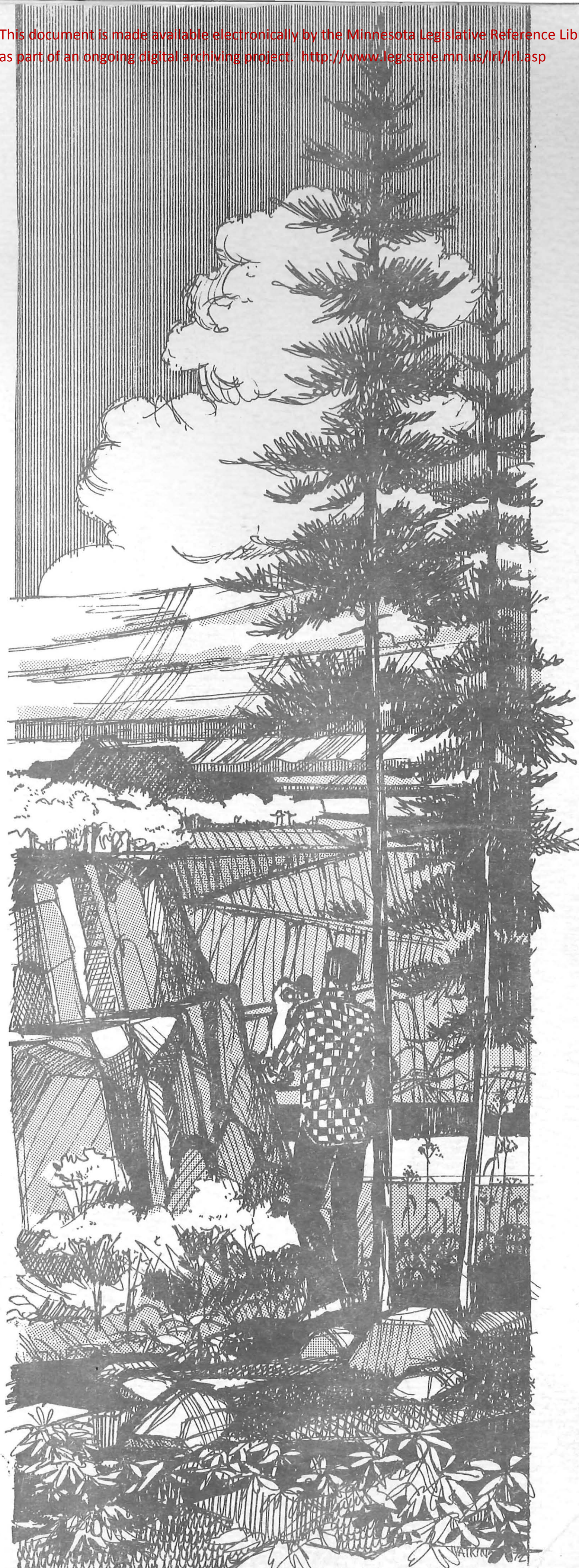
Minnesota Mineland Reclamation



A program for the reclamation of metallic mined lands

...ota Department of
... Resources

MINNESOTA MINELAND RECLAMATION

A Program for the Reclamation of Metallic Mined Lands.

JANUARY 1975

Prepared for the

Department of Natural Resources

By

Architectural Resources, Inc.

Duluth and Hibbing, Minnesota

TABLE OF CONTENTS

Charts and Maps

INTRODUCTION

The purpose of this study is to present in one concise volume, the environmental problems which have been created as a result of the mining industries which have operated on the Minnesota Iron Ranges during the past 80 years and some considerations on how these problems can be minimized. It is also meant to be used as an approach to the future metallic mining activities which may occur within Minnesota, such as copper-nickel.

The study is three-fold. First, to present the obtainable facts, on what environmental hazards have been created as a result of the extraction and beneficiation of metallic minerals; secondly, to present a series of reclamation methods, uses, evaluations and recommendations on how the problems of reclamation are being met and; thirdly to suggest a set of generalized land use recommendations on how the reclaimed land might be used in the highest and most beneficial way.

The first segment of the report deals primarily with an outline of preliminary goals and policies which the consultant feels are fundamental in any reclamation effort. These may include existing as well as proposed metallic mineral mining or beneficiation reclamation efforts.

Segment two deals with the various environmental and social problems that have resulted from past mining activity. A discussion is presented on each area such as overburden stockpiles, open pits, derelict structures, etc. Each is discussed with relation to the environmental problems created as well as the public safety hazards evidenced.

The third section deals with the reclamation methods in general, demonstration projects which have been carried out or are in process and a general evaluation and recommendations on how the existing metallic mining lands can be restored to an acceptable state.

Section four of the report makes specific recommendations on how each subsequent post-mining landform could be utilized to a better degree. Examples of land use types are discussed and graphically portrayed. (Please see map II , page 33). For each landform, recommendations have been carefully and objectively considered with the surrounding land use patterns in mind.

For the context of this report, "reclamation" shall mean to restore or reclaim a metallic mining site to a useful condition. Once reclaimed under this definition, the resultant landscape will be suitable for use as a natural area, or capable of being utilized for residential, recreational, commercial or industrial purposes. Development of future uses beyond that of natural vegetation shall be held responsible by those using the land and not necessarily by those who reclaim the land.

GOALS AND POLICIES

The need to establish rules and regulations for the metallic mining industry is an area which has had a tremendous amount of controversy. The Department of Natural Resources is now in the process of formulating a set of reclamation rules and regulations that both the mining companies and the State of Minnesota will be able to follow during the extraction of metallic minerals. For the purposes of this report on Minnesota Mineland Reclamation, the consultant felt it necessary to formulate a set of goals and policies. These would achieve a balance between the future rules and regulations of active and future mining and the inactive mining sites, of which there are a good number.

These goals and policies are quite broad in nature. However, their intent is not to be strictly adhered to but rather to be referred to when reclamation plans are presented on either abandoned, existing or future mining sites.

Goals

1. To minimize the impact on the environment by:

   a) preventing erosion;

   b) avoiding air, water and visual pollution;

   c) reestablishing vegetation, improving drainage, and landform contouring; and

   d) requiring cleanup of debris of all types at inactive mining sites.

2. To achieve objectives of state and local comprehensive land use plans by:

   a) providing for preplanned utilization of lands and waters upon the completion of mining activities;

   b) providing for access to reservoirs and adjacent lands, after mining; and

   c) reducing conflicts between mining and non-mining areas.

3. To avoid public health and safety problems by:

   a) promoting practices in the interest of the general welfare; and

   b) reducing potential hazards to public health and safety during and following mining activities.

Policies

1. Reclamation methodology must be based on present and future land use potential of the site being mined. Restoration plans shall be in conformity with any state and local comprehensive plans and must be followed with as much vigor as the mining operation itself.

2. Even where specific post-mining land use is undetermined, soil stabilization and the establishment of natural biologic succession shall be achieved at all reclaimed sites.

3. The temptation must be avoided to provide mere superficial treatment rather than permanent land renewal that deals comprehensively with environmental quality and future land utilization.

4. The reclamation program must give recognition to the responsibilities of mineland owners and operators as well as governmental agencies and planning authorities in the long-term rehabilitation of mined areas.

DEFINITION OF PROBLEMS

There are a number of problems which have arisen as a result of the mining activities throughout the Iron Ranges, some of which may be extremely hazardous to the environment as well as to people, if not rectified within the near future.

In the following paragraphs, some of the better known problems resulting from the mining activities in Northeastern Minnesota will be discussed. No attempt has been made to single out all examples falling into one or more of these definitions, as the purpose of this section is to define the overall problem and not pin-point specific examples.

In each instance, the problem is defined by identifying the harmful effects, physically, aesthetically and socially, which have been produced by the techniques used by the mining companies in Northern Minnesota.

Fig. 1 One of the many open pit iron ore mines in Northern Minnesota's Iron Ranges. Depths may exceed 300 feet. Lack of adequate safety measures near community edges have resulted in serious accidents.

Stockpiles

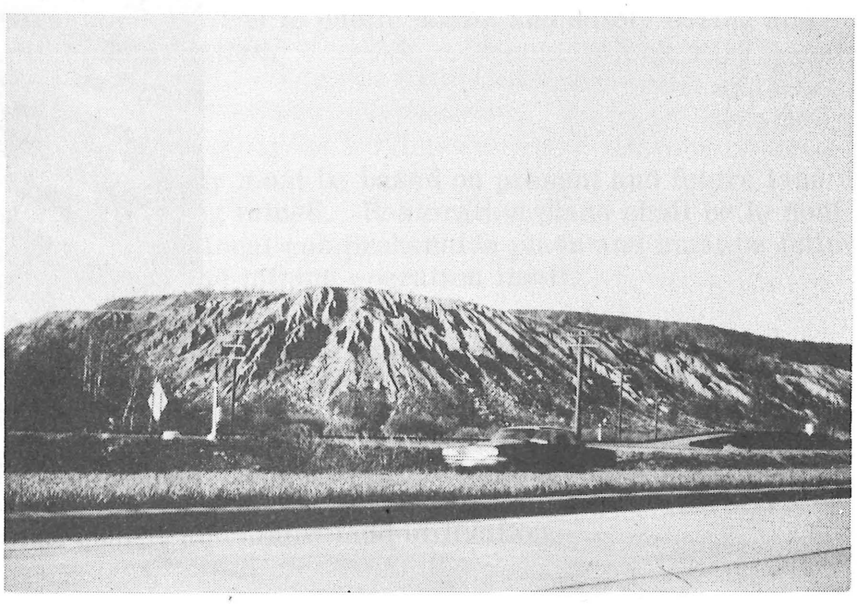
Overburden stockpiles are created when topsoils and surface materials are removed from the orebody. These unmarketable materials generally are stockpiled near the open pit operation and gradually built up into large landscape features. Individual overburden stockpiles may cover areas of one or more square miles and reach heights of several hundred feet. The size of the stockpiles, however, directly relates to the size and rate of the operation and any one open pit operation may operate several stockpiles at one time, depending on various factors.

The existing overburden stockpiles create a number of reclamation problems because of their shape, height and consistency, however, future deposition of these materials represents the least of our reclamation problems.

One of the most obvious problems of the overburden stockpiles is the soil characteristics. Because the good topsoils are absent or buried far below, the larger the site becomes, the less desirable the soils on the top. These sterile leached out surface soils make it extremely hard for grass or tree covers to germinate and mature on these sites. The result is generally barren features with little or no natural vegetation to improve the stark appearance. This condition remains until sparce vegetation naturally seeds itself and becomes established.

Because of a lack of ground cover, the erosion problems become very evident on many of the overburden stockpiles. During periods of heavy rains, the run-off causes a large amount of material to erode away from the stockpiles and often end up in nearby lakes and streams. The heavy rains and subsequent runoff can also cause vast areas of slumping to occur on the sides of overburden stockpiles. Literally tons of materials may slide down the sides of overburden stockpiles and cover large areas of adjoining property, and may even alter the drainage patterns of streams or rivers.

Fig. 2
Example of overburden stockpile located adjacent to a major U.S. highway route. Note lack of vegetation and erosion.



Erosion is also caused by the wind during dry seasons. With little or no ground cover, severe dust problems may occur, especially on active dump areas.

From an aesthetic viewpoint, these numerous overburden stockpiles appear rather naked and unnatural in their forested surroundings. This appears even more pronounced where the stockpiles occur within communities or along major transportation routes. They appear out of place because of their steep slopes, flat tops and often, the lack of vegetation.

Another aesthetic problem is created when mining companies dump overburden very near communities or major transportation routes with no screening between the stockpiles and the community or highway.

The lack of protective measures on mine stockpile areas can be a safety problem. In many instances, roads are left intact and no barriers or effective controls are placed around overburden stockpiles. This may present dangerous situations when people drive or walk around the many steep-sloped overburden stockpiles.

Very little has been done in the way of reclaiming or reusing overburden stockpile areas. Lack of stable soils, limited vegetation, and erosion are problems which need immediate attention to insure a safe and more presentable environment.

Open Pits

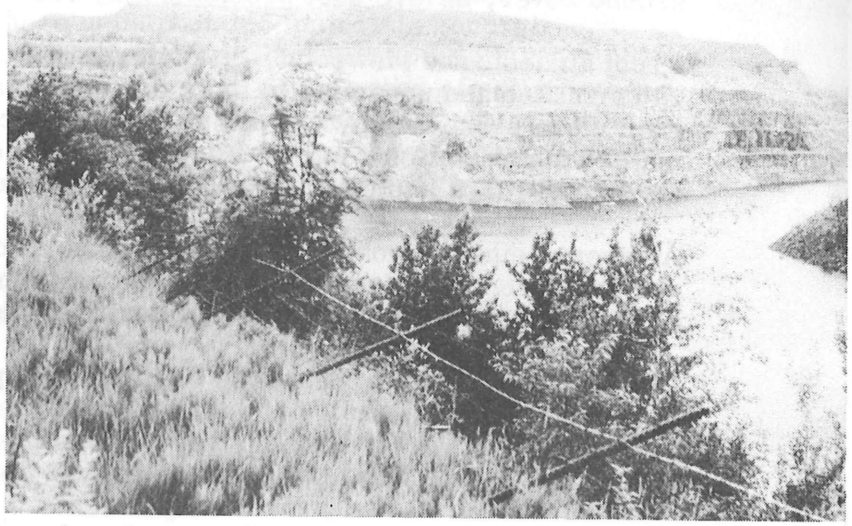
Open pit mines present a more serious problem to solve than the overburden stockpiles. The open pits are created as the overburden and ores are removed. Pits may cover several square miles and depths may exceed several hundred feet.

Problems relating to open pit areas are much harder to solve because of the size and shape of the pits themselves. The steep pit slopes present a very hazardous situation as well as an environmental concern. People approaching them carelessly to peer over the edge or even people who are unaware of their presence, could easily drop off a sheer cliff many hundreds of feet deep. Most open pits have wire fencing placed around the perimeter to discourage people from venturing too close. Over the years, however, it has been realized that these fences do not keep people out. Many examples have been cited where the fences have been cut or stolen, and access to the open pit edges is generally obtainable. Around working open pits the fences are maintained much better than around inactive pits; however, there is still the problem of people not knowing exactly where the edges are.

Inactive open pits are sometimes a problem because of the road networks which are usually left intact. These mining roads are usually found within the site and around the edges of an open pit winding downward. They become inviting for access by bicycles, motor bikes, autos and snowmobiles. Earthern barriers, which are often deposited on mining roads to prevent access, generally do not discourage vehicles other than autos.

Fig. 3

No longer used open pit operation. Water has accumulated and banks are non-vegetated. The fence has been pushed over making access easy to anyone wishing to trespass.



Bank erosion occurs at nearly all of the open pit areas because of the steep sides. During times of heavy rains, large sections of topsoil and tree cover may break off and slide down into the open pit. Sometimes this occurs in such a way that even the safety fences are missing because of erosion of the open pit edges.

