A PROGRAM TO MINE AND RESTORE A FORESTED WETLAND[1]

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Abstract.--This paper describes the program initiated by the Bureau of Mines to mine a forested wetland. The program outlined details the step by step plans set up by the Bureau and implemented using cooperating federal agencies and a private company, and why these plans are used. A cost analysis is given.

INTRODUCTION

The mining of forested wetlands in the Central Florida phosphate region is hampered by the lack of data on restoration. Many of the studies for restoring wetlands disturbed by mining deal with freshwater marshes (U.S. Bureau of Land Management). Though valuable, these studies are not directly applicable to the restoration of forested wetlands. Due to this lack of information, the State's regulatory agencies very rarely permit the mining of forested wetlands because an acre of wetland reclaimed is required for every acre mined. To secure State approval and to gain data on forested wetlands, the Bureau of Mines developed a systematic program to mine and restore a small forested wetland. The Bureau coordinated the efforts of the United States Geological Survey (USGS), the United States Fish and Wildlife Service (USFWS), and the industry cooperator, AMAX Phosphates, Inc., (Mobile Chemical, Inc.). The combined efforts (fig. 1) resulted in the program described in this paper.

[1]Paper presented at 1988 Mine Drainage and Surface Mine Reclamation Conference sponsored by the American Society for Surface Mining and Reclamation and the U.S. Department of the Interior (Bureau of Mines and Office of Surface Mining Reclamation and Enforcement), April 17-22, 1988, Pittsburgh, PA.

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DESCRIPTION OF THE MINING PROGRAM

Test Site

The test site is part of the AMAX Big Four Phosphate Mine in Hillsborough County, FL (fig. 2). The site is approximately 16 acres and is part of a 92-acre tract of land designated by AMAX, Inc. as Mining Unit No. 1C (fig. 3). A small stream channel and its associated wetlands make up the test site. The stream channel is approximately 2,500 ft long with 1,000 ft being in the site. The flow in this stream is intermittent. During the dry season, baseflow is provided by ground-water seepage (Thompson, 1984).

Premining Monitoring

The monitoring plan is designed to gather enough data from the site to determine its natural condition and to develop a comprehensive revegetation plan. In conjunction, a control site is set up to define any hydrological or ecological changes that may occur in the area unrelated to mining. Monitoring includes the collection of ecological and hydrological data and the collection of soil and water samples for analysis.

The USGS implemented the following monitoring networks at the test and control sites.

Proceedings America Society of Mining and Reclamation, 1988 pp 139-145
DOI: 10.21000/JASMR88020139

https://doi.org/10.21000/JASMR88020139

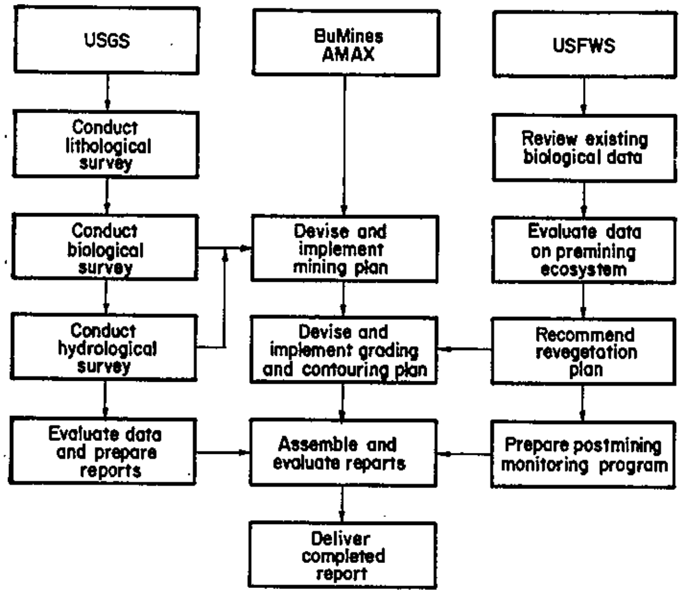

Figure 1. Diagram of Federal Agency and private cooperator responsibilities.

