QUARRY REHABILITATION FOR A GOLF COURSE

A STUDY IN REHABILITATING A LIMESTONE QUARRY

FOR A GOLF COURSE DEVELOPMENT IN MANITOBA

38

BY

ROBERT MCDONNELL

A Practicum submitted to the Faculty of Graduate Studies of the University of Manitoba in partial fulfillment of the requirements of the degree of

MASTER OF LANDSCAPE ARCHITECTURE

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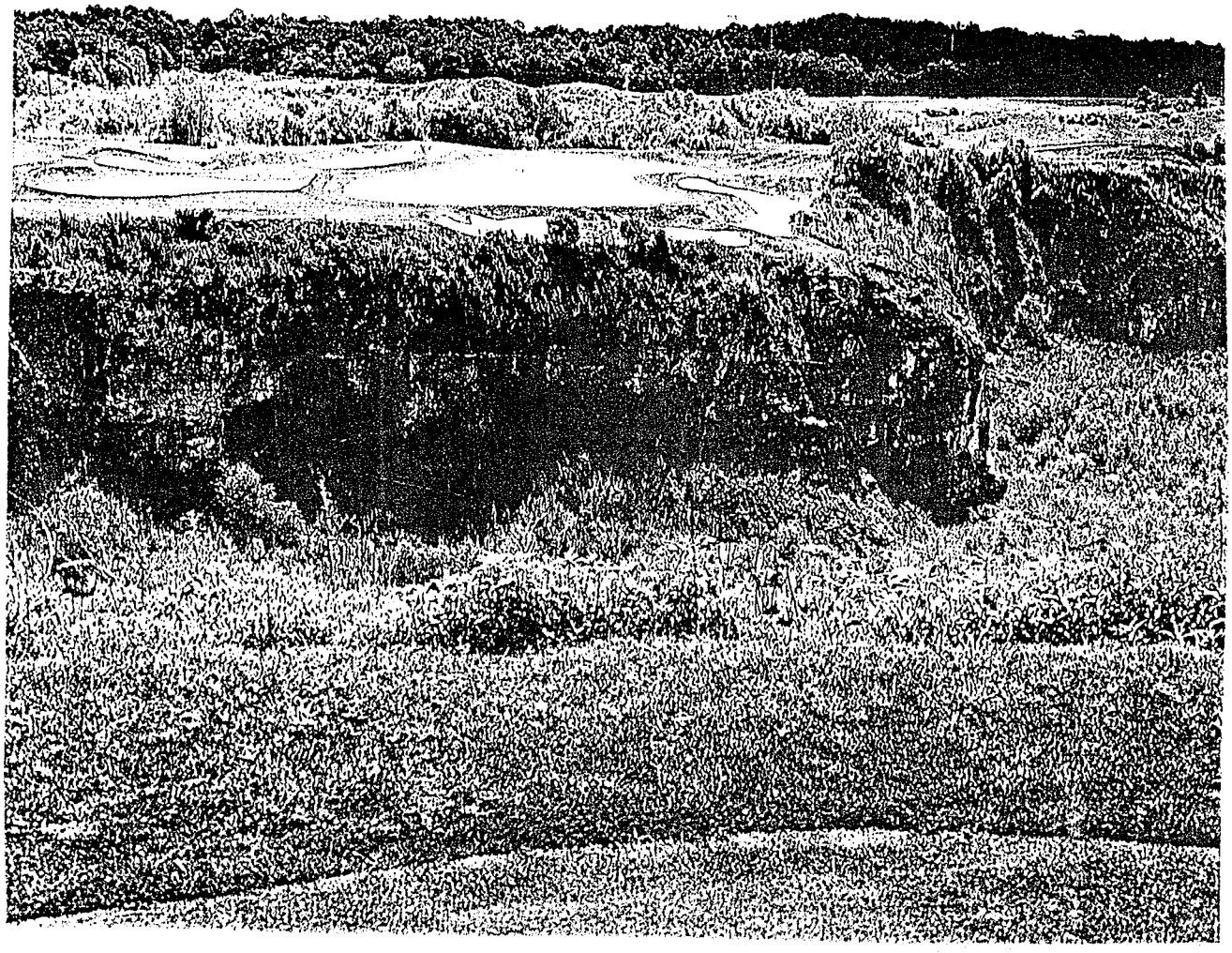
QUARRY REHABILITATION FOR A GOLF COURSE

A Study in Rehabilitating a Limestone Quarry for a Golf Course Development in Manitoba



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Abstract

Quarrying for limestone is an activity which provides essential materials for the construction industry of Manitoba. Since it is a high-bulk, low-value product, most mines are located within easy driving distance of their markets so that they may be economically viable. Consequently, the markets for these mines tend to be larger urban centres, like Winnipeg. Being close to these populations brings up social issues which sometimes put the quarries and residential areas at odds with one another. While the problems of dealing with an active mining operation are one set of issues, what to do with a quarry when it ceases to be profitable to its operators, is another concern. Looking at appropriate land uses for the quarries before they are depleted will help to assist the government agencies and quarry operators to progressively rehabilitate an operation from one land use to another.

Golf courses, paralleling limestone quarrying's situation, have their own set of development and operational issues which they must deal with. Increasing participation, heightened public and government environmental awareness, as well as higher land prices are forcing the course designers and developers to be more innovative in their approach to course design and construction. Only in this way will the game be kept at an affordable and accessible cost to the average player, without becoming an elitist sport.

This study explores the quarry rehabilitation process and how it can be integrated into the conversion of a site with an active local limestone quarry into an eighteen hole golf course. It concludes that the project could be successful in providing a unique facility which is both physically and environmentally sustainable for the developer and society at large. Design and technical information are provided as a data base for future rehabilitation activities.

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Finishing might have been impossible without all my family and friends supporting me through the trying times. Thank you all.

■ PART ONE: QUARRYING, GOLF & REHABILITATION

1.0 INTRODUCTION

1.1 PROJECT IDENTIFICATION

Prior to the start of this study, it was determined that the potential for a golf course development within a limestone quarry would be examined. The owners of a major aggregate supply in the province, expressed an interest in this type of development and a study of its practicality. After visiting several quarries, one near Stonewall, Manitoba, was chosen for the reasons that make a site suitable for a recreational after-use. The size and characteristics of the site, and market demands of the area determined if a golf course was a compatible land use for the location. The design, construction, and economics of a golf course development for a limestone quarry site has been the focus of this study. It employed a project management process outlined later.

1.2 PURPOSE

The purpose of this study is to provide the essential information from which to create a system or framework for the rehabilitative development of a site which includes a limestone quarry, into an eighteen hole golf course.

The study has been structured as follows: i) outline the issues concerning both industries in this situation ii) prepare a project management strategy addressing these issues iii) synthesize the two vastly different land uses into a single usable land form, providing technical information on how this may be accomplished.

1.3 OBJECTIVES

In the context of the stated purpose the objectives of this study are:

i) to provide a general background and overview of quarry reclamation\rehabilitation issues.
ii) to provide a background and overview of golf development issues.
iii) to provide a development and design strategy from which to approach the combination of the two uses within the framework of rehabilitation.
iv) to provide a potential solution resolving the issues addressed.
v) to determine the feasibility of such a development.

1.4 STUDY FORMAT

The study has been divided into five parts. **Part One** describes the intent and objectives of the study. It introduces the general issues in quarry rehabilitation and golf course development, including how the two can be merged. **Part Two** addresses specific project development criteria and the process for rehabilitating a limestone quarry into a golf course. **Part Three** illustrates a possible design solution which complies with the development criteria and process. **Part Four** concludes the study with any lessons learned described. **Part Five** supplies any technical data and appendices.

2.0 THE QUARRY SITUATION

2.1 AN OVERVIEW OF QUARRYING

Quarrying for rock is as old as civilization itself. Initially used as a source for building stone and agricultural lime, limestone has been worked for many thousands of years. The limestone rock mined in the Stonewall area was initially used for production of 'lime', which was trained to Winnipeg, and used for cement. Precluding limestone's use as a common aggregate material, sand and gravel deposits of the Birds Hill Region supplied most of the Winnipeg region's construction needs.

Extraction of limestone rock is limited by geological, social, and economic factors. The geological factors deal with the physical attributes of the rock itself. The economic considerations are transportation costs, and the cost of production, such as the costs of stripping off the overburden down to the rock, and comparing that expense to the return the quarried rock will provide. Since transportation costs are typically high, and aggregate is a high-bulk, low-value commodity, many of the quarries have traditionally been near urban centres where the majority of demand for the material is. Since sand and gravel deposits are diminishing, near-surface limestone deposits have become an attractive economic alternative.

2.2 QUARRYING OBSTACLES

Quarrying, while necessary to provide essential material for construction, also has obstacles facing it. As cities have expanded into the once-rural areas, there have been increasing conflicts between residents and the quarry operators. Other problems include residential development occurring near existing extraction points creating the "bad neighbour" syndrome.

> Opposition springs up now almost anywhere in Canada that major new projects are proposed...Since they are a heavy, bulky and, therefore, expensive material to transport, aggregates are usually mined close to urban areas. As cities expanded, pits and quarries

were developed further out. But now the industry is running out of places to go. The urban fringes are filling with housing and recreational lands, and environmentalists are demanding that the few spots left in their natural state be protected.

(Canadian Geographic, Jan/Feb 93, pp.79)

Sometimes potential quarry sites, and its resources, are even removed from consideration, or "sterilized", because of potential land-use conflicts and anticipated development fees and delays.

Within these different circumstances, the quarrying procedure can develop problems that are both social and environmental in nature.

2.2.1 Social Problems

Since the cost of transporting quarried stone over long distances increases its final price, the majority of the quarries are near larger urban areas where there is the possibility of social conflicts concerning homeowners and the quarry operations. They are:

i) truck traffic
ii) increased noise
iii) dust
iv) vibrations
v) the potential for unsightly site appearance after operation has ceased (many depleted quarries become unauthorized dumping grounds)
vi) physical danger (due to traffic and quarry edge conditions)
vii) potentially decreased property values of landholders on perimeter of quarry operations

(Sources: Coates\Paterson\Mulder)

These are problems that occur during the operation of the quarry. If the quarry is left in an unrehabilitated state, the physical danger of overly steep quarry walls remains, along with its generation of little, if any, revenue for the municipality it is located in.

2.2.2 Environmental Implications

Pits and quarries usually require the removal of vegetative cover and topsoil, along with the construction of processing, loading, and service areas. These activities in combination with the development of access roads, result in severe disturbances of soils, landforms, vegetation, and may also include:

i) loss of topsoil due to further erosion
ii) a change in quality and quantity of surface and subsurface water
iii) siltation of aquatic habitat
iv) contamination of soil and water through oil or gas spills

v) soil salinization
vi) alteration of any flood plains
vii) visually altering 'pristine' land

All of these potential effects highlight the need for remediation during active quarrying. This will assist in any rehabilitation for a quarry that will become depleted and vacant, or developed into another land-use.

2.3 OPPORTUNITIES THROUGH QUARRY REHABILITATION

2.3.1 REHABILITATION AND RECLAMATION

The popular understanding of reclamation, according to W.E. Coates, president of Coates and Associates, a landscape architectural firm in Guelph Ontario, which specializes in quarry reclamation projects, "probably includes remedial grading or earthworks along with rudimentary planting along property lines of a quarry that has been previously depleted and sits as an open pit. He goes on further to say,

> If the extraction operation changes from a "dig-now-and-worry-later" approach to one of planned extraction and simultaneous development for an acceptable after-use, the need for reclamation disappears. Instead of the rape-the-land approach, the operation becomes one of optimum land and resource utilization through comprehensive planning that allows extraction of mineral resources.
>
> (Coates, May 29, 1974)

An Ontario Ministry of Natural Resources study goes further and differentiates between reclamation and rehabilitation:

> Derelict land parcels are potentially capable of providing for numerous uses, all valuable to the community...rehabilitation is the treatment of land to develop and improve it into a beneficial form...both the physical appearance of the land use have been changed to an acceptable condition...reclamation is only partial rehabilitation...total rehabilitation requires an acceptable change in both the physical appearance and the first use of the pit...(reclamation) can be viewed as a first step to eventual rehabilitation.
>
> (Land Reclamation: A Fresh Look, 1984)

Within the framework of rehabilitation, the details and procedures for the quarry operation would remain the same. The simultaneous extraction and rehabilitative

process would produce a continually redeveloped site which is physically, functionally, and aesthetically acceptable.

The reality of the situation, however, is that even 20 years after Coates' statements, the industry is just now slowly changing to reflect this idealistic formula for quarrying and rehabilitation. Even today most quarries already in operation do not have rehabilitation plans in place, including the site being studied. Progressive Rehabilitation Planning would provide different advantages to the operations, some of which are:

i) using manpower and machinery more effectively.
ii) reducing unnecessary overburden movement. (according to Barry Mulder of Mulder Construction, " management of overburden is one of, if not, the biggest problem of quarry operators today" [March 21, 1995]).
iii) having completed most of the rehabilitation before the quarry becomes depleted minimizes cash outlays needed to bring the quarry and the land it is on back to saleable condition.

(Sources: Paterson\Land Rehabilitation\Mulder)

Problems still remain in how the practical reality of day-to-day operations merge with the concept of long term rehabilitation. For example, a short term plan (Five year) of material movement for a quarry may be established based on projected sales figures. However, if for whatever reason the sales increase dramatically, the quarry will attempt to meet this demand. The operations timeline could be dramatically shortened and may result in less care being taken in the movement and placement of the soil and overburden. If the quarry has no plan in place, the amount of time for planning an end use also decreases, often to the point where planning occurs near the end of the quarry's operation. This in fact is the situation in the case being studied.

Whatever the situation, the distinction between the terms being established is the difference between traditional reclamation as an after-use when quarrying is complete, and rehabilitation as a simultaneous extraction procedure integral to part of a designed process considering the whole life of the quarry.

2.3.2 OBJECTIVES OF REHABILITATION

By the nature of the land-use to be developed in a quarry, the form and extent of the rehabilitation would be set by the operator or developer. Once a plan or end use is determined any desired goals may be pursued.

The objectives of rehabilitation, therefore, are hard to establish in a strict sense. Variations in sites and goals play a part in this, as well as the difference between optimum conditions, and the goals of the owner. In the optimal sense the objectives can be discussed in a qualitative manner as follows:

i) Creating and leaving a system capable of supporting a relatively complex ecosystem.
ii) Selecting and implementing a suitable after-use with some social and economic

value.

iii) Leaving the quarry with an appearance which is not in obvious and undesirable contrast to adjoining lands.

The owner of the quarry, however, may not necessarily be concerned with ecosystems, or land aesthetics but more probably in:

i) returning the quarry to minimum standards set out by provincial guidelines.
ii) evaluating the site as an investment source, with the possibility of receiving a return on their investment over a period of time.

The obvious challenge is merging the two sets of goals to develop something which is mutually beneficial to the developer and the public at large.

(Sources: Coates\Paterson\Land Rehabilitation\Mulder)

2.3.3 AFTER-USE BENEFITS

The potential benefits from a quarry operation are considerable. From a topographical viewpoint, it creates instant terrain relief, which can create a unique situation for the prairie region. To accomplish this amount of land moving at such a large scale would normally be cost prohibitive.

Generally, being close to larger urban centres also makes them an ideal source of unique lands for potential development. If the sites are rehabilitated and developed as recreational uses, the urban populations should be considered as potential clients or users. Also, if the quarry is rehabilitated as a residential area, the new community is within commuting distance of a large job market. The quarries distinctive physical characteristics, likely enhanced through any new development may also offer a unique experience probably not found in the city limits.

The rehabilitation of the quarried land may also provide an opportunity for economic gain. Rehabilitating the quarry actually provides the owner with the greatest return potential on their initial investment, as indicated in Diagram One. According to Hittman Associates, a Lexington, Ky. planning firm, "...a well formed reclamation and pollution control plan ensures the greatest degree of success at the lowest possible cost" (Land Rehabilitation: A Fresh Look, 1984). In this way, through developing an effective end-use, the sustainability of the quarrying process is realized. The operator of the quarry may be presented with a number of land use opportunities for the land, and each would have to be studied for their potential in a rehabilitation process.

This is especially important when considering the real situations of cost effectiveness. For example, if a quarry is still in operation, the costs of moving overburden, or blasting and shaping are considerably less to the operators, simply because they still have active personnel and machinery within the area to do the work. According to the Hittman document, and echoing an earlier quote by Barry Mulder, "material handling is the most expensive part of rehabilitation" (Ibid, 1984).

Item	Policy 1	Policy 2	Policy 3	Policy 4
Description	Traditional extract and abandon approach	Client's intent based on esthetic values and continuation of current operation	Variation of Policy 2 by adding 8 acres of saleable real estate	Optimum financial return
Disposition of Remaining Resources	Sell all reserves-sand, gravel and fill material* 532,00 cu yd	Sell 239,000 cu yd sand and gravel* retain balance of sand and gravel and fill material for rehabilitation	Sell 311,000 cu yd sand and gravel* retain balance of sand and gravel and fill material for rehabilitation	Sell 311,000 cu yd sand and gravel as fast as possible retain balance of sand and gravel and fill material for rehabilitation
Term of Operation	19 years	14 years	18 Years	1 Year
Rehabilitation	None	Subdivision with 8 acre lake (Design Alts. No. 1-4)	Subdivision without lake	Subdivision without lake
Present Value of Land and Resources**	$631,600	$941,700	$975,100	$995,400

DIAGRAM ONE: Management Alternatives for a hypothetical quarry (Source:Land Rehabilitation: A Fresh Look, 1984)

2.3.4 AFTER-USE OPPORTUNITIES

Before a quarry can meet any desired rehabilitation definitions or criteria, a general list of potential after-use, ideally, should be determined prior to the planning procedure. This will only be practical for quarries with a short (10 yrs.) lifespan. In many cases the quarry will be operating for 20 - 30 years. With such a long time frame, it is almost impossible to predict what the surrounding conditions will be like, or what the economic climate will be. If development is the goal, an end use, realistically, may not be determined until well into the quarrying process. This is when a suitable undertaking will probably be considered.

Some potential after-uses for quarry development include:

1. Agriculture
2. Forestry
3. Recreation
4. Education
5. Aquaculture
6. Housing
7. Commerce

8. Industry
9. Conservation
10. Waste Disposal

Form, size, and location will be interrelated with successful uses for specific purposes. For example, a campsite location will not work away from tourist routes, just as a fish farm would not be viable in a shallow, sterile hole left from quarrying. Practical or suitable after-uses must be identified as soon as possible in the quarrying process. In this way, specific, viable, uses can be considered within a category to "custom fit" the development to the rehabilitation process.

Many of the alternatives can be accommodated in a common physical form, but many others require specific characteristics. An example would be any urban housing development which would require consideration for water quality, safety (ie. quarry wall slopes and condition), maintaining positive drainage and vehicular access. Differing, recreation uses, again, would require even more specialized characteristics.

Using this study, the owners may explore the potential of developing an eighteen hole golf course on the site, which includes the limestone quarry. The first item that would need to be determined is if the project could be plausible from a simple physical standpoint. For example: would it fit onto the site, and would it be constructable are the two questions that must first be addressed. Secondly, it would have to be determined if the project was going to feasible financially. Start- up-costs (compared with other similar developments in Manitoba) would have to be weighed against maintenance costs and potential earning power. In order to determine if the site would be compatible with a golf course development, issues concerning the game as well as its physical requirements, would have to be addressed.

3.0 GOLF DEVELOPMENT ISSUES

In the case of golf course developments,the majority of concerns or issues are environmental. The large size of the sites involved warrants that these concerns be raised and addressed. Every proposed golf course will present an unique case because existing conditions vary from one area to another, with no two sites the same.

However, as with any other projects, there are general issues that are most often encountered with any proposed golf course development. There are issues and questions that must be addressed during the planning, design, and construction process. They are:

- Does a golf course development eliminate any green space by making use of a site which is currently undeveloped ?
- Will the proposed course alter any environmentally sensitive areas that may exist on or near the site ?
- Are there significant historic or archaeological areas on the site that may be affected by the golf course ?
- What impact will the new course have on the existing ecological systems, such

as the flora and fauna habitat ?

- How will the golf course affect the existing character of the site through the alteration of topography and vegetation cover ?
- Is there any potential for water pollution during construction, or through any open source that may remain, and which leads directly to a water supply source ?
- Will the irrigation requirements of the course lead to the reduction or depletion of water supplies ?
- Will the long term application of any chemicals for turfgrass management cause water pollution from surface runoff, or infiltrate any water supplies ?

(Love, 1992, p.6)

To relate some of the general issues usually involved in course development to this particular study, it should be reiterated that this project would not in fact be eliminating any potential green spaces or altering any ecosystems. In fact this type of rehabilitation project takes potentially derelict land, enhances its character through a course design, and returns it to a more "environmentally friendly" use. Through planting within the quarry, the development would also attempt to enhance and create flora and fauna habitat, while incorporating an interesting historical artifact in a 1920's limestone kiln on its southern edge. The other general issues concerning water protection are addressed later in the study.

It is imperative that these issues relating specifically to golf course developments be identified and addressed in the early stages of the rehabilitation planning process of the project. Taking a progressive approach to any of these situations, should they arise will help in avoiding any costly delays in the development process, as well as avoiding any harmful impacts that a golf course development will present.

3.1 SPATIAL CRITERIA

The game of golf is unique among sports in that it does not use a standard playing field or court size. It has rough guidelines allowing course designers to utilize any characteristics of the land that is being developed into their designs.

According to the Handbook of Landscape Architectural Construction, approximate areas needed for a golf course development would be as indicated in Diagram Two:

The average range for an eighteen hole golf course (the industry standard) ranges from 110 - 180 acres, comprising large parcels of land to be developed. Also since it is an activity geared to the urban population, most courses lie within the urban hinterland, where any type of land use is thoroughly questioned and reviewed.

Type Course	Acres Required
Par 3 (Pitch & Putt) Total Par 27-9 holes	15-25
Par 3 (Pitch & Putt) Total Par 28-29 - 9 holes	45-60
18 - Regulation	110-180
18 hole - 6200-6500 yds.	110 min. 120 rolling 140-180
18 hole - Regulation	120-160
18 hole - Regulation	120-200
Par 3 (Pitch & Putt) FHA	20 min.
Par 3 (Pitch & Putt) NRPA	20-35
18 hole - Regulation, Colo.	150 min.
18 hole - Regulation, Wisconsin	
9 hole - FHA	45
9 hole - Tennessee State	75-90
9 hole - 3100-3400 yds.	50 min.
rolling	60
hilly	70
9 hole	70-90
9 hole - Executive	30-50

DIAGRAM TWO: (Handbook of Landscape Architectural Construction, 1976, p.460)

The site being studied is 160 acres large. So in general terms it meets the primary spatial criteria. Other factors, such as the shape of the site also will come into play. These factors, and others, are discussed in more detail later in the study, and also in Appendix A. However, for now, the basic conditions have been met, and a process can be initiated to examine how the two land-uses can be merged.

4.0 GOLF AND THE QUARRY

By analyzing characteristics of both quarrying and golf, and any common ground they might share, and opportunity to combine the two emerges. Quarrying is in the situation that, due to economic reasons, most of the aggregate producing facilities are located close to urban areas where they are often regarded as less than ideal neighbours. They also face a reputation for leaving mined out eyesores. Meanwhile the game of golf should, ideally, be seeking land within the urban fringe where it can draw upon the population base nearby. It also needs land which is compatible to its, basically, single land use strategy, and which would not be in conflict with other potential open space activities.

Both of these operations have concerns which seem to compliment each other: quarries looking for land uses after they have been, or before they are depleted; and golf looking for lands that won't be in demand for other activities and which may provide an "unique" experience or generate revenue through future surrounding developments (eg. Housing).

After reviewing several sites with the owners of the quarry, the one being studied

was selected for numerous reasons. From its close proximity to 2 mid-sized commuter centres (Stoney Mountain: population-1452, Stonewall: population-2997 [Government of Canada Census, 1991]: also listed as one of the fastest growing communities in Manitoba [Ibid]) and one major urban centre (Winnipeg: population-641,700 [City of Winnipeg, March 1995]), to good access from Provincial Highway Seven, and a proper amount of land, it was a logical choice to study. Other affirming factors were that there are no other courses (public or private) within approximately fifteen miles of the site, reducing any potential competition. South Interlake Golf and Country Club in Warren and Teulon Golf Club are the two closest facilities.

The following sections of this study will look at how these two land uses can be merged into a single use activity.

■ PART TWO: PROJECT DEVELOPMENT

5.0 PROJECT MANAGEMENT PROCESS

5.1 INTRODUCTION

With any type of project there must be a methodology, in place, or developed to assist in the management process. In quarry rehabilitation, this method should provide the direction for the planning, design and management of the venture from its conception to its realization, and beyond.

The project management process is seldom, if ever, linear, and may be broken down into components (Diagram Three) which can serve as reference points during the ongoing process. Ideally, the entire process and its stages could be incorporated into the quarrying process from start to finish. Preplanning would be the initial phase, defining the problems, and listing inventory before the quarrying process commences. Operations planning could then be incorporated to control initial development of the site and the continuing phases of the extraction process. Progressive Rehabilitation Planning, meanwhile, would take over from the Preplanning process while the extraction is occurring, and look at the ongoing operation with a final end use already determined. The Management Phase and Process refers to the ongoing control or direction that the quarry operation will receive from regular consultation. The Implementation and Post Project Management deals with construction of the project and the commitment to ensure the completed development achieves its goals.

Reality, however, has dictated that there are quarry operations which have already begun without this type of management process in place. This does not mean that it should be abandoned, but simply necessitates the deletion of some stages which do not fit into the existing scenario. For example, if the quarry operation had already commenced without any plan in place, a preliminary site development plan would be of no use.

5.2 PROJECT MANAGEMENT GUIDELINE

Diagram Three (Paterson, 1982, p.20) illustrates the Project Management Process: the phasing is shown on the top of the diagram, along with the components of the system and their occurrence along a timeline . This study will follow this framework, with revisions to the process. The Preplanning and Operations Planning Phases will be by-passed since they are inconsequential to this particular study. The other phases and components will be discussed briefly to identify their role in the development process.

6.0 REHABILITATION PLANNING

6.1 PURPOSE

This type of planning leads to the final land use, by examining and working with the quarrying process. It may be in the form of progressive rehabilitation planning, which is done simultaneously as the quarrying procedure begins and commences. Or it may begin further into the process.

The rehabilitation planning technique will be determined by the following:

1) character of the quarry operation - this determines phasing and timing of the rehabilitation process.
2) the goals of the rehabilitation - their extent and objectives.
3) the geology of the quarry landform - identifies the feasibility of different rehabilitation plans, as well as the techniques to carry them out.
4) operations equipment.

6.2 DATA INVENTORY

This is the gathering of all information to assist in the rehabilitation planning and development process. This information should take the site and surrounding areas as well as the quarry operation itself into consideration.

6.2.1 SITE DATA

Site data will pertain specifically to the quantitative aspects of the parcel of land being developed. It would include such things as:

i) Location
ii) Legal boundaries
iii) Easements and rights-of-way
iv) Size (area)
v) Access

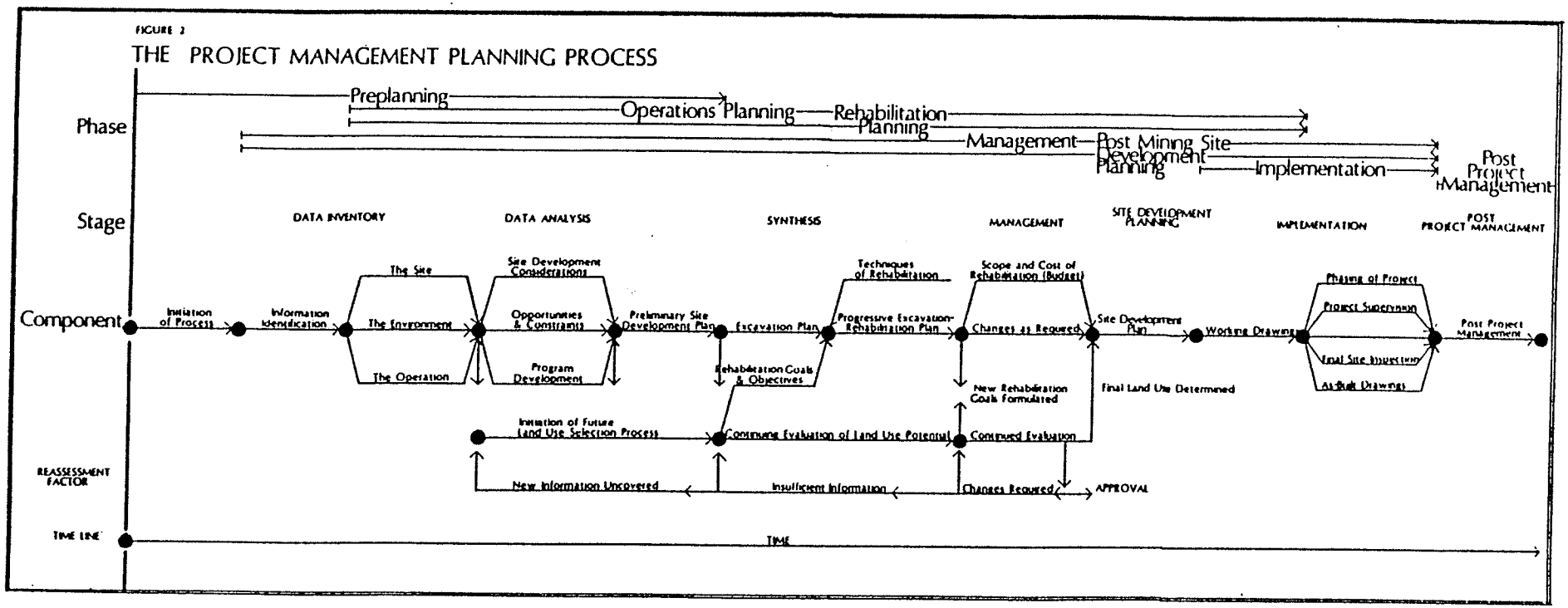


DIAGRAM THREE: Project Management Guideline

vi) Surface features & drainage
vii) Vegetation
viii) Soil type & makeup (depth, etc.)
ix) Depth to groundwater
x) Views to and from site

6.2.2 Surrounding Conditions

This information source requires gathering information concerning land uses surrounding the site to be developed. It should consider:
i) what type of land surrounds the site (ie.- is it all agricultural?)
ii) physical descriptions of the areas (eg. is it all heavy vegetative cover?)
iii) pertinent climatic data
iv) legislative controls that may affect development

6.2.3 Quarry Operations

This looks at the quarrying operation itself, and how its characteristics will affect rehabilitation. This information should include:
i) the method(s) of extraction
ii) the rate of extraction
iii) the extraction pattern
iv) any requirements for the processing equipment
(Sources - Baur, Paterson, Pit & Quarry Reclamation in Alberta)

6.3 DATA ANALYSIS

The Data Analysis Component is used to process the Data Inventory information and put it into a usable form by looking at the projected development, and any links between it and the operation, which is viewed as an ongoing system.

The analysis will take into consideration:
1) what is being developed and any special developmental considerations the site or projected use may require.
2) any opportunities or constraints the site and surrounding areas may present.
3) a program development scheme to assist in site planning.

6.3.1 Development Considerations

Every site has its own special development considerations. In progressive rehabilitation cases where the end use is not determined, general development considerations will be reviewed. This would include such things as the quality of the site and growing conditions in that particular quarry environment, any groundwater or

environmental concerns that may have been identified in the inventory stages, and possible technical responses for any of these environmental implications. The development considerations will also include any specialized concerns that any particular end use may demand. For example if residential or industrial developments are to occur, then the ability of the remaining terrain to support foundations will be a prime development consideration.

6.3.2 Opportunities and Constraints

Through the analysis of data collected in the inventory stage, a set of opportunities and constraints will emerge. As mentioned, every site is unique, so every one will have its own list. The extent and detail of the set will, again, as in the development considerations, depend on whether an after-use for the site has been determined or not.

The list or set will also be critical in developing operations and site development plans in the future.

