No. 169
Issued 10-Jun-84

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Amite River Sand & Gravel Mine Reclamation Demonstration Project
- Final Report -

August 31, 1999

Phase IV Project Efforts: CFMS Cooperative Agreement No. 537964

Submitted To:

LA Department of Environmental Quality - Office of Environmental Assessment, Nonpoint Source Pollution Unit
7290 Bluebonnet Blvd, Baton Rouge, LA 70810

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Prepared by:
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Acknowledgements

Many thanks are owed to the following parties for their contributions to the sand and gravel mine reclamation demonstration project efforts reported herein:

Judge Burrell Carter for his cooperation in use of the site lands during project efforts, maintenance and control of site access, and financial support through funding reforestation efforts, along with his interest in reclamation possibilities and words of encouragement throughout the project;

Mr. Pat Thomas of Thomas Sand & Gravel for his support during the site selection phase and for his contributions through completion of rough grading prior to demonstration project efforts;

Messrs. Anthony J. “Tony” Duplechin and Sean McLaughlin of the Louisiana Department of Natural Resources’s Surface Mining Section for their many contributions; and

LDEQ’s Nonpoint Source Pollution Unit staff, with special thanks to Ms. Jan Boydstun for her patience and support, along with the string of project officers without whom the project would not have been possible, including (in chronologic order):

Ms. Susan Vullo, Mr. Patrick Guelfo, Mr. Gary Goay and Ms. Anneliese Westphal.

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1.0 INTRODUCTION/EXECUTIVE SUMMARY.

The U.S. Environmental Protection Agency (EPA) has identified resource extraction as one of the nonpoint source categories contributing to degradation of the nation's waters, designating mining as second only to agriculture in terms of contributions to nonpoint source water quality impairment. In Louisiana, non-coal surface mining activities have been identified as a significant source of increased sediment loadings to rivers and streams, which continue well beyond the period of active industrial operations due to lack of proper restoration at most sites. Among others, those stream subsegments consisting of the upper reaches of the Amite River have been designated as not meeting their respective water quality criteria due at least in part to sediment loadings produced from sand and gravel mining activities.

During the earlier part of the 1990's, a committee of various governmental and regulatory agencies, representatives of the sand and gravel industry, and interested citizens came together to review suspected influences of sand and gravel mine operations on flooding and water quality within the Amite River Watershed. Recommendations of that committee were published in March 1992 as the final report of the Governor's Interagency Task Force on Flood Prevention and Mitigation's Amite River Sand And Gravel Committee. That report included recommendations that action be taken towards implementing regulations to control adverse impacts identified, and to provide for appropriate reclamation of lands disturbed through mine operations. Additionally, the task force recommended that one or more demonstration projects be conducted to provide for an evaluation of reclamation practices appropriate for utilization within the area. The demonstration project efforts reported herein are a direct result of those task force recommendations.

Demonstration project efforts were initiated in March 1995, with the initial phases involving selection of an appropriate and available site, and development of a site reclamation plan. After that plan was reviewed and approved by LDEQ and EPA representatives, a subsequent project phase was initiated, consisting of implementation of selected aspects. The implementation phase included grading of mine spoil and tailings materials, site preparation activities, and revegetation efforts. Phase III & IV efforts have focused on monitoring and maintenance activities conducted to ensure long-term reclamation success and to provide for an evaluation of the level of reclamation success achieved.

The reclamation philosophy established for this project mandated that reclamation techniques employed be limited to those which would not prove cost prohibitive for utilization in wide scale abandoned mine land reclamation efforts contemplated for disturbed lands of the Amite River Watershed. In terms of mine-soil characteristics, this philosophy restricted options to working with the existing surface materials as a vegetative growth media. In the Amite River Watershed, the preponderance of mine-soil materials encountered consist of tailings deposited through operation of wash-plants in separation of the desired products from the mined resources. These tailings materials are primarily comprised of fine to medium size sand grains mixed with off-spec gravel, with little to no clay or silt size particles (the finer soil particles being returned to the mine pits with effluent waters). As a vegetative growth media, these materials can best be described as extremely low in fertility and excessively well drained. Review and inspections of abandoned mine sites throughout the project area and elsewhere in the state have shown these sands to be very resistant to natural revegetative forces and normal plant succession. Sites abandoned for more than a quarter-century exist with little to no vegetative cover. Without some augmentation through reclamation efforts, sites covered with these materials remain relatively unstable and of little to no apparent ecological, agricultural, or silva-cultural value.

Practices which proved essential in reclamation of the sand mine tailings piles covering the demonstration project site included:

- Grading and Contouring to facilitate equipment access for performance of reclamation activities, and as required to support the intended post-mining land use;
- Surface Roughening through contour furrowing (simplified terrace installation) and contour tilling/culti-packing;
- Mine-soil Fertility Augmentation, including Organic Matter Additions to improve revegetation success;
- Temporary Ground Cover Establishment; and
- Permanent Vegetative Cover Planting & Establishment.