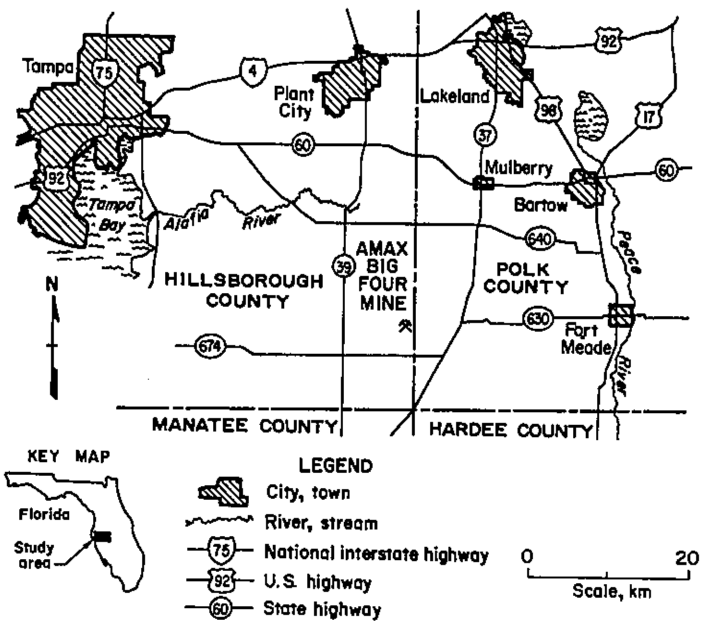

Figure 2. Location of Big Four Mine in relation to the surrounding area.

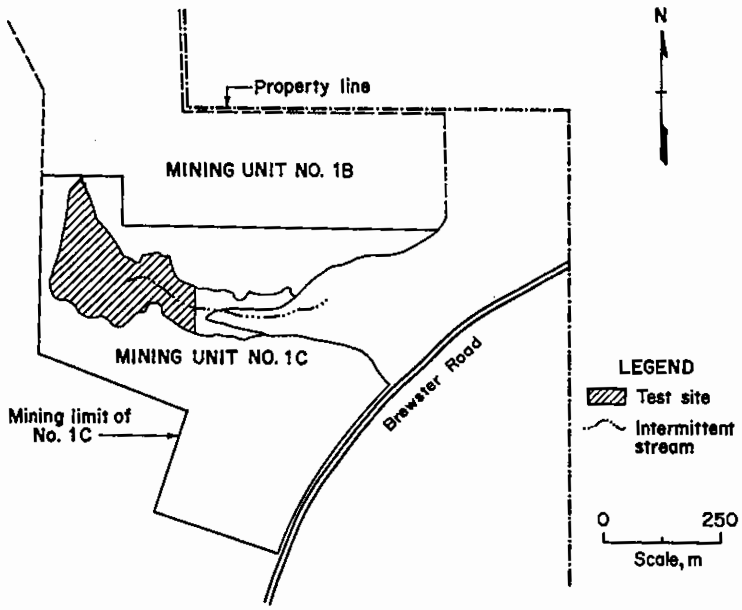

Figure 3. Mining unit No. 1C and portion covered by the test site.

Three test site linear transects (fig. 4) were established to observe the vegetative cover and gather benthic invertebrate samples. Transect A was in the test site, B was downstream in an area to be used as an unmined vegetation donor site, and C was to remain undisturbed. Information from the transects determined that the canopy and understory of the site was dominated by upland hardwoods (60 pct); the remainder of the system was freshwater swamp. Red maple, laurel oak, loblolly bay, water oak, sweet bay, red bay, swamp tupelo, wax myrtle and slash pine were identified as the dominant overstory species. Hydric indicators such as chain fern were dominant within 10 to 30 ft of the well incised creek. Flow was observed throughout monitoring. The system was almost homogenous along its entire length. The interior swamp was bordered on both sides by upland