6.3.3 Program Development

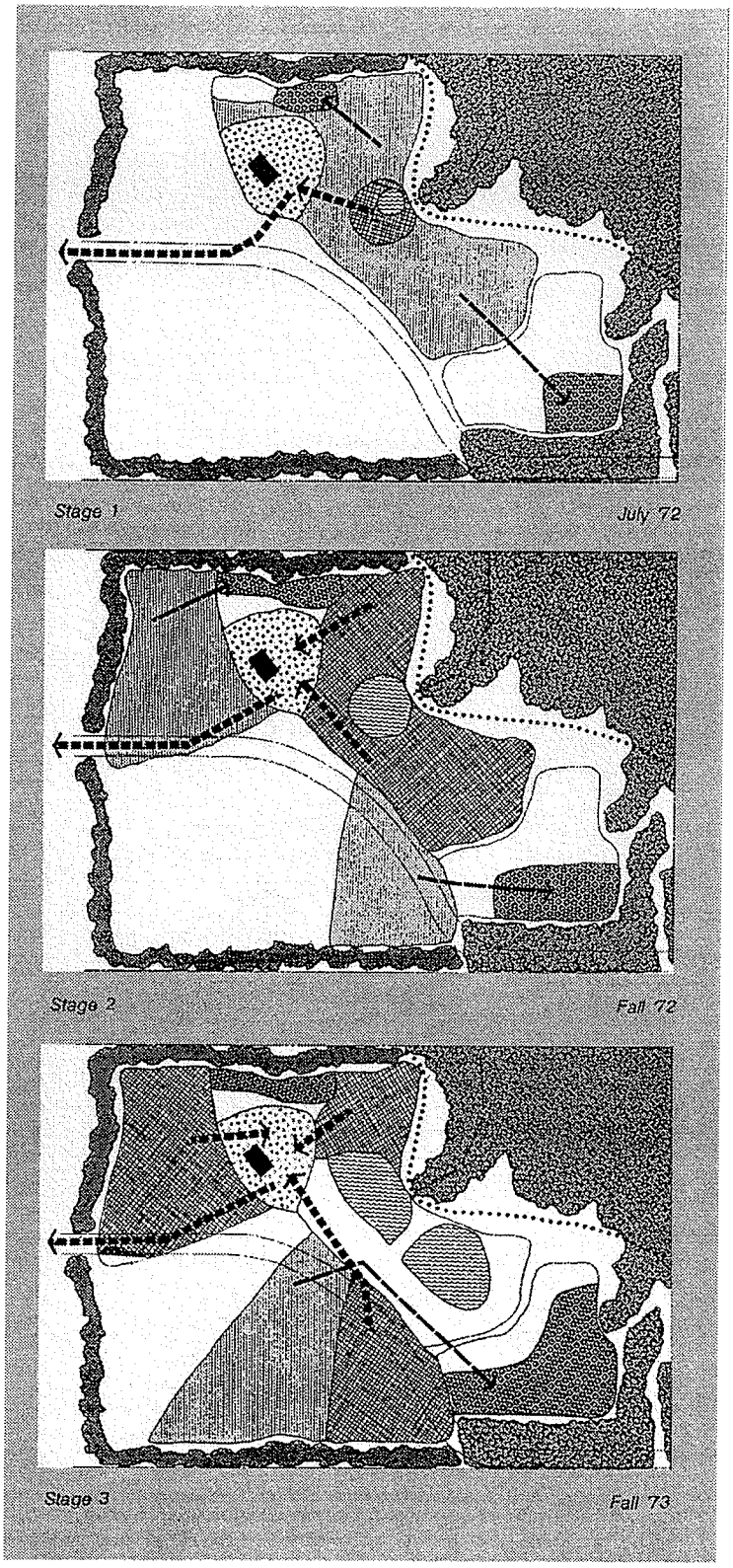
For any site development plan to be implemented, it must be designed in conjunction with a practical program developed for each quarry. The program development will look at how a quarrying process or operation will develop into a final land use. Therefore, it examines how the site can be planned to facilitate and work with these changes. It, for example, may look at the scheduling of the berming and stockpiling of the overburden, activity settings (what goes where and when it occurs), and activity linkages among other things. Diagram Four shows a generic site with a program development plan.

Although initial overburden movement is not an issue in this study, a program will be needed for such things as continuing blasting that will occur, and the replacement of overburden during the rehabilitation of the site.

7.0 CASE STUDY

7.1 MODIFYING THE MANAGEMENT GUIDELINE

Diagram Five illustrates how the Project Management Guideline was altered to accommodate the situation. In this particular case study, the quarry has already commenced operations, and with the profitable stone having almost all been quarried, the operation is slowing down and is nearly finished. Therefore, some phases of the guideline will be ignored, and the process shortened. For example, Operations Planning, which deals with the quarrying process, is not an issue, and the Preplanning Stage is greatly reduced, reflecting the situation.



LEGEND

- Property line
- Barn
- Existing trees
- Flow to Hanlon Creek
- Limit of watershed protection area
- Road R.O.W.
- Settling & clearing ponds
- Screen planting
- Plant area
- Stripping area
- Overburden movement
- Overburden stockpile area
- Extraction area
- Product movement
- Rehabilitated area

DIAGRAM FOUR: A rehabilitation sequence is diagrammed in plan form (Land Rehabilitation: A Fresh Look, 1984)

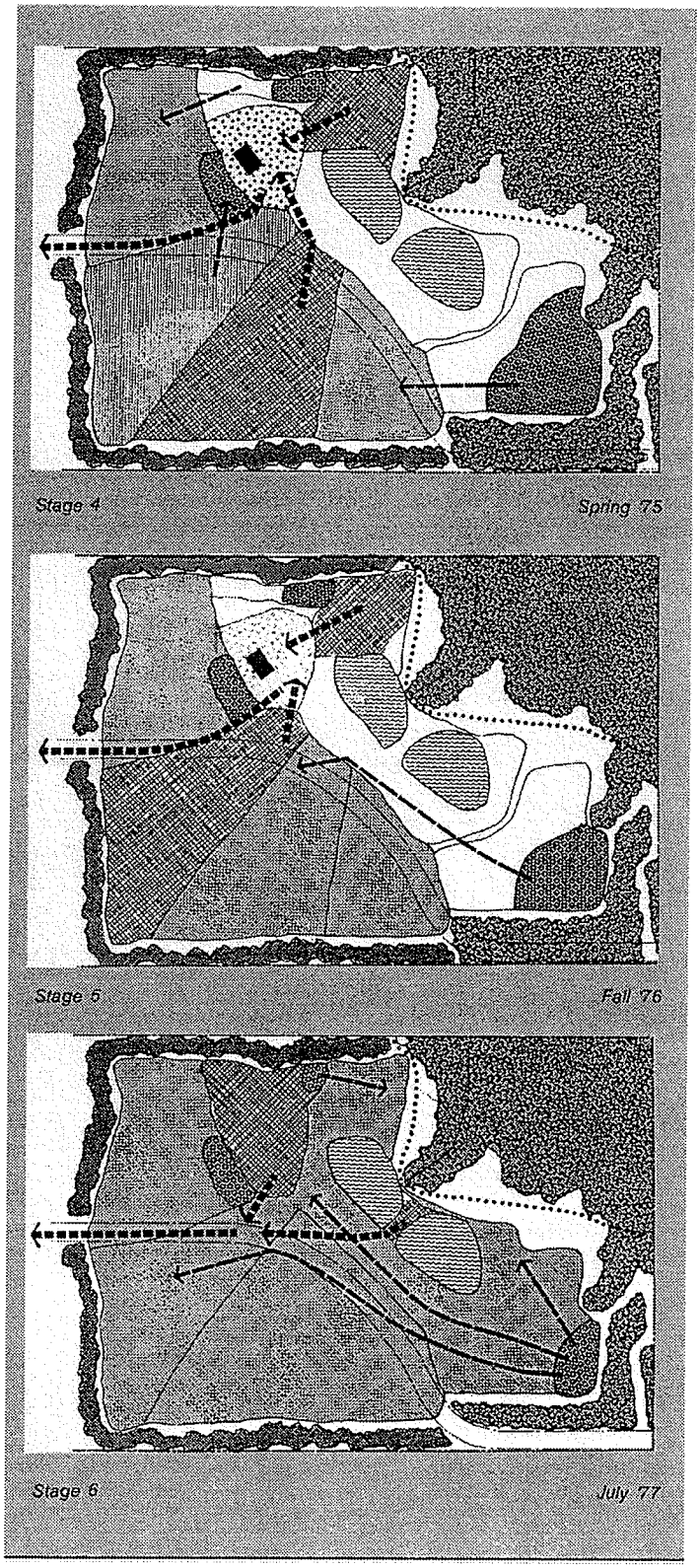


DIAGRAM FOUR: A rehabilitation sequence is diagrammed in plan form (Ibid)

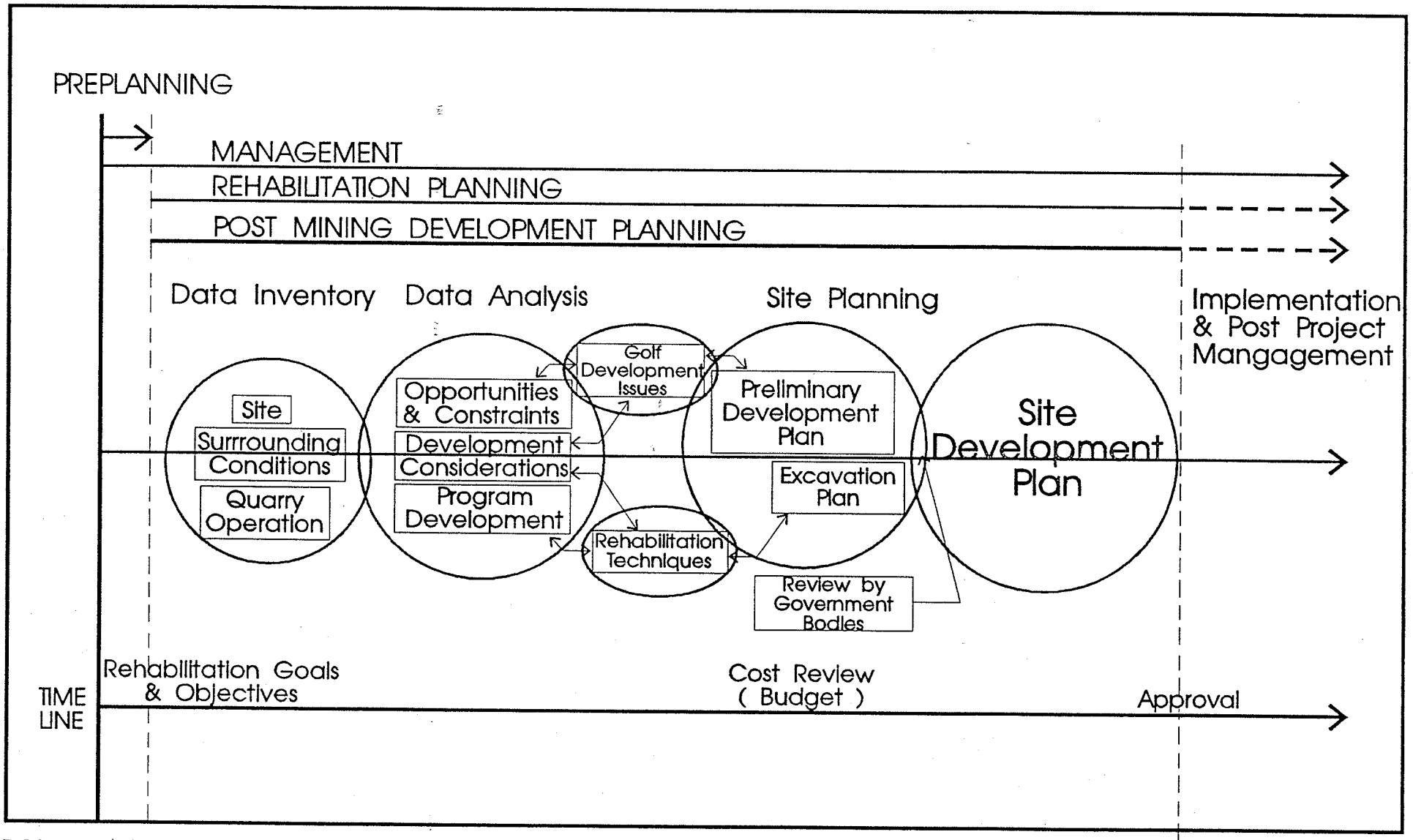


DIAGRAM FIVE: The Study's Project Management Planning Process

7.2 PREPLANNING

The Preplanning Stage consisted of identifying potential uses for the site with the potential site developers and (or) owner/operators (Mulder Mining) by considering general physical characteristics of the site, and socio-economic characteristics of the region. With a golf course being the desired development for the quarry owners, the discussions revolved around the possibilities and implications of that type of project. The preplanning also identified and acknowledged the timeline and amount of processing left within the quarry, which at that time (Autumn 1993), was approximately two to three years, depending on demand for crushed stone.

In this case, the preplanning is a springboard from which to begin addressing the particular characteristics and implications of a site with a nearly depleted, but still active, limestone quarry on it.

7.3 CASE INVENTORY

7.3.1 Site Data

From heading 6.2.1, a list for site data information was as follows:

i) Location
ii) Legal boundaries
iii) Easements and right-of-ways
iv) Size
v) Access
vi) Surface features & drainage
vii) Vegetation
viii) Soil type & makeup
ix) Depth to groundwater
x) Views to and from site

The site being studied is approximately 3 miles east of Stonewall, and 3 miles north of Stoney Mountain, Manitoba, adjacent Provincial Highway 7. Legal description of the land places it in Range 2-East Township 14 and the Southeast 160 acres of Section 4. It is 160 acres (394 hectares) in size, with a makeup of approximately 55 - 60 % open quarry, and the remaining land covered with aspen parkland type vegetation (ie: poplar / oak mix). The quarry itself is roughly rectangular and is approximately 3 - 5 metres (10 - 16 feet) below original grade, with the floor being relatively flat except for two areas which were blasted lower as test areas.

The land in the wooded area of the site rises slightly from east to west and forms a small ridge near where the eastern edge of the quarry begins. There is also a small swale running from the south-east corner of the site, in a north-west direction at an approximate angle of 60 degrees, gradually disappearing halfway into the site. Through on-site reconnaissance, major plant species for the tree and shrub layers that have been identified are as follows: tree layer; *Populus tremuloides (*trembling aspen*)[DOMINANT]*, *Acer negundo* (manitoba maple), *Populus balsamifera* (balsam

poplar), *Quercus macrocarpa* (bur oak), shrub layer; *Cornus stolinifera* (red osier dogwood), *Corylus americana* (hazelnut), *Viburnum trilobum* (highbush cranberry), *Prunus virginiana* (chokecherry), *Prunus pensylvanica* (pincherry), and *Alnus rugosa* (speckled alder).

According to Jim Petsnik of the Water Resources Branch, a well 1 mile south of Balmoral Manitoba (approx 5 miles from the site) indicated the head of the aquifer, which supplies the ground water for the area, peaked at 245.5 m above sea level in summer 1993 (an extremely wet year). This would roughly confirm the estimation of the quarry operator, Barry Mulder, of Mulder Construction, whose estimation is that the groundwater head is approximately 1.5 metres below the blasted out test areas, which are the lowest points in the quarry.

As can be seen in Diagrams Six and Seven, the site is flanked on two sides by active quarries. There are forest and residences to the north, with farmsteads and open fields to the east, beyond Highway 7.

The quarry and site can only be viewed from a roadway running east-west along its southern edge. There is berming along the quarry's south edge which will be utilized in for shaping material for the golf course. Once removed it will allow more open views into the quarry development from the roadway.

7.3.2 Surrounding Site Data

The land uses of the areas surrounding the site are as follows:

Quarrying - The site has existing quarries adjoining it on two sides, with the operations in varying degrees of activity. To the south, across the government road allowance are quarries which are no longer blasting, but still crushing rock and transporting it off-site. It's limits begin at the same eastern point of the study site, but continues further west. There are also the other quarry operations abutting the site on its western limit line. The northern-most quarry will be active for approximately 3-4 more years, while the southern one has approximately 10 years worth of production remaining for it.

Farming - The areas to the east of the site, across Provincial Highway 7, are all primarily agricultural, with some farmsteads occurring along the highway.

Residential - There are a small number of residences north of the site along the western side of Highway 7. These do not directly adjoin the site but are mentioned because in the past, these landowners have been quite opposed to the noise of the blasting practices of the quarry operations to the south, and were responsible for the quarries having to limit their hours of operation, ceasing their 24 hour-a-day activity.

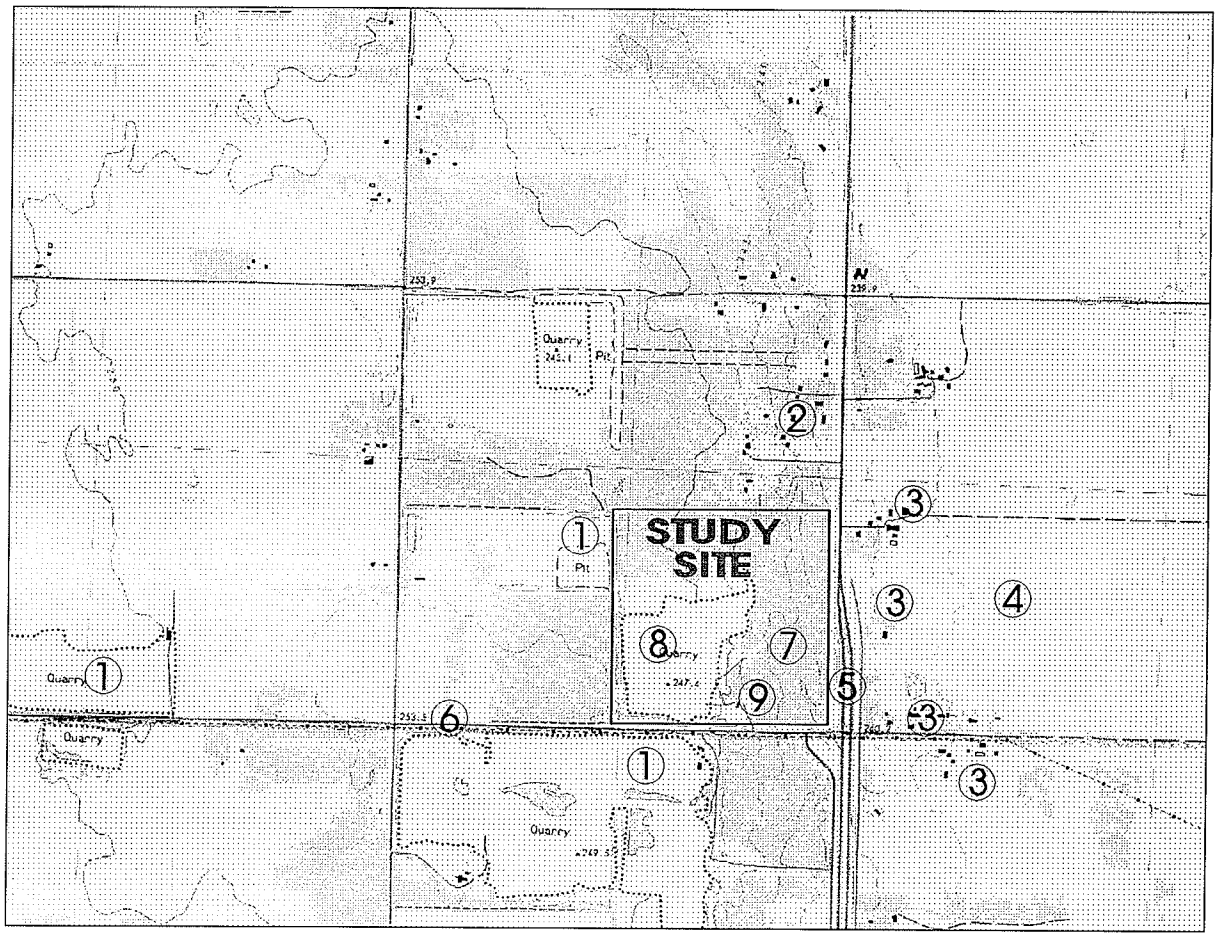


DIAGRAM 6 : Provincial Surveys Map 1983 (n.t.s.)

1 Active Quarry
2 Residences
3 Farmstead
4 Agricultural Lands
5 Provincial Highway 7
6 East-West Through Road
7 Wooded Portion of Site
8 Quarry Portion of Site
9 Weigh Station and Site Access

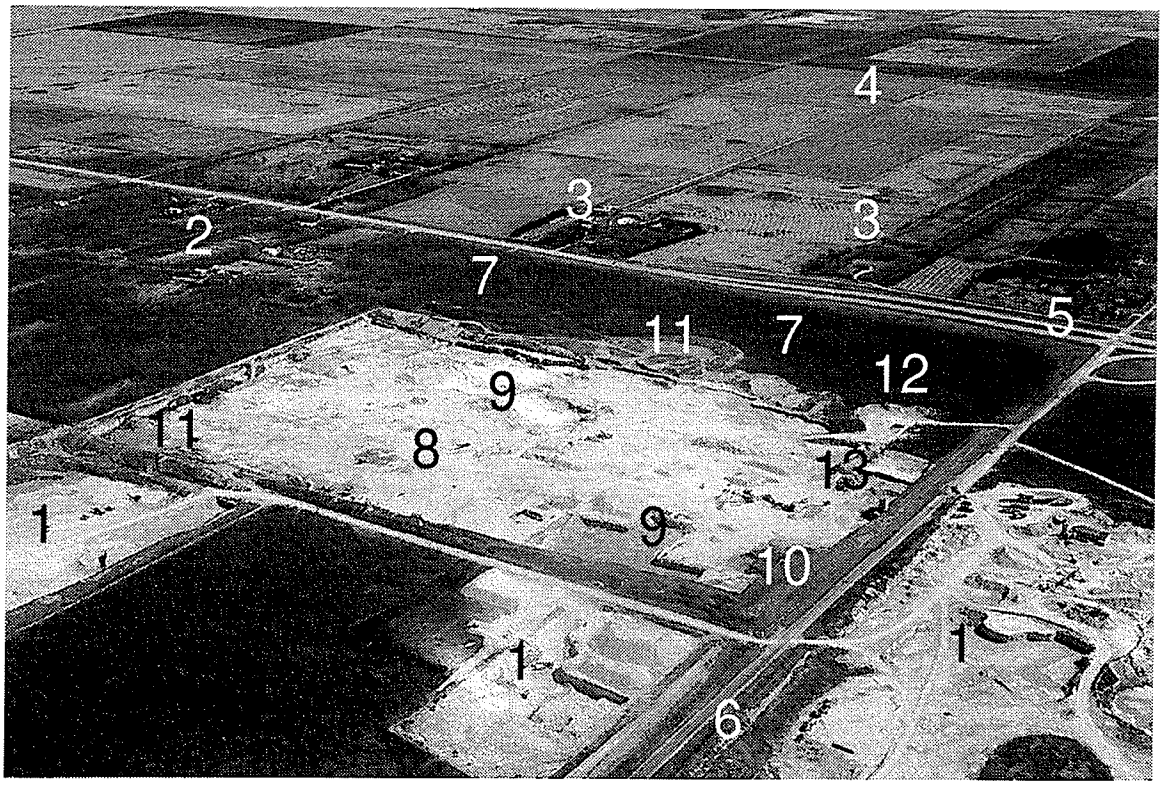


Diagram Seven: Aerial Photo (n.t.s)

1 Active Quarry
2 Residences
3 Farmsteads
4 Agricultural Lands
5 Provincial Highway 7
6 East-West Through Road
7 Wooded Area of Study Site
8 Quarry Portion of Study Site
9 Blasted Out Low Areas
10 Berming
11 Overburden Dump Areas
12 Weigh Scale and Site Access
13 Remnant Kiln

7.3.3 Quarry Operation

The quarry being studied is an open-face operation, employing the drill, blast, and crush method of extraction and processing. In this method, explosives are planted and then fired shattering the rock. Once a shelf or ledge is established, the blasting continues along its face, gradually working the shelf back and forth around the quarry. The usual depth for the blast lifts is approximately 15-20 feet, with a length of approximately 50 feet (For more information concerning this type of operation see Appendix C). These are important parameters to know if any additional blasting will be proposed or required for the new development.

The rock fragments that are then produced from this blasting are crushed to sizes according to market demand, with the majority being crushed to 1", 2", and 3/4" sizes.

7.3.4 Site Evolution

The 1983 Provincial Surveys Map (Diagram Six) shows the quarry after 12 years of operation by Mulder Construction. Before they had acquired the long term lease from Gillis Quarries for the property, it had previously been mined by others, with a small quarried hole and kiln left as reminders.

When the quarry became active again in 1981, extraction commenced near the office and weigh scale, which are located near the eastern-most edge of the rock formation, and then moved roughly in a clockwise direction, ending up back at the scale area. The quarry by this time was only about 2.5 metres deep, and went approximately halfway across the site to the north. The overburden from the site was being piled in two areas: along the western quarry edge; and also into a large mound near the edge of the bush, in the middle if the site, by means of a constructed trail.

By 1991, the quarry's northern boundary had extended to within approximately 10 metres of the property line. The operation pattern was the same as before, moving in a clockwise direction from the south-eastern area. The overburden pile on the eastern side of the quarry also increased in size. Test holes were blasted in two spots to determine the quality of the underlying rock formations, and are now approximately 7 metres deep. The air photo of Diagram Eight shows the crusher at this time to be in the north-west corner of the quarry, and illustrates a shelf where the last blasting sequence has occurred.

When this study began in 1994 the quarries had extended slightly to the east and around the existing kiln to the south (Diagram Eight). An air photo taken in April 1994 (Diagram Seven) illustrates the quarry and its activity level at that time through piles of crushed stone and machinery within the quarry.

The quarry's present boundaries have expanded to the lines indicated on Diagram Eight. The numbers within the quarry represent the approximate depth in metres to the quarry floor at their respective locations.

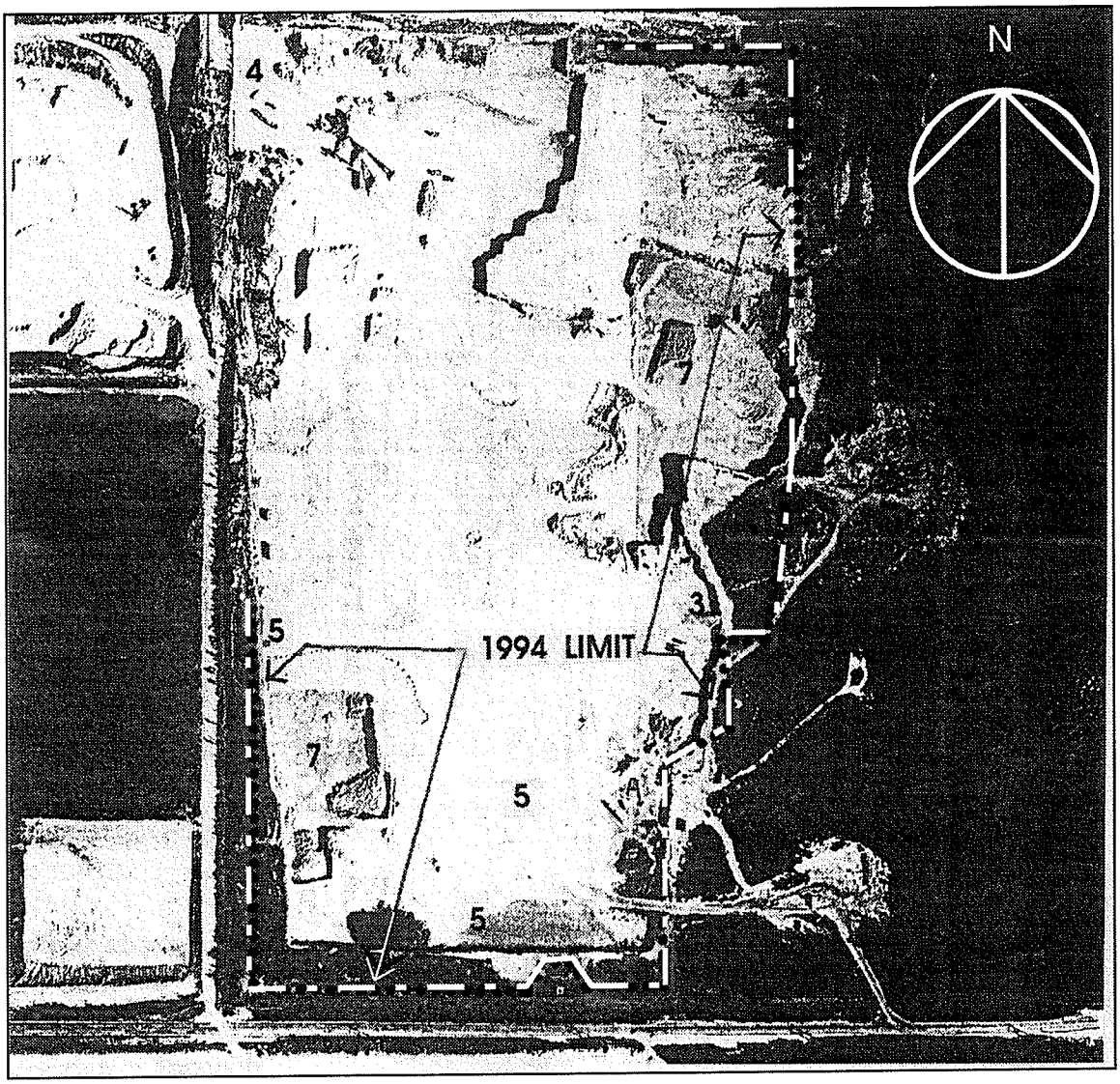


DIAGRAM EIGHT: Aerial photo of site with illustrated changes.

7.4 QUARRY REHABILITATION TECHNIQUES

Rehabilitating or transforming a quarry from an active production to a dissimilar after-use can be a forbidding, difficult process. Often all that is left to rehabilitate is a large mined out hole, with very little in the way of distinguishing features, as is the case with this study. Along with its lack of immediate physical appeal, there are other obstacles to overcome when developing in this type of environment. They include: chemical or nutrient characteristics of the bedrock that may severely limit or impede plant growth; poor soil structure of replaced overburden and a poor capacity for it to hold moisture; high surface temperatures and lack of shade, along with a highly dense surface caused by continual compaction can all combine to create harsh conditions in which to develop.

As previously mentioned, one of the first items that should be established in the quarry rehabilitation process is an end-use for the site, before it begins any transformation. The specific use will determine the techniques used to reclaim the quarry. In this particular instance, a golf course will be the final product, so a study in rehabilitation techniques tailored for that type of development will be employed.

A golf course is physically characterized by large areas of grass, and or, turf in varying degrees of refinement, often with treed portions as out of bounds regions which define the holes. These traits align the characteristics of golf course developments with those of other rehabilitation end-uses; agriculture and forestry being the two most general and researched in the industry. These rehabilitative practices will aid in the selection of appropriate vegetation types, as well as guiding the proposed development in a method of establishing a hospitable growing medium for any new vegetation.

7.4.1 Establishing a Growing Medium

Once the extraction process is complete in any area of a limestone quarry, often all that is left is a highly compacted, flat and alkaline medium. The quarry's floor and faces must be prepared to meet safety standards, for erosion control, aesthetics, and so that vegetation may grow and prosper in this hostile environment. A sequence to encourage this has been established by the mining, agriculture and forestry industries. It is: 1) Replacing Overburden 2) Ripping and Grading 3) Ensuring proper Drainage 4) Replacing Topsoil. Once these steps are complete, selection and establishment of vegetation may take place.

Before any overburden is placed on the site is often necessary to prepare the quarry floor. The use of heavy modern machinery in the extraction process can pack the quarry floor to such a degree that it becomes an impenetrable surface, with the quarry in this case study being no exception. The floor may be prepared by either ripping or blasting in areas of extreme compaction (ie. desire lines of trucks to egress points). By ripping or blasting any areas to be planted, a medium allowing better root and moisture penetration is established. This may not be needed in areas where

shallow rooted vegetation is to be established, and plant wells may be constructed where the larger deep rooted plants such as trees can thrive.

These processes both have limitations, however. Ripping is not plausible in harder limestone formations, such as the one present at the surface of this particular quarry which resist the ripping machinery. Blasting is also a costly process, and its benefits must be weighed. In this case, it is not cost effective to blast to simply break the surface crust of the quarry floor. Because of the labour costs involved, extraction of the shattered rock would be needed to make this process economical (Mulder, 1995).

Blasting, however, will be used to create deeper areas for topography variations within the quarry floor (Refer to Section 9.2). Most of the poorer quality stone below will be sold, with any remaining material to be used as a base for the overburden to be placed onto. The cost of blasting is justified using this method of treating the quarry floor. The remaining part of the surface, which will not be affected by blasting or ripping, will simply be covered by the stockpiled overburden.

• Replacing Overburden - Overburden is used for the rough grading of the site to establish proper surface drainage, and more importantly for this situation, to shape the site for a golf course. In most cases the overburden that is put back onto the quarry, was stripped from the site originally.

There are generally two main concerns when dealing with overburden; i) its quality, and ii) ensuring the lifts or layers do not become overcompacted when being laid down.

Poor quality overburden (saline, stoney, etc.) should always be replaced first in this phase. It generally has the lowest nutrient value, and is of little value for plant growth. The basic condition of the overburden in this case study is quite poor, according to Barry Mulder, of Mulder Mining (Mulder, 1995). This was later confirmed by site reconnaissance.

Before stripping occurred, the overburden was very poor quality soil, being a stoney till varying in depth from six inches to approximately 12 feet (Ibid,1995). The areas where the overburden was deepest, the highest clay content was the highest. The soil and clay overburden were removed as a single commodity and stored in a mixed state on different areas on the site. Ideally, the overburden would have been stored in an ordered fashion, so the poorest quality material may have been returned first as a base layer. Although it is of poor quality organically, the stoney nature of this overburden will provide some drainage, making it suitable for base layers in the shaping process.

It should be noted that in no instance should organic soils, landfill materials, or domestic garbage be used as an overburden or backfill source. These materials will break down, causing settlement, as well as potentially producing methane gas. Other sources, however, such as waste concrete, may be suitable as a base fill. Soil fill, however, will have to be used in the last 1.5 metres to the surface if substitute fills are used.

Thick lifts (or layers) are often utilized in reclamation for agriculture or forestry, when reshaping the quarry floors, and will be used in this case as well. In this way

compaction can be reduced by minimizing the amount heavy equipment goes over the areas being revegetated. Also, any overburden should not be put down when it is wet, as it will dry in a hardpan condition.

• Grading and Ripping -Once the overburden is replaced in an area, it must be ensured that proper slopes have been constructed and maintained for appropriate drainage to prevent water erosion, and for this case study, to ensure acceptable playing conditions. Once overburden is placed back over any pit contours, it is will be necessary to recontour the final slopes to enhance drainage and to provide access for ripping, topsoil placement and planting of vegetation. High walls may also be addressed by partially or completely grading up their faces, to an acceptable slope condition (See 7.2.3: Quarry Walls). The Provincial requirements, require that grades meeting with quarry walls not exceed 4:1 (Bailey, Feb.22, 1995). These slopes should also blend into any adjacent steep areas to prevent shelves or steep troughs. Another concern with grading design, is with the length of any uninterrupted slopes. This is because long uninterrupted slopes increase the likelihood of soil erosion problems before vegetation can get firmly established. Terracing, use of swales, ridging, and vegetation can all be used to break up long slopes (Diagram Nine).

