Closure of the Woodhull Mine Chester, New Jersey

James G. McWhorter
Geoscience Services, Bernardsville, New Jersey

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James G. McWhorter, P.G.
Geoscience Services
3 Morristown Rd
Bernardsville, NJ, 07924 USA

ABSTRACT

There are numerous abandoned iron mines that dot the landscape within the Highlands of Morris and Passaic Counties in northeastern New Jersey. In recent years, as development has continued to expand in rural communities in New Jersey, these abandoned mines have had an impact on numerous construction projects within the state.

The Woodhull Iron Mine was initially developed in the 1860's, but production was insignificant. All mining activity had ceased by the late 1880's. The mine workings consisted of a series of northeast-southwest trending magnetite-enriched zones of some 3 to 5 feet in thickness, dipping to the southeast between 55 and 65 degrees. The workings extended northeasterly from the vicinity of the present-day Chester-Gladstone Rd up to and across Rte. 206. Over time, the headwall of the workings partially collapsed, leaving behind obscure, overgrown shallow depressions at the surface.

Development at the site of the abandoned Woodhull Mine began in the late 1990's with construction of an age-restricted community of high-end town houses. Early reconnaissance efforts to locate the mine on site were unsuccessful. It was not until construction and site development was well underway that subsurface voids were encountered during placement of underground utilities. The project was temporarily halted in that part of the site until agreement could be reached between township officials, the Bureau of Mine Safety and the developer as to how best to proceed.

A Mine Closure Plan was developed, wherein specific closure criteria were outlined. The mine workings were grouted with a high-mobility cementitious grout tremied into the mine voids through angle borings drilled along the dipping plane of the mine. Approximately 1,800 yds^3 of grout were placed in the mine, effectively sealing both the voids of the mine and the partially collapsed hanging wall rocks above them. With the approval of both township officials and the NJ Bureau of Mine Safety, project development continued.

INTRODUCTION

Mining activity in New Jersey predates the Revolutionary War and probably began about 1710 (Sims, 1958). For a period of time just prior to the 1880's, New Jersey was the leading iron-ore producing state in the Union.

The Woodhull Mine is located on a tract of land approximately 1 km south of Chester, in Morris County, New Jersey. The mine was initially developed in the 1860's and worked intermittently until the 1880's, at which time the mine was abandoned because of the low cost of over-seas iron. The mine lay fallow until over a century had passed and all that remained were a few overgrown, shallow depressions left at the surface from partial collapse of the headwall of the mine.

GEOLOGIC SETTING

The mine is located within the New Jersey Highlands Physiographic Province south of the Wisconsinan Terminal Moraine. Bedrock at the site is a hornblende granite of the Byram Intrusive Suite, a middle Proterozoic unit characterized by pinkish-gray to medium-buff-weathering, pinkish-white or light-pinkish-gray, medium to coarse grained weakly foliated granite and sparse granite gneiss (Drake et al, 1996)

The Woodhull Mine was developed on a zone of magnetite (iron oxide) enrichment within the granite and concordant with the foliation. Concentrations of the magnetite approached 60% in some areas, an exceedingly high concentration of ore. The magnetite deposit had a general strike of N50ºE and dipped approximately 55º-65º to the southeast The mine was developed by running in a drift from a lower elevation from the southwest until the magnetite deposit was encountered, then the magnetite was mined using overhand stoping methods. The mined ore was collected at the bottom of the stope and hauled out along the drift by cart on rails. The ore was mined out to almost the surface, leaving just enough rock behind to support the back of the stope. Total production of ore is estimated to be 4,000 tons with the last 377 tons developed in 1885 (NJ Dept. of Labor, 1979).

The Woodhull Mine extended from very near the Chester-Gladstone Road up to and across Route 206. In about 1995 or 1996, a portion of the Route 206 highway developed a sinkhole related to a partial collapse of the headwall of the mine beneath the road. The NJ Department of Transportation backfilled the collapse zone with about 100 cubic yards of cementitious grout. The repair patch in the roadway is clearly evident in the macadam of the highway and is directly on strike with the mine as identified.

Figure 1 shows the extent of abandoned iron mines in the state of New Jersey, with the location of the Woodhull Mine identified (Newark Star Ledger, 2001).

