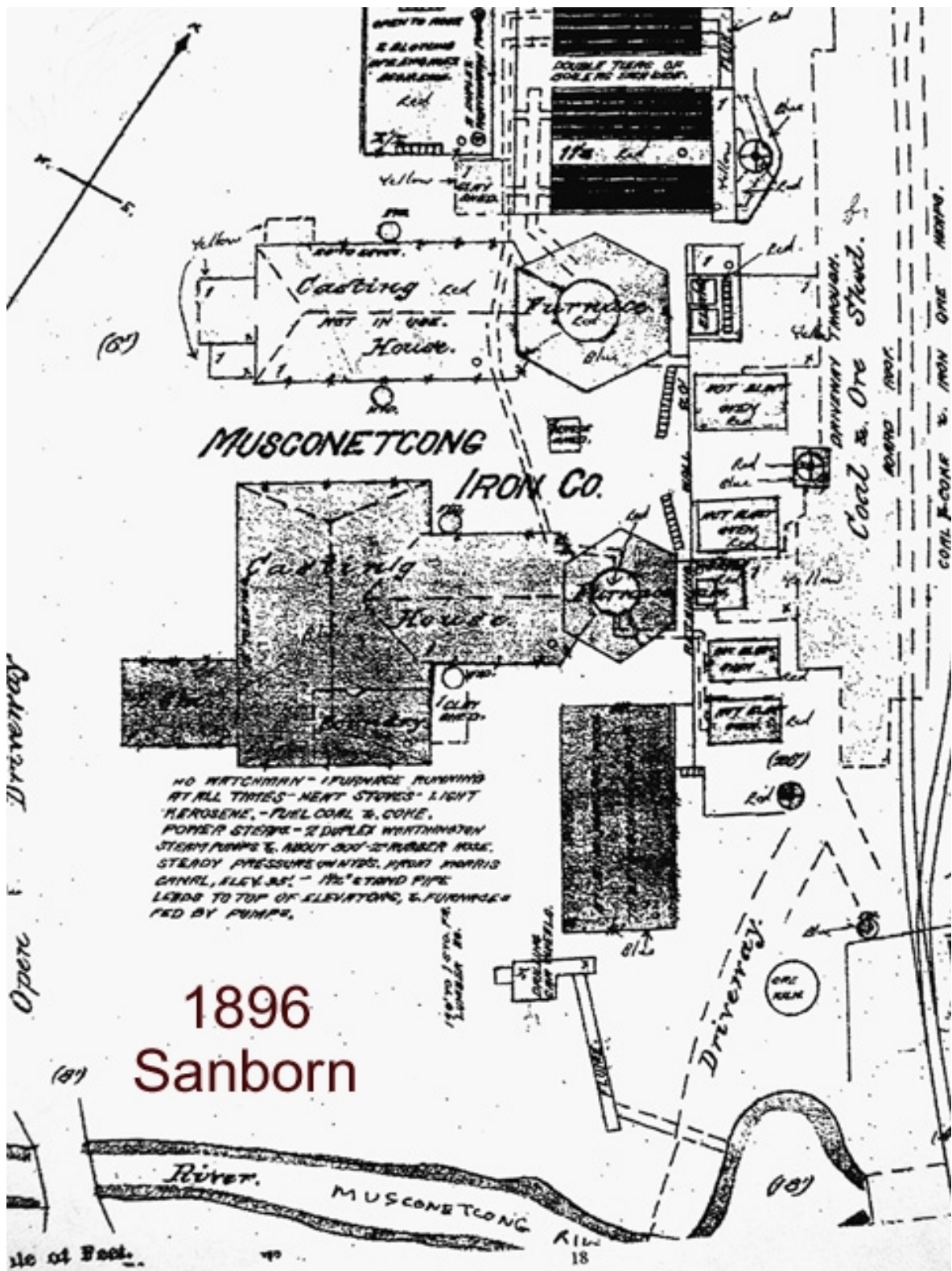


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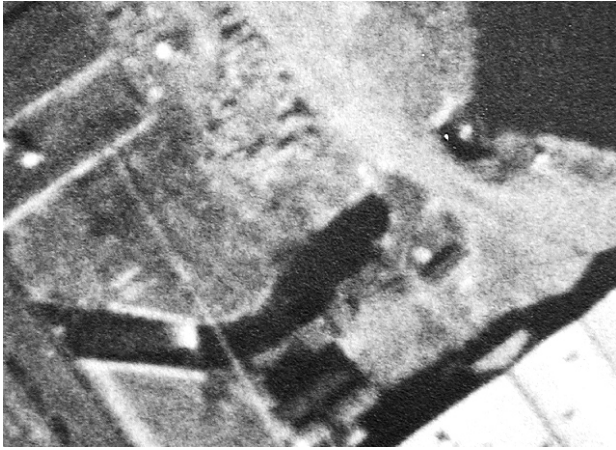
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1959



1974



1986

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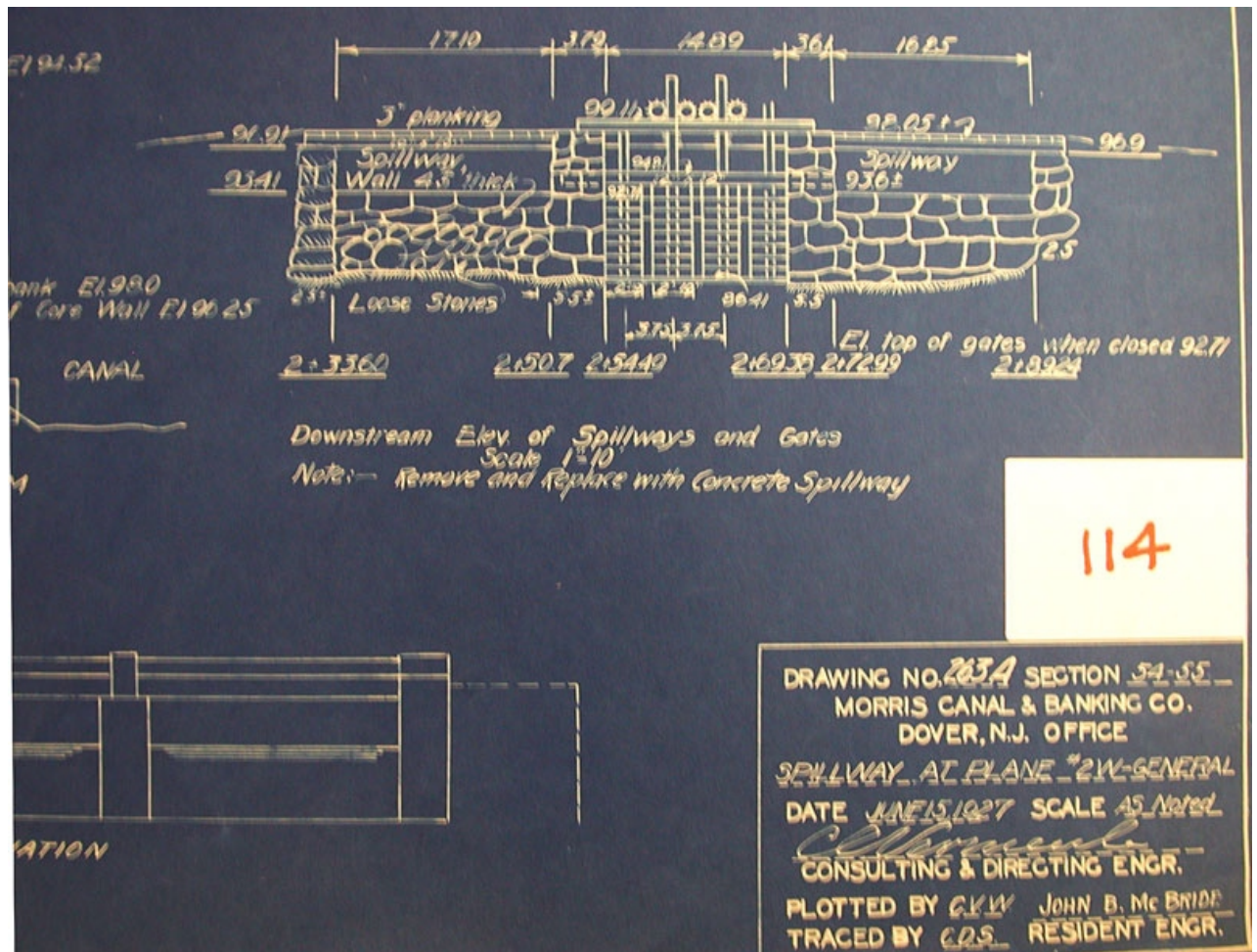


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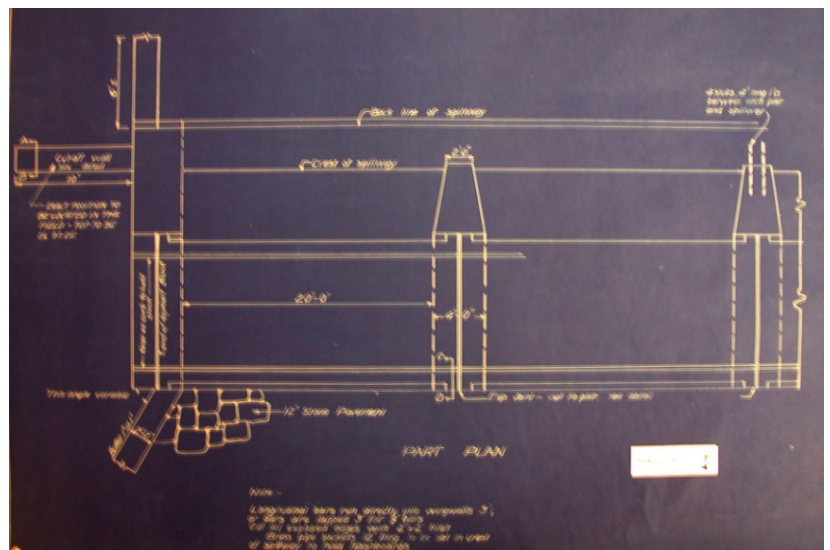
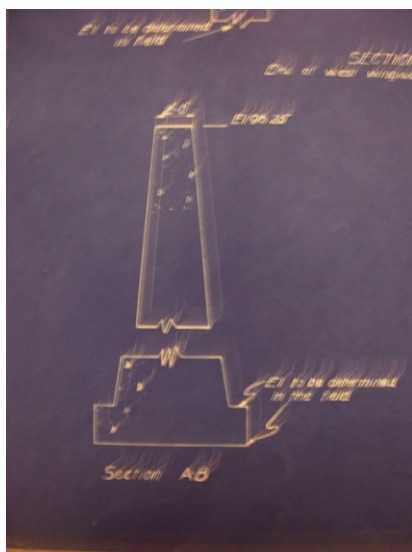


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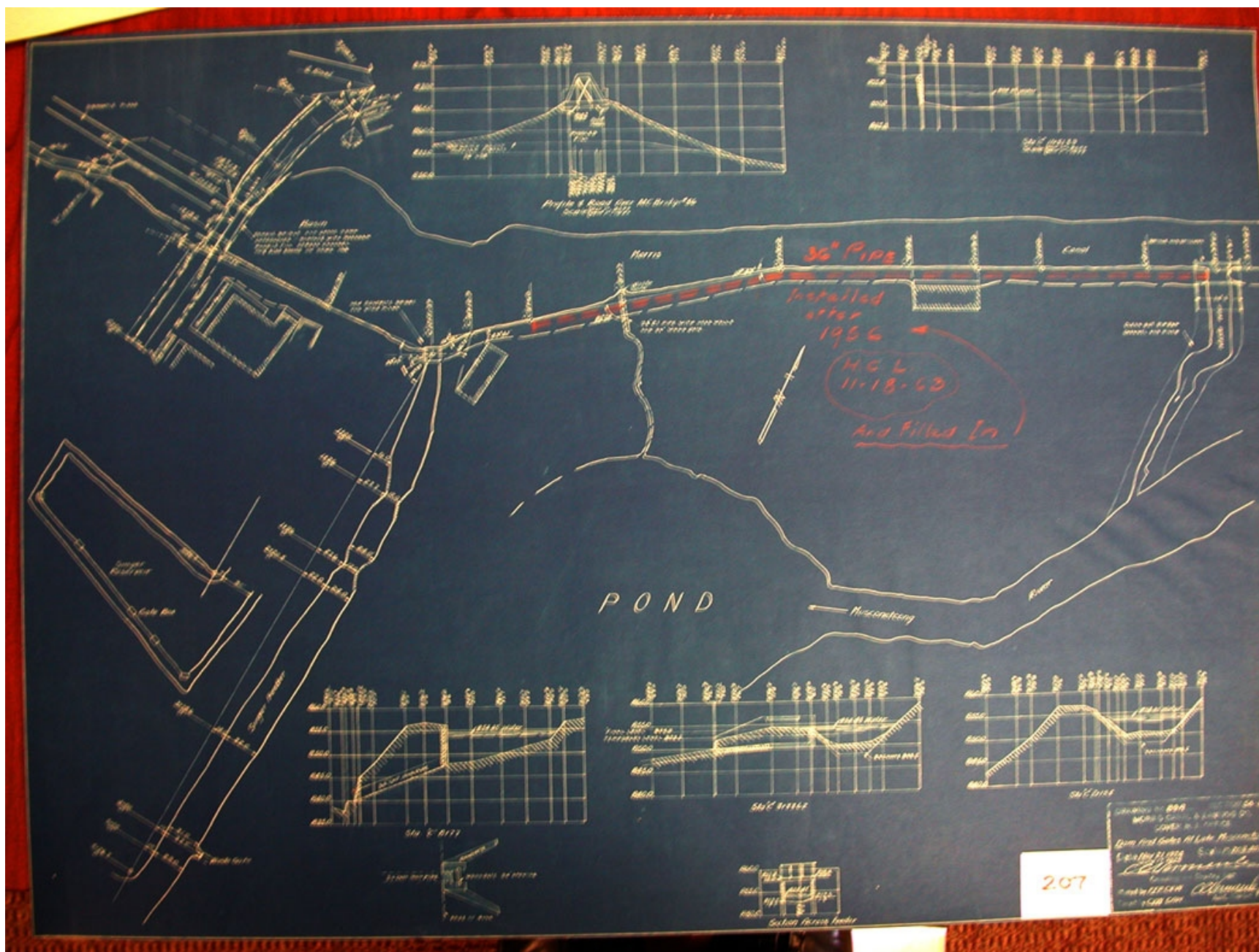


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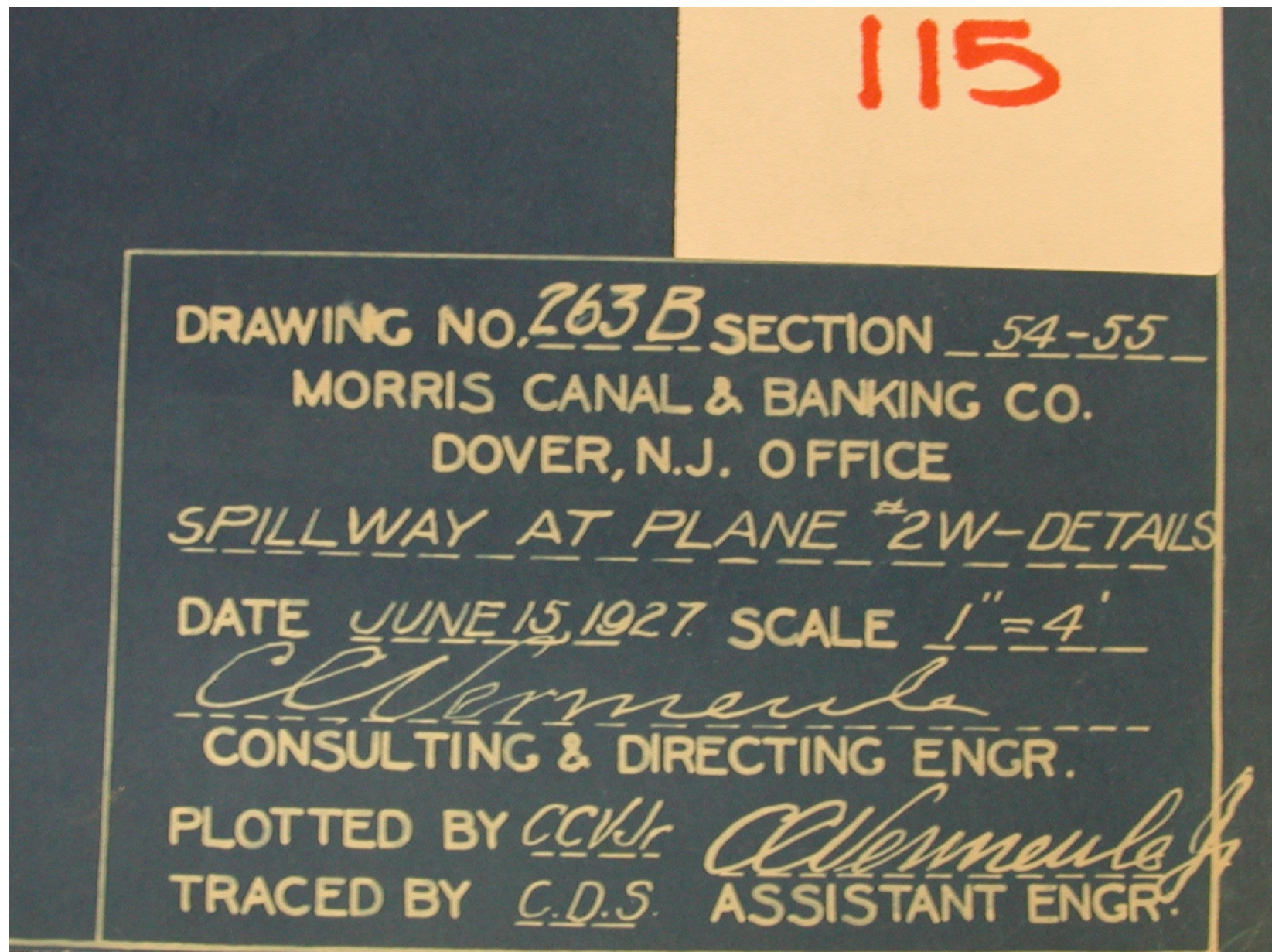
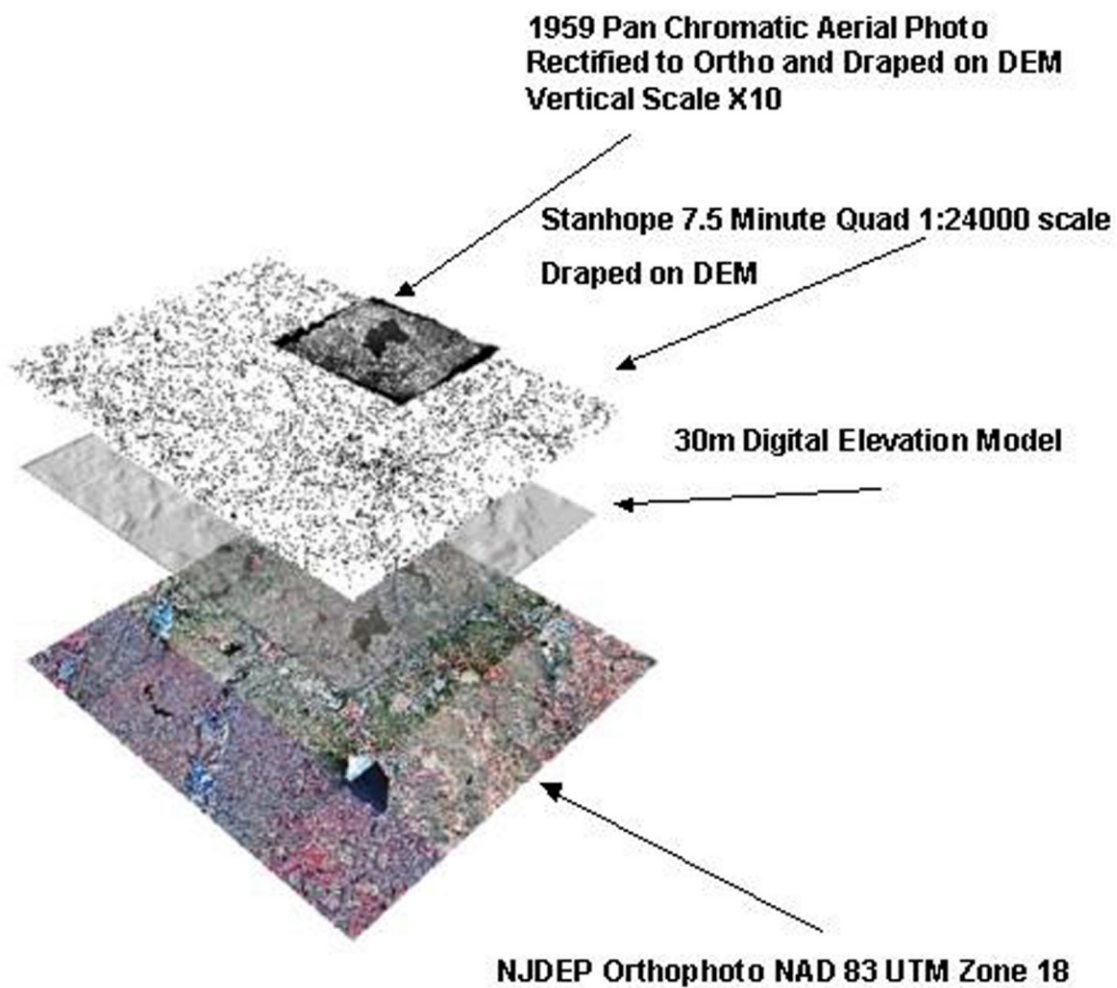


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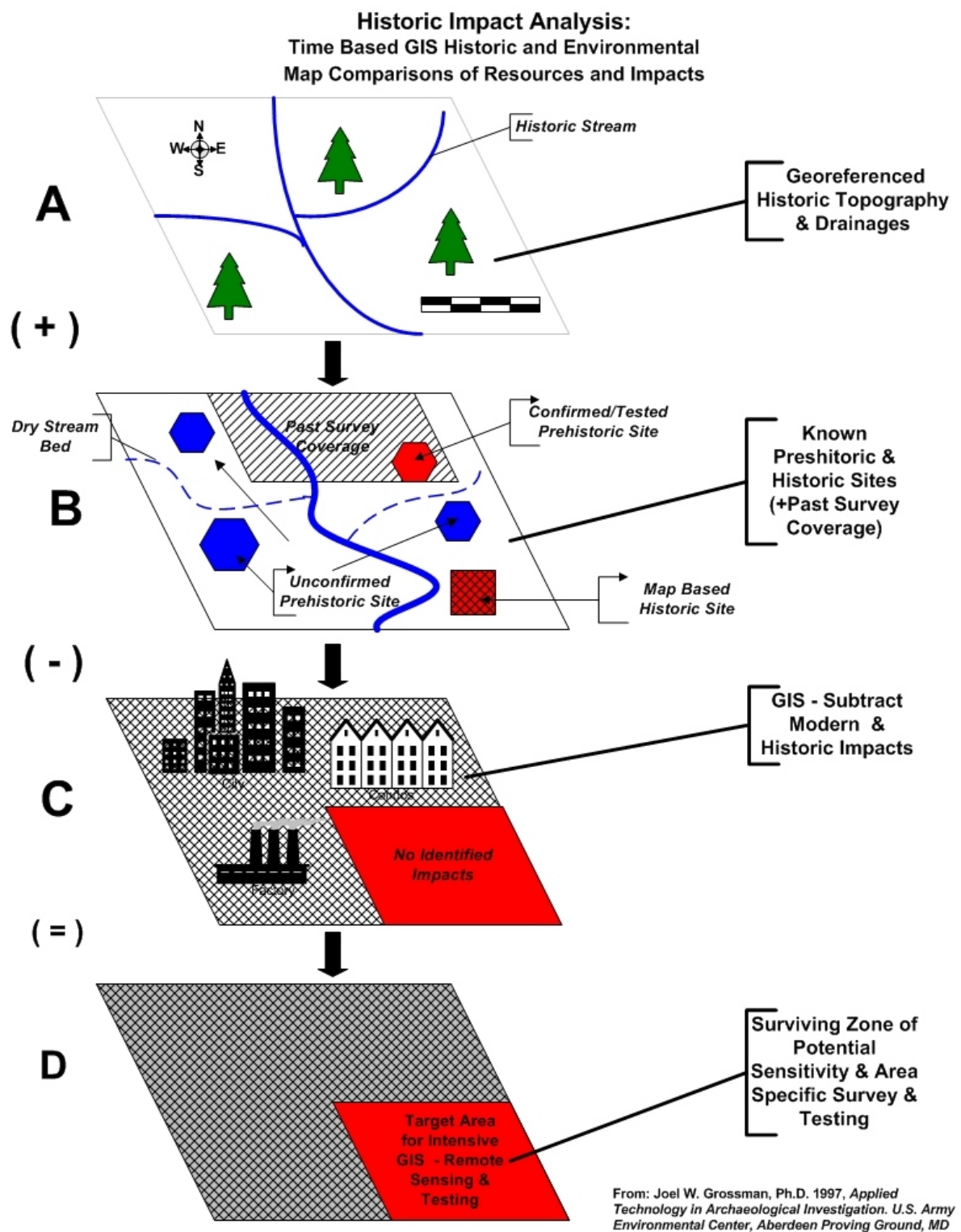
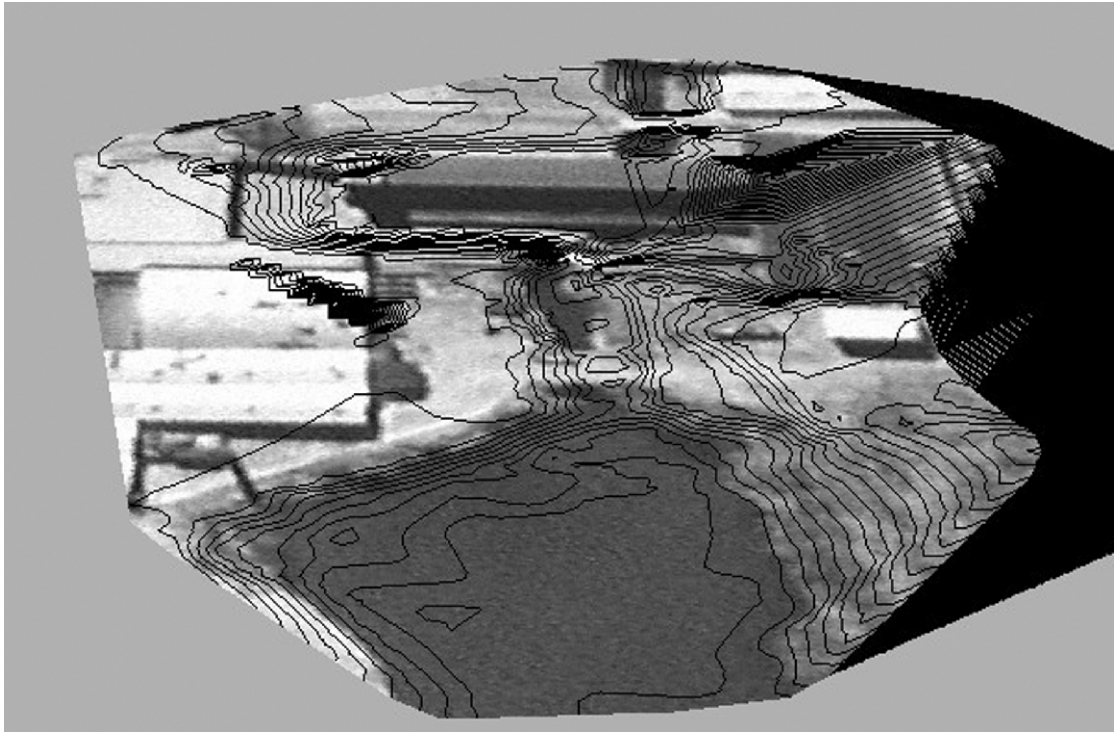


Figure: III - 1

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Furnace Pond-Looking West

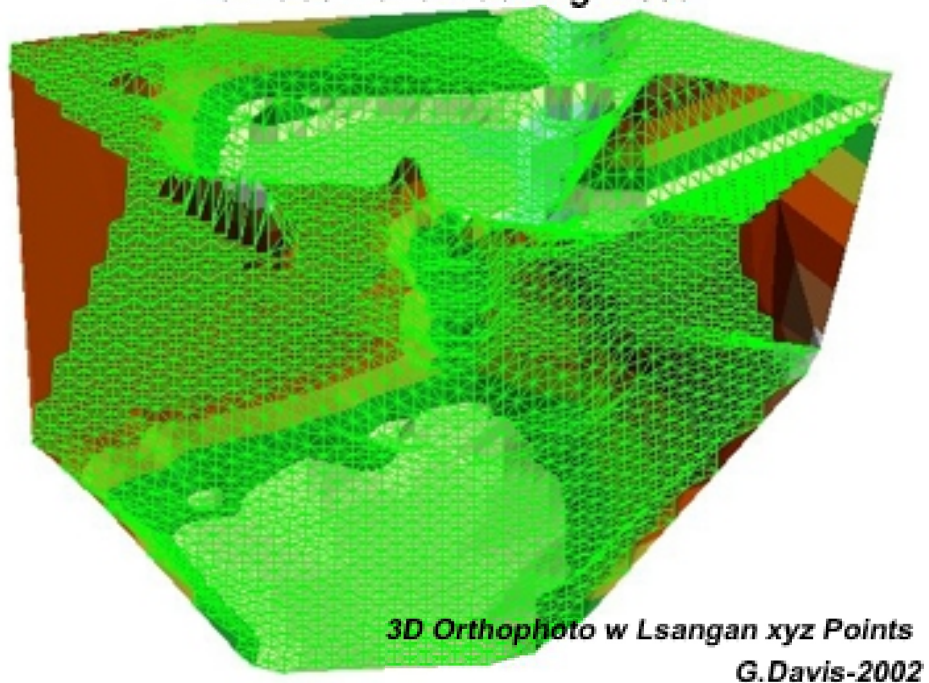


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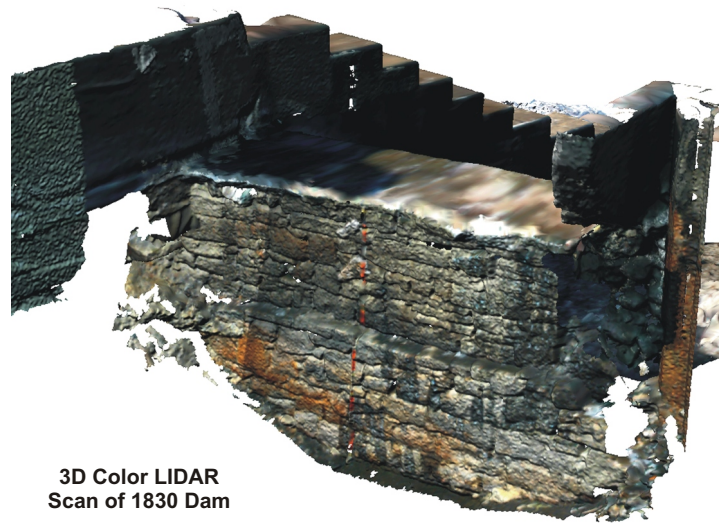
3D True-Color LIDAR of Furnace Falls Dam

Joel W. Grossman, Ph.D.