Water accumulation in abandoned open pit mines can be a problem. Immediately after mining operations cease, and the water pumping is stopped, the open pits begin filling with water. The rate is, of course, dependent on seepage, the number of springs in the mine, and the amount of runoff entering the pit. Generally, however, they fill to depths of hundreds of feet in a matter of several years. People of all ages have also been seen swimming and fishing in the filled open pits and the dangers here may be fatal, due to the rapid drop-offs and steep-sloped edges. If a swimmer were to get into trouble or a boat overturned, the consequences could be disastrous. Drownings in water filled pits have occurred over the years.

While water quality problems in existing open pit mines are not now apparent, it may be that the water quality in these open pits may deteriorate or change in the future. Close attention in the form of water quality sampling should be a consideration in all existing and future mining operations including all future nonferrous mining operations.

<u>Lean Ore Stockpiles</u>

Lean ore stockpiles or save rock consist of large dump-like piles of ore and rock that had insufficient commercial value at the time of active mining. The material is generally sorted as to size or grade and stockpiled for possible use at a future time. For many stockpiles, that time seems to be approaching, as there is an increasing need for the sized material by contractors and builders who are using the rock as aggregate and fill. Information regarding reserves and use rates of lean ore should be more accurately compiled and more widely circulated.

These lean ore stockpiles appear rather out of place and unattractive if not properly contoured and shaped.

The lean ore stockpiles may also pose a problem when erosion occurs and the material is deposited in nearby lakes and streams. When deposited from certain natural ore operations, they cause streams and portions of lakes to turn a deep red. While the red water phenomena may not pose a chemical pollution problem. their deposition is certainly an area that requires attention.

Fig. 4

Many open pits, overburden and derelict structures are open to trespass as evidenced here by youngsters climbing a low barrier in order to ride their bikes on the rim of an open pit.

Tailings

Tailings ponds are created when metallic ores are processed by a number of different methods. The result, after processing, is a slurry consisting of ground rock, which ranges in size from 3/4 of an inch to a dust like material as fine as face powder, suspended in water. The material is pumped into large diked areas. which, in the case of a large taconite operation may cover several square miles. These diked areas present a number of environmental problems due to the nature of the material contained within them.

As the material dries out in the tailings basins, high winds can carry the fine dust for miles , affecting vegetation and communities. It has been reported that the wind-blown dust has adhered to surfaces and acted as a sandblasting agent, wearing the paint from homes and autos and stripping the vegetation from the surrounding forest cover.

Within the diked tailings areas, it has also been very difficult to get plant materials to grow, and because any uncut forest cover died off when the material was pumped in, they appear for many years as barren waste lands or "deserts".

There have also been instances where the dikes have broken and the tailings materials have escaped into the nearby streams and lakes.

The tailings ponds may also alter the drainage pattern of an area by rerouting the course of streams as well as natural runoff. The probability of that happening today is much less, as newer tailings areas are better planned than the older, now abandoned, tailings areas. The engineers did not always take runoff and stream course into consideration in planning the older ponds.

Test Pits

The test pits of the Range area are those which were dug to test the potential of an orebody and to determine whether or not a full scale open pit should be established. They may range from approximately ten feet in diameter to several acres and the depths may vary from a few feet to over 100 feet.

The main problem with test pits is the lack of knowledge about their locations and conditions. A good many of these test pits were dug and later covered over with boards and timbers, and in some cases were posted and fenced. In a matter of years, these timbers and boards rotted away and the fences disappeared. People walking through the area could easily fall into one of these partially water-filled test pits. Today, test pitting of this sort is not commonly practiced in Minnesota, However, many test pits are still located throughout the mining districts of Northern Minnesota.

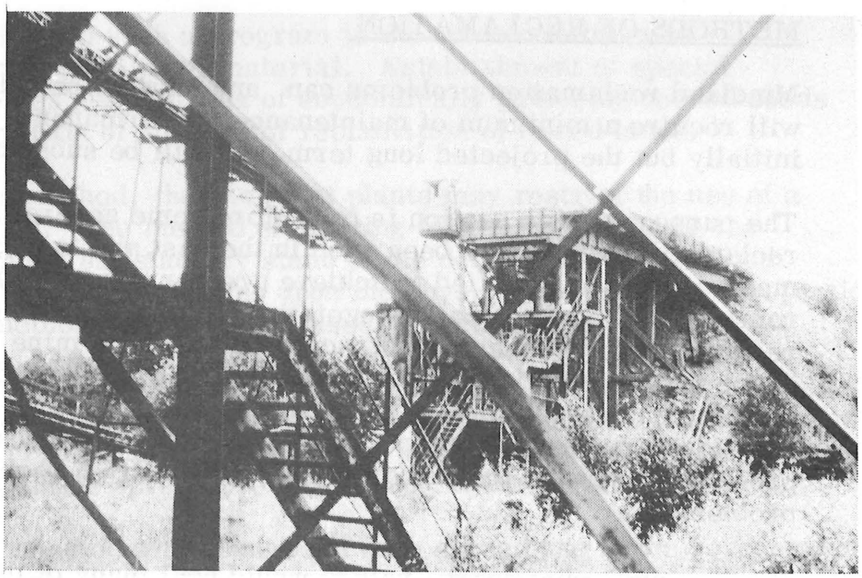
Derelict Structures

The subject of derelict structures and leftover mining materials is gradually being solved due to the high cost of scrap metal. At one time, there were a number of mining sites which contained abandoned structures and buildings. The most common were shop buildings, loading platforms, crushing machinery and abandoned rail-road sidings. Within the last few years, a good many of these sites have been fairly well cleaned up. However, there still remain a number of sites which need additional work if restoration to their original condition is to be the accepted policy.

The problems related to these derelict structures are centered around the ease of trespass and subsequent dangers to people. There are a number of areas where stairways can be climbed to old loading platforms and other structures of great heights. Jagged pieces of metal and glass litter the grounds of many closed mining sites, and with many of these sites located near communities, the attraction for exploration by youngsters is real and dangerous.

The aesthetic viewpoint is another area worthy of mention. Whenever these derelict structures and buildings are within close proximity to communities and highways, their appearance does little to enhance the surrounding landscape, and they often detract from the wilderness character of much of the Range.

Fig. 5
Abandoned structures such as these can still be found on the Iron Ranges. Jagged metal and dangerous stairways are extremely hazardous.



In some cases, these structures and the surrounding area may be considered historically significant and where possible, could be preserved as historic sites.

Underground Mines

A problem which is more isolated and not as evident is that of underground mines and the actual potential hazardous conditions left behind. Once the underground operation ceases. The shaft area is usually sealed off and the above ground structures removed. The mine workings off the shafts and drifts below, however, begin to deteriorate and gradually subsidence occurs in many of the areas that were mined in this manner. Large acreages of ground have begun to cave in because of this subsidence, and damage to surrounding structures is sometimes evident.

Future underground mining may pose subsidence problems of a different nature than that experienced with underground iron ore mining.

Summary

It should be stressed that these problems occur throughout the three Iron Ranges and are not limited to small localized areas. Nearly every inactive open pit operation has at least some and many times all of the problems mentioned in the preceding pages.

The mining companies are doing a better job today in preventing problems such as those discussed. Under existing state law, those counties having 5 or more active mines are required to have a county mine inspection system. The county mine inspectors are responsible for the safety of the mine workers as well as the general public. The implementation of the county mine inspection system has reduced a number of the safety problems discussed above.

METHODS OF RECLAMATION

Mineland reclamation problems can and should be solved in a manner which will require a minimum of maintenance. "Permanent" solutions may cost more initially but the projected long term cost will be substantially lower.

The purpose of this section is to explore some general approaches to and methods of reclamation which have been used, in the past, and to suggest ways in which these methods may be modified to achieve greater success and permanence. While remarks are confined to "revegetation", similar techniques may be applied to other reclamation processes. In direct relationship to mine reclamation procedures in the past, many times the method used was to effect the simplest, quickest, and least expensive solution. Today, with a new awareness for the environment and the need for permanent solutions to the post mining landscape, many reclamation procedures need to be improved that will assure a permanent solution to reclamation problems.

Given a number of years, nature would heal many of the scars left by mining operations. Through trail and error, natural selection dictates which plant species will survive and flourish. These same lenghty natural processes could easily be speeded up if the naturally selected successful plant species were noted by those responsible for reclaiming a post mining site. In this way, only those successful species would be used and the entire reclamation process would take far less time than natures method of revegetation.

The major elements necessary to the support of vegetation in a given latitude include:

1. Soil suitability
2. Stability of slopes
3. Slope orientation and angle
4. Moisture conditions
5. Appropriate plant materials

By reacting to and correcting any of the first four elements in the search for adequate growth of vegetation, land reclaimers have fertilized, added humus and changed the pH of the soil. Slopes have been altered in an attempt to prevent erosion, windbreaks have been erected and drainage patterns have been altered. Each of these approaches were a reaction to an immediate problem, i.e., water or air pollution, cosmetic treatment, etc. A lack of permanence has been the result of these fast and easy solutions.

One solution may very well lie in the fifth major element, namely, appropriate plant materials. By providing a wide diversity of seeds and plant materials to a given site, the land reclaimer can assure that through natural selection the appropriate plant materials will establish themselves for any given micro area. Those areas which resist a program of broad spectrum seeding can then be examined for necessary action in one or more of the first four elements to allow a reapplication of the broad spectrum seeding method.

One of the major objections to such a program is the non-availability of certain seed and non-ornimental plant material. Establishment of special reclamation plant nurseries and methods of economically gathering needed seeds may become a necessary part of successful reclamation of mined lands.

In selection of a planting method, the choice of plants may restrict the use of a particular planting method. The method of planting to be used should be the one which will give the most satisfactory stand of the desired species for both the present and for the future. Depending upon the physical and chemical properties, there are a number of methods which can be used in reclamation projects.

One of the oldest known methods of seeding is broadcasting. Broadcasting involves a hand seeder mounted on a shoulder harness. The area to be seeded is walked by one or more persons carrying these devices. The result is a thin mixture of grass or other plant materials spread evenly throughout the parcel.

Hydroseeding is another method which has seen wide spread use in the revegetation of tailings basins and overburden dumps. Grasses, other seeds, fertilizers and mulch are combined in a water solution to form a slurry and pumped through a hose from a truck-mounted tank. Depending upon the type of hydroseeder nozzle used, the area seeded can range from 20 feet to 100 feet in depth, using different mixtures of slurry for specific soil conditions. Road access is necessary for hydoseeding equipment to carry out its work, thereby restricting its use to accessible areas.

Aerial seeding is also a common practice which scatters dry seed from the air. Aerial seeding has been carried out on waste rock areas, clearings, and tailings ponds in many areas. The inaccessibility for other seeding methods in remote areas lends itself to aerial seeding. The seed is usually composed of a mixture of grasses, fertilizer and legumes which can be released from a seeder mounted on either an airplane or helicopter.

Seedling planting is a revegetation method whereby planting is done by hand or a planting machine. This method utilizes young nursery seedlings which can be spaced at desired distances and patterns to provide uniform growth and development of the seedlings. Hand planting can be most fully utilized in rocky or rough areas where there is sufficient topsoil for the seedling to develop.

One further mechanical method, not utilized as much as other methods, is the furrow seeder. Developed for operating in rough and stony terrain of Northeastern United States, the furrow seeder is pulled by a small crawler tractor with two main components -- a fireline plow and a beet planter. These components of the seeder prepare a fine seed bed and the planter spaces the seed while planting them at a uniform depth. The furrow seeder is designed for direct seeding of pines, but can also handle certain hardwood species.

Natural regrowth may be the most advisable method for certain areas which require self maintenance and cannot be handled by other methods. Natural regrowth, of course, has the limitation of time, with the succession of plants being left to chance.

To gain a better insight into the method of natural plant succession, the following section has been prepared. It summarizes what is now known about natural succession within the mined lands of Minnesota.

NATURAL PLANT SUCCESSION

Extensive revegetation is the invariable first step toward controlling the by-products of surface mining prior to future land utilization. Few publications exist to indicate that the history of experimentation has been well documented or that natural succession on mine lands is fully understood.

Before seeking to select plant materials for future reclamation efforts, some known facts about the process of pioneer plant communities that naturally invade spoil banks, stockpiles and tailings basins need to be reviewed. Little research appears to have been done on the subject of the natural revegetation of evacuated mines and wastes. A major exception is research conducted by Gilbert A. Leisman in 1952 and 1953. A paper entitled A Vegetation and Soil Chromosequence on the Mesabi Spoil Banks, Minnesota provides several interesting facts.

Leisman found that invariably, the first invaders of the spoil banks are species of herbaceous weed species brought in by wind, birds and animals. After these weedy species are established, the woody plants are first represented by quaking aspen (Populus tremuloides) and balsam poplar (Populus balsamifera). Kentucky bluegrass and white sweet clover then advance as ground covers with the weedy species remaining mostly in the depressions of banks. After the woody species are well established and variations of shade begin to exist, the ground cover types change to species such as Timothy. The Populus species usually dominate through approximately 50 years of plant succession on the spoil banks although pin cherry (Prunus Pennsylvanica) is also common.

Inventory of Herbaceous Plants

In an effort to learn more about natural succession of plants already established on waste areas of the Minnesota Iron Ranges, an inventory was taken by the special consultant during the summer of 1971. The detailed investigation included selected stockpiles, tailings basins, abandoned plant sites and other former mine units on the Mesabi, Vermillion and Cuyuna Ranges. It was discovered that most herbaceous (fleshy, non woody) plants growing in waste areas are not "native" but are "naturalized aliens". Most native flowers and weedy species cannot compete with the immigrants that almost invariably grow in disturbed soils.

Many weed types will be pushed out by the vigorous growth of more desirable plants if the soil is fertilized. Because they help control erosion, provide organic matter and pave the way for invading thickets and woodlands, it is important to learn more about all plants that help stabilize banks, rocky ledges and poor soils.

A total of 62 wildflowers and weedy species were identified by the field study team and they are listed in the following matrix entitled "Selected Herbaceous Plants". In addition to the identification, their habitat, location preference and special features have been included as well as selected comments for each.

