THE HISTORY OF ROOM-AND-PILLAR SALT MINES IN NEW YORK STATE

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ABSTRACT

The first room-and-pillar salt mine in New York State, the Retsof Mine, went into operation in 1885. The Lehigh, Livonia, Greigsville, and Sterling Mines soon followed. The Retsof Mine ultimately grew to be the largest salt mine in the western hemisphere before succumbing to groundwater inflow in 1995. The active Cayuga Salt Mine started production around 1921. It is the easternmost room-and-pillar salt mine developed in the United States. The Himrod Mine started operations in 1971. Low salt prices, geologic complexity, and environmental issues contributed to the closure of the mine by 1976. The Hampton Corners Mine is the newest mine in New York. The Hampton Corners Mine started development in 1998 and started producing salt by 2002.

Keywords: Salt, Mine, New York, History

INTRODUCTION

This paper summarizs the history of the room-and-pillar salt mining operations in New York State from their start in 1885 to the modern era. A map showing the active and historical mining locations is included.

THE RETSOF MINE

The seminal Retsof Mine started operations in 1885 after completion of its 3.7× 4.9-meter wide, 303.5-meter-deep #1 Shaft. The mine claimed an initial 5,460-metric-tons per day hoist capacity. Early main haulage ways were driven east and west [Newland, 1914; 1919]. Production headings were driven north (updip) for salt tramming ease. Room heights in the 6-meter-thick salt bed were 2 to 4 meters with salt left in both the floor and roof. The 4-meter-high rooms were worked in two benches. Rooms were 9.2 meters wide and separated by 9.2-meter pillars. There was no timbering, the mine was dry, mine air temperature was 17°C, and the mine was largely gas-free.

By 1914, the Retsof Mine had three shafts [Newland, 1914]: (1) the original shaft (Retsof #1, deepened to 308.7 meters); (2) the Retsof #2 shaft (312.3 meters deep) completed before 1894 [Luther, 1894]; and (3) the "Gray" shaft of the old Greigsville Mine, completed about 1891.

The salt faces were mined by drilling holes with compressed air drills before 1914 and with electric rotary auger drills as of 1919. The electric drill holes were 3.8 centimeters in diameter and 1.8–2.1 meters deep. The holes were packed with light charges of low-grade dynamite. Early attempts at use of coal mining undercutters were unsuccessful because of the tougher nature of salt [Newland, 1919].

Before 1917, loading after blasting was by pick, shovel, and by hand (for lump salt) into 2.7-metric-ton-capacity wooden cars. The first electric loader was employed at Retsof in 1917. The salt cars were, at first, pulled by mules on steel rails. Electric locomotives completely replaced mules by 1927.

At the shaft, the cars were run onto cages and hoisted to the top of the breaker 350 meters up from the mining level. Each shaft had two compartments with the cages being operated in balance. Car loads were dumped into bins feeding the crushers and screening plant. Coarse lumps (9–45 kilograms) were sold uncrushed principally as cattle salt [Bishop, 1892]. The crushed and screened coarse salt competed against Syracuse Diamond C and F solar salt [Bishop, 1892] and was used in the curing of hides, refrigeration, the manufacture of oleomargarine, and other various industries [Newland, 1914].

By about 1920, the original Retsof Mine plant and operation was too dilapidated to rehabilitate, so the operator, International Salt Company, started the Fuller Shaft and Plant, 0.8 kilometer south of the Retsof #1 Shaft, in July 1921 [Kreidler, 1957]. In 1923, workings from the Fuller Shaft were developed and broke into the "old" Retsof Mine. The Fuller Shaft was sunk to the "Retsof C salt bed" at a depth of 351.4 meters. This shaft served as the main production/service and exhaust air shaft until the mine closed in December 1995. The Retsof #2 Shaft also remained open until the mine closed and served as an intake airway and escapeway.