In the summer of 2000, thousand- year flood levels breached three dams on the Musconetcong River bordering Morris and Sussex Counties in the Highlands of New Jersey. One of the failed dams, at Furnace Falls in Stanhope, New Jersey, caused extensive damage to an 1874 stone bridge and to the main production facility of the modern Compac Corporation. The building spanned the river and had been built on top of the Civil War-era remains of the Musconetcong Iron Works.

The dam and channel complex were hydrologically integrated with and significant as contributing elements to the Morris Canal National Register District. A stone-lined spur from the canal fed a large reservoir behind a massive stone wall, in line with the dam, which supplied water power to drive underground compressors for the foundry's blast furnaces.

Emergency repairs mandated by the New Jersey Department of Environmental Protection for the damaged dam(discovered beneath the 1927 cement spillway) could not proceed until the loss of historic components could be avoided through engineering redesign, or documented through archaeological data recovery to State and Federal standards. A September



**3D Color LIDAR
Scan of 1830 Dam**

Photo By Joel W. Grossman, Ph.D.

2002 sensitivity evaluation and mitigation plan by the author (Grossman 2002) used GIS to define and then avoid potential impacts.

As an alternative to cutting a bypass channel into subsurface components of the associated mid-19th century cannon foundry, the river was diverted overland with six large and environmentally passive siphon pipes. Steel sheet-piling across the channel was moved upriver to avoid historic components of the cut-stone channel. In addition, New Jersey land use, natural resource, and stream encroachment permit restrictions pushed the critical dam repairs into winter (in this case, according to CNN, the coldest since 1977) to protect fish habitats.

The historic dam and channel complex were successfully excavated and documented in harsh winter conditions over two six-day field periods, in late October 2003 and January 2004. The fieldwork was done as a tightly coordinated logistical collaboration between the owner, engineers, contractor and archaeologist, in tandem with, and without delays to, ongoing construction. A range of applied technology was employed to rapidly define and capture a high resolution 3D record of the underwater pre-Civil War site.

GIS was used to scale and overlay historic maps onto modern digital and geo-referenced air photos to pinpoint the location of buried and submerged historic features (Grossman 2003a; 2004-Appendix A). Single-camera, Rolleiometric photogrammetry was used to quickly and remotely capture high precision coordinate information for later data extraction once fieldwork was done. High resolution, satellite-linked, GPS established real time grid control as the site was being exposed. High magnification digital video was applied from safe distances to record inaccessible areas.

As a high speed alternative to complex camera



**360°
Riegl
LIDAR
Scanner &
Rolleimetric
Camera
(Inset)**

The Archaeology of Furnace Falls:

**A Mitigation Report on the Use of GIS, GPS & LIDAR
for the Definition & Documentation of Furnace Falls
Dam, Spillway, Weir & Channel**

**Stanhope/Netcong
Morris & Sussex Counties, New Jersey**



Prepared For:

**Compac Corporation
Netcong, New Jersey**

Prepared By:

**Joel W. Grossman, Ph.D.
New York, New York**

Final Report to NJDEP - June, 2004

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A Mitigation Report on the Use of GIS, GPS and LIDAR for the Definition & Documentation of Furnace Falls Dam, Spillway, Weir & Channel

By

Joel W. Grossman, Ph.D.

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Compac Corporation
Furnace Falls Mitigation

Joel W. Grossman, Ph.D.

ACKNOWLEDGEMENTS

The Field Team

Archaeological Field Director/ PI	Joel W. Grossman, Ph.D.
Assistant Archaeologist	Julio Mendoza

Compac Corporation

Project Manager	Dean DeGhetto
Health & Safety	Earnie Hazelton
Buildings & Grounds	Denis Leger

Langan Engineering and Environmental Services, Inc.

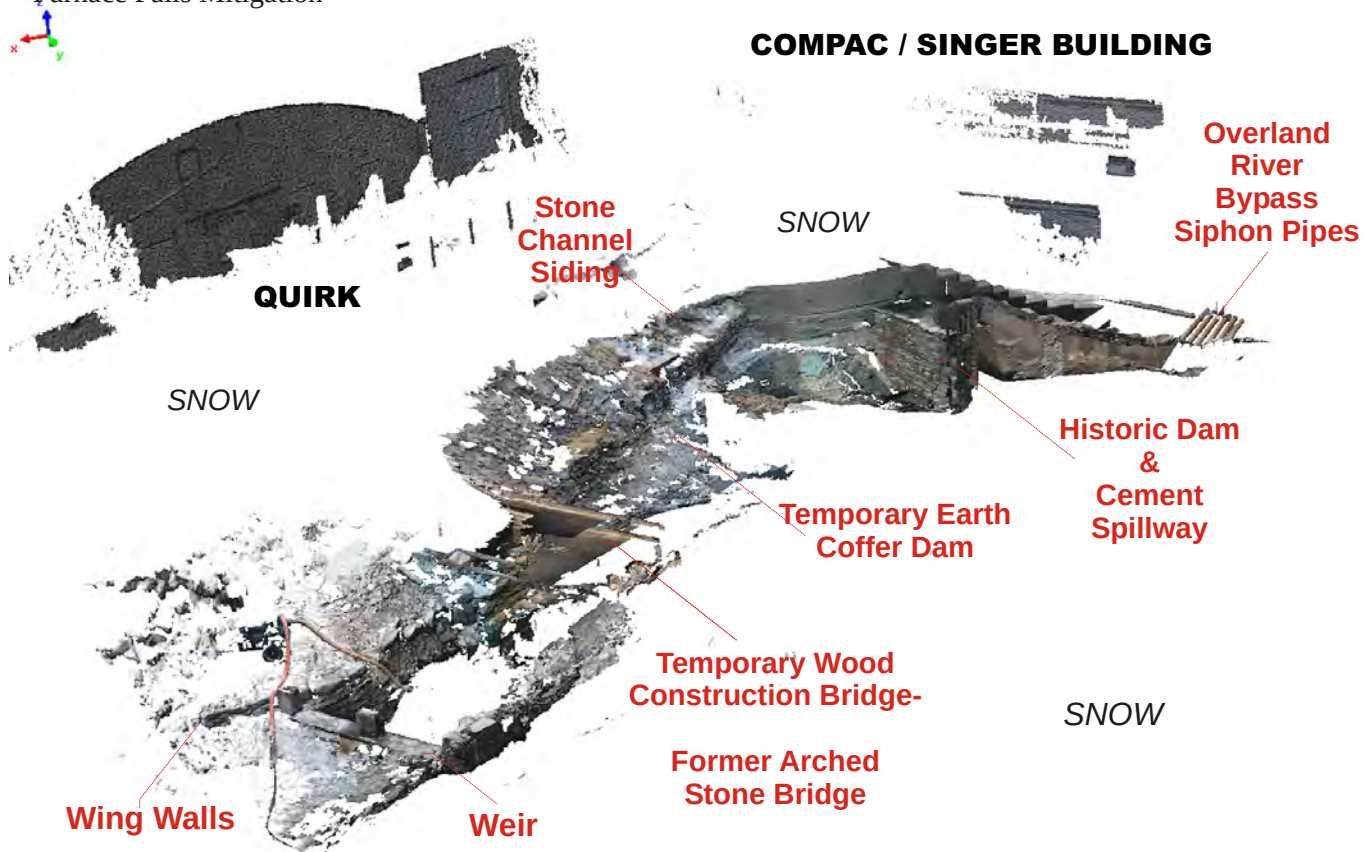
Project Engineer	Donald J. Hodson, P.E.
Field Engineer	Reza Lackpour

Naik Prasad, Inc.

LIDAR-GPS Project Coordination	Willaim Easterbrook, P.E., Vice President
LIDAR-GPS Team Leader	Dave Rupnirin, P.E.
Senior LIDAR-GPS Technician	Bart Tylutki
LIDAR-GPS Technician	Pascal Theodosiadis

Salmon Brothers Construction, Inc.

Project Construction Forman	Jeffrey L. Salmon
Equipment Operators and Staff	Jerre S. Riggs, Jr.
	Timothy F. Salmon
	Elaine Strauss-Feret
	Jetur L. Riggs
	Gretchen A. Hasselberg
	Thomas C. Salmon
	Harry Safreed



The Archaeology of Furnace Falls Synopsis

By
Joel W. Grossman, Ph.D.

This report documents the deep winter rescue excavation of historic remains within the Compac Corporation property at Furnace Falls on the Musconetcong River in Stanhope/Netcong, New Jersey. It was undertaken in January, 2004, with the objective of mitigating the loss of National and State Register eligible archaeological resources during unavoidable repair work.

The modern Compac Corporation facility was built upon top of earlier historic properties. These included the post-1830 to 1840 Musconetcong Iron works as well as the later early 20th century production facilities of the Singer Sewing Machine company.

The earlier Civil War era foundry had been built adjacent to, and hydrologically integrated with, the Morris Canal. Associated historic features visible on the site included a massive cut stone retaining wall, an arched cut stone bridge over the Musconetcong, a feeder spur and reservoir from the Canal to the foundry and ill defined submerged structural features within the river channel.

In the summer of 2000, heavy flooding led to the accumulation of debris against the 1874 stone bridge at Furnace Falls Pond, breaching and destabilizing it as well as an associated 20th century spillway below it leading into the channel beneath the Singer/Compac Corporation building. Emergency repairs were mandated by the New Jersey Department of Environmental Protection (NJDEP). The remains of the cut stone bridge were removed as a health and safety hazard and temporary sheeting installed to prevent further destruction due to flooding.

During this work, it became apparent that the emergency dam remediation could disturb or damage significant historic components associated with the Civil War era foundry. In response to this threat, the NJDEP Office of Historic Preservation mandated that Compac Corporation, as owner of the property, develop a mitigation program. The purpose of this plan was to evaluate and then protect and/or document potentially surviving historic elements within the path of the mandated construction and repair effort.

In April 2002, Compac Corporation retained archaeologist Joel W. Grossman to develop a two-part background sensitivity study and mitigation plan aimed at reducing impacts to the its property, using engineering and redesign to circumvent identified components of the historic complex wherever possible. This plan became the basis for redesign of the planned dam remediation work.

Under the lead of Langan Engineering and Environmental Services, Inc., initially proposed deep trenching through the historic site and steel sheeting operations across the channel were replaced with an overland river bypass system and the movement of the sheeting out of sensitive areas. In addition, the 2002 mitigation plan (Grossman 2002) identified remaining areas subject to unavoidable impacts from the proposed dam and flood control work. These areas were then targeted for staged archaeological investigation and mitigation prior to construction. Finally, formerly buried historic wing walls of the 1874 bridge were defined during construction and protected.

The necessary data recovery mitigation took place in two phases.

The first phase involved the exposure and documentation of two near-surface historic features within the Access Road scheduled to be used for the mobilization and movement of heavy equipment and materials into the site. Phase I was undertaken from October 28 to November 1, 2003.

The second phase was developed to be coordinated with the planned diversion and dewatering of the channel as to provide access to both the construction contractor and the archaeologist. Phase II was completed in six days between January 13 and 29, 2004.

The Phase II field excavation exposed four major historic components of the Furnace Falls complex:

- 19th century remains of the 1874 cut stone bridge
- Preserved elements of the historic stone lined channel
- Early 20th century additions to the original dam and channel as part of the state-mandated closing operations of the Morris Canal and related facilities
- Surviving remains of the original 1830 era Furnace Falls Dam. The early stonework was found buried, submerged and preserved beneath the more recent cement cap on the 20th century Singer Spillway across the Musconetcong.

This report summarizes the procedures and findings of this fieldwork. It also describes the first-time deployment of advanced LIDAR radar scanner technology, together with photogrammetry and traditional survey techniques to provide true color 3D documentation of the affected elements of the historic site complex.

The Archaeology of Furnace Falls:
A Mitigation Report on the Use of GIS, GPS and LIDAR for the Definition &
Documentation of Furnace Falls Dam, Spillway, Weir & Channel

By
Joel W. Grossman, Ph.D.
June, 2004

Introduction

Background and Compliance Context

This Phase II Archaeological Data Recovery study reports the investigation and documentation of all sections of the historic Furnace Falls Pond complex impacted by emergency dam remediation work on Compac Corporation property straddling the Musconetcong River in Stanhope/Netcong, New Jersey.

The archaeological field effort covering the dam, weir, spillway and channel took place in two phases, October/November, 2003, and January, 2004. It implemented the recommendations defined in the Furnace Falls Archaeological Mitigation Plan as adopted by the New Jersey Department of Environmental Protection, Historic Preservation Office (NJDEP-HPO), in September of 2002 (Grossman 2002).

The investigation was prompted by cultural resource stipulations of the New Jersey Land Use Regulation Program which controlled the mandated emergency dam remediation work on the flood damaged Furnace Falls Pond complex.

The challenges posed by deep winter conditions and restricted time frame of the field work were addressed through the deployment of several applied technology solutions, namely, single camera Rollei metric photogrammetry, high resolution GPS datum control receivers and a new generation of true color 3D laser radar hardware and software, LIDAR (Light Detection And Ranging -- see Site Documentation Procedures).

The Mitigation Plan

The 2002 Mitigation Plan consisted of a Phase I background sensitivity evaluation, a GIS-based site definition study of the site's internal structure as well as extent, and recommendations for design alternatives. Its primary goal was to identify, define, evaluate, and, where possible, mitigate any impacts with avoidance through redesign versus excavation. Mitigation through archaeological data recovery was recommended only where avoidance through redesign was not possible.

Undertaken between April and September of 2002, the background study focused of the historical and geographic context of the site and its National and State Register eligibility status.

The initial investigation used both traditional archival and map sources, advanced air photo map and image processing as well as GIS (Geographic Information Systems) to scale and overlay digital copies of historic maps over geo-referenced low level air photo coverage to identify and target the location of potentially sensitive archaeological remains (Figures 8 & 9, Phase I - End of Field letter, p. 3 – see Appendix I).

Scaled reconstructions of historic maps documented that the Furnace Falls dam complex was built as a critical component of the Musconetcong Iron Works (Figure 5). It also showed that its water control and power system was tightly integrated with the hydrology of the Morris Canal and its feeder canal into the foundry (Figures 2, 3 & 4). The GIS historic map analysis served as a planning tool to provide sufficient definition to permit mitigation of potential impacts through redesign and avoidance and target areas of subsurface sensitivity for archaeological documentation.

The final protocol incorporated two major redesign changes to preliminary design concepts, avoiding the potential for additional major impacts to the site from the planned dam remediation work. These design alternatives were developed as an engineering and archaeological collaboration initially between the project engineers, Langan Engineering and Environmental Services, and Joel W. Grossman, Ph.D., the project archaeologist. During fieldwork, these efforts were continued together with the project contractor, Salmon Brothers Construction, so as to address any last-minute discoveries in the field.

The initial engineering plan had proposed to drive a wall of steel sheeting across and through the former cut-stone channel. This component of the construction was redesigned to be moved to the east, closer to Furnace Pond, to avoid impacting the historic former bridge abutment or elements of the cut-stone channel (Figures 39 & 40). The second major design change involved the need to divert the river for construction purposes as well as the archaeological investigation. The initial concept called for a deep open trench to be cut through the north bank to divert the river. The background sensitivity study showed that earth moving and trenching would potentially impact historic resources eligible for the National Register, specifically the Furnace Falls dam.

The prospect of major impacts and costly archaeological fieldwork prompted the Langan Engineering design team to abandon the idea of subsurface trenching. Instead, the team proposed to divert the Musconetcong River overland with heavy pumps or by whatever means the selected contractor suggested. In the end, Salmon Brothers Construction developed an elaborate but passive overland siphoning system that was silent, required no fuel or maintenance and proved capable of both diverting and then lowering the river to provide the archaeologists and construction teams with an access to the channel (Figure 12).

The archaeological investigation of unavoidable impact areas was divided into two phases defined by the interdependence of dewatering, construction and data recovery tasks and scheduling.

Phase I addressed impacts to near surface features within the Access Road leading into the site from Furnace Street. This initial fieldwork was followed by a hiatus of two months to give the contractor time to build and activate the overland river bypass system.

Phase II mitigated unavoidable impacts to the historic channel, surviving bridge abutments and what ultimately emerged as the remains of the original post-1830 dry laid cut-stone dam of Furnace Falls.

Phase I - The Access Road Mitigation

The investigation of the access road impact corridor was undertaken over five days from Tuesday, October 28, to Saturday, November 1, 2003. The GIS-based 2002

background sensitivity study identified the presence of historic near-surface features in the impact corridor of the proposed access road and recommended investigation before the contractor could use the dirt road for heavy equipment and material. The scaled comparison of historic 19th century maps with digitized and geo-referenced air photo coverage targeted two 19th century foundry-related features (see Grossman, 2003 - Appendix I: Phase I - End of Field Letter, p. 4).

One of these, designated Feature 3, was represented by one half of the base of a circular brick chimney 15 ft. wide by 125 ft. high and formally connected to one of the foundry blast furnaces (Figure 5). The second, Feature 2, was a near surface rectangular mortared stone base or foundation related to a second foundry furnace (see Grossman, 2003 – Appendix I: Phase I - End of Field Letter, p. 5).

The coordinates of the two features within the roadway were extracted with GIS software and then measured off on the ground. The blast furnace chimney base was found within 5 ft. of its projected location, the mortared rectangular stone foundation precisely where projected.

Both were exposed and recorded in plan and profile to 1/100th ft. precision with an electronic total station, or computer transit survey instrument, and with single-camera Rollei metric photogrammetry. Satellite and air photo projection and rectification software was used to assign and imprint State Plane coordinates into each image and then stretch, or “rubber sheet,” them from a perspective view into “overhead” geo-referenced planer views of each feature, reprojected to match their measured coordinate locations and dimensions (See Phase I - End of Field Letter, Grossman, 2003, see Appendix I).

Phase II - The Channel Mitigation

The second phase of the multi-staged mitigation effort, focus of this report, concentrated on the excavation and exposure of unavoidable impacts to surviving historic elements of the channel and spillway. It took place in January, 2004.

After the redesign changes were incorporated to avoid broader archaeological impacts, the final impact corridor measured 180 ft. long by 30-50 ft. wide, stretching out between the eastern wing walls of the former bridge abutment and the lower western end

of the cement-covered spillway.

The original Mitigation Plan had called for the documentation of a single profile trench across the eastern end of the channel in the vicinity of the former 1874 cut-stone bridge and for the evaluation and documentation of the depth and structure of the channel. The resultant mitigation strategy was to be integrated with a winter construction schedule and synchronized to begin as soon as the contractor was able to bypass and stem the normal river flow with his overland siphon pipes bypass system. Once accomplished, the archaeologists were to be provided a one week window to expose and record historic elements of the dewatered channel.

The conditions and constraints were clear cut. After the access road was cleared (November 1, 2003,) the contractor had to prepare the site for heavy equipment access, build and activate the overland bypass system, divert and control the river and then lower it through dewatering.

Assuming the water could not be controlled or sufficiently lowered for more than a week, if at all, the archaeology would have to be done within a week as well. It was projected that the archaeological exposure and definition of the historic channel components (weir, dam and channel) would take at least three, possibly four days. That left one to two days to gain grid control as well as to record and document the site.

Normally time-consuming field tasks in this case would have to be accomplished within a narrow one-week window. From the perspective of the archaeological Principal Investigator, the solution not only had to be fast, but it also had to be in true color to be acceptable.

The only technology with the promise of possibly meeting this schedule with the coverage and precision to capture the entire site in mm-precise 3D color was the newest generation of LIDAR (Light Detection And Ranging, often referred to as a Laser Imaging Sensor). LIDAR scanners capable of measuring thousands of points per second over hundreds of yards with a precision of 6 mm (ca. 1/100th ft.) had been on the market since 1998. The added capability of 3D color, however, became available only in the summer of 2003.

At the onset of this project, there was only one such hardware and software system available on the market meeting these specifications. That was the recently released 3D Laser Imaging Sensor LMS-Z360i by Riegl Laser Measurement Systems from Austria.

Of all the LIDAR systems available in North America and Europe, this was the only one with an integrated digital camera capable of matching digital color, pixel by pixel, to each coordinate point. This would not only be its first test in archaeology, but according to its vendor, also its coldest.

The new system proved capable, indeed, of addressing the constraints of this deep winter field work. The discovery of the preserved eastern half of the post-1830 cut-stone face of Furnace Falls dam under the cement cap of the Singer spillway during the work shifted the logistics of the investigation to include the full exposure and documentation of the structure, but did not affect or extend the field schedule. Even though a winter storm added an extra day, the site was dewatered, exposed and defined over four discontinuous field days, and then recorded in 3D color to ca. 1/100th ft. precision in six hours on the fifth day of fieldwork (Table I).

As a final task of the mitigation component, and after a week of heavy-equipment demolition in which the contractor had removed the most recent cement wing walls bordering the spillway, the PI returned to the site on January 29th to cross-section and then record the internal construction of the dam's accessible southern end with high resolution digital macro and Rolleimetric medium format 120 mm film images.

Summary of Results

All mandated data recovery tasks were completed as scoped. Both the dam and the associated later cement spillway addition were recorded with 3D color integrated LIDAR, single camera photogrammetry and with high resolution (5.5 mega pixel) macro digital photography and digital video.

The data recovery and mitigation effort provided new information on four major components of the Pre-Civil War Furnace Falls and Musconetcong Iron Works complex.

The Weir: The cement weir with its three vertical grooved cement pods, extending up from the center and ends of a horizontal cement slab at elevation 830+ ft., was a post-1927 addition to the original cut-stone channel and bridge built in 1874 (Grossman 2002). Cutting the 10 ft. wide trench across the width of the channel revealed that the weir was of fragile and insubstantial construction that varied significantly from what had been proposed in Vermeule's 1927 "Canal Closing" blueprints (Figure 41 & 42).



The Channel Wing Walls: The archaeological exposure revealed that the original open, funnel-shaped cut-stone wing walls of the 1874 bridge abutment, or entranceway into the channel from Furnace Pond, had survived. They emerged from the frozen fill and snow as well-preserved multi-course extensions of the stone channel. Both wing walls measured between 9 and 10 ft. from top to bottom, along both sides of the channel. The cut-stone wing walls were preserved in place during construction as well.



These open, funnel-shaped wing walls at the opening of the channel were mirrored by duplicate wing walls on both the east and west sides of the formerly existing 1874 arched stone bridge. Both sides of the eastern opening of the channel were documented with LIDAR, Rolleimetric photogrammetry and high resolution digital cameras.

The Channel: The machine-assisted exposure of the entire southern embankment and three deep profile exposures -- at the east, central and western ends of the channel -- documented at least two forms of coursing -- shallow and deep -- as well as the absolute depth and structure of the southern channel embankment. The entire southern embankment was exposed and



recorded with LIDAR and photogrammetry throughout its length, from the weir to the Singer spillway, and then documented with three vertical profile sections to record the structural diversity of the coursing and stonework. No structural elements were exposed or documented on the north side of the channel west of the temporary construction bridge.

The bottom of the channel was demarcated, at its eastern end near the Weir, by the exposure of smooth, debarked logs, between $\frac{3}{4}$ and 1 ft. in diameter, as footers, or spreaders, under the cut-stone wing walls (Figure 35). The expectation that wooden footers may be present at Furnace Falls was based on the prior demonstration of similar structural elements at the bottom of exposed section of the Morris Canal in Warren County by Brian Morrell 20 years before (Morrell, 1983).

These logs, possibly cedar, were aligned with the long east west axis of the channel and set at elevation 824.5 ft., or between 5.5 and 6 ft. below the top of the post-1927 cement slab weir (830 ft. el.).

The Original Pre-Civil War Cut-Stone Dam:

The dewatering and bypass of the river between the Furnace Pond and the inlet channel under the Singer building revealed the unexpected survival of



the eastern - upriver - face of the original cut-stone dam. When laid dry, the cut-stone dam was proven to originally have been at least 16 ft. tall. It was built as a rectangular structure in plan, expanding into a sloped and inverted flat-topped pyramid shape with a 1 ft. wide step, or short terrace, at 5.5 ft. below the top of the stone dam, or ca. 6 ft. below the later 3 to 5 inch thick cement cap that covered it. The dam may possibly pre-date the 1830–1840 initial construction phase of the Musconetcong Iron Works. It was depicted on the 1828 Sykes map (Figure 2). The foundry and the associated massive 16 ft. high stone retaining wall that redefined the local topography of the historic complex appear to have been built contemporary with additions and expansions of the original Morris Canal around 1840 (Grossman, 2002).

As discussed below, the dam and the foundry retaining wall showed similar

material and workmanship which contrasted in color and source material (reddish-tan sedimentary stones -- Figure 28 b, c & d) with the gray, metamorphic stone (Figure 35 & 36) used in 1874 for both the arched cut-stone bridge and associated channel and wing wall elements.

The discovery of the stepped, truncated form of the stone dam also added significant new information on the construction and historical development of the Furnace Falls channel and dam complex. The dam façade was archaeologically exposed to its base at ca. 16 ft. below the lip of the cement-clad spillway. This profiling step revealed that the dam had been sliced off at its western side and then been rehabilitated by adding external cement cladding to its outer, downriver face.

Deep Winter Logistics and Staging

The fieldwork for the channel and weir took place during what CNN called the “Coldest January since 1977.” Temperatures fluctuated between 0 and 27 degrees throughout the field program.

Identification, definition and documentation of the historic Furnace Falls dam, weir and channel were conducted in three field segments on January 13th-14th, 19th-21st and 29th, 2004. The overall schedule was set by the DEP and the contractor to coincide with low stream levels and to be finished before the onset of the fish spawning season.

Feasibility and timing of the archaeological field effort were determined by

- (1) the need to rework the topography bordering each side of the historic channel to provide platforms and access for heavy machinery, and
- (2) the need to divert and lower the Musconetcong River.

The channel bed needed to be drained and dewatered both for the archaeological investigation and for the subsequent construction activities.

