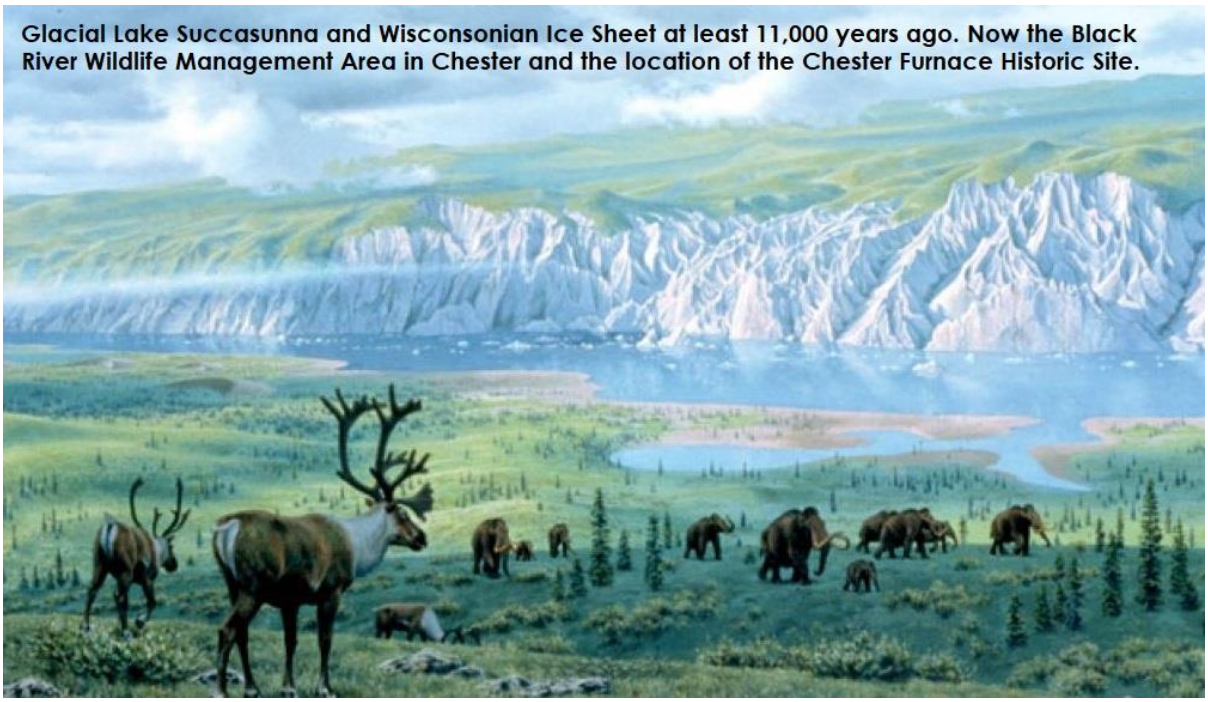
The History of the Chester Furnace Historic Site

Edward Ng – Chester Historical Society

Welcome to the Chester Furnace Historic Site. Whether you are physically walking the trails or viewing the video by Bruce Clark and Alex Louie, I want to give you additional information which will hopefully make your experience more meaningful and further spur your curiosity. Why was the Chester Furnace built here? That is a fascinating story and you should be able to answer that question by reading this article and walking the trails.

1. The Setting. The Furnace Historic Site is in the Black River Wildlife Management Area (BRWMA) which has quite a history. During the last ice age (11-85 thousand years ago), the Wisconsonian ice sheet did not get as far south as Chester and helped create glacial Lake Succasunna which would have encompassed the Furnace Site[1]. The ten-mile-long lake extended northeasterly from the current location of the Cooper Mill. Just as the BRWMA is relatively flat and marshy, so was the area around Lake Succasunna. The caribou and wooly mammoths in the artist's depiction[2] below are long gone, but the impact of another inhabitant remain - the Lenape. Research reported in 2021 show that humans were in the White Sands National Park, New Mexico, 21,000-23,000 years ago[3]. The abstract states: *The These findings confirm the presence of humans in North America during the Last Glacial Maximum, adding evidence to the antiquity of human colonization of the Americas and providing a temporal range extension for the coexistence of early inhabitants and Pleistocene megafauna*. It is reasonable to visualize the Lenape in this scene on the shores of Lake Succasunna.