Early mines in New York used small pillars [Gowan et al., 1999]. The area near the Retsof #1 Shaft was almost completely mined, leaving small pillars. The old "checkerboard" pattern plan employed a room width just under 10 meters and square pillars of the same size (75 percent extraction rate). After the 1920s, however, the Retsof Mine generally employed a larger, more rigid, pillar design. The need for improved ventilation because of increased production after mechanization of underground loading may explain the pillar size changes. Ventilation was easier to control using longer rectangular pillars. The first Meyers-Whaley loading machine was placed in service in 1916, followed rapidly by many others by 1920. The increased daily blasting, to keep up with mechanical loading, would have produced more toxic fumes. In 1919, a ventilation system was started with a mine-brattice system, and a new ventilation fan was installed in the mine.

Other notable advances in mining technology applied at the Retsof Mine were as follows:

- **1925:** The first undercutter was put in operation, improving blasting efficiency from about 45 metric tons per shot to over 400 metric tons per shot. Five additional "cutters" were hurried into operation that same year.
- **1926:** The first Goodman shovel was tried as a replacement for the Meyers-Whaley loaders, and again, results were so good that six additional Goodman shovels were also running by the following year.

- **1927:** The last of the mules was out of the mine, after replacement by "gathering locomotives" to move salt from the faces to the mainline rails.
- **1931:** Wooden haulage cars of 2.7-metric-ton capacity were replaced by steel 4.5-metric-ton cars, and then by 5.4-metric-ton cars in 1949.
- **1934:** Carbide miner's lamps were replaced by electric safety cap lamps.

In 1958, the Retsof Mine was connected to the Sterling Mine for ventilation and emergency escape purposes [Gowan et al., 1999]. By the late 1960s, the mine had advanced beneath the Genesee River and Valley.

By the early 1970s, the Retsof Mine installed an underground surge bin fed by a new conveyor system, and the rail haulage system was eliminated. Mainline conveyors led to yard or panel belts feeding each mining section, where a Stamler feeder-breaker crushed salt delivered by diesel-powered Joy shuttle cars. In the early 1980s, the shuttle cars were gradually replaced by load-haul-dump vehicles (LHDs). In 1969, Netherlands-based Akzo Corporation acquired International Salt Company and operated the mine until 1995.

During April 1975, an explosion occurred in the original Sterling B Shaft during efforts to control water inflow into the Retsof Mine from this abandoned and partially collapsed shaft. The leaky B Shaft had not been used or maintained for years. By 1975, International Salt was concerned that freshwater inflow from the B Shaft could pose a salt dissolution, collapse, and flooding risk to the then-connected Retsof Mine. Removal of a partial shaft blockage of timber and rock debris was attempted as a means of regaining airflow needed to safely access, rehabilitate, and grout off the water inflow to the shaft and mine below. A maintenance crew attempted to dislodge the shaft obstruction by pushing a large boulder into the shaft that was to drop down and knock through the debris. A methane explosion occurred upon impact. The upward force of the explosion killed four people on the surface near the shaft collar and injured others.

On November 19, 1990, a roof fall resulted in two fatalities. Deformation and fracture of roof salt can occur because of concentration of stresses (i.e., punching) by stiff pillars. After the fatalities, the mine tested small, yielding pillars to alleviate roof falls. Positive testing results led to the adoption of a yield-pillar design.

On March 12, 1994, a small earthquake occurred over the mine. Local bridge and highway damage, caused by surface subsidence, was observed. In addition, a massive roof collapse in the 2-yard south yield pillar area of the mine and methane gas and water inflow at 20,000 liters per minute were discovered underground.

At the time of the collapse and start of flooding, the Retsof Mine covered an area of approximately 26 square kilometers. As the waterline advanced from the south, mining continued to the north. Mining ceased in September 1995, all remaining open shafts were filled and abandoned, and the mine was totally flooded by December 1995.

Over the 110-year life of the Retsof Mine, approximately 125 million metric tons of salt were extracted from a 26-square-kilometer area [Gowan et al., 1999]. The record annual production was 3.5 million metric tons in 1978.