The archaeological team was mobilized that week and arrived on site on Tuesday, January 14th, for what was planned to be a four day field effort consisting of two days of site clearing and investigation followed by two days of recording with GPS and LIDAR. This schedule was interrupted by an 8-inch snow storm on Wednesday evening which

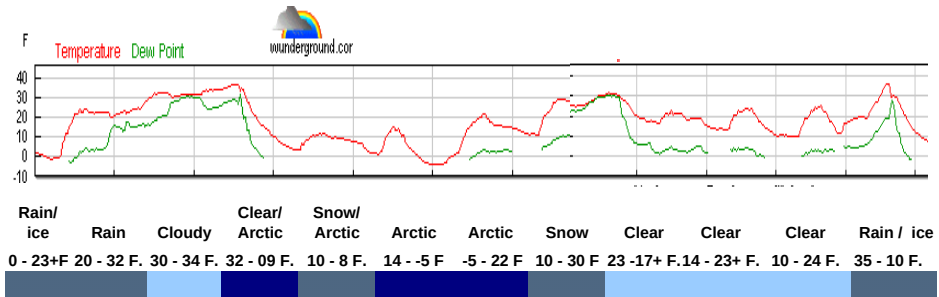
Archaeological Task Schedule Furnace Falls Dam, Weir and Channel

Table I

Joel W. Grossman, Ph.D., 2004

Day	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Monday	Tuesday	Wednesday	Thursday
Date	1/12/2004	1/13/2004	1/13/2004	1/14/2004	1/15/2004	1/16/2004	1/17/2004	1/18/2004	1/19/2004	1/20/2004	1/21/2004	1/22/2004

CLIMATE CONDITIONS

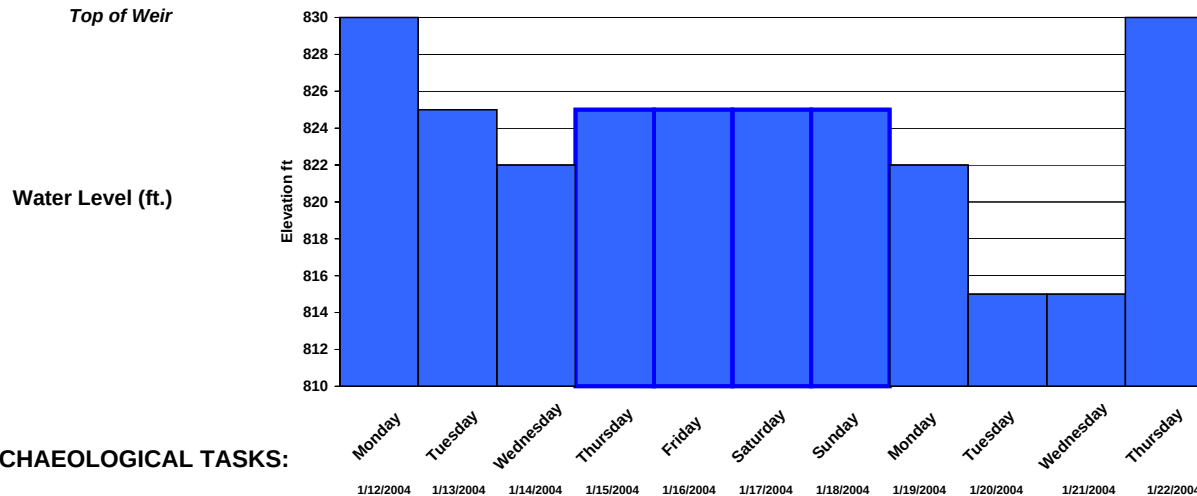


CONTRACTOR BENCHMARKS

Bypass River
Dewater Channel
Coffer Dam
Second Pump



Dewatering Depths / Day



ARCHAEOLOGICAL TASKS:

- Profile Trench-Channel at Weir
- Exp. Channel Wall
- Expose Dam - 5 ft.
- Expose Dam - 8 ft.
- Demobilize -Snow
- Expose Dam - 16 ft.
- Prep Site for Recording

GPS

- Survey Foundry Wall
- Establish Datum Control
- Survey LIDAR Targets
- Rolleimetric Photogrammetry
- 3D LIDAR SCAN - 6 hrs



forced the rescheduling of the field effort and LIDAR recording for the following Monday, January 19th.

Temperatures did not exceed the low teens during the first week but rose to between 17 and 27 degrees Fahrenheit the following week. This created ideal conditions with clear skies and temperatures well within the operating limits of the LIDAR and other electronic systems.

The relative temperature fluctuations and potential for precipitation determined the final scheduling of the LIDAR recording tasks. As a light-emitting measuring system, LIDAR does not do well in rain or snow. The proposed recording needed a window of two days of clear skies and temperatures above its lowest operating tolerance of 14 degrees F.

By Sunday night, closely monitored weather reports suggested poor conditions for Monday, January 19th, but the prospect of clear skies and temperatures above 17 degrees for Tuesday and Wednesday, January 20th and 21st. This range was above the minimal tolerance level of the battery-powered LIDAR, but would be cold enough to maintain the site as a frozen and therefore stabilized matrix of otherwise muddy channel sediments (Table I). Accordingly, the archaeologist and contractor decided to continue clearing the site on Monday and to schedule GPS datum control as well as LIDAR mapping tasks for Tuesday and Wednesday, respectively.

The original plan to focus the field effort on one trench across the channel near the post-1927 cement weir was significantly expanded upon the unexpected discovery of the surviving eastern side of the original post-1830 cut-stone Furnace Falls dam on the first day of fieldwork. The surprising finding beneath a cap of more recent cement at the spillway brought about the need to excavate the channel in order to define its form, dimensions, depth and internal structure.

When not frozen, the waterlogged deposits within the river channel would have turned into a loose slurry while under construction, prone to mud slides and subsidence. Under normal conditions, any deep exposures within the channel would have required extensive areas of sheeting to stabilize and hold back the mud. After intense discussions and strategizing, the author, as the archaeologist, and Jeff Salmon of Salmon Brothers

Construction of Netcong/New Jersey, the contractor, decided to proceed with caution, keeping staff out of the excavation channel. They used the solidity of the frozen mud to probe to the base of the dam without shoring. The field strategy was also expanded to provide for a gentle slope within the excavated channel between the stone dam and a temporary earth coffer dam built 30 ft. to the east to block the flow of water through the weir into the channel.

It had been agreed that the New Jersey Division of Parks and Forestry – Hopatcong State Park would assist in the deep winter fieldwork by restricting the flow of water from upriver dams, to the east of Stanhope, until the end of the proposed LIDAR survey of the site. Despite severe weather conditions, the bypass pipes were able to convey the flow in the river and enable the Contractor to maintain a dry work area during the entire LIDAR survey process.

The Contractor had to first control and then sufficiently reduce the flow volume and water level of the Musconetcong River within the Furnace Falls channel to make the archaeology possible. Starting in November, Salmon Brothers constructed an innovative siphon-based river bypass system which was completed by the first week of January. A total of six passive 1-foot pipes were activated by the week of January 9th.

Tuesday, January 20th, was dedicated to the establishment of precise datum control points with high resolution satellite-linked GPS stations.

Wednesday, January 21st, was set aside for the documentation of the historic channel complex with the high resolution ground based LIDAR scanning system. Heavy-machinery clearing of the debris and fill continued until the moment of the scan. Despite the extreme weather conditions, all systems worked as planned. The new generation of true color LIDAR mapping systems produced a rapid and safe 3D geo-referenced record of the historic channel, dam and weir. The scanner produced a dense cloud of coordinate points tied to the NJ State Plane Coordinate system with a resolution of 6 mm per point; a point interval of 15 mm and a scan rate of 12,000 points per second (see Appendix III - Riegl specifications).

A final field task consisted of recording a measured cross section profile of the dam. Following final design changes, the contractor demolished and removed the

remnants of more recent cement wing walls between January 21st and 29th to expose the southern end of the early cut-stone dam. The PI returned alone on the 29th and worked with heavy machinery (a 1.5 cu. ft. tracked backhoe and a heavy gauge pneumatic jack hammer) to expose and clean the dam for recording.

Discovering the Dam

At the outset of fieldwork, it was still not clear what, and if anything, the spillway could reveal. All visible surface elements of the spillway, the wing walls, the exposed top and the western, downriver, face of the Furnace Falls dam appeared to be of cement. No historic stonework or masonry suggesting an early construction date was visible.

However, several early maps and scaled historic map comparisons suggested caution. Two maps from 1828 and 1858, both predating the 1874 addition of the cut-stone bridge, showed a wide lake defined by a long, substantial looking dam structure at, or in alignment with, the modern spillway (Figures 2 & 3).

The survival of the historic dam underneath the cement cap was first discovered by Salmon Brothers Construction as an unexpected byproduct of the pre-fieldwork dewatering effort. Over the weekend before the archaeologists' arrival, the pumps and bypass pipes had lowered the water to a level 4 ft. below the lip of the spillway (Figures 17 & 18). While the top of the spillway continued to show a solid cement face, the rear, upriver, eastern side revealed the well-defined and tightly laid stonework of what emerged to be a section of the original pre-Civil War, 1830-40 era, dry-laid cut-stone dam built contemporarily with the Morris Canal.

This discovery by the contractor brought about a shift in field strategy. While the documentation of the cement spillway, prior to its removal before the opening of the channel, had from the beginning been part of the mandated Mitigation Plan, the new discovery added some field and analysis time to the overall effort. It proved inconsequential, however, to the speed and recording capabilities of the LIDAR. The site

was documented in 3D with the same number and location of survey stations as had been proposed prior to the emergence of the early component of the dam.

Diverting and Dewatering the River

The discovery of the earlier stone dam raised logistical challenges, some problematic due to the weather, others aided by the deep winter conditions. The goal was to try to dewater the channel and remove enough of the sediments in front of the eastern face of the dam to establish and record its depth. It was decided to use the extreme weather conditions to our advantage. Instead of using expensive sheeting to stabilize the steep sides of the deepening channel excavation, the decision was made to use the freezing temperatures to solidify and stabilize the unsupported structures.

The process of deep exposure was done in two stages. During the first two days of fieldwork, Tuesday and Wednesday, January 13th and 14th (before the snow storm of January 15th), a single 6-inch pump made it possible to dredge and drain the eastern face of the dam down to between 5 and 8 ft. below its crest (Figures 20 & 21). But after good progress on Tuesday, January 13, Wednesday the 14th saw no advance in the depth of the exposure. After two days of clearing out mud with the backhoe and the full time use of a single 6-inch pump, it became clear that the water level was not going deeper than 8 ft. below the spillway lip and that the waterlogged slurry of channel deposits was slumping into the trenching area faster than the large 1.5 ft. backhoe could handle. Seepage of water through the shallow weir proved too great for the single pump.

The snow storm of Wednesday evening stopped work temporarily. However, it presented a critical opportunity for both contractor and archaeologist to address the upcoming deep winter and high water logistical challenges caused by the sub-freezing conditions.

The archaeologists used the time to equip themselves with additional deep winter gear, arctic boots and ice crampons. The frozen ground and channel sidings were precarious and slippery. The addition of ice crampons provided sure footing on the slick surfaces that had to be traversed to place scales and identification breadboards for each formal recording session.

The contractor used the break to develop a strategy to go deeper, and lower the water an additional 6 ft. to give the archaeologist access to the base of the dam. Salmon Brothers Construction built a temporary earthen coffer dam across the channel immediately west of the Quirk outfall drain pipe coming out of the southern bank, half way between the bridge and the dam, to cut off seepage from the weir (Figures 45 & 54). A second 6-inch pump was added to the existing 6-inch pump within the withholding pond formed by the coffer dam to control and then lower the water level in the upper channel and to block additional leakage into the deepening exposure from the cut-stone dam façade.

Downriver, the deepening hole in front of the dam was drained of any seepage through the coffer dam with an extra 3-inch pump. In addition, the exposure area was expanded and given a gradual (1:1) slope between the coffer dam at mid-channel and the cut-stone dam downstream as an alternative to sheeting. This grade was cut so as to meet health and safety mandates and to preclude the sudden implosion of the waterlogged deposits of mixed sediments and cement debris.

Later, as a final step to bring the water level to its maximum lower limit, the 3-inch pump installed at the bottom of the pit next to the dam drained the remaining water which had pooled in front of the dam immediately before the site was cleared of machinery and planking for the LIDAR scan.

Health and Safety Issues

Access to the east side and ends of the dam was limited by the potential instability of the overhanging early 20th century cement wing walls which cut across both ends of the exposed cut-stone dam. Their lower sections had collapsed or crumbled into large slabs of concrete in the channel, leaving their upper sections suspended as precarious overhanging wings of cement 10 – 15 ft. over the empty cavity below (Figures 21, 24 & 51). For this reason, any and all human activity in the pit was restricted in the vicinity of the unsupported wing walls remnants. Only a thin sliver of access was defined in a line perpendicular to the central portion of the dam's eastern face.

Access for the archaeologists and later for the LIDAR team to the face of the dam was provided by large multi-beam wooden “tank” mats. These were hoisted by crane over the jagged surface of the frozen channel to form a bridge to the face of the dam (Figures 12 & 20). These walkways permitted the archaeologists to safely get close enough to the dam to briefly inspect its façade and to place scales and photographic breadboards on the structure.

Pre-LIDAR Site Preparations

The final dewatering and maximal exposure of the eastern face of the cut-stone dam beneath the spillway took until the morning of the last day of fieldwork. The 1.5 cu. ft. backhoe bucket, the crane-mounted crushing ball, the crane-mounted clam shell and pumped water were also used intensively to break apart and remove large chunks of the collapsed cement wing wall. They were also instrumental in removing debris which clogged both the excavation trench and the unexposed northern end of the dam at its juncture with the recent sheeting. This sheeting had been installed on an emergency basis after the severe flooding of 2000.

The first half of the one-day LIDAR-recording effort was dedicated to cleaning off the snow and ice that blanketed the site. The dam and southern retaining wall of the historic channel were flushed with water from the 3- and 8-inch dewatering pumps and with large backhoe and crane buckets of water from the channel. A cap of 3 inches of ice was chipped and smashed with the backhoe and then cleared away with the help of pump outfall hoses tied to the bucket of the small backhoe which directed and pointed the 6-inch flow from one of the dewatering pumps.

The morning of the LIDAR scan was also taken up with making the site safe for the LIDAR team. The first two survey stations were set up on the roof of the post-1901 Singer building to provide coverage of the western cement face of the spillway while clearing and dewatering operations continued upstream. Throughout the morning, the contractor and personnel from Compac Corporation worked to make the ice-covered roof safe for the technicians and equipment. As a final task before the midday start of the

LIDAR scanning, vehicles, tank mats and construction equipment were shifted off-site to provide a clear field of view for the scanner.

Profiling the Channel

The original Mitigation Plan (Grossman, 2002) recommended a single-profile trench across the historic channel to define its depth and structural characterization. Based on Vermeule's plans, it was initially assumed that the cement weir would be some 5 - 6 ft. deep and formed with a sloping or expanding cement base that flared to a wide cement base. The north-south trench was to be placed next to the post-1927 weir so as to use it for support or, better, as an already existing safety wall. Assuming a ca 5 – 6 ft. depth range, a 10 ft. wide channel would be necessary to provide for a gradually sloping side stepped back with a 1:1 slope to avoid the need for costly, and potentially impacting, steel sheeting within the channel. The trenching across the channel was begun on Tuesday, January 14. It was completed on schedule and the site was prepared for recording by the morning of the last day, Wednesday, January 21.

The progress of the clearing was slowed by the rapid buildup of suspended sediment in the water and by a spurt inflow into the channel. A second 6-inch pump was added and together, the two pumps they were able to match, and even surpass, the flow through the weir. The lowest water level reached through dewatering stayed at around 5.5 ft., or elevation 824.5 ft., below the top of the weir (at 830 ft. El). Attempts to further stem the flow of seepage from the Furnace Pond or increase the rate of pumping proved futile. However, the successful dewatering of the channel to this depth provided enough exposure to define the depth of the channel and the bottom of each wall, or channel section, in the vicinity of the weir and the former cut- stone bridge abutment (Figures 33 & 34).

On the morning of Wednesday, January 21, the turbidity in the channel from the previous day's dredging had cleared sufficiently to reveal that the base of each wall was demarcated by the presence of wooden log footers under the last course of stonework.

Wooden footers had been reported by Brian Morrell from excavations of the Morris Canal in Warren County, and it was projected that the base of the channel would be defined by wood in this case as well (Morrell 1983).

Each “footer” or “spreader” was laid east-west and parallel to the axis of the channel. Both logs were smooth and relatively thin, ca. 5 - 7 inches in thickness, and appeared to be smooth, rounded trimmed branches or thin trunks stripped or of bark. No saw or chisel marks were visible to the eyes, on film, or through the 22 power digital video lens (Figures 35 & 36, see Disk I-Digital Video Field Log).

Both could only be recorded while they were partially submerged in the constant flow of water covering the bottom of the channel. On both sides, the eastern-most end of each log, located close to the weir, was partially exposed on its uppermost side, but was covered by water towards its western, downriver, end. Both logs were recorded in and under water with digital camera and digital video and as well as in multiple Rolleimetric flat field macro views (Appendix II Index of Rolleimetric Images and Disk I for digital image files).

As recorded on the 3D LIDAR view (Figure 53, NPI Plan 3/6-Section C), the bottom of the cut-stone channel and wing wall was at El 824.5 foot. The top of each wall ranged from elevation 832 ft. on the southern wing to 834+ ft. on the northern wing wall. The depth and/or height of each channel wall in the vicinity of the former bridge abutment varied between 7.5 ft. for the southern channel wall and 9.5 - 10 ft. for the northern wall. Both walls were constructed of the same dry-laid stonework of rectangular blocks of gray metamorphic stone, ranging from ca. 1 to 2 ft. in vertical thickness and 3.5 to 4 ft. in length (Figures 41 & 42).

The profile trench across the channel brought two unexpected results. The first was the discovery that the post-1927 weir was only a shallow, near-surface structure with no actual base or wall to the bottom of the channel. The second was that the channel entrance, or easternmost channel opening and its associated cut-stone wing walls, had been preserved under modern debris and ground cover.

Defining the Weir

When excavated and exposed through dewatering, the actual weir structure turned out to be very different from that outlined in Vermeule's Canal closing plans (Vermeule 1929). Vermeule's 1927 blueprints had illustrated the proposed weir in several measured section drawings as an expanding, poured vertical cement slab with a horizontal cement footer expanding outward at its base (Figures 41 & 42). Vermeule's original blueprints did not specify depth (Grossman 2002, Figure 34, *Drawing No. 263A, NJ State Archives, Box 37, item Number 1, "Plans for work on Section 54-55"*). Notations on the drawings stipulated only that the depth of the base of the weir "El (Elevation) was to be determined in the field" (Figure 42).

The archaeological definitions and measurements of the weir recorded in January 2004 showed elements similar to Vermeule's 1927 blueprints depictions (Figures 2, 41 & 42). The top of the cement slab and its three cement "pods" with vertical beam slots were present but the weir did not match Vermeule's drawings for their underlying form and dimensions. Vermeule's Canal closing blueprints showed profiles for a vertical cement weir with a flaring cast base, like an integrated footer or spreader, extending to the base of the channel. None was present (Figure 42). The eroded base of the cement weir rested on loose gravel 3.9 ft. above the recorded bottom of the channel (encountered at a depth of 5.5 ft. below the weir, elevation 824.5 feet). Instead of extending to the bottom of the channel, the cement weir had no base and no connection to the bottom of the channel. In essence, if Vermeule's blueprint did pertain to the weir at Furnace Falls, it was not built to his specifications.

The exposure process revealed that the weir had been constructed only as a near-surface, cast rectangular cement slab without a base extending to the bottom of the channel. The slab measured 2.8 ft. by 1.9 ft. thick in section and 25.8 ft. in length (NPI Plan 3/6-Section C). The northern half of the bottom of the cement weir was heavily eroded. It had been reduced by 25 to 50 % of its original thickness at its northern end, and appears to have measured at least 2.5 to 3 ft. thick when originally built (Figure 34).

The weir appeared to be self-standing and was not built into, or structurally integrated with, the earlier cut-stone wing walls. Instead, it appears to have been poured in a form over an unconsolidated matrix of gravel and jagged furnace-derived slag that filled the channel and dominated in the dry fill along both banks of the channel.

The north end of the weir had been apparently been poured over, or onto, a large irregular boulder, ca. 18 inches in diameter, resting next to, but independently from, the northern cut-stone channel wall. The boulder appears to have subsequently broken away from the cement weir and subsided to form a large cavity immediately next to the cut-stone wing wall (Figures 33 & 35). The actual elevation of the weir varied from north to south by 3/10 ft., between 830.1 and 829.8 ft., reflecting probable subsidence into the porous gravel bedding beneath it (NPI-Plan 3/6-Section C; Plan 2/6-Section A).

Three cement pods extended upwards from the top surface of the horizontal cement slab, each with vertical board slots on either side (east and west). The cement pods measured 3.1 ft. high and 2.2 ft. wide on their east-west axis. The addition of horizontal planks into the slots thus gave the potential to raise the water level at the weir up to 3 ft., between 830 and 833 ft. elevation, above the top of the horizontal cement slab of the weir.

The weir and eastern channel were “sectioned” and recorded in plan, profile and 3D by LIDAR and with digital cameras, digital video and Rolleimetric photography (NPI-Plan 2/6-Section A; Plan 3/6-Section C; Figure 53).

The Surviving Bridge Abutment Wing Walls

The archaeological profile trench across the channel at the weir also exposed the intact eastern opening, or 19th century wing walls, of the original 1874 cut-stone bridge abutment. The outer edges of both wing walls were difficult to define during the LIDAR scan because of the amount of snow and debris on the lake side of the weir. The full extent of the wing walls had been plotted in detail in the 1979 Secco survey of the Compac Corporation property, but was not exposed during the more recent surveys after

the 2000 floods (Secco, 1979). They were not depicted on the official engineering survey plans (Figure 10).

However, between January 21st and 29th, clearing in preparation for the installation of sheeting revealed a ca. 10 ft. section of the northern wing wall which defined both the interior southern edge of the wall as well as the outside edge of the northern wing wall. In addition to the LIDAR scans, both digital and film-based photography were used to capture this section. Details were documented by Rolleimetric flat field film records (Appendix II).

The northern wing wall measured 2.5 ft. in width (Figure 35 & 53). Although not exposed equally on both sides of the channel, it is reasonable to assume that the southern wing wall had this dimension as well. The photo image suggests that both sides of each wing wall had been constructed as self-supporting double faced, dry laid, stone walls (Figure 35).

The cement weir was cast outside and to the east of the main channel formed by the bridge abutment. It was positioned to fit as a plug in the mouth of the expanding funnel-shaped wing walls, facing Furnace Pond, with little or no integration apparent with the cut-stone channel siding on either side. The channel measured 19.9 ft. in width. The cast cement weir was measured 25.9 ft. at its widest. It was placed 2.5 ft. east of the juncture, or vertex, of the channel with the expanding cut-stone wing walls to the east.

The wing walls flared at an angle of 22 degrees on the north side and 24 degrees on the south side of the weir. They extended eastward for an absolute distance of 7.3 ft. in line with the channel wall and 8.1 ft. beyond the eastern side of the weir in line with the wing wall (NPI-Plan 3/6-Section C; Figures 39, 40 & 53). In shape and orientation, the two wing walls look very similar to the inlet of the Lock 1 West of the Morris Canal currently preserved adjacent to Lake Musconetcong in Stanhope.

Project engineers and contractors have reported that the current construction plans will maintain the cut-stone wing walls in place throughout the construction and in essence incorporate them into the specifications for the channel and dam remediation. Langan Engineering and Salmon Brothers Construction specified that the "...abutment will be left in place and incorporated into the channel design." (Personal Communication

via email: D.J., Hodson, February 26, 2004). The new channel lining will grade into, and rest against, but not otherwise impact the historic wing wall structures.

The Southern Channel Embankment

The southern bank of the channel, located between the weir and the spillway to the west, contained three different levels of preservation and categories of stonework: The area of the weir and the former bridge abutment, a 60 ft. long disturbed central section between the weir and the spillway, and, at the western end, a 30 ft. undisturbed horizontal band of dry-laid boulders adjacent to the curving southern cement wing wall of the spillway (Figure 54).

Consequently, three profiles were recorded with the LIDAR to document the structural variation of the channel's exposed southern embankment (NPI Plan 1/6 Section C, Plan 2/6-Section B, Plan 5/6 Section E).

The eastern-most profile nearest to the weir (NPI Plan-1/Section C) documented the surviving lower elements of the bridge abutment. Double flaring wing walls were present on either side of the center line of the bridge's former north-south alignment. The base of the surviving bridge abutment was distinguished by a line of large, 6.5 ft. deep, stone blocks of the former 1874 arched bridge. These surviving wall elements ranged in elevation from 825.5 ft. to 832 feet (NPI-Plan 2/6-Section B, Figure 54).

The center section of the south bank of the channel was disturbed by modern, probably post-1960, intrusions associated with the installation of a 24-inch storm sewer or conduit outfall pipe draining into the central channel from Quirk Corporation. Next to the pipe was a flat-topped cement slab over a cement box of undetermined function (Figures 10 & 54).

The third and westernmost subdivision of the embankment consisted of an undisturbed, 30 ft. long, line of un-mortared cut-stone blocks or, better, what appeared as rough cut boulders with rounded edges. In contrast to the depth of the bridge abutment, this western section consisted of only a 4.5 ft. high, three courses thick, band of cut-stone blocks between 828.5 ft. and 833 ft. in elevation. Throughout its length, no stonework

was encountered below elevation 828.5 feet. This section began due west of the cement box and extended to the eastern end of the flaring cement wing wall bounding the lower spillway. A LIDAR profile across the vertical axis of this surviving section of embankment recorded the top and bottom elevations of the upper and lower coursing (See NPI Plan 5/6-Section E).

Its relative height when compared to the elevation of the weir at 830+ ft. indicates that this multi-course band of cut-stone began one course below the crest of the weir. This elevation range suggests that it may not have been installed until after the post-1927 cement weir had raised the flow levels in the channel to 830+ ft., or to between 830 and 833 with boards slotted into the weir pods (Figure 51, NPI Plan 2/6 – Section B, Plan 3/6 – Section C, Plan 5/6 - Section E).

Their position in the channel may have more to do with, and date to, the era of Vermeule's canal closing operations and the realignment of the channel spillway, co-terminus with the installation of the cement wing walls on the spillway, than the earlier 1874 cut-stone bridge and stone wing wall construction at the eastern end of the channel.

The 1830 Stone Dam at Furnace Falls

The excavation of the stone dam at Furnace Falls revealed that it was a multi-component structure consisting of elements of both the earliest period of construction at the site and the later cement additions, which probably dated to sometime within the first quarter of the 20th century.

The earlier, dry-laid cut-stone, component was visible only on the eastern face of the spillway and appears to date to the early to mid-19th century. The western face was removed at some later date, and replaced with at least two, and possibly three, episodes of added cement reinforcement, or cladding. No independent evidence (inscriptions, makers' marks or associated dateable artifacts) was recovered to set the date of these changes or additions. Only their relative composition, construction materials and elevations, which link the dam to other structural elements at the site, offer potential clues as to their relative contemporaneity (See Discussion).

The dewatering and excavation process exposed enough of the dam's face to indicate that it was built as a truncated, or flat-topped, stepped pyramid form with a 1.1 ft. wide step, or shelf, at a depth of ca. 6 ft. (5.9 ft.) below the lip of the spillway (Figure 51-52, NPI Plan 5/6-Section F). This step extended across the eastern face of the cut-stone dam and had been truncated and cut into by the later cement wing wall construction on either side. The horizontal position of one stone block in the disturbed north end of the dam (Figure 32) suggested that this step, or shelf, may have extended north and south across the path of the later wing wall builders' trench. The level of disturbance from the later cement wing wall construction, however, left its original extent and form indefinable.

No exposure was done to the north or south of either of the cement wing walls of the spillway. The 1828 and 1858 maps of Furnace Falls both, however, suggest that the original dam appears to have extended to the north and south of the most recent spillway by a considerable distance (Figures 2 & 3). The relative scale of the dam's length suggests that it may have originally extended as much as some 200 ft. across the basin to tie into high ground, bordering the Musconetcong River (Grossman 2002).

The archaeological exposure of the earliest surviving cut-stone has revealed salient new insights into the structure, size, construction and chronology of the dam. This is a summary:

The cut-stone portion of the dam was characterized by structurally and stylistically distanced elements or attributes: (1) Its form and depth, and (2) the presence of finished corners suggesting that there had been at least one former lower sluiceway.

(1) Form and Dimensions: In total, the dam measured a minimum of 15-16 ft. from top to bottom, 7.4 ft. across the east-west axis at its crest, and 11.1 ft. wide at its base (NPI Plan 5/6-Section F). The exterior cement face of the dam added later was shorter than the exposed interior cut-stone face. It sloped outwards to join the cement channel floor at elevation 819.4, or 10.6 ft. below its crest, at least three 3 to 4 ft. less in height than the opposite, upriver side of the structure. The cement-capped top of the dam

was at elevation 830 ft., and its base extended down to 814 - 815 ft. elevation on its eastern face.