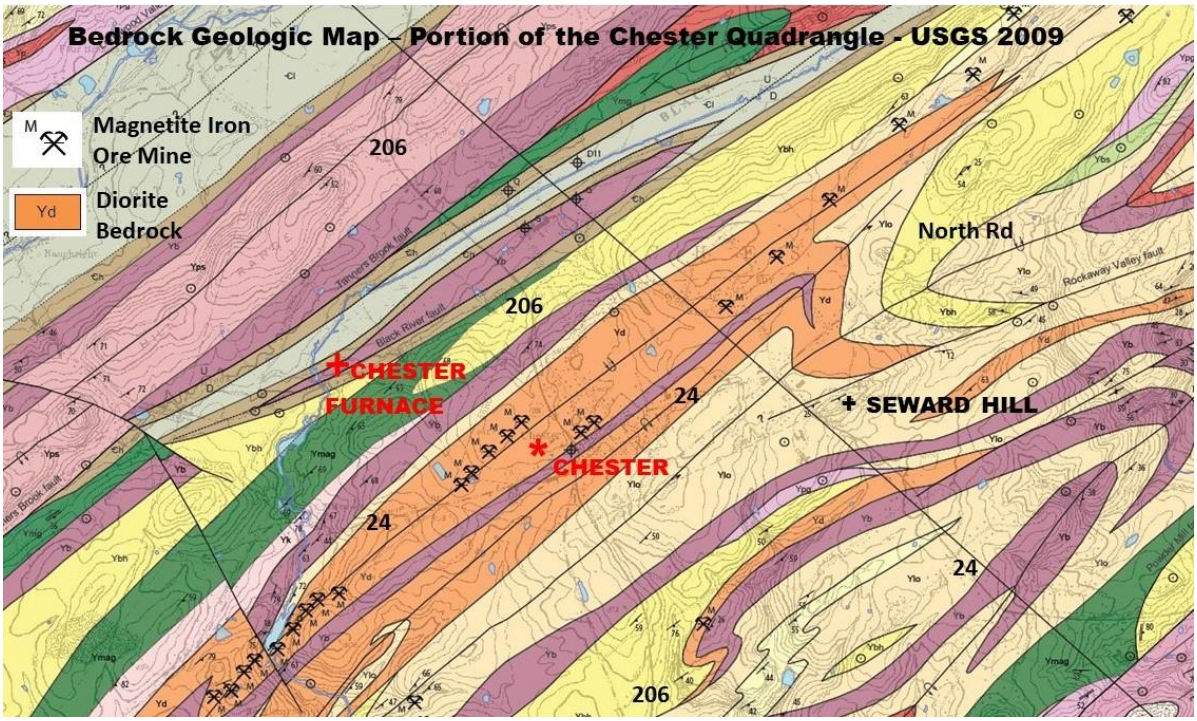
Glacial Lake Succasunna and Wisconsonian Ice Sheet at least 11,000 years ago. Now the Black River Wildlife Management Area in Chester and the location of the Chester Furnace Historic Site.

[1] Puffer, John. "The Pleistocene (Ice Age) of Chester, New Jersey". *November 2021 Chester Historical Society News & Views.*
[2] Environmental Stewards, Rutgers University. 2012. "The Glacial Geology of New Jersey – Lecture Notes".
[3] Bennett, Matthew R. et al. 2021. "Evidence of humans in North America during the Last Glacial Maximum". *Science* **373**, 1528

The history of the Lenape since their arrival in New Jersey is meticulously recounted in Herbert C. Kraft's encyclopedic book, *The Lenape-Delaware Indian Heritage - 10,000 BC to AD 2000,* published in 2001. He provides copious supporting evidence that the Lenape were in New Jersey during the last ice age. Frances Greenidge, in her book *Chester, New Jersey – A Scrapbook of History – 1713-1971*, writes about the Lenape history in and around Chester. She reports that thousands of Lenape arrowheads and hundreds of spears, tomahawks, axes, drills, hoes, grinding and polishing stones, pendants, and pottery pieces were found on Chester farms and fields. She noted that due to disease and disruption from European settlers, many Lenape left for other lands in New York and Pennsylvania. She also noted that their name for the river now in BRWMA was "Allamatunk" meaning "black rock bottom" or "black earth bottom" which the early settlers adapted and adopted calling their village, "Black River". It was not until 1799 when the current name was made official when the Township of Chester was created by separating from the Township of Roxbury.

Greenidge also noted that the "Great Roads" were based on Lenape trails. They bisected Chester, brought commerce, travelers, and helped export Chester's agricultural products. One of the Great Roads ran between Sussex and New Brunswick which was the furthest inland point on the Raritan River that large ships could travel to land their cargo, so that road was called the "Landing Road". The other Great Road connected Elizabethtown (the first capital of New Jersey now Elizabeth) in the east and Phillipsburg in the west. Part of this road is Chester's Main Street.

