environmental review team report

FELDSPAR QUARRY

Middletown, Connecticut

RC & D

EASTERN CONNECTICUT
RESOURCE CONSERVATION AND DEVELOPMENT PROJECT

ASSISTED BY: U.S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE AND COOPERATING AGENCIES

ENVIRONMENTAL REVIEW TEAM REPORT
ON
FELDSPAR QUARRY
MIDDLETOWN, CONNECTICUT

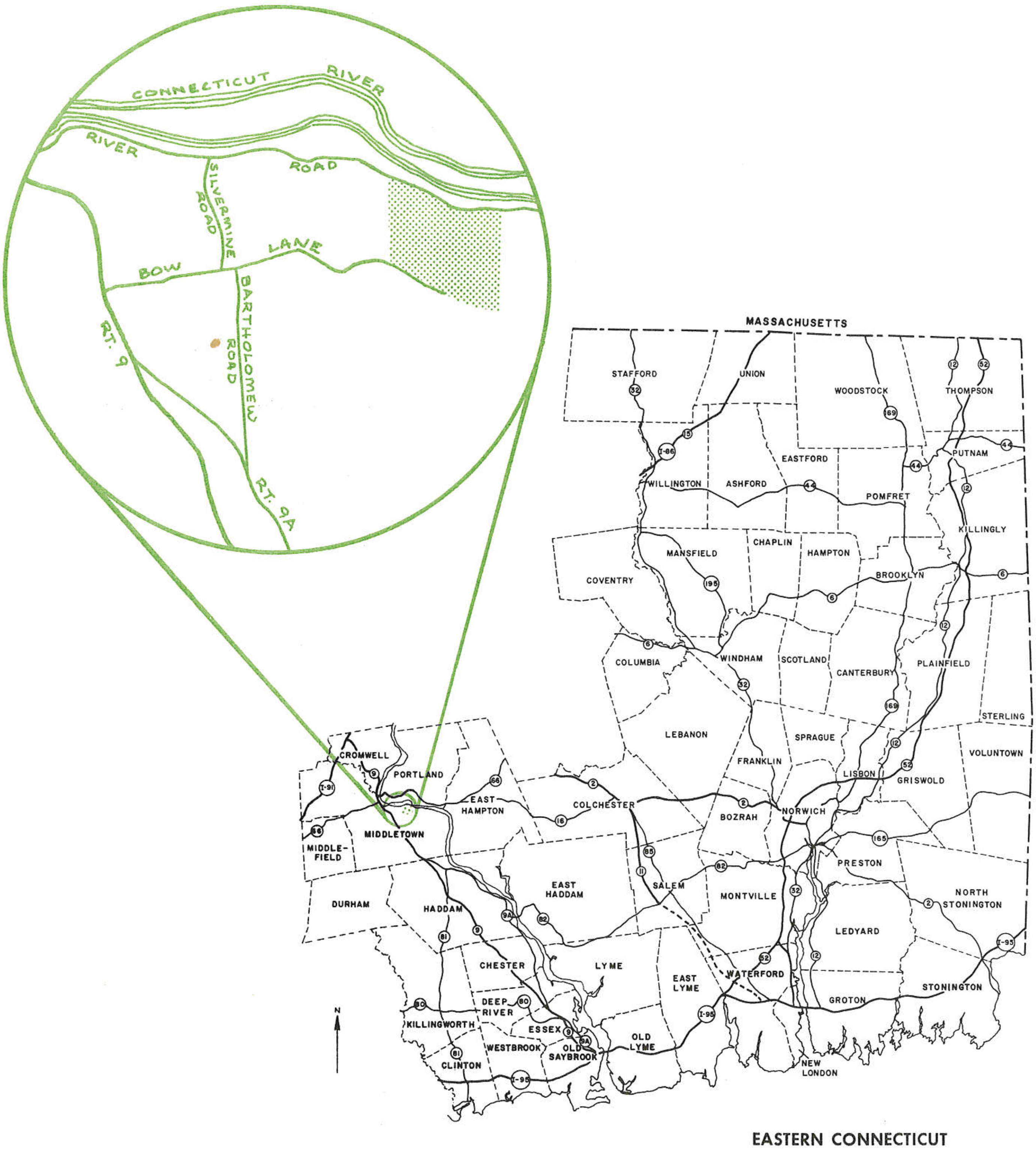
MAY 1973

Preparation of this report has been, in part, assisted by a grant from the New England Regional Commission.

EASTERN CONNECTICUT RESOURCE CONSERVATION
AND DEVELOPMENT PROJECT
Environmental Review Team
139 Boswell Avenue
Norwich, Connecticut 06360

LOCATION OF STUDY SITE

FELDSPAR QUARRY
MIDDLETOWN, CONNECTICUT



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ON

FELDSPAR QUARRY, MIDDLETOWN, CONNECTICUT

This report is the outgrowth of a request from the City of Middletown, with the approval of the Feldspar Corporation, to the Middlesex County Soil and Water Conservation District. The S & WCD referred this request to the Eastern Connecticut RC & D Project Committee for their consideration and approval as a Project measure. The request had been approved and the measure reviewed by the Environmental Review Team.