The LIDAR scan was able to capture only as far down as the water which stood at 816.5 ft., several ft. above the actual depth of the stone dam. The level of water measured against the ca. 5 ft. high, 1.5 cubic yard backhoe bucket suggested that the base extended at least 1 – 2 ft. below the standing water pooled at its base, or at least to between 15 and 16 ft. below the lip (to elevation 814 - 815 ft.) at its deepest invert in the channel.

The potential for collapse and/or subsidence from undercutting too much mandated that the northern and southern slopes of the exposure be left unexplored. Only the central point of the eastern face could be exposed to this depth.

During the LIDAR survey, the top of the stone dam was capped by a 3–5 inch thick layer of cement, which in turn was covered by eight 8 inches of snow and ice. This cover of cement, snow and ice added about a foot to the height of the original dam. It also added an artificial extension, or eve, to the top eastern corner. This frozen overhang gave a false profile signature to the LIDAR scanner at the top eastern edge. As recorded in NPI profile Section “F”, and as captured in the Rolleimetric flat-field macro image, the original edge formed a clean 90 degree juncture at its vertical eastern edge (Figures 31 & 32).

(2) **Finished Corners:** The excavation and dewatering process exposed the well-preserved, square north-east corner of the original cut-stone dam structure. The presence of this clearly defined corner, directly in line with the south side of the northern wing wall of the Singer spillway, suggests that what later became the base of the most recent cement-covered spillway may have been the upper ledge of a previously existing lower channel outlet, or sluiceway, where the later northern wing wall had been constructed. The notion that the dam had a lower sluiceway immediately to the north also correlates with the “pre-construction” blueprint of the spillway as depicted in Vermeule’s 1927 Canal closing engineering plans (Figure 41). It also fits with the earlier 1828 map showing double spillways out of the dam as it appeared before the construction of the post-1874 cut-stone arched bridge (Figure 2).

Profiling the Dam

Exposure

The DEP-mandated procedure of profiling or sectioning the dam before it was demolished presented logistical and scheduling challenges. Feedback by review staff regarding the initial fieldwork results had focused on the need of recovering controlled information on the interior structure and construction of the dam. In response, the archaeologist and contractor had evaluated several possible ways to achieve this end safely and without interrupting the ongoing construction. At first, the possibility of using a line of drill holes to cut the dam in half was considered. This would have been costly and time-consuming. It was, instead, decided to phase the archaeological procedure (cut, clean, record) into the upcoming demolition phase.

The final task, the sectioning of the dam to record a profile cross-section of its internal structure, was undertaken on Friday, January 29th, 2004.

In the intervening week since the LIDAR scan of January 21st, the contractor had removed or jack-hammered 16 -17 ft. of the former cement spillway wing walls off the pre-construction 2003 surface height of 836.5 ft. elevation, down to the surviving base of the vertical cement sidings at ca. 820 ft. elevation. The removal of the wing walls provided access to the southern edge of the dam and a means to record it in section. The opposite, northern end was inaccessible because of the density of sheeting that had been installed after the flood damage of 2000.

Once the exposed stone work had been accessed, definition, documentation and demolition steps were treated as archaeological procedures under the direct supervision of Dr. Grossman.

The day was divided into four segments based on the need to slot the photography and photogrammetry to optimum sunlight conditions (10 AM – 1 PM).

Between 9 and 11:30 AM, the Salmon Brothers team deployed a heavy-tracked backhoe and pneumatic jack-hammer to cut away the remaining wing wall and to cut a clean cross section profile through it in line with the exposed south face of the structure.

By 11:30 AM, tasks shifted to cleaning and preparation for photography and photogrammetry. Two construction workers with heavy brooms were raised onto the exposed column of the structure. They cleared snow and ice from the top surface and swept loose dirt and rubble off the top and sides of the frozen matrix. Earlier and warmer conditions had permitted the use of water to clean off the exposed eastern side of the dam. However, this day the temperatures had dropped into the teens, and it was judged to be too cold to use water to clean without the prospect of turning the feature into a dirty ice-covered mass.

The third stage was the photographic documentation, the fourth comprised the demolition and recording of the dam's upper section with digital video by 2:30 PM.

Photographic, Digital and Metric Documentation

Digital camera, digital video and Rollei metric photography were used to document the internal structure of the dam. Each of these systems was used at slightly different times over the hour between 1 and 2 PM, and each captured slightly different kinds of visual information. Neither hands-on inspection nor the recordings of detailed measurements were possible because of dangers posed by rising waters and slumping banks surrounding the structure. A 22 X zoom DV camera was used instead, from a safe distance of 60 to 75 ft. away from high ground to the south. The remote zoom recording technique provided an opportunity to perform a detailed "close-up" vertical and horizontal inspection of the exposed façade, with the same clarity as if one was inspecting it from a distance of 2 - 3 feet.

Consistent with the DEP guidelines for the submission of digital media, the DV record of the dam is included as an integral part of the report within the appended "DV Field Log" of the excavation entitled *GPS and LIDAR in the Discovery and Documentation of Furnace Falls Dam, Channel and Weir* (Grossman-Disk 1). This digital video record provides a context for the multi-medial DV close-up survey record of the dam profile. It also presents close-up and otherwise inaccessible details of the wooden footers under the cut-stone abutment and wing walls near the weir, and the LIDAR-derived 3D animations and virtual inspections around and over the excavation.

The final phase of the data documentation task was marked by the need to provide safe physical access to the structure and control the rising water long enough for the PI to take flawlessly vertical metric film photographs of the south end of the sectioned dam with the Rolleimetric camera. This proved to pose a challenge.

The contractor had built a berm and equipment access routes for the archaeologists and heavy machinery across the channel and around the dam. However, at the moment of photography at mid-day, water levels had begun to rise and breach through the berm. So that the PI could take the shots perpendicular to the mid-point of the dam, the water had to be at least temporarily controlled and an access terrace or step cut into the surrounding berm.

The digital photographs taken minutes before had documented the dam's face to a depth of 8 ft. below its crest, or to elevation 822 feet. To provide maximal coverage for the Rolleimetric photos, the PI directed the heavy equipment to couple the cutting of the lower step with the simultaneous removal of the rising waters with the 1.5 cubic yard backhoe. The shelf cut, the author dropped flat onto it, and the backhoe repeatedly scooped out water to lower it an additional 2 ft. immediately before the shot was taken. This effort increased the vertical exposure down to a maximum lowering of 11 ft. (elevation 819 ft.) below the top of the spillway at 830 feet. (Figure 32).

Aside from an unavoidable dark shadow from the brightness and angle of the sun, the automatic wide angle (90 degree) lens of the Rolleimetric and the low light, high speed (800 ASA), high resolution *Fujicolor* film captured a detailed and vivid as well as accurate color record of the exposed face of the dam. The film-based Rolleimetric provided better color accuracy than the digital photography (Figures 29 & 30), which proved adept at capturing detail but had limitations in the color accuracy of red and earth color materials (Figure 31).

All dimension and elevation measurements were derived from the LIDAR after the end of fieldwork. The total site LIDAR survey of January 21st had recorded the exposed historic structures in a series of dense "point clouds" of millions of geo-referenced 6 mm, precise 3D coordinates. Out of the field, the author selected an area to cross-section in virtual space, and through the LIDAR software, *Polyworks* and *RiScan*,

extracted a mm-precise profile drawing across the top and both sides of the dam to its base, demarcated in feet and tenths of feet in actual elevation units. The outside dimensions and elevation of corners and surfaces were defined exclusively by the LIDAR (NPI Plan 5/6 - Section F).

The image records and macro digital profile images were correlated and graphically integrated with the measured technical drawings derived from the geo-referenced coordinate-linked 3D LIDAR scan profiles. The 120 mm Rolleimetric film was scanned at a photo laboratory into a 50 Mb digital file and then adjusted with image processing software to balance light and contrast levels. The digitized film scan was then reduced in size and image resolution from 300 dpi to 72dpi for dissemination as part of the formal report (See Appendix II of Index Contact Sheets and Disk I for actual files).

The “core” outline of the dam profile was digitally “cut out” from the scanned Rolleimetric background image (Figure 31) and then imported as a layer and scaled to the LIDAR-derived profile (NPI – Plan 5/6 - Section F). to yield a measured profile drawing of the internal structure of the dam (Figure 32). This may have been the first time that LIDAR coordinate data were integrated with high resolution photogrammetry to create a measured archaeological profile (Figure 32).

Internal Structure

In profile, the interior matrix of the dam had a smooth, slightly sloping vertical cut line parallel to the poured western, or downriver, faces of the spillway (Figure 32).

At the top of the western, or downriver, side, this cement cladding measured 1.5 ft. thick. At 1.5 ft. below the western corner, the cement flared outward to form a thicker lower portion, 9.5 ft. high and 4.5 ft. thick at its base.

The smooth flat interface of the cement cladding with the core of the earlier cut-stone dam suggested that, if formally present, the earlier outer face of cut-stone had been removed and replaced with cement poured in a form on at least one or possibly two occasions. This replacement permits the conclusion that it may have been close to the same width, or east west, thickness as the original structure, or around 7 ft. across its top and 11 or 12 ft. across at its base.

A central seam of loose soil and rubble between the eastern cut-stone face and the later western cement surfacing had initially suggested the unlikely possibility that the dam had been built as a stone-faced but rubble-filled structure. However, the straight line of the inner cement seam alternatively suggests that it was poured with a frame or mold and that the loose material in the center in all probability represents fill or earth “packing” behind the cement framing. It is more likely that the apparent fill and rubble wedged between the cement and the eastern cut-stone face was placed there only after the western cut-stone face had been rebuilt, sometime in the first quarter of the 20th century.

The cement exterior cladding appears to have been added in at least two, possibly three, separate pours. This is indicated by least three different types of cement matrix visible in the digital and photographic record (Figures 29 & 30).

The first indication, as recorded by the LIDAR scan and by the digital video and photography, is that the outside face had a horizontal seam line at 5.9 ft. below the crest (el 824+), at the same elevation as, and parallel to, the eastern stone step on the opposite façade (Figures 48 & 49, NPI Plan 5/6 - Section F).

The second indication is that cutting the southern wing wall with the heavy-track jack hammer to form a clean profile section showed that there were at least two different types of cement within the interior of the outer façade of the spillway. The upper half, or upper 7 ft., of the exterior cement cladding consisted of homogenous, fine-grained cement and gravel concrete of a uniform color and consistency. Below the elevation of 823 ft., and extending down to its juncture with the cement floor of the channel leading under the Singer building, the concrete showed dense inclusions of brick fragments, or “brickbats”, in the matrix (Figure 29).

The digital photos also showed a distinct outer vertical band of concrete with a finer matrix which was devoid of brick fragments. This outer layer appears to have been added as a third cladding to the western façade of the rehabilitated Furnace Falls dam, and later spillway.

Using the large backhoe, the upper course of the dam structure was sectioned in a series of parallel vertical slices from south to north. This approach was to document any lateral variations in internal construction of the dam which might be different from what

had been recorded along the south end. There were no differences. The surviving eastern face of the cut-stone structure showed the same interior structure throughout its length.

The demolition of the dam was planned and directed in stages as an archaeological procedure. It was also recorded and monitored with digital photography and digital video. These records are submitted as part of the DV Field Log of the data recovery procedures (Disk I).

Discussion

Historic Hydrology

The archaeological investigation documented significant new information on the structure and history of Furnace Falls dam, channel and later cement weir. The combined map and archaeological evidence suggests two projections:

(1) The finished cut-stone corner represents the southern edge of a former 19th century spillway or sluiceway that was some five to six feet lower than and immediately to the north of the recent cement spillway, and

(2) At least the northern side of the later cement wing walls, and possibly both, appear to have been built into a former sluiceway.

This projection in turn suggests that the original 1840 pond was both much larger than the most recent one and that its shoreline was at elevation 824 to 825 ft, some 6 ft. lower than that formed after the 20th century addition of the weir and the raising of the cement spillway to elevation 830 feet.

The surviving cut-stone portion of the original structure appears to coincide in location and alignment with the earliest 1828 and 1858 maps of Furnace Pond (Figures 2 & 3). The photographs of the cut-stone bridge lower spillway (Figures 6 & 7), provided courtesy of the Musconetcong Foundrymen Historical Society, can now be re-evaluated in light of the new archaeological evidence provided by the elevation of the previously unknown stone step at ca 6 ft. below the top of the dam and by the discovery of the smooth finished northeast corner.

Scaled Historic Photographic Evidence

Both historic photographs appear to be contemporary and possibly taken on the same day by the same person. Both show the same elevated rail berm above the top of the bridge's arch. The historic photograph of the bridge post-dates 1896 (based on the 1896 Rogers No. 352 Locomotive in the historic photo of the cut-stone bridge and lower spillways, Hollingsworth 1984). When scaled, the presumably contemporary photograph of the spillway suggests that it was formerly much lower than the most recent cement version (Figures 6 & 7). When the height of the spillway is compared to its ca. 20 ft. width, it appears that the earlier stone spillway was at least 5 ft. lower, or only some 6 ft. high, versus 11 ft. for the recently removed cement spillway.

If correct, these two lines of evidence together suggest that the original Furnace Falls dam had at least one spillway located immediately north of the current one and that its crest was at least 5 - 6 ft. lower than the 830 ft. elevation of the most recent spillway, or at approximately elevation 824 feet.

The photo also suggests that the horizontal location of the channel outlet, or sluiceway, appears to have been realigned between the time of the photo and the building of the cement spillway. This shift, combined with the evidence of the finished corner down to the level of the step, suggests in turn that the original dam had a sluiceway at ca 824- 825 ft. in elevation and that it was located with its southern end in line with the northern former cement wing wall and that it extended 20 ft. to the north of recent cement spillway. This archaeological and structural evidence in turn suggests that the 19th century water level of Furnace Pond was most probably at the 825 ft. contour levels as well. This projection is also close to the recorded depth of the bridge and channel stonework at the eastern end of the channel. The recent waterline at 830 ft. may not have been established until after the installation of the cement weir by Vermeule's Canal closing transformations after 1927 (Vermeule 1929).

Chronological Indicators

With the exception of a single note on Vermeule's 1927 plans for a spillway and weir in the vicinity, no documentary evidence has been recovered to establish the age of these two components of the reconstructed dam-spillway complex.

Two lines of evidence, cartographic and structural, suggest, especially given the lack of REBAR reinforcing, that the cement cladding of the lower spillway may be earlier than thought and in fact date to as early as the turn of the 20th century, or around the 1901 construction of the Singer Building across the Musconetcong River. Based on period engineering literature on the history and use of concrete in general, and hydraulic concrete in particular, it may be surmised that at least some of these additions are significantly older and go back to the 1901 date of the Singer building.

American and European engineers and chemists were actively writing about and implementing the use of hydraulic concrete by the decade of the 1870s, or co-terminous with the end of the American Civil War. Between 1869 and 1873, the maturation of this technology was underscored by the appearance of three major scientific and engineering works of the uses of hydraulic concrete in maritime and marine contexts. These were the "Practical Treatise on Coignet Beton and other Artificial Stone" by Major General Q.A. Gilmore, 1871, "Report of the Hydraulic Lime of Teil" by Leonard F. Beckwith, C.E., 1873, and "Treatise on Concrete" by Henry Reid, 1869 (see Ripley and Dana, 1873, Vol. V, 210 – 211).

As early as the 1830's, French maritime and structural engineers had successfully calculated the mass of cement necessary to withstand even the strongest ocean tides and wave action for the reconstruction of the dilapidated port of Algiers. They determined by experiment that, to be "immovable in the waves," cement blocks had to be "at least 353 cubic feet in size." By 1873, concrete blocks were also used in New York harbor to build and expand the post-Civil Battery at the tip of Lower Manhattan (Ripley and Dana, 1873, Vol. V, 211).

These precedents suggest that the solid cast cement wing walls at Furnace Falls may have been built any time after 1870. However, as discussed below, given the

structural integration of the spillway wing walls with the cement façade of the dam, and the note on Vermeule's 1927 plans to "Remove and replace with Concrete Spillway" (Figure 41), it seems reasonable to project that at least some elements of the cement wing walls and facing were put in place in the late 1920's.

The Original Channel Alignment

Furthermore, the discovery that the original cut-stone dam had finished corners in the stonework, adjacent to and cut into by the builders trench of the later cast wing walls, suggests that the original spillway orientation and configuration was different from the 20th century one.

These differences in the location and alignment of the spillway in turn suggest that the later cement additions were added for the primary purpose of redirecting the channel of the Musconetcong into a realigned cement-lined channel beneath the Singer building. The new facing and wing walls were built not only to reinforce what was there but also to redirect the flow of the river into a realigned cement channel. If this is indeed the case, then it is reasonable to place the date of construction for the cement wing walls to as early as 1901, co-terminus with the building of the Singer Building and a cement-lined channel under the building.

It is also possible that the cement spillway and realigned channel were rehabilitated in several stages between 1901 and 1927. This suggestion is based on the observation that the cement wing walls appear to represent multiple phases of construction. The uniformity and parallelism in color and composition of the large, evenly-spaced, upper cement block-like steps bordering the channel west of the spillway contrast in composition and color with the lower sections of the wing walls extending east of, or upriver from, the spillway/dam. The curved, or flaring, upriver extensions to the wing walls and the presence of parallel horizontal mold or cast seams (Figure 50) suggest that these had been constructed by different techniques and possibly at different times.

Historic Topography

The new coordinate and elevation data now locks formerly ill-defined elements of the historic matrix into 3D space. This added information also suggests correlations and inter-relationships that were not previously possible to address. In addition to serving as essential benchmarks for the geo-referenced air photos of the areas, the new measurements of the top and bottom elevations of the cut-stone retaining wall now lets us extend correlations between this structure and other features on the site.

Precise elevation measurements at the top and bottom of the retaining wall in four locations now permit comparisons between it and the topography behind and above it within the access road corridor.

Topographic Correlations

The original 2002 background sensitivity study had suggested that the historic fill behind the massive cut-stone retaining wall contained a honeycomb of buried surfaces and conduits for air and water to power the blast furnaces of the foundry below (Grossman 2002).

This suggestion has been augmented by the newly available elevation measurements of the site's topography and primary historic features. The base of the wall, now partially covered by cement pavement of the modern Compac Corporation facility, consistently measured at elevation 820.2 to 820.3 feet. Equally consistent, the top of the wall measured between 834.5 and 836 in elevation and the original wall between 14 and 16 ft. in height throughout its length. These measurements, in turn, suggest that the original historic surface beneath the access road was also set to be at around 836 ft. in elevation when first filled in.

In contrast, the survey and excavation work of the Phase I access road mitigation had established the presence of buried historic features at around 845 ft. elevation. In neither exposure was the base or original surface these were built on, or into, identified.

The presence of a buried layer of the coal dust bordering the chimney base of Feature 3, at a foot below the modern access road, and the upper portion of a builder's

trench associated with the mortared stone foundation of Feature 2, suggest these features were built on, or associated with, a buried late 19th century surface 2 and 5 ft. below the modern grade. In other words, these relatively recent foundry related structures, most probably associated with the turn of the century era operations of Musconetcong Iron Works, were in turn associated with the buried surface several feet below the modern one.

The new information, provided by the precise elevations surveyed for the top of the historic 1840 retaining wall of the original foundry, now suggest the presence of at least one and possibly more, and deeper, historic surfaces at the site, beginning at or around elevation 834 and 835 feet. This is at least 9 - 10 ft. below the level of the modern grade and some 4 to 5 ft. lower than the late 19th century surface of the excavated features (Feature 2 & 3, See End of Field Letter-Appendix I) in the access road documented in October of 2003.

This new evidence also permits the horizontal linkage of the formerly ill-defined and free-floating retaining wall with the scaled historic photographic evidence on the original height and topography of the post-1874 cut-stone arched bridge at the site.

As illustrated in Figure 5, the post-1896 photograph of the cut-stone bridge documents a later phase of land fill over the original surface elevation of the bridge. A 10 ft. high berm formed an elevated platform on top of the bridge in support of the late 19th to early 20th century rail lines into the site. Based on the scaled projection of LIDAR-measured bridge elements, and its original width and height as documented in the post-1896 photo (Figure 6), the top of both the arched bridge was originally built at elevation 843 - 844 ft. in 1874.

These scaled comparisons, as well as the photographic evidence of different construction materials for the subsequent overlying rail berm, showed that the late 19th or early 20th century grade had been raised to 854 - 855 foot. It also indicates that both the bridge area adjacent to the channel and the landfill behind the historic retaining wall were built up in a series of episodes between 1840 and 1900. These additions created a “layer cake” of buried historic surfaces, between the foundry retaining wall and the reservoir connected to the spur from the Morris Canal to the east, within the Access Road.

These vertical increments were matched by horizontal expansions in the extent of the landfill as well. Essentially, beginning in 1874, the southern shoreline of Furnace Falls Pond was extended outwards to the south to support the bridge abutment constructed over the then constricted channel. These horizontal expansions redefined the shoreline of the pre-1874 Furnace Falls Pond from a wide body of water to a restricted narrow drainage.

This horizontal landfill process appears to have reduced the original extent of Furnace Falls Pond by some 100 – 150 ft. north-south and its longitudinal extent by nearly 200 ft., or the distance between the 1874 bridge and the former cut-stone dam.

Accordingly, it can be projected that there is a high probability that early foundry-related structures may be present on one or more buried surfaces at around elevation 835 to 840 feet. Any future construction activities in the vicinity of the access road or behind the retaining wall should factor in this potential for the presence of preserved, buried historic surfaces as part of any mandated archaeological testing or evaluation of the National Register eligible historic foundry complex.

In essence, these vertical and horizontal additions of land fill transformed the original topography behind the cut-stone dam. From a large open pond emerged an artificially created channel after the 1874 addition of the arched stone bridge.

These elevation projections or reconstructions also dovetail with the form and size of the original Furnace Falls Pond as depicted in the 1828 and 1858 maps of the original Furnace Pond configuration (Figures 2, 3 & 4) prior to the advent of the upriver installation of the 1874 arched cut-stone bridge.

Chronological and Material Correlations

Finally, in addition to these elevation-derived correlations, the relative contemporaneity of different components of the site is further indicated by contrasts and parallels in the workmanship and lithic materials used to construct the site.

As documented photographically (Figure 28), the workmanship and type of stone encountered in the earliest, 1830 - 1840 era Furnace Falls dam appears to be similar, if not identical, to that found associated with the heavy cut-stone wall. Both structures are

also characterized by similar, if not identical, finishing on the corner treatments. Both appear to have been made out of similar tan to red sand or limestone materials.

In contrast, the stone work, associated with the post-1874 cut-stone bridge abutment and eastern wing walls, was a visually distinct grey metamorphic material of apparently different origin.

Site Documentation Procedures

Four systems were used to record the site complex to meet the NJ State Historic Preservation Office standards and guidelines for the documentation of National and State Register eligible resources:

(1) The recently developed true-color Riegl LIDAR (laser-radar, or Light Detection And Ranging) system operated by Naik Prasad Inc. to capture a 3D record of the site with a point resolution of 6 mm (i.e., an averaged resolution of 1/100th ft.),

(2) Measured and drawn field plan and profile sketches (access road) where accessible,

(3) An EDM (Electronic Distance Meter) or Total Station computer transit for coordinate and elevation measurements, in use since the 1980's,

(4) A high resolution single camera Rollei metric photogrammetry system to record high resolution metric, or flat field, film-based records of each major feature.

Grid and datum control for the LIDAR scan was established with a high resolution GPS system capable of "on the fly" setting of coordinate points through field transponders receiving signals from geospatial positioning satellites.

LIDAR: 3D Laser Imaging Sensor

LIDAR (Light Detection And Ranging) is not new, but it is rapidly evolving as a unique recording technology and as a viable tool for archaeology. Over the last decade, archaeologists and architects throughout the world have used computer modeling to depict and reconstruct historic and ancient sites. LIDAR was applied to record threatened National monuments such as the Statue of Liberty, at Ground Zero to record the "Pile",

and to map and engineer the Second Avenue Subway (Grossman 2003a, Lapointe 2001, 2002, Loudon 2002, Moltenbray 2001), to give a few examples.

3D color-encoded LIDAR was selected because it was the only technology that held the promise of being able to record a site of this size and internal variation under dangerous conditions in a fraction of the traditional time frame, in hours rather than days.

Whereas standard archaeological field programs generally divide time and effort equally between exposure or discovery and recording, the challenges posed by the need to dewater and then hold back upriver stream flow in this case reduced the ratio for recording to about 1/5th of the field exposure time. Access for recording was calculated in time slots of minutes, at most several hours, instead of days. This new release was able to encompass scan areas over 360° horizontally and 90° vertically with each set-up. This expanded visibility, in essence, doubled the rate of data coverage over the earlier generation of systems.

The other reason for the selection of LIDAR was safety. In addition to its speed and precision (i.e. 12,000 points / second), the LIDAR provided a remote (non-contact), safe, and highly accurate means to measure form, dimensions and precise coordinates of difficult to reach or dangerous structures, such as those exposed at Furnace Falls. Unlike traditional manual measurement and mapping, and even unlike electronic transit systems and photogrammetry requiring a person to place targets and/or reflecting range pole prisms over features, the LIDAR can be deployed from a safe base station. It can be located up to 200 yards from areas of potential instability.

In this Phase II data recovery investigation, no option existed to place field personnel on, near or under the precariously exposed wing walls or ice-covered dam surface. Human contact was limited to the placing of scales on or against the individual features and the preparation of the top of the dam structure, which was brushed clean by two experienced machine operators for a period of less than 30 minutes. All other documentation activities were done at a distance of 30 to 75 ft. from the deeply exposed structure (See R. Tamblyn, 2004, for discussion of LIDAR as a safe approach to capturing metric data on bridge structures). At Furnace Falls, with the increasing depth of the dam, the remote and non-contact capabilities gained in importance.

The LIDAR scan was achieved with 11 equipment setups (Figure 16, NPI-Plan 6/6) which were recorded for about 15 minutes each. Three scans were taken at each position and averaged.

The balance of the six hour scanning session was taken up with breakdown, transport and reassembly of the equipment, as well as coping with the nagging problems of maintaining constant supply of battery power in the extreme cold.

Arctic temperatures hovering in the teens and low twenties during the fieldwork reduced normal battery life to minutes for the digital cameras and small appliances. The LIDAR was powered by independent dedicated power packs that were rated by the manufacturer to power 12 scans per battery change. At the site, however, each LIDAR pack lasted for no more than three scans before having to be changed.

The decision to use LIDAR to address the time and safety issues presented by the mitigation of Furnace Falls followed a multi-decade series of earlier solutions the PI had applied in other large scale emergency excavation projects. These included computer transits, stereo and single camera photogrammetry as well as earlier generations of the LIDAR system when they first became available in 1998 (Grossman 2003b). The selection process focused first on the availability of the most advanced and newest systems in the US and then on the availability on a seasoned engineering and survey team to go with it.

The author had been faced with the challenges of using a new and emerging technology in a 1999 emergency recording project for the State of New York in Albany, in which both single camera photogrammetry and an early prototype release of the newly developed LIDAR system were used (Grossman 2003b). Designed to survey oil platforms characterized by uniform forms and tubing at sea, as a joint venture between Chevron and DARPA, the fledgling technology proved less efficient when confronted with irregular organic forms such as hand-cut logs encountered in the Albany excavation. At that time, the LIDAR proved to be less successful as a prototype technology than single-camera photogrammetry from a 100 ft. cherry picker (ibid).

The Furnace Falls mitigation and emergency recording project five years later benefited from subsequent advances in both hardware and software. An essential aspect

in the successful application of the LIDAR was a recent breakthrough in the technology that permitted the recording of 3D space in real world color. This advance became possible through the successful computer-integration of high resolution digital photography with the coordinate-based LIDAR scanning system. This critical innovation in systems integration was made available in the summer of 2003 by LIDAR manufacturer, Riegl Laser Measurement Systems of Austria.

The Furnace Falls mitigation constituted the first deep winter archaeological deployment of this new generation of integrated 3D color radar scanning technology. The LIDAR was very fast and precise. It promised very high levels of accuracy (6 mm) with safe, i.e. remote, measurements at a rate of data collection (12,000 points per second) fast enough to beat the rising water.

True-Color 3D Documentation

In addition to speed and safety, the fact that this was the first LIDAR generation to offer integrated true-color data capture was a third motivating factor for the selection of this generation and model. This hardware innovation came attached to a computer controlled, high resolution, 6 mega-pixel Nikon digital camera with a wide field macro lens (Figures 1 c-d & 16). During each sideways sweep, the integrated camera took some 10 to 13 overlapping images, each locked into the location of the instrument and to the coordinate control targets throughout the survey zone of the site (Figures 27, 43 & 44).