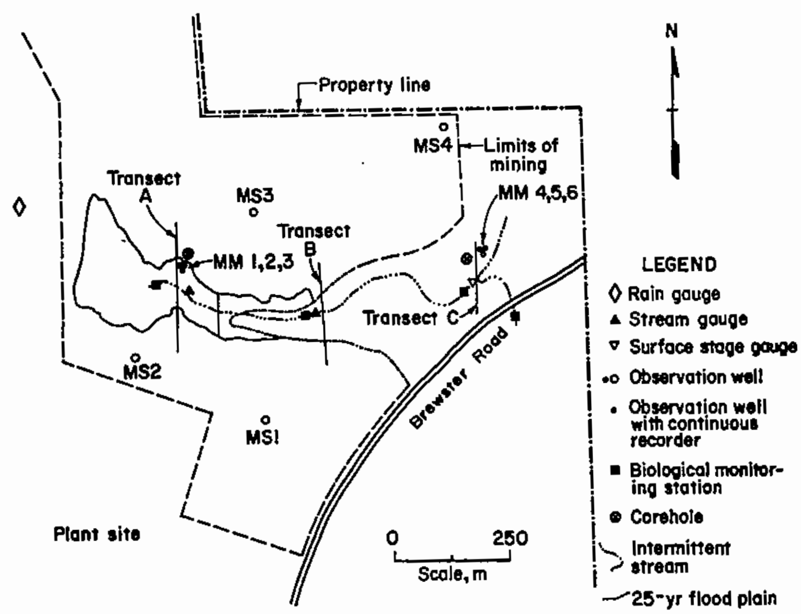

Figure 4. Locations of rain gauges, stream gauges, surface-stage gauges, observation wells, continuous recorders, and transects established by the USGS.

hardwoods. Canopy and ground cover diversity was relatively high in this system.

Ground water was observed by using the series of observation wells shown in figure 4. The placement of these wells was used to determine ground water depth and seasonal variation. A stream gauge was used to determine baseflow of the stream. Surface and ground water samples were taken to determine premining water quality. Two core holes (fig. 5), one east and one west of the site were put down to determine the lithology. Soil samples were taken from each of the transects and were analyzed for nutrients.

The control site (fig. 6) was located approximately five miles southwest of the test site. The control and tests sites had approximately equal areas of hydric vegetation and hardwood forest. The control site had one linear transect and one biological monitoring station. The transect (AC) was run east-west to intersect the stream. The transect showed that the high ground was dominated by slash pine, saw palmetto, wax myrtle, and fetterbrush. Vegetation along the stream was palm oak hammock. The overstory was dominated by water oak, sweet bay, loblolly bay, and red maple. Ground cover was dominated by saw palmetto and chain fern (Thompson, 1984). The biological monitoring station was used for benthic invertebrate sampling.

Ground water was monitored by a system of wells similar to the test site. A stream gauge was used to determine baseflow.

The test site was monitored from October 1982 to September 1983. Monitoring at the control site continues.

Site Preparation

Certain procedures such as surveying and the stockpiling of topsoil are standard for restoration efforts. Surveying is used to determine the contour and to locate major topographical features of the site before it is disturbed. The stockpiling of topsoil is standard practice for most revegetation efforts. Other procedures, unique to a project, may have to be implemented. The Bureau and AMAX determined the procedures, standard and unique, used for the test site and they are described as follows:

Site preparation began with the surveying of the area to determine the contour and to spot the stream channel. An interceptor ditch was excavated and a dike constructed to protect the downstream area from runoff, since this area was not permitted for mining. Figure 7 shows the separation of the test site and the vegetation donor site. The donor site and the area downstream was not mined, but it will be used as a source for trees and other vegetation during transplanting.

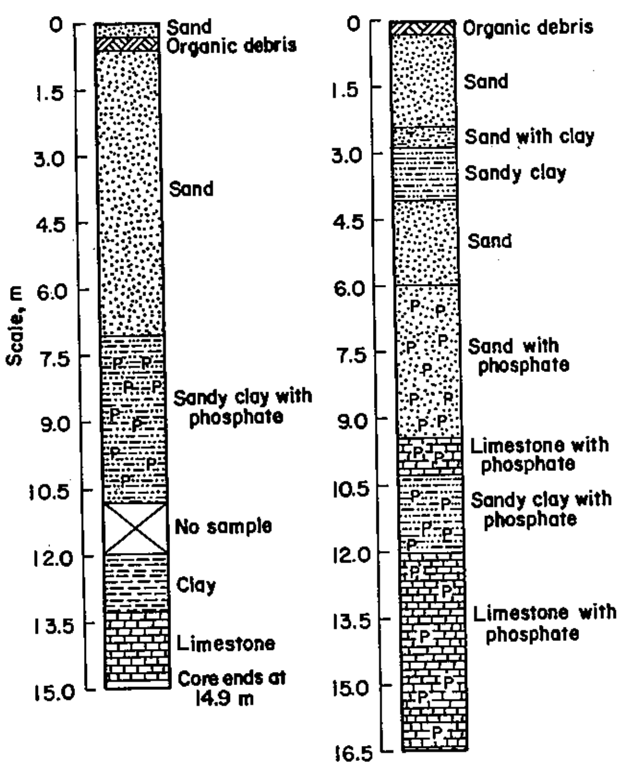

Figure 5. Lithologic cores No. 1 and 2.