The soils of the site were mapped by a soil scientist of the U.S.D.A. Soil Conservation Service. Reproductions of the soil survey, natural soil group descriptions, proportional extent of soils, and a table of limitations for urban development were forwarded to all members of the Team prior to their review of the site.

The Team that reviewed the Feldspar Quarry consisted of the following personnel: Edwin L. Minnick, Engineering Specialist, Soil Conservation Service (SCS); Ed Golden, Wildlife Biologist, State of Connecticut Department of Environmental Protection (DEP); Huber Hurlock, Forester, DEP; David Miller, Environmentalist, Extension Service, U.S.D.A.; Richard Hyde, Dan Meade, Sidney Quarrier, Hugo Thomas, Natural Resources Center, DEP; Marc Crouch, Soil Scientist, SCS; Plater T. Campbell, SCS, Geoffrey L. Colegrove, Midstate Regional Planning Agency, co-coordinators.

The Team met and reviewed the entire site on March 15, 1973. Reports from each team member were sent to the Team Coordinator for review and summarization.

This report is not meant to compete with private consultants by supplying site designs or detailed solutions to problems. The report identifies the existing resource base and evaluated its significance and also suggests considerations that should be of concern to both the administrative agency and the corporation. The results of this team action are oriented toward the development of a better environmental quality and the long-term economics of the land use.

The Eastern Connecticut RC & D Committee hopes you will find this report of value and assistance in making your decisions on this particular site.

If you require any additional information, please contact:

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or

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INTRODUCTION

The Feldspar Corporation operates a mine and processing operation on River Road in Middletown, Connecticut. The rock or "ore" that the company mines is a coarse-grained, light colored rock called pegmatite. This rock is composed primarily of feldspar, quartz, and mica with minor amounts of other minerals. The pegmatite usually occurs as lense shaped bodies of variable size and shape which are irregularly spaced throughout the country rock (more information about these pegmatites can be found in Stugard, Frederick, Jr., Pegmatites of the Middletown Area, Connecticut, U.S. Geological Survey Bulletin 1042, 1938, 66 pp., map). The pegmatite bodies are usually parallel or subparallel to the general layering of the surrounding rock. The nature of the occurrence of these bodies determine two important aspects of the mining operation: (1) the mining must take place where the desired rock type exists; (2) because of the elongate lense shape of the pegmatite bodies, surface mining usually creates a long trough.

There are a number of pegmatite bodies near the company's property on River Road, but none of them are of particularly large dimension. This necessitates the "spread out" appearance of the mining operation. Additional amounts of pegmatite rock are quarried in Portland and trucked to the River Road site for processing. The Company estimates that sufficient reserves of mineable material exist at the River Road site for several decades of operation.

The processing plant which crushes and separates various minerals, produces a currently unusable residue that is very similar to the original pegmatite in composition. Because of the amount of rock shipped in from adjacent areas for processing, the volume of residue exceeds the actual amount of rock quarried at the River Road site. The residue ranges in size from fine to very fine sand with over 55% within the silt size range. This material is stockpiled on and around the active and inactive working areas of the site.

EVALUATION

SITE DEVELOPMENT

Before any reclamation plans are developed, tests should be performed on the intended backfill material. Slope stability analysis, permeability, fertility, etc., should be determined prior to any plan for control of erosion, drainage, sedimentation, or any other proposed land use alternative. From preliminary physical tests on the intended backfill material ("tailings") the reclaimed material would appear to have severe limitations for any kind of structural development.

ROADS AND UTILITIES

River Road leading to the quarry appears to be sufficient and satisfactory. The existing roads on the site are creating erosion and sedimentation to nearby streams and the Connecticut River. Proper grades and drainage should be developed on these existing roads. All proposed roads should be located on a plan and appropriate conservation measures designed to minimize erosion and sedimentation. Roads that are below stockpiled backfill material should be protected from potential slides until such time as these stockpile areas are removed or reshaped.

HAZARDS

Natural:

The quarry is in close proximity to the Connecticut River and any disturbed areas for mining, roads, hauling, etc., are potential sediment pollution problems to the adjoining streams, emptying eventually into the Connecticut River. Wind currents as a result of the river valley may carry silt size particles for great distances through and out of the valley.

The steep terrain in the area is hazardous because of potential rock falls and earth slides created from natural causes such as freezing and thawing, tree throws and water erosion.

Man Induced:

The mineral extraction process has left high trench walls 30 to 40 feet deep that are abandoned when a pegmatite vein is no longer feasible to mine. These nearly vertical walls are a safety hazard and consideration should be given to fencing and posting these areas.

From the mineral ore a waste residue is left. The waste material is collected and stored in large piles. Erosion of these piles is presently occurring, and these eroded materials are being carried by surface runoff into the abandoned trenches, streams and eventually into the Connecticut River. These large piles could also become unstable and become earth slides. The potential for this type of movement is dependent on water and hydrologic conditions, along with other factors, such as the slope of the pile face and the cover material. Materials similar to these stockpile materials have acted as viscous fluid and flowed as a mass down relatively gentle slopes. This is another reason for performing stability tests on the stockpiled material (tailings).

The steep slopes and shallow soils above the bedrock rid the area of excess water very rapidly. In disturbed areas increasing amounts of vegetation are lost, resulting in greater peak flows. Such conditions increase the potential for channeling and the volume of sediment entering streams and the Connecticut River.

