SURFACE MINING AND RECLAMATION OF ABANDONED UNDERGROUND MINES[1]

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Abstract. Within the area that is now the Jewett Mine, there were several acres of abandoned underground lignite mines. Texas Coal Mining Regulations (Section 12.367) (Railroad Commission of Texas, 1997) prohibit surface coal mining activities within 152 meter (500 feet) of an abandoned underground mine unless jointly approved by the Railroad Commission of Texas and the Mine Safety and Health Administration. No reliable method could be found to define the extent of the underground mines, therefore the 152 meter buffer zone could not be defined. Once it was decided to surface mine the underground mines, Northwestern Resources Co. contacted and received joint approval from the regulatory agencies to mine through the abandoned underground mines and recover the remaining reserves.

Mobile equipment was used in the shallower overburden and a Marion 8200 dragline was used in the deeper overburden to uncover the lignite reserves remaining in the abandoned underground mines. A backhoe and front-end loader were used to clean the sediment out of the collapsed tunnels and mine the lignite.

Northwestern has made artifacts and information recovered during the archeological mitigation work and mining available to the community. Landowners will no longer have to be concerned about the dangers of open shafts and sinkholes. The reclamation of the abandoned underground mines was achieved without using funds from the Federal Abandoned Mine Land (AML) Program. The Federal AML tax was collected on all of the lignite tons recovered from the abandoned underground mines and will contribute to the reclamation of other abandoned mine lands. Northwestern Resources Co. is continually working to provide a low cost fuel source to Reliant Energy and in the process has been able to transform severely damaged abandoned mine lands into productive pastureland.

Additional Key Words: Texas lignite, Calvert Bluff, Wilcox Group, claypan, Post Oak Savannah, historical mine, archeology, topsoil substitution.

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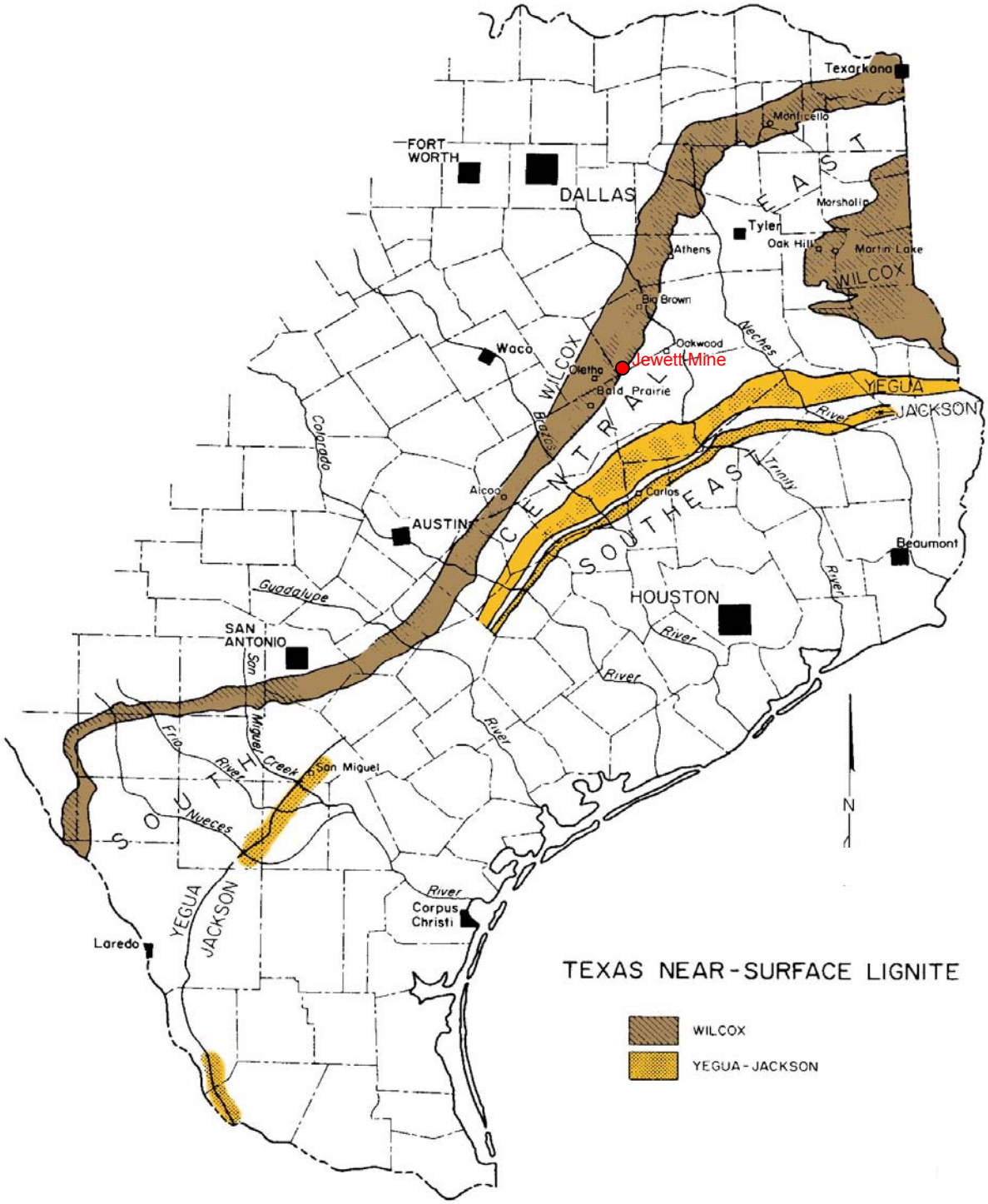
Introduction