In 1867 there was a remarkable discovery on Main St., just a couple of miles from the future Furnace Site. Perry Skellenger, while digging an ice-house behind his buildings at 2 and 11 Main St. found "a block of black rock" which he recognized as iron ore[4]. A vein of iron ore was soon identified, running behind the buildings on Main St. all the way to North Road. The Chester iron boom was born.

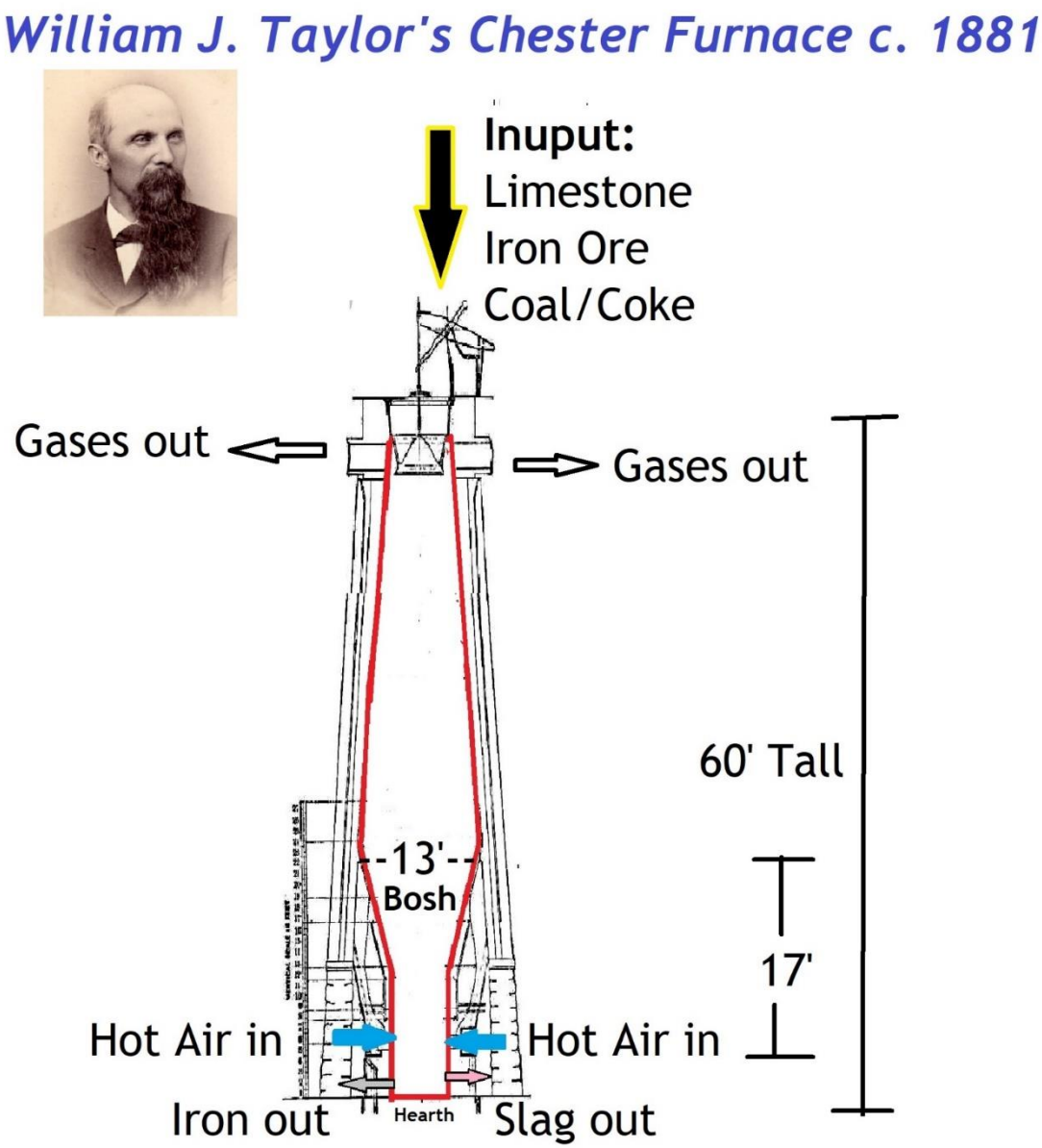


After the Civil War, the US economy expanded greatly. Iron metal was critical to many of the tools, machines, and structures powering the economy and for many years afterwards. Iron

[4] Tuttle, Joseph F. 1876. *The Annals of Morris County*

ore was the critical feedstock. Chester was blessed with seams of iron ore mostly in the form of magnetite which could be found in the diorite bedrock which trans versed Chester in a southwest to northeast direction encompassing Main St.. The USGS Bedrock map above shows the diorite bedrock punctuated by over 20 mines. The most common type of Chester ore was magnetite. The iron in magnetite is composed of three iron atoms bound to four oxygen atoms (Fe_3O_4). There are two major challenges to converting the ore to metal. The first challenge was how to remove the four oxygen atoms from the magnetite to yield metallic iron, Fe. The second challenge was that even the rich Chester iron ores were only 50-60% Fe and there were many unwanted impurities such as sand and sulfur compounds, mixed in with the ore.