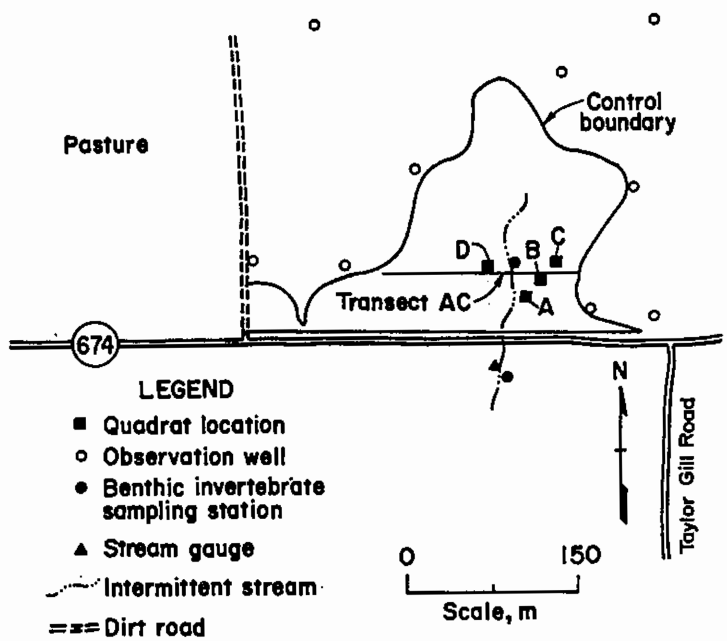

Figure 6. Network established by the USGS to monitor biological and hydrological conditions at the control site at Brewster's Ft. Lonesome Mine.

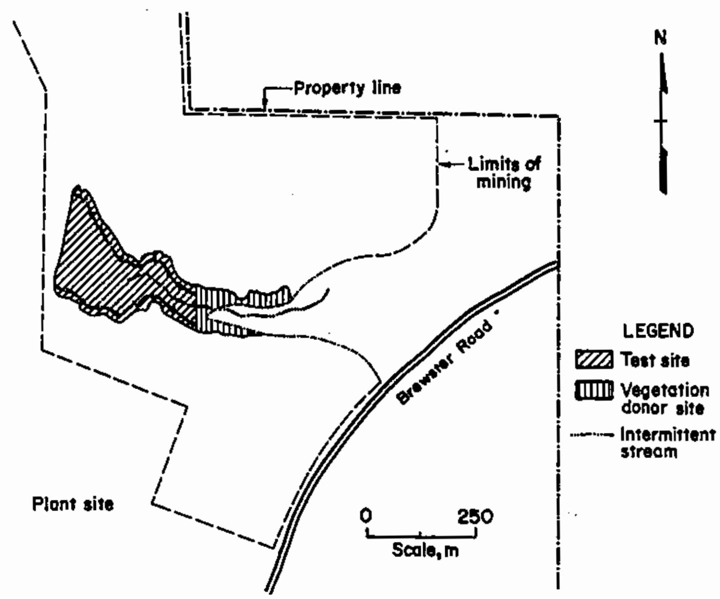

Figure 7. Test site and vegetation donor site.

The overstory was cleared by bulldozers, pushed into piles, and burned off. The topsoil was removed by pan scrapers and stockpiled within several hundred yards of the site. The stockpiles were graded and sloped for stabilization, but were not seeded because of the concern over establishing perennial plants that would be difficult to eliminate (Haynes and Crabill, 1984). Site preparation began in October 1983 and was completed in December of the same year.

Mining

This wetlands, as with most others, was part of a larger mining unit. The entire unit, including the wetlands, was mined using a 30-yd^3 dragline operating in east-west cuts. The overburden was windrowed, the ore matrix dumped into sluice boxes, slurried and pumped to the beneficiation plant. This is standard practice for the industry. Mining began in January 1984 and was completed in April of the same year.

Recontouring

The recontouring plan is used to place the site back to its original contour as closely as possible. Extra material normally must be brought in to replace the void left by the removal of the ore body. Other land features may need to be modified because of expedience or the inability to copy nature exactly. The following is the recontouring done at the test site.

