LANDSCAPE AESTHETICS
AND SURFACE MINE RECLAMATION:
ESTABLISHING THE EFFICACY OF LINKING
ETHICS, AESTHETIC PREFERENCE, ECOLOGICAL HEALTH
AND THE
CONCEPT OF SUSTAINABLE DEVELOPMENT
WITHIN THE CONTEXT OF A RECLAMATION OF AN OPEN PIT MINE

by

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We accept this thesis as conforming
to the required standard

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The field of mine reclamation has traditionally been dominated by engineers and biologists. With a few notable exceptions, landscape architects in North America have not shown a willingness to participate in reclamation activities. This unwillingness was primarily the result of the perception that the contribution of landscape architects as place-makers was irrelevant due to the often remote location of these mine sites. With advances in transportation, communications, and a rapidly expanding human population, areas that were once considered remote are now accessible. With the rise in social activism resulting from the public's desire for more sustainable forms of economic development, the government has responded by placing ever-increasing restrictions on where mines can be developed in the province of British Columbia. In response to these actions, mine operators have begun to realize that past mine management practices must now give way to new approaches if the industry is to prosper in Canada. This change has lead to a reappraisal of the role landscape architects can play in mine reclamation. For reasons based on their understanding of ethics, aesthetics, and issues of ecology, the profession appears capable of making important contributions to how mine reclamation should be practiced. Having the ability to effectively link all three themes into a coherent whole, landscape architects can move the direction of mine reclamation toward a set of goals that effectively addresses both human and ecologically-based objectives. As an important first step in this process, mine owners must be willing to accept the consequences of ever increasing public participation in all phases of mine development. Building upon the existing concept of design for closure, this participation would require that members of the affected community be involved in the planning and implementation of the mine closure plan. As a consequence of this long-term involvement, it is envisioned that the mining company and local community will develop a foundation of trust that will form the basis of a more sustainable mining industry. With their commitment to the value of public process, landscape architects can be important facilitators in bringing about this change.

# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>TITLE</td>
<td>i</td>
</tr>
<tr>
<td>ABSTRACT</td>
<td>ii</td>
</tr>
<tr>
<td>TABLE OF CONTENTS</td>
<td>iii</td>
</tr>
<tr>
<td>LIST OF TABLES</td>
<td>vii</td>
</tr>
<tr>
<td>LIST OF FIGURES</td>
<td>viii</td>
</tr>
<tr>
<td>GLOSSARY OF RECLAMATION AND MINING TERMS</td>
<td>ix</td>
</tr>
<tr>
<td>ACKNOWLEDGEMENTS</td>
<td>xi</td>
</tr>
<tr>
<td>INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>Part I - Statement of Intent</td>
<td></td>
</tr>
<tr>
<td>Project Goal</td>
<td>1</td>
</tr>
<tr>
<td>Project Objective</td>
<td>4</td>
</tr>
<tr>
<td>Expected Outcome</td>
<td>5</td>
</tr>
<tr>
<td>Part II - Literature Review</td>
<td>6</td>
</tr>
<tr>
<td>Ethics, the Environment and its Relationship to Landscape Architectural Theory</td>
<td>6</td>
</tr>
<tr>
<td>Western Views on the Cause of our Environmental Crisis</td>
<td>7</td>
</tr>
<tr>
<td>Developing a Typology of Environmental Ethics</td>
<td>10</td>
</tr>
<tr>
<td>Anthropocentric Theory of Environmental Ethics</td>
<td>11</td>
</tr>
<tr>
<td>Nonanthropocentric Theory of Environmental Ethics</td>
<td>12</td>
</tr>
<tr>
<td>How Ethics Influence Resource Management Decisions</td>
<td>13</td>
</tr>
<tr>
<td>The Ecocentrist</td>
<td>14</td>
</tr>
<tr>
<td>The Technocentrist</td>
<td>14</td>
</tr>
<tr>
<td>Ethics and Perceptions of Ecosystem Health</td>
<td>15</td>
</tr>
<tr>
<td>Environmental Ethics and Landscape Architecture: Locating the Profession along the Continuum</td>
<td>17</td>
</tr>
<tr>
<td>Bridging Anthropocentric and Nonanthropocentric Theories of Environmental Ethics</td>
<td>18</td>
</tr>
<tr>
<td>Determining Our Moral Obligations to Future Generations</td>
<td>20</td>
</tr>
<tr>
<td>Ethics and Surface Mining</td>
<td>23</td>
</tr>
<tr>
<td>Sustainability and Sustainable Development</td>
<td>25</td>
</tr>
<tr>
<td>Sustainable Development: Putting Environmental Ethics into Practice</td>
<td>26</td>
</tr>
<tr>
<td>The Components of Sustainability</td>
<td>28</td>
</tr>
<tr>
<td>Defining Cultural Sustainability</td>
<td>31</td>
</tr>
<tr>
<td>Section</td>
<td>Page</td>
</tr>
<tr>
<td>------------------------------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>Sustainable Development: Some Implications for the Practice of Landscape Architecture</td>
<td>33</td>
</tr>
<tr>
<td>Sustainable Development: Some Implications for the Mining Industry</td>
<td>35</td>
</tr>
<tr>
<td>Theoretical Approaches for Understanding Aesthetic Appreciation of a Landscape</td>
<td>38</td>
</tr>
<tr>
<td>Environmental Psychology and Aesthetic Appreciation</td>
<td>38</td>
</tr>
<tr>
<td>Aestheticians and the Aesthetic Appreciation of Nature</td>
<td>43</td>
</tr>
<tr>
<td>The Cognitive Model</td>
<td>44</td>
</tr>
<tr>
<td>Aesthetics, Ecological, and Culture</td>
<td>45</td>
</tr>
<tr>
<td>A Prescription for Action</td>
<td>47</td>
</tr>
<tr>
<td>Part III- Reclamation</td>
<td>50</td>
</tr>
<tr>
<td>Legislation Governing Surface Mine Reclamation</td>
<td>51</td>
</tr>
<tr>
<td>Linking Reclamation to Sustainability</td>
<td>53</td>
</tr>
<tr>
<td>Exploring Alternative Goals for Reclamation</td>
<td>57</td>
</tr>
<tr>
<td>Biodiversity as a Goal of Reclamation</td>
<td>59</td>
</tr>
<tr>
<td>Ecosystem Restoration as a Goal of Reclamation</td>
<td>62</td>
</tr>
<tr>
<td>Methods for Measuring the Effectiveness Of Ecosystem Management</td>
<td>63</td>
</tr>
<tr>
<td>Part IV- Learning from the Past: Case Studies on Reclamation</td>
<td>65</td>
</tr>
<tr>
<td>Case Study #1- The Chicago Controversy</td>
<td>65</td>
</tr>
<tr>
<td>Case Study #2- The Henderson Mine and Mill</td>
<td>68</td>
</tr>
<tr>
<td>Case Study #3- The McLaughlin Mine</td>
<td>68</td>
</tr>
<tr>
<td>Case Study #4- The Flambeau Mine</td>
<td>69</td>
</tr>
<tr>
<td>Case Study #5- The Equity Silver Mine</td>
<td>70</td>
</tr>
<tr>
<td>Case Study #6- Treating Coal Mine Drainage using Constructed Wetlands</td>
<td>72</td>
</tr>
<tr>
<td>Case Study #7- Slope Stabilization using Bioengineering Methods</td>
<td>75</td>
</tr>
<tr>
<td>Part V- Study Methodology</td>
<td>76</td>
</tr>
<tr>
<td>Part VI- Telkwa Coal Project Site Inventory and Analysis</td>
<td>78</td>
</tr>
<tr>
<td>Purpose of the Site Analysis</td>
<td>78</td>
</tr>
<tr>
<td>Understanding the Telkwa Site</td>
<td>79</td>
</tr>
<tr>
<td>General Project Description</td>
<td>79</td>
</tr>
<tr>
<td>DISCUSSION</td>
<td>81</td>
</tr>
<tr>
<td>Aesthetics</td>
<td>82</td>
</tr>
<tr>
<td>Ecological Function</td>
<td>84</td>
</tr>
<tr>
<td>Long-Term Sustainability</td>
<td>86</td>
</tr>
<tr>
<td>Table</td>
<td>Title</td>
</tr>
<tr>
<td>-------</td>
<td>----------------------------------------------------------------------</td>
</tr>
<tr>
<td>1.</td>
<td>White's Model</td>
</tr>
<tr>
<td>2.</td>
<td>Moncrief's Model</td>
</tr>
<tr>
<td>3.</td>
<td>Competing Theories within the Study of Environmental Ethics</td>
</tr>
<tr>
<td>4.</td>
<td>Contemporary Attitudes towards Resource Management</td>
</tr>
<tr>
<td>5.</td>
<td>Potential Environmental Impacts of Mining</td>
</tr>
<tr>
<td>6.</td>
<td>Guiding Principles of Environmental Psychology</td>
</tr>
<tr>
<td>7.</td>
<td>Estimated Value of the Bulkley River Fishery</td>
</tr>
<tr>
<td>8.</td>
<td>Open Pit Information</td>
</tr>
<tr>
<td>Figure</td>
<td>Description</td>
</tr>
<tr>
<td>--------</td>
<td>------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>1.</td>
<td>Open Pit Mine Site</td>
</tr>
<tr>
<td>2.</td>
<td>Graphical Representation of Hypothetical Relationship between Aesthetics and Ecological Integrity</td>
</tr>
<tr>
<td>3.</td>
<td>Pyramid of Intrinsic Rights</td>
</tr>
<tr>
<td>4.</td>
<td>The Traditional Model of Sustainability</td>
</tr>
<tr>
<td>5.</td>
<td>The Alternate Model of Sustainability</td>
</tr>
<tr>
<td>6.</td>
<td>Natural versus Urban scenes judged in terms of Preference and complexity</td>
</tr>
<tr>
<td>7.</td>
<td>An Example of Cultural Landscapes</td>
</tr>
<tr>
<td>8.</td>
<td>Reclamation to Self Sustainable Use</td>
</tr>
<tr>
<td>9.</td>
<td>Reclamation to a Developed Sustainable Use</td>
</tr>
<tr>
<td>10.</td>
<td>Systems Model for the Practice of Reclamation</td>
</tr>
<tr>
<td>11.</td>
<td>Constructed Wetlands for Treating Heavy Metal Contaminated Water</td>
</tr>
<tr>
<td>12.</td>
<td>Flowchart Describing Thesis Methodology</td>
</tr>
<tr>
<td>13.</td>
<td>Illustration of Mining Method</td>
</tr>
<tr>
<td>14.</td>
<td>Loading Shovel and Truck</td>
</tr>
</tbody>
</table>
GLOSSARY OF RECLAMATION AND MINING TERMS
(adapted from Michaud 1981)