The solution to the two challenges was the blast furnace. First used in the 15th century and by the 1870's had undergone 400 years of improvements. Basically, a blast furnace is a tall, irregular cylinder, lined in fire-brick. The top of the cylinder has mechanisms to allow raw materials to drop in and a fire-brick hearth at the bottom. There are small openings above the hearth to allow blasts of hot air to enter called "tuyeres" and opening(s) at the top to allow gases out. Below the tuyeres are openings or taps, just above the hearth, to allow molten iron to flow out and openings or taps above the iron taps to allow lighter waste, slag, to flow out.



2. The Chester Furnace. One of the most advanced blast furnaces of that era was built at the Chester Furnace Historic Site by William Johnston Taylor. We don't have engineering drawings

of the Chester Furnace, but I have used his writings on furnaces and aspects of the Chester Furnace in the drawing above. Taylor was an engineering genius, successful businessman, and a true gentleman[5].

The main part of the blast furnace is a fire-brick lined irregular cylinder which encloses and facilitates the chemical reactions needed to remove the oxygen atoms from the magnetite iron ore and remove other wastes in the ore. In addition to the ore, the reactions require four other inputs: a carbon source, limestone, oxygen, and heat. The carbon for the chemical reaction to remove the oxygen comes from coal and/coke (a form of coal that has been roasted without air and is a contraction of "coal-cake"[6]). Limestone is another critical input. It is not only a source of carbon, but its byproducts react with the ore impurities to form a removable waste material called slag. The two other critical inputs to the chemical reactions are heat from ovens outside the furnace and reactions inside the furnace and oxygen which come from hot air that is blown into the furnace.

The overall process is straightforward: large amounts of very hot air is blown into the bottom of the furnace through the tuyeres and the hot air rises. As the iron ore, coal/coke, and limestone accumulate from the top and travel down, chemical reactions start to occur to remove the oxygen from the iron ore. A great deal of heat is also generated. A molten mixture of those materials collects above the hearth, just below the hottest part of the furnace, called the "bosh". Hot air is forced into and through this molten mass and the chemical reactions to remove the oxygen and impurities occurs with the very high temperatures. Metallic iron is formed, sinks, and pools above the hearth. The ore impurities react with products from the limestone and to form slag which also collects above the hearth, but since slag is lighter than the iron metal, it floats on top. Taps are opened at the level of the slag, and it flows out. Taps are opened at the level of the iron metal, and it flows out to the casting area.

For those interested in the chemistry, here is an overview[7] (s=solid, g=gas, l=liquid)

Oxygen in the air reacts with coke to give carbon dioxide. This reaction also generates heat:

$$C_{(s)} + O_{2(g)} \rightarrow CO_{2(g)}$$

The limestone breaks down to form carbon dioxide:

$$CaCO_{3(s)} \rightarrow CO_{2(g)} + CaO_{(s)}$$

Carbon dioxide produced in 1 + 2 react with more coke to produce carbon monoxide:

$$CO_{2(g)} + C_{(s)} \rightarrow 2CO_{(g)}$$

The carbon monoxide reduces the iron in the ore to give molten iron:

$$3CO_{(g)} + Fe_2O_{3(s)} \rightarrow 2Fe_{(l)} + 3CO_{2(g)}$$

The limestone from 2, reacts with the sand and other impurities to form slag:

$$CaO_{(s)} + SiO_{(s)} \rightarrow CaSiO_{3(l)}$$

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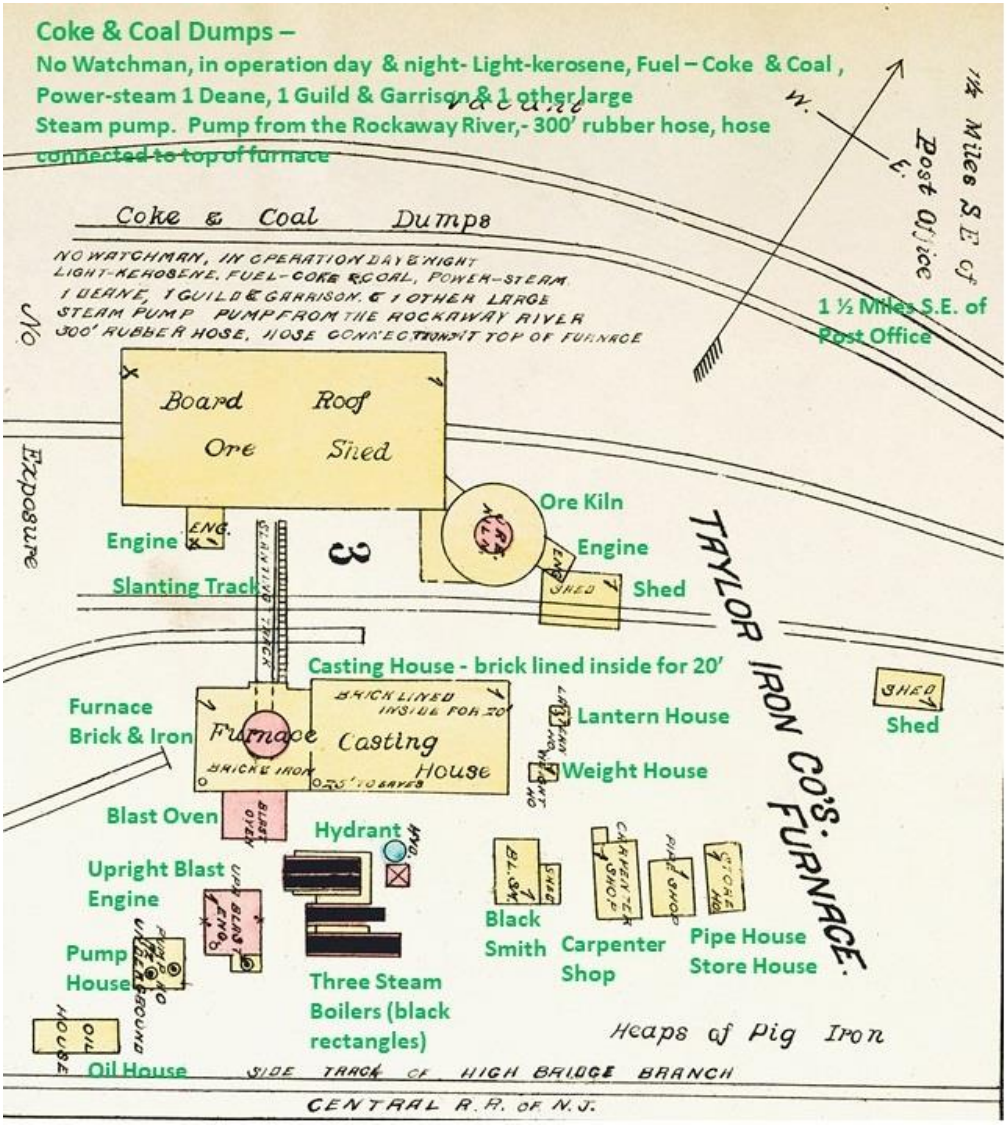
[5] Ng, Edward. 2015. "William J. Taylor and the Chester Furnace". Chester Historical Society News & Views December 2015.

[6] http://www.anselm.edu/homepage/dbanach/h-carnegie-steel.htm

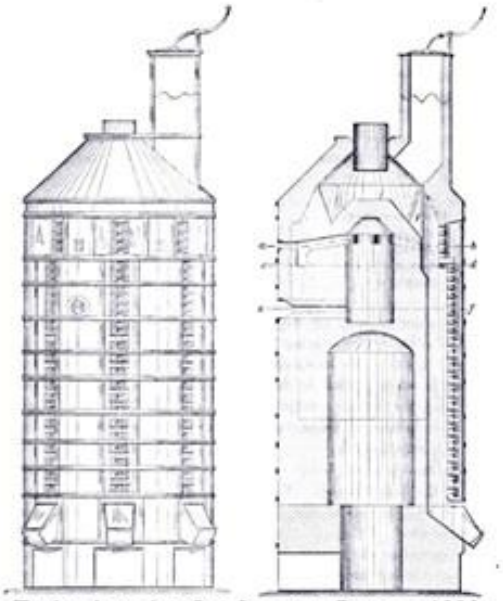
[7] http://www.s-cool.co.uk/gcse/chemistry/extraction-of-metals/revise-it/the-blast-furnace