SELECTED HERBACEOUS PLANTS (WILDFLOWER & WEED SPECIES)

IDENTIFIED GROWING ON MINNESOTA MINED LANDS

CHART I

Botanical Name	Common Name	Habitat: Moist	Habitat: Dry	Habitat: Sun	Habitat: Shade	Common On: Stock Piles	Common On: Tailings	Special Features: Foliage	Special Features: Flower	Special Features: Fruit	Comments
Achillea Millefolium	Yarrow		X	X		X			X		Common in open fields
Ambrosia Artemisiifolia	Common Ragweed		X	X		X			X		Common in open areas
Anaphalis Margaritacea	Pearly Everlasting		X	X		X			X		Collected & Dried for Winter Arrang.
Antennaria Neglecta	Field Pussytoes		X	X		X			X		Often Forms Dense Mats
Antennaria Plantaginifolia	Plantain-Leaved Pussytoes		X	X		X		X	X		Widespread on Dry open slopes
Anthemis Cotula	Mayweed		X	X		X	X		X		Covers Waste Ground
Aquilegia Canadensis	Columbine		X	X	X				X		Found on slopes, Rocky Woods
Aragis Canadensis	Sicklepod	X			X	X	X				Woods, Moist tailings
Aragis Laevigata	Smooth Rock Cress	X	X	X	X	X	X	X			Woods, rocky ledges
Aragis Lyrata	Lyre-Leaved Rock Cress		X	X		X		X			Rocks and sandy soil
Arenaria Serpyllifolia	Thyme-leaved sandwort		X	X		X		X			Sandy soil, open areas
Arenaria Stricta	Rock sandwort		X	X		X	X	X			Widespread
Aster Ericoides	Heath Aster		X	X		X	X		X		Dry open places
Aster Ptarmicoides	Upland White Aster		X	X		X	X		X		Rocks and Sandy Soil
Aster Umbellatus	Flat-Topped White Aster	X		X	X	X					Thickets, Forest Edges
Brassica Hirta	White Mustard		X	X		X	X		X	X	Fields, Waste Places
Brassica Nigra	Black Mustard		X	X		X	X		X	X	Fields, Waste Places
Cassia Fasciculata	Partridge-Pea		X	X		X	X		X	X	Dry, Sandy Soils
Castilleja Coccinea	Indian Paintbrush	X		X			X		X		Open Fields
Cirsium Altissimum	Tall Thistle	X		X	X	X	X		X		Woods, Thickets, Banks
Cirsium Arvense	Canada Thistle		X	X		X	X		X		Widespread
Cirsium Discolor	Field Thistle		X	X		X	X		X		Fields, Waste Places
Clematis Virginiana	Virgin's Bower	X			X		X		X	X	Thickets, Streambanks
Digitaria Sp.	Crab Grass	X	X	X	X	X	X	X			Anything Helps !
Erigeron Annuus	Daisy Fleabane		X	X		X			X		Wasteland, Roadsides
Fragaria Vesca	Wood Strawberry	X		X	X	X				X	Rocky woods, fields
Gnapitalium Macounii	Clammy Everlasting		X	X		X	X		X		Dry soil, Clearings
Gnapitalium Uliginosum	Low Cudweed	X		X			X		X		Damp ground, Ditches
Helianthus Annuus	Commom Sunflower	X		X			X		X		Bottomlands, Roadsides
Hypericum Perforatum	Common St. Johns-wort		X	X		X	X		X		Waste places, Fields
Lespedeza Capitata	Round-Headed Bush Clover		X	X		X	X		X		Dry Soils Sandy Fields
Linaria Vulgaris	Butter-and-eggs		X	X		X	X		X		Throughout Waste Places
Lobelis Cardinaus	Cardinal-Flower	X		X	X		X		X		A favorite wildflower
Lotus Corniculatus	Birdfoot Trefoil		X	X		X	X		X		All waste places

Bontanical Name	Common Name	Habitat				Common On		Special Features			Comments
		Moist	Dry	Sun	Shade	Stock Piles	Tailings	Foliage	Flower	Fruit	
Melilotus Alba	White Sweet Clover	X	X	X	X	X	X		X		Roadsides, waste ground
Melilotus Officinalis	Yellow Sweet Clover	X	X	X	X	X	X		X		Roadsides, waste ground
Oenothera Biennis	Common Evening Primrose		X	X		X	X		X		Roadsides, Waste ground
Parthenium Integrifouum	Wild Quinine		X	X	X	X			X		Open fields, fry woods
Parthenocissus Quinquefolia	Virginia Creeper	X		X	X	X		X	X	X	Birds attracted to fruit
Pastinaca Sativa	Wild Parsnip		X	X		X	X		X		Waste places
Potentilla Arguta	Tall Cinquefoil		X	X		X	X		X		Rocky Soil, dry areas
Potentilla Canadensis	Dwarf Cinquefoil	X		X	X	X			X		Open fields, woods
Potentilla Simplex	Common Cinquefoil		X	X	X	X	X		X		Fields, dry woods
Raphanus Raphanistrum	Wild Radish	X		X		X	X		X	X	Waste places
Rhus Radicans	Poison-Ivy	X		X	X	X		X		X	Watch Out!
Rosa Blanda	Meadow (smooth) Rose	X	X	X	X	X	X	X	X	X	Most hardy native rose
Rosa Carolina	Pasture Rose		X	X		X			X	X	Dry soil, rocky banks
Rosa Palustris	Swamp Rose	X		X	X	X			X	X	For wet or heavy soils
Rubus Allegheniensis	Blackberry	X		X		X				X	Good wildlife habitat
Rudbeckia Hirta	Black-Eyed Susan		X	X	X	X	X		X		Dry fields & waste areas
Silene Cucubalus	Bladder Campion		X	X		X	X		X		Widespread pioneer plant
Solanum Nigrum	Common Nightshade		X	X		X	X		X	X	Waste places
Solidago Altissima	Tall Goldenrod	X	X	X	X	X			X		Beautiful but bad
Solidago Canadensis	Canada Goldenrod	X	X	X	X	X			X		for hayfever suffers
Sonchus Oleraceus	Common Sow-Thistle	X	X	X	X	X	X		X		Waste places
Stellaria Media	Common Chickweed	X	X	X	X	X	X		X		Waste places
Taraxacum Officinale	Common Dandelion	X	X	X	X	X	X		X		Familar lawn weed. anywhere!
Tragopogon Pratensis	Yellow Goats-beard	X	X	X		X	X		X		Widespread
Trifolium Repens	White Clover	X	X	X		X			X		Spreads by creeping runners
Verbascum Blattaria	Moth Mullein		X	X		X	X		X		Waste places
Verbascum Thapsus	Common Mullein		X	X		X	X	X	X		Waste Places
Viola Papilionacea	Common Blue Violet	X			X	X	X		X		Damp woods, clearings

SOURCE:

Field Investigation by Special Consultant - Summer, 1971 ; using A FIELD GUIDE TO WILD FLOWERS OF NORTHEASTERN AND NORTHCENTRAL UNITED STATES; By: Roger Tory Peterson and Margaret Mc Kenny, Boston 1968.

POTENTIAL PLANT MATERIALS

The matrix of potential plant materials lists 95 trees, shrubs and ground-covers suitable for mineland locations of the Northern Minnesota Iron Ranges. Features of each plant's hardiness, height, form habitat, uses, texture, special features and growth are provided as a guide to potential use in reclaiming waste areas and for landscape design of former mine lands. Botanical names are given in alphabetical order as well as common names and general comments about each plant.

The plants were selected for their suitability in helping restore drastically disturbed surface mine areas, abandoned plant sites and waste disposal stockpiles or tailings basins. Many have little or no value as ornamentals for gardens or park areas but are important because of certain characteristics considered necessary to rehabilitate and restore natural and manmade landscape qualities. Hardiness, growth speed and potential revegation success were given prime consideration in making the selection.

All plants are suitable to the hardiness zones found on the Minnesota ranges and three plants are hardy to Zone 1 located far to the north where the average annual minimum temperatures fall below -50° F. Zone 2 plants withstood temperatures between -50° to -35° F. Zone 3 plants are hardy in the temperature range between -35° and -20° F.

The plant selection process includes many native plants as well as hardy plants introduced from Siberia, China, Japan and other countries. While a number of these plants are now growing in Northern Minnesota, many have not yet been used in mineland reclamation efforts. Trial and experimentation by iron ore and taconite operators will prove or disprove the worthiness of this preliminary list and aid in the development of an official materials selection list for future use. Agencies such as the University of Minnesota, U.S. Soil Conservation Service and U.S. Forest Service should be consulted and results exchanged with the private mining companies. In time, a computerized tape file and printout system should be designed and exchanged between all concerned. Such a cataloging system would identify the plants tried with data on soils, microclimate conditions, moisture deficiency, fertilizer program, and other related information. The overall objective of such a system would develop a method for rapid, reliable, systematic cataloging and retrieval of information about plant material success in mineland areas.

In planning for revegetation programs, it is best to follow the procedure of matching selected plant growth characteristics to the characteristics of the lands to be reclaimed. The plant materials and comments noted on the following chart become more meaningful when cross referenced and selected using the discussion of typical mined lands soils characteristics below.

Soils characteristics found within overburden stockpiles may vary greatly depending on the depth at which the material was removed. Generally, they are glacial drift materials which are medium to moderately coarse textured, limy in reaction and which have been compacted to a large degree. They are also well drained with moderate to high percolation and contain little or no organic matter. Their pH factor is generally calcareous to neutral thereby limiting the acceptance by certain plant materials without the addition of certain fertilizers or organic material.