Aquifer
A geologic formation or structure that transmits water in sufficient quantity to supply the needs for a water development, such as a well.

Backfill
The operation of refilling an excavation, including the grading of the refilled excavation. Also the material placed in an excavation in the process of backfilling.

Baseline Data
Data gathered prior to mining for the purpose of outlining conditions existing on the undisturbed site. Reclamation success is measured against baseline data.

Check Dam
A barrier across a water channel to control the water flow velocity.

Dump
Also called fill, backfill, or storage site, a dump is an area where overburden is piled during the mining process, either temporarily or permanently.

Environmental Impact Assessment
An analysis of all actions and their predictable short and long-term environmental effects, which includes physical, biological, economic, and social factors and their interactions.

Erosion
The group of processes whereby earth or rock material is worn away, loosened, or dissolved and removed from any part of the earth’s surface. It includes the processes of weathering, solution, corrosion, and transportation. Erosion is often classified by the eroding agent (wind, water, wave, or raindrop erosion) and/or by the appearance of the erosion (sheet, rill, or gully erosion) and/or by the location of the erosional activity (surface or shoreline) or by the material being eroded.

Highwall
The unexcavated face of exposed overburden and coal in a surface mine or the face or bank on the uphill side of a strip mine excavation.

Horizons, Soil
Layers in the soil and overburden that differ in genetic characteristics, composition, or structure from adjacent layers. The various horizons in a soil are generally described by a diagram representing a vertical section of the soil called a profile. The horizons are designated as follows: A-horizon, topsoil; B-horizon, mineral soil; C-horizon, parent soil material, weathered or unweathered rock fragments, and minerals.
Leaching
To remove soluble constituents from a substance by the action of a percolating liquid.

Oxidation in Soil
The combination of substances in the soil with oxygen. If the substance is a sulfide, this oxidation may result in an acidic condition.

pH
Symbol for the negative common logarithm of the hydrogen-ion concentration (acidity) of a solution. The pH scale runs from 0 - 14, with pH of 7 considered neutral. A pH number below 7 indicated acidity and a pH value above 7 indicates alkalinity or a base.

Pit
Used in reference to a specifically describable area of open pit mining.

Reclamation
The process of returning a disturbed area to its natural state, or to a state suitable for equivalent or superior use or benefit. Most frequently used in conjunction with areas whose properties have been drastically changed.

Rock Waste
Material of no present economic value other than overburden that must be removed to excavate the ore.

Soil
The loose, uncemented minerals and organic material on the immediate surface of the earth that serves as a natural medium for the growth of terrestrial plants.

Spoils
A general term relating to solid mineral waste materials resulting from the milling, concentration or refining of minerals.

Structure, Soil
Aggregates of primary particles of sand, clay, and silt into clusters.

Tailings
Waste products resulting from the grinding and treatment with chemicals to extract desired minerals.

Texture, Soil
Relative proportion by weight of sand, silt, and clay.

Weir
An obstacle constructed in a water channel to concentrate and divert the water flow and to retain the water to promote sedimentation.
ACKNOWLEDGEMENTS

Completing this thesis project would not have been possible without the support of many people and it is only fitting that I acknowledge the debt of gratitude that I owe them. First I would like to thank Luscar Limited, and in particular Allan Flemming for his willingness to supply me with the TRIM and environmental baseline data that was critical in helping me understand the Telkwa site.

Because a thesis is often only as good as the committee members that are a part of it, much of the sense of accomplishment that I now feel is the result of the support I have received from Marcello Veiga and Stephen Sheppard. Going into the thesis with only a limited knowledge of issues relating to mine reclamation, Marcello helped to keep me focused on those issues that were key to understanding the problem. I am looking forward to our trip to Brazil. I would like to thank Stephen for his advice on issues relating to aesthetics, visual preference, and solving some of the mysteries of ArcView. Your editorial comments took much of the pain out of the process of writing the thesis report. Again, thank you both for the support that you have shown me.

Finally, I must acknowledge the unfailing support I have received from my wife. Three years of study have not been easy, but with her continued patience this seemingly endless separation is now behind us (at least until this Fall's semester).

SAR
INTRODUCTION

In facing the growing urgency of environmental issues confronting human societies, we must do more than sustain the earth; we must heal, enhance and manage the life-sustaining processes of the planet and ensure the integrity and strength of the global landscape which connects them.

American Society of Landscape Architects
Declaration on Environment and Development - January 1993

Revolution in the aesthetics of nature often takes place when people start appreciating the parts of nature formerly regarded as aesthetically negative.


PART I - STATEMENT OF INTENT

Large open-pit mining operations can greatly impact the natural landscape in a host of ways. In general terms these include impacts to land and soil, surface and groundwater, air quality, wildlife habitat, and visual resources. The effect of these impacts can be felt both locally and regionally. This is possible because the scale of some surface mining operations can be immense. A single large hydraulic shovel can move over four million cubic yards of material in a single month. Some bituminous coal mines in the old Soviet Union are said to have been developed to a depth of up to 500 m or more, with in excess of 1 billion cubic meters of spoil material being removed (Dietrich 1991).

While the immediate environmental and social effects of surface mining operations may be severe during the excavation and operational phases of the mine, their impact is only temporary. The working life span of a mine is measured in decades, and typically is much shorter than that.
Of much more lasting concern, both in terms of its social and ecological impacts, is the subsequent void and vast spoil piles that are left behind once the ore body has been exhausted (Figure 1). Because mining is one of the few modern industrial activities that are known in advance to have a predetermined life span, it is important that a mine be planned from the beginning with closure in mind. Designing for closure has the potential not only to minimize the adverse environmental impacts of mining, but the socio-economic disruptions that afflict the local community following the decision to close the mine.

Figure 1 – The physical, ecological and social impact of modern mining operations are a source of much debate whenever people are faced with the prospect of a mine opening in their community.

While the task of reclaiming a mine site would appear to require the skills of a wide range of professionals, interestingly enough very few landscape architects are employed in this area. The
reasons for this are varied. Because of the physical processes involved in rehabilitating sites of this size, engineers typically have dominated the field. Additionally, there are some landscape architects that have expressed concern over the ethics of participating in an activity that claims that such devastated lands can be restored at all.

It is the contention here that not only should landscape architects become actively involved in the practice of mine-site reclamation, but that we have the ability to bring a unique perspective to the problem of how best to heal these broken lands. Whereas engineers have addressed with varying degrees of success the technical, and environmental issues surrounding surface mine reclamation, public apprehension with respect to mining would seem to suggest that some important piece is missing from the reclamation puzzle. For the purpose of this thesis project it will be argued that this missing piece is what is commonly referred to as ‘aesthetics’. In the context of this thesis project the term aesthetics will be used to encompass more than just the “principles of beauty and tastefulness” as defined by The Oxford Dictionary (1994). Rather our focus will be on the aesthetics of environments that describes the appreciative engagement of humans with the natural world. This experience is active, involving all of the senses, and as an outcome allows the participant to form both positive and negative value judgments of the environment based on knowledge and experience (Berleant 1997, Carlson,1998, and Eaton 1998). Borrowing from an idea that is just now being explored in the Department of Forest Resources Management at UBC, this project intends to pursue the following hypothesis:

• That there is a direct association between the visual quality of a reclaimed landscape (i.e., aesthetics) and its ecological sustainability. This association can be illustrated using the following graphic representation (Figure 2).
In pursuing this line of inquiry this study is suggesting that, in the context of surface mine reclamation, aesthetics means much more than just making the site look pretty. For an aesthetic solution to be truly efficacious, it is understood in this context to mean that it must be capable of functioning on many different levels (i.e., wholeness, ecological integrity, cultural cohesion, connectivity with the larger landscape).