To better understand the layout of the Chester Furnace Historic Site, we have the benefit of the Sanborn Insurance map which was done in 1886 of the "Taylor's Iron Co.'s Furnace". To provide a more three-dimensional view, the only known image of the Furnace is placed above the Sanborn map. We don't have a date for the photo, but it seems to correspond to the map. I have annotated the Sanborn map in green text to make the map text readable and translate the Sanborn symbols and abbreviations to English. The paragraph under "Coke & Coal Dumps" provides useful information about the site. Using the Sanborn map, we can identify the major elements in the photo. In the center is the wide, cylindrical "Furnace" which is made of "Brick & Iron". It is topped by a platform and machinery to add coal/coke, iron ore, and limestone into the Furnace. The "Slanting Track" can be seen in the photo on the right for carts to transport the materials. On the left side of the Furnace are pipes to capture and convey hot waste gases back to the Furnace. To the right of the Furnace complex is the "Casting House" which is



"Brick lined inside for 20'" and the walls were "25'to the eaves". Molten iron drains from the right side of the hearth of the blast furnace into the Casting House into a sand trough which fed several smaller lateral troughs in a configuration resembling a sow suckling a litter of piglets. Iron produced in this way thus came to be called pig iron[8]. In the photo, to the left of the Furnace and Casting House are three smokestacks which on the Sanborn map corresponds to steam boilers ("1 Deane, 1 Guild & Garrison & 1 other large steam pump"). The boilers are the black rectangles on the map. A steam boiler would have powered the nearby "Upright Blast Engine" which would have blown air into the "Blast Oven" to heat the air before it was blown into the Furnace. On the left side of the Upright Blast Engine was the "Pump House" which pumped water from the "Rockaway River", now named the Black River. A copious amount of water was needed for the steam boilers and to cool the tuyeres and keep them from melting when the furnace was in blast.

In the photo, to the right and above the Furnace stack was the very large "Board Roof Ore Shed". In front and to the right of the Ore Shed was the "Ore Kiln". W.J. Taylor had developed, patented, and published a paper in 1881 on "An Ore Roasting Furnace"[9]. The problem with many Chester iron ores was that they contained almost 5% sulfur compounds which were difficult to remove in the blast furnace process. Taylor and his assistant N.M. Langdon developed an ore roasting process to remove the sulfur from the ore using the kiln shown below left. The desulfurized ore was then stored in the Ore Shed. The ore roasting furnace was so successful that it was not only used at the Chester Furnace, but also sold and used at other furnaces as shown in the ad that appeared in the Bulletin of the American Iron and Steel Association, Vol. 19, 1885. In the photo, the top of the ore roasting furnace can be seen above the Ore Shed.



Taylor-Langdon Ore Roasting Furnace 1880
36' high and 14' outside diameter. Capable of roasting 50 tons/day. (TAME vol 9 1880)

THE TAYLOR-LANGDON

ORE ROASTING FURNACE.

This is the only reliable Furnace or Kiln using gaseous fuel, and it is well known that a thorough roasting and desulphurization of sulphurous iron ores can not be effected with solid fuel. Furnaces now in operation by

W. J. Taylor & Co., Chester Furnace, Chester, N. J.
Phœnix Iron Company, Phœnixville, Pa.
E. & G. Brooke Iron Company, Birdsboro, Pa.
Joseph E. Thropp & Co., Edge Hill Furnace, Edge Hill, Pa.
Chester Iron Company, Hackettstown Mines, Chester, N. J.

These Ore Roasting Furnaces, with the necessary gas producers, will be built by contract, or licenses will be granted to parties desiring to build them themselves. For full particulars address

W. J. TAYLOR, Chester, N. J.

[8] http://www.anselm.edu/homepage/dbanach/h-carnegie-steel.htm

[9] Taylor W.J., 1881. "An Ore Roasting Furnace". *Trans. of the American Inst. Of Mining Engineers*: Vol 9. May 1880 – Feb. 1881

W.J. Taylor published information on the operation of the Chester Furnace for a 20-week run in 1881[10]. As described, the furnace was 60 feet high and the diameter at the top of the bosh (hottest part of the furnace) was 13 feet. The furnace was blown through four tuyeres, each four inches in diameter. The hot air blast was 5480 cubic feet per minute. The blast ovens heated the hot air blast to an average of 760 degrees Fahrenheit. The average temperature of the gases escaping from the top of the furnace was 416 degrees Fahrenheit. Though we don't have measurements for the Chester Furnace, temperatures in the bosh would rise to 3000-degrees Fahrenheit[11]. The melting point of iron is 2800 degrees Fahrenheit.