Newly available advances in software control and post-processing capabilities allowed for the integration of each LIDAR scan, or point cloud, with digital color images taken in tandem with the laser radar. Each color pixel of the digital images was paired, pixel by pixel, with the recorded coordinate points of the LIDAR. This new capability replaced the previous practice of assigning arbitrary, or artist-selected, color schemes or pre-rendered digital image textures. This breakthrough permitted the first-ever capture of an archaeological site as a true color 3D computer model or, better, virtual reality reproduction.

This advance addressed a key deficiency in earlier attempts to use LIDAR scanning and computer modeling to reconstruct archaeological sites and monuments.

When applied to archaeological sites, both computer modeling and LIDAR renderings were consistently plagued by the problem of color, or, better, the only relative accuracy of the colorized computer model. All of these efforts had in common that the LIDAR signal returned images of relative light intensity, not true color. The raw LIDAR scans appeared as false color green-red or silvery mercury-like surfaces (Louden, 2002).

Until 2004, users were forced to use color samples from photographs or impressions of field staff to try to match and assign appropriate color to a computer-generated model, or to LIDAR scans. This approach in turn has raised concerns over the veracity of the final archaeological reconstruction.

Underscoring the problem, Harrison Eiteljorg, II, Director of the Center for the Study of Archaeology at Bryn Mawr, raised three issues of concern: (1.) The problem of “representing” versus “documenting”, (2.) the problem that, in order to be useful, the presented modeling needed to show data in a form that permits others to query the model or investigate unaddressed aspects of it, and (3.) that even though the original LIDAR data is precise, there is a large potential for subjective filtering of the data during transfer into standard engineering CAD systems by human operators (See H. Eiteljorg, II, “The Pitfalls of Virtual Archaeology”, CGW, September 2001; “The Compelling Computer Image – a double-edged sword”, Internet Archaeology, August 2000).

The new Riegl LIDAR, with its first generation integrated digital color camera, substitutes true digital color image captures for humanly defined color matching or surface “texture mapping” (assigning a pre-defined color or pattern to a computer-generated form) as part of the modeling process. Instead of assigning some color as a laminate or surface map over the metallic-looking raw LIDAR measurements, with the new Riegl LIDAR system, each color pixel is matched to its corresponding coordinates of the LIDAR point data to render what the LIDAR and digital camera actually “saw” in true color (Figures 45 - 54).

Isolating Historic Components

Finally, the ability of the LIDAR scanner to “see under and around” major obstructions by linking the results of various scan positions added an important capability to the site documentation process. At the outset of the fieldwork, it was thought that the temporary wooden bridge for providing access to both sides of the channel during construction would have to be dismantled to provide clear, unobstructed, lines of sight for the LIDAR scanner. The software’s capability to seam together different scans from different angles made the costly task of taking down and rebuilding the construction bridge unnecessary. Instead, multiple scans from either side of the bridge were stitched together with the system software into a single point cloud of LIDAR measurements. This saved the client at least three days of construction time, if not more.

The new LIDAR software also permitted the 3D removal and cutting out of all modern obstructions or recent land form changes so as to isolate and depict only the targeted historic elements. For example, the LIDAR saw the blanket of snow over the site as formless white background (Figure 45).

The modern terrain was also not the subject of the data capture. It had been altered several times since the floods of 2001 and then extensively sculptured to provide access ramps and berms around and across the site as a prelude to both the archaeology and construction. As none but the historic elements were of concern, the Naik-Prasad LIDAR technicians were instructed to extract and render only the 19th century and early 20th century components of the site. All modern items as well as the recent topography were isolated and rendered invisible. The result was a clean 3D capture of the site that presents the original historic structures - the dam, the weir and the channel walls - without modern artifacts from the most recent construction and site grading work (Figures 45 - 54).

Remote Virtual Investigation

Post-processing of the scanner point clouds also was turned around in a fraction of the traditional time frame. The raw LIDAR scans or point clouds were first registered and then geo-referenced for data extraction by the third week out of the field.

Before being able to extract elevations and dimensions from the measured scans, the technicians had to correlate the 11 different scan positions in 3D space by registering each of the raw scan or “point clouds” to common reflector targets in each view. Once integrated, the combined point cloud data was geo-referenced and re-projected into real-world coordinates set by the satellite GPS recorders to the New Jersey State Plane Coordinate system the previous day.

By February 17, the Naik Prasad LIDAR technicians started converting the raw scans into real-world geo-referenced true-color 3D models.

By February 26, they were ready to sit down with the project archaeologist to select the locations for the extraction of profile cross-sections and 3D views, all scaled and geo-referenced in feet and tenths and actual elevations above sea level. All coordinates of the historic features, dimensions and elevations were extracted from the LIDAR scan data after the fieldwork was finished.

The final task of the analysis involved the virtual investigation and documentation (with screen captures of raw LIDAR scans, extracted coordinates and dimensions) of areas and perspectives that were impossible to safely get close to in the field, such as elevated views 30 ft. in the air and close-ups under the overhanging slabs of unsupported cement spillway wing walls (Figures 22 - 24). Over the first week of March, the archaeological field director and the technicians revisited the site in 3D virtual space to “fly” through and over the site to capture detailed records of the various historic features of the channel that could not be investigated during fieldwork (Figures 45 - 54).

Real Time Datum Control – GPS (Geospatial Positioning Systems)

The LIDAR results can be only as good as the precision of the site’s datum or grid control. For this reason, LIDAR scans are taken in conjunction with various high-precision survey instruments, generally either a transit or a GPS satellite based location control system. At Furnace Falls, the ability of the LIDAR to capture the site in real world 3D coordinates depended entirely on the establishment of a tightly controlled grid of datum control points, each to 1/100th foot.

This baseline need posed a problem throughout the project, as previous survey datum control hubs set by the project engineers had been repeatedly destroyed. Points originally set in 2001 had been disturbed by, or lost because of, the intensive ongoing heavy-machinery grading and earth moving activities. During the initial access road fieldwork phase, it was necessary to resurvey into the site from distant surviving control points or survey hubs located at the south end of Furnace Road. These temporary controls were again lost during the subsequent laying of protective gravel and site grading activities in November and December.

Accordingly, the ability to re-establish new site datum controls “on the fly” was a critical criterion in the team selection process. The Manhattan-based engineering firm of Naik Prasad was selected because they maintained both the newest pre-selected LIDAR hardware systems and in-house high-resolution satellite positioning systems. This GPS hardware was capable of establishing “Third Order” datum control to a resolution of 1/100th ft. over the football field sized site within a matter of hours.

Three permanent hubs were established over a two-hour period on the morning of Tuesday, January 20th. The rest of the day was spent setting up geo-referenced, or mapped in, reflecting targets in preparation of the LIDAR scans scheduled for the following day (NPI-Plan 1/6).

These high speed GPS and survey capabilities were also used for mapping the historic post-1830 cut-stone retaining wall supporting the reservoir and canal spur leading from the Morris Canal, above the foundry site. The precise location of the wall was important because it was one of the few structures consistently visible in representation of the historic site, both in maps and in air photos.

Control points were previously limited to the immediate area of the channel and the south end of Furnace Road (none had been established for the middle and northern sections of the Compac Corporations property). This localized cluster of points in only one corner of the site rendered the digital rectification and dereferencing of available air photo coverage of limited accuracy and utility. Mapping the visible corners of the historic retaining wall provided sufficient coverage to geo-reference, or assign real world

coordinates to, other areas of air photo coverage of the site, including the access road and the Morris Canal spur and reservoir.

The satellite and computer transit team established the actual coordinates and elevations of key intersections of the historic foundry retaining wall in two hours (Figure 28). These new controls also permitted the checking of the site survey points recorded by the author earlier as an independent means of rectifying and, where necessary, repositioning each surveyed location and feature to the resolution and precision of the most recent dual receiver Naik Prasad GPS equipment.

The Single Camera Rolleimetric System

The medium format film-based metric Rolleimetric camera has a 90 degree flat field automatic lens capable of recording wide angle undistorted photographs.

The system works by taking multiple views from various angles with a scale in the field of view. Post-processing, with now inexpensive computer photogrammetry software, permits the user to first correlate each view with the other and then to geo-reference elements in the image to real-world coordinates. Once geo-referenced, the user can extract dimensions and locations from the images.

The system was developed by the Rollei Corporation in the late 1980's for intelligence and disaster recording. It was first deployed in archaeology by the author at a Federal Superfund archaeological mitigation of a Cadmium-laced Civil War site, West Point Foundry, between 1989 – 1994 (Grossman, 1994, 1997, 2003). At Furnace Falls, the Rolleimetric system was deployed as a backup and partially redundant means to capture high resolution, metrically accurate true-color film images of the site. It was used in tandem with the computer transit to record the two 19th century features on the access road in the Phase I work October (See Appendix I - Phase I End of Field Letter).

The film-based Rolleimetric initially produced traditional negatives and prints which were expensive to reproduce. For this report and to facilitate a more cost-efficient distribution, multiple views of the access road and channel features were scanned as high resolution and saved as 3 Mb image files. Each image file was enhanced through color correction and light range leveling and renamed to indicate its subject matter. For this

report, each of the files has been reduced to 72 dpi screen resolution for convenient storage and import into photogrammetry software programs. These digital archive metric images are stored on Disk 1 as part of the inventory of field records.

Data Formats and Dissemination

Data Formats

With reference to the second point raised by Eiteljorg, II (2001), the issue of accessibility and interactivity has been addressed in this submission by including both the original raw data and a number of output formats designed to let others use, measure and investigate the results. As provided on the NPI DVD Disks III and IV, the geo-referenced color LIDAR data has been saved into several common CAD formats, including Autocad and Microstation files (dxf, dwg), as well as several 3D modeling file types, specifically 3D color *.obj and web-friendly VRML files.

In addition to this hard copy report on the methodology and findings of the data recovery effort, the PI has put together a digital Video (DV) “Field Log” of the applied technology for community and/or educational distribution.

The DV format also provides a vehicle to present close-up records of inaccessible components of the site and animated 3D LIDAR scans of the recorded remains. One of the animations shows a birds eye view of the all historic elements of the site, the second a detailed “fly by” of the historic cut-stone face of the dam and the third a close-up, 360 degree views and animations of the eastern end of the channel and the post-1927 weir.

Finally, this DV overview includes the close-up video captures of the profiled dam in section as well as the wooden footers at the base of the channel.

Data Dissemination

This report is submitted in two CDR disks, one containing an Adobe pdf file of the report, the DV Field Log and scanned image files from the Rolleimetric record of the access road channel features. A second CDR disk by the author includes a single file of the geo-referenced air photography of the Stanhope/Netcong area for use by other

researchers. The Naik Prasad LIDAR data and results are reproduced and appended in two 4.7 Gb DVD disks.

Disk I: (CDR-Total 284 Mb): Four Folders: A. Digital Adobe pdf copy of Final Report Text and Appendices including an Adobe pdf copy of the November 2004 Phase I Access Road “End of Field” letter report. (32.8 Mb); B. Final Report Plates (pdf-18.3 Mb); C. Final (Rev1) LIDAR-derived measured CAD plans & profiles (Adobe pdf & DWG-98.7Mb); D. A Windows Media Player (WMV) version of the author’s Digital Video Field Log of the project and its results – “The Archaeology of Furnace Falls” (171 Mb); Folder also includes a small 4 Mb WMV LIDAR animation of the 1830 Dam.

Disk II: (CDR-666 Mb): A single file disk containing a geo-referenced and reprojected digital image of a 1959 black and white air photo of the Stanhope/Netcong and Lake Musconetcong study area is saved as a GEOTIFF image with embedded coordinate data (NAD83 – UTM) at 1 meter, or ca.3 foot resolution(Robinson Aerial). File compatible with desktop GIS software packages for the extraction of coordinates and dimensions of visible features, such as the route of the Morris Canal through Stanhope.

Disk Set III (DVD-4.16 Gb) & IV (DVD-2.28 GB): Total: 6.44 Gb: Two DVD disks from Naik Prasad Inc. of LIDAR data and results. **Disk III** contains the GPS datum control settings, all LIDAR instrument sets up and control parameters, all raw and color-encoded scan data and all geo-referenced 3D color LIDAR reconstructions and images of the documented historic elements. Rendered 3D CAD and 3D color models are stored in a variety of exportable file formats: *Microstation* CAD *.dwg; STL, *.obj (a common color-encoded 3D modeling file), and as WRL web- friendly files. Four rendered 3D animations, or “fly byes”, of the dam, channel and weir are included as digital AVI files. DVD **Disk IV** includes two 3D viewer programs (*Polyworks-Demo* and *RiView*) to manipulate the raw 3D color and geo-referenced 3D LIDAR scan captures and models. These can be used to explore the site in virtual space from viewing angles and positions which were inaccessible or too dangerous in the field.

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Appendix I

Phase I – End of Field Letter – Access Road Mitigation

JOEL W. GROSSMAN, PH.D.

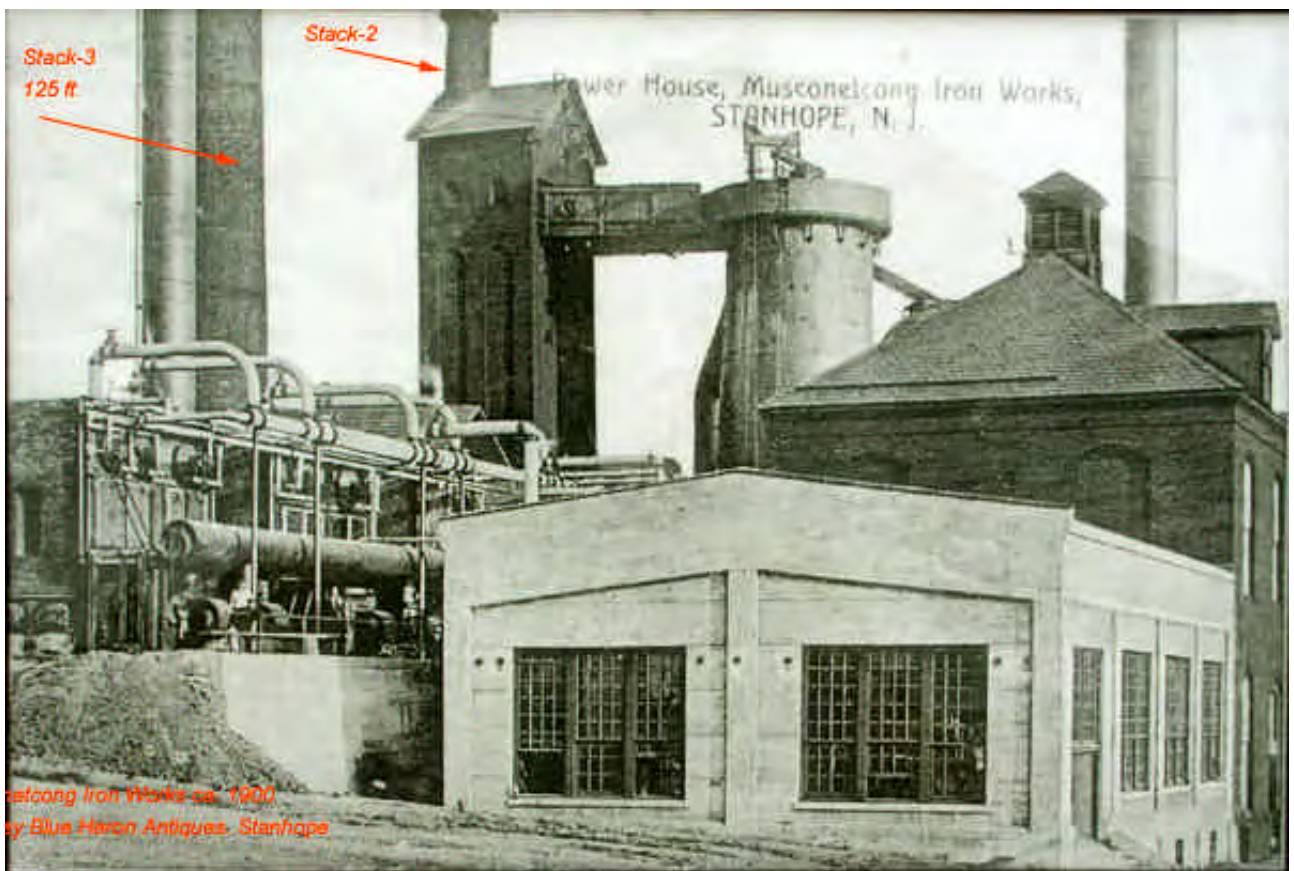
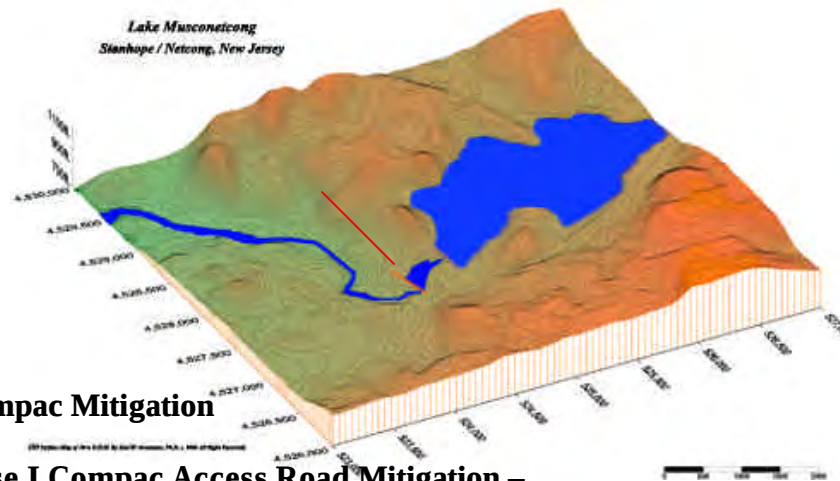
520 WEST 218 ST., APT. 5G
NEW YORK, NEW YORK 10034
TEL: 212 942-3314

November 18, 2003

**TO: Dean DeGhetto
Project Manager
Compac Corporation
Netcong, New Jersey**

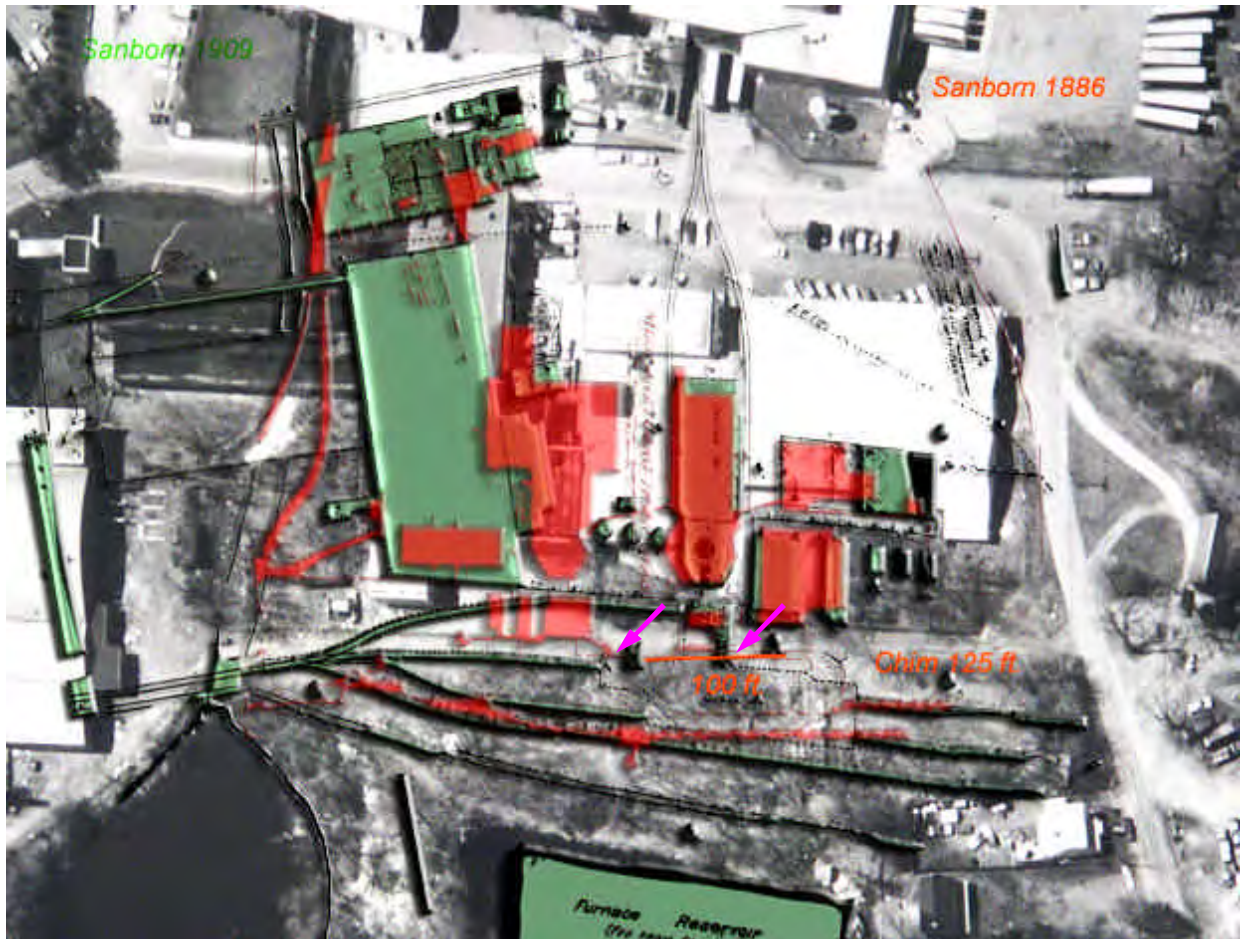
**FROM: Joel W. Grossman, Ph.D.
Principal Investigator, Compac Mitigation**

**RE: End of Field Letter – Phase I Compac Access Road Mitigation –
Task Completion**



INTRODUCTION: I submit this End of Field report on the recently completed fieldwork on the Access (or, "Latex") Road into Compac property and Furnace Pond to substantiate my prior verbal representations that all field tasks and goals have been achieved for this first phase of the two stage scope of work and mitigation plan (Grossman, 2002) as mandated by the NJDEP Office of Historic Preservation and Dam Safety permit stipulations.

2. GIS AND AIR PHOTO BASED HISTORIC FEATURE LOCATION:



The goal of this first Phase I effort was to locate, identify, record and protect with reburial two historic foundation elements, designated Features II and III, belonging to mid nineteenth and early twentieth century foundry smoke stacks. Both will be in jeopardy from impacts due to subsequent heavy equipment construction activities across and within the Access Road which leads into production-critical tanker delivery and construction corridor routes for the Compac dam remediation program.

Both features were located and exposed as planned over a three day field period between Wednesday and Friday, October 29 – 31, 2003. Feature III, designated Stack 3, and consisted of the ca. 1900-1920 base of the third 125 ft. high foundry chimney of the Musconetcong Iron Works. Although only generally dateable from map sources, the recovery of four diagnostic fire bricks with well preserved makers marks will help refine its date of construction. Feature II, described as *Cobble Platform-Stack 2*, consisted of a massive stone and mortar foundation or footer base for the second chimney or associated rectangular stack structure built at the foundry. Both features had been initially identified as key structural elements on two historic Sanborn Insurance maps of the property dating to 1886 and 1909, respectively.

Their actual position was established by scaling two Sanborn Insurance maps as digital layers over a digitally enlarged subsection of a 1986 air photo of the site. The original 1"=800 air photo was initially enlarged photographically to a scale of 1"=300 ft. by Robinson Aerial of Morristown,

New Jersey. This print was then digitally enlarged to a scale of ca. 1"=60 ft. (1":58.8 ft – actual) as a 14 Mb image file by Joel W. Grossman and then overlaid as color coded digital copies of the 1886 and 1909 insurance maps. From this composite, the location and distance between each feature was measured on the ground and targeted for machine and manual exposure. Both features were located and exposed within five feet of their projected historic map-based locations.

3. FEATURE EXPOSURE AND DEFINITION



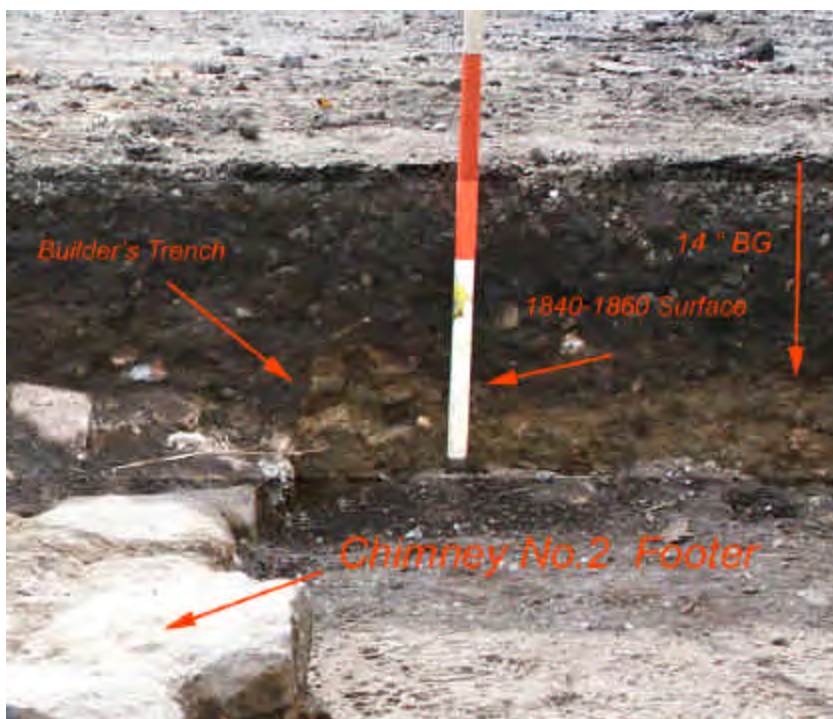
Half of the first feature, **Feature III – Stack 3**, the base of the 125 ft. circular brick and fire brick stack had survived as a surface outcrop in the road. The western half of the chimney base had been previously destroyed by unrelated remediation activities within the last 15 to 20 years. Enough of its form was exposed and recorded to reconstruct its original diameter and construction.



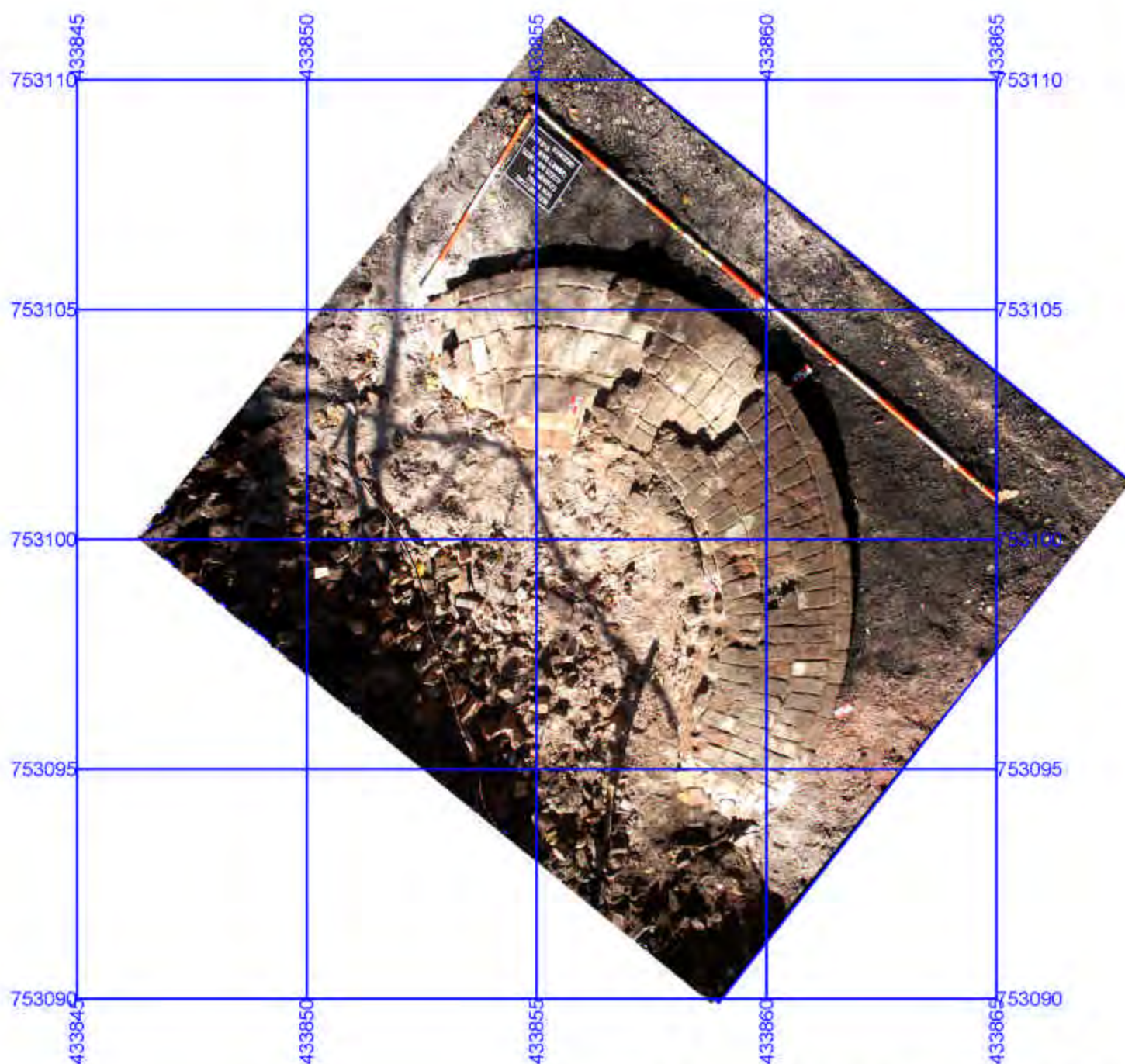


The second feature, **Feature II – Cobble Platform - Stack 2**, consisted of a large rectangular stone boulder and mortar foundation matrix exposed within the Access Road at a depth of 14 inches below grade. Approximately $\frac{1}{4}$ to $\frac{1}{2}$ of its original size was exposed in a ca. 10 by 15 ft wide-area trench, sufficient to document its original size, shape and orientation.