Goal of the Thesis Project

The goal of this thesis project is to test the validity of this hypothesis by developing and assessing aesthetically derived reclamation solutions and correlating them against indices of ecological health and the concept of sustainable development.

Project Objectives

In order to attain this goal, the author has established the following set of objectives:
• Develop the ethical argument for the involvement of landscape architects in the field of surface mine reclamation;

• Assess aesthetic quality/ecological integrity and draw conclusions on the relative association between them;

• Identify a definition of ecological sustainability and key ecological indicators that is appropriate to open pit mine reclamation;

• Determine if there are generally accepted visual indicators of ecologically sustainable landscapes;

• Determine potential visual indicators of sustainable landscapes specific to surface mine reclamation;

• Demonstrate how these visual indicators of ecologically sustainable landscapes would appear through the development of a reclamation design for the Telkwa Project Area;

• Identify implications and/or design principles that may be applied to other mine reclamation sites; and

• Identify areas of possible future research in the field of mine reclamation.

Expected Outcome

Upon completion of this design thesis the following products will have been produced:

• A philosophical rational for the involvement of landscape architects in the field of surface mine reclamation;

• A definition of sustainability that is specific to surface mine reclamation;

• A set of possible visual indicators of ecologically sustainable landscapes that would be applicable to surface mine reclamation; and
PART II- THE LITERATURE REVIEW

During the research phase of this thesis project, it quickly became apparent that in order to confirm the validity of the hypothesis it would be necessary to examine the works of researchers from a diverse range of disciplines. This included restoration ecology, sustainable development, environmental ethics, aesthetics, mine reclamation, and visual resource management. Though extensive, this review by no means covers the full range of thought on the issues surrounding mine site reclamation. What this thesis has endeavored to do is provide the reader with the background information necessary to understand the core issues that have and/or will shape the future debate on how open pit mines should be reclaimed in this country.

Ethics, the Environment and its relationship to Landscape Architectural Theory

Environmental ethics is a branch of moral philosophy that concerns itself with questions relating to man's proper relationship with nature, his understanding of natural processes, his responsibility to maintain ecological function, and his obligation to preserve a viable ecosystem for the benefit of future generations (Pojman 1997). By comparison, landscape architecture is a profession that concerns itself with practical issues relating to these very same questions. Interestingly enough, until very recently little has been done to connect the profession with a specific theory of environmental ethics (Thompson 1998). Because morality forms the basis of how individuals and/or society ought to live, it (ethics) is the point of reference from which all
our actions will ultimately be judged. Taken in this light, this thesis paper will first explore the following issues:

- Review the various arguments for explaining the ethical roots of our current ecological crisis;
- Review the two contrasting ethical perspectives that shape our understanding of what is a healthy ecosystem;
- Identify how environmental ethics applies to the profession of landscape architecture; and
- Identifying possible ways for reconciling competing ethical theories and how this can influence our understanding of the concept of sustainable development.

Through the study of ethics it is not only possible to understand the roots of our current ecological crisis, it is also possible to discover the means for reconciling our material needs with the capacity of the earth to provide for them.

**Western Views on the Cause of Our Environmental Crisis**

In studying ethics, one is interested in arriving at answers to questions that are central to understanding the human condition. This is where the individual and society come together to debate such moral concepts as “right” and “wrong”, “good” and “evil”, “action” and “consequences” (Pojman 1997). In answering these questions, ethics provides mankind with rules of conduct that are grounded upon moral values. These moral values in turn serve as the basis for how a society is ordered. In Western societies, it is common to look to our Judeo-Christian religious roots for the basis of our current moral behaviour. In the pages that follow, three
different perspectives are offered to explain the effect that religion has had in shaping our understanding of our relationship with nature.

In his analysis of the ethical roots for our current ecological problems, Lynn White (1967) concluded that our arrogant and exploitive attitude toward nature is a reflection of early orthodox Christian teachings. According to the Book of Genesis, mankind's moral obligation to nature was set forth by God when He presented the world to Adam and Eve. "God blessed them, saying to them, 'Be fruitful, multiply, fill the earth and conquer it. Be masters of the fish of the sea, the birds of heaven and all living animals of the earth.'" (Genesis 1-3). Drawing upon this and other stories from the Old Testament, White drew several important conclusions. First he argued that by creating this artificial separation between mankind and the natural world, "Christianity made it possible to exploit nature in a mood of indifference to the feelings of natural objects." (White 1967, p 12).

A second and equally important point for explaining our present environmental crisis is the medieval Christian idea that through science one can come to understand the mind of God. Drawing these two ideas together, White concluded that the Holy Bible provided our moral justification for the exploitation of nature, while science and technology provided the means.

Table 1 - White's Model showing the relationship between religion and the environment (adapted from Moncrief 1997)

| Judeo-Christian Tradition | Science and Technology | Environmental Impact |

Though in many ways provocative, White's thesis was open to criticism on a number of points. First is White's own admission that there are numerous examples outside of the Judeo-Christian world where humans had adopted land use strategies that were clearly destructive to the
environment. It might also be asked why, if our current environmental crisis is the necessary outcome of Judeo-Christian religious teachings, are these problems global in nature rather than being confined only to being confined to the Western world? A more reasonable explanation for the current crisis suggests that other factors have clearly played a role in shaping the planet's environment. These forces include the nature of the capitalist economic system, Third World development, urbanization, the direction of technological advancement, democratization, individualism and consumerism (Moncrief 1970). Though Moncrief acknowledges that Judeo-Christian teachings have probably influenced the 'character' of these forces, he argues that it would be greatly overstating the net effect of religion to suggest that it is the primary cause of our current ecological problems. The model he used to describe the connection between religion and the environment places much greater emphasis on the importance these other factors have played in shaping our world.

Table 2 - Moncrief’s Model showing the relationship between religion and the environment (adapted from Moncrief 1997)

|---------------------------|---------------------------------------------------------------------------|-------------------|----------------|-------------------|------------------------|-----------------------------|---------------------------|

A third perspective is offered by Patrick Dobel. Unlike White, Dobel believed that an environmental ethic is in fact an essential characteristic of the Judeo-Christian religious tradition. Citing heavily from both the books of the Old and New Testament, Dobel began by asking the question "Who owns the earth?" (Dorel 1977). For Christians the Bible clearly states that ownership over the earth is held by God. Resolving the issue of who owns the earth clearly has an
impact on our study of environmental ethics. In creating the earth, God established an everlasting covenant between Himself and all creatures of the earth.

And God said, “This is a sign of the covenant which I make between Me and you and every living creature that is with you, for all future generations: I set my bow in the sky, and it shall be a sign of the covenant between Me and the earth.

Genesis 1:30

By entering into this covenant with God and nature, mankind has accepted limits to his own power on earth. Instead of behaving like arrogant exploiters of the earth’s resources, humans are expected to assume the role of stewards over the earth’s resources. As stewards, no one generation has the authority to break the covenant that has been granted by God. Furthermore, humans are further obligated to take steps to improve the earth as a legacy for those people who will come after us. In developing a moral philosophy based on the “ethics of stewardship”, Dobel has laid the groundwork for understanding environmental ethics in terms of our moral obligation to future generations.

Developing a Typology of Environmental Ethics.

While the history of the branch of moral philosophy known as environmental ethics is relatively short (Berleant 1997, Porteous 1996, Thompson 1998), its disciples have in that time created a plethora of discreet theories relating to its correct and proper interpretation. These can be simplified by grouping them under the headings of anthropocentric and nonanthropocentric theories of environmental ethics (Table 3).
Anthropocentrism Theory of Environmental Ethics

Anthropocentrists believe that humans alone are vested with the ability to make moral judgments, or have intrinsic worth. The rest of nature, both animate and inanimate, are considered to have no value outside of their ability to serve human needs. The anthropocentric theory of environmental ethics can in turn be further subdivided into egocentric and homocentric views. The former view holds that mankind is engaged in a unending competitive struggle against one another. In terms of the natural environment, the outcome of this competition is the gradual depletion, and eventual destruction of the natural environment (Hardin 1977).

Homocentrists view the human condition in a very different light. Here the goal that mankind should to be striving for is a system based on universal social justice. Nature is again perceived as nothing more than an exploitable resource, but this is now tempered with the tacit acknowledgment that long term human happiness is possible only with the adoption of policies aimed at natural resource conservation.