THE OTHER EARLY GENESEE AND LIVINGSTON COUNTY MINES

The Lehigh Mine

The Lehigh Mine, the second mine developed in New York, started operations upon completion of its 3.7×7.3-meter-wide shaft by the fall of 1892 [Werner, 1917]. The shaft was 244 meters deep with the top-of-salt at 233 meters. The 244-meter hoist trip from the surface to the mine level took 17 seconds. The shaft house at Lehigh was 46 meters tall [Werner, 1917].

Headings were made north-south and east-west. Dynamite was used for blasting. Salt was moved underground on mule-drawn cars set on rails. Salt was hoisted to the breakers, and once run through the breakers, the salt was ready for the market. In December 1892, the mine installed an electric plant for aboveground and underground lighting.

The Lehigh Mine operated until fall 1894 when it was sold to Retsof. Werner [1917] reports that all transportable equipment and machinery were moved to the Retsof Mine.

The Livonia Mine

The Livonia Mine started operations upon completion of its 4.3×7.3-meter-wide, 437-meter-deep shaft in August 1892 [Hall, 1894]. The shaft was sunk by drilling a series of 3-meter-deep holes arranged in two rows that were angled in toward the shaft interior. They were loaded with sticks of dynamite and a v-shaped wedge of rock was reduced to rubble. As the muck was cleared, drilling and blasting of benches and corners of the excavation squared up the opening. Muck was cleared out of the shaft using a 700–900 kilogram capacity steel bucket connected via a 3.8-centimeter-diameter steel cable to a 60 horsepower (hp) hoisting engine. At surface, the muck was loaded into carts run on rails and dumped over nearby north- and west-facing slopes into swamp lands north of the shaft [Luther, 1894].

The Livonia Mine had a short life, but documentation on the shaft sinking is remarkable. An arrangement between the mine and the New York State Geological Survey allowed for detailed logging and fossil collection [Hall, 1894]. The top-of-shale (i.e., bedrock) was encountered in the shaft beneath glacial drift at a depth of about 21 meters. The shaft was bottomed at 437 meters on August 13, 1892, after penetrating two salt beds whose tops were at 418 meters and 430 meters [Hall, 1894; Luther, 1894].

Strata in the upper half of the shaft were heavily jointed, requiring the shaft to be both timbered and lined [Luther, 1894]. Timbers used in the shaft construction included 30.5×35.6-centimeter white oak "bearers," 25.4×25.4-centimeter hard pine "wall plates," 25.4×25.4-centimeter hard pine "studdles," and 12.7×20.3-centimeter hard pine guides for the cages. The back sides of the timber framing were lined with 5-centimeter-thick vertical planking, and the void space between the rock and the planks was filled with muck.

The timbers divided the shaft into three compartments [Luther, 1894]. Two compartments were for hoisting. The third compartment was equipped with ladders for emergency egress. The third compartment also contained speaking tubes, compressed air pipes, bell wires, and electric light wires. A portion of this third compartment was also partitioned off and used as a fresh ventilation air conduit. The air shaft was connected to a 4.9-meter-diameter fan at surface.

The shaft leaked water. A 400–500 barrel cistern was installed 30 meters down from the surface to collect fresh water seeping from glacial drift and shallow fractured shale bedrock. A second cistern was installed at 335 meters to collect high sulfur "bitter water" entering the shaft from brown, sandy rock at 319 meters.

The plant was powered by coal-fed steam boilers. Steam powered a 100 hp Corliss breaker engine for the crusher and sieves, a 60 hp engine for the fresh air ventilation fan, a 60 hp compressor to drive 12–15 Howell rotary auger drills, a 10 hp upright engine to drive the dynamo for electric lighting, and a 1,000 hp hoisting engine to drive the 2.4-meter-diameter drum around which the flat wire cable (15 centimeters wide by 1.9 centimeters thick) was wrapped for hoisting the cages. Water demand for the boilers was 95,000 liters per day [Luther, 1894]. Water was supplied from a local stream, but pump works were established at Conesus Lake as a backup.