Wind erosion losses from a given area depend on the particle size and cloddiness of the surface material; on the surface roughness and surface moisture content; on the wind velocity or force; on the amount, kind, and orientation of the vegetation; and on distance across the field along the direction of the wind force. In this case, the small particle size of the major portion of the waste material (approximately .0074 mm.), the lack of cloddiness, the smooth surface of the piles of material, the minimum amounts of vegetative cover, and the extremely exposed site tend to increase the odds of large amounts of wind erosion. In fact, they more than offset the moderating effects of frequent rainfall and generally mild Connecticut climate.

The capacity of a wind to cause soil movement is proportional to the wind speed cubed, times the duration of the wind, after the wind speed attains a certain minimum (approximately 10 mph at 1 ft. above ground). The extremely exposed position of the spoil banks looked at in this review, which are on the ridge top facing the valley where the majority of winds blow from the northwest or southwest (up and down the river valley), insures that this threshold is probably reached quite often.

Rough calculations (utilizing the relationships presented by E.L. Skidmore and N.P. Woodruff, <u>Wind Erosion Forces in the United States and Their Use in Predicting Soil Loss</u>, Agriculture Handbook No. 346. Washington, D.C., U.S.D.A., Agriculture Research Service, 1968, p. 42, with general climatic data from J.J. Brumback, <u>The Climate of Connecticut</u>, Connecticut State Geological and Natural History Survey Bulletin No. 99, 1965) indicate that approximately 95 tons/acre/year of clay sized waste material (powder) will be blown off each cleared area that is greater than 200 feet in length in the north-south direction, and 75 tons/acre/year loss from a 100 foot clearing. Assuming twenty acres are exposed continuously, this results in a minimum total of 1500 tons/year.

AESTHETICS AND PRESERVATION

Land reclamation has not been the policy in the past, which gives the quarry operation the appearance of being more extensive than it really is. Forestry should be considered in the reclamation of this area to improve aesthetics and to control wind erosion and surface washing of spoils.

Grass should be planted and allowed to grow uncut for a year to offer some shade for tree seedlings. Seed or seedlings could be used. If the spoil mounds are kept, trees should be planted or seeded on the lower two-thirds to get about 500 per acre (trees 10 feet apart). The same purpose would be served by planting patches with trees 8 feet apart and 20 to 30 foot grass laneways between patches. Species suggested are pitch pine, cottonwood, and larch (Asiatic or European). Openings should not run north-south, as that would channel prevailing valley winds and increase the chances of a blowdown in later years.

The existing vegetation is on a site that does not justify investments in managing for forest products. However, the diversity of the area provides the potential for a substantially high wildlife population.

In the process of reclamation, seeding the least used roads with drought resistant grasses would provide the necessary forage and insects for wildlife production. Planting of trees and shrubs will provide food and cover for the wildlife, as well as stabilization of the area's soil.

Disturbance of existing trees and shrubs, such as gray birch and staghorn sumac, should be at a minimum during reclamation because of the food and cover they provide.

This site offers a rare opportunity to return significant areas of land to forest and wildlife production while also reducing the hazards and improving the aesthetics of the area.

SERVICES TO SUPPORT DEVELOPMENT

The Feldspar Corporation will require few if any additional services from the town for its continued operation.

COMPATIBILITY OF SURROUNDING LAND USES

The Feldspar Quarry is located in the I-3 zone. This zone is intended for special industrial uses such as laboratories, public utilities and manufacturing. The land to the south and west of the quarry is zoned R-1, low-density zoning with a minimum lot size of 40,000 sq. ft. for dwellings not served by public sewer or water.

The blowing of waste material up and down the river valley and the occasional blasting necessary for the mining operation do not present significant conflicts with neighboring residential areas. Should future residential development occur in the area, however, some sort of vegetative buffering should be planted on the west and south of the quarry area to abate the air pollution.

Increasing residential building is a possibility within the next five to ten years due, in large part, to the contemplated continuation of the 20" water mains supplying the eastern part of Middletown. Furthermore, according to a report by Cahn Engineers, the Canel site aquifer is expected to supply much of Middletown's future water needs. A 24" main is anticipated along Bow Lane, thus providing water for the area in question.

The Cahn report also states that the area can expect to rely upon on-site septic tank and leaching field systems for sewage disposal thus keeping with the long range intent of the R-1 zone.

ALTERNATIVE LAND USES FOR THE AREA

The possibility of using one of the abandoned quarry pits for a landfill operation has been considered by Middletown. A report by Richard Hyde from the Natural Resource Center of the Connecticut Department of Environmental Protection, reviewing the Feldspar Quarry as a potential landfill, is included in the appendix of this report. From his report it would appear..."that the site preparation and management necessary to maintain a suitable landfill would economically and physically be unfeasible."

The future industrial use (i.e. those uses permitted in I-3 zone) of the land occupied by the Feldspar Corporation would be limited by, (1) the rugged steeply inclined terrain and (2) the limited industrial access to the site via River Road.

The characteristics of the backfill material and stockpiled "tailing" material presents severe limitations for most kinds of structural developments. Structures of any kind should be discouraged until test results have been obtained and reviewed regarding slope stability, waterholding capacity, shear strength, etc.