Northwestern Resources Co. (NWR) operates the Jewett Mine located approximately half way between Houston and Dallas, Texas near Interstate 45. The Jewett Mine is a surface mine with more than 12,150 hectares permitted and that delivers between 6.3 and 7.3 million tonnes of lignite per year to Reliant Energy's Limestone Electric Generating Station adjacent to the mine. The mine uses three Marion 8200 draglines, a Marion 8750 dragline, a bucketwheel excavator with an around-the-pit conveyor and a mobile equipment fleet to mine multiple lignite seams from the upper portion of the Calvert Bluff Formation of the Wilcox Group. Figure 1 is a delineation of the near surface lignite within the Wilcox Group in Texas. This illustration was adapted from Kaiser (1978) and the location of the Jewett Mine has been added to the figure. The sediments that make up the Calvert Bluff Formation are alternating fluvial-deltaic deposits (Kaiser, 1976) and the lignite seams are interbedded with clay, sand and silt beds. The Carrizo Formation of the Claiborne Group overlies the Calvert Bluff Formation. The Carrizo Formation was deposited in a near-shore fluvial, deltaic and marine environment. Both formations are Eocene in age and the sediments strike northeast and dip southeast at about two degrees. The mineable lignite seams at the Jewett Mine are from 12 to 67 meters in depth and range from 0.6 to 4.5 meters in thickness.

The Jewett Mine is located within the Post Oak Savannah ecological region of Texas (Gould, 1975). The terrain ranges in elevation from 90 to 245 meters and varies from gently rolling to hilly. The prevalent tree species of the Post Oak Savannah are post oak (*Quercus stellata*), blackjack oak (*Q. marilandica*) and cedar elm (*Ulmus crassifolia*) and the dominant grasses are prairie climax grasses such as little bluestem (*Schizachyrium scoparium*), Indiangrass (*Sorghastrum avenaceum*), switchgrass (*Panicum virgatum*), purpletop (*Tridens flavus*) and inland sea oats (*Chasmanthium latifolium*) (Gould, 1975).

Figure 1. The distribution of near surface lignite deposits in the Wilcox Group in Texas. Adapted from Kaiser, 1978.



Historical Mining

In the early 1900's, there were two underground mining complexes, totaling 258 hectares, within the area that is now the Jewett Mine. The underground mines were abandoned by 1931. By the time the boundary of the Jewett Mine was established in the 1980's, the land over the abandoned underground mines was heavily wooded and checker-boarded with subsidence. Shafts and addits had been left open. As late as 50 years after the mine was abandoned, sinkholes were appearing and many were beyond the mapped boundaries of the underground mine.

The underground mines and associated town site were determined to be National Register of Historic Places (NRHP) eligible. A detailed archeological survey and mitigation project was completed on the remains of the underground mine workings and associated town, as required by the Texas Coal Mining Regulations (Railroad Commission of Texas, 1997). Mitigation activities included compiling all information possible on the underground workings and the people that were associated with them. The research determined that lignite was originally removed from the underground mines by the room and pillar method (Lebo and Austin, 1992). The coal seam varied from 1.8 to 3.3 meters thick. The pillars varied in thickness from 2.4 to 3.6 meters wide depending on the thickness of the overburden. The rooms were generally 3.0 to 3.6 meters wide and could be as long as 60.8 meters (Lebo and Austin, 1992). After excavating the length of the room, in some areas the room was widened as lignite was mined on the retreat allowing the roof to collapse behind (Lebo and Austin, 1992). The overburden depths varied from 6.1 meters to almost 45.6 meters.