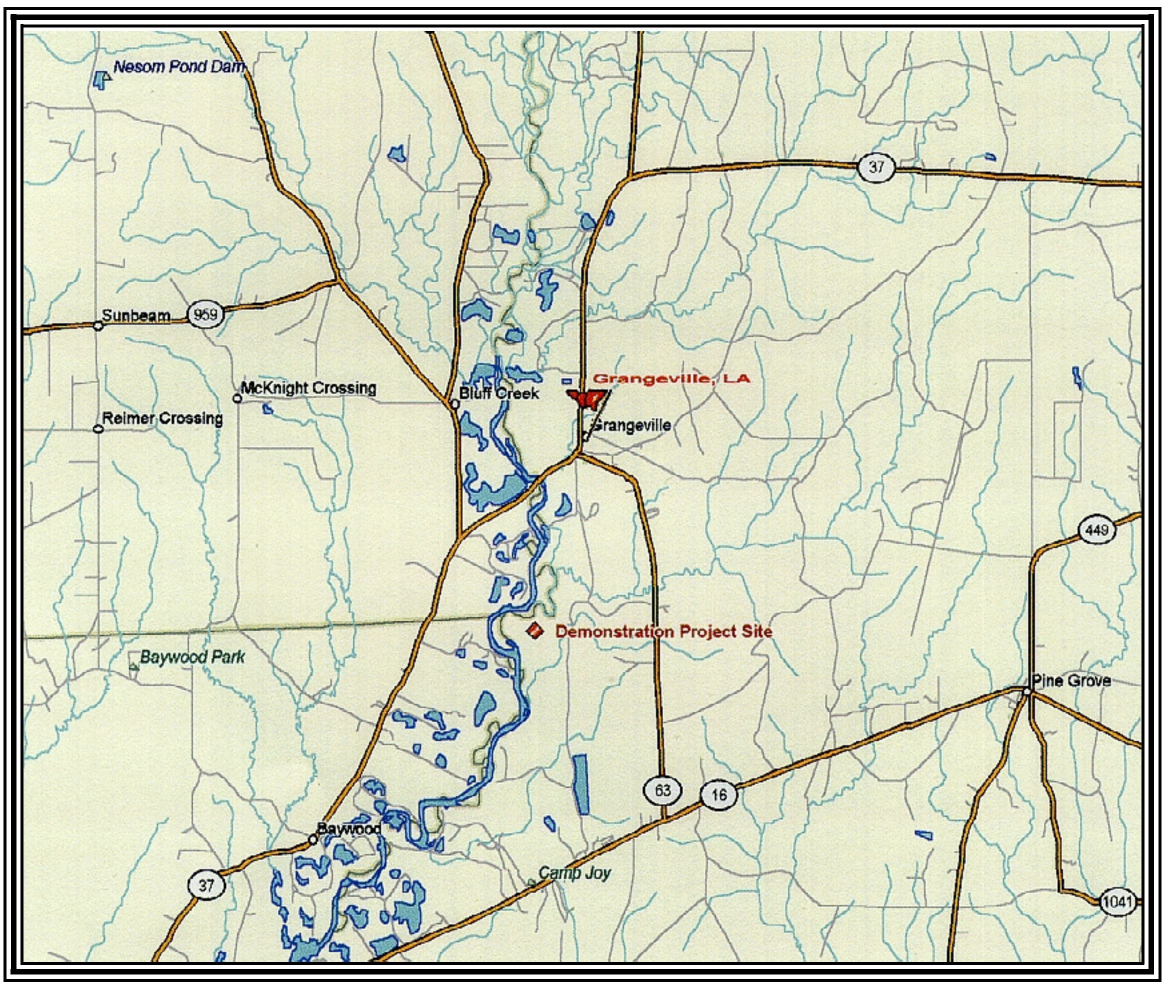
Through implementation of these practices, sand tailings encountered at the demonstration project site have been stabilized with a dramatic reduction in the apparent level of localized soil movement, relative rates of erosion and offsite sediment transport, and establishment of vegetative species to maintain control of erosive forces and to support a beneficial post-mining land use.

Descriptions of the practices utilized and results obtained are contained herein. Project activities included photo-documentation of events and results achieved. Selected photo images have been included. A more extensive set of site photographs taken in conjunction with project activities has been prepared and submitted in digital format.

2.0 Site Selection / Site Location.

Site selection activities were conducted during the initial phase of project activities. A complete account of site selection procedures utilized is contained in the report for that project phase, submitted in December 1995 under Contract 24400-95-42. Site selection processes resulted in securing an appropriate lease on a tract of land from an owner interested in reclamation possibilities. The selected site is located on the east bank of the Amite River, approximately 1.5 miles southwest of Grangeville, LA in St. Helena Parish.

The demonstration project site is located near Latitude 30°42'58"N-Longitude 90°50'39"W, lying within the N½ Sec 7, S½ Sec 67, and NW¼ Sec 69, all of Township 4 South - Range 4 East. Reclamation activities have been confined to two sand tailings piles covering a combined total of 16.2 acres. Site ingress and egress are provided though a private road with controlled access. Initial project plans called for inclusion of an additional 3 acre tailings pile area which was later excluded from project efforts to avoid damages to pine seedlings established by the land owner prior to project initiation.



3.0 Reclamation Plan / Demonstration Project Plan Development & Implementation.

Project planning efforts included preparation of a conceptual reclamation plan and cost estimate submitted under the aforementioned contract in January 1996, along with a more detailed plan submitted in April 1996. Plans submitted to and approved by DEQ & EPA included a reclamation strategy calling for elimination of certain higher cost reclamation practices so as to ensure the viability of procedures utilized for implementation throughout the surrounding watershed. Plan specifics were adjusted throughout the project as needed to accomplish reclamation success.

The previously referenced Final Report of the Amite River Sand and Gravel Committee included several reclamation options judged to be potentially applicable to problems faced in the site vicinity. These included:

(1) utilization of tolerant plant species (being those adapted to infertile, droughty sites);

(2) long-term improvement of soil (through growth of temporary vegetative crops and soil amendment applications); and

(3) organic soil amendment applications.