The acreage undisturbed by the mining operation may be suitable for low density development now and in the future. Limitations mainly would be shallow depth to bedrock and steepness of slopes in the area. Depending on the success of reclamation efforts, the reclaimed areas may also prove suitable for residential use. Ascess in these cases would be Bow Lane since River Road's excessive grade would not meet local road standards.

Potentially, the site would most readily be adapted for passive recreation, educational use, and forest and wildlife management. The excellent view of the Connecticut River makes the site particularly appealing.

GENERAL COMMENTS

Several comments and recommendations have been made regarding the zoning code of the City of Middletown, Connecticut, in particular Article IV Supplementary Regulations, Section 41, Natural Resource Extraction Regulation. The specific regulations are cited below with the appropriate comments following.

41.04 *EXTRACTIONS LEGALLY UNDERWAY AT TIME OF THESE REGULATIONS*

Operations involving natural resource removal legally in existance at the time of passage of these regulations may continue for a maximum period of one year. During that time application for Commission approval shall be made following these regulations. Operations for which approval application is not made and received shall be in violation of this Code.

It is unclear whether the applicant has an obligation to restore the previously extracted areas to reclaimable land. It would be advisable to have any previously extracted area if not returned to reclaimable land at least left in a safe condition.

41.07 *CRITERIA DURING EXTRACTION*

(This regulation includes ten separate criteria which can be found in the zoning document noted above.)

These criteria include no provision for safety where deep pits are open. Fencing and/or posting should be considered.

41.08a *CRITERIA FOR RECLAMATION*

(a) Except where rock face or outcropping occurs, in its original natural state, banks shall be reworked so that no slope is greater than two feet horizontally to one foot vertically and the entire extraction area shall be covered with four inches of topsoil. The topsoil shall be seeded until successfully covered with vegetation.

The 2 to 1 slope required is at an angle of 26° which is only 4° less than the angle at which sand becomes unstable. The slope should probably be changed to 3 or 4 to 1 for the materials at the site. More detail concerning the slope stability of the material should be obtained, so that an adequate safety factor can be built into the regulations.

From a safety standpoint, a maximum depth might be considered for vertical rock faces left as a result of extraction.

41.09 *COMPLIANCE ASSURANCE*

Approval shall not be given until the applicant has provided a surety bond of not less than $2,000 for each acre of land to be disturbed by extraction or storage of soil *or rock material. The bond shall guarantee that upon termination of the extraction operation the surface of land shall be restored in conformity with the approved reclamation plan. Upon such satisfactory reclamation the bond shall be released to the applicant.*

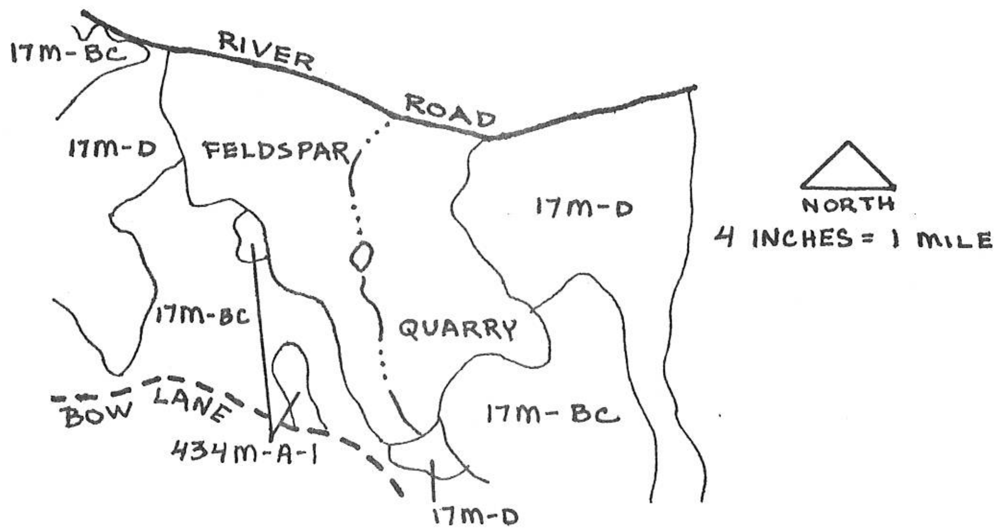
Approval may be withdrawn at any time during the approval period, after reasonable notice to the operator, upon finding by the Commission that the applicant has failed to conduct the operation in conformity with the previously accepted proposal and/or the criteria set forth in these regulations.

Perhaps a better basis for the surety bond where pits are the method of extraction would be volume rather than area. The major cost to restore this type of operation would be the backfilling.

It would appear that the major problems with the land reclamation program are ones that can most effectively be handled by a good conservation plan. Since the team's on-site review, a contract has been signed between the Feldspar Corporation and the Soil Conservation Service for the development of a conservation plan. The plan, which is near completion, will include reclamation of abandoned areas, improvement of undisturbed areas, and erosion and sedimentation controls on the active site.

APPENDICES

SOIL MAP
PROPERTY OF FELDSPAR CORPORATION, MIDDLETOWN, CONNECTICUT



Prepared by: UNITED STATES DEPARTMENT OF AGRICULTURE, Soil Conservation Service.