The mine rooms were 9 meters wide and spaced 15 meters apart. The 15-meter-wide walls were then worked to leave 7.6×9.2-meter pillars spaced 9.2 meters apart. Mine faces were not undercut. The faces were worked by drilling 3.8-centimeters diameter, 3-meters-deep holes aligned in at least four vertical rows of four holes each. The outer two rows were drilled about one-third of the face-width in from the ribs. The two interior rows of holes were drilled at an angle so that the ends of the holes 9 feet in nearly touched. Blasting charges were 1½ sticks, 0.34 kilogram of 20 percent dynamite per hole [Luther, 1894].

Salt was hauled underground in mule-drawn carts on rails capable of holding 2.25 to 2.7 metric tons. After blasting, large lumps of salt were hand-picked and loaded onto carts. The remainder of the salt was then shoveled onto carts. Hoisting up the shaft proceeded using two counter-balanced cages that ran at a rate of about 65 kilometers per hour. The lumps were brought to surface and spread out on a large platform to harden so that they could be handled without breaking.

The headframe hauling compartments extended to the top of the breakers at 27.5 meters above ground in the 43-meter-tall breaker building. There, salt was gravity-fed through the crusher and sieves.

The salt was marketed in various sizes [Luther, 1894]. Large lumps (23–90 kilograms) were sold as cattle licks in western states, and small lumps (2.3–23 kilograms) were used for cattle in eastern states. The granular salt was graded from No. 4 (coarsest) to No. 1 (finer) to C (finest). These grades of salt were used in refrigerators; hide curing; packing and pickling of beef, pork, and fish; and for brine making. Salt dust, or O size, was used in the manufacture of sodium bicarbonate, bleaching powder, soap, and for agricultural purposes.

Once the salt was processed, it was loaded on railroad cars and shipped via a short line (the Livonia & Lake Conesus Railroad) to the Erie Railroad. About 35 to 50 rail cars of salt were shipped daily [Werner, 1917].

The mine operated for about 7 years before being purchased and then shut down by the Retsof Mine. The surface facilities were fully decommissioned by 1908.

The Greigsville Mine

The Greigsville Mine was started October 15, 1890, on the west side of the Delaware, Lackawanna & Western (D.L.&W.) railroad tracks, 1.2 kilometers north of Greigsville Station, and only 0.8 kilometer west from the Retsof shaft [Bishop, 1892]. A single shaft, 6.7×3.4 meters in cross section, was installed. The depth of the shaft was not reported in the literature, but it was known to penetrate only into the uppermost salt bed. The proximity of the Greigsville Shaft to the Retsof #1 Shaft suggests a depth of roughly about 300 meters.

The Greigsville Mine operated for several years before it was purchased by the Retsof Mine in 1895 and shuttered. The Greigsville Mine was eventually connected to the expanding Retsof Mine.

The Sterling Mine

The Sterling Mine started operations in 1907 [Werner, 1917]. Shaft sinking was challenging at this site. The initial A Shaft, 6.1 meters square in cross section, was abandoned during sinking because of water inflow and was backfilled.
The 3×5.8-meters wide B Shaft was successfully completed to a depth of 343 meters. The shaft was timbered throughout its entire length with oak and lined with hemlock planking [Werner, 1917]. The shaft was divided into two hoisting ways, each 1.8 meters by 2.4 meters and a ladder

road 1.2 meters by 2.4 meters.

The Sterling C shaft, 3.7 meters by 3 meters wide and 339.5 meters deep, was completed in 1909. The B shaft then served as the production shaft, and the C shaft became the service shaft.

During 1908, the mine produced 216,000 metric tons of marketable salt [Truax, 1960]. The rugged facility was designed to produce 1,000 tons per day [Newland, 1907]. Early mining procedures were similar to those practiced at Retsof [Newland, 1914]. Initially, the salt faces were drilled and blasted in a "V" cut [Truax, 1960]. Auger drills, driven by small electrical motors, were used to install the blasting holes from 2 to 3 meters deep [Werner, 1917].