Interviews with several mine operators active within the Amite River Watershed indicated a predisposition to the idea that reclamation would necessitate "dirting", translated as covering or capping mine tailings materials with more fertile soil materials, including topsoil replacement. Preliminary evaluations concluded that while such practices would most probably result in improved post-mining productivity, implementation of such practices would be cost prohibitive when considering probable post-reclamation land uses and associated land values and/or earnings potential. Economic feasibility mandates included in the reclamation strategies developed for this project eliminated any form of topsoil replacement or capping from consideration. Furthermore, experience indicates that the practice is not essential to reclamation success.

<u>Application of organic soil amendments</u> was eliminated from consideration as an economically viable alternative during initial reclamation planning efforts due to anticipated costs of material acquisition, transport, and application. However, after initial failures in establishment of temporary vegetative cover, additional reviews were conducted, resulting in identification of a practical and affordable organic soil amendment for utilization in reclamation efforts. This material (*i.e.,* pelletized broiler litter) or an equivalent substitute was found to be essential in achieving reclamation success under conditions encountered. Results obtained indicate that further studies should be conducted to evaluate organic matter addition levels and application techniques. Agricultural waste utilization schemes derived could prove critical in development of mine reclamation strategies for the Amite River Watershed and similar areas.

Reclamation procedures provided for in initial demonstration project plans included:

- grading & contouring of mine soil surfaces to facilitate equipment accessibility and to provide for effective erosion control;

- application of lime & fertilizer based on soil analysis results;

- selection & planting of tolerant plant species for establishment of herbaceous ground cover followed by reforestation of the demonstration project area; and

- stimulation of natural soil formation processes and mine soil nutrient buildup through growth of leguminous forage and return of biomass generated to the soil surface.

3.1 GRADING & CONTOURING.

Reclamation efforts at the site were initiated by the mining company prior to its selection for demonstration project purposes. Those efforts consisted of grading tailings piles to create a gently sloping topography more accessible to reclamation equipment than normally encountered at mine sites within the Amite River Watershed. Additional grading was completed as part of final site preparation efforts. Topographic surveys of the site were completed following completion of grading efforts in order to collect required input data for erosion rate modeling efforts conducted as part of reclamation success evaluations.

Photographs depicting typical mine site conditions within the Amite River Watershed, as well as specific photographs of pre-reclamation conditions at the demonstration project site are provided in Appendix A.

3.2 SURFACE ROUGHENING.

Upon completion of final grading efforts, the first temporary vegetative cover plantings were conducted. Heavy rains followed within days, revealing the degree of erosion rates being experienced at the site. The majority of applied seed and emergent seedlings were eroded from site slopes and deposited at lower elevations where deposition occurred. For the most part, displaced seed were deposited in pools where they germinated and subsequently died due to lack of soil cover. These failures emphasized the need for site preparation strategies incorporating surface roughening techniques to lessen erosional rates by reducing runoff velocity and shortening the effective length of site slopes. The techniques employed included installation of a series of **contour furrows** established on a gradient of 1 to 1.5 percent across the primary slopes. Trial installations were conducted employing a dozer blade attachment on a light-weight track-mounted excavator. Based on the success achieved with these installations, a light-weight terrace plow was fabricated and fitted on a suitable tractor to provide for additional contour furrow installations. A rotating laser level was also employed in layout of the second generation of contour furrows installed, providing a simple and accurate way of laying out furrow paths.

Surface roughening, in the context of sand and gravel mine site and construction site reclamation, does not equate to NRCS Conservation Practice Standard (CPS) 609, which is prescribed for purposes of wind erosion, but rather to the combination of conservation practices employed to roughen the soil surface for purposes of slowing runoff rates, thus increasing rainfall percolation and resultantly reducing the overall rate of runoff, erosion of soil surfaces, and the quantity of sediment transported from a given site. Surface roughening in this situation should be conducted along the contour, similar to terracing. (Terracing in this context is not intended to indicate conformance with NRCS's terracing standard CPS 600.) Techniques employed are less permanent, and may be installed using less rigorous specifications. When installed along an appropriately uniform gradient, contour furrow installations, a form of surface roughening, will normally result in variable spacings, due to irregular slope gradients found at most abandoned mine sites. Care should be taken during equipment operations conducted after installation of contour furrows to avoid crossing furrows. Contour furrows may require periodic maintenance until vegetation is established. Photographs depicting contour furrow installations at the demonstration project site are provided at the end of this section.

Initial failures in establishment of temporary vegetative cover also resulted in employment of an additional surface roughening technique designated as **contour culti-packing**. This practice may be considered a form of contour tillage; however, equipment utilized results in minimal disturbance to established vegetation. The culti-packer is a traditional piece of farm equipment used in seed bed preparation and pastureland establishment practices. For this project, utilization of two different equipment units was required. The standard agricultural implement was utilized where mine-soil conditions would allow, resulting in the most satisfactory results. However, where trafficability conditions were most severe (*i.e.*, in areas of loose dry sand) a lighter weight implement was required. An appropriate unit was fabricated using automotive wheels strung together on a single axle. Performance of the fabricated unit was satisfactory, and served as an invaluable tool in establishment of initial temporary vegetation under specific conditions encountered at this site. After adequate root systems were established through ryegrass establishment, the standard culti-packer could be used throughout, due to associated improvements in mine-soil trafficability.

Contour culti-packing improves reclamation results through formation of a groove and mound patterned surface which tends to trap soil moisture, thus reducing rainfall runoff rates and providing increased available moisture critical to establishment of vegetative cover. When employed immediately after seed application, culti-packing enhances seed to soil contact, resulting in improved revegetation success. Results obtained through employment of contour culti-packing techniques are documented in the photographs that follow.