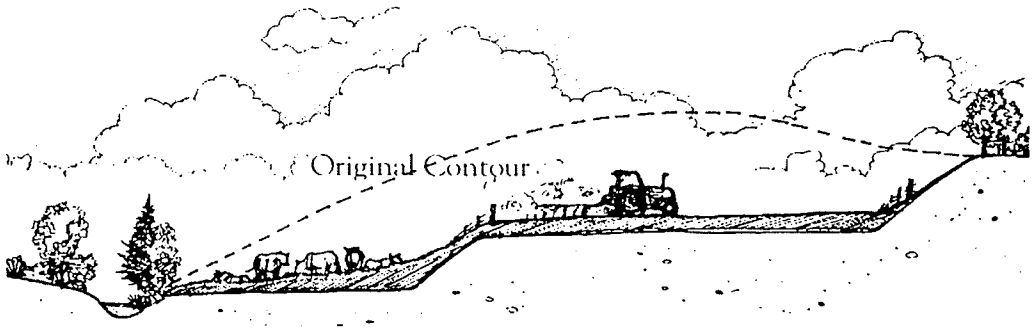


DIAGRAM NINE: Terraces, swales, and ridges used to minimize soil erosion (Pit and Quarry Reclamation in Alberta, p.55)

If compaction does occur during the placement and grading of the lifts, then ripping should utilized to loosen the soil. Compaction breaks down soil structure, reduces its water holding capacity increasing runoff, and hinders penetration of rooting and

nutrient uptake from the soils. Ripping is done by deep ripper blades (Diagram Ten) or plows, preferably to a depth of approximately .5 metres below the surface. In general, the deeper and more extensive the ripping the greater the success of plant growth. Ripping will improve the soil conditions by: breaking up any surface crust of the overburden; increasing water infiltration (reducing runoff, erosion and allowing saline to leach downward); creating a better root zone; and bringing up any large stones that may surface through frost heaving.

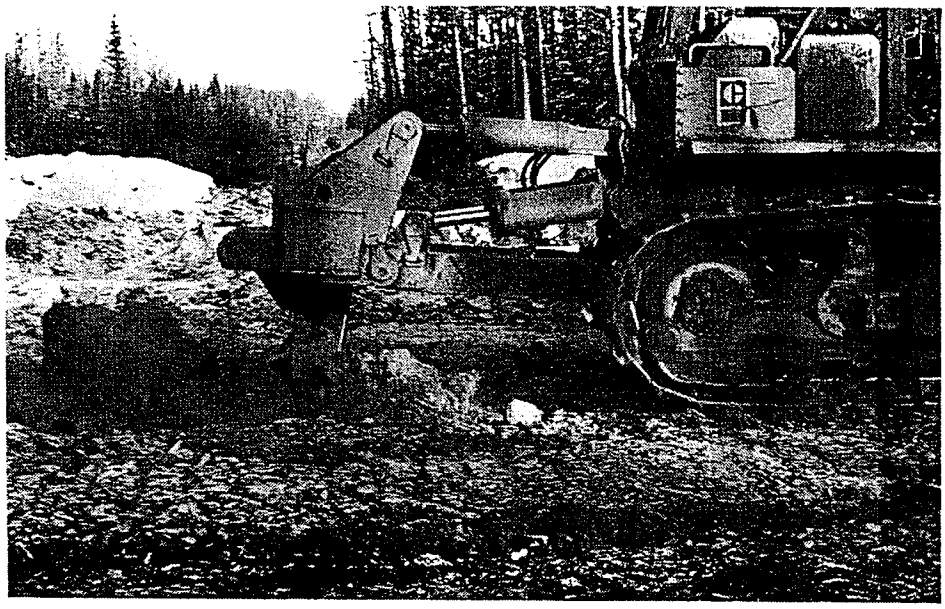


DIAGRAM TEN: Soil Ripping (Pit and Quarry Reclamation in Alberta, p.56)

• Drainage - Establishing adequate drainage is essential in the construction of any golf course, and demands especially strict measures to ensure this type of development will succeed in a rehabilitated quarry. Here, hardpan conditions may exist in the quarry floor, which will not allow water to pass downward. Ensuring water ponding or flooding does not impede the available playing time on the course is vital in areas in and around Winnipeg, where playing seasons are already limited by climate. Proper drainage must also exist to ensure control of any runoff that may have the opportunity to go directly into a groundwater source through any susceptible areas.

Re-establishing site drainage can be achieved by numerous methods including using interceptor drains and grassed water runs to slow the velocity of any runoff water, preventing soil erosion, or using subsurface drainage systems which are often used in golf course designs. Drainage systems for quarries are almost always enclosed, so grading to impoundment areas will allow runoff to accumulate in areas which will not affect the planned activity. This method is also employed in this case

study (See Section 9.1, Diagram Fourteen). These areas will catch any runoff, and allow any sediment or chemicals to leach out of the water through plant filtration and aeration methods, before being reused as an irrigation source (See 9.1.2: Water Catchment Areas).

• Replacing Topsoil - Ideally the topsoil from any operation will have been stripped and stored separately to ensure its quality for replacement. If it was not, as in this particular case, and any other good soil is not on site, a local topsoil source should be secured. This helps to ensure compatibility with the subsoils being used in the rehabilitation. Topsoil is not essential, but greatly enhances growing conditions for vegetation: " As little as 2 - 3 in. of soil will reduce the time required to attain good quality vegetation from six to eight years (using no topsoil), to perhaps four to six years" (Land Rehabilitation: A Fresh Look, 1984). In this instance where a quarry is being developed for use as a golf course., topsoil should be replaced in all areas of play, to a depth of approximately one foot.

As mentioned, there was no high quality topsoil to be recovered from this site. However, approximately 240 acres of topsoil, at a depth of 3 feet, was stripped and stockpiled at a nearby site also being quarried by Mulder Mining, under the company Camaro Enterprises (See Diagram Eleven). This ensures an adequate amount of topsoil for this proposed project, dismissing the possibility of having to incur additional cost of importing from another supplier.

Since golf is a specific use for a rehabilitation process, construction requirements also have specific recommendations. A sandy-loam soil is the ideal medium for building a golf course on. The loam helps retain enough moisture for healthy grass growth, while the sand allows for proper drainage to allow the course to stay open after heavy rains. While this type of mixture bolsters the course's drainage, while providing a good nutrient value for the sod and/or seed, importing peat would not be cost effective. According to local course designers the topsoil being used will retain moisture well enough in this situation(Olson, 1995). The cost of importing sand to improve drainage potential, will have to be weighed against the fact that the stoney till, and blast rock used as a base will provide a good drainage base for the greens and fairways. This will be a cost decision based on optimum (topsoil w/ sand, peat) versus good (sand,no peat). Sand, however, will have to be used as a final topping for the greens, with the grass being seeded directly into it.

7.4.2 Selection and Planting of Vegetation

Certain types of grasses and grass mixes are recommended for different uses on a golf course (See Appendix B for a complete listing). The grasses are recommended for their hardiness and ability to provide a quality playing surface for the game.
The main types to be used for golf course construction in southern Manitoba are; Kentucky bluegrass and different fescues for the fairways and rough, bentgrasses for the greens, with the tee boxes often being a mix of the three. Annual ryegrass is usually utilized a nurse grass to help the permanent vegetation get established.

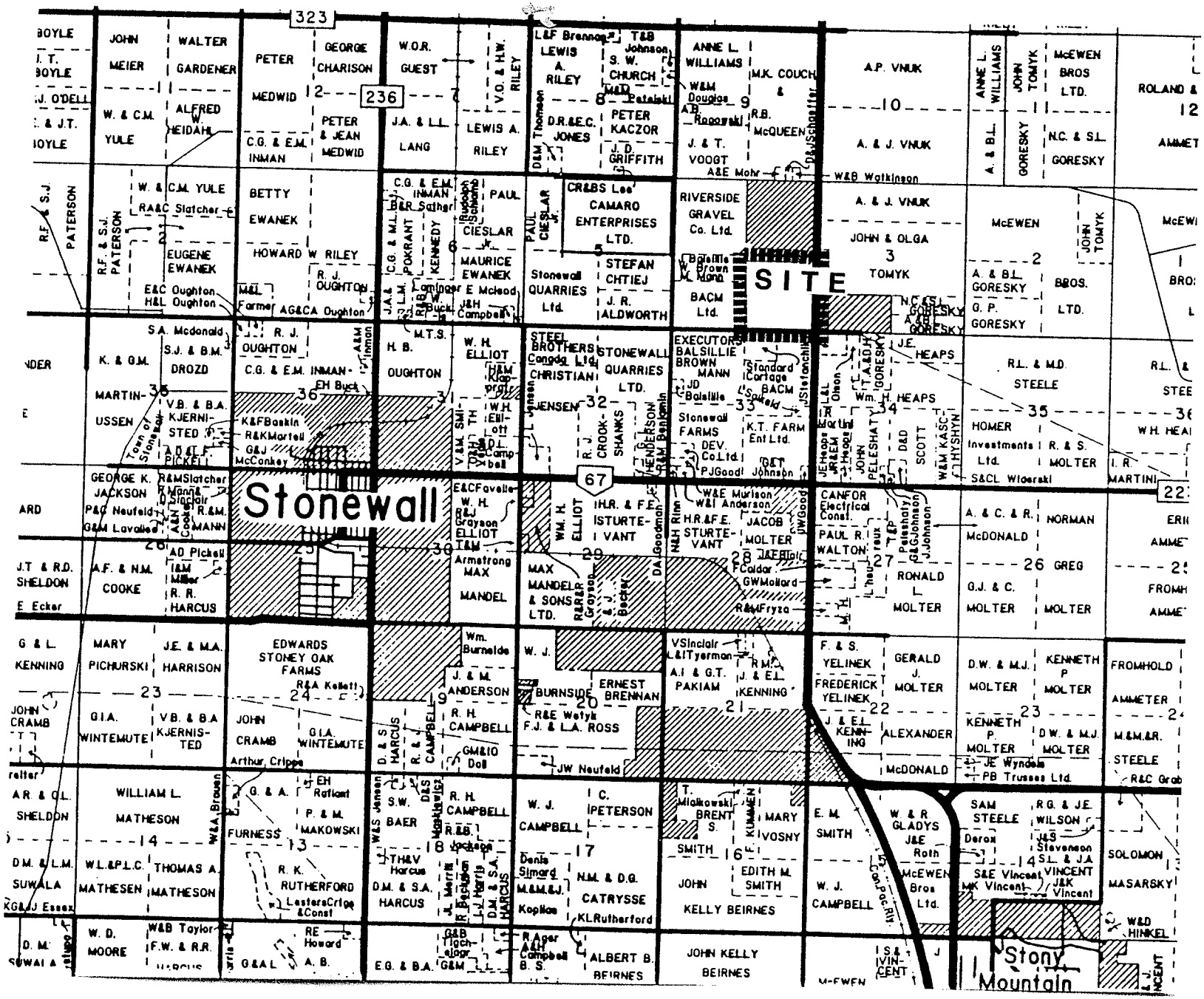


DIAGRAM ELEVEN: Land Surveys Map

The bentgrasses have traditionally been used on the greens because of their ability to thrive under low mowing heights, while providing a fine, thick carpet on which to play. Kentucky bluegrass commonly have been used in the target hitting areas on the fairways, with the roughs made up mainly of fescues. In this situation, the Kentucky bluegrass provides a lush blue-green target to aim for, with the finer, lighter coloured fescues framing it. Other than appearance, and lack of available local sod, however, there does not seem to be any reason why fescues are not used as a dominant fairway grass. Fescues also seem to have the advantage in that they are suited to poorer quality soil, require less energy input than bluegrass do, and are also a less expensive seed to purchase.

(Sources: Campbell / Furber / Peters)

Methods of planting the grasses will have to be evaluated on their merit versus cost. Techniques vary from seed drilling, to broadcast seeding to hydromulching. Whatever method, or methods are chosen, they will have to be tailored to fit: the topography and soil conditions of the site; availability and capability of the equipment; costs; and the treatment or "look" required for the various areas of the golf course.

The selection of any other types of plant material for the design, such as tree and shrub species, will have to go through a selection process to determine the most suitable species for the concept of a golf course development, and to ensure their survival in a rehabilitated quarry environment. Species will have to be selected on their rehabilitative value, ease of propagation, availability, and maintenance requirements. A good way of determining what species will thrive on site, is to go to any other depleted pits or quarries in the area and inventory the vegetation growing in them. Other than doing that, consultation with experienced nursery and seed industry people, along with other golf course superintendents, will assist in the selection process. Also, since the quarry is a severe situation to grow in, a more species-rich planting list should be utilized. Species-rich systems are typically healthier, less prone to the dangers of disease outbreaks in a single species, and provides better habitat for wildlife (For a list of trees and shrubs suggested for quarry rehabilitation see Appendix B).

As the plant species are being selected, the form of the plant material and method to propagate them must also be decided upon. There are various methods used to install the vegetation, each with its own advantageous and disadvantages. They include using; seeds, bare - root stock, containerized stock, cuttings, sprigs, rhizomes, plugs, and/or wildlings. Each form should be selected on their chance of survival, cost, maintenance and aesthetic effect. For more information concerning this also see Appendix B.

The time of planting for any type of vegetation should occur as soon as possible after the topsoil has been put down to minimize any surface erosion, and improve the quality of the soil. Timing of the planting varies from species to species, including the grasses, but is usually best in spring due to the availability of moisture, and when excessive heat will not burn the young plants.

7.4.3. Quarry Walls

Quarry walls are an imposing physical entity. They also define the quarry and are a potentially be an interesting presence to play along, acting as out-of-bounds for some of the proposed holes. Treatments of the walls can be varied from grading up the slope with earth to varying extents, to leaving the walls almost completely exposed. This treatment depends on the effect desired by the designer, but also must consider Provincial requirements, and liabilities to the owners or operators of the development (Diagram Twelve).

The reasons these walls are safety hazards and act as potential liabilities, vary. Anyone tumbling over the edges and hurting themselves in a fall, or fragments of rock coming loose and falling into any new development within the quarry are two obvious examples of concerns with these features .

The walls should be visually inspected by a landscape architect prior to construction to identify any potentially dangerous areas. Any areas of concern may be dealt with through selective blasting along the wall faces. This can serve to reduce the extent of rock face through blast piles, and limit the amount of wall from which loose rock could fall from. The varied sizes of fragmentation in blast piles would introduce a varied microtopography for vegetation establishment; indenting the crest line of the wall face, giving it a more 'natural' appearance; blast piles seen from above may provide visual clues from the edge of the quarry, warning of a drop; and reducing the vertical change in locations of choice may provide design opportunities; the blast piles may be used as a shaping medium if there is a limited supply of overburden.

Blasting the walls has not been considered as an option in any of the areas for this case study. This is due to: the costs involved with blasting; the fact that there is sufficient and stoney overburden for any shaping; and the proposed golf course layout does not lend itself to having this done in any area.

7.5 CASE ANALYSIS

7.5.1 Development Considerations

From the case data inventory the major development considerations to convert the site being studied into an eighteen hole golf course would be as follows:

<u>Water Table Contamination</u>

- ensuring that no runoff from the golf course which may contain any type of chemicals in it, goes directly into the two areas on the quarry floor that have been blasted lower than the remaining quarry or possibly leaching through any fissures in the quarry floor.

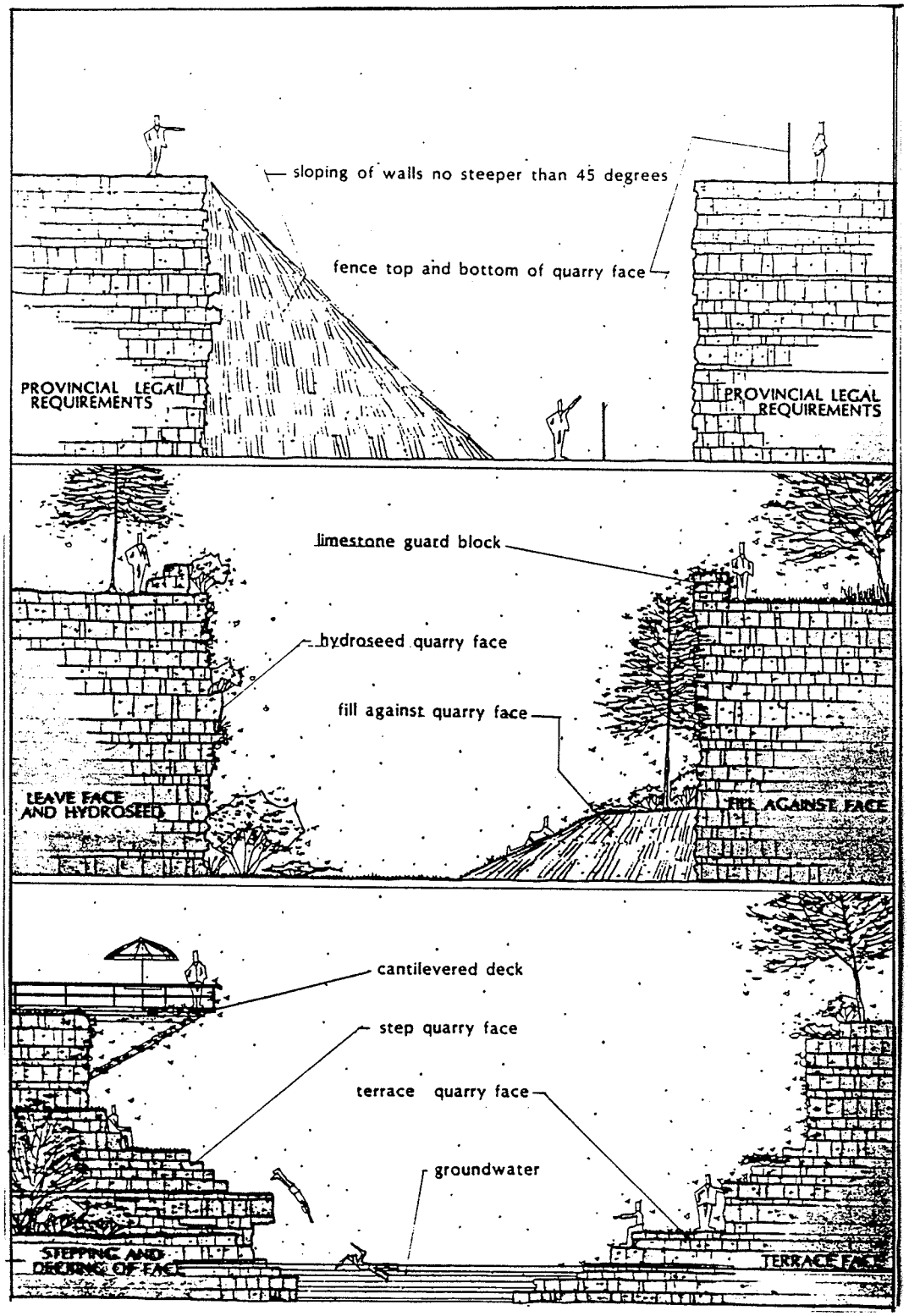


DIAGRAM TWELVE: Examples of quarry wall treatments (Paterson, 1982, p.33)

Configuration vs Costs

- deciding on the approach to the course design and configuration. This would determine how much of the quarry area would be seeded (ie - with fill and topsoil)and how much overburden and fill would be required. The configuration of in-play areas are also dependant on the course design strategy which is meant to supply target clientele with a challenging course on which to play.
  The other consideration is the amount of earth moving and shaping would be required, and how much of it would be covered by the Province of Manitoba's Quarry Rehabilitation Reserve Account.

Unwanted Neighbour Syndrome

- possibly attempting to mask out sights, sounds and dust from neighbouring quarries to the south and the west if possible.

Aesthetics

- with the course to be partially developed in an unique setting (ie: the quarry), there exists an opportunity to emphasize the features and characteristics associated with it.

Edge Conditions - Liabilities

- Within the nature of quarrying for limestone, steep edge conditions are created. The owners\operators of the site are liable for any injuries that may occur because of improperly identifying these drop-offs or by not prohibiting peoples access to these steep edge conditions.

7.5.2 Opportunities & Constraints

As mentioned in section 6.3.2, the opportunities and constraints are determined by examination of the data inventory and development considerations, to form a list. With the end use of an eighteen hole golf course in mind, the following is a list of opportunities and constraints for the site being developed:

Opportunities

- vegetation buffer to the north and east sides of site, acting as wind screens, and providing contrast to quarry.
- quarry's depth provides opportunity to emphasize "up-and-down" play within a golf course design.
- sufficient overburden for extensive shaping
- walls an interesting out-of-bounds feature.
- water features coming off quarry walls: aesthetically pleasing, and practical in that they will aerate water sources.
- limestone kiln contributes to 'character' appeal of site.

Constraints

- quarry form, depth has largely already been determined.
- blasted out test holes predetermine where water hazards will go, limiting routing options.
- base of test holes less than 2 metres above groundwater table.
- noise and dust from surrounding quarry activity.

8.0 POST- MINING DEVELOPMENT PLANNING

8.1 PURPOSE

The post-mining development planning incorporates all other planning phases to come up with a plan for the quarry when production ceases. The post mining planning would actually begin with the management and rehabilitation planning, synthesizing information gathered in the different stages. This process comes to the forefront after the all the issues and site information have been dealt with. At this time, prior to the final design, a program, budget, preliminary development plan and construction schedule should be developed.

The program for this case study is that an eighteen hole golf course is to be built as a public or semi-private facility. It will have a clubhouse for year-round activities, storage facilities, practice facilities, and an appropriate amount of parking for this type of development. The budget, and construction schedule are out of the scope of this study, however, the rough cost and potential revenue generation of the proposed design will be examined later in this study.

8.2 PRELIMINARY DEVELOPMENT PLAN

The preliminary development plan involves correlating the accumulated data and development goals into a design scheme. It should illustrate things such as: designated activity areas, circulation patterns, access/egress points, utility locations, water bodies and drainage flows, rough areas and numbers of specimens for replanting. Diagram Thirteen illustrates these items in the study site.

At this time, an application for an Environmental Licence, which is awarded by the Province of Manitoba, should also be prepared and entered. (See Review by Government Bodies, Diagram Five)

■ PART THREE: PROJECT RESOLUTION

9.0 SITE DEVELOPMENT PLAN

9.1 DESIGN CONSIDERATIONS & SOLUTIONS

Within the general development considerations for the site, more specific design parameters must be addressed. These will relate to the requirements of the project by looking at anticipated user groups, and how they will utilize the facility, as well as any specific environmental considerations that must be dealt with.

- Who is playing

  Since the proposed course is to be a semi-private or public facility capable of hosting tournaments, it must be assumed that the course should aim to accommodate golfers of varying ability. The holes and routings should provide an adequate challenge to the scratch golfer, while not being overwhelming to the bogey player, whose average shot lengths differ considerably (See Appendix A). Design of the facilities such as parking, and other amenities should also reflect the needs and desires of the anticipated clientele.

- Environmental conditions of the quarry

  A priority of the design is to ensure that drainage for the portion of the course which is within the quarry is planned so that no water runoff directly reaches the low areas without some form of mitigation. This will include designating areas to catch or slow any surface water movement, so any possible contaminants may be filtered out. This would also to allow the quarry's irrigation needs to be self sustaining, and ensure the groundwater resources remain safe. Long term maintenance and energy costs of the golf course development are also to be considered.

- Working with Existing Site Conditions and Mining Methods

  Decisions on where to place things such as access points, clubhouse facilities, and water hazards within the final design were largely predetermined by existing site conditions, and were utilized within the new design to save costs. The ability of the site to provide for basic construction materials and its ability to sustain a golf course should also be considered. This includes: utilizing overburden resources effectively, ensuring importing of material does not take place; recycling water by handling any runoff to the low points, and then using them as water features and irrigation sources; using the quarrying

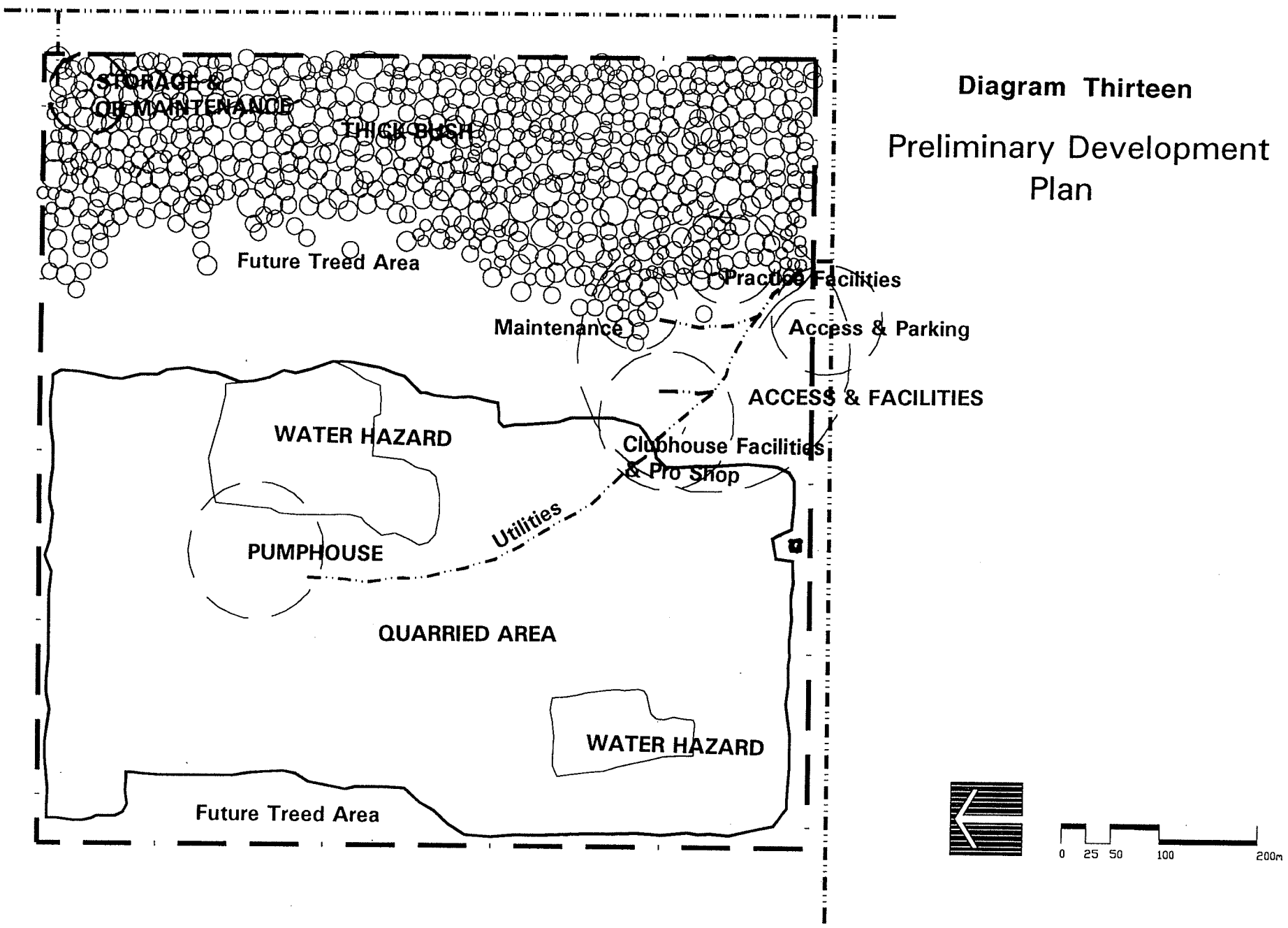


Diagram Thirteen

Preliminary Development Plan

procedure to further develop topography within the quarry floor by blasting out new low areas, and as means of establishing other low areas to drain to, which will be heavily planted with trees and act as a sort of 'dry well'.

- The Development of New Landscape

A limestone quarry does not necessarily have to be viewed as a potential eyesore, or a liability to the owners, or area it is situated in. The creation of varying topography and rock cliffs through the quarrying process provides for an exciting opportunity to emphasize the changed landscape from the general conditions surrounding the site and around the Winnipeg region. With the rehabilitation of the quarry, earth will be moved in and shaped over its floor and up the walls to form the new terrain of the golf course. The character of the remnant quarry will be preserved through the remaining walls and areas of exposed rock. The desired aesthetic or 'look' for this new landscape generally, however, is to be that of an open, mainly grassed prairie, within the limits of the quarry. It is meant to seem as though the quarry had been reclaimed through a natural process, with a golf course laid into this 'new' landscape.

9.1.1 General Design Solutions

Edge conditions - Mitigation for edge conditions would be to utilize some form of fencing along with vegetation near the top edges of the quarry to identify the edges, alleviating any liable conditions for the owners of the site.

Facilities - Parking for 100 cars, clubhouse and pro shop 3000 ft^2 (2 level, 6,000 ft^2 total), 2 maintenance/storage sheds each approximately 1800 ft^2. One shed will be used for both maintenance and storage, with an adjacent compound in which to lock up golf carts. The other shed is to be used primarily for storage only. These figures were determined by a short survey of similar type facilities in and around the Winnipeg region to determine rough design guidelines.

Holes - Initial shot length based on a 250 yd drive (carry & roll) from the back tee placement (See Appendix A, Diagram Twenty three). There are, however, no carries of that length over water with no alternate areas to shoot for. All hole widths are an average of approximately 45 - 55 yards at critical points (approximate landing point areas),with the minimum width being 39 yards on a par three.

Greens - Greens have been designed large, with an average area of approximately 6052 ft^2 (562m^2). This allows for a larger target for players of varying ability, while also allowing for a variety of pin placements, reducing wear on the greens.

Vegetation - Trees are to be utilized in mass plantings to: separate holes; provide

visual relief; act as "sponge" areas for excess runoff. More trees will also be planted to augment the existing woodland area on the eastern portion of the site. Native grasses will be utilized as much as possible in out-of-play areas for aesthetic purposes, and to also reduce maintenance costs. Maintenance and energy requirements will also be considered when selecting the grasses for the golf holes.

9.1.2 Specific Design Solutions

Water Catchment Areas and Water Table Protection - At present there are two test areas blasted lower than the main quarry floor. These areas are used in the routing plans for the golf course as water hazards, but will also be utilized as the irrigation sources for the golf course as well. They will be partially backfilled with overburden to reduce any overly steep edge conditions, partially lined with a polyethylene synthetic pond liner, and then filled through the well system that will service the clubhouse and maintenance facilities.

A synthetic and not natural (clay) liner will be used because of the clay's angle of repose, which disallows it from being used on steeper conditions. Clay used in these circumstances, 'slumps', causing uneven lining for the ponds. Also the stoney overburden used as backfill, or any exposed limestone left within the holes, have little or no clay content, and the clay cannot adhere to the surfaces.

The existing blasted out areas on the site constitute approximately 34790 m^2. At an approximate depth of 7 metres, and 5 metres with backfill (Mulder) this would give the course the availability of approximately 46 million [45,953,763] gallons (US). This would be a more than adequate supply source, since industry standards based on .5 million gallons used a day (.25 inch application over 18 holes), with a desired reserve of approximately 7 - 10 million gallons (Sources: Furber / Peters / Solimka).

The existing low areas will be augmented by additional, shallower blasted out areas, which will act as catchment areas for any runoff. A major concern of this proposed development, was the protection of the water table below the quarry. Since water leaching through any fissures in the quarry floor, or the low areas presented a real problem, means of mitigation were implemented. A plant filtration system, using different native water plants (See Appendix B) will be used in the catchment areas to allow any chemical particles to settle out, or attach themselves to the plants. The clay, and synthetic pond liner will also help to ensure no pollutants reach the water table through the low areas. This type of system has been used in other golf courses as a means of mitigation (Marzolf, 1994). Through proper grading the filtered water will be gradually released back into the main retaining ponds. Due to the gradual slope of their banks and the shallowness of these areas, a clay lining will be utilized for these additional areas. This will also give the water plants a rooting medium in which to grow .

Ensuring no pollutants will reach the water table through fissures on the rest

of the quarry floor, is managed through other means. Ensuring proper drainage to heavily planted, or water catchment areas will be the first measure. The grass thatch of golf courses has also proven through extensive testing (Cohen, 1992), to be an effective filtering agent, removing almost all potential pollutants before they leave the root zone. The final form of mitigation, is the replaced overburden, which will slow or absorb any excess water, ensuring protection of the water resource.

Vegetation

Holes - An approximate 60/40 mix of fescues and bluegrass will be used for the fairways, with bentgrass utilized for the greens and tee areas. The rough areas will consist predominantly of the tall fescues mowed to varying heights. The grasses of the main landing areas of the fairways will predominantly be a mix of fine fescues (creeping and chewings), with some bluegrass cultivars also in the mix. The fescues are used predominantly because of their ability to withstand poorer soil and growing conditions, their low maintenance requirements, and their ability to withstand the rigors of public play (Sources: Furber/Peters). An annual ryegrass will initially be used on the fairways to provide early ground cover, and help establish the bluegrass and fescues. For seeding rates see Appendix B.

Out-of-Play Areas- The majority of the out-of-play areas will be planted with a mix of native grasses and wildflowers, with any remaining areas left as exposed limestone rock and rubble. The exposed rock will provided for an interesting hazard, contrast the vegetation, and act as a reminder to the past quarrying activity.

Although start-up costs for establishing native vegetation are quite high, utilizing this type of plant material does have its advantages. One of them, according to John Morgan of Prairie Habitats, is that the native species from the area will thrive in the low nutrient, alkaline conditions of the poor quality overburden to be used in the shaping of the golf course. Other considerations in using native planting include:

i) Appearance - the predominantly grassland nature of the parkland/prairie region would blend well with the grasses of the golf holes, giving a 'links' feel to that portion of the course. This design approach would also contrast the more 'closed in feeling' of the holes in the wooded portion of the site, providing for a contrast in golfing circumstances. Planting larger vegetation along the fairways was limited as it would mask out open views of the quarry escarpments, detracting from the 'experience' of golfing in this unique setting.

ii) Rehabilitative Value and Ease of Propagation - since they are native species from this particular region, the seed mix has the greatest chance of survival compared with cultivars or exotic species.

iii) Maintenance - there is virtually no maintenance required for native stands, eliminating the need for costly fertilizers. herbicides, and man-hours in maintaining them. The diverse nature of the planting eliminates any one disease significantly affecting the areas. Seasonal burning, simulating natural conditions, is the only maintenance required other than occasional mowing if desired.

iv) Costs - this is the only area where native revegetation is forbidding. Since seed stock is hand picked, costs for reseeding can run from $2000 -3000 per acre. Also since seed stocks are limited, they must be ordered up to 1 1/2 years in advance (Source: Morgan, 1995)

The species mix and placement in relation to the holes will depend on growth pattern and height of the grasses and flowers. For example, a mix with predominantly higher growing vegetation will be sown the furthest away from the fairways.