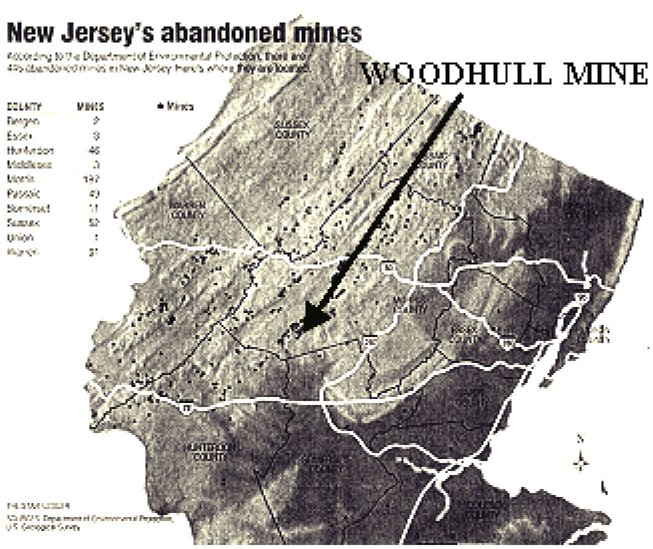

Fig. 1 Abandoned Iron Mines in New Jersey

DISCOVERY OF THE MINE

Early attempts at identifying the location of the mine were unsuccessful at the site, even though the developer and his geotechnical consultant knew that it could be present on the property somewhere. It was not until utility excavation was underway on the northeastern portion of the site that voids were detected in the subsurface after minor blasting was required to get a storm drain invert to the proper elevation. Subsequent air-track probing identified additional subsurface voids. At this point, all work was stopped on this portion of the site until a complete picture of the subsurface could be developed.

An intensive investigation of the subsurface was initiated, using both air-track probes and diamond drilling techniques to evaluate the geometry of the subsurface workings beneath the site. Figure 2 shows the plan view of the eventual geometry of the workings beneath the site. Three basic areas were identified; a western zone of approximate area of 2100 ft^2 in plan, the main, or central, portion of the mine, approximately

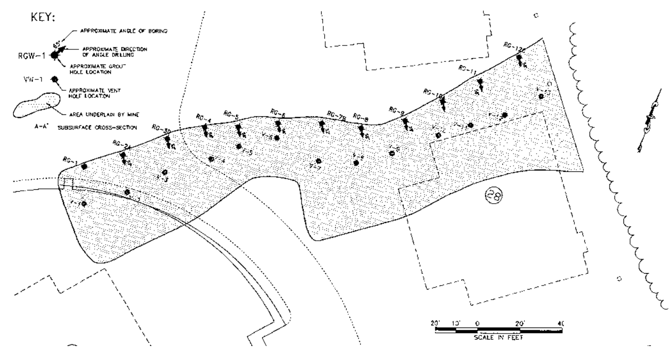

Fig. 2 Plan of Woodhull Mine

12,300 ft^2 in plan area and an eastern zone, approximately 3100 ft^2 in plan area.

Typically, the mine had been developed to a depth of about 100 feet below grade. The use of an adit, as was done at this site, accomplished two very important things here; it allowed the area above the level of the adit to be drained of groundwater, thus not requiring the use of pumps to dewater the workings and secondly, it allowed the ore to be extracted without the use of raising works. Profits were maximized!

No evidence was encountered at the site that the mine was developed to greater depths than the level of the adit.

PREPARATION OF THE MINE CLOSURE PLAN

Once the mine workings were discovered on site, it became necessary to adhere to NJ Bureau of Mine Safety standards. A mine closure plan was prepared that outlined the steps that were to be taken to safely close the mine and to bring the property back up to a condition where it could continue to be developed as intended. Figure 3 provides a schematic of the closure criteria developed for the plan. Essentially, the closure criteria provided a field-applied verification process that allowed mine closure on a hole-by-hole basis. Grout takes in each hole were monitored, thereby allowing estimates of additional grout required in adjacent holes based on cross-section volumes. Grout logs for each