Surface Roughening

- Simplified Double Terraces approximating topographic contours -Initial 1996 Efforts
  - Reduced Effective Slope Length
  - Slowed Runoff Rate
  - Increasing Stormwater Retention
- Rough Installation Using Trackhoe w/Blade
- Improved Terraces Installed in 1997
  - Surveyed In at 1% Fall Using Laser Level
  - Inter-Terrace Spacing Varies w/Topography


Contour Furrows - Trial Installations


Contour Furrows - Surveyed Terrace Plow Installations


Contour Furrow Maintenance

Cultipacking

Along Topographic Contour Trends

- Surface Roughening
  - Runoff Entrapment
  - Rainfall Infiltration Rate Increases (Puddling)
  - Micro Slope Length Reduction
- Seed Bed Enhancement
  - Improved Soil - Seed Contact
  - Improved Soil Moisture Conservation

Culti-Packing

Contour Culti-Packing

Light-Weight Culti-Packer Pulled by ATV

3.3 MINE-SOIL FERTILITY AUGMENTATION.

Samples of site mine-soils were analyzed to determine nutrient content, with results confirming minimal fertility levels anticipated. Mineral fertilizer application prescriptions were developed based on these analyses. Fertilizers were applied periodically during the initial project years using traditional mineral fertilizers. Initial vegetative establishment found mixed results, with a high degree of seedling mortality in those areas where sands expressed more distinct droughtiness characteristics. Early into the project, a source of organic soil amendments was secured in the form of pelletized broiler litter which could be applied using a seeder attachment affixed to an ATV (All Terrain Vehicle or “4 wheeler”). After review and evaluation of product analytical data and results obtained in other applications of these materials were conducted, broiler litter applications were made in conjunction with a supplemental seeding event. A product performance evaluation was established through applying mineral fertilizers uniformly across the entire project site, while withholding broiler litter applications from an area bound by two contour furrows within the site. This routine was maintained throughout the vegetative establishment period, with photographs being taken to document the results obtained. Findings indicate that organic soil amendment applications should be considered as a viable practice for utilization in reclamation of similar mine sites. In the case of this project, revegetation efforts were considered to be a failure where broiler litter applications were withheld. After completion of an adequate product performance evaluation, broiler litter applications were made to the control area, resulting in successful establishment of vegetative cover in that portion of the site.

During Phase IV project efforts, soil amendment applications were discontinued in order to provide for an evaluation of survivability of vegetative cover without continued site maintenance. Results obtained indicate that an adequate stand of perennial vegetation was established to provide for erosion control needs of the site, and to support interstitial ground cover needs associated with site reforestation. Small plot tests conducted indicate that reclamation success could be improved through application of organic soil amendments at more generous rates. Additional studies should be conducted to provide for optimization of application rates on various mine-soil materials. In situations where agricultural waste utilization may prove synergistically beneficial to animal agriculture operations, unit costs of organic soil amendments should be improved.

Selected photographs documenting revegetation successes associated with broiler litter applications follow. Additional photographs documenting results obtained are provided in Appendix A.

Broiler Litter Utilization

Reclamation Enhancements with Lagniappe

- Organic Matter Additions
  - Dramatic Increase in Initial Growth & Stand Establishment
  - Improved Plant Vigor & Survivability
- Agricultural Waste Utilization
  - Utilization of Waste Products Posing Threat to Surface Water Resources in Poultry Production Areas

Pelletized Broiler Litter at ≈ 150 lbs/acre

April 98 - With & Without Poultry Litter Additions

Note Control Are with No Poultry Litter

3.4 REVEGETATION & REFORESTATION EFFORTS.

Demonstration project plans called for:

- selection & planting of tolerant plant species for establishment of herbaceous ground cover followed by reforestation of the demonstration project area; and

- stimulation of natural soil formation processes and mine soil nutrient buildup through growth of leguminous forage and return of biomass generated to the soil surface.

In consideration of species tolerant of low fertility and droughty mine-soil conditions, utilization of a number of native grasses is often recommended. However, the availability of sources of native plant seed materials and cost associated with utilization of such materials is an important factor affecting feasibility of abandoned mine reclamation efforts in the demonstration project area. As indicated in previous project reports, a wide variety of vegetative species were planted in conjunction with demonstration project efforts. Species found to be most applicable for utilization in reclamation efforts in the project area were those most readily available at local seed outlets and which have been traditionally utilized by the contractor in prior reclamation efforts. These species include:

- Common Bermudagrass (*Cynodon dactylon*) as a perennial ground cover,
- Gulf Ryegrass (*Lolium multiflorum*) as a cool season annual,
- Crimson Clover (*Trifolium incarnatum*) as a cool season annual legume, and
- Browntop Millet (*Panicum ramosum*) as a warm season annual.

NRCS's Conservation Practice Standard for Critical Area Plantings (CPS 342) serves as an appropriate guideline in selection of suitable species for use in mine reclamation. Increases in seeding rates will provide for more immediate establishment of vegetative cover critical to mine site reclamation in certain cases.

As previously noted, reclamation plan implementation initiated with several unsuccessful efforts at establishment of a temporary vegetative cover on the sand and gravel wash-plant tailings covering the site. These initial failures prompted evaluations which revealed that emergent vegetation on the ridge and upper slopes was being uprooted by erosional forces, and plants on the lower slopes were being covered with derived sediment.

Erosion and sedimentation processes occurring on the site indicated the need for installation of support practices to reduce the erosion potential of rainfall runoff being experienced. Support practice installations, discussed in Section 3.2, resulted in reduced erosion and downslope deposition rates facilitating establishment of temporary vegetative species. With proper mine-soil fertility augmentation, namely broiler litter applications (discussed in Section 3.3), successes were achieved in establishment of a temporary vegetative cover which rapidly brought about drastic reductions in erosion rates.