Diagram Sixteen shows the groundcover of the course. Type 1 will be the predominantly longer stemmed grasses and flowers such as the little bluestem, and coneflowers. Type 2, which is closest to the holes, will consist of shorter varieties such as the sheeps fescue, june grasses, and blue gramma grasses. Type 3 is to be a predominantly showy flower mix within the seed stock, providing colour accents within the course. Varieties such as the Dotted Blazing Star, and Three Flowered Avens would be utilized, along with other species to provide seasonal color within the development.

The trees and shrubs that will be introduced onto the site will be a mix of conifers and deciduous plants. Trees that will be used will include: Green Ash (*Fraxinus pensylvanica*), Cottonwood (*Populus deltoides*), Trembling Aspen (*Populus tremuloides*), Balsam Poplar (*Populus balsamifera)*, Scots Pine (*Pinus sylvestris*) and Eastern White Cedar (*Thuja occidentalis*). Shrub varieties will include: Common and Creeping Juniper (*Juniperus communis & Juniperus horizontalis*), Mugo Pine (*Pinus mugo*), Red Osier Dogwood (*Cornus sericea*), Staghorn Sumac (*Rhus typhina*), Virginia Creeper (*Parthenocissus quinquefolia*), and Highbush Cranberry (*Viburnum trilubum*) and Chokecherry (*Prunus virginiana*) will be used as underplanting for the trees in areas out of play. For information concerning these plant types see Appendix B. These same trees and shrubs will also be utilized in the planting along the quarries edge.

9.1.3 Course Description and Analysis

This course design attempts to offer an unique golf experience in Manitoba for the person playing it, by: utilizing water features which cascade over the quarry faces along holes two and nine; large areas of exposed limestone boulders and rip-rap to act as interesting contrasts to the different vegetation, and as an out-of-bounds feature, as well as a reminder to the player of the site's past use; exposed rock faces of differing heights coming into play along, splitting and coming across some of the holes such as two, four, five, six, eleven and twelve; including the chance to play into

or across the old quarry ridges, which are an unusual feature in the prairie landscape.

Aside from its aesthetic aspirations, the design also attempts to address the practical nature of golf course design. The pacing and difficulty of the holes was also considered, with an easy downhill start to allow less skilled golfers begin the round quickly and easily. The holes gradually become more difficult, finishing each round with increasing drama and difficulty. The front nine has two par threes, compared to the back nine's three par threes, to quicken the pace of play through the front nine: which is desirable for a public course, where often golfers often only play the front portion of the course. The length of the course is not prohibitive to the various types of golfers (even from the back tees), but will play slightly longer than its indicated yardage because of the up-and-down movement of the holes through the elevation changes. Sand, rock and water hazards are also placed at varying lengths from the tees and greens, in and along the holes, to act as strategic components in the play of the course. There are also many occasions within the design for reward of good play, and strong shot-making, as well as opportunities for the average or beginner player to make it through some holes using alternate target areas should they choose to do so. There is also, always an opportunity for the higher handicap player to roll shots up onto the green, rather than play over (or out of) any sand hazards.

Routing:

Hole 1 [Back (b)375 yds Middle (m) 361 Front (f) 351 par 4] Heads out in a northwest direction (no morning sun problems) from the original grade down into the quarry, with a gradual drop in elevation of approximately 14 feet . The green is straight-away, and the hole is broad at over 40 yards wide. [Green area (g)8290 ft^2 Fairway width (fw) 43yds]

Hole 2 [b445/ m420 / f387yds par 4] Continues in a northwest direction, dog-legging to the left,slightly towards the green, which is partially hidden by cliff face and set into an indentation in the quarry wall, awarding longer drives from the tee. A bunker to the right of the green forces approach shots to the left, skirting a corner edge of the quarry's wall. A small artificial waterfall and shallow water feature behind the green are meant to give a grotto-like feel to the green area. [g 8830 ft^2 fw 40yds]

Hole 3 [b399/ m375/ f342 yards par 4] The hole begins from elevated tee boxes on new earthwork, into a dogleg right which heads out almost due south. There is an approximate ten foot drop between tee and green, with most of the change in elevation occurring just after the turn in the hole. This will reward a particularly long tee shot with an additional roll, reducing the length of any approach shot. A large bunker guards the left side of the fairway, and two sand traps frame the approach to the green. [g 6070 ft^2 fw40 yds]

Hole 4 [b187/ m162/ f139 yards par 3] Long par 3 rising slightly in a south-eastern direction toward the green. A portion of exposed rock wall from the new

blast areas is left exposed to the height of approximately four feet. It crosses the hole about two-thirds of the way to the green, and is meant as a real, as well as psychological obstacle adding interest to the hole. Two pot bunkers are set off the front of green to catch any errant shots. [g 6560ft^2 fw 41yds]

Hole 5 [b460/ m430/ f374 yards par 4] Long par 4, playing in a north west direction, with initial carry over water hazard for the two forward tee positions. A split fairway is used, employing the new blast walls. The higher portion of the fairway demands the longer carry over the water but awards the drive with a more direct approach shot to green. A small gorge, approximately 30 feet wide and 80 yards from the green, is left from the blasting and crosses the hole to force the golfer into trying to carry it with their approach shot, or lay up before it and chip to the green. [g 4330 ft^2 fw 51yds]

Hole 6 [b500/ m473/ f427 yards par 5] Long par 5 playing due east, up and along the north cliff face (out of bounds). Once over the quarry edge, it then plays slightly downhill into the existing wooded area. The tee drive is awarded by length if it clears the quarry edge, affording a straightaway downhill approach shot. The green, however, is guarded from the left by a large sand trap, which comes slightly around its front-left corner. [g 5650ft^2 fw 57yds]

Hole 7 [b402/ m371/ f347 yards par 4] Rising slightly uphill, the hole doglegs slightly to the right. Fairway sand traps ensure that long hitters must also be accurate, and play down the center of the fairway. The second shot must also be accurate to hold a forward tilting green set into a downhill slope (The change in elevation from the quarry ridge to the green is almost twelve feet). The green is also guarded by bunkers on its left side. The hole plays in a westward direction. [g 4700ft^2 fw 55yds]

Hole 8 [b174/ m148/ f126yards par 3] A mid-to-long par 3 playing eastwardly. The shot is almost blind, with the green being elevated being about twelve feet above the back tee elevation. The tee shot must also carry the water hazard which parallels the line of play, and avoid two sand traps which frame the front of the green. The large green helps to moderate any effect of these challenges. [g 7900ft^2]

KILNRIDGE GOLF COURSE

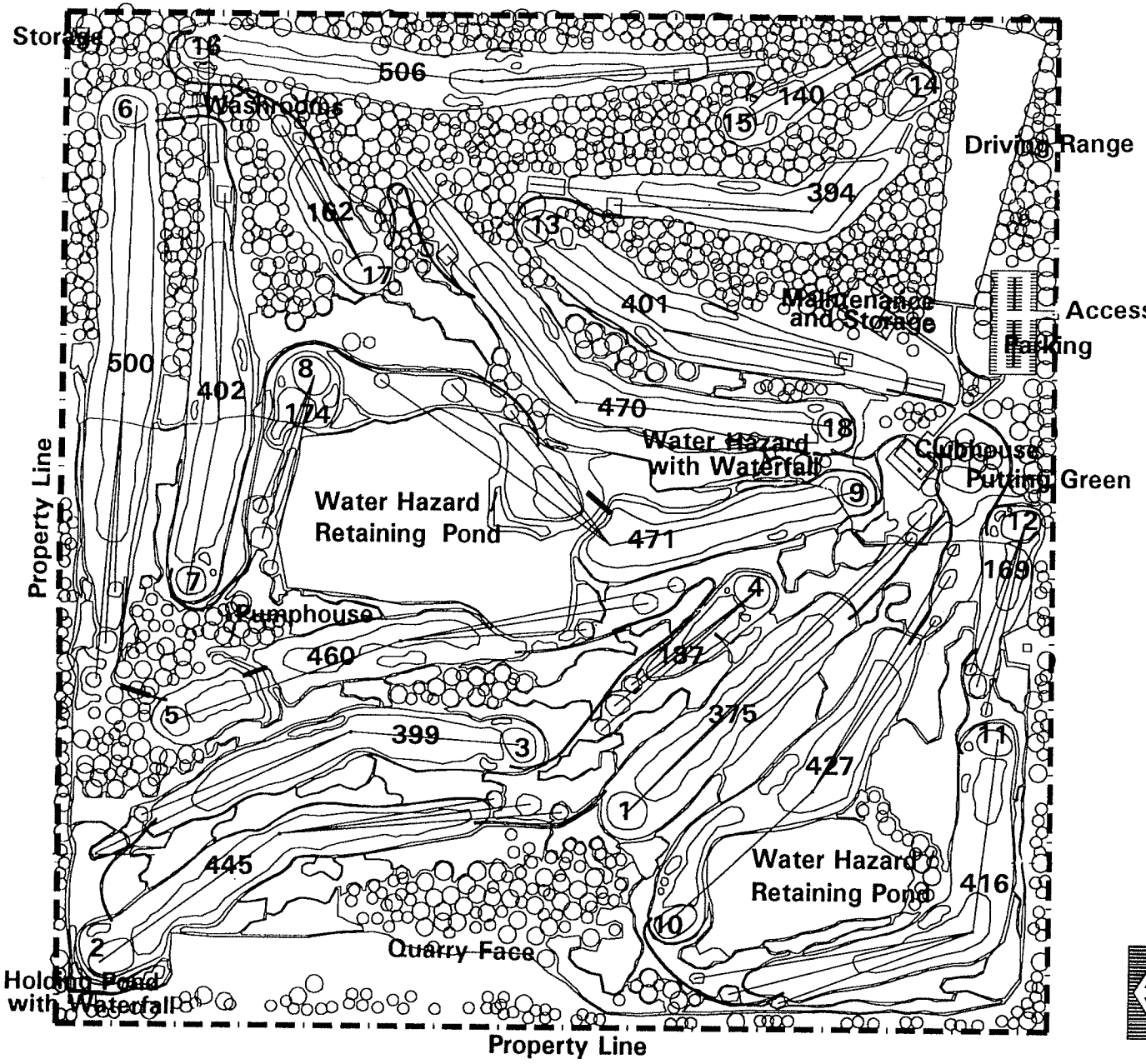
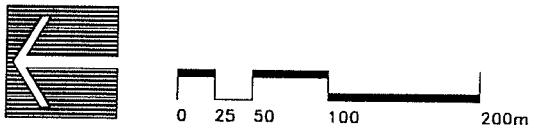


Diagram Fourteen

Concept Plan

Note: All distances in yards



KILNRIDGE GOLF COURSE

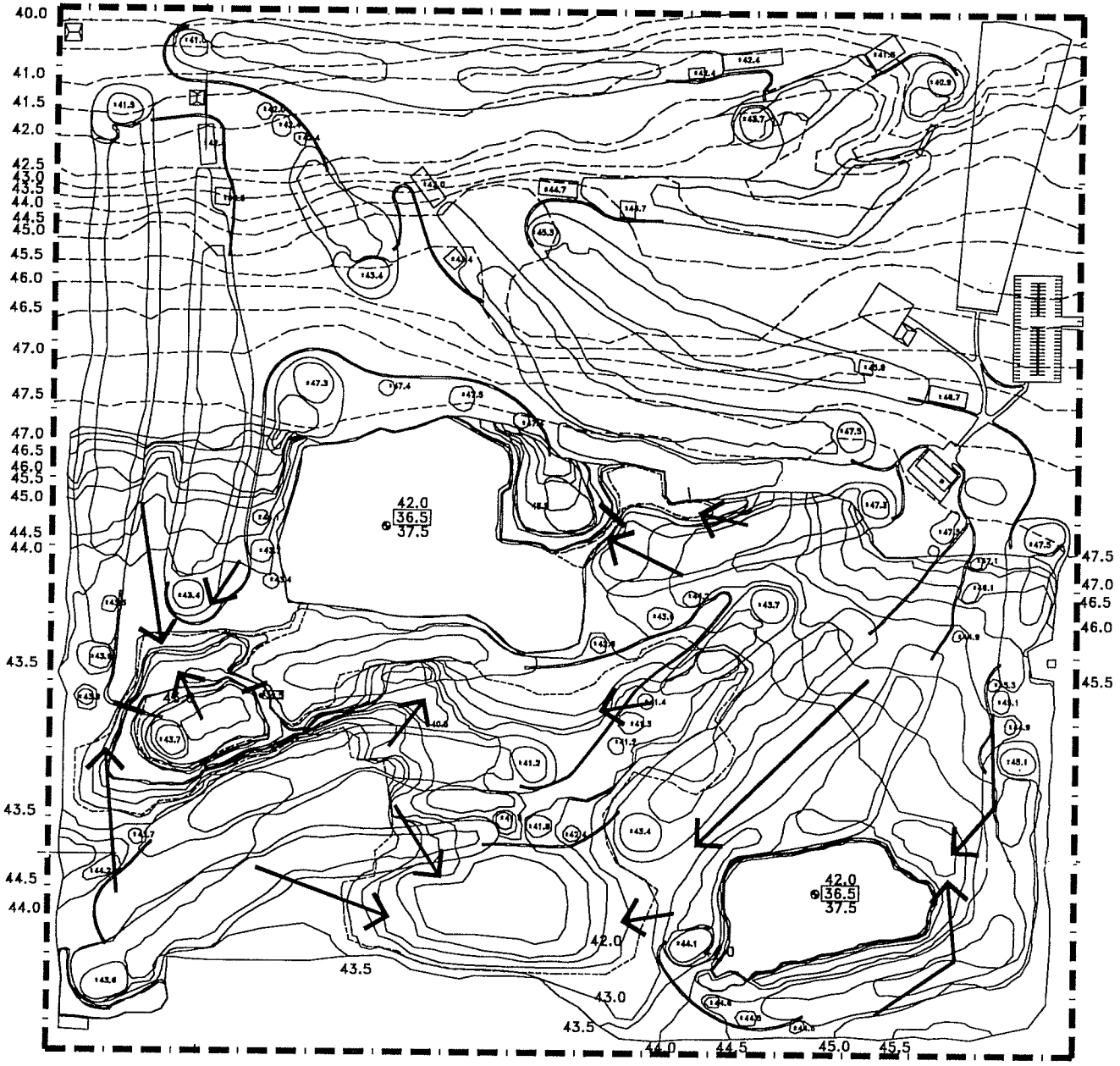
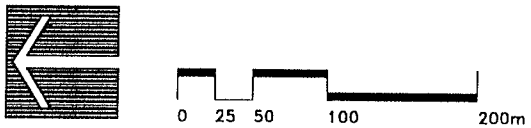


Diagram Fifteen

Grading Plan

- **Contours at .5 meter Intervals relativeto sea level (200M +)**
- **Existing Contour** ————————
- **Proposed Contour** — —— — —
- **Extent of Excavation** - - - - - - - -



KILNRIDGE GOLF COURSE

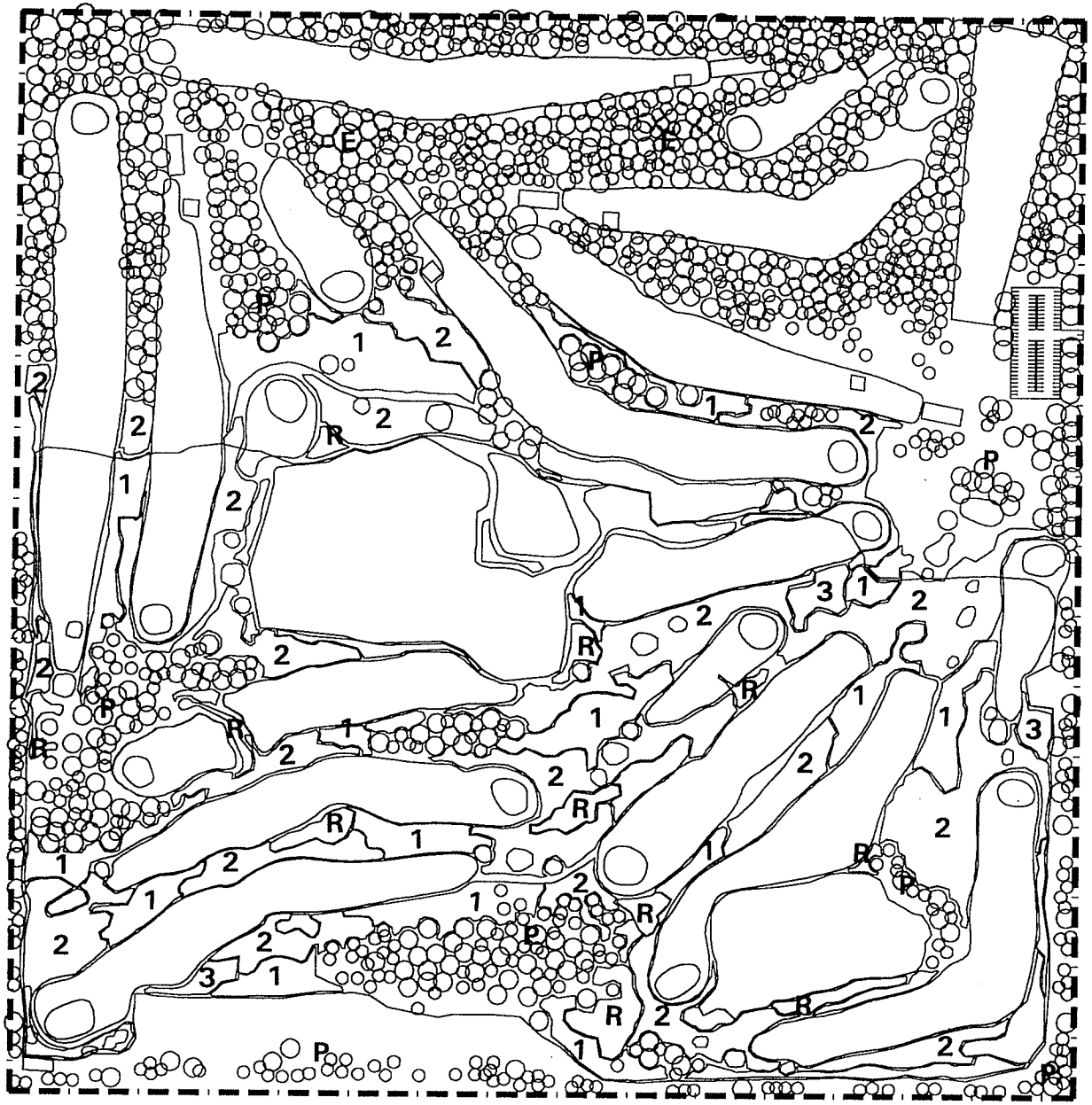
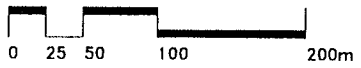


Diagram Sixteen

Planting Plan

1 - Mid-height prairie grass mix
2 - Lower height prairie grass mix
3 - Wildflower mix
R - Exposed Rock
P - New tree & shrub planting
E - Existing vegetation



Hole 9 [b471/ m419/ f367 yards par 5] An extremely challenging hole to finish the front nine. The golfer hits from elevated tee boxes near the quarry ridge, where they must decide on whether to try and clear the creek connecting the water hazards, or lay up on a slight downhill slope. The elevated green, perched near the edge of the quarry face, demands an accurate approach shot on the uphill portion of the hole. The front portion of the dogleg plays in a southwest direction, with a slightly southeastern approach to the green. [g 4150ft^2 fw 64yds]

Front Nine Yardage **- b3413 m 3159 f2860 yards** ***Par*** **36**

Hole 10 **[b427/ m400/ f360 yards par 4]** Parallels hole 1 in the tee-off direction, and elevation change, except the hole doglegs slightly right for the second shot. The second shot must clear a water hazard, which also skirts the front portion of the green. So a longer first drive, which can stay to the right of the fairway, but out of the large sand trap, is rewarded with a shorter water carry. A bail-out area to the right of the water hazard is provided for less adventurous golfers. However, the green's main axis is angled to accept the shots from over the water much more easily than from the narrow portion of the fairway around the water, which is also guarded by various sized bunkers. [g 6660ft^2 fw 62yds]

Hole 11 **[b418/ m388/ f348 yards par 4]** A sharp dog leg left, playing south then east. The tee shot must avoid the parallel water hazard and fairway bunker to the left , while the earthwork along the quarry face also slopes toward the water hazard. The second shot is the toward a slightly elevated green, which is set against the backdrop of a buttress-like ridge with the old kiln perched upon it. [g 4830ft^2 fw49yds]

Hole 12 **[b169/ m147/ f136 yards par 3]** A mid-length par 3, this hole plays east and uphill, similar to hole 8. The tee shots first must avoid the kiln and the quarry wall, which protrudes from the right into the front portion of the fairway. The elevated green is relatively small and close to the quarry face, while the area to its left and back left corner are guarded by bunkers, forcing the golfer to make an accurate tee shot. This hole has an elevation change of approximately ten feet. [g 6420ft^2]

Hole 13 **[b401/ m369/ f316 yards par 4]** This hole is reached after a 100 yard walk past the parking area. This hole commences the portion of the back nine into the wooded part of the site. This front part of the hole plays parallel to the rising natural topography (east to west) of the site, with fairway traps framing the optimum approach line to the green. The slope of the fairway rises east to west, with the dog leg portion playing slightly downhill, in a northeastern direction. [g 3400ft^2 fw 55yds]

Hole 14 [b391/ m369/ f314 yards par 4] A left-turn dogleg, this hole's green is situated behind the creek bed, and is guarded on the left by a sand trap, so an accurate approach shot is required, or the golfer may be playing out of the seasonal hazard (it will be allowed to fill with spring runoff) or bunker. The hole plays slightly downhill for its entire length, moving in a south then southeastern direction. [g 3400ft^2 fw 46yds]

Hole 15 [b140/ m120/ f109 yards par 3] A straight forward, short par 3, the hole rises very slightly from tee to green, and plays toward the northwest. The green is framed by a mounded trap to the left, and a pot bunker to its front right. [g 5660ft^2]

Hole 16 [b506/ m476/ f429 yards par 5] A par 5, playing in a northerly direction and doglegging slightly to the right, this hole's fairway rises moderately from the east to the west. Fairway bunkers frame the fairway for tee shots, while a mounded bunker warns golfers to stay to the right side of the green which is small to challenge approach shots. [g 3400ft^2 fw 46yds]

Hole 17 [b162/ m138/ f122 yards par 3] A mid-length par 3, this hole plays slightly uphill to the southwest, with a raised green as a target. A large sand trap will catch any overly short shots to the left of the green, while a pot-style bunker will penalize any shots short and to the right of the target. [g 6150ft^2 fw 45yds]

Hole 18 [b470/ m442/ f394 yards par 5] The tee shot plays slightly uphill to the northeast. An overly long shot is penalized by the water hazard which runs along the right side of the dog leg portion of the hole toward the green. Playing southward along the last portion of the hole affords the golfer a scenic view across the water pond, onto the quarry. [g 4530ft^2 fw 50yds]

Back Nine Yardage **- b3084 m2844 f2528yards** ***Par*** **- 34**

Total Yardage **- b6497 m6003 f5388yards** ***Par*** **- 70**

9.2 EXCAVATION PLAN

The excavation plan (Diagram Seventeen), shows the area (in hatch) which is to be blasted down to a lower elevation than the existing floor of the quarry. The dashed line indicates the extent of the area to be blasted and excavated. Arrows indicate the basic drainage patterns that are to be implemented after the blasting. Large amounts of blasted rock rubble will be left in these areas to act as a sort of dry well, with overburden being lain over top to the grade indicated in Diagram Fourteen. In this case the blast lift may be approximately 2.8 - 3.5 metres deep, depending on the rock stratification, so at this point, the grading figures for the areas within the new

excavations are approximate.

There are three reasons for this additional blasting : additional blasting will create instant relief within the otherwise flat quarry floor; the poorer quality rock can be used as a base shaping medium, providing an excellent drainage base for the overburden on top, with any excess being sold at a profit to the quarry operators; thirdly, the deeper blasted areas will provide points and areas for runoff and/or wells for tree planting.

10.0 COSTS AND INCOME

10.1 CONSTRUCTION COSTS

Service (Power) for Pumphouse
(Approximately 350 metres @ $ 44/m. $15,500

Clearing

Clearing and Grubbing
20 acres @ $1500 per acre $30,000

Earthwork

Rough Grading
Government NIL

Mulder $250,000.00

Shaping $500,000.00
(Greens, tees,& fairways)

Bunkers $4000.00

KILNRIDGE GOLF COURSE

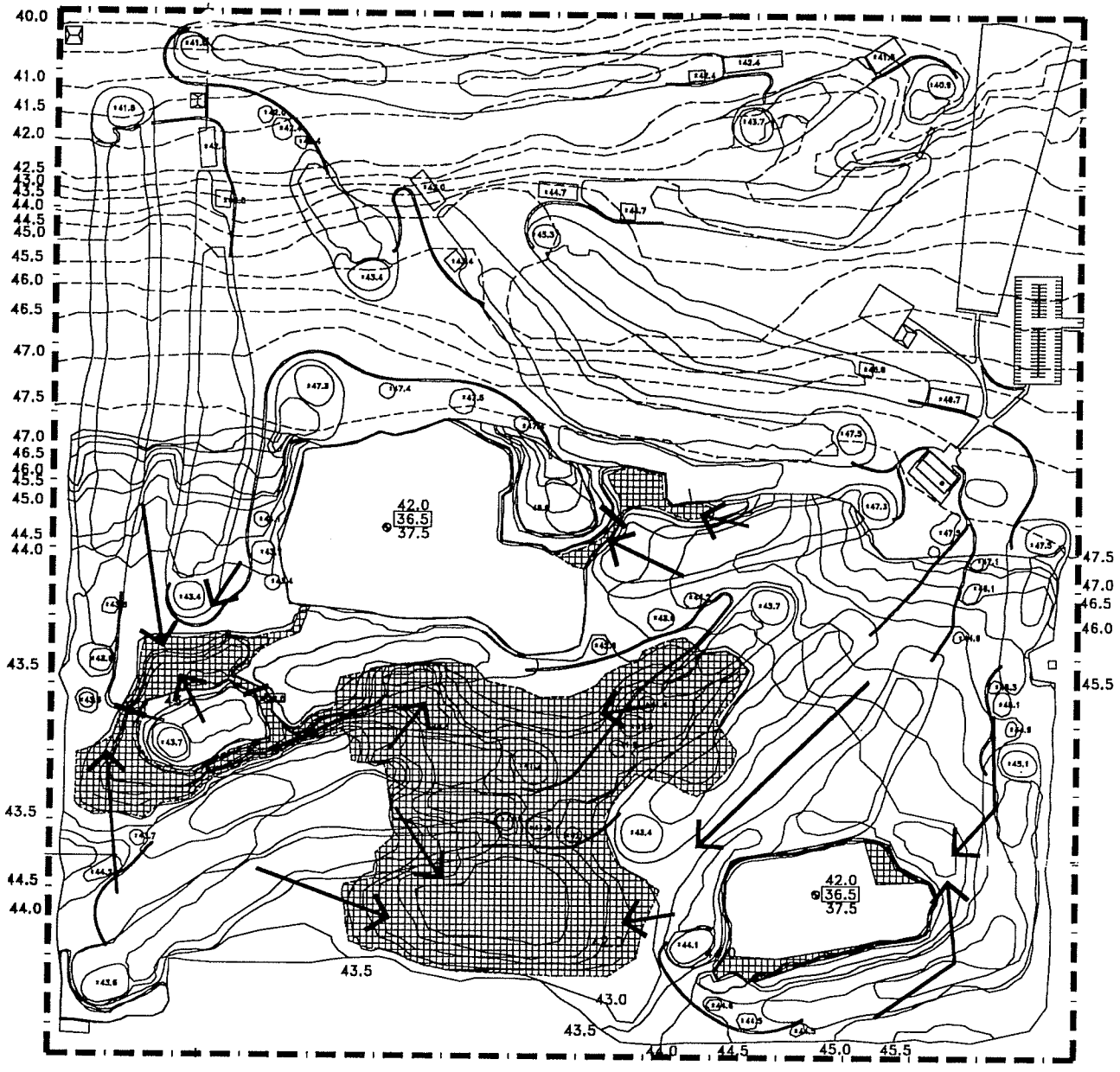


Diagram Seventeen

Excavation Plan

- **Extent of Excavation** - - - - - - - -
- **Area of Excavation**

0 25 50 100 200m

Materials

Irrigation System (Fully Automated)	$325,000. (using high density poly-ethylene piping)
w/ central control & software	$ 350,000.00
Pond Liner	
Approximately 38,000m^2 needed	
@ $8.00m^2	$305,000.00
Clubhouse & Facilities	$475,000.00
(3000 ft^2 clubhouse [@ 100 ft^2] & 2 X	
1600 ft^2 maintenance [one for superintendent,	
and maintenance, with a cart storage compound	
- other for storage only]	
Parking lot & cart storage area(gravel)	
3460 yd^2 @ $10 per yd^2	$34,600.00
Sand (Greens and Bunkers)	
3650m^3 @ $12.50	$45,625.00
Topsoil	NIL
(from nearby site)	
Start up Costs	
Machinery, etc	$325,000.00
Soft Costs (flags, benches, washers etc..)	$10,000.00
Grow in Costs	$125,000.00
(Superintendent salary, seed, fertilizer & misc.)	

Planting

Native	30 acres	$90,000.00 (labour included)
Holes & Driving Range		
fairways	108726m^2	$16,000.00
roughs	99118m^2	$5,500.00
greens & tees	10771m^2	$2,500.00
range	11447m^2	$700.00
surplus seed to overseed		$8,000.00
pre-planting fertilizer		$15,000.00
seeding & fertilizing labour		$20,000.00

Trees and Shrubs

Approximately 350-400 trees within golf course@ $200.00 per tree (specimen-planted)	$80,000.00
Approximately 300 shrubs @ $50.00 per shrub (planted)	$15,000.00
Edge planting approximately 150 trees and shrubs planted under Quarry Rehabilitation Fund	NIL

TOTAL CONSTRUCTION COSTS **$2,723,425.00**

(Sources: Grant / Morgan / Olson / Peters)

10.2 MAINTENANCE COSTS

Maintenance costs will vary from course to course depending on the intensity of grooming that the course superintendent or players demand. Factors in maintenance costs include: labour; fertilizers and other top dressings; fuel; and seed along with other less expensive items.

Based on a nine month contract maintenance costs for an eighteen hole golf course can be expected to run from $250,000.00 - $400,000.00. Of this amount, approximately 2/3 of the costs will go to labour (Olson/Peters/Grant).

10.3 EXPECTED INCOME

Income for the development will be based on the revenues generated by golf only. Therefore, the exploration of other potential revenue sources, such as the rental of the clubhouse facilities, will not be included in the scope of this study.

The numbers of rounds played on golf facilities in Manitoba will vary depending on their location, the weather experienced during the golfing season, and the type of facility it is (ie. public or private). A general range of 25,000-35,000 rounds per season can be used as a rough base for calculating income for a golf development (Don Craig, Manitoba Golf Association, 1995). Green fees for most public courses around the Winnipeg region vary from $15.00 - $20.00 during the week, and $20.00 - $30.00 during the weekend.

If the range was to be averaged at 30,000 rounds per year based on a $20.00 green fee, the income for the development for a particular year could be roughly estimated at approximately $600,000.00 per annum.

■ PART FOUR: CONCLUSION

Quarry operators in today's world face far more responsibility for their actions than in years gone by. No longer can they walk away from an operation without any form of remediation or plan in place. Quarry rehabilitation is a practical and resourceful way of facilitating this type of change in one land use to another. Although the economic nature of limestone quarrying does not always allow for long range planning, a small list of a compatible land uses should be decided on before the quarry has become depleted. This allows the rehabilitation process to make the transition from the mining process to a suitable land use much more smooth and effective .

This study has examined aspects of golf course developments to see if it would be a compatible land use to be considered for a site with a limestone quarry on it. By analyzing the physical and economic parameters of golf, it appears that the two are compatible if development methods specially suited to a quarry are employed.

Any development for a quarry environment, including a golf course, must utilize a proper management guideline to accomplish its goals. The management guideline used helped to ensure that proper steps were followed to identify any constraints or opportunities of the site, address and review any issues pertinent to both land uses, implement a development strategy, and ensure proper timing for items such as permits, and environmental reviews (if the development proceeds). It also helped to identify development considerations, such as any environmental impacts generated by the construction of a golf course in a quarry, would present. Water table contamination, proved to be the greatest concern, and mitigation methods were implemented to ensure safety of the resource from the proposed development.

Although the final cost of building an eighteen hole golf course will vary widely depending on each site and the expectations or desires of the developer, an average cost range is generally from 2 - 2.5 million dollars (Olson, 1995). With a rough estimate of 2.7 million dollars, the expected cost to construct this particular design is on the higher end of the scale. However, this can partially be attributed to developing within a quarry. The necessary use of expensive pond liners drove up the projected costs considerably, while the massive amounts of earth moving required for reshaping the quarry floor was another large expense. Proposing the use of native plant material also increased the start-up costs by nearly $100,000.00, although it should be noted that future maintenance costs for those areas would be greatly reduced as a result of their minimal requirements after establishment. Areas of potential cutbacks to bring down the costs could include reducing the scale of the proposed clubhouse facility, and the native habitat areas. Another part of the design that could potentially be examined, is to see if the fairway and green areas can be reduced in size. Although this is not desirable, and was not examined in the scope of this study, it may prove to be an economic necessity if the development was to proceed.