Over the 20-week period in 1881, the average production was 34 tons of iron per day. The fuel used was about 90 percent coal and 10 percent coke. Each ton of iron produced required 1.24 tons fuel. The amount of limestone used was 0.91 tons per ton of iron. Since the yield per ton of iron from the iron ore was 47.8%, each ton of roasted iron ore required 2.59 tons of coal/coke and 1.90 tons of limestone.

The Feb. 2, 1884, Dover based Iron Era newspaper reported that even better production was achieved several years later – 43.4 tons iron production per day!

The Chester furnace of W.J. Taylor & Co., 13x60, reached an output last week of 304 tons, exceeding its usually good weekly average of 290 tons. This is probably the best work ever done in a furnace of this size with anthracite fuel. The ores used were three-quarters Chester sulphury ores which previous to going into the blast furnace were roasted in the Taylor-Langdon Ore Roasting Furnace. The iron made from these ores is very strong and tough, and is used almost entirely for special mill purposes, thus demonstrating their value when properly prepared and desulphurized. The roasting is done with gas made in separate gas producers and no coal is used in the Roasting Furnace. One and a half cwt. of pea coal or screenings from the furnace is used per ton of ore roasted. We are informed that this is the only roasted ore in the country in which gaseous fuel only is used for heating the ore.

The Chester Furnace started operating July 4, 1879, and ceased operating only 10 years later in 1888. A tiny snippet in the Iron Era (June 30, 1888) announced "The Chester Furnace has ceased operation on account of tariff and poor sale of iron." The entire Chester mining and iron ore industry was done in by economics. Iron ore was easier and cheaper to extract from the open pit mines of the Lake Superior region. With improved rail transport to Western Pennsylvania, where bituminous coal was readily available, centers such as Pittsburgh became the leaders in iron production. In 1890

FOR SALE.

ANTHRACITE BLAST FURNACE.

THE Chester Furnace, at Chester, Morris county, New Jersey, is now for sale. It is 13 by 60 feet, is in good repair, and can be put in blast in a month. The furnace, together with 100 acres of land, dwelling houses, etc., will be sold at a bargain. It has direct connections with the New Jersey Central and Delaware, Lackawanna, and Western railroads. For further particulars inquire of or address

W. J. TAYLOR, *Brown Building, Philadelphia.*

[10] Taylor, W.J. 1886. "Comments on the Operation of the Warwick Furnace". *Trans. of the Institute of Mining Engineers.* Vol 14, 1886.
[11] https://www.engr.psu.edu/mtah/essays/blast_furnace.htm

with no commercial improvement in sight, the Chester Furnace was put up for sale at a "bargain price" in the ad shown above[12]. However, there were no takers.

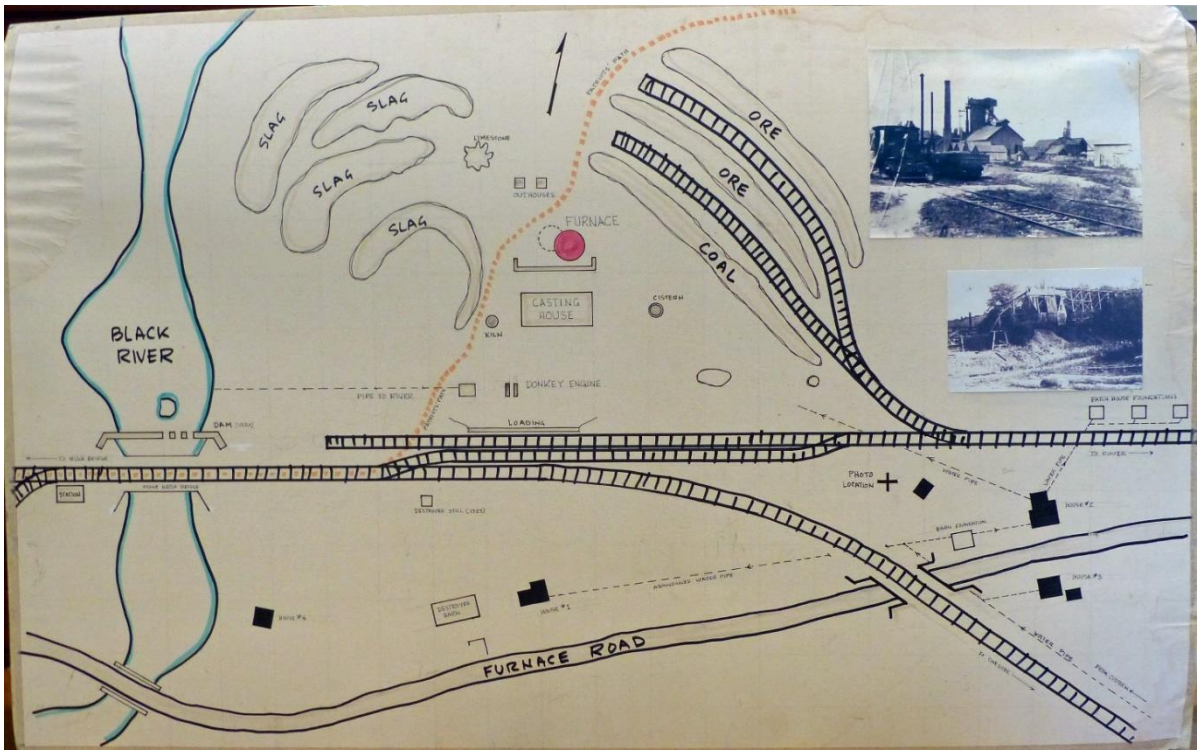
Finally, several lines appeared in the July 31, 1891, edition of the Iron Era, "The mines have all suspended operations" and "The Chester Furnace is being torn down. It will be taken to High Bridge and converted into a steel plant." That is why there is scant physical evidence of the Chester Furnace at its site by the Black River. After a series of owners, the Furnace site property was bought in 1919 by the Central Jersey Power Company, the precursor to JCP&L. They had plans to dam the Black River and create Lake Takene[13] as a resort area for their employees. They knocked down and cleared the remaining Furnace buildings[14]. The plans for Lake Takene failed after the dammed Black River flooded the roads and areas east of the Furnace. Remnants of the dam in the Black River at the Furnace Site are the only surviving evidence of the Lake Takene folly.