It is important to note that the distinction between egocentric and homocentric (or the other competing theories of environmental ethics) perspectives are by no means absolute. Instead they should be understood to exist along a continuum, which makes it is possible to be a homocentrist and still believe that animals do possess certain intrinsic rights. Such rights as they exist are apportioned according to an animal’s degree of sentience. According to this yardstick, humans would be seen as occupying the apex of the rights pyramid, with all other living creatures taking a subordinate position (Figure 3).
Nonanthropocentric Theories of Environmental Ethics

Nonanthropocentrists place a completely different emphasis on the relative moral weighting accorded to humans and other living organisms. Here it is understood that all forms of life (and in some cases even non-living things) are accorded intrinsic value. Again as in the previous discussion, those that ascribe to this general philosophy exist along a continuum. At one extreme are those philosophers (Naess 1977, Taylor 1977) whose notion of biospherical egalitarianism holds that all forms of life from humans to single celled organisms share "the equal right to life and blossom" (Naess 1977, p 135). Less radical forms of this movement in environmental ethics have sought to focus the debate around the question of what moral consideration humans should give to other forms of life. (Goodpaster 1978, Leopold 1949). Here it is understood that plants and animals, while possessing intrinsic moral value, should not be seen as having moral worth equal to that of human beings.
<table>
<thead>
<tr>
<th>Anthropocentric</th>
<th></th>
<th></th>
<th>Nonanthropocentric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Egocentric</td>
<td>Homocentric</td>
<td>Biocentric</td>
<td>Ecocentric</td>
</tr>
<tr>
<td>Self-interest</td>
<td>Greatest good of the greatest number</td>
<td>Members of the biotic community have moral standing</td>
<td>Ecosystems and/or the biosphere have moral standing</td>
</tr>
<tr>
<td>'Laissez faire'</td>
<td>Stewardship of nature (for human use and enjoyment)</td>
<td></td>
<td>Duty to the whole environment</td>
</tr>
<tr>
<td>Mutual coercion (mutually agreed)</td>
<td></td>
<td></td>
<td>Holism</td>
</tr>
<tr>
<td>Classical economies</td>
<td>Utilitarianism</td>
<td>Moral extensionism</td>
<td>Deep ecology</td>
</tr>
<tr>
<td>Capitalism</td>
<td>Marxism</td>
<td>Animal rights</td>
<td>Land ethic</td>
</tr>
<tr>
<td>New Right</td>
<td>Left Greens</td>
<td>Bio-egalitarianism</td>
<td>Gaianism</td>
</tr>
<tr>
<td></td>
<td>Eco-socialism</td>
<td></td>
<td>Buddhism</td>
</tr>
<tr>
<td></td>
<td>‘Shallow’ ecology</td>
<td></td>
<td>American Indian</td>
</tr>
<tr>
<td>Thomas Hobbes</td>
<td>J.S. Mill</td>
<td>Albert Schweitzer</td>
<td>Aldo Leopold</td>
</tr>
<tr>
<td>John Locke</td>
<td>Jeremy Bentham</td>
<td>Peter Singer</td>
<td>J.Baird Callicott</td>
</tr>
<tr>
<td>Adam Smith</td>
<td>Barry Commoner</td>
<td>Tom Regan</td>
<td></td>
</tr>
<tr>
<td>Thomas Malthus</td>
<td>Murray Bookchin</td>
<td>Paul Taylor</td>
<td></td>
</tr>
<tr>
<td>Garrett Hardin</td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Most landscape architects?</td>
<td></td>
</tr>
</tbody>
</table>

**How Ethics Influence Resource Management Decisions**

In the study of moral philosophy it is understood that the ethical model to which one subscribes will prove instrumental in guiding one’s real-life actions (Pojman 1997, Thompson 1998). In terms of the various competing theories of environmental ethics it has been shown that each has a very different view of the proper relationship that should exist between humans and nature. As a consequence of these differing viewpoints, each theory can be examined on the basis of how morally founded attitudes toward the environment will impact resource development policies (Table 4). In developing this model Thompson was attempting to show the effect ethics has on shaping land management decisions.
The Ecocentrists

Ecocentrists believe that the proliferation of science and technology resulting from the Industrial Revolution and the Information Age is largely to blame for our current environmental crisis. Here solutions to environmental problems are thought to reside at the local level through a combination of grass-roots politics, the rejection of materialism, and community self-reliance (Van der Ryn and Cowan 1996). Where technology is to be used, its selection should be based on its appropriateness to the situation as perceived by members of the affected community.

The Technocentrists

Technocentrists believe that the resolution for the earth’s current and future environmental problems can be found in technology. This belief extends from one extreme that places no limits on the restorative powers of technology to those who take a more cautious approach. In this latter group technology is combined with wise environmental management, full cost accounting, and in-depth risk assessment to produce ecologically healthy environments.
Table 4 - Contemporary Attitudes toward Resource Management (adapted from Thompson 1998)

<table>
<thead>
<tr>
<th>Technocentrism</th>
<th>Ecocentrism</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Belief in the retention of the status quo in the existing structure of power, but a demand for more responsiveness and accountability in political, regulatory, planning and educational institutions.</strong></td>
<td><strong>Demand for redistribution of power towards a decentralized, federated economy with more emphasis on informal economic and social transactions and the pursuit of participatory justice.</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Intervention</th>
<th>Accommodation</th>
<th>Communalism</th>
<th>Gaianism</th>
</tr>
</thead>
<tbody>
<tr>
<td>Faith in the application of science, market forces and managerial ingenuity.</td>
<td>Faith in the adaptability of institutions and approaches to assessment and evaluation to accommodate environmental demands.</td>
<td>Faith in the cooperation capabilities of societies to establish self-reliant communities based on renewable resource use and appropriate technologies.</td>
<td>Faith in the rights of nature and of the essential need for co-evolution of human and natural ethics.</td>
</tr>
</tbody>
</table>

| Business and finance managers; skilled workers; self-employed; right wing politicians; career-focused youth. | Middle ranking executives; environmental scientists; white collar trade unions; liberal-socialist politicians. | Radical socialists; committed youth; radical-liberal politicians; intellectual environmentalists. | ‘Green’ supporters; radical philosophers. |

**Ethics and Perceptions of Ecosystem Health**

Human perceptions of ecosystem health are in large measure the byproduct of our ethical stance. This implies that we either view the world from a ‘utilitarian’ perspective - where we assign value to nature only when it has the potential for human use - or from an ‘ecological’ perspective where a functioning ecosystem is seen to have intrinsic value (Perly 1998). Deciding on which perspective we use to see the world will have a profound effect upon how we interpret the signs of ecosystem health. For instance, from a utilitarian perspective, one might interpret the presence of dead and/or dying trees in a woodlot as an indication of poor forest health. This interpretation would stem from the point of view that the economic value of the wood has been lost, or that the aesthetic value of the forest has been diminished.
Looking at those same dead or dying trees from an ecological perspective, a different observer might have had a completely different interpretation of the scene. This is possible because from an ecological perspective, forests should be capable of satisfying a range of needs not limited solely to human uses. In this context the visible presence of snags could be perceived as a key indicator of ecological health.

Looking further at the issue, Norton (1991, quoted in Perly 1998) developed a five-part framework for characterizing ecological health based on the following axioms:

- Axiom of Dynamism. Nature is viewed primarily as a set of processes, rather than as objects;
- Axiom of Relatedness. All Processes are inexorably linked to all other processes;
- Axiom of Hierarchy. For reasons mainly due to differences in temporal and spatial scale, processes are not related equally. Instead they tend to unfold as systems within other systems;
- Axiom of Creativity. Nature is fundamentally a creative process where energy flows from one system to the next; and
- Axiom of Differential Fragility. Ecological systems vary in their ability to absorb and respond to human-related activities.

This view of nature as a complex, dynamic, and thoroughly interconnected system that is inseparably linked to the human species, is seen by Perly (1998) and others as vital to our understanding of the ethical foundations that underlie resource-based management decisions.
In his historical examination of the belief systems of landscape architects, Thompson concluded that as a profession they should be categorized according to his model of environmental ethics as 'accommodators'. He based this conclusion on the general tendency of landscape architects to design human interventions in the landscape that are in harmony with natural processes. Though they reject the interventionist position for its naive faith in technological solutions, landscape architects are equally uncomfortable with the environmental radicalism displayed by the followers of the Gaia hypotheses. This middle-of-the-road approach to environmental ethics has served the interests of landscape architects in the past, but Thompson speculates that the profession is now at a crossroads in terms of its continued relevance to the debate on environmental issues. In the face of global warming, overpopulation, ozone depletion, and a myriad of other seemingly intractable environmental problems, it would appear that the profession's existing approaches to environmental design are inadequate to the task at hand (Olin 1997). What may be needed is a re-examination of our anthropocentric bias and an openness to consider the benefits of a more ecologically centered approach to landscape design.

Is such a reappraisal of our professional bias a realistic objective? Or should we conclude, as the landscape architect Laurie Olin does, that in the face of misdirected government policies and unbridled consumer avarice, there is "little that the field of landscape architecture can do about the situation." (Olin 1997). While this statement is fundamentally true, this author would argue that this acknowledgment of the profession's limitations in no way diminishes its importance in creating the conditions for the resolution of the planet's environmental problems. This is possible because landscape architecture is a profession whose system of core values is
based on a perceived ethical responsibility to serve the interests of the community and the environment (Olin 1997, and Lyle 1994). The methods that a landscape architect uses to serve these interests can be grouped under the following headings:

- Adopting a holistic approach to problem solving. In this context 'holistic' can be used to describe both their interdisciplinary ties with other professions (e.g., engineers, planners, architects, biologists etc.), as well as the approach landscape architects take when preparing design proposals for a site (e.g., biophysical, cultural, historical, and visual inventories etc.);
- The importance of public process for sound decision-making; and
- The power of design.