Several parties could also potentially benefit from a golf course development if it were to proceed. The municipality would benefit from a new attraction and tax revenue source. The Provincial Government Agencies would be relieved of monitoring one less quarry operation, and would be left with a prototypical rehabilitation project

from which other similar operations could base planning procedures on. The towns nearest the course (Stoney Mountain and Stonewall) could potentially see offshoot business through increased vehicular traffic. Society would benefit by having a green space, where there was none developed, while golfers would have a new and unique course on which to play.

Although golf is an ancient pastime, and quarrying an even older activity, they are both being obliged to adapt to today's realities. Land use conflicts and environmental awareness are forcing quarry operators and course developers to re-examine their goals and expectations of what can and cannot be done. Hopefully, this study has demonstrated that these two divergent land uses can be merged within the framework of an appropriate process to produce an unique amenity to be enjoyed by people of all ages.

■ APPENDIX A : GOLF COURSE DESIGN PRINCIPLES

GOLF COURSE DESIGN

The architecture of golf courses requires judgements in visual design concepts, technical and construction knowledge, and an appreciation of the player's view of the game. Whether or not a course is judged to be good is subjective. However, a good courses will constantly provide an interesting game of golf, have aesthetic appeal, and will be easily maintained. This appendix lists some of the basic components in golf course design. It is a rudimentary overview, with complete books being dedicated to this complex subject. The following material is meant to be an accessory to the subject matter and should be considered as such, and not as a complete overview of the subject. The list of references contains works with more extensive writings concerning the game of golf.

Basic Design Guidelines

Property Selection

There are various factors in selecting a piece of land on which to build a golf course. In the time until the 1960's courses were built on land that was ideal for the game. During that time, however, developers began selecting property with residential development, not golf, as their main concern. This is still true today, with the rest of the courses developed by private or municipal sources on land so poor they cannot be used for any other purpose, making the land cheaper to acquire.

The main factors for evaluating property are acreage, topography, soils, vegetation, and important in today's world, any environmental considerations concerning the property.

Acreage

An eighteen hole course and practice facility will generally require a minimum of something near 150 acres. This figure is increased if there area extensive wetlands, steeply hilled areas, or if the parcel of land is oddly shaped so that there is no room to get holes in and out of any corners. (Sources: Doak \ Handbook of Landscape Architectural Construction)

Topography

Besides the proper acreage, topography is the primary quality of any property being considered for course development. If the topography is ideal, almost no heavy construction will be needed, except from the shaping of the greens, tees, and bunkers. This factor reduces the costs of development significantly.

The hillier a property is, the more acreage will be needed to lay out a workable course. Long slopes of 10 percent generally cannot be used within the closely mown area of the course, because a golf ball will continue to roll until it reaches a flatter spot. Steep slopes can generally only be taken up in areas just off the foot of the tee boxes.

Also if a course has a large elevation change over the length of the course (150 feet

or more), it will be strenuous to walk (Doak , 1992, p.16). A greater difference is workable if the course is stretched out on a line, or if carts are used (which would eliminate it from any tournaments,where players must walk).

Soils

Sandy loam is the ideal soil type for golf courses, as it retains moisture well, but also provides enough drainage for courses to be able to stay open after heavy rains. For the same reason it limits any construction delays from wet weather.

With modern construction practices, courses can be built on virtually any type of soil. Construction costs, however, get driven up, and some soils may prevent turf from reaching proper playing conditions. Pure sand can even be used to build a course on with the modern irrigation systems used today. Most modern greens built on bases of pure sand. However, the advantage of good drainage and easy shaping using sand can be offset by the quick leaching of fertilizers and chemicals, requiring more frequent applications.

Heavy soils, such as the clays found in much of southern Manitoba, have more inherent problems. During droughts, unirrigated areas may become dry and cracked causing balls to run on excessively. In wet weather, the same soils may lead to standing water or extremely soggy situations, making mowing difficult, and causing golf cart damage.

Shallow rock is also another situation that may be encountered. Blasting out any rock is a costly proposition, however, there must be approximately three feet of earth between the irrigation lines and the finished grade of the fairways. If any part of the piping is in rock, the development costs will rise astronomically.

Vegetation

Native vegetation can add immeasurably to the character and beauty of a golf course. Holes can be cleared through the forest, but trees along the edges of the clearings, previously unexposed to the elements, are subjected to new stresses. A property with natural clearings might also change the development costs, as clearing through dense woods can cost as much as $3,000 per acre (Doak, 1992, p.19).

Natural ground covers, such as grassland areas or even desert conditions should also be evaluated for their potential. By leaving these natural areas undisturbed construction and maintenance costs can potentially be reduced.

Environmental Considerations

Even if all the situations listed previously are favorable toward a golf course development, it may be impossible to build a course, due to environmental restrictions.

The most common problem encountered is that of securing the water supply for the course. With large irrigation requirements, a reliable water source must be found. Small streams or ponds cannot sustain the volume needed, so large lakes or underground sources are the alternatives. The use of effluent is even becoming more common as an irrigation source, but again must be large enough for the demand. Also reliance upon municipally-controlled sources can mean rationing in times of

drought.

Ecologically sensitive areas such as wetlands are also potential problems to be avoided as much as possible. Property considered valuable wildlife habitat, or archaeologically significant may also have restrictions placed upon them by environmental agencies.

Routing

The golf architect's primary task is to route the 18 holes through the parcel of land, taking advantage of the site's best assets.

A search to find the best routing for a property is subjective, since no two people can agree on the composition of an ideal golf course. Different routing plans should be tried to see which is the most appropriate to the site, and its development priorities (ie. How the course will work with any other components of the development: an example would be a housing development with a golf course). Trade-offs are inevitable and must be weighed for their merit.

The routing of the course should also reflect the needs of the target clientele of the proposed golf course, as well as the design philosophy of the course architect.

The plan usually revolves around the topography and making the holes interesting. Undulations in the groundwork make the game more attractive, and should be used if occurring naturally.

Working with any topographic information, the course can be laid out by locating the greens first on a plan and then working backwards. High and low points can be identified and then worked into the course plan. Many natural holes may be found this way, because the same features may be used in differing schemes. The holes after suggesting themselves must be worked into suitable loops of nine or 18, either by; extending walks between holes; by laying out holes on less than ideal terrain; or by intelligently shaping the earth to extend holes or to occupy the space between them.

Sequence and Length of Holes

The arrangement of the holes within the design, according to their individual par ratings and designs, is important to the golfers' enjoyment of the game. The normal sequence is to begin the course with a couple of relatively easy par four holes, to allow the golfers to 'warm up', and allow play to begin quickly and smoothly from the clubhouse. The front and back nine holes usually end with a challenging par four or five, which are intended to leave a lasting impression on the golfer.

While theoretically this should allow for a par five or three between every par four this is usually never possible. The designer has the opportunity to compensate, however, by designing the holes within their minimum to maximum lengths for their par rating.

The general theory is to provide distinct character between holes without duplication, and to keep the game flowing smoothly for all types of golfers who may play the course.

Length for golf courses in general can vary due to the fluctuation in hole lengths.

Diagram eighteen indicates a range for recommended course lengths.

	Par	Minimum yds.	Champion-ship yds.	Par 3 holes	Par 4 holes	Par 5 holes
18 hole Regulation	70-72	6200-6500	6700+	4@ 130-200 yd.	10@ 350-470	4@ 471-550
9 hole Regulation	35-37	3000-3200	-	2	5	2

DIAGRAM EIGHTEEN: Recommended course lengths (National Golf Foundation, 1978, p.65)

Design of Golf Holes

The United States Golf Association has set rough guidelines for the lengths of holes to which the various pars are described. For men, a par three is up to 250 yards, a par four is 251 to 470 yards, and a par five is anything longer than that. For women, a par three is up to 210 yards, a par four is 211 to 400, and a par five is 401 yards and greater.

In today's game, it is not fair to discriminate men from women, because there may be many instances where stronger women players will play the same course length as high-handicap male players. So the tee lengths should not be used to differentiate between men and women, but only indicate the difference between the different tee positions.

Par Three Holes

A par three is essentially a one shot hole, with the tees hazards and green all within easy visible reach. The golfer must attempt to reach the green in one shot to reach par on these types of holes. Within the course design, there should be a variety of lengths for the holes, encouraging the golfer to use an assortment of club types.

Par Four Holes

Par four holes make up the majority of holes for a golf course. Therefore, they should have the greatest variety of the three hole types, which also makes them the greatest design challenge for the architect. With the par four holes the golfer attempts to reach the green in two strokes: the tee shot, and then the approach shot.

Par Five Holes

Par five holes are basically a long par four, with changes in club technology making it a birdie type hole for the scratch player. Diagram nineteen illustrates basic dimension guidelines for the par four and five holes.

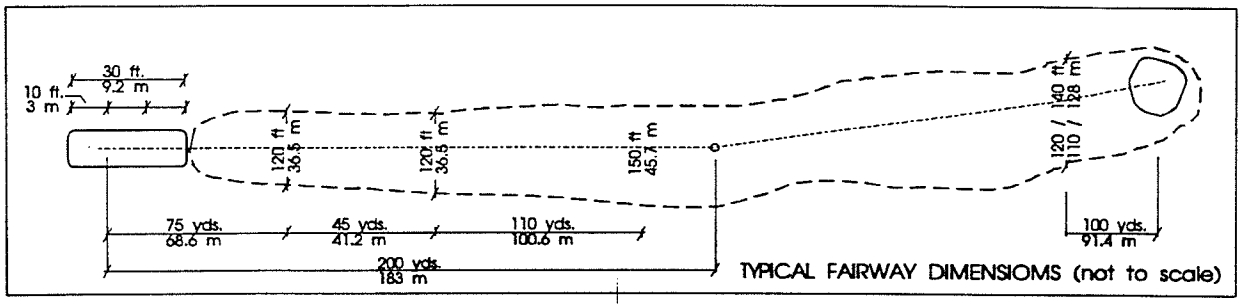


DIAGRAM NINETEEN: Typical fairway dimensions (Handbook of Landscape Architectural Construction, 1976, p.463)

Greens

In a perfectly played par round, half the strokes will be putts, and the ability to get approach shots or chip shots to hold on the green will be affected by the design and maintenance of the greens.

Proper green design concerns two separate but interlocking issues: how the green complex affects approach play, and how the surface of the green will present any difficulties in putting.

A well-designed green is composed of a series of reverse curves, with convex flowing into concave. These green contours should be subtle and blend into the surrounding landscape, making the green look as if it had originally been situated there. The greens may also be built in two levels, with one flowing into another. Again, it is imperative that the change between the levels be natural and not too severe, adversely affecting any normal play.

The orientation, shape and slope of the green should also relate to how the hole is to be played, and the possible strategies for the approach shot. This presents an unlimited number of possibilities of ways that the designer may experiment with green shape, depth, and contouring.

There is no rule of thumb for determining the minimum size and dimensions for a green. Generally, a more shallow green is used for short approach shots, with deep ones for long approaches. The long axis is usually placed on line with the approach shot. Any single green of less than 3000 ft^2 is likely to cause maintenance problems through concentrated wear and tear. The size of the greens will should reflect the expected traffic flows, but generally should fall into the 4000 - 5000 ft^2 size range, with smaller greens being the exception (Source:Doak / Olson).

Other aspects of green design that should be considered are traffic patterns, and possible pin placements. Sod compaction and strategy are offshoots of these problems, and should be addressed. Diagrams twenty to twenty-two illustrate these concepts.

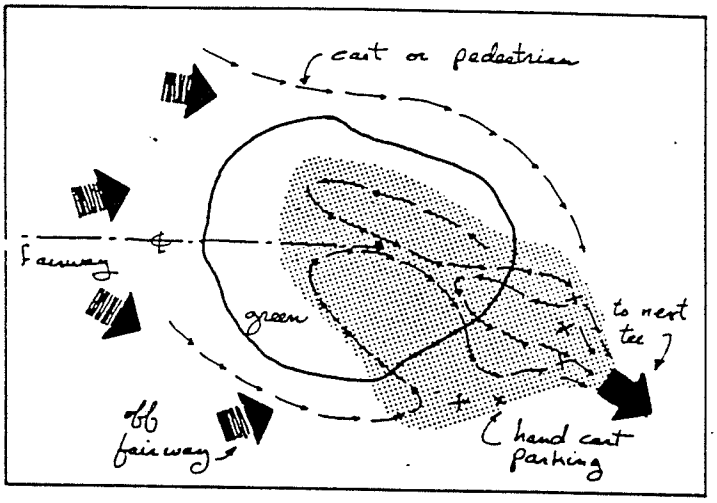


DIAGRAM TWENTY: Shaded areas indicate typical circulation areas with arrows indicating traffic flow direction (Handbook of Landscape Architectural Construction, 1976, p.465) .

Fairways

The fairways, like the greens, should reflect the natural character of the land forms the course is laid out on. The overall shape and composition of the fairways will typically be tied to the strategy behind the design for the hole.

The fairway designs will often present the golfer with various options on

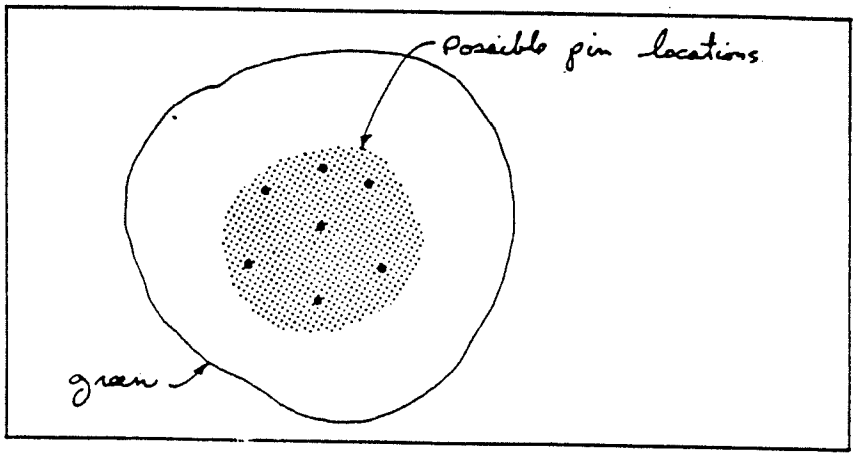


DIAGRAM TWENTYONE: Circular greens limits the possible pin positions (Ibid, p.465)

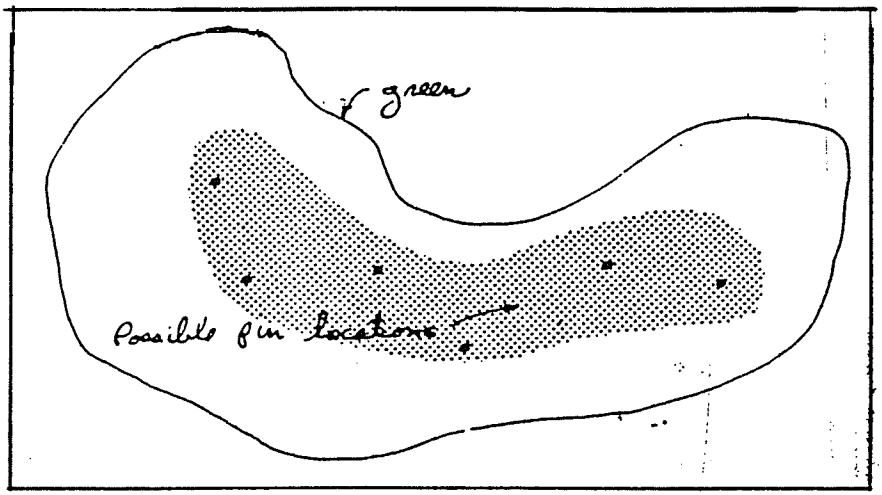


DIAGRAM TWENTYTWO: Irregular shaped green provides greater opportunity for variety in pin placement (Ibid, p.467).

how to approach the hole by altering the direction and length of their shot. Players of less ability must have the option of taking routes to the green which are less hazardous than the ones that may be attempted by the more accomplished player. Thus, players of varying ability may get enjoyment from a hole through different routes to the green through or over any hazards designed into the fairway.

One method course designers use to vary the use of too many straight holes is the offset or dogleg hole. It is crucial in designing the dogleg to know how far golfers can be expected to hit their drives, and to allow for the differences between the stronger and weaker players. Since tournament proffesionals now drive 250 - 300 yards, and high-handicappers anywhere from 150 yards on up, the dogleg hole is becoming harder to reconcile between the two (Doak, 1992, pp 125). Diagram twenty-two illustrates the standards sets out the average hit and roll lengths for different types of golfers (National Golf Foundation,1992).

Within the fairway, the grasses are mown to varying heights to indicate the optimum line to the hole. Roughs of moderate height grasses then provides a suitable partial-stoke penalty for driving out of the fairway. Without some distinction between fairway and rough, the player would always take the shortest route to the hole: the direct line. By mowing the fairway in curves reflecting the topography, or in twists and turns offset from the direct line, the game becomes more interesting. The fairways cut in irregular curves will look more natural, and will also provide placement clues in assisting the player to locate any balls in the rough.

SHOT LENGTH TABLE -- Men and Women (All Distances in Yards)					
Length of Shot		Scratch Golfer		Bogey Golfer	
		Men	Women	Men	Women
Drive	Carry	225	190	180	130
	Roll	25	20	20	20
	Total	250	210	200	150
Distance Covered After 1 Shot		***250***	***210***	***200***	***150***
2nd Shot	Carry	200	170	150	120
	Roll	20	20	20	10
	Total	220	190	170	130
Distance Covered After 2 Shots		***470***	***400***	***370***	***280***
3rd Shot	Carry			150	120
	Roll			20	10
	Total			170	130
Distance Covered After 3 Shots				***540***	***410***

DIAGRAM TWENTYTHREE: Suggested shot lengths for different golfers (National Golf Foundation, 1991)

Tees

The tee is the beginning point for every hole, and great importance is placed on the condition and aesthetics of the tees to leave a lasting impression on the golfers. The tees should be designed to be in harmony with their natural surroundings. This often requires the use of multiple free-form tees, unless space limitations force the tee into a geometric form.

Typically there are three to four different placements for the golfer to tee-off from. These alternate tee placements are meant to make the game more enjoyable and playable for every type of golfer. The provision of forward tees also has an economic benefit to the club. By shortening the course for the beginner, the architect reduces the length and acreage of fairway to be maintained. If using long rectangular tee boxes, the boxes must be orientated properly, and not set up so that the players align themselves off the fairway.

The size for the tee areas is primarily a function of traffic. Each hole should have a square foot of tee for every round played on an average month. This translates to approximately 3000 - 5000 square feet per hole . This suggested figure must be doubled on par three holes where divots are commonly taken. On

multiple tee grounds, fifty to sixty percent of the total area should be dedicated to the middle tee areas, twenty to thirty percent on the forward tee, with the remainder on the back tee. (Source: Doak, 1992)

Bunkers and Water Hazards

The hazard should consist of a natural site feature whenever possible. Bodies of water, existing sand areas, ridges or depressions all may present themselves as opportunities to shape the holes to fit the hazard.

Bunkers are built for a number of purposes. They can be used to penalize a missed shot, or to warn players of potentially worse situations outside of them. They can also be built for visual purposes, such as to assist a player in a blind shot situation, by indicating the proper line to pursue. Sand traps are a part of both traditional and contemporary golf and should be employed. Diagram twenty-three shows construction guidelines for the two types of bunkers most commonly used.

Water can provide the most dramatic moments or the most frustrating. Water,however, is not an ideal playing hazard. It creates an unplayable situation, when the nature of golf is to play the ball from where it lies.

Three factors should be considered when designing holes with water

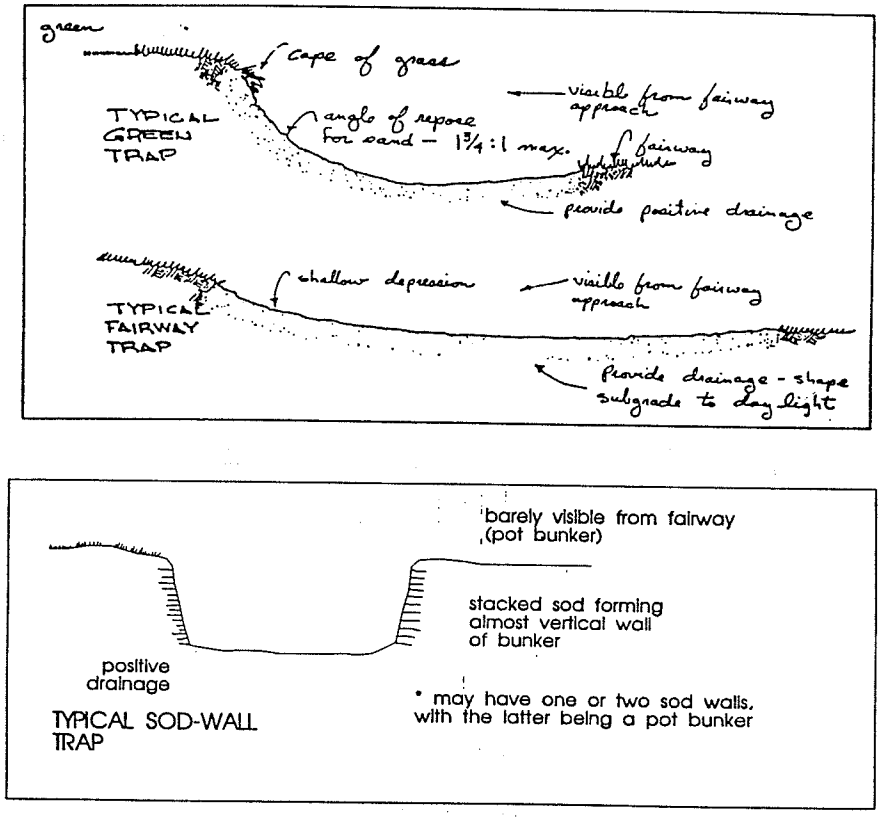


DIAGRAM TWENTY FOUR : Construction of Bunkers (Handbook of Landscape Architectural Construction, 1976, p.465).

hazards in them: the hazard must be visible; there must be a way around the hazard for the beginner player; and the effect of the hazard should be maximized for the scratch golfer, who usually easily escapes from bunkers.
(Source: Doak, 1992)

Design philosophies

The most simplistic approach to design is to lay the hazards out from the tee forward to the green, placing bunkers to punish players for a topped drive, a hooked or sliced shot, or an off-line approach. Since the purpose is to punish a poor shot, this style of design is known as the "penal school of architecture". An example of this is the severe bunkering and sand traps of Hole Two at Pine Valley (Diagram Twenty Five).

Since the early 1900's the choice of designers has been the "strategic school of design". The approach of this philosophy is to reward a good shot with an improved or advantageous lie for the second or approach shot. For example, a green may heavily defended or tilted on one side, so that there is a distinct advantage to placing a drive in a certain part of the fairway. This is the case of Hole Three at Sunningdale Course in England (Diagram Twenty Six).

The "heroic school" of design is an offshoot of the strategic: a clear advantage is gained on the approach shot from a long carry from the tee. The ideal form of the heroic hazard is diagonal, so that every player has the opportunity carrying their chosen portion of the hazard. The best courses are actually those which borrow from all three approaches, lending variety to their designs. Pete Dye's design for the first hole at Long Cove rewards a long drive with a shorter, more direct line to the green. A massive sand trap runs along the hole to the right, tempting players to try and cut across it at the furthest point possible toward the green, rewarding or penalizing the risk taker (Diagram Twenty Seven).

Construction and Maintenance

The construction of an eighteen hole golf course is an enormous undertaking, requiring the preparation of hundreds of acres and the expenditure of millions of dollars. However, over the course of time, greater sums will be spent on the maintenance of the course. It is imperative, therefore, that proper construction procedures originally be followed order to alleviate any future problems.

The construction process is not a linear series of steps, but overlapping ones, done in the following order:

1. Permits and Engineering.
2. Design, including irrigation design and pumping station.
3. Clearing if needed. This is often accomplished in two phases, with an initial narrow clearing line down the centerline, after which the hole may be shifted to avoid specimen trees before final clearing limits are determined.

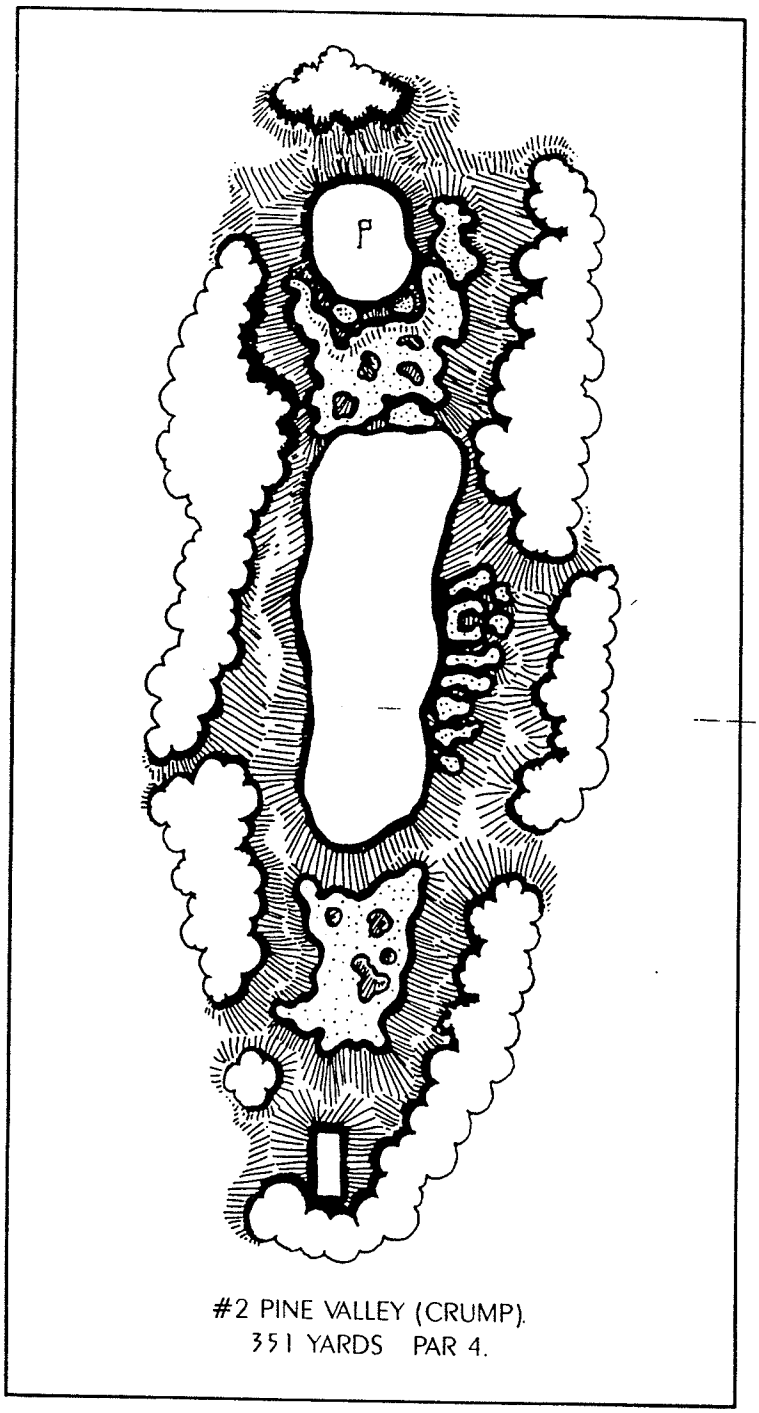


DIAGRAM TWENTY FIVE (Doak, 1982, p.67)

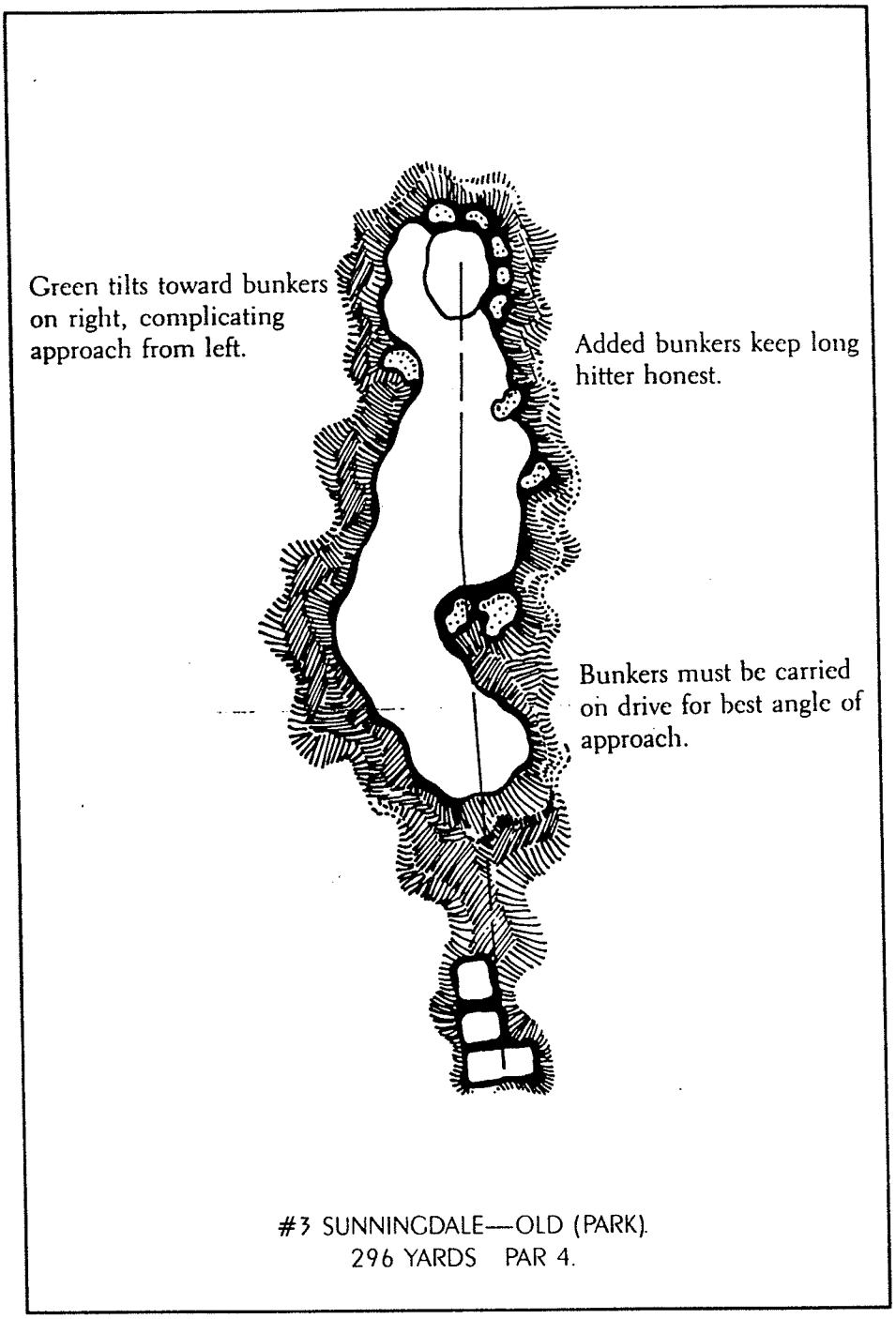


DIAGRAM TWENTY SIX (Ibid, p.68)

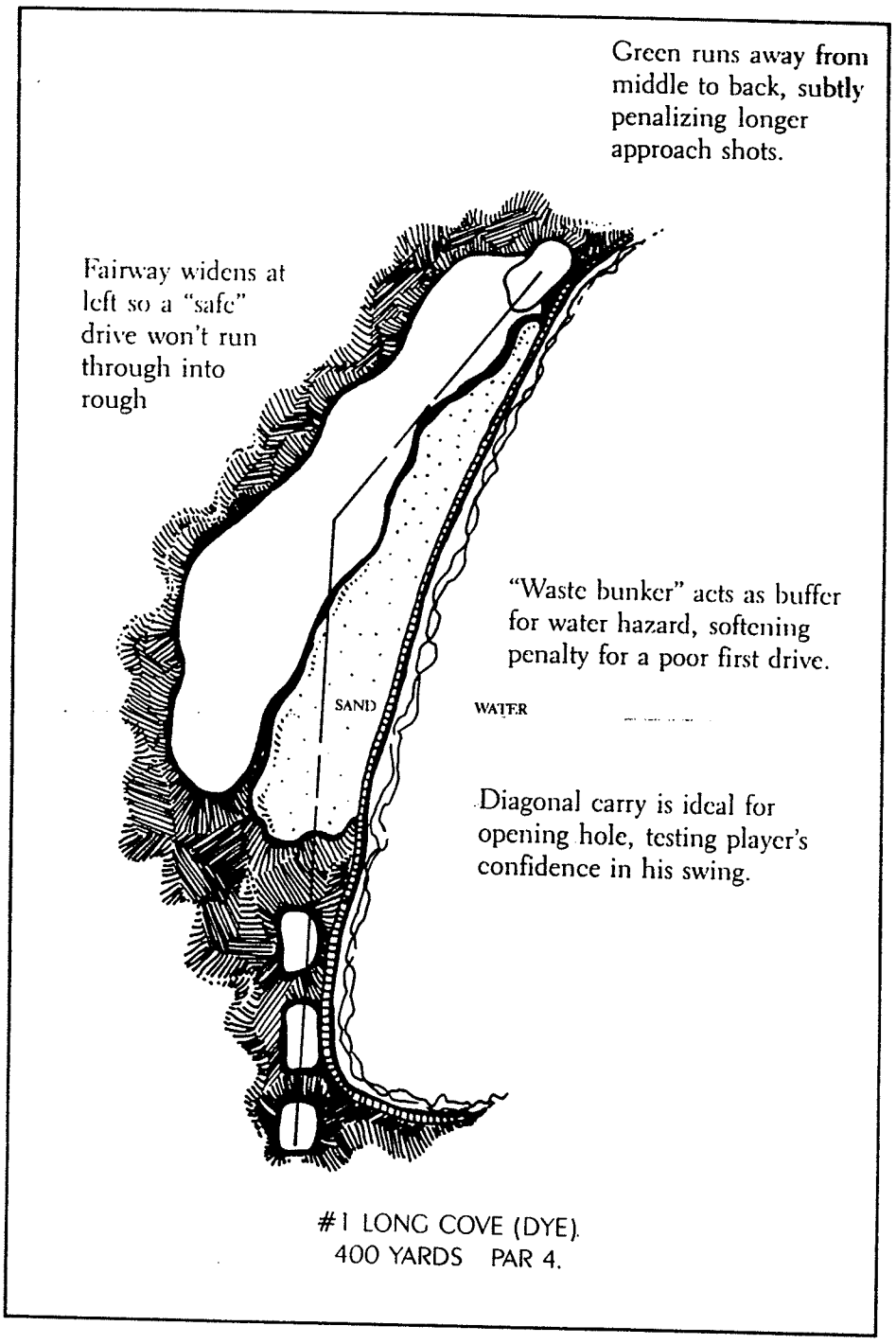


DIAGRAM TWENTY SEVEN (Ibid, p.70)

4. Grubbing, and the removal of roots and ground cover.
5. Heavy earthmoving.
6. Shaping of features(greens,tees, mounds, bunkers, etc.).
7. Drainage installation, including tile under greens and bunkers.
8. Irrigation installation.
9. Final grading of all surfaces, including installation of greens mix.
10. Construction of cart paths.
11. Seeding, and/or sodding.
12. Grow-in.