POTENTIAL PLANT MATERIALS MATRIX

CHART II

Botanical Name	Common Name	HARDINESS ZONE 1	HARDINESS ZONE 2	HARDINESS ZONE 3	TYPE: DECIDUOUS	TYPE: EVERGREEN	HEIGHT: OVER 75 FEET	50 - 75 FEET	25 - 50 FEET	10 - 25 FEET	5 - 10 FEET	2 - 5 FEET	LESS THAN 2 FEET	FORM: LOW, SPREADING	VASE SHAPED	COLUMNAR	WEEPING	ROUNDED	PYRAMIDAL	HABITAT: WET	MOIST	DRY	SHADE	SEMI-SHADE	SUN	USES: HEDGE/SCREEN	FILTER	WINDBREAK	WILDLIFE HABITAT	BANKS/ GROUNDCOVER	TEXTURE: COURSE	MEDIUM	FINE	SPECIAL FEATURES: FOLIAGE	FLOWERS	BARK	FRUIT	GROWTH: RAPID	MODERATE	SLOW	SOILS pH: ACID	NUTURAL	ALKALINE	Remarks
Abies Balsamea	Balsam Fir			●		●		●						●						●					●	●						●						●			●			Native to North Woods
Acer Ginnala	Amur Maple		●		●			●						●							●			●	●	●	●		●			●		●			●	●			●			Vivid Scarlet Fall Color, Few Pests
Acer Negundo	Box Elder		●		●			●										●				●		●	●	●		●	●			●			●			●				●		Weed Tree
Acer Nigrum	Black Maple			●	●		●											●			●				●	●						●								●	●			Slow Growing, Native
Acer Platanoides	Norway Maple			●	●		●											●							●							●		●	●			●						Red and Heat Resistant Varieties
Acer Rubrum	Red (Swamp) Maple			●	●		●								●					●	●				●	●						●		●	●			●						Narrow Columnar Form Variety
Acer Saccharinum	Silver Maple			●	●		●								●					●	●			●	●	●			●			●		●				●			●			Easily Damaged by Ice & Wind
Acer Saccharum	Sugar Maple			●	●		●											●			●			●	●	●						●		●						●	●			Sap is Tapped for Syrup & Sugar
Amorpha Canescens	Lead Plant		●		●							●		●								●								●			●		●			●						Grows Well in Poor Dry Soil
Betula Alleghenlensis (Lutea)	Yellow Birch			●	●		●									●				●	●			●	●				●			●		●		●		●						Should do Well in Moist Tailings
Betula Nana	Dwarf Artic Birch		●		●								●	●								●			●				●	●			●						●					Does Best in Gravelly, Acid Soil in Full Sun
Betula Papyrifera	Canoe Birch		●		●			●										●			●		●	●	●	●		●				●		●		●		●						Noted for Beautiful Bark
Betula Pendula (Alba)	European Birch		●					●									●		●		●			●	●	●							●			●		●			●			Several Popular Varieties
Caragana Arborescens	Siberian Pea Shrub		●		●					●				●								●		●	●	●	●	●	●				●		●				●		●			Hardy Windbreak & Screen
Celtis Occidentalis	Hackberry		●		●		●								●							●		●	●				●				●			●		●						Grows well in Poor Soils
Cornus Alba Sibirica	Siberian Dogwood		●		●						●					●					●		●	●		●	●		●		●			●	●	●	●			●				Best Variety for Red Bark. Deer Love It.
Cornus Alternifolia	Alternate Leaved D.			●	●					●						●					●		●	●		●	●		●		●			●	●		●		●					Native
Cornus Canadensis	Bunchberry		●			●							●	●							●		●						●	●	●			●	●		●		●		●			Beautiful Ground Cover in Moist Woods
Cornus Sericea Stolonifera	Red Osier Dogwood		●		●						●							●			●			●	●	●	●		●	●	●			●	●	●	●			●	●			Native of Swamps; Favorite Deer Browse
Coronilla Varia	Crown Vetch			●	●								●	●									●	●	●					●			●	●	●			●						One of Best Grown Covers for Soil Erosion
Crataegus Succulenta	Fleshy Hawthorn			●	●					●								●			●				●	●		●				●		●	●		●	●			●			Hardiest of Hawthorns - Native
Fraxinus Americana	White Ash			●	●		●											●			●			●	●		●		●			●		●				●						Rapid Grower
Fraxinus Pennsylvanica Lanceolata	Green Ash			●	●		●										●			●				●	●		●		●			●		●			●	●						Var. Summit Developed at Stillwater, Minnesota
Ilex Verticillata	Winterberry			●	●						●							●		●	●			●		●			●			●		●			●			●	●			Needs Moist, Acid Soils
Juniperus Cummunis	Common Juniper		●			●					●			●								●			●	●	●	●	●	●			●							●	●			Many Varieties Ranging from 2 feet to 36 feet Tall
Juniperus Virginiana	Eastern Red Cedar		●			●	●									●			●	●	●			●		●	●	●	●			●		●			●			●	●			Hardiest and Most Popular of the Tree Junipers
Larix Decidua	European Larch		●		●		●									●			●	●	●				●	●			●				●	●				●			●			Excellent Fall Color Before Loosing Needles
Larix Laricina	American Larch (Tamarack)	●			●		●									●			●	●	●				●	●			●				●	●				●			●			One of Hardiest Plants, Beautiful Fall Color
Ligustrum Amurense	Amur Privet			●	●					●						●						●		●	●	●			●			●		●				●			●			Hardy Hedge Plant
Ligustrum Obtusifolium Regelianum	Regel Privet			●	●							●		●								●		●	●	●			●			●		●				●			●			Low Growing, Horizontal Brnaching Variety
Lonicera Canadensis	American Fly Honeysuckle			●	●							●						●			●			●	●	●	●		●			●		●			●	●						Native
Lonicera Chrysantha	Coralline Honeysuckle			●	●						●					●					●			●	●	●	●		●			●		●			●	●						Recommended for its Hardiness & Height
Lonicera Maack II	Amur Honeysuckle		●		●						●					●					●			●	●	●	●		●			●		●			●	●						Recommended for its Hardiness & Height
Lonicera Morrow II	Morrow Honeysuckle			●	●						●							●			●			●	●	●	●		●			●		●			●	●						Most Hardy Honeysuckle Vine
Lonicera Sempervirens	Trumpet Honeysuckle			●	●								●	●							●			●	●					●		●			●							●		Some Varieties Bloom all Summer Long
Lonicera Tatarica	Tatarian Honeysuckle			●	●						●					●					●			●	●	●	●		●			●		●			●	●					●	Dependable and Hardy Shrub - Many Varieties
Malus Baccata	Siberian Crabapple		●		●				●					●	●							●			●	●			●			●		●	●		●			●		●		One of Hardiest Crabapple; Columner Variety
Malus 'Flame'	Flame Crabapple		●		●					●					●							●			●	●			●			●		●	●		●			●				Developed by University of Minnesota
Malus Ioensis 'Plena'	Betchtel Crabapple		●		●				●						●							●			●	●			●		●			●	●		●			●				Native Crabapple, Mnay Varieties
Picea Abies	Norway Spruce		●			●	●									●			●		●				●	●	●	●	●			●		●				●			●			Many Varieties, Some Columnar and Dwarf
Picea Engelmann II	Engelmann Spruce		●			●	●												●		●				●	●	●	●	●			●		●				●			●			
Picea Glauca	White Spruce		●			●	●												●			●			●	●	●	●	●			●		●				●			●			Native Spruce. Var. 'Densata' - Black Hills Spruce
Picea Mariana	Black Spruce		●			●		●											●	●	●				●	●	●	●	●	●		●		●						●	●			Native Spruce for Wet Soils
Picea Pungens	Colorado Spruce		●			●	●												●			●			●	●	●	●	●	●		●		●						●		●		Many Varieties including Blue & Silver Colors
Pinus Banksiana	Jack Pine		●			●		●											●			●			●			●	●			●		●					●		●			Good for Loose, Dry Soils
Pinus Cembra	Swiss Stone Pine		●			●		●											●			●			●	●	●	●	●			●		●						●	●			Dense Foliage, Very Hardy
Pinus Mugo	Swiss Mountain Pine		●			●							●	●								●			●				●			●								●	●			Low Dwarf Varieties; 'Mugho', 'Compacta'
Pinus Resinosa	Red Pine		●			●		●											●			●				●		●	●			●		●		●		●			●			Grows Well in Poor Soils
Pinus Strobus	Eastern White Pine			●		●		●											●			●				●		●	●				●	●		●			●		●			One of Best Pines for Ornamental Use
Pinus Sylvestris	Scotch Pine		●			●		●											●			●				●	●	●	●				●	●		●		●			●			Pituresque and open. At Least 25 Varieties
Polygonum Cuspidatum (inc. Reynoutria)	Japanese Fleece-Flower			●	●								●	●								●			●					●		●		●	●			●				●		Fast Growing Ground-Cover for Poor Soils
Populus Alba	White Poplar			●	●		●								●							●			●	●	●				●			●		●		●				●		Best Large-Tree Poplar
Populus Berolinensis	Berlin Poplar		●		●		●									●						●			●	●	●				●			●				●						Hybrid of Narrow Habitat. Withstands Cold Heat
Populus Candicans	Balm-of-Gilead			●	●		●								●							●			●	●	●				●			●				●				●		Sometimes Called Balsam Poplar (P. Balsamifera)
Populus Deltoides	Cottonwood		●		●		●								●							●			●	●	●				●			●				●				●		Rapid Grower, Stands Droughts & High Temperature
Populus Tacamahaca (Balsamifera)	Balsam Poplar		●		●		●								●							●			●	●	●				●			●				●						Hardy Early Invader of Spoil Banks
Populus Tremuloides	Quaking Aspen	●			●		●								●							●			●	●	●		●			●		●		●		●			●			Extremely Hardy Native, Called "Popple"
Prunus Americana	American Plum			●	●				●									●				●			●	●	●		●			●			●		●	●				●		Native Fruit Tree Favored for Bloom & Fruit
Prunus Besseyi	Western Sand Cherry			●	●						●				●							●			●	●	●		●			●			●		●	●			●			Native Ornamental
Prunus Xcistena	Purple-Leaved Sand Cherry		●		●						●				●							●			●	●	●		●			●		●	●		●	●			●			Purple Leafed Cross De. in South Dakota
Prunus Maack II	Amur Chokecherry		●		●				●						●							●			●	●	●		●			●		●	●	●	●	●						Bark Peels Off in Thin Strips Like Birch
Prunus Maritima	Beach Plum			●	●						●							●				●			●	●			●			●					●	●				●		Dense Shrub, Good Fruit, Light, Sandy Acid Soil.
Prunus Pennsylvanica	Pin Cherry		●		●					●					●							●		●	●	●	●		●			●		●	●		●	●			●			One of First 'Nurse' Trees to Appear After Cutting
Prunus Pumila	Sand Cherry		●		●						●			●								●			●	●			●	●			●		●		●	●						Often Prostrate, Try as Ground Cover
Prunus Tenella	Russian Almond		●		●							●		●								●		●	●	●			●										●		●			Hardy Shrub From Southeastern Europe
Prunus Tomentosa	Manchu Cherry		●		●						●							●				●		●	●	●			●			●			●		●	●						Hardy Shrub from China & Japan
Prunus Virginiana	Choke Cherry		●		●				●									●			●	●	●	●	●	●	●		●			●					●	●				●		Favorite Fruit for Pies, Jams, Jellies & Wine
Quercus Macrocarpa	Bur Oak		●		●		●											●			●			●	●		●	●	●		●					●				●	●			Hardy Member of White Oak Group
Quercus Rubra	Red Oak			●	●			●										●				●		●	●	●	●	●	●									●			●			Fastest Growing Oak. Excellent Fall Color
Rhus Glabra	Smooth Sumac		●		●					●						●						●		●	●			●	●			●		●				●			●			Useful for Sterile Soils and Banks
Salix Alba	White Willow		●		●			●							●					●	●			●	●				●				●	●				●						Upright Willow For Moist Soils, Fast Growth
Salix Discolor	Pussy Willow		●		●					●				●						●	●			●	●				●				●	●				●					●	Glossy Leaves
Salix Lucida	Shinning Willow		●		●					●					●					●	●			●	●				●				●	●				●						Good Shrub for Moist Soils, Rapid Growth
Salix Tristis	Dwarf Gray Willow		●		●							●		●						●	●			●	●				●	●			●	●				●						Poor Soil Ground Cover. Hard to Find in Nurseries
Salix Uva-Ursi	Bearberry Willow	●			●								●	●						●	●			●	●				●	●			●	●				●			●			Creeping Mat like. Glossy Leaves. Very Hardy
Sorbus Americana	American Mountain Ash		●		●				●						●						●			●		●							●	●	●		●	●			●			Native
Sorbus Aucuparia	European Mountain Ash		●		●				●						●						●			●		●							●	●	●		●	●				●		Taller and More Colorful than Native Mountain Ash
Sorbus Decora	Showy Mountain Ash		●		●				●						●						●			●		●							●	●	●		●	●						Larger, Brighter Fruit Than South Americana
Symphoricarpos Albus Laevigatus	Snowberry			●	●						●				●							●	●	●		●			●	●		●		●	●		●	●			●			Valued for Berries. Will Hold Soil on Steep Banks
Taxus Canadensis	Canada Yew		●			●						●		●							●	●	●	●					●	●			●	●					●		●			Hardiest of Yews, Withstands Shade
Thuja Occidentalis	American Arborvitae		●			●		●											●		●			●		●			●				●	●						●		●		Native with Many Varieties
Tilia Americana	Basswood (American Linden)		●		●		●											●			●		●	●			●		●										●		●			Native Common in Minnesota Woodlands
Tilia Cordata	Littleleaf Linden			●	●		●											●			●			●	●		●		●				●							●				Valuable For Poor Soils.
Viburnum Acerifolium	Mapleleaf Viburnum			●	●						●					●						●	●	●		●	●		●			●		●	●		●	●			●			Of Value For Shaded Areas
Viburnum Dentatum	Arrowwood		●		●					●						●					●				●	●			●			●		●	●		●	●						Fast Growing in Most Soils
Viburnum Lentago	Nannyberry		●		●				●							●						●		●	●	●			●			●		●	●		●	●						Colorful Foliage and Fruit
Juniperus Horizontalis	Creeping Juniper	●			●							●	●								●			●				●	●			●							●		●			Excellent for erosion control in hot dry soils

SOURCES: Minnesota, University of, Various Agricultural Extension Bulletins, St. Paul, 1968-71.

Robinson, Florence Bell. Useful Trees and Shrubs. Card File of 599 Hardy woody plants. Champaign, Illinois, 1948.

Wyman, Donald. Wyman's Gardening Encyclopedia. New York, 1972.

Shrubs and Vines for American Gardens. New York, 1961.

Trees For American Gardens. New York, 1959

Soil characteristics of tailings areas are quite variable, however, certain characteristics are similar. They consist of finely ground rock fragments to coarse materials which have been compacted to a high degree. Their rate of permeability is quite rapid, however, and the nature of their construction usually leaves water standing in a portion of the tailings basin. The pH factor is variable and chemicals that were added druing the ore dressing process may be present in the tailings material.

Lean ore or save rock usually consists of coarse and very coarse textured materials which have been removed from the mine and stockpiled for potential later use. Slopes are generally steep, permeability is rapid and organic material is low to non-existant. As in tailings, the pH factor varies greatly and more analysis is needed in each site before application of fertilizers or organic materials.

There are a number of other reclamation alternatives which should be briefly discussed in addition to the revegetation of sites.

During the actual open pit mining operation, thought should be given to various ways of contouring or sloping the pit faces, creating a more desirable slope. In this way, it would be far easier to replant the sloped edges of open pit areas and the dangerous drop offs and erosion problems would be reduced or even eliminated in some instances.

Substantial new techniques for underground mining operations should also be explored to reduce the reclamation problems posed both during and after operation. The topic of subsidence has been discussed. However, the problem may be greatly enlarged if any new underground operations are initiated. A subsidence control program would keep the problem of sinking ground to a minimum in the future mining districts of Northern Minnesota. One area that has had limited study and testing, has been in the area of overburden reshaping. More effective methods of overburden shaping should be explored to reduce the problems of revegetation, slumping, and related post mining reclamation problems.

In summation, reclamation techniques and methods have been given much more attention in the past decade than ever. New processes and planting methods have been developed that will greatly reduce the existing and anticipated reclamation problems.

It should be stressed that the final outcome of all reclamation efforts should be toward that of creating environmentally suitable landforms, consistant with or similar to those surrounding the site.

It would be sheer folly to expect that mining sites be returned to their previous natural state. What should be expected, however, is that once mining has ceased in a given location, that site be reshaped and vegetated so as to create a suitable environment, at least similar to that of the surrounding terrain and free of unnatural dangers to both animal and human populations.

DEMONSTRATION PROJECTS

There is presently not enough research and practical field experience data readily available in Northern Minnesota to make a realistic evaluation of present and past mining reclamation accomplishments. In other parts of the country, the reclamation efforts have received much more publicity and the results are more easily obtainable. In this section, a discussion will be made of some metallic mining companies in both Minnesota and throughout the country who are actively involved in the reclamation of metallic mining areas.

Erie Mining Company

Erie Mining Company, located in the eastern end of the Mesaba Iron Range near the community of Hoyt Lakes, seems to be a leader in Minnesota in publishing accounts of reclamation efforts. Since a good part of their actual mining operations are not within an urban influence area, their efforts toward reclamation cannot be easily recognized by the surrounding citizenry.

They have put into practice and follow very closely the concept of "multiple resource management". This program deserves close attention and recognition for other mining areas, due to its success. All mining companies should plan their reclamation programs within such a management concept that fully utilizes land use planning of the total environment for any compatable use including those of minerals, timber, water, wildlife and recreation.

The reclamation work at Erie began back in 1948 when the decision was made to use vegetation to stabilize the exposed slopes of the tailings basins. A study was undertaken with the University of Minnesota to experiment with plant materials to determine the types that would thrive on such a sterile, hostile environment as the taconite tailings. This work is frequently referred to as the first attempts at revegetation of taconite tailings basins.

Over the next decade or so, literally dozens of plant species have been experimented with along with fertilizer mixes, planting techniques, moisture and temperature control. The main objective of these early efforts was to stabilize and reduce the erosion problem on the backslopes of the taconite tailings ponds. Because the backslopes are constructed on approximately 1:2 inclines, the use of standard farm equipment was rendered ineffective. The process of hydro-seeding (as explained in the methods section) has been used with considerable success. Separate applications of fertilizer, seed and mulch are shot onto the backslopes. The results have proven to show thick summer plant growth and stabilized conditions with the oldest slopes having developed limited sod and natural soil conditions.

The high success ratios experienced on the backslopes and ponds is due largely to the inclusion of commercial fertilizer in the tailings. Approximately 1,000 pounds per acre of 11-55-0 fertilizer is applied to the surface of tailings ponds for temporary vegetation and approximately 2,000 pounds of the same type is applied to the permanent backslope plantings per acre. The need to apply the root developing phosphorous compound to the tailings resulted in the development of the "Klodbuster", a specialized piece of equipment which breaks up the top layer of tailings and allows the phosphorous to leach into the tailings four to five inches.

Seeding variety on the tailings basins and backslopes has been a never ending trial and error method. Over the years approximately 50 varieties have been attempted and the results to this date are promising. Legumes, because of their nitrogen fixing ability have shown the greatest promise. Varieties such as clover, alfalfa, birdsfoot trefoil, caragana and European alder have been tested and show a large degree of success.

Through the years, Erie Mining has worked very closely with the Soil Conservation Service in setting up test plots for experimental seed varieties such as the western wheats, reed canary, hard fescues and rye grasses.

In addition to extensive work and success on the backslopes of the tailings basins, much has also been done on the interior of the basins to reduce wind erosion and to experiment with methods of stabilization when the basin is completed. The main effort has been to plant annual species, since the basins are constantly being raised and anything permanent would be eventually lost. Varieties which have had great success include oats, barley and millet, where one year of protection is necessary. If several years of cover is needed, annual rye grasses and alfalfa are used.

Erie Mining has also started reclamation efforts on overburden stockpiles. Experiments have been conducted in the shaping of the stockpiles to hold the plant materials while maturing. Many varieties of plants ranging from legumes and grasses to deciduous and coniferous seedlings and hybreds have been established with good results. The growth on the overburden is much slower and the erosion problems are somewhat greater to overcome, than that experienced with tailings backslopes. However, effort is being made to reestablish plant growth and return the subsequent landform to a more natural environment.

All efforts at Erie Mining have not been totally successful. However, through trial and error selection and experimentation they have eliminated a number of species and techniques which other owners will not have to try. Their efforts have met with steady progress and their concern to return the environment to a more natural setting are evident in the reclamation programs.

Erie's staff forester has authored several resource articles which explain in much greater detail the role Erie Mining has played in reclamation programs. Two are available from the organizations listed in the bibliography at the end of this report.

Hanna Mining Company

Hanna Mining Company, also located in Northern Minnesota, operates a number of both natural ore and taconite facilities on the western end of the Mesabi Iron Range. They too, have a concern for the revegetation of mined areas and tailings ponds and have written several reports and project papers on the subject.

Efforts toward reclamation of both tailings basins and stockpiles began in the form of experimental plots more than twenty years ago to select hardy species that would flourish on the sterile soils remaining. The planting and seeding was done in the form of test plots ranging from three to over 350 acres at over 40 Hanna locations throughout the Mesabi Range. Nearly all of the seeding done during the early years was through the use of a seed drill which has compartments for fertilizer, grass seed and legumes.

Attempts have been made at terracing the sloped areas prior to seeding and adding mulches to the soils to curtail erosion during germination. The use of snow fencing was also initiated by Hanna operations to reduce wind velocity on tailings basins.

It was determined in these formulative years that the most favorable periods for planting falls between May 15th and June 15th. Prior to this time, the winds are usually much more frequent and the precipitation is lower, causing more seeds to fail. The period from June 15th on into the summer was also found to be inadequate because of high temperatures reaching as much as 130° on the basins and slopes.