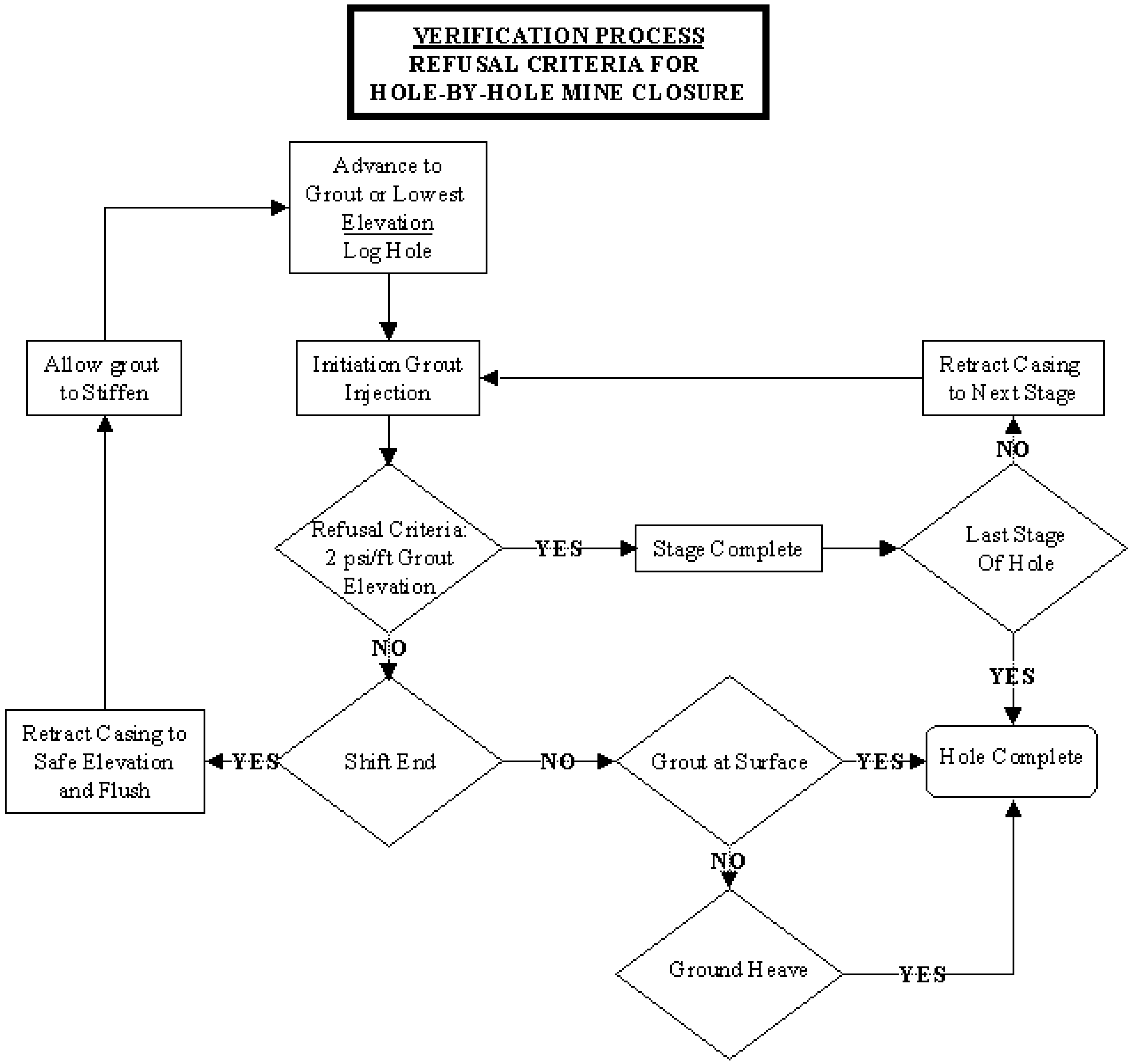

Fig. 3 Closure Criteria

hole were maintained and grout cubes were taken on a random basis. 7-day and 21-day breaks were noted for additional QA/QC control. A minimum compressive strength of 500 psi was required. Almost all grout cubes tested at 21 days were greater than 1000 psi.