(Sources: Doak / Love / Olson)

The golf course architect must be careful not to design features which are difficult to maintain. Course maintenance is already under pressure to maintain the 'perfect look' year-round to appease members expectations. The problem is that there is a law of diminishing returns on extreme maintenance. For example, if a golf course spent $300,000 per year to get the turf 85 percent perfect, it probably will take another $300,000 to improve it another 10 percent (Doak, 1992, p.206). Additionally, artificial maintenance practices will look out of place if the architect has designed his course to fit into the natural landscape.

The answer may simply lie in lower expectations of the golfing public, the superintendents, and course architects, to what standards golf courses should be maintained at. In this way the cost of golfing may stay accessible to the 'average person'.

■ APPENDIX B : QUARRY REVEGETATION

REVEGETATION GUIDELINES

Selection of Revegetative Species

One of the most critical steps of the rehabilitation process is the selection of plant species to be used on the site. The species selection must reflect the future use(s) of the site and its goals. For example, if the site is to be rehabilitated for livestock grazing, then the species selected should be useful as a forage crop. In this study, it was determined that a golf course was to be the end use for the quarry so any species should be selected with that use in mind.

Proper revegetation of the site will be essential for providing the designated areas with permanent vegetative cover, preventing erosion, and transforming the quarry portion of the site into a more ecologically productive area. For these reasons species selection will involve the following general parameters:

- Rehabilitative Value of the Species

This will include physical and biotechnical characteristics of any species being considered. For example, deep rooting type plants may be desired for slope stabilization, or nitrogen fixing plants may be needed to improve soil conditions.

- Physical Requirements of Species

Soils put back into the quarry, are usually not soils in a pedological sense, but a jumbled overburden,with all layers mixed into one blend. The texture, depth, fertility, permeability, water retention capacity and pH of the soil should be analyzed to help in deciding on plant species. For example, it would be futile to try and grow a species that prefers well - drained acidic soils in anything with a high clay content.

- Ease of Propagation

- Mechanical Limitation

Some species require specific planting requirements which may be unsuitable for certain areas within the site.

- Time of Planting

If planting is required to a specific time of the year, it may eliminate some species being considered which can not be propagated at that time.

- Species Compatibility

When a mixture of species are being planted, care must be taken not to plant competing species.

- Availability and Cost

- Nutrient and Maintenance Requirements

- Resistance to Disease and Insects

(Sources: Lowe/ Paterson / Watson, Parker & Polster)

One of the best ways to determine what species should be used for rehabilitation is to observe older quarries in the area, which have been recolonized by native vegetation. This may provide a list of species which are more naturally adapted to the conditions of a limestone quarry.

With these general guidelines in mind, a species list will have to be determined for the specific use of a golf course development. This will involve identifying plant lists for in and out of play areas. For a listing of potential grasses shrubs, and trees used for quarry rehabilitation and golf course fairways see Figures Twenty Nine A-C.

Methods of Planting

As the plant species are being selected, the method of planting must also be determined. In some cases, due to availability or site conditions the decision will already be made, however all alternatives should be considered. They are:

- Seeds

Planting seeds is usually the least expensive and most effective means for revegetating a site. Generally seeds should be used when the species can be expected to germinate easily and sufficient moisture for germination is expected. Seeding is best for large areas that require complete coverage. The disadvantages with seeding are that, it will not provide an immediate form of erosion control and, seed establishment is very dependant on weather conditions following propagation.

Generally there are two basic techniques for planting seeds; seed drilling or seed broadcasting (which also includes hydroseeding). The decision on which technique to use will depend on site characteristics, capability and availability of the seeding equipment, cost, and desired effect or look. Diagram Twenty Eight discusses the relative advantages and disadvantages of the different techniques.

Seed drilling is the superior technique when site condition permit it. Furrows are created by the drill, filled with seeds at a specified rate, and then covered back over with earth in one operation. Drilling can be conducted by either hand or machines utilizing specialized equipment.

The advantages of seed drilling include: the seed is set to the proper depth ; additional ground cover or mulch is not required; and soil compaction can be accomplished with packer wheels attached to the drill.

Limitations include that this machinery can only be used on slopes of 3:1 or less, and that the drills may not be durable enough for extremely rocky soil. Seed drills also must be calibrated according to what type of seed is being planted, with the possibility where all seeds may not be planted in one process occurring.

Characteristics	Drilling		Broadcasting			
	Machine	Hand	Hydroseeding	Other Machines	Hand	Aerial
Topography	Steep slopes and access are problems; if slopes are greater than 3:1, broadcasting recommended	Less limited	Can handle steep terrain, depending on distance	May be limited by steep terrain	Less limited	Unlimited
Obstructions	Limits use	Unlimited	Unlimited	Somewhat limited	Unlimited	Unlimited
Compacted Soil	Possible	Possible	Not acceptable	Not acceptable	Not acceptable	Not acceptable; soil must be rough enough for wind and rain to cover seeds
Seeding Depth	Variable and controlled	Variable; somewhat less controlled	Lays on top of the soil	No direct control; depends on soil	No direct control	No direct control
Seed Size	Variable if drills can be adjusted	Variable if hand-held machines can be adjusted	Small seed	Variable	Variable	Variable
Season	Limited by moisture	Limited by moisture	Limited by low expected moisture	Less limited	Less limited	Less limited
Precipitation	Slightly critical	Slightly critical	Very critical; more success when annual precip. exceeds 12-14 inches	Very critical	Very critical	Very critical
Soil Texture	Not critical	Not critical	Critical	Critical	Critical	Critical
Seed Distribution	Uniform	Uniform if person is well trained; seeds can be precisely placed	Less uniform	Less uniform	Not uniform but can be specific to one area	Not uniform
Mulching	Separate treatment	Separate	Same treatment possible but not advised	Separate	Separate	Separate
Cost	Medium	Depends on how many people needed	High	Low	Depends on number of crews needed	Low if surface area to be covered is extensive
Equipment	Special in some cases	Some hand-held equipment available	Scarce	Available	Some hand-held equipment available	Various types available; can be contracted out
Seed Rate	Less than broadcasting; drastically disturbed sites such as spoils require much heavier seeding rates than do sites where topsoil and some plant cover are intact. Examples: 10-15 lb/acre drilled on north-facing gentle slopes with small grass seed; 25-30 lb/acre if species seed is large; 40-45 lb/acre if conditions are severe, such as south-facing steep slopes	Same as machine drilling	More; as much as double the drilling rate	More	More	More; 1/3 more than drilling
Trash in Seeds	Must be cleaned from seeds	Must be cleaned from seeds	Cleaning not critical	Cleaning not critical	Cleaning not critical	Cleaning not critical
Time required/acre to seed	Middle range	High range	Low range	Low range	High range	Lowest

DIAGRAM TWENTY EIGHT: Advantages and disadvantages to different seeding methods (User Guide to Vegetation, 1979, p.40.)

DIAGRAM TWENTY NINE A

REVEGETATION SPECIES GUIDE	Adavantages & Constraints	Growth Habits	Soil Texture			Soil Drainage				Soil Fertility			Drought Tolerance
			sandy	loamy	clayey	dry	well drained	mod. well drained	poorly drained	low	high	medium	
Temporary Grasses													
Barley *Hordeum vulgare*	Can be used In rotation to prevent soil erosion		○	○	○		□	□					
Oats *Avena sativa*	Fast establishing cover crop retards soil erosion		○	○	○		□	□					
Rye *Secale cereale*	Fast establishing cover crop retards soil erosion		○	○	○		□	□					
Perennial Ryegrass *Lolium perene*	Rapid seedling growth, fast-covering nurse crop retards soil erosion	erect, tufted, 30-60 cm. tall	○	○	○		□	□			◇		●
Permanent Grasses													
Canada Bluegrass *Poa compressa*		erect, medium sod, former 30-60 cm. tall	○	○		□	□	□	□	◇	◇		○
Creeping Red Fescue *Festuca rubra*	Useful on dry, sandy, shady areas	loose, tufted	○	○	○	□	□	□		◇	◇	◇	○
Crested Wheatgrass *Agropyron cristatum*	Good slope stabilizer, large deep roots, suitable on dry slopes	erect tufted bunchgrass, 50-70 cm. tall	○	○		□	□	□		◇	◇		○
Kentucky Bluegrass *Poa pratensis*		dense sod - formerly 30 - 80cm.	○	○	○		□	□	□		◇	◇	●
Western Wheatgrass *Agropyron cristatum*				○	○		□	□	□		◇	◇	○
Tall fescue *Festuca elatior*	One of the best grasses for poorly drained soils, remaining green	tufted bunchgrass to 100 cm.		○	○		□	□	□		◇	◇	○

Legend

Drought tolerant ○
Not Drought tolerant ●
Moderate tolerance ◑

DIAGRAM TWENTY NINE A

REVEGETATION SPECIES GUIDE	Adavantages & Constraints	Growth Habits	Soil Texture			Soil Drainage				Soil Fertility			Drought Tolerance
			sandy	loamy	clayey	dry	well drained	mod. well drained	poorly drained	low	medium	high	
Permanent Grasses	**cont.**												
Orchard Grass *Dactylis glomerata*	High requirement plant	tufted bunch-grass 60-100cm.	○	○		□	□	□	□		◇	◇	◑
Timothy *Phleum pratense*	Establishes easily, very hardy, inexpensive seed	erect bunchgrass	○	○	○	□	□	□			◇	◇	●
Reed Canary Grass *Phalaris arundinacea*	Does well on poorly drained land	Tall, coarse grass,.6-1.5 m	○	○	○		□	□	□	◇	◇		○
Smooth Brome *Bromis inermis*	Early sring growth, good ground cover for slopes	Tall, leafy	○	○	○	□	□	□	□		◇	◇	○
Redtop *Agrostis alba*		Low growing, to 60cm.			○	□	□	□	□	◇	◇		◑
Legumes													
Crownvetch *Coronilla varia*	Requires 2-4 years to establish. Hardy once established					□	□	□			◇	◇	
Dutch White Clover *Trifalium repens*	Shallow root system	Low, creeping		○	○		□	□	□	◇	◇		●
Alfalfa *Medicago sativa*	Well adapted to lime soils, ideal soil improver	slender,erect, up to 1m.	○	○	○	□	□	□			◇	◇	○
Birdsfoot Trefoil *Lotus corniculatus*	Adapts to poor soils, soil stabilizer	Sililar to alfalfa, 30-75cm.	○	○	○	□	□	□	□	◇			◑
Red Clover *Trifolium hybridum*	Easy to establish, fast growing	erect or spreading, 40-80cm.	○	○	○	□	□	□		◇			●

Legend

Drought tolerant ○
Not Drought tolerant ●
Moderate tolerance ◑

DIAGRAM TWENTY NINE A

REVEGETATION SPECIES GUIDE	Adavantages & Constraints	Growth Habits	Soil Texture			Soil Drainage				Soil Fertility			Drought Tolerance
			sandy	loamy	clayey	dry	well drained	mod. well drained	poorly drained	low	medium	high	
Legumes cont.													
Alsike Clover *Trifolium hybridum*	Nurse crop, short lived, non-spreading	erect to decumbant, 20-80cm.	○	○	○		□	□	□		◇		○
Sweet Clover *Melilotus spp.*	Excellent soil builder	Erect plant, .2-2.5m	○	○	○	□	□	□	□	◇	◇		●

SPECIES	Adavantages & Constraints	Growth Habits	Methods of Establishment	Soil Moisture			Soil Fertility			Drought Tolerance
				dry	moist	wet	low	med.	high	
Ground Covers										
Common Juniper *Juniperus communis*	Tolerates dry, shallow,infertile high pH soils	Low evergreen to 1m.	Cutting, seed, seedling,or small plants (up to 30cm. diameter (dia))	□	□		◇	◇		○
Creeping Juniper *Juniperus horizontilas*	Same as Common Juniper	Low evergreen, to 30cm.	Same as Common Juniper	□	□		◇			○
Mugo Pine *Pinus mugo*	Prefers moist soils, but tolerates harsher conditions	Conifer shrub to 3m.	Transplants up to 30 cm. bare root, balled and burlaped or container	□	□		◇	◇		
Virginia Creeper *Parthenocissus quinquefolia*	Requires 2-4 years to establish. Hardy once established	Trailing shrub, will climb with supports		□	□		◇	◇		○

Legend

Drought tolerant ○
Not Drought tolerant ●
Moderate tolerance ◑

DIAGRAM TWENTY NINE A

REVEGETATION SPECIES GUIDE	Adavantages & Constraints	Growth Habits	Methods of Establishment	Soil Moisture			Soil Fertility			Drought Tolerance
				dry	moist	wet	low	medium	high	
Shrubs										
Amur Maple *Acer ginnala*	Susceptible to lime-induced schlorosis.Good fall colouring	Deciduous shrub or small tree up to 5m	Cutting, seed, seedling,or small plants (up to 30cm. diameter (dia))		□		◇	◇		○
Caragana *Caragana aborescens*	Tolerant of very dry,rocky, infertile soils	Decidous (dec.)shrub up to 3m.	Same as above, as well as bare root cuttings	□	□		◇	◇		
Red osier Dogwood *Cornus stolinifera*	Native species, good quarry colonizer, red bark offers winter col;or	Dec. shrub up to 2m.	Same as above, as well as bare root cuttings	□	□	□		◇	◇	●
Silverberry *Elaeagnus commutata*	Fixes nitrogen in soil, adapted to dry, alkaline, infertile soils	Dec. shrub up to 2m.	Direct seeding, seedlings suckers, or bare root	□	□		◇	◇		◑○
Tatarian Honeysuckle *Lonicera tatarica*	Adaptible to poor lakaline soils, prefers moisture	Dec. shrub up to 3m.	Cuttings, small plants or bare root		□	□	◇	◇		◑
Potentilla *Potentilla fruiticosa*	Prefers sun, tolerates poor, dry soils and temperature extremes	Dec. shrub up to 1m.	Cutting, seed, seedling,or small plants	□	□		◇	◇		◑○
Snowberry *Symphoricarpos albus*	Tolerant of most cond-itions including high lime soils, coarse text-ured rockey soils	Dec. shrub to 1-2 m.	Cuttings, small plants or bare root	□	□		◇	◇		
Common Lilac *Syringa vulgaris*	Slow to establish, prefers moist soils	Dec. shrub to 3-5 m.	Cuttings,or small plants (up to 30cm. dia.), bare root		□			◇	◇	◑

Legend

○ Drought tolerant
● Not Drought tolerant
◑ Moderate tolerance

DIAGRAM TWENTY NINE A

REVEGETATION SPECIES GUIDE	Adavantages & Constraints	Growth Habits	Methods of Establishment	Soil Moisture			Soil Fertility			Drought Tolerance
				dry	moist	wet	low	medium	high	
Shrubs										
Nannyberry *Viburnum lentago*	Prefers moist or wet soils of medium fertility	Dec. shrub up to 3-6m.	Seed or cuttings, small plants ,or bare root		□	□		◇		◑
Highbush Cranberry *Viburnum trilobum*	Prefers good, moist soils	Dec. shrub up to 3m.	Same as above		□	□		◇	◇	◑
Saskatoon *Amelanchier alnifolia*	Tolerant of moderately alkaline soils, prefers open sites,light well drained soils	Dec. shrub up to 6m.	Seeds, transplants	□	□		◇	◇		○
Prickley Rose *Rosa acicularis*	Tolerates wide range of soil condtions and textures, volunteers in other local quarries	Dec. shrub up to .5-1.0m.	Seeds, cuttings, bare root	□	□	□	◇	◇		◑
Common Wild Rose *Rosa woodsii*	Prefers full sun moister soils, but will tolerate a wide range of conditions	Dec. shrub to .3 - 2m.	Seeds, cuttings, bare root- transplants easily	□	□		◇	◇		◑
Bebb Willow *Salix bebbiana*	Tolertates mildly alkaline soils, standing water	Dec. shrub or small tree up to 10m.	Seeds, cuttings, bare root- transplants easily	□	□	□	◇	◇		●
Buffaloberry *Sheperdia argentea*	Fixes nitrogen, prefers light weel drained soils, can tolerate poor mod-erately alkaline soils	Dec. shrub or small tree up to 5m.	Seeds, root cuttings- transplants easily	□	□		◇	◇		◑
Staghorn Sumac *Rhus typhina*	Tolerates dry infertile soils	Dec. shrub to 3-5 m.	Root cuttings, small plants,or bare root	□	□		◇	◇		○

Legend

Drought tolerant ○
Not Drought tolerant ●
Moderate tolerance ◑

DIAGRAM TWENTY NINE A

REVEGETATION SPECIES GUIDE	Adavantages & Constraints	Growth Habits	Methods of Establishment	Soil Moisture			Soil Fertility			Drought Tolerance
				dry	moist	wet	low	medium	high	
Trees										
Manitoba Maple *Acer negundo*	Grows almost anywhere, however prefers sites with sufficient moisture	Dec. tree from 8-15m.	Seedling, bare root, cuttings	□	□	□	◇	◇		◑
Silver Maple *Acer saccharinum*	Susceptible to lime induced iron schlorosis grows well on wet sites	Dec. tree from 12-25m.	Same as above, as well as containerized plants		□	□		◇	◇	●
Paper Birch *Betula payrifera*	Requires higher maintenance, susceptible to insects, needs well drained sites	Dec. tree from 8-15m.	Same as above	□	□			◇		◑
Green Ash *Fraxinus pennsylvanica*	Tolerates dry infertile soils, but prefers well drained soils	Dec.tree up to 12m.	Same as above	□	□		◇	◇		○
Tamarack *Larix laricina*	Native coniferous tree with slow to medium growth rate	Coniferous (con.)tree 12- 20m.	Seedlings, transplants, containered plants	□	□		◇	◇		●
White Spruce *Picea glauca*	Prefers moist well drained soils, will not perform well on dry or exposed sites	Coniferous (con.)tree 12- 20m.	Seedlings, transplants, containered plants and balled and burlapped	□	□	□	◇	◇		◑
Jack Pine *Pinus banksiana*	Adaptable to poor dry soils, preferably not with alkaline soils	Con. tree 8-20m.	Bare root seedlings	□	□		◇	◇		○
Scots Pine *Pinus sylvestris*	Introduced conifer,prefers dry sandy soils - crown opens as tree ages giving it a pictuesque form	Con. tree 10-25m.	Seedlings, transplants (balled and burlapped)	□	□		◇	◇		○

Legend

Drought tolerant ○
Not Drought tolerant ●
Moderate tolerance ◑

DIAGRAM TWENTY NINE A

REVEGETATION SPECIES GUIDE	Adavantages & Constraints	Growth Habits	Methods of Establishment	Soil Moisture			Soil Fertility			Drought Tolerance
				dry	moist	wet	low	medium	high	
Trees										
Balsam Poplar *Populus balsamifera*	Native tree,grows almost anywhere, however prefers sites with sufficient moisture	Dec. tree from12-15m.	Seedlings or small trees, transplants	□	□	□	◇	◇		◑
Cottonwood *Populus deltoides*	Native, large, fast growing tree often found growing naturally in pits and quarries	Dec. tree from 15-20m.	Seedlings to 1m., transplants, containerized		□	□		◇	◇	◑
Trembling Aspen *Populus tremloides*	Tolerates variety of site conditions, often found volunteering in pits and quarries	Dec. tree from 12-15m.	Seedlings or small trees, transplants, root cuttings	□	□	□	◇	◇		◑
Hybrid Poplars *Populus sp.*	Short lived under arid conditions (20-25 yrs)	Dec.trees 12-20m.	Same as above		□	□	◇	◇		●
Pin cherry *Prunus pennsylvanica*	Native tree spreading with age to form clumps- excellent for wildlife	Dec. tree 4-7m.	Seedlings, transplants, containered plants	□	□		◇	◇		◑
Chokecherry *Prunus virginiana*	Prefers moist well drained sites	Dec. tree 4-5m.	Seed, seedlings	□	□			◇		◑
Eastern White Cedar *Thuja occidentalis*	Native coniferous tree, slow to medium growth rate	Con. tree up to 12m.	Transplants, containerized plants	□	□	□	◇	◇		◑
Laurel Leaf Willow *Salix pentandra*	Prefers moist well drained sites	Dec. tree 12-15m.	Cuttings, containerized plants		□	□	◇	◇		○

Legend

Drought tolerant ○
Not Drought tolerant ●
Moderate tolerance ◑

DIAGRAM TWENTY NINE A

REVEGETATION SPECIES GUIDE	Growth Habits	Soil Texture			Soil Drainage				Soil Fertility			Drought Tolerance
		sandy	loamy	clayey	dry	well drained	mod. well drained	poorly drained	low	high	medium	
Water Plants												
Arrowhead *Sagglitaria cuneata*	Bottom growing plant, is almost all submerged except for the floating leaves	○	○	○								
Cat-tail *Typha latifolia*	Upright, shoreline plant up to 1.5m high	○	○	○								
Giant Reed Grass *Phragmites communis*	Upright, shoreline plant up to 2.5m high	○	○	○								
Hardstem Bullrush *Scirpus acutus*	Upright, shoreline plant up to 1m high	○	○	○								
Richardsons Pondweed *Potamogeton richardsonii*	Submerged	○	○	○								
Water Milfoil *Myriophyllum exalbescens*	Submerged	○	○	○								

Legend

Drought tolerant ○
Not Drought tolerant ●
Moderate tolerance ◑

FINE FESCUES

Creeping Red (Festuca rubra)
Chewings (Festuca commutata)
Hard (Festuca longifolia)

Description: The three Fine fescues all produce a turf of very fine bristle-like leaves. They will form a very dense, fine leafed turf. These fescues are very drought tolerant. Under dry conditions the leaves contract, reducing transevaporation, thus conserving water. Fescues have demonstrated superior performance in shaded conditions and should be the dominant grass(es) where sunlight is significantly reduced.

The Creeping types produce reasonably aggressive rhizomes and possess a strong creeping tendency. The Chewings types may produce short rhizomes but generally are more bunchlike. The Hard type is best noted for its ability to survive under very minimal fertility and moisture conditions. Fine fescues contain about 615,000 seeds per lb.

Varieties

VICTORY
Chewings fescue: Has received the highest scores in national test rating. Victory produces an excellent, dark green turf, and is an excellent blender with modern Kentucky bluegrass cultivars. Has good resistance to Corticium red thread, Sclerotinia dollar spot, Helminthosporium leaf spot, and Powdery mildew. Requires about 1/2 the nitrogen of Kentucky bluegrass.

SPARTAN
Hard fescue: This cultivar has received excellent ratings nationwide. Spartan has good resistance to Corticium red thread, Helminthosporium leaf spot, and Net blotch, Anthracnose and Powdery mildew. It produces a dark green, very persistent and dense turf. Spartan has excellent cold tolerance, resists drought and heat, and produces an excellent turf in shade.

JASPER: Strong spreading and dark green, it is an excellent shade grass which also can be used in the open sun, because of its good shade and drought tolerance. A low maintenance variety, it resists leaf spot and melting out and gives excellent resistance to leaf and stem rust and dollar spot.

AZAY
Sheeps fescue: This cultivar of European origin is virtually maintenance free. It is attractive as common ground cover – producing a blue green sward of unique colour and very attractive when seeded with wild flowers.

PICKSEED CANADA INC. Box 304, Lindsay, Ontario K9V 4S3 705-878-9240 FAX 705-878-9249

CREEPING RED FESCUE
(Festuca rubra L)

BRETT-YOUNG SEEDS LTD.

TOLL FREE: 1-800-665-5015

WORKING WITH CANADIAN FARMERS FOR OVER 50 YEARS.

Best suited to: Use as a component in mixtures for areas that have poor soil quality, fertility and where winter conditons are severe. Creeping Red Fescue is a major component of most home lawn and recreational mixtures.

Seed Size: 540,000 seeds per pound

Seeding rate: 3-6 lbs./1,000 sq. ft.

Germination rate: 14-21 days

Plant type:

texture: fine

blades: narrow, veined

roots: strongly rhizomatous

PERFORMANCE CHARACTERISTICS:

	LOW	MODERATE	GOOD	V. GOOD	EXCELLENT
Heat Tolerance			X		
Cold Tolerance					X
Drought Tolerance				X	
Compacted Soil Tolerance				X	
Shade Tolerance				X	
Wear Tolerance				X	

PEST PROBLEMS

Potential Diseases:

dollar spot, drechslera, fusarium blight, fusarium patch, leaft rust, necrotic ring spot, ophiobolus, powdery mildew, pythium, red thread

Potential Insect Pests:

Chinch bugs, White grubs, Greenbugs, Sod webworms, Grasshoppers

MANAGEMENT RECOMMENDATIONS

Mowing Height:

Never below 1/2 inch, does best between 1 to 2 inches.

Fertilizer Rate:

5 lbs. of Nitrogen per 1,000 sq. ft. per year

CHEWINGS FESCUE
(Festuca Rubra L. var commutata)

BRETT-YOUNG SEEDS LTD.

TOLL FREE: 1-800-665-5015

WORKING WITH CANADIAN FARMERS FOR OVER 50 YEARS.

Best suited to: Use as a component in mixtures for fine texture and to increase the shade tolerance.
Seed Size: 540,000 seeds per pound
Seeding rate: 3-6 lbs./1,000 sq. ft.
Germination rate: 14-21 days
Plant type:
texture: fine - very fine
blades: narrow, veined
roots: non rhizomatous

PERFORMANCE CHARACTERISTICS:

	LOW	MODERATE	GOOD	V. GOOD	EXCELLENT
Heat Tolerance		X			
Cold Tolerance				X	
Drought Tolerance			X		
Compacted Soil Tolerance		X			
Shade Tolerance				X	
Wear Tolerance			X		

PEST PROBLEMS
Potential Diseases:
dollar spot, drechslera, fusarium blight, fusarium patch, leaf rust, necrotic ring spot, ophiobolus, powdery mildew, pythium, red thread

Potential Insect Pests:
Chinch bugs, White grubs, Sod webworms, Grasshoppers.

MANAGEMENT RECOMMENDATIONS
Mowing Height:
Never below 1/2 inch, does best between 1 to 2 inches.
Fertilizer Rate:
5 lbs. of Nitrogen per 1,000 sq. ft. per year

Brett-Young Seeds Ltd. warrants to the extent of the purchase price that seeds sold are as described on the container within recognized tolerances. Seller gives no other warranty, expressed or implied.

TALL FESCUE

TURF TYPE

(Festuca arundinacea)

Tall fescues, developed for turf use, are significantly different from their old, forage grass forerunners, such as Ky31, FAWN, GOAR. They produce a turf of an attractive, dark green colour, generally more coarse than other lawn species, but not unattractive and similar to some cultivars of Kentucky bluegrass. Tall fescue is a nonspreading bunch grass, and should be seeded at high rates. Tall fescue has a very strong rooting ability, sending its roots down deep for moisture, thus earning a deserved reputation for drought tolerance. Modern varieties resist the ravages of heat, often the bane of other grasses, which has led to the wide use of Tall fescue in the transition belt of the U.S. Tall fescue contains ± 220,000 seeds/lb.

Varieties

MUSTANG: This popular cultivar consistently scores high across the continent. It is fine textured, dark green and forms a dense turf. Mustang has good environmental tolerances to cold and heat alike. It will tolerate low mowing heights. Mustang is one of the most popular varieties used in America.

CROSSFIRE: This is the "very" turf ... very deep rooted and very dark green. It grows low and slow and is also very tough. It has very good heat and drought tolerance and is – of course – very resistant to wear.

MINI-MUSTANG: A very low grower, it is very dark green and dense. Deep rooted, it grows much slower than traditional Tall fescues, provides excellent turf quality, and additionally offers excellent heat and drought tolerance and good overall disease resistance.

SHORTSTOP: Another low, slow growing variety, it can be mowed quite close, less often than other turf types. Very dark green, it has good heat and drought tolerance, is very resistant to traffic damage, and is very good at resisting leaf spot and other diseases.

PICKSEED CANADA INC. Box 304, Lindsay, Ontario K9V 4S3 705-878-9240 FAX 705-878-9249

TALL FESCUE
(Festuca arundinacea Schreb)

BRETT-YOUNG SEEDS LTD.

TOLL FREE: 1-800-665-5015

WORKING WITH CANADIAN FARMERS FOR OVER 50 YEARS.

Best suited to: Sports fields, dry and sandy areas and golf course roughs. It can also be used where salinity is a problem.
Seed Size: 220,000 seeds per pound
Seeding rate: 4-8 lbs./1,000 sq. ft.
Germination rate: 10-14 days
Plant type:
texture: coarse - medium coarse
blades: shiny underside
roots: bunch type

PERFORMANCE CHARACTERISTICS:

	LOW	MODERATE	GOOD	V. GOOD	EXCELLENT
Heat Tolerance				X	
Cold Tolerance		X			
Drought Tolerance				X	
Compacted Soil Tolerance				X	
Shade Tolerance		X			
Wear Tolerance				X	

PEST PROBLEMS
Potential Diseases:
crown rust, fusarium patch, ophiobolus, pythium, typhula

Potential Insect Pests:
White grubs, Sod webworms, Grasshoppers

MANAGEMENT RECOMMENDATIONS
Mowing Height:
Never below 1 inch, does best between 2 to 4 inches.
Fertilizer Rate:
Maximum of 2 lbs. per 1,000 sq. ft. of Nitrogen

Notes: If used in a mixture, tall fescue should make up at least 80%. If less than 80% turf may appear uneven and clumpy.

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PICKSEED® Technical Fact Sheet

KENTUCKY BLUEGRASS

(Poa pratensis)

Description: A very perennial, winterhardy specie which produces a dense, wear-tolerant turf. Spreads and fills in by underground rhizomes. Small seeded (± 1,000,000/lb.). Kentucky bluegrass is an apomictic specie, so varieties are extremely uniform. Fairly slow to establish, so early spring, or late summer seeding is recommended. Leaves have a boat shaped tip, and are quite broad. Modern varieties can be mowed to 3/4" (2 cm). Most Kentucky bluegrass varieties are adversely affected by shade. Some will tolerate reduced sunlight, but generally do not perform well in dense shade.

Varieties

ALPINE: This new cultivar was developed by Dr. C.R. Funk at Rutgers University. Alpine is a very decumbent type selected as a running mate to Nugget. It is dark green, very low growing, winterhardy, has resistance to leafspot and dollar spot, and has reasonable seed production. Its winter-hardiness has sparkled in test areas at the University of Manitoba in Winnipeg and throughout extensive tests in Norway.

AMERICA: A dwarf, robust variety with a dark to medium green colour. Excellent cold tolerance and broad adaptability.

BANFF: A very winter tough variety, originating from the Banff Springs Golf Course. Highly tolerant to snow mould and powdery mildew. Dark green leaves.

BRONCO: A broad leafed robust variety with dark colour and a decumbent growth habit. Very deep rooted for excellent tolerance to drought and a strong rhizomatous root system for sod strength and high tolerance to traffic.

CREST: A low growing variety with dark green colour and a medium leaf texture. It is an aggressive spreading bluegrass with good rhizeme development and a medium turf density.

FYLKING: This graceful leafed Swedish cultivar produces an attractive fine leafed turf with good disease resistance.

INDIGO: A low-growing dwarf, it has fine leaf texture and excellent disease resistance. Very dark green, this variety is ideal for sod and very well suited for high-quality blends and mixes.

NUGGET: A unique variety with early fall and late spring dormancy. Significantly superior winter-hardiness (proven in Eastern Canada and Scandinavia) is to be expected from this Alaskan development. Very dwarf type, dark green, and shade tolerant. Fine leafed.

TOUCHDOWN: Superior, vigorous variety from a golf course fairway on Long Island. Excellent competitiveness against Poa annua. Spreads quickly in open areas. Medium to dark green (emerald) with medium to broad leaves. Excellent choice for golf course fairways and tees.

PICKSEED CANADA INC. Box 304, Lindsay, Ontario K9V 4S3 705-878-9240 FAX 705-878-9249

KENTUCKY BLUEGRASS
(Poa Pratensis L.)

BRETT-YOUNG SEEDS LTD.