Trees and shrubs have also been hand planted with rather high success. The varieties which have had the highest success rates are black elder, locust, golden willow and russian willow. There are failures in a number of plant varieties tried such as walnut, cottonwood, roses, kudzo and trumpet vines.

After much experimental work was completed with sufficient data collected on vegetation type, fertilizer and planting techniques, Hanna went ahead with extensive planting on many of their sites. Very dramatic results can be seen in areas which have received a good amount of reclamation effort.

The Mesabi Chief natural ore tailings pond near the City of Keewatin has been extensively planted and shows great promise. The Harrison tailings pond at Cooley was also planted with black locust, brome grass and clover as well as other plants with adequate success.

Other natural ore tailings ponds such as the Perry pond near Cooley, the Mississippi group of ponds near Keewatin and the Hanna ponds near Coleraine, have also been planted with grasses, legumes and trees to hold erosion and to reclaim the area for a future use.

Hanna has also voluntarily adopted a four point policy which is worthy of mention. Very briefly, they attempt to (1) remove the topsoil and save for future cover; (2) remove overburden and deposit in mined out areas; (3) cover overburden with topsoils; and (4) slope and plant final excavation areas.

Hanna Mining has had many years of reclamation efforts behind them and while many have been very successful, there have also been failures and frustrations. They are, however, concerned with new methods and ideas and have worked with the University of Minnesota, College of Forestry on revegetation programs.

Other Minnesota Mining Companies

The remainder of the metallic mineral mining companies in the state of Minnesota have also been experimenting to different degrees on processes and ways of reclaiming specific sites within their operations. There are no known published findings, however, on the methods and degrees of effectiveness actually accomplished, and for that reason they are not included within this section.

Reclamation In Other States and Countries

It has long been held by some Minnesota mining companies that there are many differences between surface mining operations on the Mesabi Range and surface mining reclamation experience for other minerals elsewhere. Certainly reclamation techniques and methods must recognize regional, topographic and climatological differences as well as different types of mining and land use potentials. Successful reclamation programs in other states and other countries should be studied, however, as methods, techniques, equipment and even many plant materials have been successfully used in varied types of mining operations.

A Canadian firm, Erocon Limited, has pioneered reclamation of various mineral areas on a wide range of sites extending from northern Ontario to central Florida. They claim to have successfully reclaimed mined land waste ranging from a pH of 0.5 to 9.8 and from unsorted boulders to fine-mesh material in settling ponds. Erocon's methods are advertised to build up topsoil at the rate of up to one inch in ten years. (It takes nature about 100 years to build up one inch of topsoil). The company has pioneered a combination of crownvetch and other legumes such as ten varieties of trefoil, according to prevailing climate and soil conditions. Bacteria, an essential prerequisite to successful plant growth, is added to sterile tailings at the rate of about one pound per acre, together with seeds and fertilizer. A more rapid formation of organic matter in the soil and dramatically improved rate of growth is thus claimed.

In another instance, the Henderson Project of American Metal Climax represents a $200 million venture to mine molybdenum in some of Colorado's most scenic country. During early work on the project, the company met periodically with conservation groups to develop a plan whereby the ore body could be mined with minimal impact on ecological values. Reclamation was only part of the plan of action adopted. An important decision reached was to make the mining operation blend as gracefully as possible with the surrounding landscape.

In the state of Georgia, some 25 commercial products are now mined including metallic ores such as iron ore, titanium, bauxite, barium and zircon. While better known for its national leadership in marble and granite quarrying, Georgia also leads the world in surface mining of kaolin, the clay used widely in coating of paper. The Georgia Surface Mining Act became effective January 1, 1969, and since that date, mining companies have prepared reclamation plans as an integral part of mining plans, both in the expansion of existing mines and in the opening of new mines. In developing reclamation plans, surface miners can choose the purpose for which lands are to be reclaimed, provided the use is of an economic or social benefit and receives the approval of the Land Reclamation Section, Environmental Protection Division, Department of Natural Resources. Mining companies are required to post bonds to insure that reclamation is completed. Posted bonds are not released until reclamation of a mined area is approved. Although developed prior to the laws now in effect, open pit iron ore mines and stockpiles of overburden in West Georgia have been converted to gently rolling lands that now support stands of pines or row crops of peanuts or corn.

A number of other states also have implemented mineland rules and regulations.

Among these is Montana which has enacted rules and regulations which require the operator to reclaim all affected mining lands so as to encourage productive land uses and guarantee the protection of health safety and general welfare of the people. Furthermore, an operator is required to secure a permit which covers securities and fees as well as restrictions for permitted and non-permitted mining practices with reference to post mining activities.

Various other states have also implemented strict mineland practices covering the bonding, permit requirements and reclamation of the land used for mining purposes. Among these are Colorado, Kansas, North Dakota, Iowa, Oklahoma and Ohio.

Ontario, Canada has also taken a strong position for the reclamation of mining sites. They require a complete site plan prior to mining and the site plan must cover the size and extent of the project as well as reclamation procedures which will be implemented when mining ceases. They also require a fee program of up to $5,000 yearly to a total of $100,000 after 20 years of mining to cover any reclamation costs not performed by the operator.

In 1965 a Federal Interagency Field Appraisal team made field reconnaissance examinations to evaluate 56 reclamation projects in the Appalachian states. While most of these were reclaimed bituminous coal strip mines, there were also iron and manganese surface mines involved in the study. Among the conclusions of the appraisal team:

- Reclamation effort was unsuccessful in each case where surface mining was conducted on slopes greater than 28 degrees.
- Effective protective cover was established on only 48% of the disturbed land.
- Nearly all sites lacked adequate storm runoff control although stream sedimentation was reduced in most reclaimed areas after several growing seasons where an adequate vegetative cover had been established.
- The most common form of reclamation practiced consists of tree planting, with some legume and grain seeding.
- Reclamation efforts have been only partially successful due to failure to recognize water quality control as a major problem.

Strip mine reclamation demonstrations have been conducted by the Tennessee Valley Authority (TVA),cooperating with mining companies, state agencies and forest experiment stations. A series of booklets and before and after colored slides are available from the TVA as a guide to what the areas were like upon abandonment of the mine, what was done, and the types of vegetation and wildlife existing after a few years. One of the demonstrations, where cost records are readily available, was accomplished for approximately $100 per acre. Although the TVA demonstration booklets describe only abandoned coal strip mines, they are also cooperating on research projects of copper and other metallic ore mining areas within their region that extends into seven states.

In England, already short of land, the problem of changing derelict mine land into healthy and useful landscapes has been an important issue for some time. While much of Britain's reclamation is related to coal, clays and building stone quarries, they also have many thousands of acres of derelict land resulting from metalliferous mining including iron ore, copper and tin . Most recent efforts have resulted from the Landscape Reclamation Research Project of the University of Newcastle.

Work relating to design principles as well as techniques for specific operations and circumstances since WWII has been carried out at nine selected areas with varying kinds of problems. Among the types of research being conducted in 1971, the following have particular application to the mineland problems of Minnesota:

- Survey and analysis of both naturally occurring and artifically planted vegetation.
- Regional landscape reclamation plan to avoid confusion and duplication of effort.
- Evaluation of previous techniques of reclamation (Great Britain, West Germany, Holland and other countries).
- Landform design based upon economics, aesthetics, topographic factors and functional requirements of land use.
- Visual assessment and attitudes of citizens before and after reclamation.
- Legal and financial aspects of reclaimed land management.
- Long-term maintenance and management.

The research projects are designed to avoid going over ground already covered in previous studies and to document failures as well as demonstrations of success.

Despite the hundreds of references to reclamation easily traced down in a literature search, most technical publications on the engineering aspects of mining still fail to consider reclamation as an important part of the mining operation. A case in point is Methods of Working Coal and Metal Mines in three volumes published in 1966, in New York, as well as several foreign countries. With a total of 1,545 pages, less than one page is devoted to "land reclamation" and the entire reference is to strip mining of coal.

EVALUATION OF RECLAMATION EFFORTS

A brief evaluation of the efforts put forth thus far by the various mining concerns on the Minnesota Iron Ranges is necessary for beginning a formal continuing reclamation program.

A comprehensive investigation to determine the effectiveness of past and present reclamation in Minnesota is recommended for the future and it will be necessary to establish goals and define criteria for measuring effectiveness. If, for example, the primary aim was to stabilize the soil and this was achieved, the effect would be termed "effective", even though restoration of aesthetic values left much to be desired. Likewise, screen planting along highways does nothing toward eliminating the more serious problems of health and safety hazards or the usability of reclaimed lands and watercourses.

As evidenced by selected field work inspections by the consultant, since 1961, efforts are being made by several mining companies to reclaim areas which they have disturbed (pits) as well as to reclaiming man-made areas they create (tailings/stockpiles).

In most instances, the operating companies are aware that reclamation must take place within their operations if they are to maintain good liaison with the general public. At least three companies employ a staff forester who is responsible for all reclamation efforts. Others have consultant foresters assisting the mining operator with erosion control and reclamation.

The selection and experimenting with various plant materials can also be considered a step in the right direction. If many plant varieties are attempted, each company quickly deems which cover to rely on and which are rendered ineffective. More must be done to catalogue and exchange lists of the most successful plants.

Another positive feature noticed is that in the area of new tailings ponds, vegetation is being reestablished. Some companies are not waiting until a pond is complete; rather, some are immediately planting on the backslopes and within the pond to rectify past problems of air pollution.

It was also evidenced that some companies are experimenting with non-native trees and shrubs, exotic grasses and hybred species which could provide more growth to barren areas.

In the area of cleaning up derelict structures and post mining waste, it was noticed that a good percentage of the no longer used facilities have disappeared since the consultant's last previous investigation in 1969-70. It is realized that this is due in part to the high cost of scrap steel; but more so, to the county mine inspection system.

In an evaluation such as this, we must also look as objectively as possible at some of the efforts which are not obtaining the results of creating a more natural environment or the capability thereof in the future. Without downgrading the efforts now being made; there is much additional work which remains to be done.

More work is needed in the revegetation and contouring of stockpiles. It appears extremely difficult to establish and hold vegetation on steep slopes. Efforts were made to plant these slopes. However, erosion, wind and extreme temperature stunted and many times rendered useless the efforts being made. Other instances were noted where no vegetation except the natural succession varieties were surviving. It is the opinion of the consultant that additional reclamation work is needed throughout the Iron Range. What is being done represents but a small part of the vast areas which are in immediate need of reclamation. Actually, no company has yet come forward in Northeastern Minnesota with a unit of land that they claim has been "reclaimed" for a new use.

We do not know the permanency of much of the ongoing reclamation effort. Not enough research and technical data has been assembled on whether or not the fertilized slopes and tailings ponds will continue to revegetate or whether they will eventually be leached out and begin to erode away, again causing serious problems.

A critical evaluation was also made of the need to alter or redesign the abandoned open pit mine features located throughout the mining regions. Extensive engineering feasibility is needed to explore ways to check the erosion problems and lack of any life-supporting ground cover on the edges of open pit. The new open pit mines are being developed in somewhat similar fashion to the abandoned open pits and will therefore cause the same concerns and problems when the operation ceases.

RECOMMENDATIONS FOR FUTURE RECLAMATION PROJECTS

In the preceeding section on demonstration projects, an appraisal of the various methods of mining reclamation as commonly practiced was offered as well as an overall evaluation of successes and failures observed. In order to bring that discussion into perspective, a series of recommendations on the improvement of reclamation practices and theory follows with the expectation that the general post-mining landscape can become a positive feature for our changing environment.

The following recommendations will require the cooperation of the state and local governments as well as the various mining companies if the Minnesota Iron Ranges are to achieve a more natural and useful environment:

1. SURFACE MINE RECLAMATION COMMITTEE

   This committee should be formed of public agency and mine industry representatives and the public, similar to the committee that was active about five years ago in developing the Iron Range Trail and reviewing the early drafts of proposed rules and regulations of mining areas. Its purpose would be to assist and update reclamation activities and to promote support and demonstrate better techniques of mine land restoration.

2. DEVELOPMENT OF PLANT LISTS

   Through federal, state and local agricultural groups as well as private organizations, a complete cataloging of plant types and their basic development needs should be established. The plant listings should include their fertilizer, moisture and nitrogen fixing capabilities and other solid and micro-climate needs. This comprehensive list could be assembled with the help of various mining companies who have had many years of experience in the selection of appropriate grasses, legumes, shrubs and trees. It would be highly valuable to companies who either do not have the time or the resources to develop their own suitable plant lists for their reclamation effort.

3. DEMONSTRATION SITE

   Somewhere within the Iron Ranges, the surface mine reclamation committee should pick a site for a major demonstration effort on post mining reclamation. The demonstration would include many of the basic components found within the problem section so that various methods can be attempted. Such a site is the Giants Ridge Unit or any of the twelve sites recommended for experimental projects in the 1972 report, A Plan for the Reclamation of Mined (Metallic) Lands in Minnesota.

4. DEVELOPMENT OF EXPERIMENTAL NURSERIES

There is a need to establish improved or additional sources of seed for use in the reclamation effort. Many times a staff forester or consultant tests a seed variety and obtains excellent results. The problem then becomes evident when the seed type is not available or in a short supply. If private nurseries cannot be persuaded to raise seed types necessary for reclamation needs, it is suggested that the state or federal agricultural departments begin their own. It is quite possible that a University Experimental Station could also assist along these lines. The only problem that could be envisioned is the reluctance to raise seed types which may be controversial in nature. If, for example, thistles are proven to be extremely hardy for establishing permanent ground cover on overburden slopes, then the public nursery may want to raise that particular seed or make it enticing enough for private seed growers to do so. (In order to achieve the above recommendation on questionable plant species, a thorough examination and possible amendment to the existing "Noxious Weed Law" would be required).

5. LANDFORM DESIGN

The need to further the work started on the design of man-made landforms is an area of importance. Much could be done on the design factors for overburden stockpiles, open pits and tailings ponds so that the end product could produce beneficial landforms which could have numerous uses. In many mining areas, the plant sites and landforms are being developed in the same way as during the very early periods of mining 40 to 50 years ago. A research program for improved site design standards could be of extreme importance to future mining activity. Clearly, the talents of landscape architects must be used in addition to engineers, foresters and other disciplines.

6. REGIONAL RECLAMATION PLANS

There are two separate reclamation plans which the consultant feels are necessary for an improved environment occurring within the mining regions of the Iron Ranges. The first major reclamation plan should include all land use considerations for future mining areas. These would include areas where mining activity may enlarge and come into conflict with urban areas or transportation corridors. It also may include new mining endeavors such as copper- nickel or precious metals. If such a plan were developed and closely coordinated with other state, county and local plans, the chances for conflicts between the mining company and the remainder of the environment may be reduced substantially in the future.

The second of these should be formulated and adopted by the State of Minnesota for the entire list of abandoned mining sites. Careful analysis should be made of each abandoned mining area and reclamation efforts could then be begun on a site by site cleanup and planting campaign. Since the current legisltaion calls only for reclamation of future metallic mining areas, such a plan for abandoned areas would be extremely important.