PRELIMINARY SURVEY, SUBJECT TO CHANGE.

SOILS ON THIS PROPERTY:

Soil Symbol	Soil Name, Description
17M-BC	Hollis-Charlton rocky complex, 3-15% slopes.
17M-D	Hollis-Charlton rocky complex, 15-35% scopes.
434M-A-1	Leicester-Ridgebury-Whitman very stone fine sandy loam.

Natural Soil Group	Soil Symbol	Descriptive Legend
C-3b	434M-A-1	Non-stony, stony, or very stony soils with high water table during most of the year.
D-1	17M-BC	Rocky and very rocky soils with slopes less than 15%.
D-2	17M-D	Rocky and very rocky soils with slopes more than 15%, and extremely rocky soils.

DESCRIPTIONS OF NATURAL SOIL GROUPS

UPLAND SOILS - OVER COMPACT TILL

Poorly and very poorly drained soils

C-3a Non-stony or stony soil with a high seasonal water table.

C-3b Non-stony, stony, or very stony soils with a high water table during most of the year.
434M-A-1 Leicester-Ridgebury-Whitman very stony fine sandy loam.

These nearly level soils occur on drumlins - hills smoothed and elongated north to south by the movement of glaciers. They are underlain by compact glacial till and have a hardpan 16 to 36 inches below the soil surface. Permeability above the hardpan is moderate but the pan drastically reduces percolation. The poorly drained soils in group C-3a have a high water table that remains within 6 inches of the soil surface during the wettest part of the year. The high water table often persists until late spring and may recur after prolonged or heavy summer rains.

The very poorly drained soils in group C-3b have water ponded on the surface for significant periods in winter and spring. The water table usually persists within 3 feet of the soil surface throughout the year.

Urban. These soils have severe or very severe limitations for most urban uses. Intensive and costly drainage and land fill measures are required to overcome wetness.

Recreation. These soils have severe or very severe limitations for picnic areas, camp sites, and play areas but have potential for conservation uses and environmental enhancement. Pond sites are found in these areas, but difficulty of construction increases with the degree of stoniness.

Wildlife. These soils of group C-3a are poorly suited for the production of openland wildlife habitat. Dependable growth of desirable food and cover plants is limited by the poor natural drainage. The habitat required by woodland or wetland wildlife species can be developed, improved, or maintained but moderate treatment is required.

The very poorly drained soils in group C-3b are poorly suited for the production of openland and woodland wildlife habitat. Dependable growth of desirable food and cover plants is hindered by their wetness. Habitat for wetland wildlife can be developed, improved, or maintained on the soils, but stoniness imposes difficulties in constructing water impoundments.

Woodland. Productivity for wood crops is fair on the soils in group C-3a and poor on the soils in group C-3b. Wetness poses severe problems in the use of equipment, the survival of tree seedlings, and windthrow of trees. Competition from other plants is a problem.

Cropland. With drainage, the soils cleared of stones in group C-3a are suitable for the production of silage corn and adapted hay and pasture crops. The stoniness and wetness of the soils in group C-3b make them unsuitable for agricultural crops.

UPLAND SOILS - ROCKY AND SHALLOW TO BEDROCK

D-1 Rocky and very rocky soils with slopes less than 15 percent.
17M-BC Hollis-Charlton rocky complex, 3-15% slopes.

D-2 Rocky and very rocky soils with slopes more than 15 percent and extremely rocky soils.
17M-D Hollis-Charlton rocky complex, 15-35% slopes.

The soils of groups D-1 and D-2 occur mostly on the rougher areas of the uplands. They may occupy narrow ridge tops but most often are on steep side slopes. The soils are underlain by hard bedrock and the areas contain barren rock outcrops. In many places, hard rock is less than 20 inches below the soil surface. These areas provide contrast in the landscape and scenic outlooks.

Urban. Rock outcrops and soils shallow to bedrock cause severe problems and high construction costs when developing this land for urban uses. Occasional pockets of deeper soils can be utilized for individual home sites.

Recreation. Picnic areas and camp sites are very difficult to develop and access is usually a severe limitation. However, the terrain provides an attractive setting for these uses.

Wildlife. These soils are poorly suited for the production of openland wildlife habitat. The habitat for woodland wildlife species can be established, improved, or maintained but moderate treatment is required. It is impractical to develop wetland wildlife habitat on these soils.

Woodland. The productivity of most of this land is poor for wood crops. Pockets of deeper soil within these areas have fair productivity. Equipment operation is very difficult because of rock outcrops. Seedling survival and windthrow of trees are problems on the shallower areas.

Cropland. These soils are not suited for the production of cultivated crops because of rock outcrops and shallowness. Scattered areas with deeper soils and less numerous rock outcrops can be used for improved hay, pasture, and orchards.