TOLL FREE: 1-800-665-5015

WORKING WITH CANADIAN FARMERS FOR OVER 50 YEARS.

Best suited to: Open sunny areas such as sod production and by itself or in a mixture for golf courses, home lawns and playing fields.
Seed Size: 2,200,000 seeds per pound
Seeding rate: 2-4 lbs./1,000 sq. ft.
Germination rate: 21-28 days
Plant type:
texture: fine
blades: blunt, v-shaped
roots: strongly rhizomatous

PERFORMANCE CHARACTERISTICS:

	LOW	MODERATE	GOOD	V. GOOD	EXCELLENT
Heat Tolerance			X		
Cold Tolerance					X
Drought Tolerance			X		
Compacted Soil Tolerance				X	
Shade Tolerance		X			
Wear Tolerance				X	

PEST PROBLEMS
Potential Diseases:
dollar spot, drechslera, fusarium blight, fusarium patch, leaf rust, necrotic ring spot, ophiobolus, powdery mildew, pythium, red thread, smuts, summer patch typhula.

Potential Insect Pests:
Chinch bugs, Billbugs, White grubs, Greenbugs, Sod webworms, Grasshoppers.

MANAGEMENT RECOMMENDATIONS
Mowing Height:
Never below 1/2 inch
Fertilizer Rate:
At least 3 lbs. of Nitrogen per 1,000 sq. ft. per year

Notes: Kentucky Bluegrass is not salt tolerant. A blend of at least 3 Kentucky Bluegrass varieties is recommended to increase the range of disease and pest resistance.

Brett-Young Seeds Ltd. warrants to the extent of the purchase price that seeds sold are as described on the container within recognized tolerances. Seller gives no other warranty, expressed or implied.

COLONIAL AND CREEPING BENTGRASS

(Agrostis tenius and stolonifera)

These two related grasses are widely associated with golf course turf. They will tolerate very low mowing, making them naturals for putting greens and tees. More recently, many golf course fairways are being seeded or overseeded with Bentgrass. They are a soft, lighter green colour, fine leafed, and aggressive in their spreading habits. Bentgrasses often develop a deep, cushiony growth which will need continual renovating, thinning and an advanced level of management. The Creeping types spread by surface stolons, while the Colonials tend to spread by short, weak rhizomes. Certified seed should always be used to ensure purity of variety and type (Creeping vs. Colonial). Seed count varies from 8,000,000 to 10,000,000/lb.

Varieties

NATIONAL
Creeping bentgrass: A new variety developed by Pickseed West, National traces to clones collected in Manitoba by Dr. A.C. Ferguson. National produces a very attractive dark green, decumbent and smooth turf. National is a robust, winterhardy variety with excellent adaptability to Northern U.S. and Canadian golf courses.

PENNCROSS
Creeping bentgrass: This tried and proven F1 type variety has exhibited its qualities globally. Penncross is very vigorous, mows neatly and short, and stands up well to both winter and summer stress.

PENNEAGLE
Creeping bentgrass: Developed by Dr. J. Duich at Penn State University. Penneagle is less dense than Penncross, so may be better adapted for fairways use where less intensive management than on tees and greens prevails.

EXETER
Colonial bentgrass: This proven variety has an attractive medium green colour. It is best suited for use on tees and for overseeding fairways. It was developed by Dr. R. (Dick) Skogley at the University of Rhode Island.

PICKSEED CANADA INC. Box 304, Lindsay, Ontario K9V 4S3 705-878-9240 FAX 705-878-9249

CREEPING BENTGRASS
(Agrostis stolonifera L.)

BRETT-YOUNG SEEDS LTD.

TOLL FREE: 1-800-665-5015

WORKING WITH CANADIAN FARMERS FOR OVER 50 YEARS.

Best suited to: Golf course putting greens and lawn bowling greens.
Seed Size: 7,800,000 seeds per pound
Seeding rate: 0.5 - 2.0 lbs./1,000 sq. ft.
Germination rate: 7-10 days
Plant type:
texture: fine - very fine
blades: veined
roots: stolonifirous (spreading by above ground shoots)

PERFORMANCE CHARACTERISTICS:

	LOW	MODERATE	GOOD	V. GOOD	EXCELLENT
Heat Tolerance	X				
Cold Tolerance			X		
Drought Tolerance	X				
Compacted Soil Tolerance	X				
Shade Tolerance				X	
Wear Tolerance	X				

PEST PROBLEMS
Potential Diseases:
dollar spot, fusarium blight, fusarium patch, necrotic ring spot, ophiobolus, pythium, red thread, smuts, typhula

Potential Insect Pests:
Chinch bugs, White grubs, Sod webworms, Grasshoppers.

MANAGEMENT RECOMMENDATIONS

Mowing Height:
1/2 inch or less

Fertilizer Rate:
Approx. 3 lbs. of Nitrogen per 1,000 sq. ft. per year

Notes: Should only be used on putting greens and lawn bowling greens because of its high maintenance requirements, never on home lawns.

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PERENNIAL RYEGRASS

Turf Type

Description: Perennial ryegrass is a reasonably large seeded specie (±) 250,000/lb. Large seed size and vigorous, quick germination make it a very easy to establish specie. Most ryegrasses are "bunch" grasses with little spreading ability, although vigorous cultivars produce a high number of tillers per plant. Perennial rye will usually germinate in 5 - 10 days, and quickly establish a solid plant. Its leaves are dark green with a very shiny underside. Most varieties go through a stage of "tough" mowing in the late spring, especially during their reproductive cycle. They can be mowed short and used successfully to overseed worn sports turf or ravaged fairways and tees.

Varieties

BLAZER II:	A very winterhardy cultivar which ranked at the top of this trait in Winnipeg. An attractive dark green variety with consistently high scores.
CUTTER:	The newest release from Pickseed Research. Cutter is dark green, very fine-leafed and highly uniform. Cutter has outstanding resistance to disease, establishes very quickly and tolerates low mowing. It is endophyte enhanced with over 90% seeds carrying this natural biopesticide.
DASHER II:	This new variety has good stem rust resistance. It also is enhanced with high endophyte – a biological resistance to insect feeding damage. It is dark green, fine leafed, and produces excellent dwarf turf.
EDGE:	Also dark green with fine leaf texture, it has excellent, trial-tested turf quality and is moderately dense. It establishes quickly, offers good tolerance to heat and drought, and provides very good disease and insect resistance.
EXPRESS:	A high endophyte, high turf quality, lower growing cultivar, it has excellent density, seed production, and good stem rust resistance. Dark green with medium fine leaf texture, it provides good heat and drought tolerance.
FIESTA II:	A new variety which will soon replace its famed predecessor. Fiesta II is fine leafed, and a generation ahead in terms of disease and pest resistance.
LOWGROW:	This quick establishing, dense, low growing turf requires less mowing. It has a very fine leaf texture, is dark green, mixes well with dwarf blue grasses and fine fescues, and offers excellent winter hardiness and very good heat tolerance.

PICKSEED CANADA INC. Box 304, Lindsay, Ontario K9V 4S3 705-878-9240 FAX 705-878-9249

PERENNIAL RYEGRASS
(Lolium Perenne L.)

BRETT-YOUNG SEEDS LTD.

TOLL FREE: 1-800-665-5015

WORKING WITH CANADIAN FARMERS FOR OVER 50 YEARS.

Best suited to: Use as a component in mixtures for sports fields, home lawns, golf courses and to overseed divots in golf course fairways and tee boxes.
Seed Size: 220,000 seeds per pound
Seeding rate: 3-6 lbs./1,000 sq. ft.
Germination rate: 7-10 days
Plant type:
texture: fine
blades: veined
roots: non spreading

PERFORMANCE CHARACTERISTICS:

	LOW	MODERATE	GOOD	V. GOOD	EXCELLENT
Heat Tolerance		X			
Cold Tolerance		X			
Drought Tolerance			X		
Compacted Soil Tolerance				X	
Shade Tolerance		X			
Wear Tolerance				X	

PEST PROBLEMS
Potential Diseases:
crown rust, rusarium patch, ophiobolus, red thread, smuts, typhula

Potential Insect Pests:
Grasshoppers

MANAGEMENT RECOMMENDATIONS
Mowing Height:
Will tolerate mowing at 1/2 inch
Does best at 1 1/2 to 2 inches
Fertilizer Rate:
2 lbs. of Nitrogen per 1,000 sq. ft. per year

Notes: New types of turf type Perennial Ryegrass contain Endophyte which helps to increase its tolerance to insect pests.

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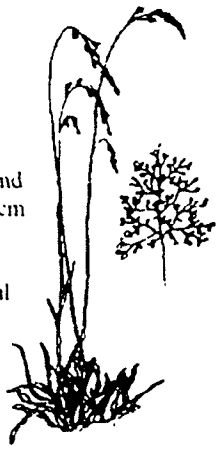
Native Prairie Grasses

Prairie Habitats native grasses are a selection of tough , hardy and beautiful species adapted to a wide range of soil and moisture conditions. They make an unusual addition to any flower garden and are excellent for border plantings. Grasses provide important support and weed control for any wildflower meadow.

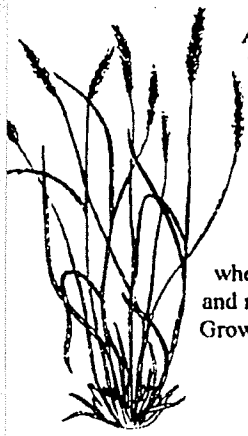
kali Cord Grass
)artina gracilis)
:aline and alkali tolerant
ive grass, it usually grows
wet meadows. Graceful
d head textured like cord
lwine. Excellent for
erbanks, ditches and low
as. Height 70 cm (28 in).

Blue Grama
(Bouteloua gracilis)
One of the prettiest and most interesting plants of the prairie, Blue Grama sports 2 flag-like seedheads on either side of the stem. Short (to 20 cm or 8 in) and very drought tolerant, requires little mowing in a lawn. Also an attractive accent plant for the wildflower garden.

Hair Grass
(Agrostis scabra)
A grass of the aspen parkland prairies with a beautiful reddish stalk and seed head. Grows to 50 cm (20 in) high. A quick growing species, it is among the most colourful of the early season grasses. Makes a nice low growing mix with little bluestem. Plants



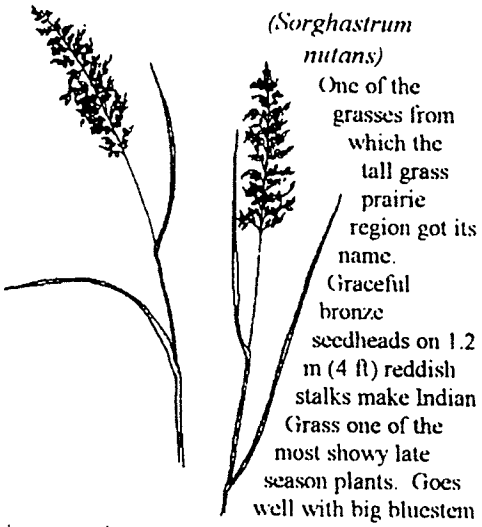
Bog Muhly Grass
(Muhlenbergia glomerata)
A short (to 30 cm or 12 in) tufted grass with a cone-like seed head. Grows well just about anywhere. A shorter grass that flowers in late summer. Very attractive.



Awned Wheatgrass
(Agropyron unilaterale)
Long plumes adorn each seed giving this grass a willowy look. The main wheatgrass of the tall and mixed grass prairies. Grows to 80 cm (32 in).

Canada Wild Rye
(Elymus canadensis)
A tall, spectacular grass, Canada Wild Rye has a seed head with very long awns or threads off each seed. One of the few prairie grasses that will do well in partial shade, it grows along the edge of aspen bluffs, woodlands as well as in open areas. Easy to grow. To 120 cm (4 ft).

Indian Grass
(Sorghastrum nutans)
One of the grasses from which the tall grass prairie region got its name. Graceful bronze seedheads on 1.2 m (4 ft) reddish stalks make Indian Grass one of the most showy late season plants. Goes well with big bluestem in restorations and border plantings.

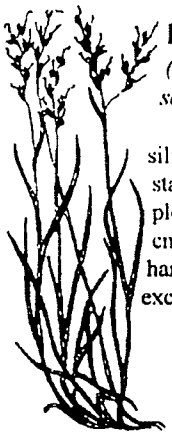


g Bluestem
ndropogon gerardi)
More than any
ier grass, Big
uestem IS the
l grass prairie.
ll, shoulder
gh, reddish
uve stalks with
-pronged seed
ad. In mid to
e summer it
ates waves of
lour across the
idscape. This was
grass that nourished
llions of bison on the
l prairie. A spectacular,
g-lived, and showy grass,
g Bluestem is a prime
mponent of any tall grass prairie restoration.
also makes an excellent border in a formal
rden and holds its colour well for dried
angements.

Fringed Brome
(Bromus kalmii)
An elegant, rare grass that grows up to 1m (3 ft) tall. The cascading seedhead is quite distinctive.Suitable for border plantings or individual specimen clumps. A showy prairie grass. Plants 1.95, seed $2.00.

Green Needle Grass
(Stipa viridula)
This cool season perennial grass is very tough and resilient in addition to being beautiful. Excellent for dry areas. To 1 m (3 ft).

June Grass
(Koeleria cristata)
A short (to 30 cm or 1 ft), drought tolerant species of the mixed grass prairie. Beautiful, showy white, open seedhead appears in mid-June. Likes rock gardens and sunny areas

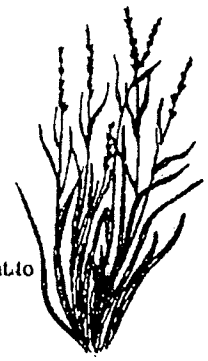


Little Bluestem
(Schizachyrium scoparium)

Short and delicate, with silvery seed heads and reddish stalks, Little Bluestem is a pleasure to look at. 40 to 50 cm (20 in) high. Tough and hardy as well, this grass is excellent for landscaping.

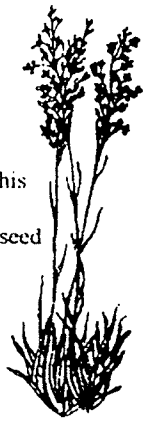
Mat Muhly
(Muhlenbergia richardsonis)

Fine-leaved, diminutive grass (to 30 cm , 12 in) with small tufts of seeds. Makes a lovely complement to shorter wildflowers.



Needle and Thread Grass
(Stipa comata)

A delicate and graceful dry-adapted species with a curly-plumed seedhead. Grows to 80 cm (32 in) high.



Nuttall's Alkali Grass
(Puccinellia nuttalli)

A salt tolerant native species, this showy grass often grows around wetlands and ditches. A feathery seed head makes this one an attractive landscaping species. Grows to 40 cm (16 in.) tall.

Rough Fescue
(Festuca hallii)

Rare grass from which Canada's fescue prairie region got its name. Like the tall grass prairie, little original fescue prairie remains today. A pretty bunchgrass with open seedhead. Height 50 to 80 cm.(20 in.)

Sand Bluestem
(Andropogon hallii)

Similar to Big Bluestem, but with a beautiful silvery blue cast to the leaves and stem. 3-pronged seedhead covered with dense white hairs gives it a fuzzy appearance. Very rare in the wild, we are pleased to offer this unusual grass for the first time this year. Will reach 1 to 1.5 m (4.5 ft.) in height.

Sheep Fescue
(Festuca saximontana)

Sheep fescue is a short, jade green, tufted bunchgrass with spiky leaves. One of our most popular landscaping grasses. Very attractive when planted with other grasses or short wildflowers for contrasting colour. Height to 20 cm.(8 in.)

Sidecoats Grama
(Bouteloua curtipendula)

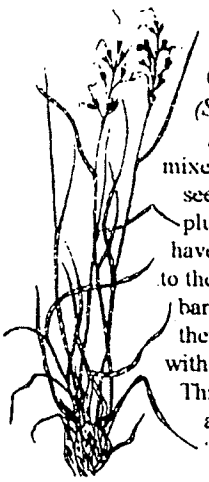
A rare and unusual grass. The most colourful flowers of any native grass. Its name comes from the oat-like seeds that arrange themselves neatly along one side of the stalk. 60 to 80 cm (28 in.) tall.

Slender Wheatgrass
(Agropyron trachycaulum)

A graceful, early season grass, up to 1 m (3 ft.) in height. Adapted to a wide variety of conditions from wet to dry. Fast growing. Provides good nesting cover for prairie birds.

Slough Grass
(Beckmannia syzigachne)

A medium height species with unusual seed heads that look like stacks of small plates. At home along streams, ditches and shallow marshes.



Spear or Porcupine Grass
(Stipa spartea)

A prime component of the mixed grass prairie, the large seeds and graceful long plumes of Porcupine Grass have an interesting adaptation to the plains environment. The barbed seeds literally screw themselves into the ground with changes in humidity. This ensures that the plants are self seeding.

Sweet Grass
(Hierochloe odorata)

Considered a holy grass by native North Americans, Sweet Grass is a low growing, early season species with a golden seedhead. Its pleasant scent is very evident where it grows, and stays with the plant years after it has been dried. Makes wonderful baskets and dried arrangements. Our most popular grass.

Switch Grass
(Panicum virgatum)

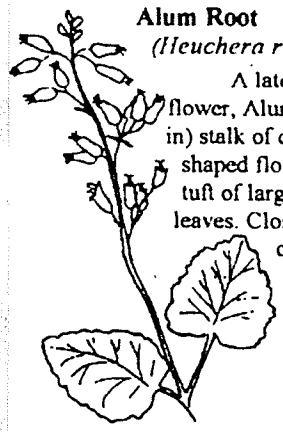
One of the dominant grasses of the tall grass prairie, Switch Grass grows best in deep fertile soils that are well watered. It has an attractive openly branched seed head that is sought after by many birds. Grows to a height of about 1 m.(3 ft.). Habitat destruction has meant that this species has nearly disappeared from the wild in Manitoba.

Tall Dropseed
(Sporobolus asper)

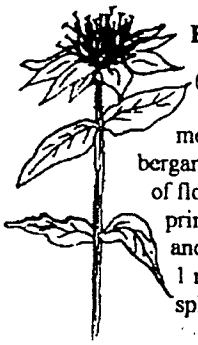
A medium height (to 1 m/ 3 ft.) late season grass with narrow seed heads enclosed in a sheath. An uncommon prairie species with good colour.

Native Prairie Wildflowers

Prairie Habitats' hardy native wildflowers cover the spectrum of colour and habitat types from Canada's tall and mixed grass prairies. Nearly all plants are perennials that come up year after year. They make superb additions to regular gardens, or will create eye catching groupings on their own in your yard. They are excellent for attracting butterflies and birds to your property.

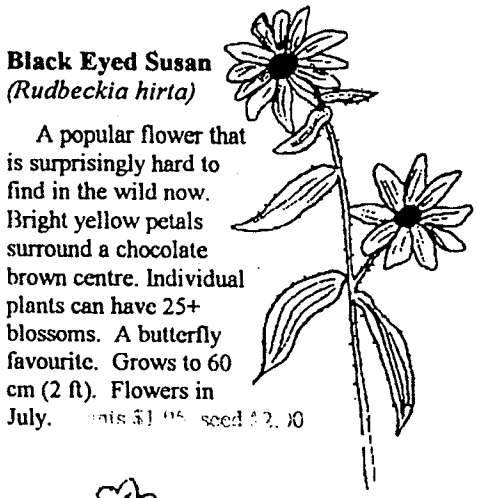


Alum Root
(Heuchera richardsonii)
A late spring blooming flower, Alum Root's 30 cm (12 in) stalk of creamy white bell shaped flowers arises from a tuft of large maple-like leaves. Closely related to the coral bells.

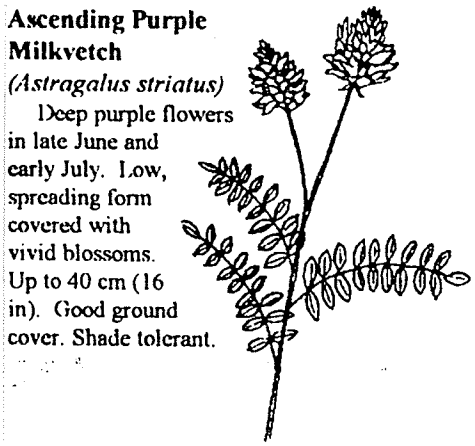


Bergamot
(Monarda fistulosa)
The most spectacular member of the mint family, bergamot's showy purple masses of flowers bloom in July. A prime habitat for butterflies and hummingbirds, it grows to 1 m (3 ft) tall. Makes splendid tea.

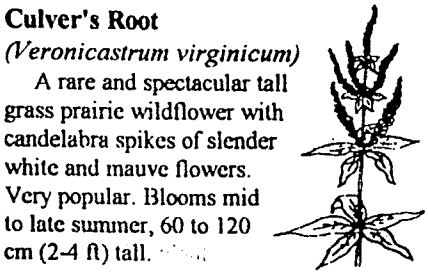
Crowfoot Violet
(Viola pedatifida)
Tiny mauve violets with deeply indented "crowfoot" shaped leaves. Flowers June and September. A very popular flower with our customers. Shade tolerant. 15 cm (6 in) tall.



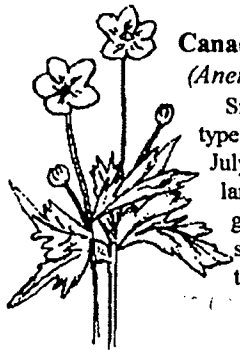
Black Eyed Susan
(Rudbeckia hirta)
A popular flower that is surprisingly hard to find in the wild now. Bright yellow petals surround a chocolate brown centre. Individual plants can have 25+ blossoms. A butterfly favourite. Grows to 60 cm (2 ft). Flowers in July.



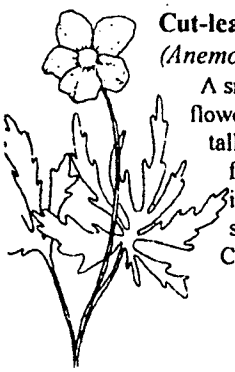
Ascending Purple Milkvetch
(Astragalus striatus)
Deep purple flowers in late June and early July. Low, spreading form covered with vivid blossoms. Up to 40 cm (16 in). Good ground cover. Shade tolerant.



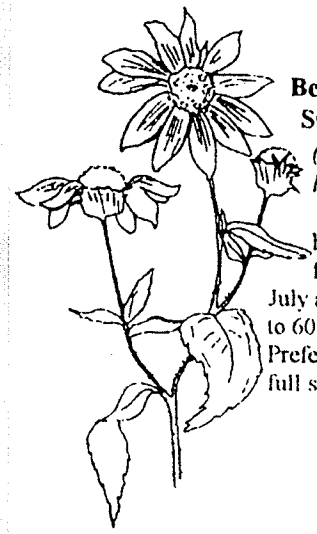
Culver's Root
(Veronicastrum virginicum)
A rare and spectacular tall grass prairie wildflower with candelabra spikes of slender white and mauve flowers. Very popular. Blooms mid to late summer, 60 to 120 cm (2-4 ft) tall.



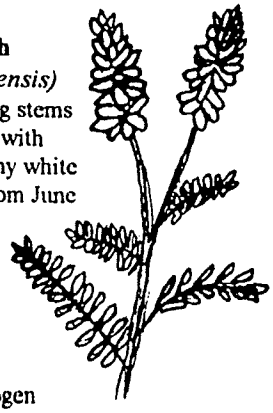
Canada Anemone
(Anemone canadensis)
Snowy white buttercup type flowers in June and July. Will spread to form large patches. Excellent ground cover for partial shade. 40 cm (16 in) tall.



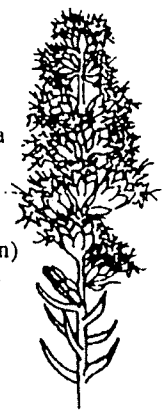
Cut-leaved Anemone
(Anemone multifida)
A small but spectacular flower up to 40 cm (16 in) tall. White to pinkish-red flowers in June. Deeply indented leaves are similar to Prairie Crocus.



Beautiful Sunflower
(Helianthus laetiflorus)
A colourful, happy prairie flower. Blooms July and August. Up to 60 cm (2 ft). Prefers dry areas in full sun.



Canada Milkvetch
(Astragalus canadensis)
Densely branching stems to 80 cm (32 in) tall with large spikes of creamy white blossoms that last from June through August. Very fragrant and popular with butterflies. Good nectar producer. Enriches the soil by making its own nitrogen fertilizer.



Dotted Blazingstar
(Liatris punctata)
Short, feathery spikes of purple flowers makes this one a real treat to look at. Dotted Blazingstars prefer drier areas, but will do well in any sunny spot. Grows about 30 cm (12 in) high, flowering in early to mid-summer. Excellent for rock gardens.

elenium
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A delightful,
tton-tufted
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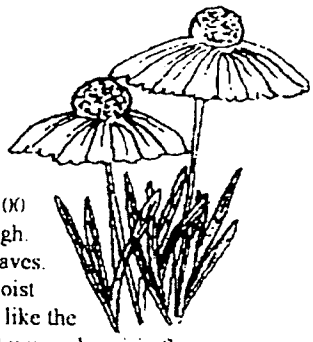
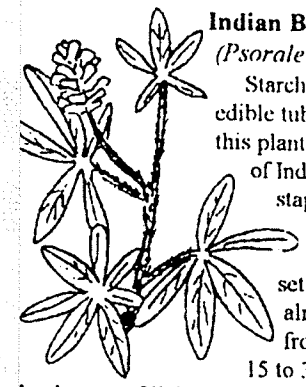
stalks 50 to 100
(20–40 in) high.
nce-shaped leaves.
ows best in moist
s. We really like the
k of this most unusual prairie flower.

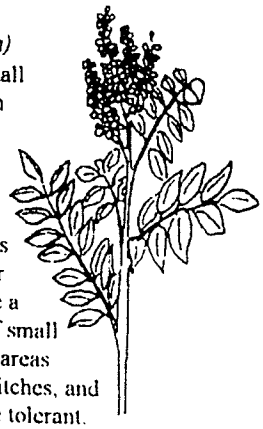


Indian Breadroot
(Psoralea esculenta)
Starchy roots produce edible tubers that give this plant its other name of Indian Potato. A staple food of the plains Indians and early settlers, it is almost gone now from the prairies. 15 to 30 cm (6-12 in) h, clusters of light bluish purple or white wers bloom in June. This plant has an open, nching form with lupine-like leaves.

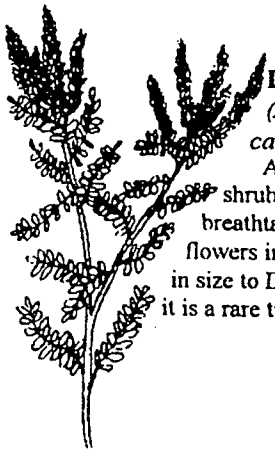


dian Hemp
ocynum cannabinum)
A woody shrub of aspen parklands and irie edges. Was used by native peoples to ke rope. Drooping heather-like, bell-shaped ite flowers at the ends of branches. Shade rant, it will spread to form large colonies, ing in areas that are difficult to grow other cies in. To 1 m (3 ft) high.

digo Bush
norpha fruticosa)
One of the rarest tall ss prairie plants in nitoba, this shrub ws to 1m (3 ft) h and 1m (3 ft) oss. Vivid deep ple blossom spikes m this spectacular nt in June. Foliage a green network of small ves. Prefers moist areas h as riverbanks, ditches, and land edges. Shade tolerant.

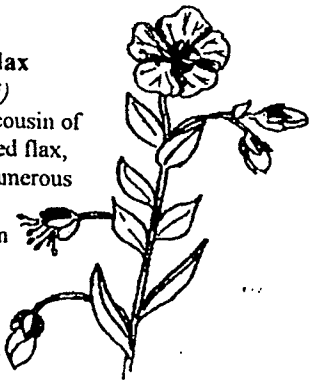


Kalm's Lobelia
(Lobelia kalmii)
Tiny but showy blue trumpet-shaped flowers in mid-summer. Slightly darker blue flowers than the Spiked Lobelia. Both species like moist conditions.



Leadplant
(Amorpha canescens)
A silvery coloured shrubby legume that has breathtaking metallic blue flowers in mid June. Similar in size to Dwarf False Indigo, it is a rare treat on the prairie.

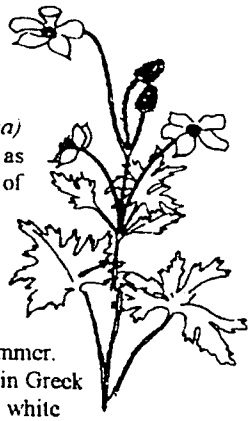
Lewis Wild Flax
(Linum lewisii)
A perennial cousin of the annual oilseed flax, this plant has numerous baby blue flowers on 30 cm (12 in) stalks. Although individual flowers only last one day, the plant keeps putting out new ones every day, giving a summer long show of delicate beauty.



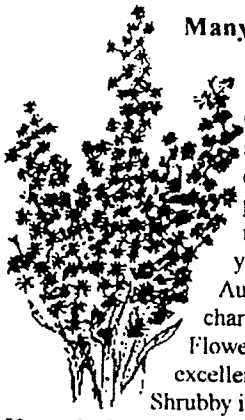
Lilac Flowered Penstemon
(Penstemon gracilis)
Also called Beardtongue, this dainty orchid-like flower grows up to 50 cm (20 in) high. An easily missed component of our native prairies that makes a welcome addition to any landscape.

Low Goldenrod
(Solidago missouriensis)
A short species, from 20 to 50 cm (8-18 in) tall, with reddish stems and tufts of compact terminal yellow flowers. One of the earliest flowering of the goldenrods - in July and August.

Long Fruited Anemone
(Anemone cylindrica)
Sometimes known as thimbleweed because of its thimble shaped woolly seedhead, this plant is one of several species of anemones that grace the prairie in spring and early summer. The name "anemone" in Greek means windflower. Its white flowers grow on stalks up to 40 cm (16 in) high.



Many Flowered Aster
(Aster ericoides)
Aster is from the Greek word meaning star - an appropriate description of these pretty plants. Dense masses of white and yellow flowers in August and September characterize the Many Flowered Aster. An excellent nectar producer. Shrubby in form, it will grow to 50 cm (20 in) high and 30 cm (12 in) across.

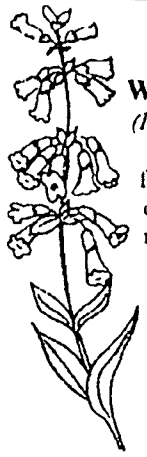


Meadow Blazingstar
(Liatris ligulistylis)
Tall spikes of purple flowers up to 1 m (39 in) high are a trademark of this mid-summer tall grass prairie beauty. An excellent native prairie replacement for that noxious weed lythrum or purple loosestrife. Ruby-throated hummingbirds are attracted to Meadow Blazing Stars, (and so are people, too!!).

Narrow-leaved Sunflower
(Helianthus maximiliani)
Tall (to 2 m, 6.5 ft) showy native sunflower with many blossoms per plant. Grows quickly and easy to establish. Blooms mid-summer through fall. Goldfinches love to eat the seeds, and will be attracted to your yard if you have this plant.

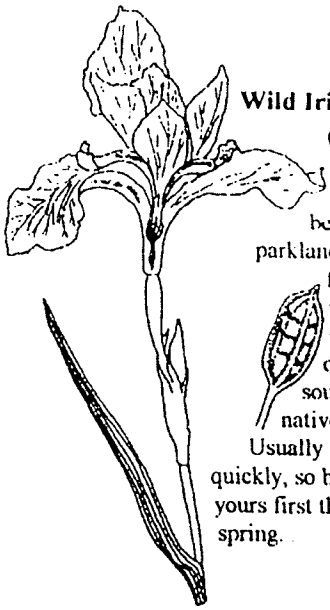
Three Flowered Avens
(Geum triflorum)

Many people know this plant as "Prairie Smoke" A short, mid spring reddish-purple flower that occurs in clumps of 3. The flower's woolly seedhead then shoots up, literally turning the ground a smoky hue when the plant grows in large colonies. Makes a beautiful evergreen ground cover. Ideal rock garden plant.



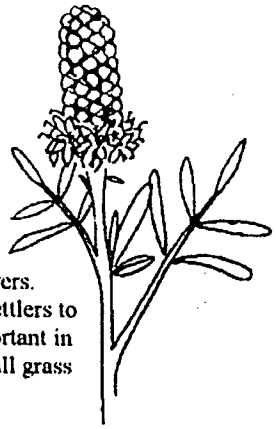
White Penstemon
(Penstemon albidus)

Large, showy white tubular flowers. Reaches a height of 30 cm (12 in). A plant of the mixed grass prairie.



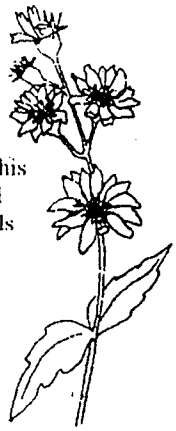
Wild Iris
(Iris versicolor)

A delicate beauty of parkland and boreal forest wetlands, wild irises are one of the most sought-after native plants. Usually sold out quickly, so be sure to get yours first thing in the spring.



White Prairie Clover
(Petalostemon candidum)

Similar to Purple Prairie Clover but rarer and with white flowers. Used by the early settlers to treat measles. Important in the ecology of the tall grass prairie.

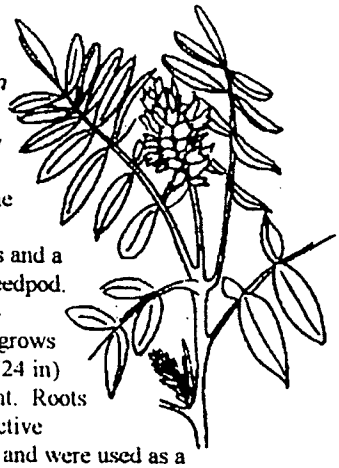


Upland White Goldenrod
(Solidago ptarmicoides)

The only white goldenrod, this one blooms in late summer and fall. Attractive round seedheads appear after the flowers. Low growing, up to 30 cm (12 in).