7. GOVERNMENT -- COMPANY-PUBLIC INFORMATION EXCHANGES

At the present time, informational exchanges in the reclamation efforts being made by the various mining concerns and the state and federal governments along with the public, is not as substantial as it could be. Many times, as evidenced by the consultant's research, the state or federal agencies know very little about the actual reclamation efforts being made. The proposed State Mineland Reclamation Committee would overcome this deficiency. If, once a year, leaders of both groups -- the government and the mining officials -- could get together in a symposium atmosphere and frankly discuss efforts being made by both parties, it would surely result in improved recognition of all efforts. Progress reports on success and failures, a series of before and after slides, movies and printed booklets should also be part of an exchange of information program.

8. COMPANY TO COMPANY EXCHANGES

Exchanges of information, successes as well as failures, and proven techniques could also be done on a company to company exchange basis. Symposiums could be held dealing with reclamation techniques exclusively and could be attended by the many mining officials dealing with reclamation, and public interest as well as conservation organizations. Key reclamation speakers could be brought in to discuss new techniques and research results.

9. ENCOURAGEMENT OF STAFF EXPERTS AND CONSULTANTS

At the present time, there are a few mining companies in Minnesota who employ staff foresters to organize and implement reclamation efforts on their particular site. Other mining concerns have used consultants in the past to organize reclamation projects and then follow through with analysis. None presently employ or engage landscape architects as is the case in other states. We would encourage all mining companies to hire reclamation staff or consultants to plan for the orderly reclamation of all mining operations.

10. SPONSORSHIP OF RESEARCH GRANTS

Government officials and the mining concerns should also begin a program of grants for research and design projects to deal in reclamation efforts exclusively. These grants could be used by educational institutions or private foundations to further develop plant species or techniques that would result in improved reclamation. The Department of Landscape Architecture at the University of Illinois is a key example of an institution which actively carries on research projects in the area of reclamation. Their research projects and experiments are sponsored by the National Sand and Gravel Association. Programs of similar nature could be initiated in Minnesota, and if all mining companies cooperated, the results would be far greater than if each company attempted such research on their own.

11. LEGISLATION

A critical recommendation for improving the reclamation efforts presently underway in the metallic mining areas of the state is legislation that would deal with the improvement of the abandoned or "inactive" mines. These areas have been either exhausted or held inactive for many years, and little effort has been put into reclamation. The 1973 legislation provides only for reclamation of present and future mining activity; it does not include the now abandoned areas. The most serious mistakes and problems are not found in the actively mined areas, but in the old mines which have been closed in the last few decades.

FUTURE USE OF MINED AREAS

The matrix chart entitled "Potential Land Use" indicates some of the major mining components found at most mine sites and the types of land uses that might be considered usually suitable or acceptable under certain conditions after mining operations have ceased. Mining-associated uses such as warehousing and service industries frequently occupy former mine sites in Northern Minnesota, although a fine residential neighborhood is situated on a surface stockpile in Hibbing and some mining components have been converted to recreational uses. In other states, such diverse uses as schools, fairgrounds, industrial parks, airports, hospitals, state and local parks and apartment complexes have been constructed in mined-out, drastically disturbed surface mined areas.

The chart helps emphasize the fact that mining components, such as surface stockpiles, caved ground, and abandoned plant sites, are generally most suitable for open space type uses including recreation, forestry and wildlife habitat. Residential, commercial, industrial and other urban-type uses have more restrictive site requirements and thus do not have the potential of being located in as many of the listed mining components as the open-type uses.

Chart III

POTENTIAL LAND USE

o USUALLY SUITABLE

x CONDITIONALLY ACCEPTABLE

MINING COMPONENTS	RESIDENTIAL	COMMERCIAL	INDUSTRIAL	PARK & RECREATION	FORESTRY	GAME & FISH HABITAT
OPEN PITS				x		x
SURFACE STOCKPILES	x	x	x	o	o	o
LEAN ORE/SAVE ROCK						x
PLANT SITES (ABANDONED)	x	o	o	x	o	x
CAVED GROUND				o	o	o
TAILINGS BASINS				x	x	x
RESERVOIRS				o		o

Two additional graphic aids have been prepared to assit in completing the picture on mineland reclamation problems and opportunities for the future. While these two maps are general in nature and do not pertain to specific sites, they do present an overview of the existing mining-related problems and the possibilities for future land use relationships.

In order to gain a better understanding of specific inactive mines and specific post mining problems, it is suggested that the reader refer to A Plan For The Reclamation of Mined (Metallic) Lands in the State of Minnesota. prepared for the Minnesota Dept. of Natural Resources in 1972.

Map 1 - A "Cluster of Exhausted and Inactive Mines" illustrates the pattern formed by clusters of existing exhausted and inactive mines across more than 100 miles of the Mesabi and Vermillion Iron Ranges. Also shown on this map is a generalized indication of the type of mining components found within each cluster. All sites outlined contain open pits and surface stockpiles of overburden. Most units also have lean ore and save rock stockpiles and many contain tailings basins. Although the main buildings and derelict structures have been removed from most abandoned plant sites, rock debris and remains of minor structures should be cleaned up at a number of sites. Such "housekeeping" improvement is especially needed on the Cuyuna Range where unsightly conditions are readily seen from several public roadways.

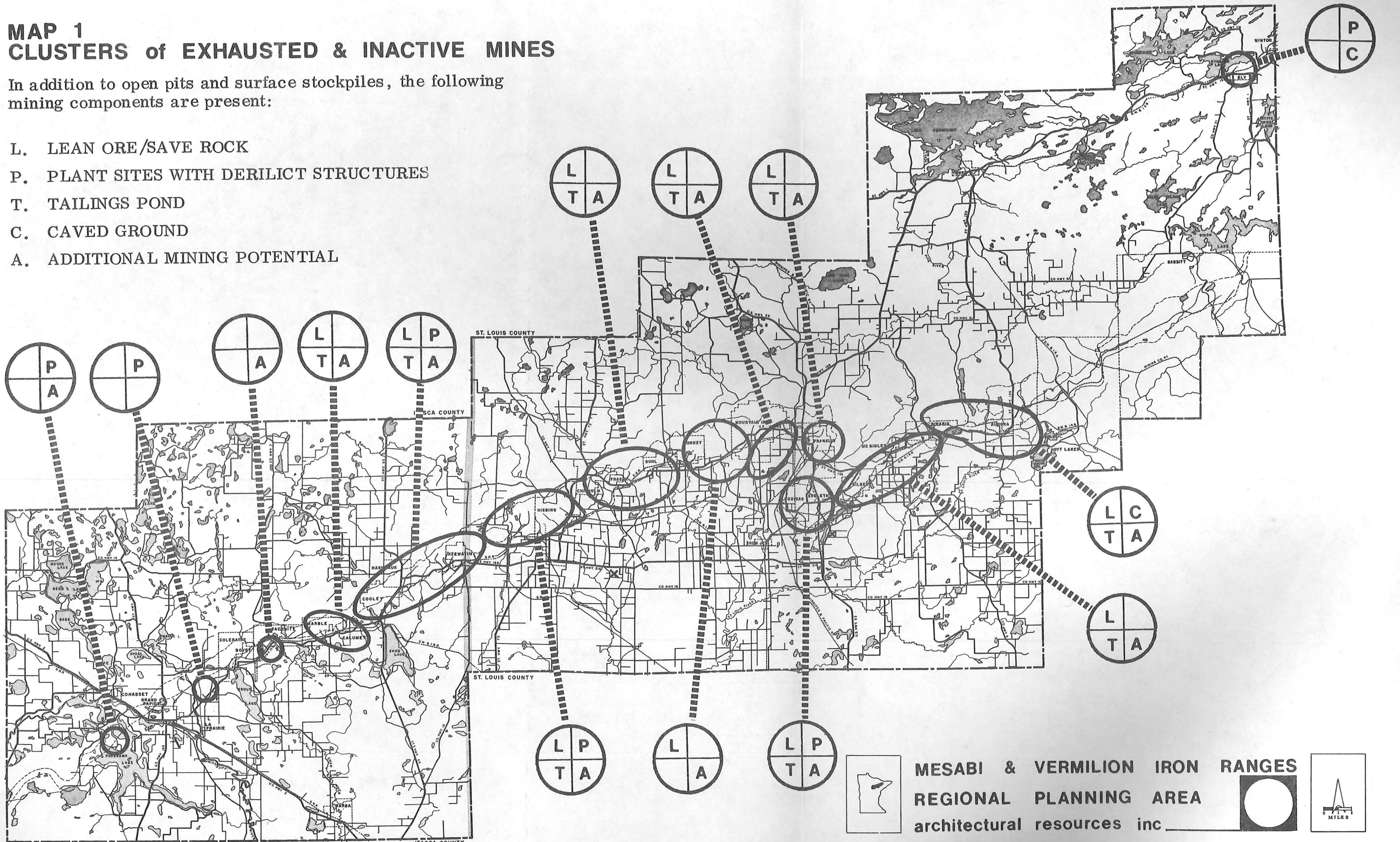
Test pits exist throughout the region but a complete inventory does not exist. Caved ground resulting from land subsidence and settling of underground mines are found in several areas of all three ranges. The largest caved ground area is located within Ely where an area of about two miles in length has subsided due to underground mining activities of nearly 70 years.

There are eight inactive and six exhausted mines on the Cuyuna Range. Most of these contain lean ore stockpiles and abandoned structures. Caved ground and tailings ponds also exist to a lesser degree.

MAP 1
CLUSTERS of EXHAUSTED & INACTIVE MINES

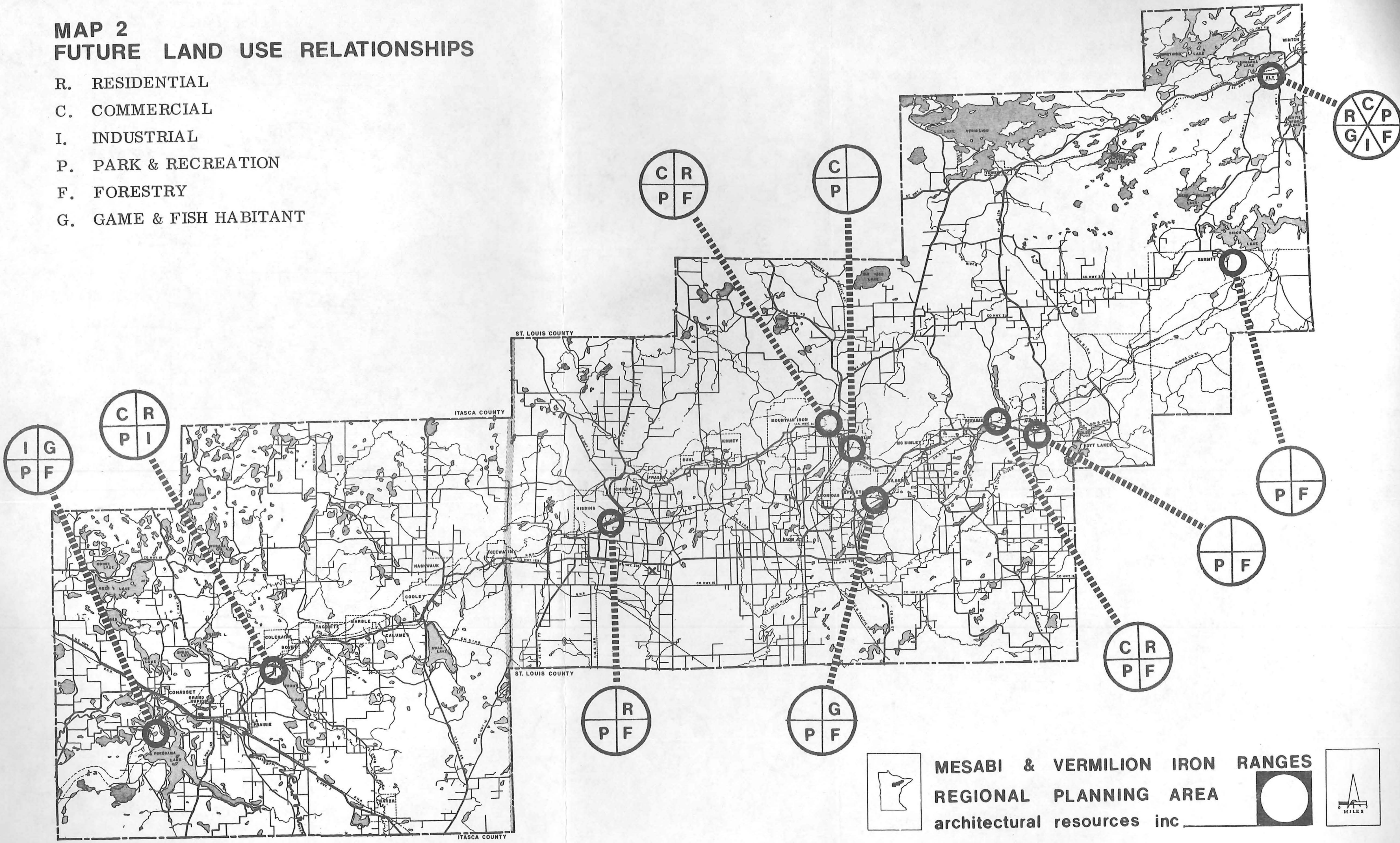
In addition to open pits and surface stockpiles, the following mining components are present:

L. LEAN ORE/SAVE ROCK
P. PLANT SITES WITH DERILICT STRUCTURES
T. TAILINGS POND
C. CAVED GROUND
A. ADDITIONAL MINING POTENTIAL



MAP 2
FUTURE LAND USE RELATIONSHIPS

R. RESIDENTIAL
C. COMMERCIAL
I. INDUSTRIAL
P. PARK & RECREATION
F. FORESTRY
G. GAME & FISH HABITANT



In order to gain a better perspective on how these no longer used mining sites might be able to be used in the future land use plans for Northern Minnesota, a second graphic aid follows:

Map 2 - "Future Land Use Relationships" is a generalized land use analysis indicating how existing mined-out areas might be reclaimed for non-mine-related uses. Although it will be the responsibility of local governments to establish future land use controls through zoning ordinance enforcement, the major land uses shown are considered by the consultant to be among those most suitable for currently inactive mined areas.* Of the ten selected sites, five have suitable lands for residential and commercial uses, three provide the requirements for certain types of industry, all have park and recreation potential, eight have the attributes for forestry and three could provide the requirements for certain types of industry, and three could provide possible habitat for game and fish.

In determining the future and use suggestions, a major criteria was the location of the particular segment. It can readily be seen that all mining sites were not included. A majority of these sites not shown have a potential for future mining activity and until a determination is made on their future, it would be impossible to suggest post mining land use potentials.

With relation to residential, commercial and industrial uses, the main criteria was the potential for these uses in any given area. They were selectec only in those areas where they could actually be needed because of anticipated community growth.

*The consultant has prepared the official land use plans and zoning ordinances for St. Louis and Itasca Counties, as well as ten communities and one township within the study region.