Taken in combination, these methods permit a landscape architect to potentially play an important role in addressing public concern for the sustainability of resource-based industrial development.

Bridging Anthropocentric and Nonanthropocentric Theories of Environmental Ethics

In their search for a new environmental ethic that can reconcile the apparent divergent interests of man and nature, philosophers have struggled with the question of the intrinsic value of species. In his attempt to reconcile the anthropocentric and nonanthropocentric ethical positions, the philosopher James Sterba (1997) argued that by isolating the most morally defensible positions of each side, one finds that they share a common set of ethical principles for attaining environmental justice. In Sterba's view this commonality is found in each side's acceptance of the 'principle of human preservation'. This principle holds that in the pursuit of their basic needs, it is permissible for humans to aggress against the basic needs of other species. Only when humans are
pursuing luxury needs are they prohibited from violating the basic needs of other species. While recognizing the superior intrinsic value of human beings, this middle position accepts that other forms of life also have intrinsic value.

What Sterba did not address is the question of short versus the long-term needs of the human species. For instance, in our quest to meet today's basic needs is it permissible to consume the last of a certain resource and thereby deny its use to future generations? How we as a society wish to answer this question will in large part determine what sort of planet future generations will inherit.

Working on this problem, of balancing the needs of man and nature, Norton (in Thompson 1998) developed what he termed the \textit{theory of convergence}. This theory held that "policies designed to protect the biological bequest to future generations will overlap significantly with policies that would follow from a clearly specified and coherent belief that nonhuman nature has intrinsic value" (p. 188). This theory contains two important elements for our study. First is the understanding that while the underlying arguments of the two ethical positions (anthropocentric versus nonanthropocentric) may be substantially different, the environmental policies adopted by each may be directed toward the same goal (i.e. environmental justice). Second is the notion that people living today have some moral obligation to protect the interests of future generations. This idea has important implications for those wishing to evaluate the moral dimensions of the concept of sustainable development.
Determining Our Moral Obligations to Future Generations

Human beings have lived on the earth for approximately 100,000 years. Short of a disaster of cosmic dimensions there is no known natural event that would prevent mankind from being alive many thousands of years into the future. At issue in the context of this thesis is the question of what, if anything, are our moral obligations to these future generations of humans. Addressing this question requires the reader to consider several contrasting points of view (Pojman 1997). First is the issue of determining the extent to which we have a moral obligation to nonexistent persons. Assuming we can answer this question, the second problem we face is arriving at some common agreement on who these future people are, and what needs and values will they have. Again, assuming that these questions can be answered, we are finally left with the problem of balancing the perceived needs of future generations against the actual needs of people living today on the earth.

Are there reasonable moral arguments that we can use to help determine the extent of our obligation to future generations? The political economist Robert Heilbroner has devoted much thought to critiquing the work of other economists who have written on this question. Many traditional economists have deferred to reason in order to dismiss the idea that we have an obligation, moral or otherwise, to future generations (Heilbroner 1997). If reason cannot provide us with foundation that we are looking for, Heilbroner suggests that we look no further than our own humanity for the answer. Though we are all creatures of self-interest, what stays our hand in placing our own selfish interests above the rest of society is what Adam Smith referred to as the “man within the beast” (p. 278). It is the inner voice of our conscience that literally forces us to act in the long-term interests of humanity. As Heilbroner concluded: “it is one thing to appraise
matters of life and death by the principles of rational self-interest and quite another to take responsibility for our choice." (p.278)

Starting from this same concern with balancing current human needs against our moral obligations to future generations, Garrett Hardin argued for the establishment of an environmental dictatorship whose raison d'etre would be to manage the planet's natural resources. Well known for his pioneering work on environmental issues dealing with the concept of the commons, Hardin believed that unless extraordinary measures were taken to preserve the earth's resources, there would be nothing of value left for future generations to inherit. For the poor especially, Hardin believed that narrow self-interest completely overwhelms any rational argument to conserve for the future. Only under conditions of material prosperity, even if confined to a selected few, does a society have the potential to look beyond its own immediate needs to consider those of future generations. Under this scenario Hardin is suggesting that wealthy industrialized nations are uniquely placed to defend posterity's interests against the demands of today's self-interested poor.

While his hypothesis concerning the self-destructive nature of man is relevant to today's environmental crisis, Hardin's prescription for change (in the guise of a new privileged ruling elite) seems much less persuasive. Though many Third World nations appear to be set on an irrevocable course of environmental destruction, the wealthiest nations of the earth appear to be just as reckless in their efforts to exploit nature. In this regard it is worth considering what agricultural researcher Dr. Jean Mayer wrote concerning the effect wealth has on environment health.

1 It is an unfortunate fact that environmental degradation appears to be endemic to every form of modern development. For every Three Gorges Dam project, clearing of the tropical rainforest, or hunting to extinction of a wild animal in the world's developing nations there is a Hanford nuclear processing facility, west coast old growth clearcut, Sydney tar pits or overfishing on the Georges Bank in the developed world.
It might be bad in China with 700 million poor people but 700 million rich Chinese would wreck China in no time ... It is the rich who wreck the environment ... occupy much more space, consume more of each natural resource, disturb ecology more, litter the landscape ... and create more pollution.

(Mayer quoted in Moncrief 1970)

Up until now the weight of argument has been directed against the possibility that reason could be used to help us make decisions with respect to our moral obligations to posterity. Is this a valid conclusion, or does reason have a place in this discussion? Derek Parfit, a professor of philosophy at Oxford University took up this challenge and came to the conclusion that rational discourse can, in fact, provide us with a means for justifying intergenerational rights and responsibilities (Parfit 1997). In a carefully crafted series of arguments, Parfit effectively critiques one of the central tenets of traditional ethics.

Personal identity has to do with being the same person over time. According to traditional ethics, we think that those who are harmed by our actions must be able to say that they would have been better off but for our actions. But in the case of energy and resource depletion, different people will be born than would have been had we had better policies. So, according to this view, these people cannot complain about our bad policies, since but for them, they wouldn't exist.

(Parfit 1997)

In place of the traditional approach, Parfit offers an alternative ethical proposition: That a policy should be considered bad if those it affects in the future are deemed to be worse off than those who might have lived had a different policy been adopted. In the context of this thesis the implication of this statement lies in its acceptance that we who are alive today are accountable for pursuing environmental policies that could have made a positive different in the quality of life for future generations. Before we move on to explore the specific character of these environments,
we will conclude this section with brief examination of the ethical issues surrounding surface mining.

Ethics and Surface Mining

Surface mining brings both costs and benefits to the communities that it affects. Those that stand to gain or lose from the operation of a mine are typically referred to as stakeholders (Cragg et al. 1997). Ethics requires that a mining company identify the nature and extent of its obligations to these stakeholders. How can a company determine its ethical responsibilities to stakeholders? Cragg et al. (1997) suggest that a company must address stakeholder concerns in four key areas:

1. The development of a mine requires the voluntary participation of many individuals. Because truly voluntary participation is built upon informed choice, the company is required to disclose any information that may affect a stakeholders's decision to become involved with the project.

2. The company must identify all involuntary stakeholders and determine the extent to which the development will impact their lives. Cragg et al. (1997) describe an involuntary stakeholder as occurring "whenever a decision-making process exposes people to direct and significant risks which they would not willingly assume, or about which they have no knowledge." (p.10) An example would be a company that fails to accept its responsibility for reclaiming the site after the mine has closed.

3. Ethics requires that the company engage in the fair distribution to stakeholders of the costs and benefits that flow from the project. This includes actions that mitigate
risk to stakeholders. It also includes actions that allow for fair compensation to those who are adversely affected by the development. Finally, it includes actions aimed at guaranteeing fair distribution of the benefits of mining.

4. An ethical company has an obligation to avoid actions that cause undue harm to stakeholders. For example, this may require a company to forgo a development that contains unacceptably high human or environmental risks.

In assessing a company’s ethical responsibilities, is it necessary to consider the environment as a separate stakeholder? Some environmentalists have argued that the answer is yes (Naess 1973, Suzuki 1998). They believe that the interests of man and the environment cannot be reconciled within a modern capitalist economy. Given the scale of most mining operations, the potentially adverse effect on local environments can be considerable. A partial list of possible mine-related environmental impacts are listed in Table 5. Conversely, Cragg et al. (1997) suggest that for practical reasons it is not necessary to isolate nature as a separate stakeholder. They maintain that policies aimed at protecting human well being will inevitably lead to policies that protect the environment.
Table 5- Potential Environmental Impacts of Mining (adapted from Cragg et al 1997)

**Biophysical Impacts**
- Destruction of natural habitat at the mine site and waste disposal sites.
- Destruction of adjacent habitats as a result of emissions and discharges.
- Destruction of adjacent habitats arising from influx of settlers.
- Changes in river ecology due to siltation and flow modifications.
- Alteration in water tables.
- Change in land form.
- Land degradation due to inadequate rehabilitation after closure.
- Land instability.
- Danger from failure of structures and dams.
- Abandoned equipment, plant and buildings.