The most dramatic temporary vegetative establishment results were achieved through ryegrass plantings. Ryegrass stubble and root systems established during the fall and early spring served as the principal deterrent to erosional forces through the first summer following establishment, with common bermudagrass being seeded within the residual ryegrass cover during the spring. Ryegrass plantings were withheld the following year in order to minimize competition to the permanent vegetative cover (*i.e.*, common Bermudagrass). In the early spring of the 2nd year, common bermudagrass from the prior years plantings emerged as the dominant species. Native grasses and forbes also proliferated.

Project results indicate that once conditions are established which will support vegetative growth, native volunteer species will soon invade the site, providing for an adequate variety of species to support long-term reclamation success, especially where post-mining land uses of forestry and/or wildlife habitat are selected. It is further suggested that any specialty plantings (as in wildlife food plot establishment) should be deferred until reclamation success has been achieved with more economical species. Optimal species to be utilized should be seen as a variable specific to site conditions and post-mining land use objectives.

Loblolly pine seedlings were utilized as the principal species in reforestation efforts due to land owner preference and seedling availability. Although direct seeding efforts conducted during the first year of project efforts were not considered to be successful, longleaf pine seedlings continue to emerge as a result of those plantings. When compared to loblolly seedlings, the scattered longleaf plants resulting from direct seeding applications appear to be healthier and more vigorous. Observations suggest that additional trials should be conducted using direct seeding techniques in conjunction with future reclamation efforts in similar circumstances. It is assumed that a higher success level would have been achieved if direct seeding efforts would have been delayed until the 2nd year. Additionally, direct seeding trials incorporating contour culti-packing and organic soil amendment applications should be evaluated in future demonstration project efforts at a similar site.

Reforestation efforts included direct seeding in the 1st year of reclamation, followed by two consecutive plantings of loblolly seedlings. High mortality rates in the first seedling plantings were attributed by some to effects of broiler litter applications. However, drought conditions that summer were shown to result in high pine seedling mortality rates throughout the area. Based on landowner wishes, broiler litter applications were curtailed six months prior to the 1998/99 loblolly planting event.

4.0 EVALUATION OF RECLAMATION SUCCESS.

The primary objectives of mine site reclamation are to (1) implement appropriate management practices for reduction of erosion rates to a level which will minimize sediment contributions to non-point runoff to a level which will not result in significant adverse impacts to the surrounding environment, and (2) to prepare the lands for return to some beneficial post-mining land use. As defined by Munshower [1], "*reclamation* is used to refer to the construction of topographic, soil, and plant conditions after disturbance, which may not be identical to the pre-disturbance site, but which permit the degraded land mass to function adequately in the ecosystem of which it was and is a part." Evaluations of project activities and results achieved indicate that both primary objectives have been accomplished at the demonstration project site to an acceptable degree; that is, erosion rates have been significantly reduced, and the land has been prepared for return to the selected post-mining land use.

In evaluating the level of success achieved when reclaiming recently mined lands, it is natural to compare post-reclamation conditions to pre-mining conditions. This is appropriate in that variables which are controllable during the mining process can certainly affect the outcome of subsequent reclamation efforts. Such an evaluation therefore may constitute a review of not only results of the reclamation efforts, but also the mining practices which defined the range of economically feasible opportunities available to the reclamation practitioner. In the case of coal and lignite mining operations, regulatory mandates exist which require that lands are required to a condition designated as being "as good or better than" pre-mining conditions. This, of course, is not the case in unregulated sand and gravel operations in Louisiana, nor is it an appropriate criteria for evaluation of the level of success achieved in reclamation of abandoned mine lands. Therefore, this evaluator has judged it to be more appropriate to reflect upon the degree of improvement achieved as a more meaningful yardstick in evaluation of reclamation success when dealing with abandoned mine lands. One could also pose the question, "Were the benefits derived worth the investment made?", necessitating a cost-benefit analysis of abandoned mine land efforts. Such an analysis is beyond the scope of these project efforts, and would constitute derivation of a significant number of intangible values associated with the worth of water quality improvements, wildlife benefits, esthetics, etc. However, evaluations conducted by a number of federal agencies have found the cost of mine land reclamation to be justified on sites within the jurisdiction of their programs. Logic suggests that a cost-benefit review of reclaiming abandoned mine sites with the Amite River Watershed would provide similar results.

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[1]Practical Handbook of Disturbed Land Revegetation, Frank F. Munshower, Lewis Publishers, 1993

4.1 MODELING EFFORTS & RESULTS.

Several vehicles exist for use in evaluation of mine land reclamation success. This evaluation has utilized the RUSLE model following "Guidelines for the Use of the Revised Universal Soil Loss Equation (RUSLE) on Mine Lands, Construction Sites, and Reclaimed Lands" [2] issued by the U.S. Office of Surface Mining. Results of these evaluations are provided in the following paragraphs. Several critical terms utilized in association with review of RUSLE model results include:

- **Erosion** meant as a combination of processes by which earth materials are entrained and transported across a given surface;

- **Soil Loss** which refers to that material actually removed from the particular hillslope or hillslope segment evaluated; and

- **Sediment Yield** from a surface is the soil loss less deposition occurring within depressions, terraces and/or channels within the hillslope, or at the toe and other boundaries of the hillslope evaluated.

The RUSLE model adheres to the structure of its predecessor, the Universal Soil Loss Equation[3] which defined average annual soil in tons per acre per year (A) by the formula:

$$A = R\ K\ LS\ C\ P$$

Equation variables utilized as model input factors are defined as follows:

R (rainfall/runoff erosivity);
K (soil erodibility);
LS (hillslope length and steepness);
C (cover-management); and
P (support-practice).