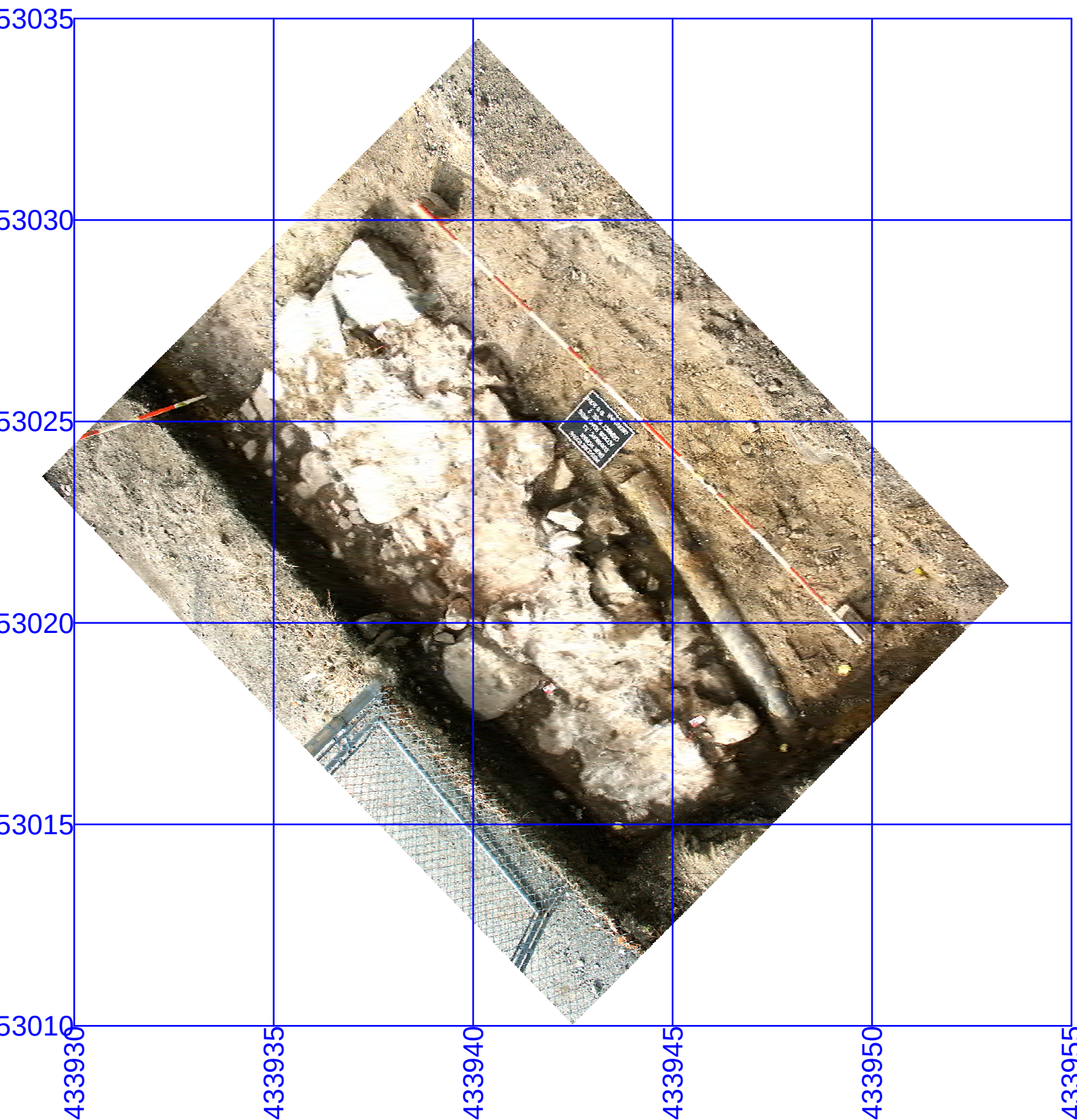
The stone footer platform was oriented ca 6 – 8 degrees off access with the modern road alignment, but parallel to the orientation of the post-1840 stone retaining wall which separated the lower foundry from the Morris Canal and spur to the foundry's reservoir above it.

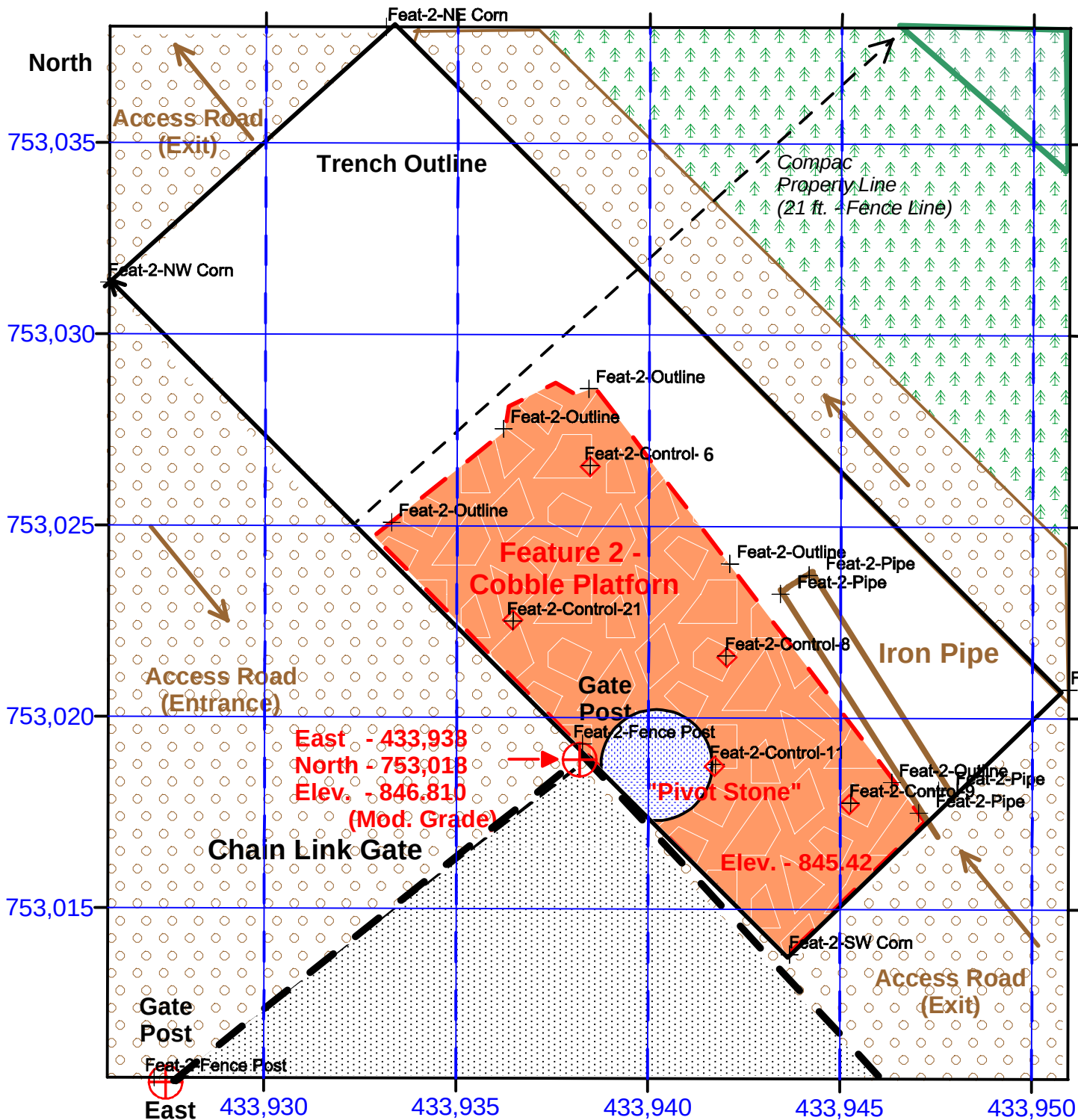


Compac Access Road -Georeferenced Feature 3 - Chimney 3
New Jersey State Plane Coordinate System - NAD83



Compac Access Road- Feature 2 -Stone Platform-
New Jersey State Plane Coordinate System
Geotiff - NAD 83





Feature 2 - Cobble Platform Plot of Total Station Data Compac Corporation Stanhope/Netcong, New Jersey

By Joel W. Grossman, Ph.D.
November 8, 2003

Coordinates & Elevations

East	North	Elev.	Point id
433938.467	753026.586	845.406	Feat-2-Control-06
433941.750	753018.78	845.419	Feat-2-Control-11
433936.462	753022.521	845.712	Feat-2-Control-21
433942.013	753021.617	845.422	Feat-2-Control-8
433945.266	753017.784	845.289	Feat-2-Control-9
433927.149	753010.571	846.810	Feat-2-Fence Post
433938.283	753019.314	846.934	Feat-2-Fence Post
433933.298	753025.09	845.169	Feat-2-Outline
433936.206	753027.541	845.723	Feat-2-Outline
433938.425	753028.593	845.762	Feat-2-Outline
433942.108	753024.026	845.421	Feat-2-Outline
433946.342	753018.317	845.229	Feat-2-Outline
433933.126	753038.042	846.508	Feat-2-NE Corn
433943.689	753013.818	846.813	Feat-2-SW Corn
433925.926	753031.35	846.543	Feat-2-NW Corn
433950.943	753020.742	846.578	Feat-2-SE Corn
433943.427	753023.240	844.727	Feat-2-Pipe
433944.168	753023.729	844.733	Feat-2-Pipe
433947.045	753017.524	844.670	Feat-2-Pipe
433947.564	753018.112	844.733	Feat-2-Pipe



Feet



NAD 83
NGVD 29

**Phase I Compac Corporation Archaeological Mitigation
Edited Total Station Survey Data
Surveyed 11-01-03 JWG**

<u>East</u>	<u>North</u>	<u>Elev.</u>	<u>Label</u>	<u>Description</u>
Datums				
433,539.065	752,991.289	818.729	Station-3011	AA-Datum-3011
433,647.975	753,228.052	831.286	Station-3012	AA-Datum-3012
433,679.898	753,282.516	834.657	Station-3013	AA-Datum-3013
Access Rd -Ret. Wall				
433,782.087	753,166.164	841.779	ACCESS-GATE	Access Rd. Gate Post
433,795.409	753,179.373	841.518	ACCESS-GATE	Access Rd. Gate Post
433,728.157	753,261.166	838.717	BW	Access Rd-BRW
433,744.053	753,241.323	838.528	BW	Access Rd-BRW
433,778.092	753,202.142	840.669	BW	Access Rd-BRW
433,802.126	753,176.185	842.976	BW	Access Rd-BRW
433,718.699	753,271.795	839.672	TW	Access Rd-TRW
433,745.600	753,241.289	843.078	TW	Access Rd-TRW
433,768.699	753,213.848	843.614	TW	Access Rd-TRW
433,802.563	753,180.255	845.814	TW	Access Rd-TRW
Fence				
433,629.659	753,131.634	823.636	FENCE	Chain Link Fence
433,634.794	753,112.615	822.185	FENCE	Chain Link Fence
433,690.413	753,205.179	832.950	FENCE	Chain Link Fence
433,711.527	753,184.296	833.450	FENCE	Chain Link Fence
433,739.080	753,208.570	838.395	FENCE	Chain Link Fence
433,807.581	753,136.357	843.597	FENCE	Chain Link Fence
433,889.100	753,051.015	846.643	FENCE	Chain Link Fence
434,060.975	752,893.947	850.835	FENCESOUTH	Chain Link Fence
Mod. Comp Blds.				
433,615.520	753,094.249	821.923	COMP-ENT	Comp. Bld-N Door
433,624.365	753,102.108	821.918	COMP-ENT	Comp. Bld-N Door
433,691.142	753,164.787	823.473	COMP-NEMETA	Comp. Bld-NE Corner-Metal Bld.
433,584.033	753,065.217	820.376	NWCORN-COMP	Comp. Bld-NW Corner-Brick
433,676.434	753,151.439	822.495	COMP-NEBRIC	Comp. Bld-NW Corner-Brick
433,710.455	753,144.083	824.520	COMP-METSE	Comp. Bld-SE Corner-Metal Bld.
Feature 2				
433,938.467	753,026.586	845.406	PLAT2-6	Feat-2-Control-6
433,941.750	753,018.780	845.419	PLAT2-11	Feat-2-Control-11
433,936.462	753,022.521	845.712	PLAT2-21	Feat-2-Control-21
433,942.013	753,021.617	845.422	PLA2T-8	Feat-2-Control-8
433,945.266	753,017.784	845.289	PLAT2-9	Feat-2-Control-9
433,927.149	753,010.571	846.810	PLAT2-POST-	Feat-2-Fence Post
433,938.283	753,019.314	846.934	PLAT2-POST-	Feat-2-Fence Post
433,933.298	753,025.090	845.169	PLATOUT	Feat-2-Outline
433,936.206	753,027.541	845.723	PLATOUT	Feat-2-Outline
433,938.425	753,028.593	845.762	PLATOUT	Feat-2-Outline
433,942.108	753,024.026	845.421	PLATOUT	Feat-2-Outline
433,946.342	753,018.317	845.229	PLATOUT	Feat-2-Outline
433,933.126	753,038.042	846.508	PLATOUT-NE	Feat-2-NE Corn
433,943.689	753,013.818	846.813	PLATEX-SW	Feat-2-SW Corn
433,925.926	753,031.350	846.543	PLATOUT-NW	Feat-2-NW Corn
433,950.943	753,020.742	846.578	PLAT-SE	Feat-2-SE Corn

433,943.427	753,023.240	844.727	PLATPIPE	Feat-2-Pipe
433,944.168	753,023.729	844.733	PLATPIPE	Feat-2-Pipe
433,947.045	753,017.524	844.670	PLATPIPE	Feat-2-Pipe
433,947.564	753,018.112	844.733	PLATPIPE	Feat-2-Pipe
Feature 3				
433,861.512	753,096.566	845.807	CH3-11	Feat-3-Control-11
433,858.821	753,099.533	845.754	CH3-21	Feat-3-Control-21
433,860.197	753,102.903	845.783	CH3-6	Feat-3-Control-6
433,854.559	753,105.680	845.420	CH3-8	Feat-3-Control-8
433,856.156	753,102.629	845.540	CH3-9	Feat-3-Control-9
433,849.033	753,092.758	846.386	EX-CENTPOST	Feat-3-Excav. Outline-Cent-FPost.
433,854.379	753,110.601	845.575	EX-NE	Feat-3-Excav. Outline-NE Corn.
433,842.118	753,100.256	845.728	EX-NE-POST	Feat-3-Excav. Outline-NE FPost
433,868.150	753,096.611	845.940	EX-OUT-SE	Feat-3-Excav. Outline-SE Corn.
433,855.726	753,085.661	846.385	EX-POSTSW	Feat-3-Excav. Outline-SW FPost.
433,852.386	753,105.262	844.896	CH3-OUTLINE	Feat-3-Outline
433,854.557	753,102.179	844.752	CH3-OUTLINE	Feat-3-Outline
433,857.523	753,100.747	845.623	CH3-OUTLINE	Feat-3-Outline
433,857.699	753,104.933	845.593	CH3-OUTLINE	Feat-3-Outline
433,858.266	753,098.453	844.946	CH3-OUTLINE	Feat-3-Outline
433,858.281	753,094.835	844.897	CH3-OUTLINE	Feat-3-Outline
433,860.264	753,094.040	845.378	CH3-OUTLINE	Feat-3-Outline
433,861.589	753,099.469	845.791	CH3-OUTLINE	Feat-3-Outline
433,861.603	753,099.455	845.792	CH3-OUTLINE	Feat-3-Outline
Topo				
433,530.850	753,018.346	818.950	FURNRD-TOPO	Topo
433,535.289	753,045.741	818.710	FURNRD-TOPO	Topo
433,536.224	752,995.093	818.869	FURNRD-TOPO	Topo
433,552.087	753,075.189	819.339	FURNRD-TOPO	Topo
433,558.034	753,025.758	818.874	FURNRD-TOPO	Topo
433,558.310	753,013.724	819.176	FURNRD-TOPO	Topo
433,560.186	753,007.705	819.301	FURNRD-TOPO	Topo
433,562.241	753,038.814	819.043	FURNRD-TOPO	Topo
433,583.934	753,076.236	820.799	FURNRD-TOPO	Topo
433,596.752	753,145.378	822.856	FURNRD-TOPO	Topo
433,621.164	753,135.344	823.993	FURNRD-TOPO	Topo
433,621.347	753,184.164	826.571	FURNRD-TOPO	Topo
433,653.601	753,186.827	828.931	FURNRD-TOPO	Topo
433,666.214	753,193.197	830.433	TOPO	Topo
433,676.342	753,204.760	832.765	TOPO	Topo
433,681.725	753,200.012	831.714	TOPO	Topo
433,682.036	753,231.611	832.909	FURNRD-TOPO	Topo
433,686.623	753,191.031	833.490	TOPO	Topo
433,693.978	753,207.620	834.921	TOPO	Topo
433,699.801	753,209.320	835.492	TOPO	Topo
433,701.477	753,264.658	834.262	FURNRD-TOPO	Topo
433,706.289	753,173.317	835.622	TOPO	Topo
433,706.924	753,191.390	836.524	TOPO	Topo
433,714.609	753,220.984	835.082	TOPO	Topo
433,724.214	753,181.433	838.036	TOPO	Topo
433,730.885	753,198.458	837.272	TOPO	Topo
433,816.769	753,152.930	843.319	ACCESSTOPO	Topo
433,822.581	753,129.455	844.418	ACCESSTOPO	Topo
433,879.072	753,069.363	846.620	ACCESSTOPO	Topo
433,936.834	753,039.942	846.570	ACCESSTOPO	Topo
433,965.589	752,996.272	846.908	ACCESSTOPO	Topo
434,016.453	752,963.031	847.334	ACCESSTOPO	Topo
434,044.601	752,916.226	849.226	ACCESSTOPO	Topo
434,073.717	752,903.627	849.892	ACCESSTOPO	Topo

Appendix II

Index of Rolleimetric Images



001-Dam Profile.tif



002-Dam-Profile.tif



009-Dam.tif



010-Dam.tif



011-Dam.tif



012-Dam.tif



001-Feat2.tif



002-Feat2.tif



003-Feat3.tif



004-Feat3.tif



005-Feat2.tif



006-Feat3.tif



007-Feat3.tif



008-Feat3.tif



017-Feat2.tif



014-Weir.tif



015-Weir.tif



016-Weir.tif

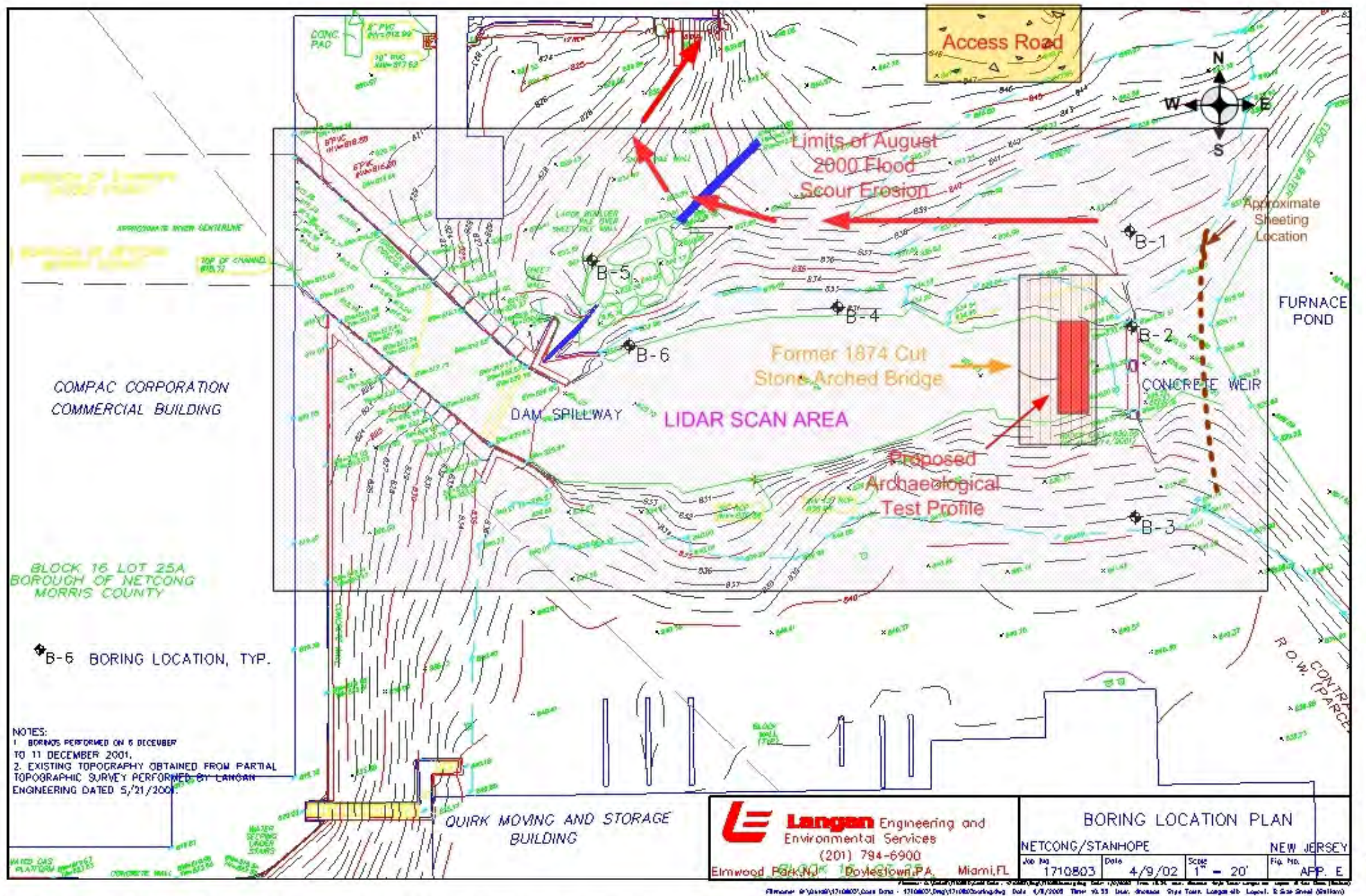


Figure 7. Project Plan of Furnace Pond Falls showing topography, zone of deep flood scour damage, locations of Langan test borings, proposed LIDAR 3D scan area, relocated sheeting plan, proposed N-S archaeological profile cut and former 1874 stone bridge.

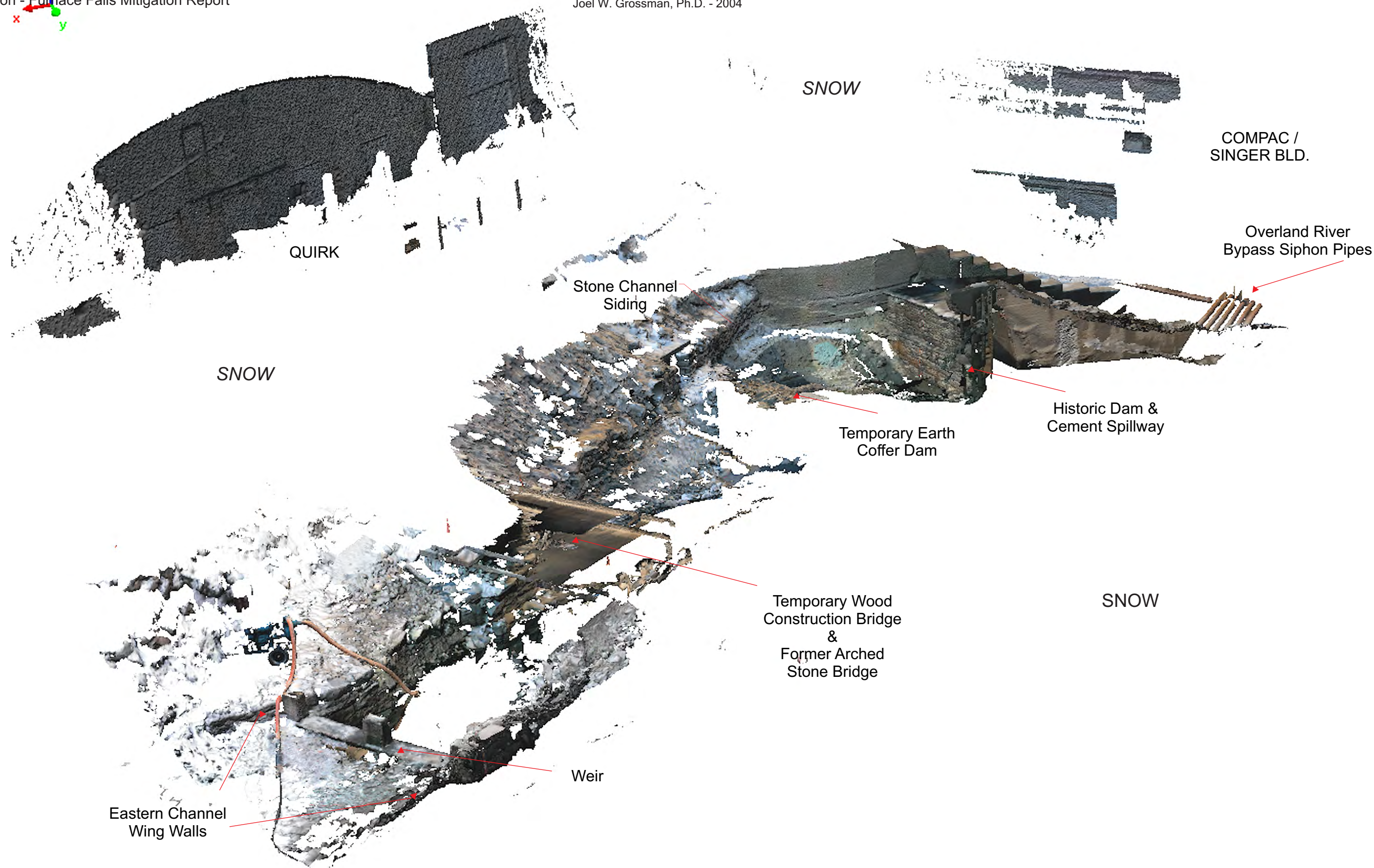


Figure 45: Overhead view, looking south-west, of eleven registered color LIDAR scans of the Furnace Falls channel, weir and Dam-Spillway recorded in six hours on January 21, 2004. Temperature range: 10 - 24 degrees F. Snow was “seen” as white.