Underground Mine Definition

Texas Coal Mining Regulations (Section 12.367) (Railroad Commission of Texas, 1997) prohibit surface coal mining activities within 152 meters of an abandoned underground mine unless jointly approved by the Railroad Commission of Texas and the Mine Safety and Health Administration. Multiple experimental geophysical methods were used in an attempt to define the underground mine limits in order to establish the buffer zone. Methods used included ground penetrating radar, resistivity profiling, seismic reflection and refraction and radio wave imaging

(Carlisle et al., 1997). In the area of the Jewett Mine, the material above and below the target lignite seam is heterogeneous due to the fluvial-deltaic depositional environment of the lignites. This contributed to problems in many of the methods (Carlisle et al., 1997). In addition, the cavities were not consistent targets. The cavities were not necessarily interconnected; cave-ins left isolated pockets and a cavity could be completely or partially filled with water or mud or a combination. Also high soil moisture and a shallow water table contributed to the problems encountered with the geophysical methods (Carlisle et al., 1997).

The maps compiled for the archeological mitigation indicated the potential for economical reserves remaining in the abandoned mines. The underground mines were in a low ratio area and if lignite could be recovered, it would be more economic than deeper reserves. In addition, mining through the abandoned areas would reclaim dangerous shafts and sinkholes, greatly improving the quality of the land. The decision was made to mine through the underground mines and recover the remaining lignite. Northwestern Resources Co. received permission from the proper regulatory agencies to mine through the abandoned underground mines to recover the remaining reserves and reclaim the area.

The Beargrass Mines were the first mines that would be encountered by NWR operations. Mining of the Beargrass Mines served as a test case before NWR committed to mining the larger group of mines, the Evansville Mines.

Artifacts Discovered

While mining through the abandoned mines, NWR unearthed the remains of several coal cars. Northwestern immediately notified the Texas Historical Commission (THC) and they determined that the coal cars did not add significantly to the information already gathered for the mitigation of the underground workings. The THC left the fate of the coal cars to the discretion of NWR. Northwestern decided to restore and display three of the coal cars recovered from the underground workings. Prewitt & Associates, NWR's archeological consultant, and the THC suggested that NWR contact the Nautical Archeology Conservation Research Laboratory at Texas A&M University in College Station, Texas. The Conservation Research Lab agreed to do the restoration work and NWR provided the funding for the project. The Research Lab specializes in the restoration of nautical artifacts such as shipwrecks. Since the coal cars had

been submerged for decades, the restoration and preservation methods used on ancient shipwrecks could be used on the coal cars. Figure 2 is first of the three restored coal cars.

Figure 2. Reconstructed and restored coal car from the abandoned underground mines.

The cars had a 1.4 tonne capacity. A worker could load up to eight cars in a day and was paid 25 to 35 cents per car. There were two different styles of cars recovered from the abandoned underground mines. The first type, shown in Figure 2, had higher sides and was shorter in length. The second type recovered had lower sides and was longer in length. A variety of wheel designs with different spoke patterns and various stages of complexity were encountered. The very first cars found in the Beargrass mines had wheels with hubs that turned directly on the axle; cars found later had hubs with bearings. Originally, mules were used to pull the cars to the surface. In later years, a cable system was used to pull the cars to cages and to lift the cages out of the shafts. Approximately 1.8 million tonnes of lignite were removed from the underground mines from 1907 to 1931.

Dewatering

The Jewett Mine is in a relatively high rainfall region (greater than 40 inches per year) with a shallow ground water table. Before the Beargrass Mines or Evansville Mines could be surface mined, a drilling program was implemented to locate and dewater as many cavities as possible. The location and dewatering of cavities was a complex process. Different methods of well completion were tried until a successful method was found. Once a cavity was located, a length of 15.2 cm diameter screen was lowered to the approximate depth of the floor of the cavity. A pump was lowered in the casing to the depth of the screen and the cavity was dewatered. The historical maps were used to help locate the main tunnels as a target for dewatering. Completely dewatering as many cavities as possible was necessary to maintain safe working conditions in the pit. If mining operations broke into a water-filled cavity, the water could flood the pit.

Surface Mining

Once dewatering operations were complete, NWR used mobile equipment in shallow cover and a dragline in the deeper cover to remove the overburden above the underground mine areas. Mining the lignite presented a unique problem. Once uncovered, the lignite seam was a mix of tunnels filled with mud, timbers, rail and solid pillars of lignite. A trackhoe, sitting on the floor of the lignite seam, was used to clean the mud, timbers, rail and weathered lignite from between the solid lignite pillars. Then the lignite pillars were mined using a front-end loader.