In simplified terms, the equation suggest that the rate of soil loss from a particular soil surface is a function of the characteristics of rainfall received, physical & chemical properties of site soils, site topography, the degree of cover provided the soil surface (vegetation, etc.), and the management practices utilized at the site.

4.1.1 R Factor Determination.

The R or rainfall erosivity factor is derived from climatological data for a site vicinity derived through review of historic rainfall records. Lookup tables are provided with the RUSLE model which include R factors for numerous cities within the United States. For purposes of these evaluations a site location of Baton Rouge, LA was utilized; resulting in an **R factor** selection of 625.

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[2] Guidelines for the Use of the Revised Universal Soil Loss Equation (RUSLE) Version 1.06 on Mined Lands, Construction Sites, and Reclaimed Lands, Galetovic, et. al., August 1998

[3] USLE, Wischmeier and Smith, 1978

4.1.2 K Factor Determination.

Mine-soil erodibility, designated as the **K factor**, must be calculated through input of data including particle size distribution, organic-matter content , soil structure classification, and permeability. Mine-soil characteristics can vary significantly within a single hillside, even more so than is found with natural soils. In the case of the selected demonstration project site, mine-soil characteristics were found to be fairly uniform, facilitating use of a single set of soil properties for the hillslope evaluated. Data required for K factor computation were derived through soil sampling and analysis conducted as part of demonstration project activities. Coarse-textured soils, such as those found at the subject demonstration project site, have relatively low erodibility factors due to high infiltration rates. Where mine-soils are higher in silt content, erosion rates and resultant sediment transport rates can be significantly higher, with increased potential adverse impacts to offsite surface water quality.

Data utilized to compute erodibility of demonstration project site mine-soils include:

- silt and very fine sand content	= 15%	- Structure Classification	= fine granular
- clay content	= 5%	- Permeability	= rapid
- Rock Cover	= 2%	- Hydrologic Group[4]	= A
- Coarse Fragment >3 in. in diameter	= 0%	- Surface Texture	= sand
- Coarse Fragment <3 in., passing m 10 sieve	= 100%		

A site **K factor of 0.49** was calculated for site mine soils using the above parameters and a soil organic matter level of 0% for all cases evaluated. Model sensitivity trials indicate that even the slightest increase in soil organic matter levels would result in K factor reductions and consequently lower soil loss estimates. Near surface organic matter levels are anticipated to occur over time through litter accumulations. Organic fertilizer amendment applications will also result in soil organic matter content increases, with corresponding soil erodibility level reductions. Organic matter in soil reduces erodibility through production of compounds that bind soil particles together, increasing aggregation and susceptibility to detachment by raindrop impact and surface runoff. Model results imply that practices such as manure additions can benefit soils through reduction of susceptibility to erosion, in addition to fertility benefits derived. These factors, along with results of these demonstration project efforts indicate that organic matter additions could play an important role in reclamation of mine-soils encountered in the Amite River Watershed.

[4]Engineering Field Manual for Conservation Practices - Soil Conservation Service, April 1975

4.1.3 LS Factor Determination.

Grading of mine site surfaces effects soil loss and sediment transport rates which are evident in RUSLE model results through manipulation of the LS Factor utilized. Modeling efforts conducted did not include an evaluation of erosion and sediment production reductions achieved through site grading efforts accomplished by the mining company prior to demonstration project initiation. The LS factor utilized in project evaluations were therefore held constant, although factors which would be derived through evaluation of typical abandoned mine land sites within the Amite River Watershed would be much higher, resulting in prediction of higher soil loss and sediment production rates.

A topographic survey of the demonstration project site was conducted to provide data required for LS Factor determination. A hillside portion of the site was selected for modeling. Slope length and gradient characteristics were measured as follows:

Segment 1	length = 25 ft.	gradient = 2.0%
Segment 2	length = 110 ft.	gradient = 4.5%
Segment 3	length = 80 ft.	gradient = 1.0%
Segment 4	length = 35 ft.	gradient = 1.5%

RUSLE computed LS Factors for the 4 slope segments as follows:

	Segment 1	Segment 2	Segment 3	Segment 4
Segment LS Factor	**0.167**	**0.809**	**0.211**	**0.361**

The RUSLE model combined these segments to create an effective segment profile having a horizontal length of 250 ft, and an equivalent slope of 2.41%. An **overall LS factor of 0.491** was computed for the hillslope, using a general land use type of "disturbed fill, subsoil, no rock cover."

Slope configurations found at abandoned mine sites throughout the Amite River Watershed have much steeper gradients than those produced during reclamation preparations conducted prior to initiation of demonstration project activities. In general, as slope length and/or gradient increase, soil loss increases. Topographic conditions at such sites would result in significantly higher LS factors than those computed for the demonstration project site. Higher erosion rates would be predicted under those conditions.

4.1.4 C & P Factors.

The C & P factors entered into RUSLE are those most controllable by the reclamation practitioner. The cover-management factor (C) represents the effects of vegetative cover, management, and erosion control practices on soil loss and sediment transport rates. The P factor represents the support practices used to reduce the erosion potential of site runoff through their influence on drainage patters, runoff concentration, runoff velocity, and hydraulic forces exerted by runoff on site mine-soils.

RUSLE model runs were conducted to calculate soil loss and sediment yield rates for nine (9) cases, representing snap shots in time relative to the subject demonstration project reclamation efforts. These cases evaluated include:

- Pre-Reclamation Conditions
- Contour Furrow Installations
- Contour Tillage Implementation (Culti-packing)
- Combined Contour Furrow & Contour Tillage Installations
- 1st Year Revegetation Conditions
- 2nd Year Revegetation Conditions
- 3rd Year Revegetation Conditions
- Projected 5th Year Revegetation Conditions; and
- Projected 10th Year Revegetation Conditions.