Overburden was graded using the largest possible bulldozers available to limit compaction. Overburden from the mined upland area north of the site, was used to replace the matrix removed during mining, bringing the test site to rough grade. The upland area had sand tailings pumped between the windrows to make up for the volume lost. The final grade at the test site was placed using pan scrapers and bulldozers. The pan scrapers were used to haul and place the stored topsoil. Bulldozers were used to grade the actual contour. A sharp, meandering swale was placed for the original channel. This design will result in a channel nearly identical to the original, yet reduce the potential for erosion that would be caused by reconstructing the natural steep banks. Grading began in January 1985 and was completed in February 1986.

Revegetation

The revegetation plan developed by the USFWS is based on information gained from the premining monitoring. The plan includes anticipated maintenance activities, a method to evaluate the site after restoration, and postmining monitoring. The following is the plan outlined for this test site. The plan will be carried out by company personnel.

Vegetative islands will be taken from the downstream donor site (fig. 7) and transplanted along the meandering swale by a front-end loader. These "islands" are to consist of the topsoil and vegetation that will provide ground cover for the site. One or two larger trees, to provide ground cover shading, will be spaded with each island. Four to six islands per acre are planned to be placed. Handplanting of the community dominants, identified during the premining monitoring, will begin after the islands are in place. The community dominants are red maple, laurel oak, loblolly bay, water oak, sweet bay, red bay, swamp tupelo, wax myrtle, and slash pine. The seedlings and potted stock will vary in height and be planted at random to insure a staggered canopy.

Maintenance activities will consist of supplemental planting of tree seedlings, transplanting additional vegetative islands where natural species have not outcompeted invading weed species, mowing around small seedlings to enhance their survival, irrigation, and the use of herbicides. Irrigation will have to be used if the upland area has not been restored by the time planting begins.

Restoration of the project site will be evaluated based on the following criteria:

A. Tree species are viable and surviving with an average of 400 trees per acre and no acre has fewer than 200 trees. Short-term success will be determined after the first full growing season (Spring, 1989) as a survival average of 400 trees per acre. Long-term success will be determined after five full growing seasons (Spring, 1993) as tree cover exceeds 33 pct of the vegetative cover, and no acre has tree cover of less than 20 pct (Haynes and Crabill, 1984).

B. Herbaceous layer vegetation is naturally reproducing. In developing permit stipulations, the regulatory agencies involved recognized that it would be unreasonable to expect a postmining condition equal to or even nearly equal to the premining condition within a 5-yr evaluation period. However, if the restoration effort is truly successful, the postmining forest community and other related ecological factors will evolve toward the premining condition with the increasing age of the site (Haynes and Crabill, 1984).

Postmining monitoring will be conducted by the company. Plans call for the replacement of the observation wells and stream gauge used during premining monitoring. Survival rates of the planted stock will be taken. Samples from the streambed will be taken to determine biological activity and its progress.

RESULTS AND DISCUSSION

Cost

The cost of earthwork was approximately \$1.50/m^3 of material moved. Earthwork included all material moving activities such as removal and replacement of overburden, distribution and rough grading of overburden, and the final contouring with stockpiled topsoil.

Estimated revegetation costs include seeding and overstory planting. Seeding with mulching for erosion control costs \$525 to \$600 per acre. Costs for overstory planting will vary with the type planted. Bareroot seedling cost is \$14 to \$30 per thousand plus \$0.30 per tree for planting. Potted stock cost is between \$3.50 and \$20, depending on size, plus an additional \$1 per tree for planting. The cost for tree spading is approximately \$25 per tree. An estimated 6,000 to 7,000 trees will need to be planted.

The following are costs per acre. Monitoring represents premining and postmining combined.

Earthwork....................\$5,700
Revegetation.................\$2,000
Monitoring...................\$3,600

CONCLUSIONS

The most important part of the program is the premining monitoring plan. In a system as complicated as a forested wetland, the premining monitoring plan gives the essential information needed to develop the revegetation plan. It is very doubtful that a forested wetland in Central Florida could be permitted to be mined without some sort of premine monitoring. The implementation of the revegetation plan is next in importance. Close supervision of this area is needed to insure a successful completion to the program. Site preparation, mining, and recontouring, although important, are handled by mine personnel every day and are for the most part routine.

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