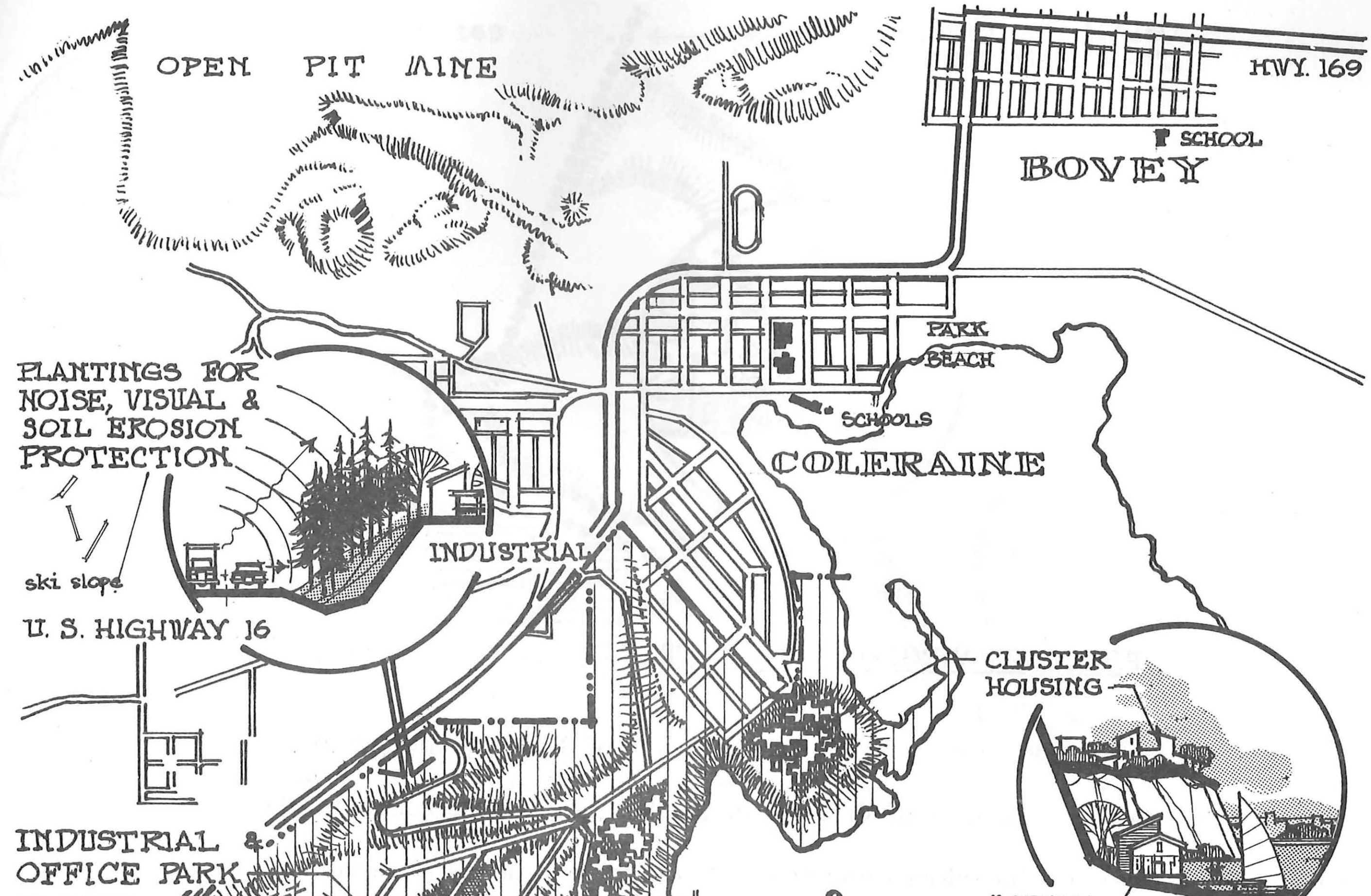
DEMONSTRATION UNITS

To illustrate possible ultimate reuse of minelands, three demonstrations or experimental projects are shown in map and sketch form for locations in the west, central and easternmost sections of the region. These demonstration projects have been developed by the consultant and it is felt that they could serve a useful purpose in the Minnesota State Mineland Reclamation project. The demonstration sites suggested contain environmental problems typical of other locations where mining activity has ceased. For a more detailed descrition of the proposals and existing conditions within each unit, see the January, 1972 Plan for the Reclamation of Mines (Metallic) Lands in the State of Minnesota.

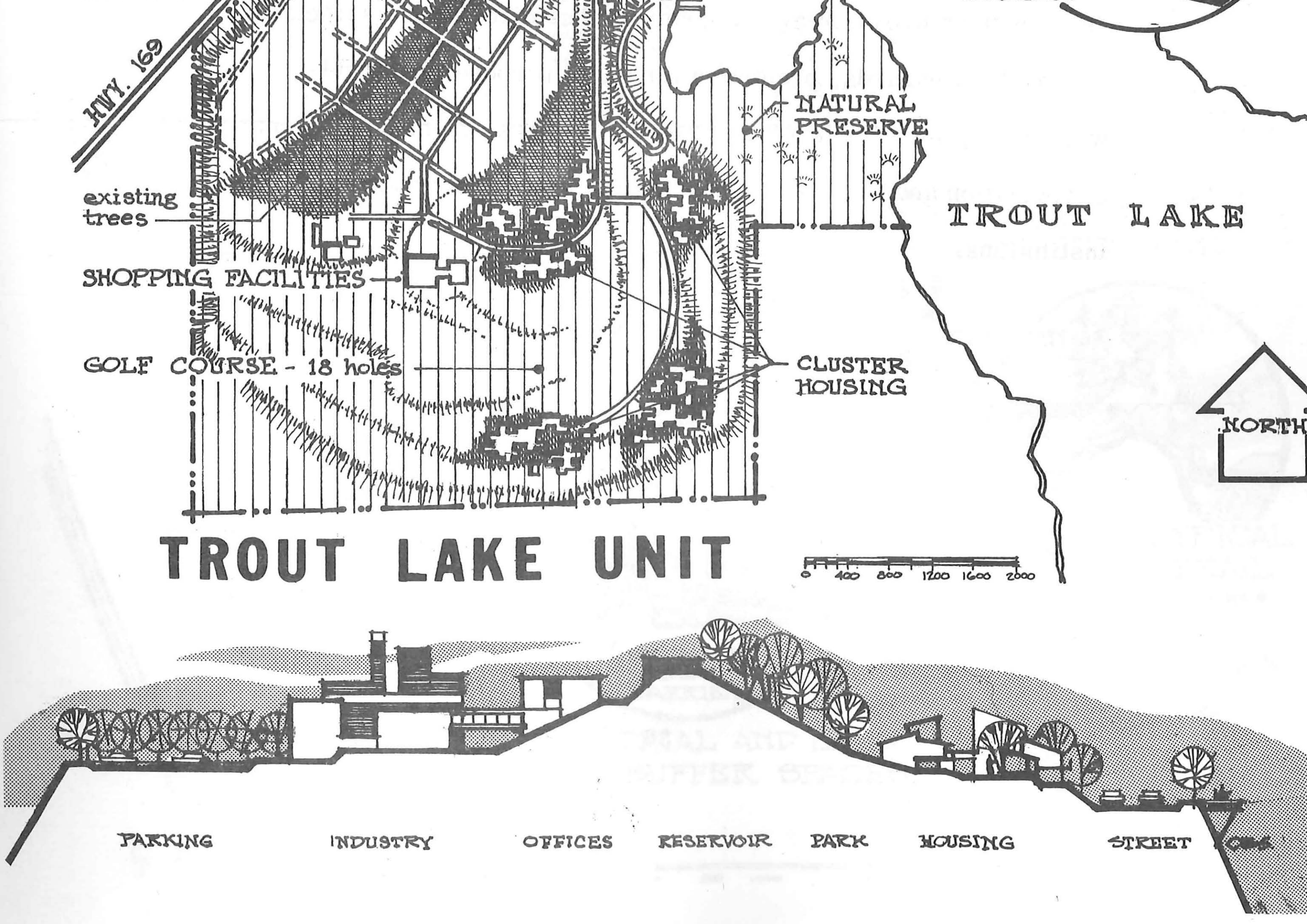
It should be noted that while these three demonstration units may seem rather complicated and expensive, their purpose is meant solely to suggest what potential there is for particular post-mining sites in Northern Minnesota. Prior to any construction of any portion of these suggestions, extensive engineering and architectural studies must be completed to guarantee their safety. It may be that portions of these units may not be economically or structurally feasible, however, the potential for wide and varied uses on the mining sites of the Iron Ranges of Minnesota should not be underestimated.

PROPOSED TROUT LAKE DEMONSTRATION UNIT

On the western shore of Trout Lake adjacent to the southern limits of the City of Coleraine is a large stockpile of surface overburden which was once used for a landing strip. This could be a model area for demonstrating how a planned unit development could be created from a mine dump. Amenities such as a golf course, marina and other recreation facilities would separate an industrial-office park from clusters of single family homes and apartments. Plantings on the slopes would reduce noise from nearby U.S. Highway 169.

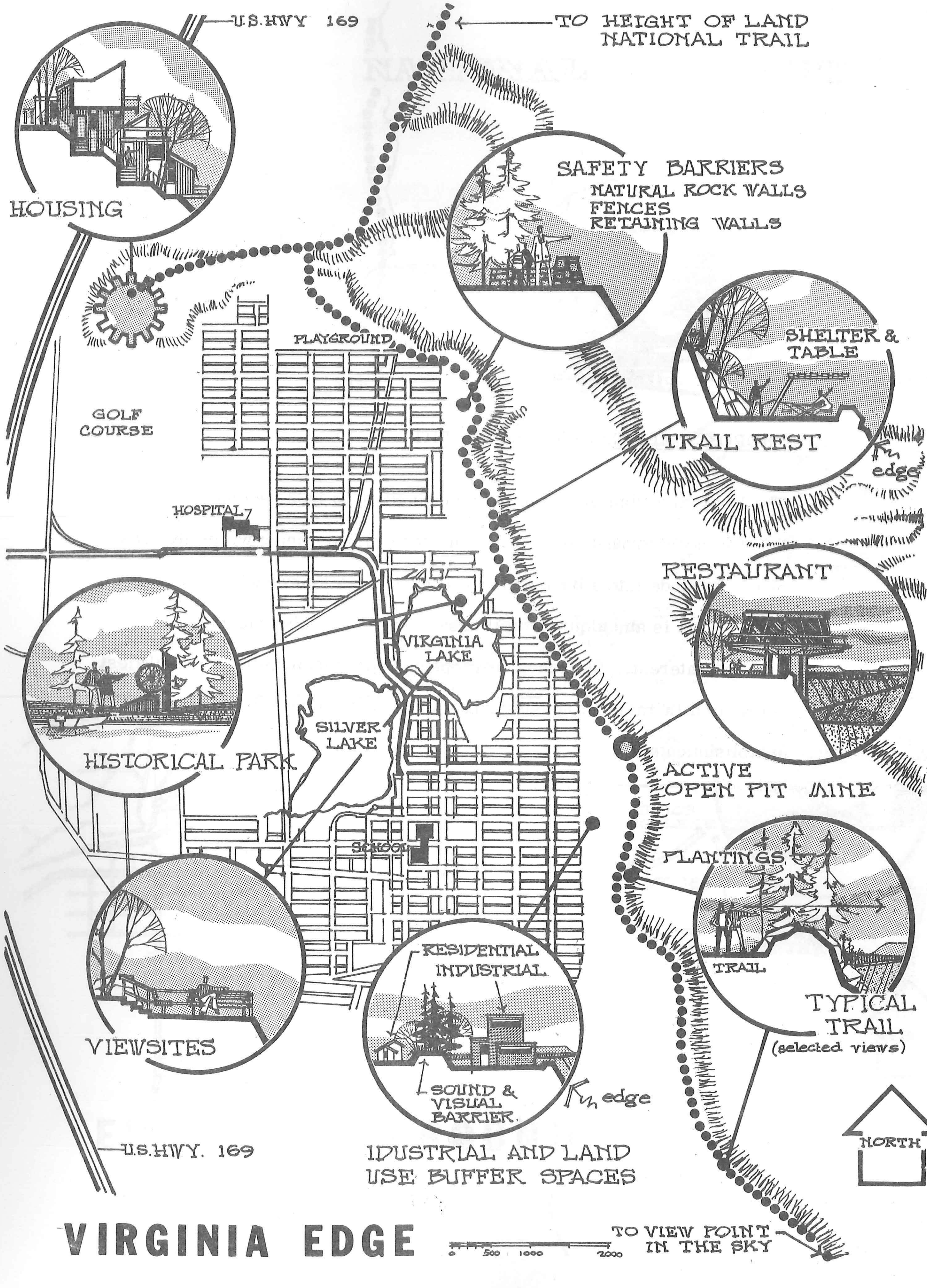


TROUT LAKE UNIT



PROPOSED VIRGINIA EDGE UNIT

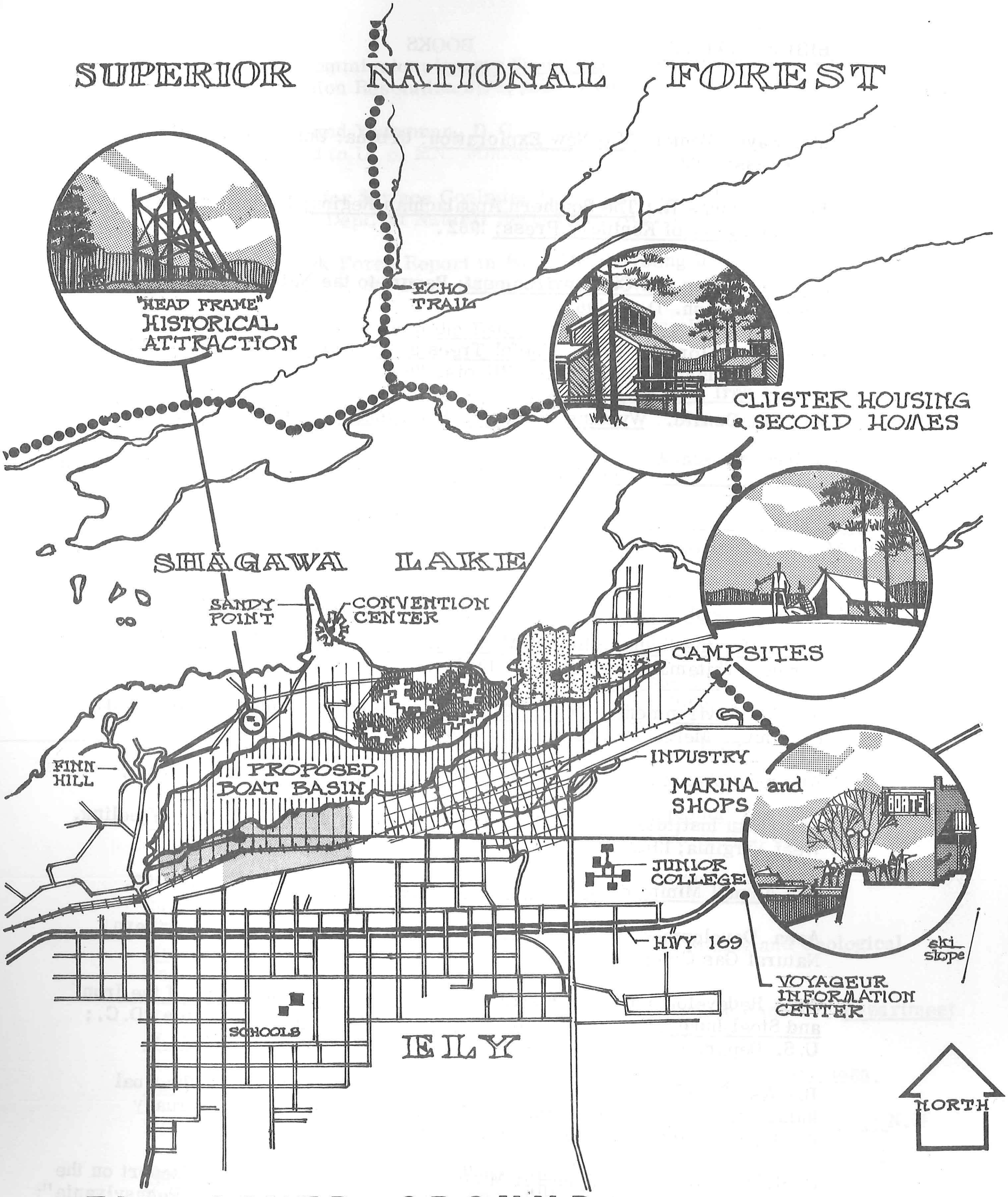
The redevelopment and rehabilitation of the north and eastern edge of the City of Virginia is an ideal place to demonstrate the various techniques and possibilities for use of the margin of a deep pit in an urban area. Experiments here include the screening of industrial hazards, promotion for multi-purpose trails and waysides, protective fencing and other barriers, re-establishment of vegetation and incorporation of visitor related facilities and institutions.