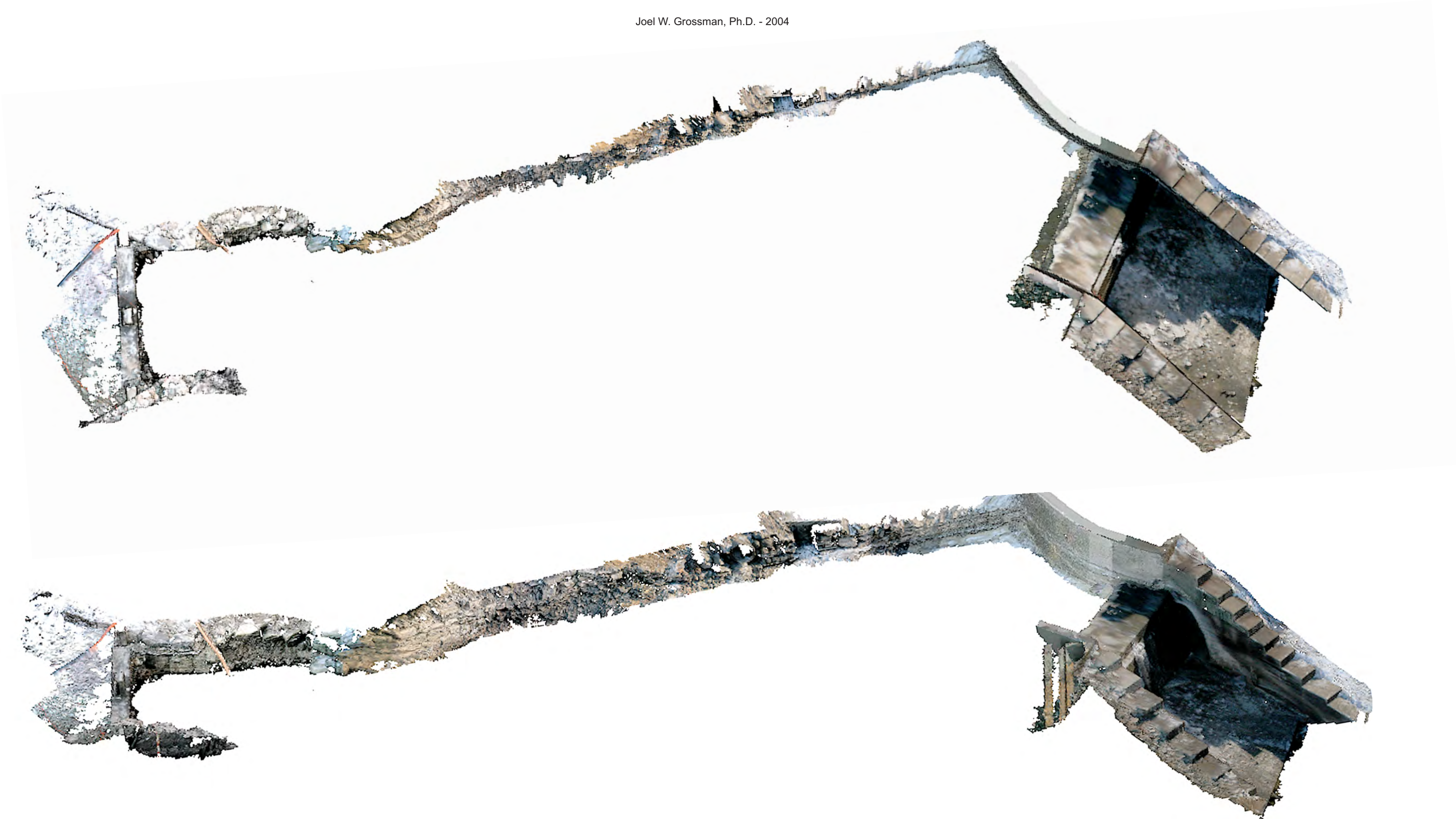


Figure 46: Overhead composite views of nine registered 3D color LIDAR scans of the Furnace Falls channel, weir and Dam-Spillway depicting only surviving historic features



Figure 47: Virtual 3D color LIDAR overhead perspective view looking east at western cement face of Singer Spillway, with southern bank of channel and weir to the rear.

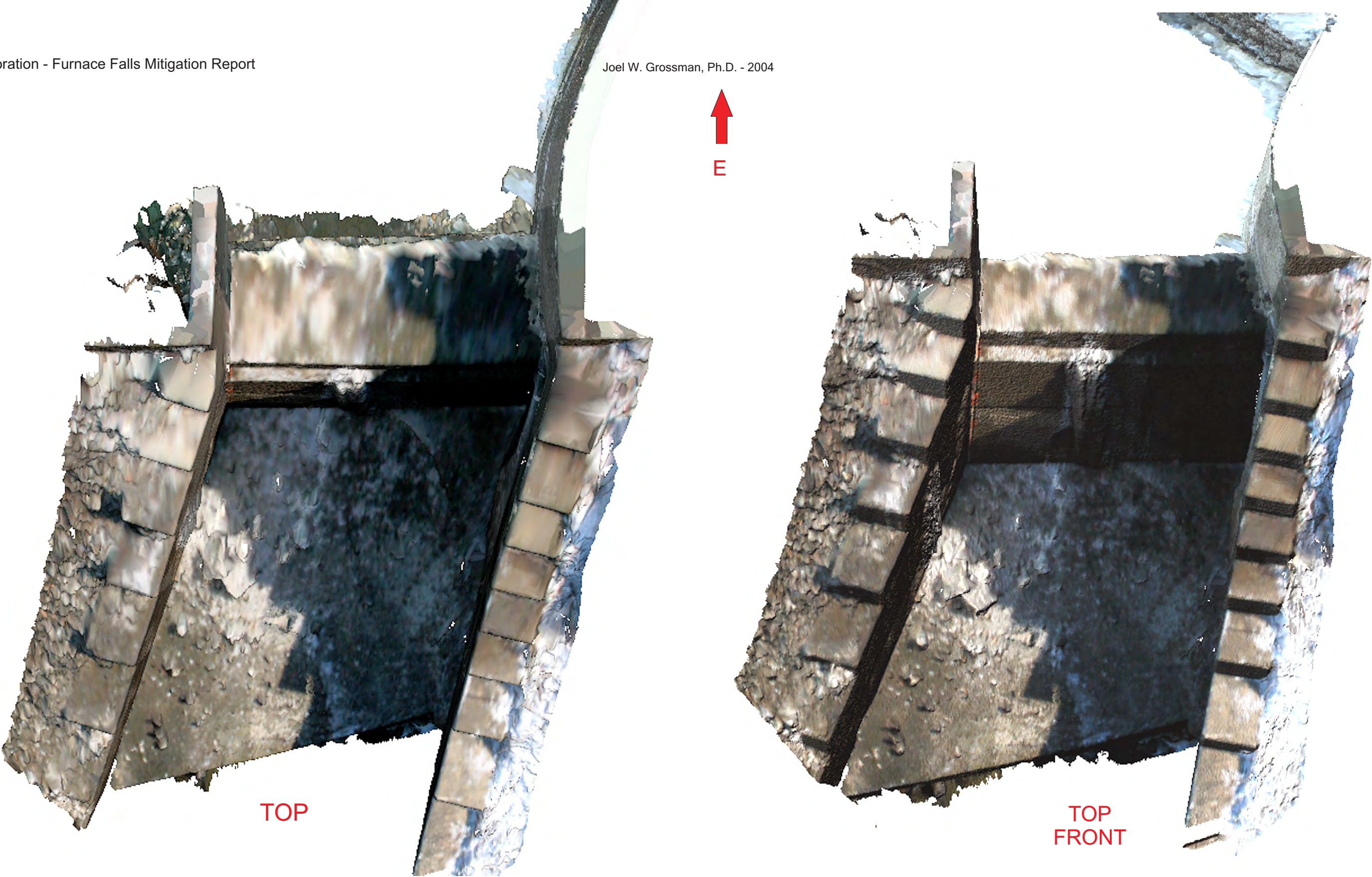


Figure 48: Two virtual 3D overhead views of the top and front (western) face of the recent cement Spillway additions to underlying early 1830 era cut stone dam.

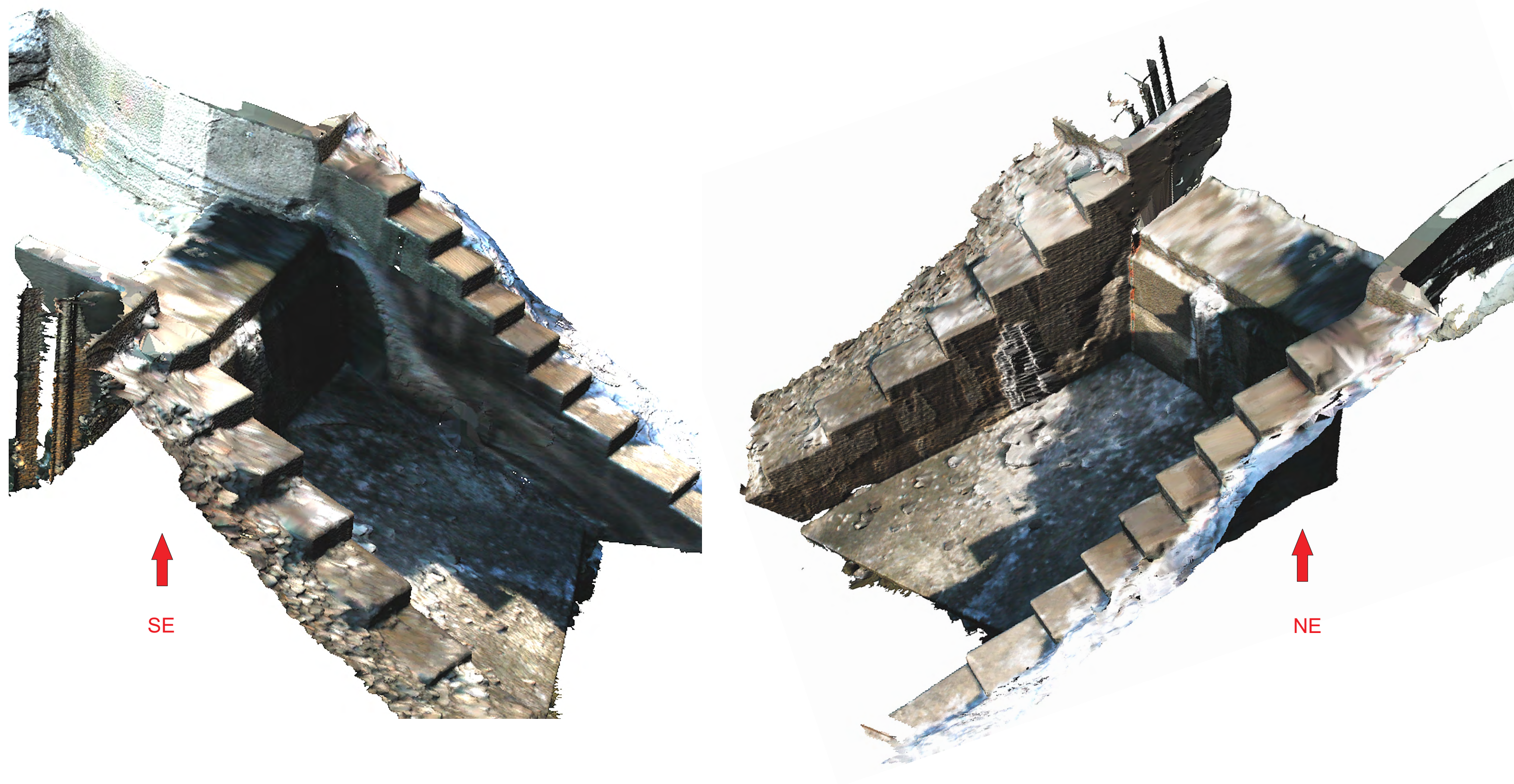


Figure 49: Two virtual overhead 3D color LIDAR scans looking southeast (left) and northeast (right) at the top and front (western) face of the most recent cement Spillway.

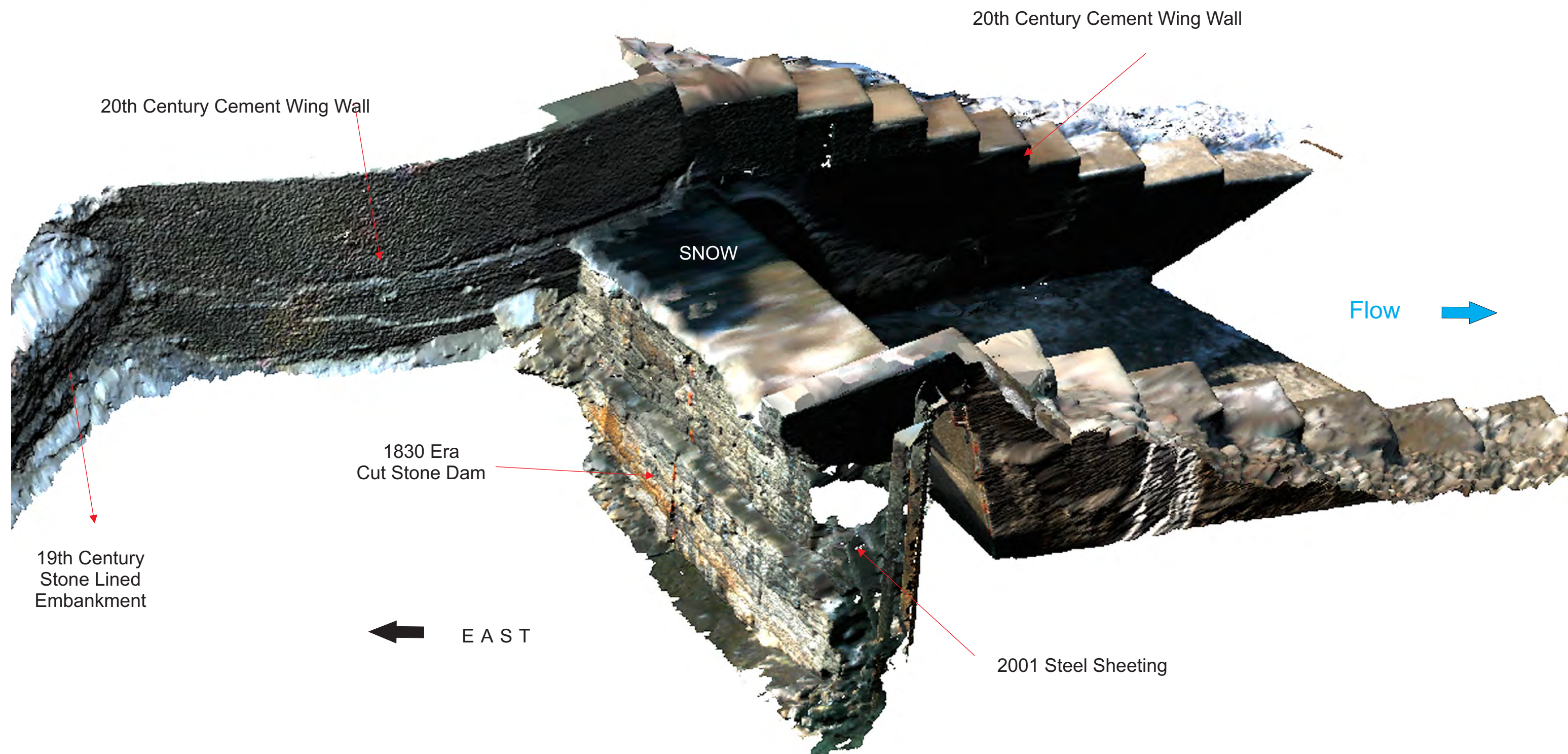


Figure 50: Virtual 3D Color LIDAR birds eye view of partially exposed historic Furnace Falls Dam, looking southwest and down from 50 ft., at its eastern cut stone face, later covered by 20th century cement cladding and cut into by cast cement wing walls.

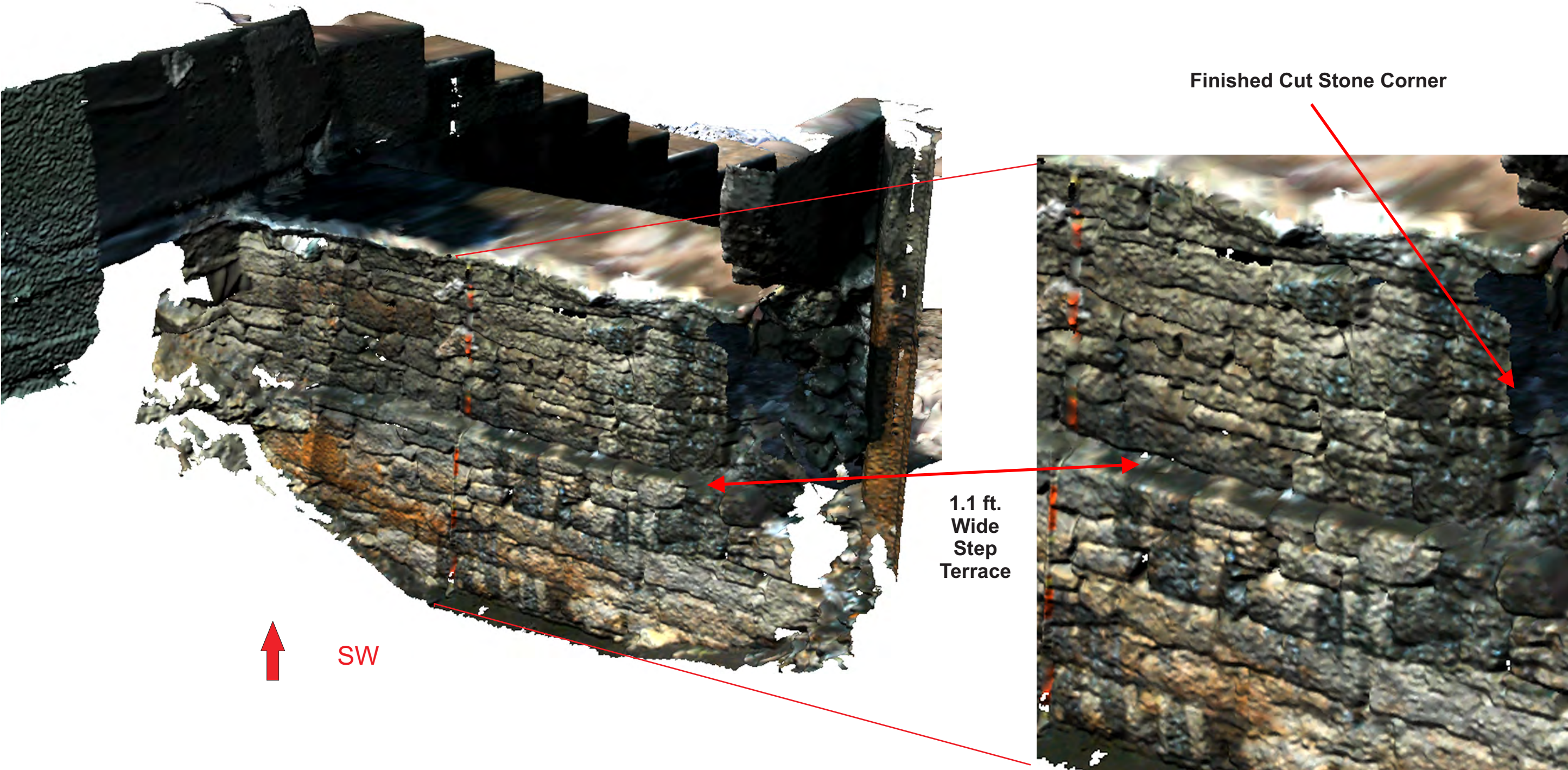


Figure 51: Virtual 3D color LIDAR perspective, looking south-west, highlighting finished northeast cut stone corner of historic Furnace Falls Dam. Although disturbed by the construction trenches and cement work of the later wing walls, the finished edge suggests a former, early 19th century, sluiceway to the north of the recently removed cement Spillway. The ability to “reinvestigate” the site in geo-referenced 3D color space provided otherwise unavailable access and proximity to areas of the dam too dangerous to approach during the excavation.

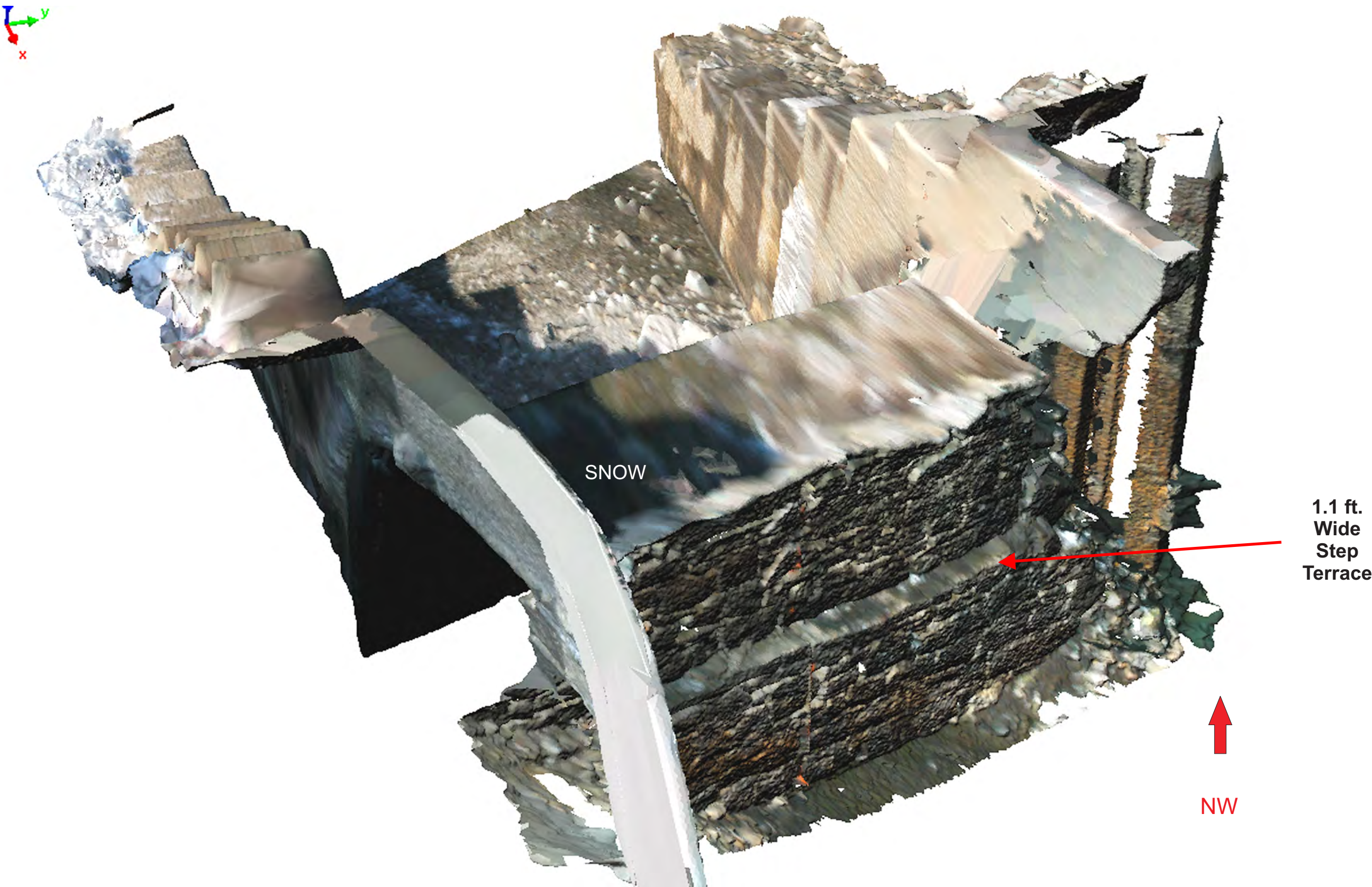


Figure 52: 3D color LIDAR view looking northwest at exposed eastern cut stone face of historic Furnace Falls Dam showing 1.1 ft wide step terrace 6 feet below the top of the spillway.

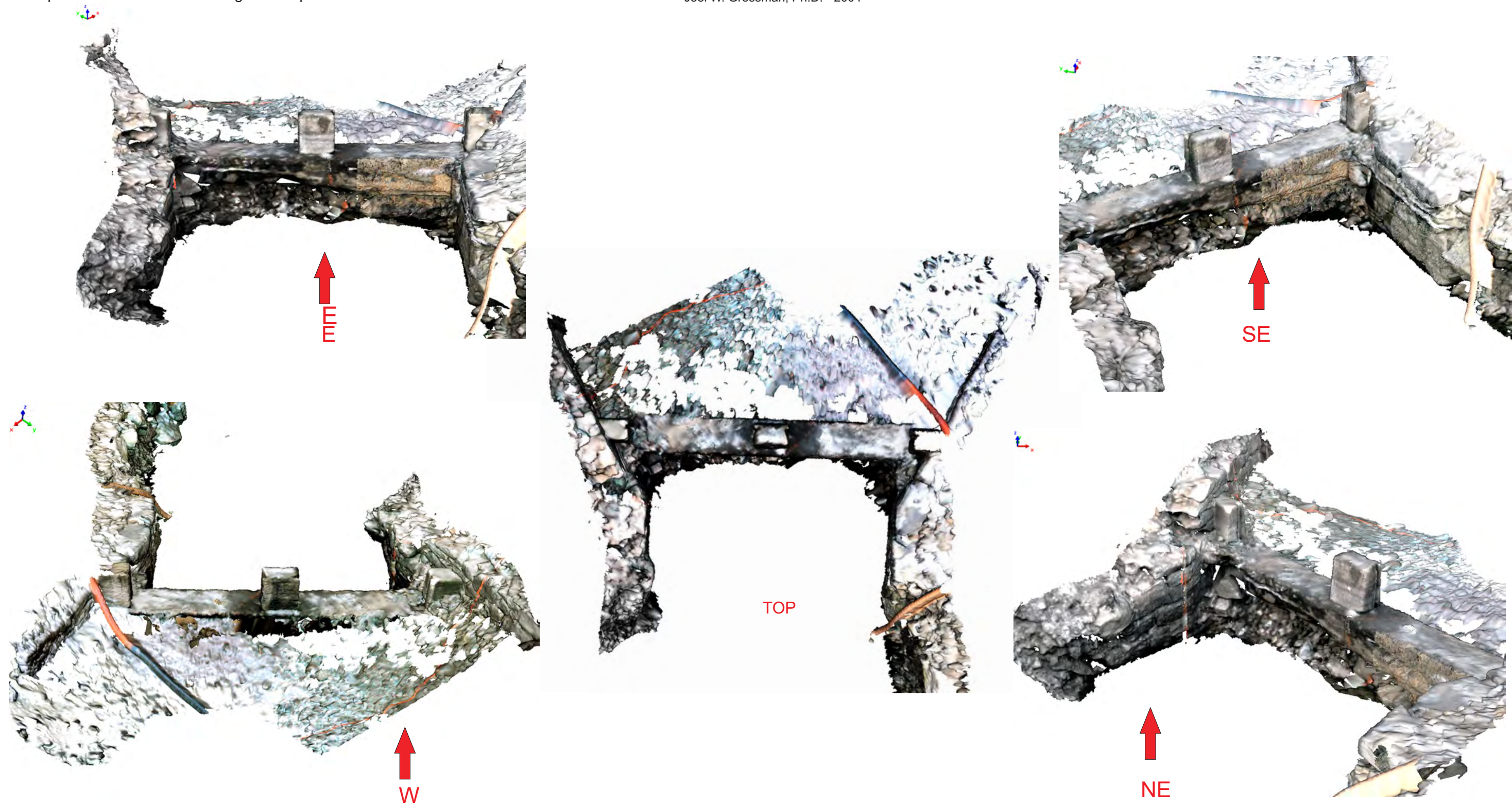


Figure 53: 3D color LIDAR scans of post-1927 cement Weir and earlier, 1874, cut stone wing walls of former arched bridge at Furnace Falls Pond.