To date, NWR has mined through approximately 154 hectares of the abandoned underground mines. The reserves recovered in the Beargrass and Evansville mines were approximately 50 percent of the original reserves. This recovery rate was slightly higher than the estimated rate and the lignite quality was not noticeably different from the same seam in other areas of the mine.

Reclamation

The native soils in the vicinity of the underground mines are predominately deep sands. The surface soils are fine sands and loamy fine sands that are strongly acid to slightly acid. The

subsoils are up to 2 meters in depth. The subsoils are loamy fine sands to sandy loams and are strongly acid to neutral in pH. Other soils in the area of the underground mines have thin surface layers that consist of medium to strongly acid fine sandy loams with a subsurface layer that is strongly acid or very strongly acid clay (Natural Resource Conservation Service (NRCS), 1989). The dense clay subsoil, called a claypan, restricts plant growth. The water holding capacity of both types of soils is low and they are droughty in the summertime. Both types of soils require a management program with regular applications of lime and fertilizer to maintain productivity (NRCS, 1989).

Texas Surface Coal Mining Regulations (Railroad Commission of Texas, 1997) allow for the use of topsoil substitute material for the reclamation of surface mined areas. At the Jewett mine, dragline spoils are regraded and covered with four feet of mixed oxidized overburden material that is hauled around the pit by a truck-shovel operation or the bucketwheel conveyor system. The haul-back process breaks up the claypan and mixes it with the overlying, coarser-grained material. In a study of the properties of east Texas lignite mine spoil by Dixon et al. (1980), it was shown that the spoil material had a greater water and nutrient holding potential than the native soils. In addition, when less-weathered sedimentary material is brought to the surface it provides a new source of exchangeable bases (Dixon et al., 1980).

In the area of the abandoned underground workings, the oxidized overburden cover material was removed from in front of the dragline by a truck-shovel operation. The cover material was hauled around the pit by end dumps and placed on the regraded dragline spoil. Backfilling, grading and cover operations in the area of the Beargrass Mines were completed in 2000. The postmine surface and subsoils are sandy loam througout. Postmine areas are revegetated with a mix of native and introduced grasses and forbs to create a diverse vegetative cover. Grasses and forbs commonly included in the mix for the Jewett Mine are King Ranch bluestem (*Bothriochloa ischaemum*), Indiangrass (*Sorghastrum nutans*), switchgrass (*Panicum virgatum)*, Wilman lovegrass (*Eragrostis superba*), sideoats grama (*Bouteloua curtipendula*), partridgepea (*Chamaecrista fasciculata*) and Illinois bundleflower (*Desmanthus illenoensis*). A seedbed was prepared by discing to an eight-inch depth. A Grasslander seeder with packer was used to spread the seed. The grass and forb species used at the Jewett Mine are adapted to the low fertility inherent to this area, provide habitat for wildlife and require minimal inputs to sustain the stand.

The Jewett Mine has also become a nesting area for the Federally endangered Interior Least Tern. During the 2000 nesting season, the Interior Least Tern selected the reclaimed Beargrass Mine area as a nesting site. All reclamation operations in the area were suspended until the Terns had nested and migrated out of the area.

Summary and Conclusions

Mining through the underground workings will benefit many, including the landowners, the community, Reliant Energy and Northwestern. Typically, abandoned mine lands are reclaimed with funding from the Federal Abandoned Mine Lands (AML) program. The reclamation of the Beargrass and Evansville underground mines has been achieved without using funds from the Federal AML program. In addition, the Federal AML tax was collected on all of the lignite tons recovered from the abandoned underground mines and will contribute to the reclamation of other abandoned mine lands. Northwestern is maximizing the recovery of lignite resources and is helping to keep energy costs down by mining through the abandoned underground mines. If NWR chose not to mine through the underground mines, the low-ratio lignite reserves remaining in the underground mines would have been left as well as the 152-meter buffer zone around the perimeter of the mines.

Northwestern has made the artifacts and archeological information recovered during mitigation work and mining available to the community. The coal cars (that would have remained buried had the area not been mined) and other items are on display at the mine. Popular documents summarizing the history of the underground mines were distributed to employees and historical clubs throughout the area.

The land above the abandoned underground mines was checker-boarded with subsidence. Even though the underground mines have been abandoned for over 50 years, new sinkholes were continuing to appear at any time making it difficult to clear for pasture, construct roads or other improvements and some sinkholes even entrapped animals. In the surface mined and reclaimed underground mine areas the landowners will no longer have to be concerned about the dangers of open shafts and sinkholes. Northwestern Resources Co. is continually working to provide a low cost fuel source to Reliant Energy and in the process has been able to transform severely damaged abandoned mine lands into productive pastureland.

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