**Pollution Impacts**
- Drainage from mining sites, including acid mine drainage.
- Sediment run-off from mining sites.
- Pollution from mining operations in riverbeds.
- Effluent from mineral processing operations.
- Sewage effluent from the site.
- Oil and fuel spills.
- Soil contamination from treatment residues and spillage of chemicals.
- Pollutants leached from tailings, disposal areas and contaminated soils.
- Air emissions from sites near living areas or habitats
- Release of methane from mines.

While the information contained in Table 5 is indicative of the added concern most mining executives have with respect to environmental issues, for landscapes architects this table begs a number of serious questions: What about cultural, visual, and other land use impacts that result from mining? If mining is to be seen as sustainable from a broader perspective, all of these potential impacts must be taken into account prior to the approval of a mine development permit.

**Sustainability and Sustainable Development**

Though the arguments put forward by Sterba (1997), Norton (in Thompson 1998), and Cragg et al. (1997) are not without their detractors, they do offer a way of reconciling the major points of contention that has long divided the study of environmental ethics. By accepting the convergence hypothesis we acknowledge in theory that two ethical paths can lead toward the same goal. The next step requires that we evaluate the theory at the level of practice. This step
will allow us to begin the process of understanding our reclamation practices as the physical manifestation of our ethical principles. In starting this process let us first begin with the concept of sustainable development. For the purposes of this study this concept is important for three reasons. First, the majority of researchers writing on the subjects of sustainable development and sustainability are in agreement that the scientific method contains too many limitations for understanding the true dimensions of our current environmental crisis. They conclude that an ethics-based argument is much more likely to lead to an effective response to the problem of environmental degradation (Mebratu 1998). Second, it is through the application of the sustainable development that we see the convergence view of environmental ethics make the transition from theory to policy. This second point is important because it will allow us to begin the process of understanding existing mine reclamation practices as the physical manifestation of our ethical principles. Thirdly, many landscape architects have come to align themselves with the concept of sustainable development. What the implications are for the profession from this decision has yet to be determined.

Sustainable Development: Putting Environmental Ethics into Practice

The term sustainable development first appeared as part of the World Conservation Strategy put forward by the Union for the Conservation of Nature in 1980 (Mebratu 1998). The proposals contained in this strategy were seen by many as a major breakthrough in that it now brought the element of time into the debate on the effects of economic development on the environment. This idea was developed further with the release of Our Common Future in 1987 (more commonly known as the Brundtland Commission). Prepared by the United Nations Commission on Environment and Development (UNCED), the report defined sustainable
development as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs... Sustainable development requires meeting the basic needs of all and extending to all the opportunity to fulfill their aspirations for a better life.” (Thompson 1998, p.189)

With its emphasis upon the elimination of poverty and social equality through economic growth, this definition is clearly homocentrist in outlook. It also demonstrates a very clear understanding that at the heart of the concept of sustainable development lies an implicit moral obligation to consider the interests of future generations. While not addressing directly the question of the intrinsic value of other species, the Brundtland Report does conclude that sustainable development cannot be achieved if human consumption of natural resources exceeds the carrying capacity of the earth's ecosystem.

Following its initial release, the Brundtland Report's prescription for sustainable development was given wide acceptance. Part of the reason for this acceptance lay in the ability of its readers to interpret the concept in almost an unlimited number of ways. A study conducted in 1994 found that some 80 different definitions and interpretations of the term were found to exist in the literature (Mebratu 1998) Not surprisingly, this flexibility of meaning has now lead some experts to assert that the concept has evolved into nothing more than an overused cliché. While acknowledging the limitations of Brundtland's definition of sustainable development, for the purposes of this study this is the definition that will be used. This decision carries with it the following advantages and disadvantages.
Advantages

- With its emphasis on the moral obligation to consider the needs of future generations, this definition is consistent with ethical conclusions drawn by Norton’s convergence hypothesis; and

- It is the definition that has been accepted by the Canadian Government in the context of the mining industry (Government of Canada 1996). Though some may see this as placing undue limits on the value of the final design proposals, the author believes that the inherent flexibility of the definition will in fact promote greater latitude during the design phase.

Disadvantages

- Though the definition recognizes that economic growth and environmental protection are inseparably linked, some have argued that in a practical sense, the basic goals of each are inherently incompatible (Mebratu 1998); and

- There is a clear emphasis on business leaders to provide leadership in the field of sustainable growth yet the history of modern capitalism would suggest that this hope is misdirected (Pepper in Mebratu 1998, Van der Ryn and Cowan 1996)).

Three Components of Sustainability

The generally accepted view of sustainable development holds that there is a distinct separation between natural, social, and economic systems (Figure 4).
The central tenets of the traditional model maintain that:

- Each of the three systems is considered to function independently of the other.
- Where the three systems converge is considered to be the area where sustainability occurs. Areas outside of this zone of convergence are thought to contain activities that are unsustainable.

In recent years this model has undergone increasing criticism from those who find that it contains an unacceptable anthropocentric bias (Mebratu 1998, Thompson 1998, and Van der Ryn and Cowan 1996). Rather than view human social and economic systems as separate from the natural world, all three systems are now considered to be inseparable (Figure 5).
The ideas presented by this alternative model are particularly important for addressing the questions raised in this thesis. With our emphasis on the interplay between ethics, aesthetics, and the environment there is a requirement to view the concept of sustainable development in a more holistic sense. By adapting the alternative model we are better able to understand, as Mebratu suggests, the workings of the *parts*, the *whole*, and the important interactions that occur between the *parts* and the *whole*. In this case we can see that human social systems provide the necessary bridge between the environment and our economic systems. A necessary by-product of this view is the acceptance of the idea that cultural conventions play an important role in how we shape the landscape (Gorham 1997, Smiley 1997, Meine 1997, and Nassauer 1997). How we choose to
design our shopping malls, city plazas, neighbour hood parks, or any of a million other artifacts of human civilization are all reflections of our cultural conception of nature. It is for this reason that some researchers in human ecology have come to conclude that cultural landscapes are an essential pre-condition of a sustainable society (Nassauer 1996, Thayer 1994). It will be through our examination of the concept of culturally sustainable landscapes that we begin to see the fundamental connection that exists between aesthetics, economic development, and the environment.

Defining Culturally Sustainable Landscapes

The concept of cultural landscapes grew out of an awareness that the link between humans and their environment was a great deal more complex than traditional models would indicate. The prevailing view within the field of ecology maintains that environmental damage is a necessary consequence of human attempts to extract value from the land (Philips 1998). This view was in part based on early assessments of the cause and effect relationship between European settlement in North America, and the subsequent destruction of that continent’s natural resources. Only recently have researchers begun to develop a clearer understanding of the true relationship that existed between man and nature prior to the arrival of Columbus. Throughout North, Central, and South America, enormous tracts of land, once thought to be pristine, were actually the products of sophisticated land management strategies put in place by aboriginal peoples (Barry 1998, Phillips 1998). Rather than being the cause of environmental damage, it now became clear that under certain conditions human actions in the landscape could be quite beneficial to the health of the local ecosystem (Thayer 1994). In his research on the subject,
Phillips found sufficient evidence to conclude that:

- As we enter into the next millennium, the mythical notion of a pristine environment only exists as a product of our imagination;
- In certain circumstances, the impact of human settlement to natural ecosystems can, in fact, add to biodiversity; and
- Cultural landscapes typically are the product of systems that support sustainable land use.

For decision-makers that are interested in implementing resource development policies that are sustainable, the significance of these new findings is profound. No longer could one assume *a priori* that there is necessarily a direct and inverse relationship between human-modified landscapes, and landscapes that exhibit high levels of biological diversity. In examining the land management practices of certain aboriginal communities, it is reasonable to suggest that sustainable development is possible under certain conditions. What is necessary is a willingness on the part of resource planners to approach the issue of development from the context of how historic cultural, social, and economic forces have come together to shape the local environment. Rather than choose standardized high-tech approaches, resource developers should instead be seeking solutions that are compatible with local technology, cultural values, and social conventions (Phillips 1998, and Van der Ryn and Cowen 1996). Using this alternative approach it now becomes possible to implement development programs without necessarily destroying the underlying conditions that allowed for the formation of a particular cultural landscape.

If we accept the idea that culture can help guide our economic development decisions, it naturally follows that we need to be more explicit in how we use this term *cultural landscape*. Early definitions were limited to very general statements that showed the link between culture and
nature (Phillips 1998). Given that virtually every landscape on earth has somehow been affected by the human activity, these definitions are not particularly useful in helping to identify cultural landscapes. Some progress was made in 1994 when UNESCO updated the operational guidelines of its selection criteria for selecting World Heritage sites. A new category of cultural site, ‘cultural landscapes’, was created in recognition of the important role these landscapes can play in guiding our understanding of sustainable societies. The guidelines reflect an understanding that nature is an integral part of a cultural landscape.