Salt was hand-loaded onto mule-drawn cars that ran on rails. The salt cars were loaded into dual cages that ascended the shaft's hauling compartments in alternating sequence. The head house built over the shaft was 38 meters high above ground surface. At the surface, the carts were dumped without leaving the cages [Werner, 1917]. The salt was fed into crushers and then passed over a set of three copper mesh sieves and separated by size accordingly.

The operation was powered by four massive boilers of 250 hp each. Two four-valve driving engines, one 150 hp and the other 190 hp, supplied the dynamos that furnished electricity to the plant. The hoist had a two-faced conical drum that was controlled by two engines with steam cylinders 45.7 centimeters by 107 centimeters, capable of developing 500 hp.

An electric locomotive was introduced underground to move salt cars around March 1910. Undercutters, initially unsuccessful in salt mining, were in use at the Sterling Mine by June 1925 [Truax, 1960].
The mine reached a production of 469,254 metric tons in 1918. The postwar depression year of 1920 saw production of 368,507 metric tons. The peak production year was 1923 at 505,169 metric tons. However, by 1929, production had fallen to 350,078 metric tons. Truax [1960] attributed declining production to the availability of mechanical refrigeration to ice cream manufacturers.

By 1926, the company recognized the need to find other markets for salt. An exploratory hole was drilled 242 meters below the mine floor in an unsuccessful search for potash [Truax, 1960].

The Sterling Salt Company sold the plant to International Salt Company, who operated the nearby Retsof Mine. The Sterling Salt Company was officially dissolved on May 30, 1930. International Salt Company closed the mine in June 1930, ending 2 decades of operation that saw 8,089,938 metric tons of salt extracted from 171.4 hectares. International Salt Company did, however, adopt "Sterling" as their trade name for products.

The Sterling Mine was later connected to the ever-expanding Retsof Mine in 1958. The C shaft was placed in service for ventilation and emergency escape purposes [Gowan et al., 1999]. The leaky B shaft was apparently not put back in use.

THE CAYUGA SALT MINE

The Cayuga Mine is the deeper and larger of two room-and-pillar salt mines presently operating in New York. The Cayuga Mine started operations in 1923 and has extracted salt from four different levels in the Syracuse Formation.

The production shaft was completed in 1918 at a depth of 451 meters to the shallowest (#1) salt bed. The surface plant was then completed, and mining began in January 1923. The highly variable, contorted nature of the #1 salt bed was soon discovered. In January 1924, the mine shut down, because the impure, contorted salt could not be mined profitably.

By June 1924, the Cayuga Rock Salt Company deepened the shaft to the relatively pure #4 salt bed level at 587 meters below surface. Mining restarted about 1927. Again, the salt bed was highly contorted, but the purity was high, and the miners were able to follow "rolls" (synclinal folds) where salt was thickest. The #4 salt bed was mined in an "open stope" manner. Room widths and heights varied from 2.4 meters to 30 meters wide and 1.8 meters to 10.7 meters high.

By 1927, undercutters were employed. The muck from the undercut and blasted salt faces was loaded onto cars pulled by a battery-powered locomotive.

The 1.2-meter-diameter #2 Shaft to the #4 bed was added around 1931 for ventilation and emergency egress. Salt was moved to the shaft bottom by rail, and skips hoisted salt to surface. The skips dumped into a bin at the roof level of the surface mill building where salt was crushed and screened to size for various markets. In the 1930s, a diesel generator house was constructed to provide power for the mine; excess power was reportedly sold to the nearby community of Myers. Four large "Buckeye" generators were used as described in a 1938 *Diesel Engine Progress Magazine* article. The mine's #4 bed capacity gradually rose to 540,000 metric tons per year.

During the 1960s, core holes were drilled to the bottom of the Syracuse Formation in a successful search for deeper, undeformed salt beds. In 1968, Cayuga Rock Salt drove two slope tunnels down to the tabular, pure #6 salt bed at a depth of 702 meters below surface. Mining the vast flat-lying #6 salt could be easily modernized.