3. Another Taylor. So, it is not surprising that without much physical evidence, memories of the Chester Furnace faded, and the site lay in obscurity for nearly 74 years. However, another Taylor family came to the rescue, i.e., Len and Lois Taylor (nee Key), when in 1964 they bought the house at 40 Furnace Rd. That house has a special history. It was originally built by William J. Taylor when he first moved to Chester[15]. In 1875 he moved in, with his second wife Mary, daughters Virginia, Margaret and Helen and son Knox.

So how did the 20th Century Taylors do? In their memoir, "Finding the Chester Furnace[16]", Len and Lois Taylor recounts: *Imagine how the Taylors felt when they discovered their property bordered the former site of the Chester Furnace. Our love affair with the Furnace started about the first month we moved to Chester Township, along with years of research. That research proved difficult since the residents who could still remember the standing buildings and who played among the structures as children had "zero" interest in the history of the site.* Len not only kept his passion for uncovering the Furnace's past for almost 50 years but passed it onto anyone who would show an interest. He was well known for leading tours of the Furnace site for the Chester Historical Society. Above is a picture from the

[12] 1890. *Bulletin of the American Iron and Steel Association*, page 47.
[13] For background see Clark, Bruce. Lake Takene Unfulfilled, April 2015 Chester Historical Society News & Views.
[14] Taylor, Len. 1981. History of the House at 40 Furnace Road, Chester Township. CHS Archives
[15] For more information on William J. Taylor, see Ng, Edward, 2015, W.J. Taylor and the Chester Furnace, December 2015 Chester Historical Society News & Views.
[16] Taylor, Len and Lois. 2008. Finding the Chester Furnace. March 2008 Chester Historical Society News & Views.

Observer Tribune of him and Dana Taylor (no relation) sitting on a slag heap on a cold tour on Nov. 27, 1987. Len led tours annually until he passed away in 2013.



One of the most beneficial products of the Taylor family's exploration of their backyard was a map which Len drew and would use to orient hikers on his Furnace tours. The 27" x 43" poster is shown right. He would make a more polished version of the map for Larry Lowenthal's book, Chester's Iron Heyday published by the Chester Historical Society in 1980.

Len didn't want to sentimentalize Chester's history. He believed the projects to preserve and use our history for education would take lots of work and be never ending. That is true for the work to establish the Chester Furnace Historical Site in 2015. It was through hard work by the Patriots' Path Trail Steward, Bruce Clark, the building skills of Eagle Scout Jack Suter, and the Chester Historical Society to set the trail and create the informational kiosks and placards. The work continues. Len's map is the basis for the map developed by Bruce Clark and most recently published in the May 2020 CHS News & Views which is also available online[17]. As Len predicted the work goes on. The upcoming video by Alex Louie and Bruce Clark will walk you through the Chester Furnace Historical Site. ENJOY!!

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17 http://historicchesternj.com/images/CHS_Newsletter_May_2020_Covid19_Charles_Tippett_bottles_Historic_Chester_Furnace_Site_compact_file.pdf