VIRGINIA EDGE

PROPOSED ELY CAVED GROUND UNIT

The Ely Guide Plan prepared by the consultant in 1962 recommended that the caved ground resulting from underground mining within the City of Ely be made into a boat basin by allowing water flowage from Shagawa Lake. This is an unique natural area with sites of historic and geologic interest. A planned development might include tourist facilities, recreation, a range of housing types and limited industry and research establishments.



ELY CAVED GROUND

BIBLIOGRAPHY

BOOKS

Mac Kaye, Benton; The New Exploration; Urbana; University of Illinois Press; 1962

Ford, Thomas R.; The Southern Appalachian Region; Lexington, Kentucky; University of Kentucky Press; 1962.

Surface Mining and Our Environment; Report to the Nation, U.S. Dept. of the Interior, Wash. D.C. 1967.

Robinson, Florence Bell. Useful Trees and Shrubs. Card file of 500 hardy woody plants. Champaign, Illinois, 1948.

Wyman, Donald. Wymans Gardening Encyclopedia, New York, 1972

_______________, Shrubs and Vines for American Gardens, New York, 1961

_______________, Trees for American Gardens, New York, 1959.

RESEARCH PAPERS

A Plan for the Reclamation of Mined Lands in the State of Minn., Aguar, Jyring, Whiteman, Moser, Jan. 1972.

AIME. Environmental Quality Conference, Preprint Volume, Am. Inst. of Mining, Met., and Pet. Eng., June 1971.

American Aggregate Corporation; Project Parkland; Greenville, Ohio;

American Institute of Park Executives; The Crisis in Open Land; Wheeling, West Virginia; 1959.

31st Annual Mining Symposium; Misc. Notes and Abstracts; Jan. 1970.

Area Development Department; Iron Ore; Omaha, Nebraska; Northern Natural Gas Company; 1961.

Area Redevelopment Administration; Pertinent Characteristics of the Iron and Steel Industry as Related to Area Redevelopment; Washington, D.C.; U.S. Department of Commerce; 1964.

Brooks, David B.; "The Impact of Surface Mine Population on the Coal Industry: The Case of Kentucky", AIME Proceedings from February 16-20, 1969; annual meeting at Washington, D. C.

Central Pennsylvania Open Pit Mining Association; "Progress Report on the Reclamation and Represtation of Strip Mined Areas, in Central Pennsylvania"; Phillipsberg, Pennsylvania: 1959.

County Planning Commission; Quarry Standards; Santa Clara, California; Planning Commission Resolution 6178; passed 1961

Dickinson, S.K., and Youngman, D.G.; "Taconite Tailing Basin Reclamation", Abstract presented to U. of MN. Mining Symposium, Jan., 1971.

Guidelines Manual for Surface Coalmine Operators, Land Reclamation Committee, State of Maryland, Dept. of Natural Resources, Aug. 1973.

"Inter-Agency Task Force Report in Base Metal Mining Impacts," Minn. Dept. of Natural Resources, St. Paul, Minn., Jan. 1973.

Introduction of Tree Cover in the Estevan Spoil Banks, Holland, C.M., Interim Report, Dec. 1972.

Iron Mining Industry of Minnesota; Facts about Minnesota Iron Mining; Virginia, Minnesota; 1958.

Johannes, C.A.; "Iron Ore Mining and Processing Waste Disposal"; Minneapolis, Minnesota; Department of Health; 1956

Johnson, Craig; Practical Operating Procedures for Progressive of Sand and Gravel Sites; Silver Spring, Maryland; National Sand and Gravel Association and University of Illinois; 1965.

Land Use Planning Legislation, State Requirement and Response, Western States Water Council, Salt Lake City, Utah, Aug. 1973.

Layton, Layton and Associates; Environmental Proposal for Reclamation at South Works, U.S. Steel Corp.; Chicago, Illinois; 1968.

Legal Problems of Coal Mine Reclamation, University of Maryland School of Law, March 1972.

Mineral Resources, Supply, Availability and Environmental Effects. Edwards, J., Weaver, K.N., State of Maryland, Dept. of Natural Resources, 1971.

"Minesite, an Environmental Plan". Brice, W.C., Minnesota Dept. of Natural Resources, St. Paul, Minn., Jan. 1974.

Mining and Ecology in the Arid Environment, Dept. of Mining and Geological Engineering, University of Arizona, March 1970.

Murray, D.R., "Vegetation of Mine Waste Embankments in Canada", Department of Energy Mines and Resources, Ottawa, Canada, Jan. 1973.

National Coal Association; New Vistas for Mined Land; Wash. D.C.; 1969.

NEMDA; Taconite and Northeastern Minnesota, The Present -The Future: N.D,

Nonfuel Mineral Resources and the Public Lands, Vol. 111, Minerals and the Environment, University of Arizona, July 1969.

"Possible Environmental Impact of Base Metal Mining in Minnesota," Birce, W.C., Minn. Dept. of Natural Resources, St. Paul, Minn., June, 1972.

Public Land Law Conference, University of Idaho, Moscow, Idaho, Oct. 1966.

Reclaiming Strip-Mined Land by Establishing Game Management Areas. Gwynn, T.A., progress report, Knife River Coal Mining Company, Bismark, N.D., July 1966.

Rehabilitation of Drastically Disturbed Surface Mined Lands, Georgia Surface Mined Land Use Board, Nov. 1971.

Reserve Mining Co.; "A Respect for Nature...A Response to Need"; Silver Bay, Minnesota, 1969.

Schellie, K.L. and Rogier, David A.; Site Utilization and Rehabilitation Practices for Sand and Gravel Operations; Indianapolis.

Schellie Associates (for National Sand and Gravel Association); 1964.

State of Wisconsin; Taconite and the Landscape 2; Wisconsin Department of Resource Development; 1963.

Surface-Mined Land Conservation and Reclamation, annual report, Dept. of Mines and Minerals, Springfield, Illinois, 1972.

United Nations; Economic Aspects of Iron Ore Preparation; Geneva; 1966.

U.S. Department of the Interior; Study of Strip and Surface Mininging Appalachia; Washington, D.C.; 1966.

U.S. Department of the Interior; Surface Mining and our Environment; Washington, D.C.; 1967.

University of Minnesota; Proceedings of 28th Annual Mining Symposium; January 16-18, 1967.

Walton, William C. (compiler); "Summary of Information on Federal Agencies and Responsibilities, Water and Related Land Resources Field in Minnesota"; U. of M. Water Resources Research Center, Information Circular #99. (1969).

PERIODICALS

Anonymous, "Reclamation, Restoring Beauty and Balance," Mining Congress Journal, Feb. 1972, reprinted from U.S. Steel News, Nov. 1971.

Anonymous, "Roaming the Range", Living in Minnesota; N.D.

Anonymous, "Tailings and Other Failings", Audabon, May, 1973.

Brooks, David B.; Letter for the "Mesabi Iron Pits", Landscape Architecture; p. p. 194-197; April 1969.

Brooks, David B.; "Strip Mining Reclamation and the Public Interest," American Forests; March, 1966.

Camphell, D.K., "Open Pit Mining in 1972, a year of consolodation", Mining Congress Journal, Feb. 1973.

Dickinson, S.K.; "Experiments in Propagating Plant Cover at Tailing Basins", Mining Congress Journal, Oct. 1972.

Flawn, Peter T. "Geology and Urban Development," Baylon Geological Studies; Spring 1965.

"Guidelines to Successful Reclamation", Stearn, E.W., Rock Products, June, 1971.

"J. & L. Planting Program to Control Sand at Benson Mine", Skillings Mining Review; Feb. 7, 1970.

Lane, Richard D.; Forest Service Reclamation Research, (reprint from Mining Congress Journals); May, 1968.

Leiaman, Gilbert; A Vegetation and Soil Chronosequence on the Mesabi Spoil Banks; Emporia; Kansas State Teachers College; 1957. (Reprint from Ecological Monographs 27: 221-245.

Merritt, Paul C.; "Mesabi Enters a New Era", Mining Engineering; October, 1965.

Michaelson, C.D.; "Joint Mining Ventures Abroad: New Concepts for a New Era", Mining Engineering; April 1969; p.p. 73-78.

Mined-Land Conservation Conference; "Mined-Land Conservation" (Series of newsletters, most of 1965 issues).

"Mined Land Reclamation and Public Relations", Laird, A.M., Canadian Mining and Metallurigical Journal, Oct., 1973.

Mink, L.L., Wallace, A.T., Williams, R.E., "Impact of a Well Managed Tailings Pond System on a Stream", Mining Congress Journal, Oct., 1971.

"On Reclaimed Soil Bank, Timber," Jones, W.G., Coal Age, Nov., 1971.

"Ontario Firm Combines Public Relations and Restoration". Toles, G.E., Rock Products, May 1972.

Peplow, E.H., "Western Mining's Land Restoration Efforts," Mining Congress Journal, Sept., 1970.

Peteau, D.R., "Engineering Geology Considerations and Approach in Assessing the Stability of Rock Slopes," Canadian Mining and Metallurgical Bulletin, May, 1972.

"Professional Image in the Environmental Age", Barton, W.R., Mining Engineering, March, 1972.

"Reclamation, Restoring Beauty and Balance", Mining Congress, Feb., 1972.

"Reclamation, Restoring Beauty and Balance is U.S. Steel's Goal", Coal Age, Oct., 1973.

Reiss, I.H., "Land Reclamation Can Even be Profitable", Mining Congress Journal, Dec., 1971.

Reiss, I.H., "Strip Mine Reclamation", Mining Congress Journal, April 1973.

"Re-seeding Program in Placer's Good Housekeeping", Canadian Mining and Metallurgical Bulletin, May, 1972.

Riley, C.V., "Design Criteria of Mined Land Reclamation", Mining Engineering, March, 1973.

Rulli, J.F., "Reclamation at Big Horn Mine," Mining Congress Journal, June 1971.

"Soil Properties of Materials in Copper Mine Tailing Dikes", Ludeke, K.L., Mining Congress Journal, Aug., 1973.

Sullivan, G. Don; "Current Research Trends in Mined-Land Conservation and Utilization", Mining Engineering; March, 1967; p.p. 63-67.

Thirgood, J.V., "Rehabilitation of the Mining Environment in British Columbia", Canadian Mining and Metallurgical Bulletin, Aug., 1971.

Toland, G.C., "About Tailing Dams - Construction, Sealing and Stabilization", Mining Engineering, Dec., 1971.

U.S.B.M. Finds Many Ways to Stabilizing Mineral Wastes", Dean, K.C., Mining Engineering, Dec., 1971.

Zube, Ervin; "A New Technology for Taconite Badlands," Landscape Architecture; January 1966; p.p. 136-143.

NEWSPAPER ARTICLES

Anonymous; "Americas Environment is Deteriorating"; Minneapolis Tribune; Nov. 2, 1969.

Anonymous; " Congress Eyes Strip Mine Reclamation"; Duluth News Tribune; March 9, 1967.

Anonymous; "Consider Improvements of Mining Lands"; Grand Rapids Herald-Review; March 21, 1968.

Anonymous; "Economy and Environment"; Duluth News Tribune; October 23, 1969.

Anonymous; "Experimental Mine Dump Planting Shows Promise"; 1969

Anonymous; "Iron Range Trail Bill Recommended"; Duluth News Tribune; April 3, 1969.

Anonymous ; "Like the Last of the Mohicans"; East Range Journal; September 12, 1969.

Anonymous; "Tailings Basin Study Planned"; Hibbing Daily Tribune; July 19, 1968.

Anonymous; "The Future of Iron Mining in Itasca County"; Grand Rapids Herald-Review; No date given.

Anonymous; "Tree Planting Improves Tioga Mine Dumps"; Grand Rapids Herald; September 1, 1969.

Karlstrand, Elmer; "Measure Introduced for New Iron Range Trail"; Duluth News Tribune; February 27, 1969.

Lane, Roger; "Find New Life in Old Iron Mines"; Hibbing Daily; October 30, 1964.

Wright, C.E.; "Industry Miracle in Florida"; New York Times; March 5, 1967.

MISCELLANEOUS SOURCES

Davis, Dick, Mined Land Reclamation Makes New Life For Georgia Acres, Outdoors in Georgia, July 1973.

Erocon Limited, Erocon Makes It Green, Dan Mills, Ontario, 1970.

"Maps and Letter from Pittsburgh Pacific Company"; Cooley, MN; January 1, 1970. (from E.J. La Sart, Engineer to Jarle Leirfallom).

Minnesota Legislature; "An Act Relating to Mining; establishing an Iron Range Trail; granting the commissioner of conservation certain powers and duties in regard to mineland reclamation; providing penalties; appropriating money." H.F. 1207, Chapter 774; 1969, revised 1971, 1973.

Peplow, Edward H. Jr., Western Mining's Land Restoration Efforts, Mining Congress Journal, Setpember 1970.

Rossman, George; "Presentation to the Legislative Committee on Taxation of Iron Ore"; February 16, 1961.

Tennessee Valley Authority, Strip Mine Reclamation After Five Years (one of a series of booklets), TVA Division of Forestry, Fisheries and Wildlife Development, Norris, Tennessee, 1969.

U.S. Department of the Interior, Study of Strip and Surface Mining in Appalachia-An Interim Report to the Appalachian Regional Commission, Government Printing Office, Washington, D.C., June 1966.

U.S. Steel; "Welcome to the Minnesota Iron Ore Country"; No date given.

University of Newcastle upon Tyne Research Team, Landscape Reclamation, Volumes 1 and 2, surrey, England, Vol. 1, 1971. Vol 2, 1972.

Woodruff, Seth D. Methods of Working Coal and Metal Mines (Three Volumes,) New York.