Cargill Salt Division purchased the mine around 1970. The underground haulage system was changed from carts pulled by battery locomotives to front-end loaders feeding conveyor belts. An underground crushing and screening plant was built. By 1975, the production capacity increased to over 720,000 metric tons per year.

The Cayuga Mine presently has three shafts. The #1 Production Shaft has four compartments: two for skipping, one for an emergency cage, and one for a ladderway. The inside dimensions are 2.8 meters by 8.2 meters. The #2 Shaft was completed around 1931 as a 1.2-meter-diameter airway and escapeway. The #3 Shaft was drilled in 1975 and completed in 1976 at 3.4 meters inside diameter as an intake airway and service shaft, extending from the bottom of the 702-meter-deep #6 salt bed to surface.

The flat-lying, #6 salt bed permitted a regular room-and-pillar mine layout. From 1969 to 1976, the layout used 9.8-meter rooms on 36.6-meter centers, leaving 26.8-meter-square pillars. Roof problems prompted experimentation with the "yield-pillar mine design." From 1976 to present, the mine has successfully used 4.6–6.1 meter square pillars and 9.2–12.8 meter wide rooms. Overall extraction is about 55 percent.

In 1989, a surface conveyor belt and bin system replaced the old concrete "mill building" to improve efficiency. A new production headframe was added in 1991. By 1995, the mine was producing over 1,456,000 metric tons per year.

A new underground screen plant was commissioned in 1995. German Salzgitter Maschinenbau AG "SMAG" equipment was then introduced and allowed different blasting techniques, which, combined with the SMAG equipment reliability, increased crew production by 40 percent.

In 2001, a compactor was added to the screen plant that converted up to 27 metric tons per hour of waste salt "fines" back into saleable-sized particles. Additionally, the "scoops" that dig and haul the blasted salt to the crusher were replaced by larger capacity, reliable "Elphinstone" models thereby allowing a 40 percent reduction in the original fleet of loaders while achieving higher production. Today, the mine is capable of producing over 2,093,000 metric tons per year. Twelve mining machines are operated by remote wireless control.

The underground communication system, completed in 2006, allows staff to make telephone calls from the mining "face" area to anywhere in the world. Laptop computers in active mining areas can access the Cargill network and the Internet.

MORTON SALT HIMROD MINE

Morton Salt Company's Himrod Mine started production around 1972. The mine's two shafts were sunk by the Cementation Corporation of Canada [Chronicle Express, 1970]. The shafts were 610 meters deep (design depth) and overlain by 54-meter-tall concrete towers.

The shafts were sunk by drilling and blasting methods. Mucking was done by use of a Cryderman mucking machine [Spence, date unknown]. The device was about 10.7 meters long with a clam shell bucket at the end of a telescoping boom.

Some strata penetrated by the shaft yielded water, so the shaft was lined with concrete. The shaft liner was installed in 6.1-meter increments.

Water supply for the plant was provided by a company-owned water system installed at Severne Point on Seneca Lake. Power to the plant site was backed up by diesel-powered generators. The mine's rail system, connected to the Penn-Central Railroad, was accommodated 400 hopper cars.

The Morton Mine is approximately 625 meters deep. Ventilation was provided by two 300 hp fans at surface [Spence, date unknown]. The mine was designed to have a workable capacity of approximately 2.3 million metric tons per year. Early production was about 1,200 tons per day [Thompson, 2007]. By October 1974, the mine covered an area of approximately 1.3 square kilometers. The extraction ratio appears to have been 50 percent.

In June 1974, a miner was killed by a rock fall [Dumas, 1980]. In July 1974, two miners were injured in an explosion. In September 1974, 120 workers went on strike. During September, an earthen lagoon wall collapsed spilling approximately 11,400,000 liters of saline water into Seneca Lake.

Other environmental problems associated with the surface parts of the operation also apparently developed. Airborne dust and saline water runoff from the plant were alleged by local residents to have killed trees, lowered yields from farm fields, and created spawning problems for rainbow trout in a local creek [Thompson, 2007].