USDA, SCS, 1/18/71

RC & D REVIEW OF MIDDLETOWN QUARRY FOR POTENTIAL USE AS A SANITARY LANDFILL

BY RICHARD HYDE, NATURAL RESOURCE CENTER

The use of an open-ended, trench cut rock quarry for a sanitary landfill presents several considerations to be evaluated which are unique to this situation as well as quarries in general when compared to landfills placed in overburden. These considerations are:

1. The surface water drainage within the quarry area and its interaction with the natural topographic systems.

2. The alteration to the groundwater hydrologic system as a result of the quarry operation.

3. The problems associated with erosion within and outside the mining area.

4. Accessability to and quality of base fill, daily cover, and final cover materials.

5. The lack of knowledge of leachate flow through joints, fractures, foliation and bedding planes of crystalline bedrock; the leachate attenuation and its interaction with the geologic and hydrologic systems.

6. The production of leachate within the landfill and the special design requirements needed to alleviate the problems.

7. The accessibility of the site in terms of road networks, proximity to population centers, and season.

8. The operation of the landfill in terms of the techniques for refuse disposal, compaction, and covers, with special considerations for wind and odor problems.

9. The natural hazards resulting from rockfalls and the presence of high cliffs.

10. The finish cover and reclamation of the landfill and surrounding quarry.

It would appear from site observation and available information that the site preparation and management necessary to maintain a suitable landfill would economically and physically be unfeasible.

The following remarks pertain to the use of abandoned quarry excavations as possible sites for municipal solid waste disposal. Specifically, this paper will concern itself with the Feldspar Corporation's quarry in Middletown, Connecticut, but it is hoped the conclusions reached here can also be extended to include bedrock excavations in general.

The information and conclusions are based on data gathered from an on-site inspection made March 15, 1973, by the RC & D Environmental Review Team; the report, "The Feasibility of Using Abandoned Quarries as Sites for the Disposal of Solid Waste," by the Wesleyan University Environmental Research Group; the Middle Haddam quadrangle topograhpic map; the Middle Haddam quadrangle bedrock map (open filed with the U.S. Geological Survey-Geologic Division); and the procedures and requirements for sanitary landfill initiation and operation for the State of Connecticut.

Site Location and Geology

The quarry in question is located in the White Rock area of Middletown, south of the Connecticut River, and approximately a mile west of the existing Power Plant on River Road. To the east, about a half a mile, is the fault separating the eastern Connecticut crystalline uplands from the Triassic Basin. Geologically this area has undergone extensive isoclinal folding followed by doming and emplacement of pegmatite dikes. These feldspar rich dikes are the object of the present mining operation. The host or country rock surrounding the pegmatite is the Bolton Schist, a biotite-quartz schist which includes quartzite units and some large lenses of quartz. The pegmatite intrusions are medium to coarse grained, rich in plagioclase feldspars, and, in addition, contain microperthite, quartz, muscovite, beryl, garnet, and tourmalene minerals. The pegmatite intrusions have been emplaced parallel with the host rock bedding planes and the regional foliation, which in general strikes North-South. Measurements taken indicate the regional foliation generally dips to the west at angles ranging from 20° to 45°, however, the jointing and fracture patterns and their intersections dip to the east.

Surface Topography of the Excavation

In order to make the mineral extraction process economically feasible, only pegmatite zones covered by a minimum thickness of country rock are mined. When too thick a cover has to be removed from above the current working vein, or the trench walls become too high to meet safety standards, the cut is abandoned and a more accessible dike is started. Land reclamation of abandoned areas has not been the policy of the present operator. As a result, the quarry operation is spread over a large area and gives the appearance of being much more extensive than it really is. The abandoned trough being considered for the purpose of a future sanitary landfill for the town of Middletown is located in the northwestern section of the quarry. It has been cut vertically into the land surface, 30 to 40 feet deep, and for an approximate lateral distance of 900 feet. This form of vein mining results in the trough floor and anywhere from 10 to 30 feet of the lower side walls to consist of unrecoverable pegmatite. Above this the country rock, Bolton Schist, is exposed up to the original land surface.

Surface Drainage and Collection

The natural surface drainage of the entire quarry is to the north and ultimately into the Connecticut River. A small brook flows through the middle of the mining area and this is augmented and paralleled by numerous scattered intermittent streams which come into existence during periods of rain. Within the excavation in question the floor is relatively flat in places but generally dips gently in a north by northwest direction, so water channeled through this cut normally would flow out the entrance to join with the topographic drainage toward the Connecticut River. At the present time a berm or earthen barrier has been placed across the cut's entrance for the purpose of controlling erosion and sedimentation by retarding water movement from the trough to the downslope areas. From the mined ore a waste residue is left after the extraction process has been completed. This waste material is collected and stored in large piles, one of which is located along the upper edge of the potential landfill excavation. Erosion of this pile into the trench and toward the Connecticut River is present occurring because precautionary and corrective measures were not instituted in the past. These eroded materials, once carried into the trench by surface runoff, accumulate and form ponds and mudholes particularly just behind the earthen dam. The finer grained tailing particles trapped within the excavation probably then enter bedrock joints and fractures to block and inhibit much of the ponded water from moving into the rock zone. If this is the case then it would seem likely most of the water leaving this basin is primarily the result of surface evaporation, although some seepage through the base of the earthen dam was observed.