Differences between these cases are expressed through implementation of support practices affecting the P factor, and evolution of revegetation success evidenced by reduction of the C factor over time.

Pre-Reclamation Evaluation.

The Pre-Reclamation case provides an estimate of soil loss and sediment yield after completion of site grading but prior to implementation of erosion and sediment control practices. RUSLE results for this case are as follows:

- Soil Loss = 15 tons/acre/year
- Sediment Yield = 15 tons/acre/year
- Sediment Deliver Ratio = 1

This case utilized a P Factor of 1 with a C Factor of 0.9822 attributed to 2% rock cover and showing 1 year since last physical disturbance.

Contour Furrow Installations.

Contour Furrow installations were evaluated assuming no change in C from the pre-reclamation case (C=0.9822). The practice was modeled equivalent to graded terrace installations on an average spacing of 65 feet with an outlet grade of 0.4%, resulting in a P Factor reduction to 0.68. Model results for this case indicate:

- Soil Loss = 10 tons/acre/year
- Sediment Yield = 6.2 tons/acre/year
- Sediment Deliver Ratio = 0.42

Contour Tillage Installations.

Contour tillage was conducted in the form of culti-packing between the contour furrow or terrace installations. This practice was modeled with and without inclusion of the contour furrow practice with the following results:

- Soil Loss = 8.2 tons/acre/year with contour furrows, 11 without
- Sediment Yield = 6.1 tons/acre/year with contour furrows, 11 without
- Sediment Deliver Ratio = 0.41 with contour furrows, 0.73 without

Comparisons between contour tillage with and without contour furrow or terrace installations indicate the combined practices are much more effective used together than alone. Model results agree with field observations made on areas where culti-packing alone was tried without contour furrow installations. No change in C factor was assumed (*i.e.*, C = 0.9822) for these cases. The P factor for culti-packing was calculated as 0.55 with contour furrows, and 0.725 without. Model input regarding P factor calculation for contour tillage included a furrow gradient of 0.01% and ridge height of 3 to 4 inches. Additional model input utilized a cover level of 2% at both time of disturbance and after consolidation, and a roughness factor of 0.4.

Revegetation Success Level Evaluations.

All cases including revegetation of the site surface assume P factors derived through installation of contour furrows with culti-packing between the terrace-like furrows. C factors were varied to model revegetation success levels evident for the 1st, 2nd, and 3rd year of site reclamation, as well as projected revegetation success levels for the 5th and 10th year following initiation of site reclamation efforts. The following table indicates C factor variable differences utilized to model the revegetation cases, along with the C factor computed for each case.

	1st Year Vegetation	2nd Year Vegetation	3rd Year Vegetation	5th Year Projection	10th Year Projection
Top 4" root mass (lb/ac)	960	1200	1560	2040	2400
% Canopy Cover	40%	50%	65%	85%	100%
Average fall height (in)	0.1	0.1	0.1	0.1	0.1
random roughness (in)	0.4	0.4	0.4	0.4	0.4
yrs since last disturbance	1	2	3	5	10
% vegetative residue	5.0%	5.0%	6.0%	7.5%	10.0%
C-VALUES	**0.2214**	**0.1324**	**0.0586**	**0.0126**	**0.0004**

Input data utilized for the evaluation of revegetation contributions to soil loss rate reduction (*i.e.*, C factor computation input) were based on a combination of field observations, professional estimates, and vegetative proliferation predictions. Predicted soil loss rates based on these estimated input values should be interpreted as being more qualitative than quantitative.