Environmental issues, in combination with a glut of deicing salt in the market at the time, apparently led to a decision by Morton Salt to close the mine on May 18, 1976.

HAMPTON CORNERS MINE

The Hampton Corners Mine started production in 2002. It is the most modern salt mine presently operating in the United States. In 1998, American Rock Salt Company contracted with Frontier–Kemper to sink shafts at Hampton Corners. The production shaft was sunk to a depth of 437 meters.

The mine uses a standard room-and-pillar design to mine the same bed of salt that was principally mined at the Retsof Mine. The mine uses conventional drilling and blasting for 16-meter-wide by 4-meter-average-height rooms, with LHD haulage to primary crushers feeding conveyor belts.

The mine's screening and crushing operations take place mostly underground, minimizing surface salt dust. The Hampton Corners Mine has large on-site storage capacity and an efficient layout for loading bulk trucks and railcars. The American Rock Salt Company Web site reports daily production capacity of about 16,000 metric tons per day and 2008 production was estimated at about 4 million metric tons.

ACKNOWLEDGEMENT

The authors would like to thank all the Retsof Mine retirees who provided insight and checked facts and to David Chichelli of American Rock Salt LLC for the Retsof Mine and the Hampton Corners Mine information. The authors would also like to thank the Yates County Historian, the Wyoming County Historian, Town of Warsaw Historical Society, the Livingston County Historian, Onondaga Historical Association, Dundee Area Historical Society, Dr. William Keily of the New York State Geological Survey, and the Salt History Museum for their assistance.

REFERENCES

Bishop, I. P., 1892. *Report on Development of the Salt Industry of Central New York for the Year 1891*, New York State Museum, Albany, NY, Report for 1891, Annual Report No. 45 Series, pp. 53–64.

Chronicle Express, 1970. "Report No. 2 on the Salt of the Earth," newspaper article published in the *Chronicle Express*, Thursday, June 25.

Dumas, M., 1980. "For $3 Million in Damages–Salt Mine's Neighbors File Suit," newspaper article, unknown publisher, hand-dated January 31, 1980, provided by the Yates County Historian, Penn Yan, NY.

Gowan, S. W., S. M. Trader, and L. L. Van Sambeek, 1999. "The Discovery of an Apparent Brine Pool Associated With Anomalous Closure Patterns and the Eventual Failure of the Retsof Salt Mine," *Solution Mining Research Institute Fall Meeting*, Washington, DC, October 3–6, pp. 241–272.

Hall, J., 1894. *Report of the State Geologist*, New York State Museum, Albany, NY, Report for 1894, Vol. 2, Annual Report No. 48.2 Series, pp. 9–29.

Kreidler, W. L., 1957. "Occurrence of Silurian Salt in New York State," *New York State Museum and Science Service Bulletin*, Number 361, Albany, NY.

Luther, D. D., 1894. *The Livonia Salt Shaft*, New York State Museum, Albany, NY, Report for 1893, Annual Report No. 47 Series, pp. 215–324.

Newland, D. H., 1907. "The Mining and Quarry Industry of New York State: Report of Operations and Production During 1906," *New York State Museum Bulletin*, No. 112, Albany, NY.

Newland, D. H., 1914. "The Mining and Quarry Industry of New York State: Report of Operations and Production During 1913," *New York State Museum Bulletin*, No. 174, Albany, NY.

Newland, D. H., 1919. "The Mineral Resources of New York State," *New York State Museum Bulletin*, No. 223–224, Albany, NY.

Spence, G., date unknown. *Morton Salt Company–Engineering Feat*, newspaper article, unknown publisher, provided by the Yates County Historian, Penn Yan, NY.

Thompson, P., 2007. "Morton Salt: Himrod Plant Has Interesting History," newspaper article published in *The Observer*, Wednesday, July 11.

Truax, C. N., Jr., 1960. "Sterling Salt Company, A History 1905–1930, Sterling Salt at Retsof," published by the Retsof Mine, International Salt Company, Clarks Summit, PA.