Erosion

The formation of intermittent streams during periods of rain probably has always been important to the surface drainage of this region. Because of the naturally occurring steep slopes and shallow soils above the bedrock surface, these streams rapidly rid the area of excess water the soil and vegetative covers cannot retard. In undisturbed areas an equilibrium has been established between the forces of erosion and the forces inhibiting the flow of surface runoff. When this equilibrium is upset from the mining operation, increasing amounts of the stabilizing soil and vegetation are lost to erosion, resulting in an increase in the amplitude of peak flows and a decrease in the length of time for these flows. Such conditions increase the potential for flash flooding and the channeling of large volumes of rain water and eroded materials into streams, rivers, and abandoned excavations during shorter periods of time. This situation would just aggravate the drainage problems of a landfill located in an abandoned excavation as well as reducing the amount of water entering the groundwater system.

Cover Material

It was indicated the waste tailings might be utilized for the four feet of fill required to separate the refuse from the bedrock as well as a refuse cover after each day's deposition. These tailings comprise 90 percent of the unprocessed ore and mineralogically they are the same as the extracted produce but their size range makes them unacceptable to the Feldspar Corporation's customers. Approximately 55% of this waste is finer than a 200 mesh size, placing most of this residue within the silt grain size grouping. The Wesleyan group investigated these abundant tailings for use as a refuse cover material. Their investigation tried to answer the following questions: What chemical differences to water and effluent result when using tailings as a cover material and the soil presently being used at the existing Middletown refuse area; what rates of fluid percolation can be expected through the tailings and soil; and what long term effects can be expected from contact of water and effluent with pegmatite, schist, tailings and soil. Other investigations were carried out but the results were inconsistent or the results were too insignificant to indicate trends. To answer the above questions, three foot layers of compacted garbage, separated by six-inch sections of the soil or tailings, were placed in 7 1/2' high by 10 1/2" diameter polyvinyl-chloride sewer pipes. Water was added at the top of the columns, recovered at the bottom, analyzed, and the results compared. For specific chemical results, see "The Feasibility of Using Abandoned Quarries as Sites for the Disposal of Solid Waste." The final results indicated the clay-rich soil tested retained almost all of the fluids put into the column while the column using tailings passed large quantities of the liquid. The effluent collected at the base of the pipe using soil proved to be of a better overall quality than the pipe containing the tailings. To determine what long term effects the water and effluent have on the soil, pegmatite, schist, and tailings, 200 gram samples were placed in flasks with distilled water and a synthetic effluent. The result showed minor changes to the fluids indicating undesirable chemical reactions probably do not occur between these materials; water and/or a landfill effluent.

As it has been indicated, the use of tailings as a cover material will mean the rapid infiltration of surface water and a resulting effluent of poor quality. By using these waste piles for this purpose, however, they would at least be disposed of but the problems this may cause may be just as bad or worse. If it is determined the tailings are not a desirable cover, then the existing piles will have to be disposed of by filling one of the abandoned excavations, regrading, hauling it away, or a combination of the three. Each of these courses of action will have its own inherent problems and costs. If a soil of better quality is to be used as a cover material, the mining and transportation costs must be borne.

Bedrock Hydrology

The subsurface hydrologic systems operating within the rocks of this region can only be interpreted from the limited amount of information available for the area and these can only be expressed in relative terms. Conclusions reached here are based on accepted assumptions of groundwater flow through consolidated materials, however, with the addition of more definitive data the picture will be more accurate and broader in scope, but the general trends will probably only change slightly. Pore spaces and the connections between pore spaces in crystalline rocks are found to comprise a small percentage of the total volume, resulting in lower porosity and permeability values when compared to other rock types. For this reason, movement of groundwater through this bedrock is primarily by way of the various cracks, faults, joints, fractures, foliation planes, and points of unit contact. The foliation and bedding planes within the quarry area dip to the west, so some water probably moves along these surfaces in that direction. On the other hand, the bedding and foliation planes are held rather tightly together, as compared to the eastward dipping joints, fractures, and their intersections. This situation probably causes greater volumes of groundwater to flow through these rocks in a more easterly direction and eventually discharging into the Connecticut River. But the movement of water through bedrock is not well understood and certainly cannot be precisely plotted and predicted, given the multitude of variations that can occur from place to place and without a much more extensive subsurface investigation than what has taken place here. If observation wells were to be placed at various locations within the quarry area, the static water levels monitored throughout the year, and water samples analyzed, then the water table gradients and water chemistry could be determined. With this information, a more comprehensive picture of the seasonal and long term watertable fluctuations, the direction of groundwater movement, and the chemical changes resulting from the passage of groundwater through the crystalline rock environment may be determined and understood.

Landfill Hydrology

To operate the trench in question as a sanitary landfill, the state code requires certain conditions for the site and its operation be met. The State of Connecticut requires at least four feet of clean fill be placed between the base of the refuse and the top of the bedrock surface. This means the clean fill will have to be hauled in from some external source or the waste tailings from the extraction process be utilized. As it has been stated previously, little if any water passing into the trench probably exits through the bedrock fracture system but more likely by evaporation and surface flow through the excavation's entrance. In this case, fill material placed on top of standing water bodies will reduce the chances for evaporation and thus cause greater quantities of water to accumulate within the excavation. For this reason, prior to placing the four feet of fill over the bedrock surface, some system of draining or dewatering would have to be instituted. If nothing is done to control water flowing in from the existing land surface and drains are not placed under the fill material a perched water table condition will likely result. In time, this perched water level will fluctuate with the seasons and refuse within the cut may be subject to occasional saturation. This periodic wet and dry condition will result in the production of large volumes of leachate. This fluid will drain toward the mouth of the trench and eventually seep out from under the fill material onto the land surface, even if the entrance is riprapped. The state requires that refuse shall not be deposited to cause or contribute to pollution of ground or surface waters. If, however, drains are incorporated into the system the leachate flow could possibly be concentrated and collected and perhaps treated as it exits from the trough. But all of these things add to the cost of any landfill operation and may evan make it too expensive to operate. Treatment plants for landfill leachates is a new, relatively untested concept and probably is not an acceptable alternative for this site.