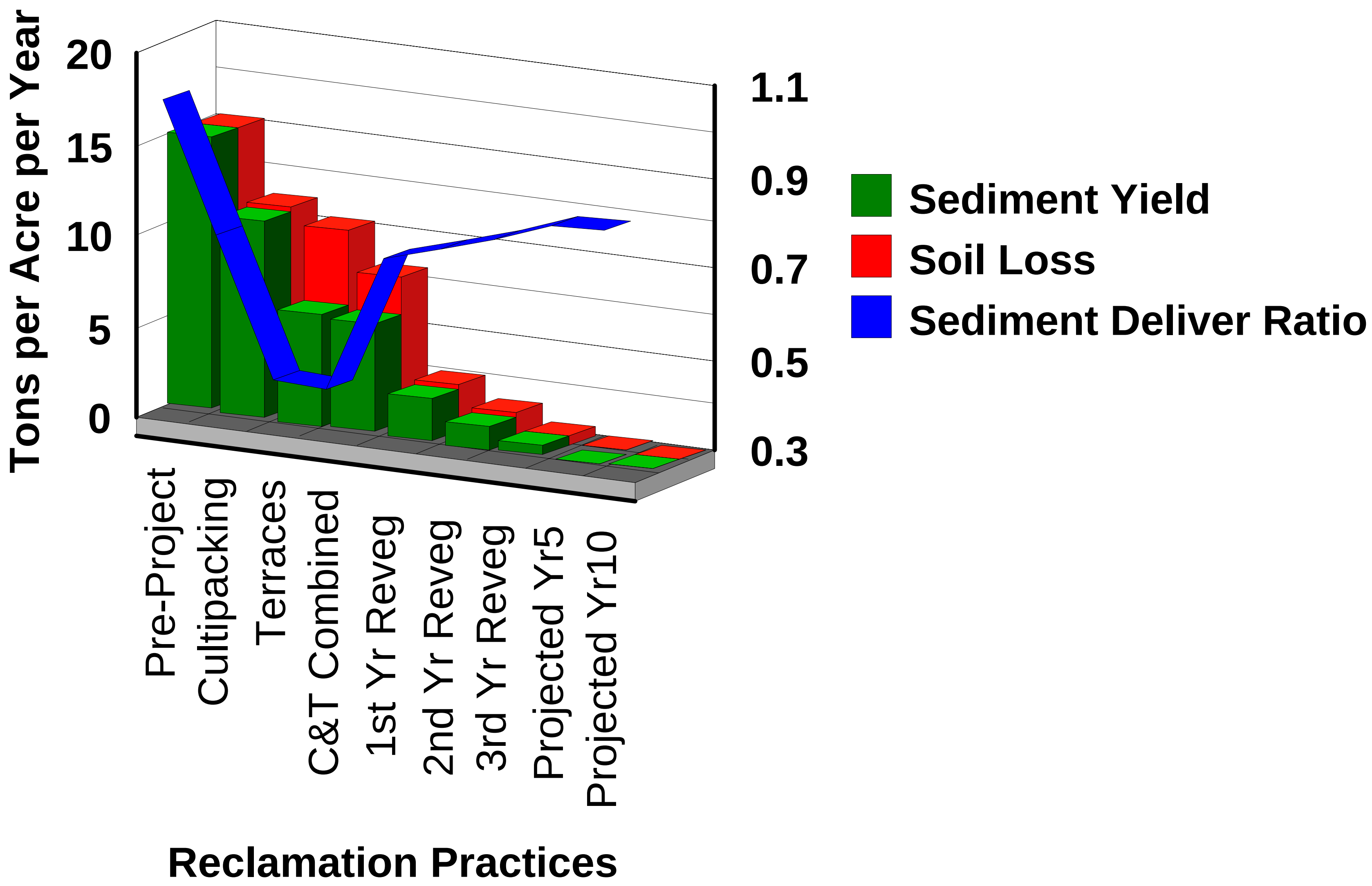
Soil loss rates (tons/acre/year) calculated for the revegetation cases chosen showed a reduction from 8.2 with support practices alone to 2.4 based on 1st year revegetation accomplishments. Subsequent revegetation year models assumed maintenance of support practices and increases in revegetation success during the 2nd and 3rd year, with soil loss rates being estimated at 1.5 and 0.7 tons/acre/year respectively. Soil loss for conditions projected in year 5 indicates a reduction of a rate of 0.16, falling to 0.01 by the 10th year. Estimated sediment yield rates for all years equal the estimated soil loss rates. Sediment Deliver Ratios were estimated at 0.71, 0.76, 0.80, 0.84 and 0.85 respectively.

4.1.4 Modeling Results Summary.

The graph provided on the following page illustrates the degree of change in estimated soil loss for conditions observed prior to initiation of reclamation efforts in comparison to those measured during demonstration project efforts and anticipated during future years with continued revegetation success. Soil loss reduction rates derived through RUSLE model computations for reclamation successes accomplished and those predicted have been assessed in terms of percentage reduction from the pre-reclamation case, or rather post-grading condition, as follows:

	Soil Loss	% Reduction	Sediment Yield	% Reduction	SDR
Pre-Reclamation Condition	15		15		1
Contour Furrowing	10	33.3 %	6.2	58.7 %	0.42
Contour Culti-Packing w/CF	8.2	45.3 %	6.1	59.3 %	0.41
1st Year Revegetation	2.4	84.0 %	2.4	84.0 %	0.71
2nd Year Revegetation	1.5	90.0 %	1.5	90.0 %	0.76
3rd Year Revegetation	0.7	95.3 %	0.7	95.3 %	0.80
5th Year Projection	0.16	98.9 %	0.16	98.9 %	0.84
10th Year Projection	0.01	99.9 %	0.01	99.9 %	0.85

RUSLE Modeling Results



4.2 CONCLUSIONS.

Site mine-soil materials were found to be unstable, theoretically due to their lack of soil structure compounded by the lack of cohesive soil particles in the profile. The lack of stability of site mine-soils expressed itself not only in their susceptibility to accelerated erosion rates, but also in poor trafficability. Major limitations to equipment selection were realized during initial project efforts as of result of these conditions. Traditional farm tractors were found to be useless. Even walking across the site was found to be difficult. ATVs were found to be the primary equipment suitable for use in performance of reclamation activities, along with a light-weight tractor equipped with high-flotation tires. A light-weight trackhoe equipped with a dozer blade was also utilized.

Throughout the project, trafficability conditions served as a useful marker in measuring reclamation success accomplished through establishment of vegetative root systems serving to stabilize the mine-soil materials. Equipment limitations were found to be lessened during periods of higher soil moisture which proved to be an important factor during initial reclamation efforts. Apparent trafficability was found to increase dramatically through root system development.

Benefits of reclamation are evident through comparisons in trafficability, erosion rate reduction and establishment of vegetative species which will support a productive post-mining land use. However, site mine-soils have not changed appreciably, with low fertility levels and droughtiness being permanent limitations to site utility. Reclamation potential at this or any other abandoned mine site is a result of mining practices employed and considerations given to future site utilization. Lack of reclamation planning during mining activities can not be entirely remedied through implementation of reclamation practices, especially where economic feasibility is a mandatory consideration. Improvements in mining practices will result in improved reclamation success. Results achieved through demonstration project site activities indicate that viable alternatives exist for reclamation of similar abandoned mine lands within the Amite River Watershed without employment of cost prohibitive reclamation practices. Erosion rate modeling results provide quantitative evidence of the high level of success achieved towards satisfaction of project objectives.