GROUTING OF THE MINE

Grout injection holes were drilled utilizing a Davey Kent 750 diesel-powered hydraulic drill rig fitted with a down-the-hole hammer. Casing was advanced with the drill string thus enabling stabilization of the hole. The holes were drilled along the plane of the mine, roughly at anywhere from 55º to 65º from the horizontal. Figure 4 provides a typical cross-sectional view of the mine.

Because there were substantial volumes of soil and rubble-rock left behind in the mining process within the mined out areas, it was necessary to closely monitor grouting pressures during the grouting process. The casing was retracted as grout reached the bottom of the casing. A criterion of 2 psi/ft of head of grout was used as a bench mark for casing withdrawal and grouting of the next stage. At the end of a shift, the casing was withdrawn about 10 ft for safety and re-inserted to the top of hardened grout at the beginning of the next shift.

Vent holes were drilled vertically to intersect the mine opening in the middle to upper third of the mine to allow for the air and water to escape from the mine as grouting proceeded. The vent holes were also used to visually confirm grout placement by observing grout overflow at the surface.

Grout mixes typically were delivered via ready mix trucks and had the following characteristics: 2000 lbs. Sand, 900 lbs. Flyash and 300 lbs. cement Enough water was added to provide a very fluid, high mobility grout. The ready mix grout was dumped into an Allentown positive displacement pump and injected into the mine as previously described. Pressures were monitored at the casing collar and grout takes entered onto each grout log for each grout hole.

For those areas of the mine adjacent to the property boundary, primarily on the northeastern end of the site, barrier grout holes were drilled on 3-foot centers. A stiff compaction grout mix was used in these holes to establish a grout bulkhead in the mine to prevent off-site migration of grout during grouting operations in these areas. In addition to the barrier grout holes drilled at the eastern end of the main property, additional barrier grout holes were placed at the point where the property line met the right-of-way for Route 206.

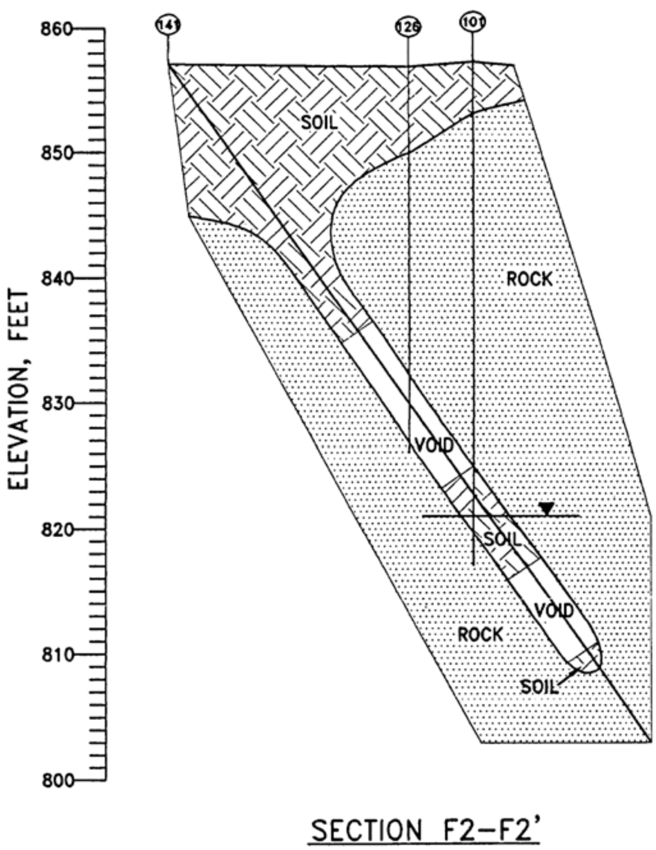

Fig. 4 Typical Mine Cross-Section

Approximately 1800 cubic yards of grout were emplaced in the Woodhull Mine. Verification of grout emplacement was by visual observation as well as pressurization of 2 psi per foot of grout head at the casing collar of the injection point. Weekly progress meetings with the regulators enabled changed conditions in the field to be dealt with quickly and resolved to the satisfaction of all parties. The closure of the mine was deemed complete and the development of the site was completed.

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