Accessibility

State codes require approach roads be open to the general public and kept passable to vehicular traffic during all seasons of the year.

The location of this quarry is relatively close to the road and high above the main highway access. Because of the steep slopes this location could prove to be a problem for trucks and automobiles carrying refuse into the site during winter and severe weather conditions. In addition, quarries, as opposed to traditional landfill sites, are generally located some distance from population centers and along limited road distribution networks. Both of these problems must be carefully evaluated when selecting landfill sites.

Landfill Operation

The actual deposition of the refuse could be done in one of two ways. It first could be dumped into the cut from the top, or secondly, it could be trucked in along the base of the excavation, the same way as the ore was carried out. Cover materials could be handled in similar manners. The disposal method from the top of the cut would mean some collection and entrapment of refuse on the walls of the cavity and thus cause possible odor problems. On windy days, large quantities of paper refuse would be exposed during the dumping operation to possible undesirable wind transport away from the fill area. Once the refuse has been dumped into the excavation, it would then have to be moved around, leveled off, and compacted by heavy earth-moving equipment. Cover material, if dumped into the cut in this manner, also would be subject to wind transport and heavy equipment redistribution within the excavation area. On the other hand, if refuse is hauled into the trench by truck, at least while operations are confined to the lower and middle levels, the problems associated with "wall" odor and wind transport will generally be averted. This system would also require a minimum of heavy equipment redistribution of cover materials but the cost, in terms of trucking, probably will be high.

Leachate Costs

The operation of a sanitary landfill at this site in all likelihood will result in the production of an effluent leachate which will drain and exit through the mouth of the excavation. If this leachate is concentrated, collected, and treated at this point, the costs for the initial installment of the system will have to be made as well as the operating costs of the treatment plant during the landfill operation. Once the site is filled to capacity the production of leachate will continue for some undeterminable length of time into the future, requiring the landfill operator to continue operation of this treatment plant.

Hazards

By operating a landfill in abandoned quarry excavations, there is always the potential danger for public and maintenance crew injuries resulting from falls off high cliffs and being hit by rock slides.

Land Reclamation

Under present regulations the quarry operator is responsible for the reclamation of the disrupted and mined areas. If the town utilizes some of the excavations for sanitary landfills, then there may be some question as to who is responsible for the final land reclamation.

In conclusion the use of abandoned trench cut rock quarries for sanitary landfills, as opposed to the more traditional unconsolidated overburden sites, presents many new factors, problems, and costs which must be evaluated, understood, and specially designed for. The indication is that quarries in general are not suitable for the location of sanitary landfills for the following reasons.

1. Natural topographic drainage systems probably have been

altered to such an extent by the mining operation that surface water may be channeled through or directly into the bedrock excavations. Situations of this nature could require costly and time-consuming diversion and drainage measures be instituted to keep landfill deposits from becoming eroded or saturated. Water accumulating within excavations faster than bedrock joints and fractures can carry it away may result in perched water table conditions existing within the refuse deposits. Specially designed underdrains or channels cut through the rock will help to alleviate this problem. Typically bedrock mining operations are located in irregular terrain and traditionally the managers of these mines are slow in reclaiming abandoned land. As a result the disturbed areas are highly susceptible to erosion of the surface soil and vegetative covers, resulting in aggravation to the problems associated with surface drainage, water accumulation and groundwater levels. Landfills situated within overburden overcome many of the above mentioned drainage and erosion problems easily, rapidly, and inexpensively by the use of heavy equipment to contour the land, put in drainage ditches, and build earthen barriers.

2. Bedrock excavations generally are located where adequate supplies of high quality cover materials are in short supply, necessitating the added costs of locating, mining, and transporting this material from external sources.

3. Because so little is known about the direction, rate of movement, and attenuation of leachate fluids through bedrock, the possibility of contaminating valuable potential and existing water supplies is always present. Landfills in overburden settings can also contaminate water supplies but the hydrology is easier and less costly to decipher and map than at bedrock sites.

4. Entrance for the public must be guaranteed year round, but quarry operations generally are relegated to the less topographically accessible locations and away from town population centers, unlike most other sanitary landfill settings.

5. The operation and maintenance of bedrock landfills are more apt to require special site designs to accommodate leachate drainage, collection and treatment facilities which probably must be operated even after the landfill has been exhausted. Natural hazards to working personnel and the public, resulting from irregular topography and rock falls are more possible in these areas. Land reclamation and responsibilities are less well defined at this point in time and they would require evaluation and agreement between the landfill operator and the quarry management.