Werner, C. J., 1917. *A History and Description of the Manufacturing and Mining of Salts in New York State*, Tobias A. Wright Press, Huntington, NY.

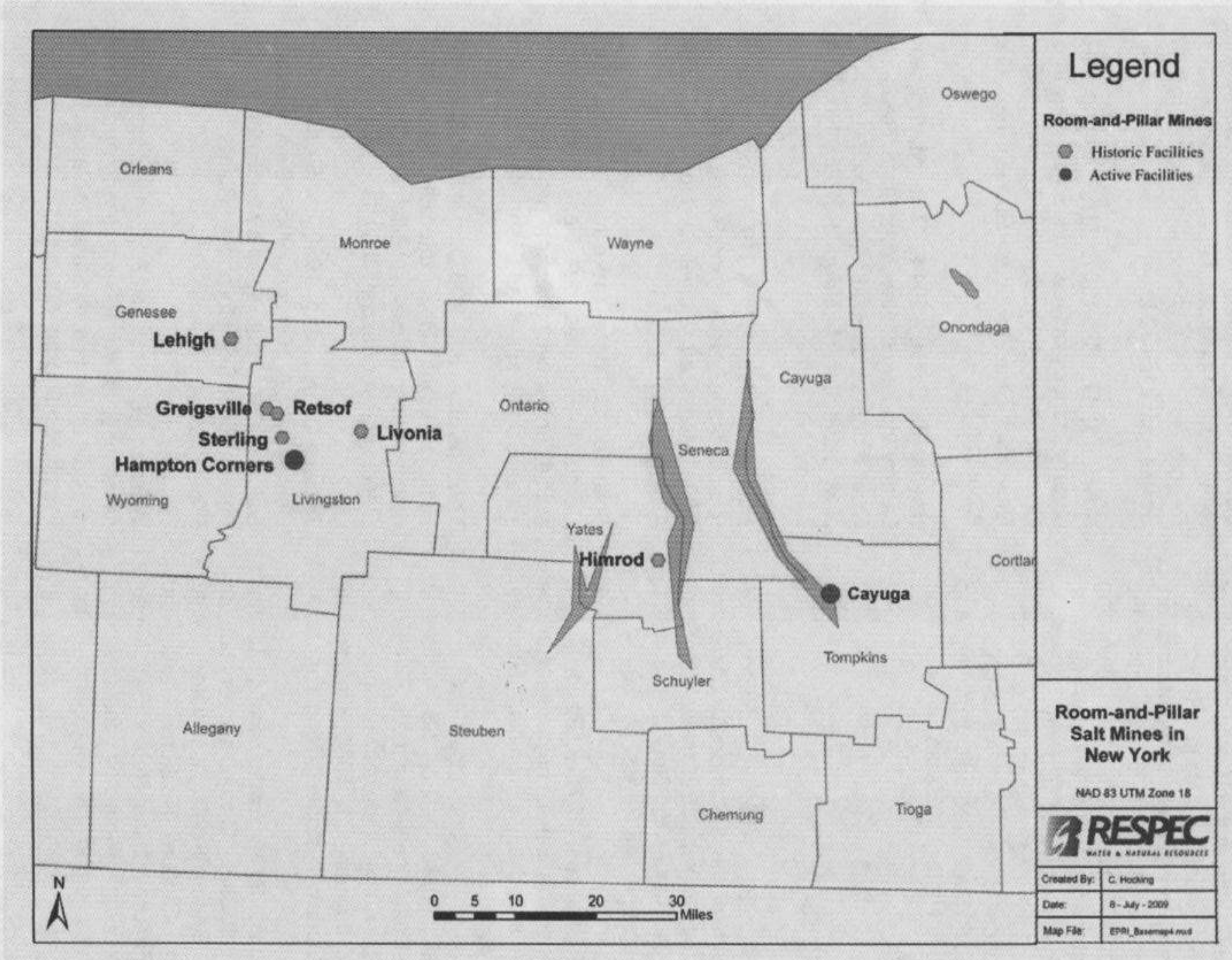

Figure 1. Site Location Map