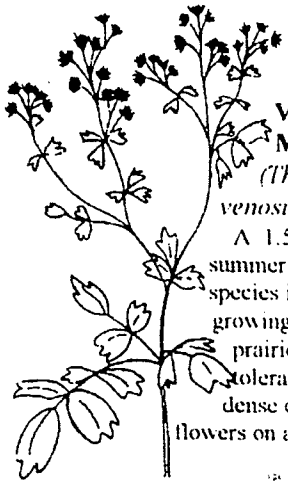
Whorled Milkweed
(Asclepias verticillata)

Finely branched leaves with greenish white flowers. Fragrant and very attractive to Monarch butterflies.



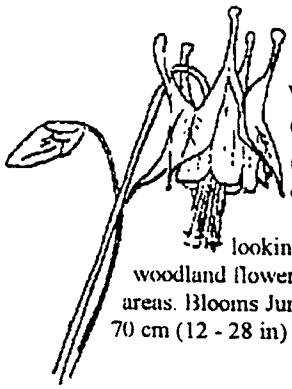
Wild Licorice
(Glycyrrhiza lepidota)

A shrubby woodland/ prairie legume with creamy white flowers and a velcro-like seedpod. Flowers mid-summer and grows up to 60 cm (24 in) Shade tolerant. Roots have a distinctive licorice taste and were used as a candy by pioneers.



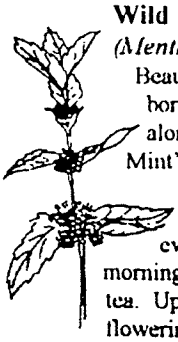
Veiny Meadowrue
(Thalictrum venosum)

A 1.5 m (5 ft) early summer flower, this species is often found growing in woodlands and prairies. Shade tolerant. A striking dense cluster of white flowers on a long stalk.



Wild Columbine
(Aquilegia canadensis)

An exotic looking red and yellow woodland flower. Prefers shady areas. Blooms June and July. 30 to 70 cm (12 - 28 in) high.



Wild Mint
(Mentha arvensis)

Beautiful light blue flowers borne at the base of leaves along the square stems. Mint's sweet smelling fragrance is especially evident on cool damp evenings and early mornings. Makes a wonderful tea. Up to 50 cm (20 in) tall, flowering in early summer.

White Cinquefoil
(Potentilla arguta)

Tall, graceful yellow-white flowers on spikes 30 to 60 cm (12 - 24 in) high. Blooms in June and July. The Ojibway Indians used this plant to help control bleeding.

Wild Strawberry
(Fragaria glauca)

A shade tolerant ground cover, this native plant bears delicious fruit that is far tastier than commercial varieties. Small white flowers in early spring. Spreads rapidly by runners. Excellent low growing ground cover, less than 8 cm (3 in)

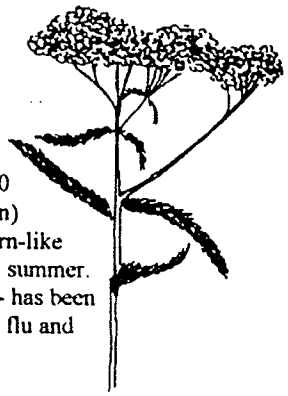
Wild Peavine
(Lathyrus venosus)

A climbing vine up to 2 m (6 ft) tall. Deep purple, very showy flowers in mid-summer. Pea-like pods. Good native trellis covering.

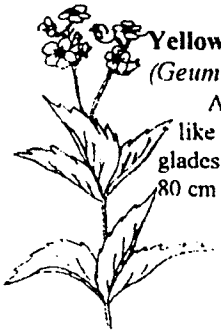
Willow Aster
(Asper hesperius)

Multi-branched aster with numerous flowers ranging from white to pink to violet in colour. Prefers moist areas.

Yarrow
(Achillea millefolium)



Dense, flat-topped clusters of white flowers on 30 to 60 cm (12 - 24 in) stalks. Delicate, fern-like foliage. Blooms all summer. A medicinal plant - has been used to treat colds, flu and toothache.



Yellow Avens
(Geum aleppicum)

A pale yellow buttercup-like flower of woodland glades. Shade tolerant. Up to 80 cm (31 in) high.

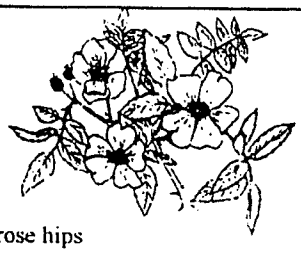
Yellow Coneflower
(Ratibida columnifera)

One of our favourite wild-flowers. Deep brown cone-shaped centre surrounded by long yellow petals. Enjoy the beauty of this unusual, easy to grow wildflower in your garden . Blooms all summer. Plants up to 60 cm (24 in).

Yellow Evening Primrose
(Oenothera biennis)

A tall (to 1.5 m, 5 ft) showy yellow flower of early summer. It is a biennial - growing a rosette of leaves in its first year, then sending up a flower spike in its second year. Unusual in that it opens first in the evening and blooms in the moonlight. Its sweet fragrance attracts night flying moths that pollinate the flowers. Easy to grow . Many medicinal properties.

Wild Rose
(Rosa woodsii)



Delicate pink, fragrant blooms cover this well known prairie shrub in early summer. Edible rose hips provide excellent winter colour.

THE SHADY CORNER

Everybody seems to have a shady little nook that sun-loving prairie plants are not suited to. Try the species listed below. While none will grow in total shade, all they require is a couple hours of sun per day.

Grasses

Canada Wild Rye	Fringed Brome
Hair Grass	Sheep Fescue

Wildflowers

Bergamot	Canada Anemone
Crowfoot Violet	Indian Hemp
Cut Leaved Anemone	Wild Peavine
Giant Hyssop	Graceful Goldenrod
Harebell	Purple Boneset
Indigo Bush	Long Fruited Anemone
Northern Bedstraw	N. Bog Violet
Oblong Leaved Gentian	Philadelphia Fleabane
Spiked Lobelia	Tall Coneflower
Upland White Goldenrod	Veiny Meadowrue
Wild Columbine	Wild Licorice
Wild Sarsaparilla	Wild Iris
Wild Strawberry	Yellow Avens

WHAT ARE "WILDFLOWERS"?

Just about everywhere tliese days you can find packets of "wildflowers". Canned meadows, wildflower mixtures, low maintenance ground covers are all readily available. Virtually none of these have any claim to being Canadian native prairie species. Most are from other countries if not other continents. Species that are not native to the prairies, not hardy here and often cause great disappointment when and IF they grow. Many are common weeds.

Our wildflowers are not from California, Oregon or Europe. All of ours are grown from seed carefully collected by PRAIRIE HABITATS staff on actual remnant prairies of southern Manitoba. All are hardy and well adapted to Manitoba conditions.

As a definition, we consider native wildflowers and grasses to be those species that occurred here naturally at the time of settlement, and were not brought in from other regions or continents. Conserving the native genetic stock that has all but disappeared here is of paramount importance to us, so we don't carry any seed that we have not harvested locally.

Site Preparation

The most important factor in any planting of native prairie species is proper site preparation. Whether you are planting a corner of the yard or many acres, time spent now in good site preparation will pay big dividends later.

Native plants are well adapted to our prairie environment, having lived here for thousands of years in a stable community. But they are no match for the host of non-native weeds. These aggressive species have the ability to muscle out nearly anything that grows, particularly on disturbed soil.

To have a successful prairie garden or restoration, these invasive weeds must be brought under control before planting begins. Elimination of perennial weeds is of paramount importance. The site must be clean and weed free as they compete with your prairie plants for light and moisture.

The type of weed control measures depend upon your plot. Small plots can be worked over with a rototiller every week for 2 to 3 months during the growing season. Black plastic can be staked out as a ground cover to kill weeds. Larger plots can be cultivated as in summerfallowing. Roundup or other herbicides may be used for problem areas that cannot be controlled by other means.

The site should be smooth and well packed to ensure the seeds have good soil contact. A good rule of thumb is that the soil is firm enough to plant if your footprint barely registers on it. June is the best time for planting prairie species in Manitoba.

For small plots, seed should be broadcast evenly over the whole area and lightly raked or rolled in. Don't bury the seeds deeply or they will not grow. Keep well watered until plants are well established.

Larger areas can be seeded with a seed drill or fertilizer spreader, using an inert carrier like cracked wheat to carry the light fluffy prairie seeds through the machine. Seed shallowly, no deeper than 1 cm (1/2 in).

Remember, prairie plants are perennials. They do not show a great deal of growth above ground in their first year. They prefer instead to spend their time putting down a deep, extensive root system to help carry themselves through adverse conditions like drought and cold. Be patient - prairie takes its time in establishment - from 2 to 5 years will be needed if you start from seed. Wild seeds have quite variable germination rates as a survival mechanism to ensure that they all do not germinate at the same time. If you require an "instant" prairie, seedling plants will mature more quickly.

Mowing as necessary during the growing season high enough to avoid most prairie seedlings, but low enough to cut off the heads of weeds before they mature, will help your planting along.

Broadcast Seeding is considered to be a less desirable planting process, in that the seeds are scattered on the ground's surface and are more susceptible to the varying elements. Broadcast seeding may be done by hand or machine utilizing specialized equipment, such as in hydroseeding or aerial seeding.

The advantages of broadcast seeding are: that it is a more economical seeding process than drilling; the seeds (and fertilizer) all may be distributed at the same time; the slope of the land is not critical.

Limitations to broadcast seeding include: the fact that the seeds are not in the soil where germination and establishment normally occur; the seeds are exposed to predators such as birds and rodents; mulches are required to prevent seed drifting, reduce soil temperatures, and help retain moisture.

As a broadcast seeding technique, hydroseeding is the most expensive seeding technique. Seeds, fertilizers, and soil amendments (such as a wood fibre mulch) and a soil stabilizer (binder) are held in continuous agitation in a slurry mixture, which is applied with a high pressure stream of water. Up to 112,500 litres of slurry can be applied in a fifteen minute period. (Schiechti , 1980, pp 43).

There are obvious advantages to this type of seeding: hydroseeding is very fast and offers complete area coverage up to a distance of 65 metres, allowing it to access difficult areas and steep slopes; the technique also provides erosion and drought control for the seedlings in their most vulnerable stage of establishment.

Disadvantages of hydroseeding include: it is generally the most expensive method of seeding; if the slurry is not applied within thirty minutes of mixing, germination rates may be reduced; the seed itself may not come into direct contact with the soil if seed, mulch, and binder are applied in a single operation. The germination rates are greatly improved if the process is a two - step operation, which would also increase costs.

Aerial seeding is another option in which either fixed-wing aircraft or a helicopter are used to seed the site. This technique is probably not required or practical for most quarries.

Revegetating areas to native prairie habitat using seed is another variation on the seeding method, as this method has its own particular procedures and requirements. Using seed is the accepted technique for propagating of large areas of an acre or more, whereas sprigs, cuttings, or wildlings can be utilized in smaller plots.

The problems in planting wild seeds is that their germination rates are not as predictable as those of nursery grown stock. The native prairie grasses and ground covers are nearly all perennials which take a longer period to grow to maturity. The first year is spent by the plants in establishing an extensive root system to ensure its survival in any drought. Approximately 2 - 5 years is required for the plants to mature if the area is started from seed.

The most important factor in establishing native prairie stands is proper site preparation. The plants of the native prairie are well adapted to survival in the ancient prairie environment, but cannot compete with newer non-native weed types which are more aggressive, particularity in disturbed soil. This is directly applicable to the situation of quarry rehabilitation , where overburden and topsoil

that has been stripped from the site is replaced. In this situation, any weedy species must be controlled before seeding can take place.

The type of measures of weed control can vary depending on the configuration and size of the area to be seeded. Rototilling first and then staking black plastic out over the weeds can be used in small plots, while cultivating larger areas with machinery is another option. Herbicides can then be used on any problem zones.

The areas to be planted, should then be smoothed and packed to ensure the seeds have good soil contact. Large areas are planted with a properly calibrated seed drill or fertilizer spreader, using an inert carrier in the mix, like cracked wheat, to carry the light prairie seeds through the machine. The seeding should be no deeper than .5 inch, or 1 centimetre. If the areas are too steep for seed drills, a broadcast seeding method is used, even though it is a less desirable method. June is usually the best time to plant prairie species in Manitoba.

(Source: Morgan, 1995)

- Bare-Root Stock

Bare root stock is nursery stock that has been grown in seed beds for one or two years, and then dug up, with any excess soil from removed from their roots. It provides a way of establishing a fast growing cover on a site, and is less expensive than planting containerized stock. Bare-root stock is also easier to ship, store, handle, and plant than container grown material. Planting, however, is limited to specific times of the year (usually early spring) and the plants are more difficult to cultivate than container grown stock.

Recommendations for planting of bare-root stock are:

i) Bare-root plants should have long roots to tap any deep soil moisture, and soils in quarries to be rehabilitated often have shallow rocky soils.

ii) Spacing of individual plants ought to be at least 1 - 1.5 X the diameter of the mature plant.

iii) When planting where risk of plant failure is high, cross-wind furrowing mulching to conserve moisture, and good water maintenance is required for one of two growing seasons.

- Containerized Seedlings

In this process, treated evergreen (usually spruce or pine) seeds are grown in peat filled discs for approximately 12 weeks, and then hand or machine planted. The basic advantage of containerized seedlings over bare - root stock, is that production of the seedlings is more flexible, the planting season is extended, and the shock of planting is lessened with the seedling being in an established rooting medium.

- Cuttings, Rhizomes and Sprigs

Cuttings are pieces of stems that are either rooted off-site and then planted on the site or directly cut from a plant and replanted on the quarry site. Rhizomes are underground stems or grasses, sedges or forbs which are rooted and replanted on

the site. Sprigs are pieces of grasses or sedges that can be rooted and transplanted to the site.

The advantage of cuttings is that they are compatible with direct seedlings, are easily propagated, and usually provide a ground cover within a short period of time. However, they are usually only available in the early spring, the optimum time to plant them, from distributors. Sprigs and rhizomes are cuttings from herbaceous plants and rooted in containers or flats. Sprigs are a better method of establishing some grasses than seedlings (eg *Phragmites communis* or Giant Reed Grass is an example).

- Container Grown Plant Stock

This plant stock is nursery-grown bare-root stock that has been put into a container and grown for one to two years. This type of planting is recommended for various situations: where immediate ground cover is needed to prevent erosion; when an immediate visual presence through more mature planting is desired for aesthetics or screening purposes; and where harsh site conditions demand that more mature and established growth are used to help assure high survival rates after transplanting. Containerized stock is more costly than most other planting methods, and requires more time to carry out.

Basic recommendations for planting containerized material is as follows:

i) Planting can occur anytime through the growing season, with watering and maintenance being conducted through the first two growing years.

ii) The hole for planting should be approximately 1.5 times larger than the diameter of the plants rootball, with the bottom surface scarified. The container is then removed and the plant placed into the hole with the rootball intact, and the soil is then firmed around it, with a watering saucer formed on the surface. The depth of the hole is to be slightly deeper than the rootball.

iii) Plant spacing should not be less than 1-1.5 times the diameter of the crown of the plant.

- Native Wildlings

Native plant material from the site or in close proximity to the site may also be utilized as a plant material source. Larger specimens can be relocated by being dug up with a front - end loader or, preferably, a tree spade. The tree spade is preferable because it creates a rootball for the transplanting process, and is better designed to handle the vegetation.

Timing

Time of planting is almost as critical as the type of planting in ensuring the vegetation survives to maturity. The correct time to plant depends on different factors such as: general climate of the area; type of planting stock and its

moisture requirements; and sufficient dryness, allowing machinery on-site.

In general, planting times should correspond to the time of year when the precipitation is greatest. Diagram Thirty illustrates the best times to plant in the Northern Great Plains Region, which includes the areas around Winnipeg. As mentioned previously, contrasting this matrix, the best time for seeding native prairie grasses and wildflowers is in June or mid-summer.

The preferred time to plant other grass seeds is in early spring until June. This is because of the available moisture and few hot nights, which puts less stress on the young plants. Late in the summer is the next best choice; again because of cooler nights, and available time in which the plants can establish themselves before the winter frosts.

Deciduous trees and shrubs should be planted in the spring or fall, either before or after they have leafed out. Planting in the fall is more risky, however, since the plants have not had a chance to set new roots and will be susceptible to frost heaving (Lowe, 1979, p.19). Planting in mid-summer is not recommended at all, because of the considerable moisture stress the plants will be under , making their survival probable in the quarry environment unless highly maintained.

The best time to move conifers is in the early fall or later in the spring. Roots cease growing in the hot summer months, so the best success is found in late August and September when the soil is warm and root growth continues immediately.

Maintenance

The various types of planting for a golf course within a quarry and parkland habitat will require different types of maintenance practices. The fairways, greens, and tee areas will require the highest levels of maintenance on the site, with the native plantings (after a period of time), the least. The cost of maintenance should also be justifiable (see Appendix A, p.62, concerning the law of diminishing returns). Considering that the project is meant to be environmentally sustainable, and less dependant on chemicals for its viability, low maintenance type planting should be utilized.

Trees and shrubs should be watered thoroughly after planting, and especially during the summer months, receiving a complete soaking. Since they will be planted into disturbed soils, the plants should be examined for any types of nutrient-type deficiencies. Table Thirty One shows fertilizer application guidelines, for any extra nutrient applications.

Different mulches such as wood chips and straw (there are other types) can be used in the tree and shrub beds to: prevent erosion; inhibit evaporation; moderate soil temperatures; suppress weed growth.

Mowing should be conducted two or three times per growing season to reduce ground cover competition around trees and shrubs. Cultivating should also be required around the trees and shrubs to control weeds, reduce soil crusting, and improve water infiltration.

Native prairie material requires no special maintenance one it is established

	Control Plots			Topsoil Plots			Subsoil Plots		
Grass/Legume Type	Days to Germ.	% Germ. at 23 Days	Plant Ht. (cm) at 23 Days	Days to Germ.	% Germ. at 23 Days	Plant Ht. (cm) at 23 Days	Days to Germ.	% Germ. at 23 Days	Plant Ht. (cm) at 23 Days
Tall Fescue	7	100	6-7	20	70	1-2	23	20	1-2
Creeping Red Fescue	6	20	6-7	20	70	1-2	23	2	0-1
Kentucky Bluegrass	18	90	2-3	23	3	0-1	27	nil	nil
Perennial Ryegrass	6	100	7-8	19	80	2-3	20	60	1-3
Brome Grass	6	100	6-7	19	80	1-3	20	50	1-2
Timothy	6	100	5-6	20	30	0-1	23	3	0-1
Yellow Blossom Clover	3	100	7-8	14	80	2-3	14	70	secondary leaves
Alsike Clover	5	100	5-6	14	80	secondary leaves	14	75	secondary leaves
White Clover	5	100	4-5	18	90	secondary leaves	18	70	secondary leaves
Trefoil	5	100	5-6	18	90	secondary leaves	18	70	secondary leaves
Crown Vetch	10	75	3-4	20	30	no secondary leaves	21	1	0-1
No. 1 Mix	6	100	5-6	20	80	1-2	23	50	no
41% Timothy	5	100	5-6	5	100	secondary	14	50	secondary
22% Alsike Clover						leaves			leaves
No. 2 Mix									
42% Creeping Red	6	100	6-7	20	60	1-2	23	55	0-1
Fescue	5	100	5-6	18	90	secondary	18		secondary
33% Trefoil						leaves			leaves
25% Perennial Ryegrass	6	100	7-8	19	90	3-4	20		2-3
No. 5 Mix									
40% Creeping Red Fescue	6	100	6-7	20	60	1-2	23		0-1
50% Tall Fescue	8	100	6-7	20	60	1-2	23	50	0-1
10% Perennial Ryegrass	5	100	7-8	19	80	2-3	20		1-2
50% Yellow Blossom Clover	5	100	7-8	14	90	secondary leaves	14		secondary leaves
50% White Clover	5	100	4-5	18	90	secondary leaves	18	80	secondary leaves

TABLE THIRTY: Planting Timing Matrix-Northern Great Plains (User Guide to Vegetation, p.36)

FERTILIZER APPLICATION GUIDELINES

Trees and Shrubs

At Time of Planting: U. of M. Department of Horticulture recommends:

1. Starter solution of 2.25 kg of 10 - 52 - 17 per 375 litres of water. Place the tree or shrub in the hole and backfill the hole half-way before pouring in the solution. Apply ½ to 5 litres of water on large shrubs and trees, depending upon their size.

P. Tucker, U. of Guelph, recommends:

2. Starter solution of 1.36 kg of 20 - 20 - 20 per 375 litres of water. Do not apply either fertilizer later than mid-July to avoid late succulent growth which will not harden off before winter.
3. Pellet-type fertilizer (i.e. Osmocote or Mag-Amp.)

Established Trees and Shrubs(U. of Manitoba recommendations)

The ideal time to apply fertilizer to trees and shrubs is in the early spring just before growth starts.

Deciduous Tree and Shrub Beds: In cultivated ground,broadcast and lightly work into the soil under the branches 16 - 20 - 0 or 14 - 14 - 7 at the rate of ½ litre/10 sq. meters. Note: Do not broadcast fertilizer if sod or pasture is around the tree or shrub bed.

Evergreen Trees and Shrubs: require less fertilizer than deciduous species. In cultivated ground, broadcast under the branches 16 - 20 - 0 or 14 - 14 - 7 at the rate of ¼ litre/10 sq. meters. Note: The root systems are very shallow so it is preferable not to work fertilizer into the soil.

Turf Seeded Areas:(U. of Manitoba recommendations)

At Time of Seeding: Just prior to seeding, broadcast 10 - 30 - 10 or 11 - 48 - 0 at a rate of 5 kg./100 sq. meters and work into the upper 4 inches of soil.

Established Lawns: Nitrogen may be applied at least twice during growing season- in early spring and early September.

Suggested rate is 1.5 - 2.5 kg. of nitrogen/100 sq. meters/year. Phosphate may be applied (if required) in spring at a rate of 500 grams/100 sq. meters.

TABLE THIRTY ONE: Fertilizer Application Guidelines (Paterson , 1982, p.95)

other than an occasional seasonal burning in late spring to invigorate the growth. While it is establishing, any weeds that appear should be mowed down before they germinate, to decrease any competition.

■ APPENDIX C : QUARRY MINING OPERATIONS

QUARRY MINING OPERATIONS

Quarry operations will vary from site to site, depending on each ones physical characteristics, as well as depending on the quarry's product specifications. For example, some quarries will be crushing stone, while others will be cutting.

This section will look at the quarry being studied, which is presently being mined by Mulder Mining. It is meant to better describe the operation process as background information for the design within the quarry, and as a source of information for any further rehabilitation studies.

Rock Formations

The operation being studied is a limestone quarry operation, which is a common type found in the Rockwood area near Winnipeg. The bedrock being mined is usually limestone, with some possible variances in the type of stone being found. Limestones can depart widely from their theoretical composition of calcite, which is pure limestone (calcite = calcium carbonate = $CaCO_3$). The majority of the limestone bedrock utilized within Manitoba varies between its theoretically pure form of $CaCO_3$ and that of dolomite ($MgCO_3$). Dolomite and limestone, however, are so similar, they are often found in adjacent beds or intermixed with each another.

(Paterson, 1982, p.44.)

The highest quality limestone (or dolomite) is pure white, with other various shades or colours of rock occurring naturally. This colour range is due to impurities in the rock or weathering. Colours range from greys to pinks and rusts. As the limestone's purity decreases it becomes more clayey, shaley, or sandy.

The quality of the stone also dictates what type of end use it will have as well, with the higher quality stone being used in higher stress situations. This is due to any impurities in the stone reducing its engineering properties. The stone being mined in the study site is of the Gunton and Penitentiary type of the Stoney Mountain Formation, with the Gunn member close below the existing floor level of the quarry. (Mulder, 1994). Diagram Thirty Two lists the different formations and their attributes. The limestone being mined in the study site is of the high quality type, making the quarry a crushed stone operation (Ibid, 1994).

Crushed Stone Operations

The operation being studied is quite common throughout the area, and has a definite process or steps involved (See Table Thirty Three). They are :

1)Clearing

This involves the removal or repositioning of any vegetation or structures that are located within the boundaries of the planned excavation. Typically this process is

SUITABILITY OF BEDROCK FOR AGGREGATE PRODUCTION

Formation	Member or Unit	Rock Type	Potential Aggregate Quality	Uses
Interlake Group			High	
Stonewall		dolomite	High	
Stony Mountain	Williams	dolomite	Low	
	Gunton	dolomite	High	crushed stone
	Penitentiary	dolomite	Medium	crushed stone
	Gunn	calcareous shale-thin limestone interbeds	Low	
Red River	Fort Garry (upper)	dolomite and limestone	Medium High	crushed stone, high-calcium limestone
	Fort Garry (lower)	dolomite	Medium	crushed stone
	Selkirk	dolomitic limestone	Low	Tyndal Stone
	Cat Head	dolomite to dolomitic limestone		crushed stone, rubble, rip rap
	Dog Head	dolomitic limestone		
Winnipeg		koolnitic shale and quartzose sandstone		

DIAGRAM THIRTY TWO: Bedrock of the Winnipeg Region and its Production Potential
(Paterson, 1982, p.47)

carried out by a large front-end loader or bulldozer to remove any of the existing vegetation. Grubbing, or tree stump removal is then carried out, along with removal of any trash litter. The material is then either burned on site, hauled away, or buried in the earth berms that are typically built around the quarry.

2)Stripping

This involves the removal of the overlying overburden on the proposed quarry site. Overburden will consist of the topsoil and any underlying earth material over the rock. Typically, overburden is stripped from the site to be used in any earth berming around the periphery of the quarry, acting as a visual screen.

Ideally, the topsoil should be stripped and stored separately from the rest of the overburden for future use in the rehabilitation process. However the typical situation in the Rockwood area is for all of the overburden to be stripped and piled together (Mulder, 1995).

In this particular study, the topsoil was, for the most part, a stoney glacial till, giving it relatively little value for re-use. The current stripping procedure at Mulder Mines as with others in the area, is to use front-end loaders (Mulder, 1995; Paterson, 1982, p.48). Other methods of removing overburden are to use : a caterpillar tractor (usually for areas larger than a front-end loader can efficiently handle); or a belly dump scraper for even larger operations. The advantage of the scraper is that it can separate the topsoil layer from the rest of the overburden. If there is more than 1.5 metres of overburden, then the operator usually contracts out a belly dump scarper. This is due to the relative inefficiency of a front-end loader to handle this type of work (Paterson, 1982, p.49)

Stripping of the overburden usually occurs in phases: as the quarrying for an area becomes more complete, stripping occurs on the area to be worked next. Provincial regulations require that overburden be stripped in advance of the working face to at least twice the height of the quarry face.

3)Excavation

The excavation process used by Mulder Mining is a basic procedure utilized widely in Manitoba (Mulder, 1995). It involves drilling, blasting, mucking and crushing.

i) Drilling

Using pneumatic or percussive drills a series of holes are drilled to allow charges to be lain into them, fragmenting the rock. The commonly used rock drill is called an "air track" which is a compressed air drill mounted on a small crawler or tracked unit.

A series of vertical holes are then drilled parallel to the quarry face. The diameter, spacing, and depth of these holes influence the amount of rock that will be broken loose from the parent rock along the quarry face. Typically, the quarry operators drill approximately 6.35 cm diameter holes, with 2 - 2.6 metre spacings between the holes, to a depth of six

metres (Paterson, 1982, p.50). Drilling to a depth of less than 3 metres proves uneconomical for the operators, when manpower and fuel costs are factored in to muck the rock (Mulder, 1995).

ii) Blasting

Blasting is usually carried out in two stages (if necessary). Primary blasting is carried out using an ammonium nitrate (fertilizer) and fuel oil mix. The amount of explosive charge varies between operations, and blasting is usually carried out twice a day (Mulder 1995). Black powder is used in secondary blasting to reduce the size of any boulders that are too large to move.

In a correctly done blast, the majority of the rock will be broken under the strain of gravity when it slumps, rather than through the explosive force of the blast. Typically, the line of holes that are fired parallel to the quarry face will produce a new flat face from which to blast. The operators will usually work one long face as well, mucking one blast while setting explosives along another portions of the face.

iii) Mucking

Mucking is the term used to describe the removal of the blasted stone from the quarry floor. Mulder Mines along with most operators use a front-end loader with a five metre bucket for this part of the process
(Mulder, 1995). The loader is then used to load the "muck" onto trucks, or even to carry the stone to the processing unit if it is nearby.

4)Processing Plants

The majority of crushed stone operations utilize portable processing plants to crush the rock into the various specified sizes. Although different operations will own different units, the process is the same throughout the area.

i) Grizzly

The grizzly is a primary screen with large openings that facilitates three purposes:
1) It serves as a dump point for blasted rock.
2) It reduces the load of the primary crusher by rejecting stone that is too large, or allowing stone that does not require crushing to bypass it. 3) It controls the rate the fragmented stone feeds into the primary crusher, preventing jamming and ensuring it runs at its optimum efficiency.

(Source: Mulder\Paterson)

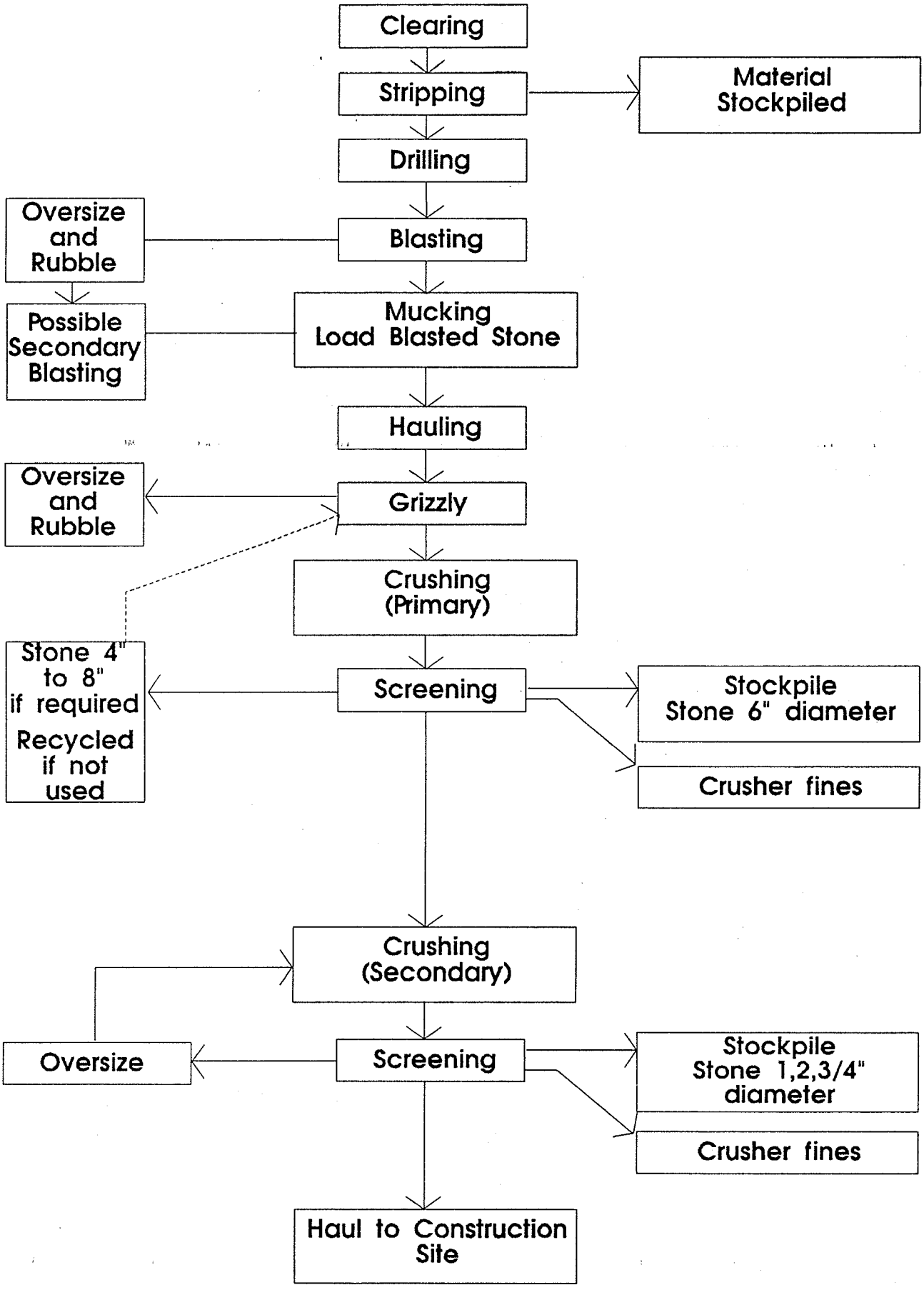


DIAGRAM THIRTY THREE: STEPS of a CRUSHED LIMESTONE QUARRY OPERATION

ii) Primary Crusher

This is the first point where rocks are reduced down to a more uniform size. Primary crushers are usually jaw crushers which produce a coarse product of about 6 inches (15 cm.) in diameter (Mulder, 1995).

iii) Screening

Screening at this point, after the primary crush, serves the same purposes as points two and three describing the grizzly's function. The screens will generally be in a series, shaking or vibrating, filtering out the different sized particles. Screens may be made from bars welded together,sheet steel, rubber, or wire cloth with different shaped holes.

iv) Secondary Crusher

This type of crusher is required to produce a more uniform and specific sized product than the primary crusher. The secondary crusher is generally of the Cone or Gyratory type (Paterson, 1982, p.52). These types use a conical crushing member rotating around a vertical axis inside a fixed bowl or mantle. The secondary crush produces a variety of sized particles, with the majority being of the 1,2, and 3/4inch variety (Mulder, 1995).

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