Cultural landscapes often reflect specific techniques of sustainable land use, considering the characteristics and limits of the natural environment they are established in, and a specific spiritual relationship to nature. Protection of cultural landscapes can contribute to modern techniques of sustainable land use and can maintain or enhance natural values in the landscape. The continued existence of traditional forms of land use supports biological diversity in many regions of the world. The protection of traditional cultural landscapes is therefore helpful in maintaining biological diversity.


While seeing this as an advance over previous attempts to describe the function and value of cultural landscapes, attempts by UNESCO to define specific categories of cultural landscapes reflects that institution’s interest in clarifying the process for identifying World Heritage sites. These categories were selected as a means for recognizing and preserving landscapes of outstanding merit, and consequently are not useful in helping one identify more common examples of cultural landscapes.

Sustainable Development: Some Implications for the Practice of Landscape Architecture

If the concept of sustainable development is to become one of the central tenets of landscape architecture, the profession will need to come to terms with the question of how this
decision might conflict with our existing ethical, aesthetic, and economic ideas on development. In practical terms it would suggest that landscape architects should not only design to protect the environment, but where possible design to regenerate it. Two landscape architects who have written extensively on the probable implications of sustainable development to the profession are the John Lyle and Robert Thayer. In Lyle’s book, *Regenerative Design for Sustainable Development* (1994), he dealt with the question of how sustainable landscapes can provide for man’s basic biological needs: air, food, shelter, fuel and water. In this sense Lyle can be viewed as remaining wedded to the profession’s traditional homocentric roots, but his pursuit of the idea that designed landscapes can serve human needs in ecological ways gives his ideas a certain radicalism. If realized, these designed landscapes would be small scale, use renewable forms of energy, maximize the recycling of wastes, and function in a myriad of other ways that mimic our understanding of natural systems.

Building upon Lyle’s work, Thayer (1994) developed a hypothesis that centered on the question of what a sustainable landscape might necessarily look like. Using his understanding of energy flows in nature, Thayer concluded that “sustainable landscapes need not copy the surface appearance of nature, but must emulate the independent and efficient structure and function of natural systems.” (p. 239). Similarly he argued the merits of making apparent the functioning of our human-influenced landscapes. By showing how our sustainable technologies worked, humans would not only take pride in these systems, but they would also gain a “more direct contact with and greater understanding of the natural systems we must protect.” (p. 243).
Sustainable Development: Some Implications for the Surface Mining Industry

Growing public concern over the state of the environment has proven to be a force for change in the mining industry. The terms and conditions which a mining company is able to develop, operate, and close a mine site reflect a changing public attitude concerning the social, economic, and environmental impacts of mining (Brevik et al 1997, Carbon 1997, Cragg et al 1997 and Cordes 1997). The public’s demand for the industry to become more sustainable is forcing many companies to re-examine their operating practices. However, this begs several important questions: Can mining be sustainable? and What is the relationship between sustainable development and post mine activities? (Lavkulich 1991). Answers to these questions are complex, contentious, and constantly evolving in response to changing circumstances. One approach for simplifying these issues is to understand mining as an interim use of the land. In this regard mining is deemed to be sustainable only in the context that its effect upon the surrounding ecosystem and local community is sustainable. Given this understanding of the connection between mining and sustainability, it naturally follows that the issue of reclamation assumes critical importance when reestablishing the sustainability of both the ecosystem and community that were impacted by the operation of the mine (Baker 1998, Powter et al. 1991).

In attempting to develop a useable working definition of the concept of sustainable development as it relates to non-renewable resource industries, most of the current efforts have been focused in the direction of the exploration, development, and operational phases of the mining cycle. Only recently has attention shifted to the question of what sustainable development means once the mine has closed. To be sustainable over the long term, one possible goal of a reclaimed mine site would be to support a productive environment that is consistent with the land
use practices of the surrounding area, be non-polluting, and is visually compatible with its geographic setting (Lavkulich 1991). To achieve this goal, the reclamation effort must address certain scientific and social concerns. In terms of science, the reclaimed site must focus on establishing a sustainable water, nutrient, and energy cycle, as well as create the conditions for promoting natural succession. Viewing reclamation in this way, one sees that it is not necessary to immediately recreate the natural landscape as it was before the disturbance. Instead, the objective of the reclamationalist would be to adopt measures that quicken the establishment of natural processes that make a landscape ecologically sustainable on its own (Lavkulich 1991, Thayer 1994, and Zuckerman in Whittey, 1997).

Significantly, this interpretation is at odds with existing Canadian Government regulations that require mine operators to restore the site to the condition that existed prior to the opening of the mine. One possible explanation for this involves the human predilection for the quick fix solutions. To allay public concerns, mining companies are under increasing pressure to re-vegetate exposed sites as quickly as possible. This has led to an approach to reclamation that is driven by short-term results (Burton 1991 and Lavkulich 1991). Ultimately this approach has proven to be self-defeating because it often failed to meet the expectations of the affected community. This has resulted in growing public pressure on elected officials to legislate ever more restrictive laws governing mining activities. Therefore, in addition to understanding the science that underlies a sustainable reclamation project, mining companies must also be cognizant of the role the public can play in this process. This includes involving the local community in establishing the goals of the reclamation project, as well as keeping them informed during the implementation phase. By

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2 Examples of this include the decision to cancel the Windy Craggy Mine in Northwestern BC, and a gold mining project near Yellowstone National Park. Both decisions came in response to public concerns over the perceived adverse environmental impacts associated with these mines.
engaging the public in all phases of the decision-making process. A possible result is a reclamation effort that sustains nature, while adding to the quality of life of people in the area. If the public is not allowed to become part of the process, it is unlikely that the project will be sustainable. Even well-conceived projects will likely be impeded or disregarded because they failed to take into consideration the cultural context of the site (Lavkulich 1991, Nassauer 1997, and Thomson 1997).

Up until this point it has been argued that a knowledge of environmental ethics is essential for understanding the past, present, and future role landscape architects will play in resolving the earth's environmental crisis. We have traced the connection that exists between ethics, our moral obligations to future generations, the intrinsic value of living organisms, and outlined some of the limitations associated with the United Nations' definition of sustainable development. Finally, we have begun to sketch out what a sustainable landscape might look like, but before we can proceed further it is first necessary to develop an understanding of what some writers have called the new aesthetics of landscape ecology (Berleant 1997). While a concern for aesthetics has always played a role in the practice of landscape architecture (Thompson 1998), does the profession's new environmental focus represent a radical shift in the understanding of aesthetics as it pertains to landscape design, or is its goals much more modest? How this question is answered will not only affect the outcome of the Telkwa reclamation design, it will also speak to the continued relevance of the profession as an effective instrument for redressing environmental ills. We will begin with a review of the relevant theoretical literature on the subject of human landscape preferences. By understanding the mechanisms that are at play when humans assign value to a particular landscape, designers will be better placed to successfully address the physical and emotional needs of contemporary society.
Theoretical Approaches for Understanding Aesthetic Appreciation of a Landscape

Accepting the implications of the definition of cultural sustainability suggests that if humans are to preserve, much less create sustainable landscapes, they must first come to understand what in the landscape attracts human interest and appreciation. One way of accomplishing this by referring to the work done of environmental psychologists in the area of landscape preference studies. An alternative method for understanding human preferences in the landscape is offered by the aestheticians themselves. Though there are other theories available to explain human preference decisions, these two approaches provide the reader some sense of the range of opinion on the subject of environmental aesthetics. The reader will also note the number of similarities that exists between the two approaches.

Environmental Psychology and Aesthetic Appreciation

At its most basic level environmental psychology can be defined as “a behavioral science that investigates, with an eye toward enhancing, the interrelationships between the physical environment and human behaviour.” (Veitch and Arkkelin 1995, p. 4). Environmental psychology contains a number of guiding assumptions and principles that are clearly relevant to the study of the Telkwa site (Table 6).

Table 6 - Guiding Principles of Environmental Psychology (adapted from Veitch and Arkkelin 1995)

1. The environment, physical as well as social, typically exerts a steady-state influence on the behaviour of its inhabitants.
2. The influence exerted by the environment is indirect; i.e., the environment acts to influence people’s emotional states, which in turn mediate their overt behaviour.
3. Environment-evoked emotions are best depicted in terms of three distinct dimensions: pleasure-displeasure, degree of arousal, dominance-submissiveness.
4. The environment-influenced behaviour of the individual is dependent upon the extent and the configuration of the dimensions of emotions aroused.
The general principles of environmental psychology tend to support the argument that this author has been making up till now; that human behaviour is largely influenced by the combination of cultural and environmental elements, and that if these elements are disrupted it will evoke both a physical and emotional response. Whether these responses are interpreted as being positive or negative could have a profound effect on probability that a particular landscape is more or less likely to survive according to the criteria offered by this thesis to describe culturally sustainable landscapes.

On the subject of preferred landscapes, the psychologists Stephen and Rachel Kaplan (Kaplan and Kaplan 1982) have devoted almost thirty years pursuing this line of research. What their research has shown is that viewer preference can be generalized as follows:

- In terms of **content**, people overwhelming prefer natural landscapes over man made ones. The ‘greener’ the setting, the stronger the sense of human attachment; and
- In terms of **process**, the preference was toward environments that permit ‘involvement’ and ‘making sense’. In this context, an involving environment is one that is able to convey to the viewer a sense of mystery. Likewise for an environment to ‘make sense’ it must project a sense of orderliness.