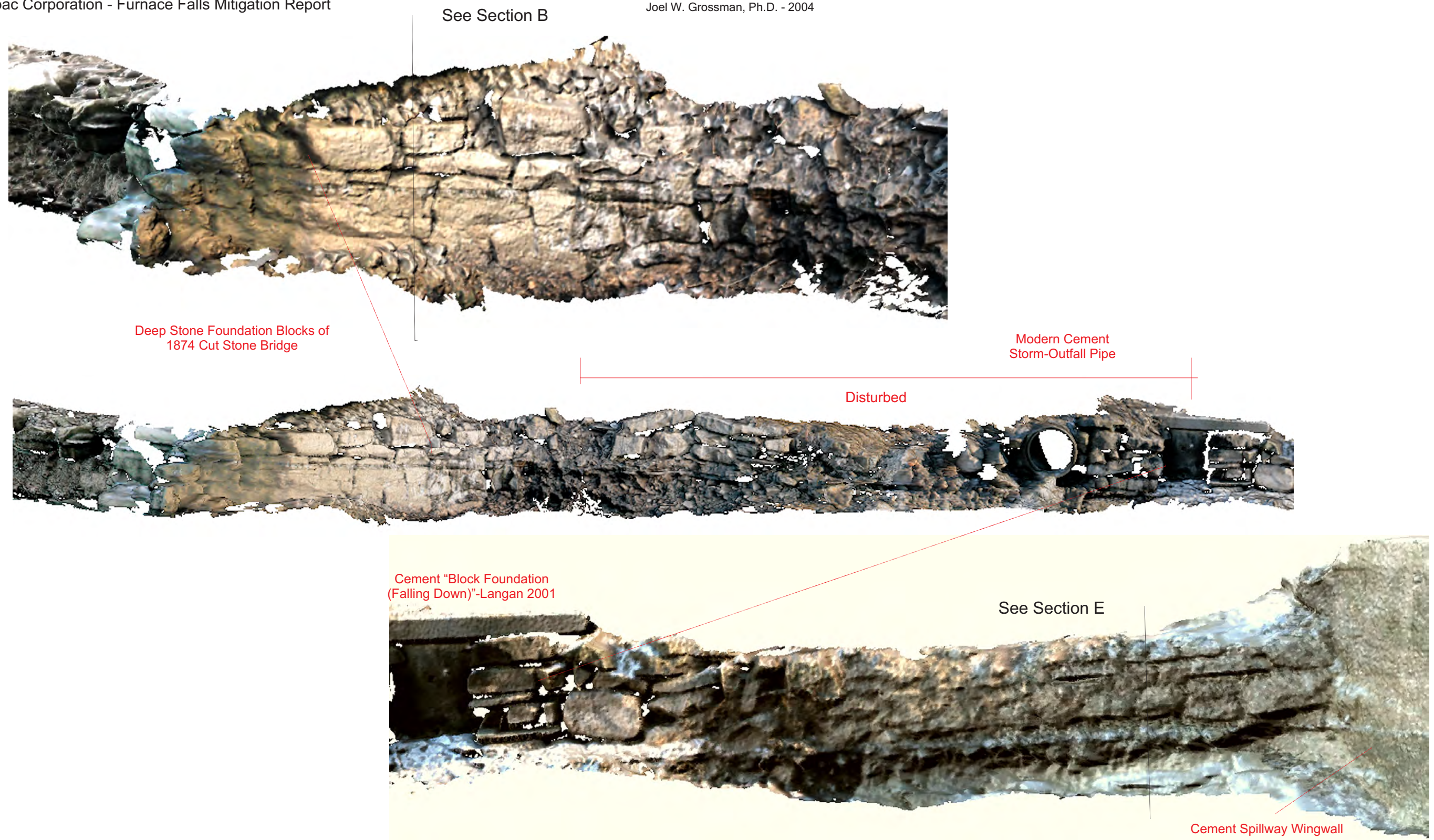


Figure 54: 3D color LIDAR scans of three sections of the south embankment of Furnace Falls channel: 1) The eastern end (top), near the former 1874 cut stone bridge, contained large, seven foot deep, stone blocks of the former bridge abutment between elevations 827 and 835+ feet. 2) The center section was disturbed by modern, ca. 1960, intrusions associated with the installation of a storm sewer outfall pipe and cast cement utility box. 3) The western 30 ft. section (right), adjacent to the cement Spillway wing wall, consisted of a three-course, five foot high, line of cut stone blocks between elevations 828 and 834 ft.



Figure 31: Rolleimetric film-based macro flat field photograph of southern profile of Furnace Falls Dam exposed to 11 feet (el: 819 ft.) below lip of spillway(@ 830 ft.). Note imbedded calibration marks for photogrammetric image rectification. *Photo by Joel W. Grossman, Ph.D.*

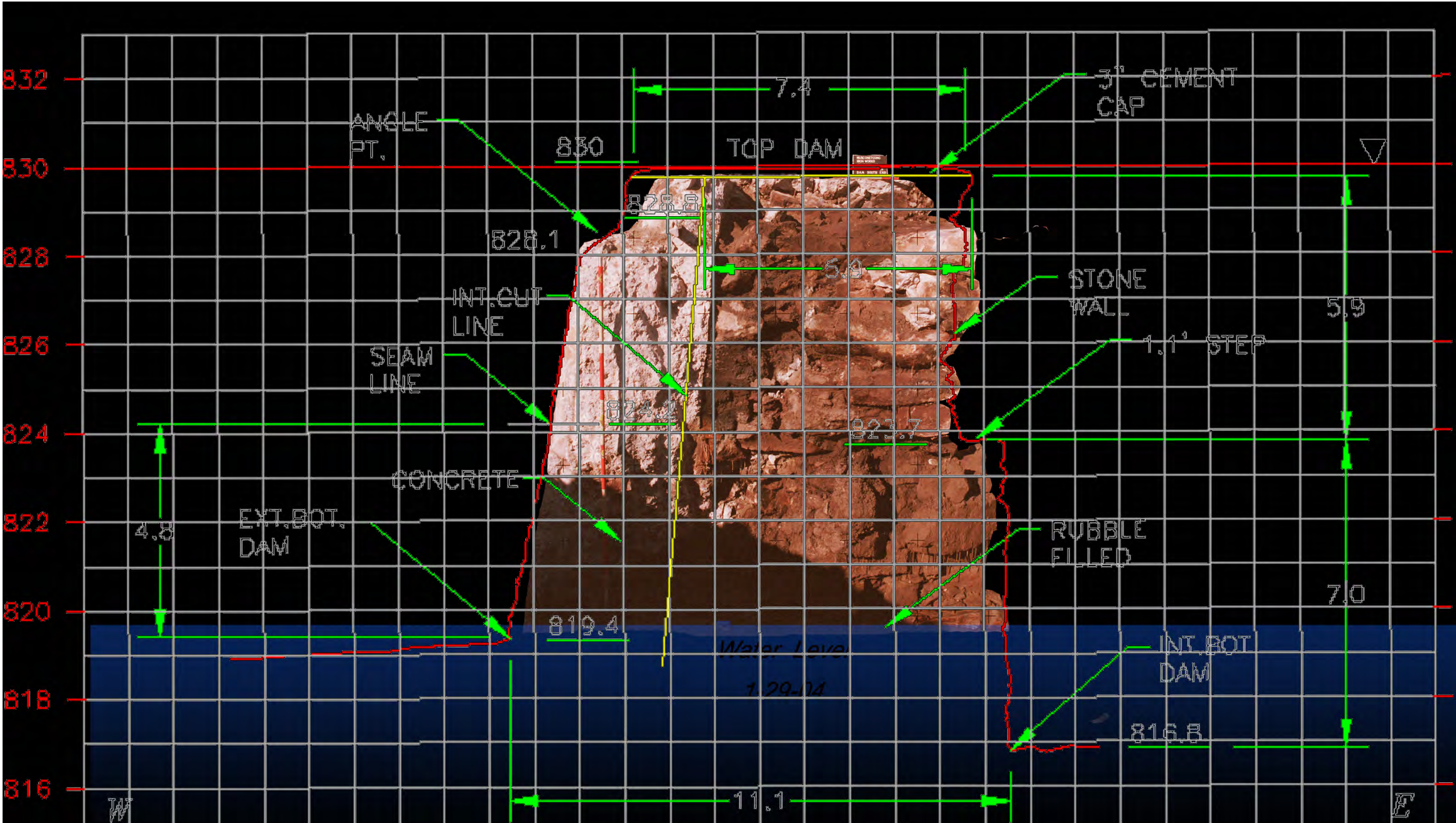


Figure 32: Digital composite of Rolleimetric film-based metric photo of south end of 1830 era cut stone dam, scaled and overlaid onto LIDAR derived elevation and dimension profile measurements relative to water level on January 29, 2004. Rolleimetric photo and composite by Joel W. Grossman, Ph.D. All Rights Reserved c2004.



Figure 27: Panoramic composite, looking west at the exposed eastern face of the 1830 era Furnace Falls dam, taken by integrated, computer controlled, Nikon digital camera mounted on the Riegl LIDAR scanner. The “seamed” digital picture, which shows the scanner’s field of view (what it “saw”), was matched, pixel by pixel, to the 6 mm. precise LIDAR scanner-derived coordinate points, to render the true color 3D data captures of the formerly submerged dam. Overlapping digital photo series were taken with flash after sunset during final LIDAR scan of dam on January 21, 2004. Temperature range: 10 - 14 degrees F.



Figure 26: Digital macro photograph of east facade of Furnace Falls cut stone dam taken with natural light on afternoon of LIDAR scan, January 21, 2004. Note iron oxide stains and lighter band denoting depth of historic channel sediments.

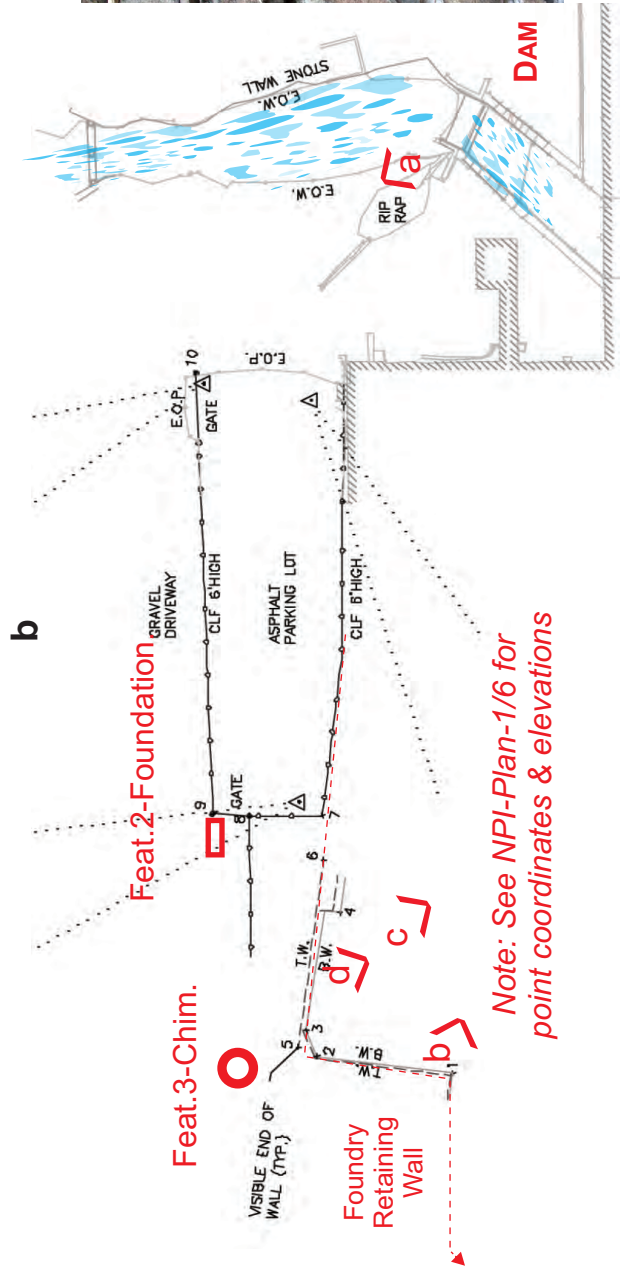
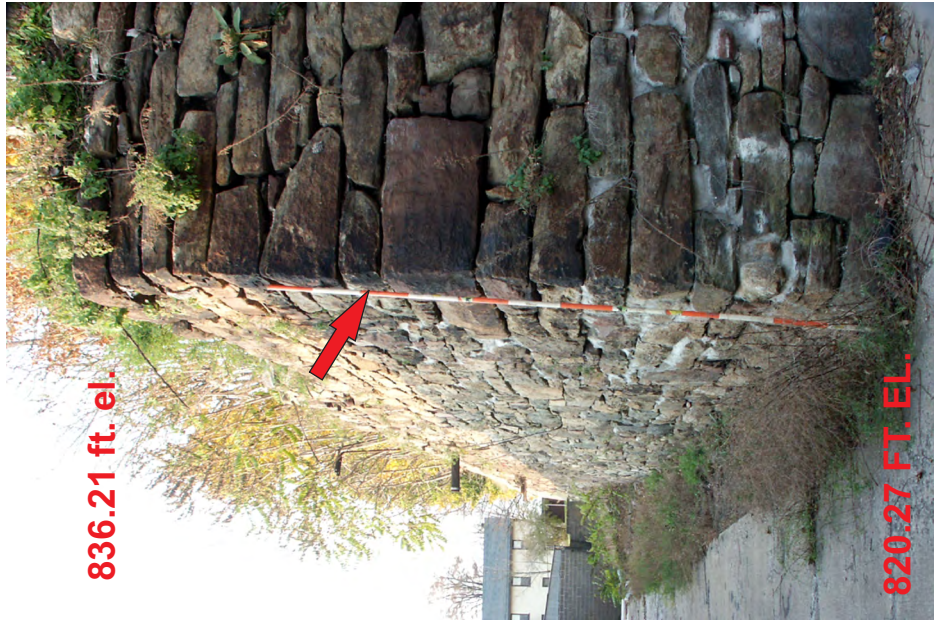


Figure 28: a) Digital photo looking southwest at eastern cut stone face and 6 ft high square finished northeast corner of the cut stone dam suggesting a former lower sluiceway(@ ca 824 ft. el) immediately north of the cement, or Singer, Spillway; b-d) Location map and structural details from the post-1840 Retaining Wall of the Musconetcong Iron Works supporting the Canal Spur Reservoir into the Foundry from the Morris Canal. The masonry of the 16 ft. high Foundry Retaining Wall has dry laid stonework comparable to that encountered in the cut stone dam. Note rust colored iron oxide stains at corner of Retaining Wall from former blast furnaces.



Figure 24: Rolleimetric flat field film image, looking west, at eastern face of Furnace Falls Dam exposed to 16 feet below spillway lip, January 21, 2004. Photo by Joel W. Grossman, Ph.D.

JOEL W. GROSSMAN, Ph.D.

511 West 232 Street, Apt.W43, Bronx, NY 10463 (212) 920-4648 www.GeospatialArchaeology.com jwgnyny@gmail.com

PROFESSIONAL PROFILE:

- **Experienced Educator, Public Speaker and Author:** North American, South American/Andean Archaeology, Environmental Archaeology, Historical Archaeology of the Northeast US/New York, Archaeological Method & Theory, Field and Laboratory Techniques in Archaeology.
- **Strong Research, publication and project management record** in the archaeology, ethnobotany and ethnohistory of Andean South America and the Northeast United States.
- **Internationally recognized** for the innovative planning and mobilization of multi-disciplinary applied technology solutions for logistically challenging archaeological contexts.
- **Expert in the Design and Implementation of training programs** in archaeological field and laboratory methods and the use of geospatial (Historic-GIS) strategies in land use history and historic preservation.
- **Expert in the cultural geography, economic history & human ecology of Dutch New York.**

PROFESSIONAL ACCOMPLISHMENTS& EXPERTISE:

Directed over 30 major archaeological expeditions and emergency rescue field operations (data recovery and mitigation planning solutions) for national and international agencies throughout the US and Latin America.

Directed the archaeological study of early metal technology and the economic origins of non-market Andean highland economies in Peru; early man sites in California and the eastern US, and important 17th, 18th and 19th century Colonial and Civil War-era sites in New York and New Jersey.

Developed multi-agency (NJ Meadowlands Commission, the USEPA, USA Army Corps, New Jersey DEP, and NOAA) environmental management plan based on the innovative use of historic GIS and 3D terrain modeling to project archaeological sensitivity within the now submerged New Jersey Hackensack Meadowlands.

Planned and directed the first archaeological all-weather terrestrial and marine HAZMAT surveys and excavations of chemically and radioactively contaminated "Superfund" sites in North America.

Directed critical large-scale archaeological mitigation projects in New York City-including the discovery of the original 17th Century Dutch West India Company settlement in Lower Manhattan, and New York's first municipal Almshouse under City Hall Park.

Trained international teams in the use of advanced applied technology in archaeological field and laboratory procedures.....in Peru, Mexico, Brazil, the Caribbean, Hungary and Russia.

WORK HISTORY:

Visiting Scholar's Program	PACE UNIVERSITY	2012
Visiting Scholar's Program	NETHERLANDS INSTITUTE OF HERITAGE	2009
Consultant-Dutch Archaeology	MUSEUM OF CITY OF NEW-HENRY HUDSON EXHIBIT	2009
Senior Archaeological Advisor	NJ MEADOWLANDS PLAN, USACE-HUNTER RESEARCH	2005-2006
Archaeological Project Director	EMERGENCY DAM REMEDIATION, STANHOPE, NJ.	2002-2004
Director of Applied Technology	R G A ARCHITECTS AND PLANNERS, INC., N.Y.	1997-2001
President/ Principal Scientist	GROSSMAN AND ASSOCIATES, INC., N.Y.	1986-1996
Principal Archaeologist/Director of New York Office	GREENHOUSE CONSULTANTS, INC.	1982-1985
Founder & Director	RUTGERS ARCHAEOLOGICAL SURVEY OFFICE, RUTGERS	1976-1981

EDUCATION:

Ph.D. University of California, Berkeley; Dissertation: *Early Ceramic Cultures of Andahuaylas, Apurimac, Peru.*

B.A. University of California, Berkeley

AWARDS AND APPOINTMENTS: Fulbright-Special Career, Ford, NSF & OAS-Andres Bello fellowships; elected Fellow-Explorers Club (1999); Institute of Andean Studies; Hudson River Environmental Society; Dutch Visiting Scholars program of the Netherlands Institute of Heritage and invited speaker for the 2009 Quadcentennial Henry Hudson celebrations, Exhibit and Program Advisor in Dutch Archaeology: New Amsterdam History Center; Museum of the City of New York.

LANGUAGES: Spanish

JOEL W. GROSSMAN, Ph.D.

SELECTED PUBLICATIONS & TECHNICAL STUDIES

- 2015 (with Lucille Johnson and Dorothy Peteet) The Archaeology of Little Wood Creek: New Chronometric Evidence. *Archaeology of Eastern North America*, Vol. 43, pp. 173-198
- 2013 The Waywaka Gold: New Chronometric Evidence. *Andean Past*. Vol11, pp123-138. Cornell University Latin American Studies Program, Ithaca, N.Y.
- 2013 A Low Status Late Intermediate Offering Deposit, Andahuaylas, Apurimac Peru. *Andean Past*. Vol11, pp283-290, Cornell University Latin American Studies Program, Ithaca, N.Y.
- 2011 Chapter8: Archaeological Indices of Environmental Change and Colonial Ethnobotany in 17th Century Dutch New Amsterdam. In: *The Environmental History of the Hudson River: Human Uses that Changed the Ecology, Ecology that Changed Human Uses*. pp.77-122. Ed. Robert E. Henshaw. State University of New York Press, Albany, NY.
- 2010 (By Tamara Stewart with editorial input by JWG-Highlights Dr. Grossman's Superfund work at West Point Foundry) "Excavating Hazardous Sites", Vol.14, No.1, pp38-42. *American Archaeology*, Albuquerque, NM, Spring 2010.
- 2008a [Future of Archaeology in 21st Century: Human-Landscape Interactions](#). In: *Encyclopedia of Archaeology*. Pearsall, D. (ed.). Vol.2, pp.1458-1476. Elsevier/Academic Press, Oxford, England. Vol.2, pp.1458-1476.
- 2008b [Inter-Regional Studies: Archaeology of Toxic and Hazardous Environments](#). In: *Encyclopedia of Archaeology*. Pearsall, D. (ed.). Vol.3, pp.2134-2156. Elsevier/Academic Press, Oxford, England.
- 2006 [Cultural Resource Investigation of Ten Sites in the Hackensack Meadowlands Restoration Project, Hudson and Bergen Counties, New Jersey](#). Prepared for the US Army Corps of Engineers, Region II, New York by Hunter Research with contributions and recommendations by Joel W. Grossman, Ph.D. and Dorothy Peteet, Ph.D., Lamont Doherty Earth Observatory. Contract No. DACW51-01-D-0018 Delivery Order No.0046.
- 2004 The Archaeology of Furnace Falls: A Mitigation Report on the Use of GIS, GPS & LIDAR for the Definition and Documentation of Furnace Falls Dam, Spillway, Weir & Channel. Prepared for the NJDEP & Compac Corporation, Netcong, NJ, NJDEP Acc.No.MULTC541a.
- 2003 From Raritan Landing to Albany's Riverfront: The Path Toward Total 3D Archaeological Site Recording. In Fisher, Charles, Ed. *People, Places and Material Things: Historical Archaeology of Albany, New York*. Chapter 15: Battles and Breakthroughs. New York State Museum Bulletin 499, pp.167-186. The University of The State of New York, The State Education Department, Albany, NY.
- 2002 Joint Engineering and Archaeological Mitigation Plan for the Furnace Falls Pond Dam, Weir, Spillway and Channel, Stanhope/Netcong Morris and Sussex Counties, New Jersey. Prepared for Compac Corporation, Netcong, New Jersey. September 1, 2002. NJDEP Acc.No.MULTC541.
- 1997 Applied Technology in Archaeological Investigation. U.S. Army Environmental Center, Aberdeen Proving Ground, Maryland, 139 pp.
- 1996a Archaeological and Historical Sensitivity Evaluation of the U.S. Radium Facility—Tasks 1, 2, 3, 4 & 9, City of Orange, Essex County, New Jersey. Draft Final Report—Revision II Prepared for Malcolm Pirnie, Inc. & USEPA: Subcontract No. ARCS-C-018. September, 1996.
- 1996b The Prehistoric and Historic Archaeology of West Branch Dam #1, Carmel, New York: Stage 1A/1B Findings and Recommendations. Prepared for John G. Waite Associates for the New York DEP as part of the West Branch Dam Remediation, February, 1996.
- 1995 "Historic and Cultural Resources" in Draft Environmental Impact Statement on the Special Area Management Plan (SAMP) for the Hackensack Meadowlands District, NJ. Prepared for CDM, the USACE, NOAA, USEPA, NJDEP and the Meadowlands Commission. June 1995.
- 1994a "High Caliber Discovery", *Federal Archaeology*. Vol.7, No.2 pp.38-43, Summer 1994.
- 1994b The Role of Espionage and Foreign Intelligence in the Development of Heavy Ordnance at the West Point Foundry, Cold Spring, New York. In: *Look to the Earth: The Archaeology of the Civil War*. C. Geier, Editor, University of Tennessee Press.
- 1994c Hackensack Meadowlands Archaeological and Historical Sensitivity and Impact Evaluation, Vols. I-II. Prepared as part of the Multi-Agency Special Area Management Plan (SAMP) for the USACE, NOAA, USEPA, NJDEP and the Meadowlands Commission

JOEL W. GROSSMAN, Ph.D.

- 1994-1978 "Archaeology: The Western Hemisphere," Annual Review of New World Discoveries. Editor/ Author, Encyclopedia Britannica Yearbook (Chicago).
- 1993a Stage II Archaeological Data Recovery and Mitigation Results of the Investigation of the Historic Coal Gasification Works at the Niagara Mohawk Power Corporation site, Saratoga Springs, Saratoga County, New York. Prepared for the Niagara Mohawk Power Corporation and the USEPA, Region II.
- 1993b The Archaeology and Economic History of the Civil War Era Workers' Housing Complex at West Point Foundry, Cold Spring New York. (Grossman et al.). USEPA and USACE, Region II, New York, NY.
- 1992a A Stage I Archaeological and Historical Sensitivity Evaluation of Foundry Cove and the Cold Spring Waterfront [GIS, marine geophysics and sub-bottom sedimentation & trace element coring of Foundry Marsh], USEPA, Region II.
- 1992b Stage IA Archaeological and Historical Sensitivity Evaluation of the Hackensack Meadowlands, New Jersey. Prepared for the Hackensack Meadowlands Development Commission, NJDEP & USEPA.
- 1991a The Archaeological Discovery and Excavation of R.P. Parrott's Civil War Era Gun Testing Facility at West Point Foundry. Prepared for the USEPA, Region II.
- 1991b "The Buried History of City Hall Park: The Initial Archaeological Identification, Definition and Documentation of Well-Preserved 18th Century Deposits and the Possible Structural Remains of New York City's First Almshouse." NYC Department of General Services, New York, NY.
- 1991c Excavation and Analysis Results of Archaeological Investigations at Medianía Alta (L-23) and Vieques (L-23), Loiza, Puerto Rico. Puerto Rico Aqueduct and Sewer Authority (PRASA), San Juan, P.R.
- 1991d Stage IA Cultural Resource Survey of the Montclair, West Orange and Glen Ridge Study Areas, New Jersey. [U.S. Radium Dump Area Superfund investigation], CDM Federal Programs Corporation & USEPA Region II.
- 1990 The Excavation, Analysis and Reconstruction of Transitional Period, Late Woodland Period, and Colonial Occupations at the Little Wood Creek Site, Fort Edward, Washington County, New York. USEPA and the Washington County Sewer Authority, USEPA Proj.-C36-1305-01.
- 1987 The Waterfront of Colonial New York: An Intensive Archaeological Sensitivity Study of Potential Surviving Archaeological Remains within the Defined South Ferry Development Parcel. Prepared for the Zeckendorf Corporation, New York, NY. Vol. I: 76pp, Text & Plates; Vol. II: Map Reconstructions & Geospatial Survivals.
- 1985 The Excavation of Augustine Heerman's Warehouse and Associated 17th Century Dutch West India Company Deposits: The Broad Financial Center Mitigation Final Report. 3 vols., Prepared for the Landmarks Preservation Commission, New York, New York, by Greenhouse Consultants, Inc.
- 1983 Demographic Changes and Economic Transformations in the South Central Highlands of Pre-Wari Perú. *Nanpa Pacha*, Number 21, pp.45-126. Institute of Andean Studies, Berkeley, California.
- 1982a Seeing Underground: the Feasibility of Archaeological Remote Sensing in Coastal and Highland Peru. Prepared for the Instituto Nacional de Cultura, Lima, Peru. UNESCO, OAS, & the Andres Bello Fund.
- 1982b Raritan Landing: The Archaeology of a Buried Port. Rutgers Archaeological Survey Office, New Brunswick, New Jersey. Prepared For the USEPA-Region II and the Middlesex County Sewer Authority.
- 1980a Defining Boundaries and Targeting Excavation with Ground-Penetrating Radar: the Case of Raritan Landing. *Environmental Impact Assessment Review*, Vol.1, No.2, Plenum Publishing Corporation
- 1980b The Status and Potentials of Predictive Surveys in New Jersey. In: *New Jersey State Plan for Historic Preservation*. Trenton: State Historic Preservation Office.
- 1977 (with David A. Fredrickson) A San Dieguito Component at Buena Vista Lake, California. *The Journal of California Archaeology*, Vol.4., No.2. Pp.173-190.
- 1972 An Ancient Gold Worker's Tool Kit. *Archaeology*, Vol.25, No4, pp.270-275.

JOEL W. GROSSMAN, Ph.D.

RECENT INVITED CONFERENCE PAPERS

- 2013 "Early Foods and Medicines of 17th Century New Amsterdam: Cross-cultural Plant Population Exchange and Environmental Change in the Lower Hudson Valley". Invited paper for the *Ecology of New York City: Organisms, Environment and History* conference. Sponsored by the Columbia University Seminar on Population Biology. Columbia University, New York. April 20, 2013.
- 2010 "The Archaeology of Environmental Change in the NY/NJ Harbor Estuary." Sponsored by the *Hudson River Foundation* in cooperation with the *New York/New Jersey Harbor Estuary Program*. New York, NY. March 24, 2010.
- 2009a "Archaeological Indices of Environmental Change and Colonial Ethnobotany in 17th Century Dutch New Amsterdam". Hudson River Environmental Society (HRES) Conference: *Environmental History of the Hudson River*. Hyde Park, New York. November 6, 2009, Peekskill, New York. (SUNY Press) 2009b
- 2009b "New Insights into the Material Culture of 17th century New Amsterdam". Invited paper for the conference. "Four Centuries of Dutch-American Relations, Sponsored by AWAD (the Atlantic World and the Dutch), the Netherlands Institute for Heritage, and the National Archives of Holland, Amsterdam. October 15-16, 2009.
- 2009c "History vs. Natural Disaster: Applied Geospatial Solutions for Emergency Discovery and Documentation in Archaeology". Long Island GIS Users Group, Brookhaven National Laboratories, Brookhaven, New York May.
- 2008 "The Colonial Cartography and Buried Landscape of 17th Century New Amsterdam." Invited paper before the Annual Meeting of the North East Map Organization (NEMO), Chester, Vermont. June 5-6, 2008.
- 2007 "Archaeology, Technology and Environmental Change". Invited paper before the UN-NGO Workshop: "From the City to the Countryside: Climate Change Impact on the Beijing Olympics and Climate Impact on Rural Development". 60th Annual UNDPI/NGO Conference: "Climate Change :How It Impacts Us All," 5-7 September 2007. United Nations, New York