This discovery lead the Kaplan’s to formulate a model that specifically deals with the issue of how people form aesthetic responses to a particular environment. Their model is built on the premise that “four factors determine our reactions to an environment: coherence, legibility, complexity, and mystery.” (McAndrew 1993). How these four factors influence landscape preference is best understood by dividing landscape into two separate but related forms of experience: what we are experiencing currently and what we could experience in the future. For
our current experience to be positive a landscape must be seen as both coherent and complex. A coherent landscape is one whose separate elements combine to form a unified whole. A landscape is defined as complex when it contains a variety of different visual elements.

Landscapes that stimulate the viewer to consider the possibilities of future experience must be rich in elements that are both legible and mysterious. Legible elements are those that assist the viewer in reading the landscape, such as definable mountains, shorelines or other visible edges. Mystery on the other hand refers to those elements that suggest to the viewer that something greater lie just beyond the immediate field of view. Such a landscape invites the viewer to indulge their curiosity by stepping into the scene and exploring it.

Building upon the Kaplan's early work, other researchers in this field have attempted to identify those particular elements in the natural landscape that are the most and least favoured elements (McAndrew 1993). Even after considerable research, the underlying reasons for these preferences remains unclear. Theories for explaining human preference choices range from Appleton's (1996) "atavistic sensitivity" theory to explain the human fondness for savannah-like landscapes to Smith's (Porteous 1996) reliance upon neuropsychology and the human limbic system to explain human reactions to the urban environment. Nassauer has also spent a great deal of time in attempting to explain the connection between culture and the landscape. Nassauer's (1989 and 1997) research suggests that there is a definite link between a person's cultural conventions on what society considers beautiful and their people's individual preference for certain types of landscape. She has found that people tend to prefer a particular landscape when it conforms to either their aesthetic notion of what is scenic, or when they interpret it as being consistent with their aesthetic convention of what signifies that a place is cared for. Where the
work of the Kaplans, Appleton, and Nassauer come together is in the conclusions that they draw with respect to human preferences in the landscape. In general they found that the most favoured landscapes are those that exhibit the following characteristics:

- Open meadows surrounded by woodlands;
- Large, dense forests (especially deciduous) that contain minimal underbrush but an abundance of grass cover;
- The appearance (both visual and auditory) of a wide range of animal species;
- The presence of clean, fresh water. Waterfalls in particular are given high ratings;
- Areas that contain a degree of 'ruggedness';
- Intrusions of natural elements into urban landscapes are typically viewed as positive;
- Environments that display complexity; and
- Environments that exhibit obvious signs of human care and attention.

The least favoured are those landscapes that contain these elements:

- Swampy areas or areas of water containing algae;
- Unkempt landscapes, whether they are in an urban or rural setting; and
- The intrusion of man made elements into natural environments are typically viewed as negative.

In general researchers in environmental psychology have concluded that humans display a definite and measurable pro-nature bias (Figure 6).
Though the work of environmental psychologists appears to contribute greatly to the understanding the nature of human preferences in the landscape, it is not without its critics. Studies that have examined the importance of age as a predictor of preference have produced contradictory results. Similar contradictions have occurred in studies involving gender and socio-economic class-related variables (Porteous 1996). Other points of criticism have centered on questions relating to scientific methodology. The sampling of environments is seen as too small, and the choice of sampling subjects too narrow, to provide results that can be interpreted as representative of the general population (Berleant 1997 and Porteous1996). Finally, in the case of the environmental psychologists who have sought to explain human landscape preferences as a consequence of biological processes, (e.g., Appleton and Smith) other research on the subject of preference suggests that are other factors need to consider. For instance, Hodgson and Thayer (in Van den Berg et al. 1998) found that viewer preference of natural landscapes can be greatly influenced by something as simple as how the photographs are labeled. For example, human
preference ratings of a disturbed landscape have been shown to vary considerably depending on whether the disturbance was identified as either natural or manmade. Participants in these studies consistently preferred the photographs identified the cause of the disturbance as naturally occurring. These results would seem to suggest that the environmental psychologist's understanding of human landscape preferences is less than complete.

Aestheticians and the Aesthetic Application of Nature

At a general level all aesthetic questions center on the issue of preference. In deciding to choose one thing over another, a person must engage in the act of discrimination. When discrimination is combined with the ability to distinguish between good and bad, the individual is thought to have acquired taste (Porteous 1996). Within aesthetic philosophy an intense debate has been raging over the questions:

- Is there a correct and appropriate way of appreciating nature (Eaton 1998);
- What is an aesthetic experience of nature, and how does one determine if that experience is an appropriate way to engage nature; and
- Once we have determined that we are having an aesthetic experience of nature, how does one then determine if that experience is good or bad.

Though a number of theoretical models have been put forward in an attempt to answer these questions, the cognitive model in particular appears to address issues that are central for understanding the relationship between aesthetics and viewer perception of ecological health.
The Cognitive Model

This model was built on the premise that the proper appreciation of nature, as in art, starts from a foundation comprised of knowledge (Berleant 1997, Carlson 1998, and Eaton 1998). When evaluating art, a competent critic draws on both years of experience, and an extensive knowledge of art history to evaluate the object of their attention. Through the process of informed evaluation, the art critic uses a culturally derived system of values to determine if a piece of art is either good or bad. Similarly, to properly appreciate nature an objective critic of the environment must possess a general knowledge of the working of the natural world. More specifically, ecological knowledge that focuses on the complexity and interdependence of difference environmental systems. Armed with this knowledge the environmental critic can then discriminate between good and bad environments. In this context a ‘good’ environment is one that is characterized by a high degree of ecological integrity. Lacking this scientific knowledge, the viewer cannot be certain that he or she is actually appreciating nature or something else in the environment (Carlson 1998 and Eaton 1997). Accepting the implications of this model, it is logical to conclude that “only with knowledge will sustainable practices develop.” (Eaton 1998, p. 154)

With its focus on knowledge as a necessary pre-condition for the appropriate aesthetic appreciation of nature, the cognitive model has been criticized on the grounds that it over-intellectualizes the human experience of nature. Robert Stecker (1998) has attacked the model on the grounds that it unnecessarily invalidates the aesthetic experience of those who view nature with an uneducated eye. Stan Godlovitch (1998) found that the cognitive model seems to discount the role that mystery plays in heightening ones aesthetic experience. Emily Brady (1998)
has criticized the model from the perspective that it fails to account for the significance human imagination plays in our aesthetic appreciation of nature. While these criticisms all carry a certain validity, the appeal of the cognitive model for the purposes of this thesis rests in its understanding of the connection between beauty, ecosystem function, and cultural sustainability. The argument proceeds as follows: If people understood how beautiful a healthy ecosystem is, it is assumed that they would take greater care in preserving such ecosystems. If the hypothesis is true that positive aesthetic response causes one to care for a landscape, it is important for landscape architects to produce designs that generate this type of aesthetic response.

Aesthetics, Ecological Function, and Culture

As we know from our earlier discussion on culture, societal norms play a critical role in how people decide what is visually appealing (Figure 7). The change in the aesthetic appreciation of rugged mountain landscapes during the eighteen century is often cited as an example of how evolving cultural norms can shape our understanding of what a beautiful landscape is (Porteous 1996 and Saito 1998). Contemporary society’s growing interest in tidal marshes and inland wetlands reflects a modern aesthetic based not on the sublime, but instead on issues relating to ecological health and sustainability. The shift in the public’s attitude toward what some aestheticians have characterized as the scenically challenged parts of nature, came about only as a result of the growing awareness citizens had of the contribution these systems play in maintaining the overall health of the environment (Saito 1998).
Humans are known to be irresistibly drawn to beautiful landscapes, and through our cultural conventions we as a society have developed an innate sense of how a visually attractive landscape should appear. As we have seen in our discussion of landscape preferences, people tend to characterize a landscape as being beautiful when it conforms to their aesthetic ideal of what is scenic. A landscape is also thought to be attractive when it is seen as consistent with our aesthetic convention of what signifies a landscape that is cared for (R. Kaplan 1982, Lynch 1982, and Nassauer 1997). These two aesthetic notions are so culturally ingrained that they have been characterized as a powerful force for creating and protecting landscapes (Eaton 1997 and Nassauer 1997). The initial impetus for creating Canada’s system of National Parks came from the realization that people would pay to see these examples of sublime nature. Likewise our continuing love affair with pastoral nature grew out of our cultural conventions of what a landscape of care should look like.
A Prescription for Action

Given our cultural affinity for the both the scenic aesthetic and the aesthetic of care, Nassauer (1997) has suggested that there would be great benefits to society if land managers could "attach ecological health to these lawlike aesthetic conventions." (p. 68) But sculpting nature to look scenic, or making a landscape look neat and tidy could create the antithesis of ecological health. Instead she argues that we must develop new cultural paradigms of what beauty in the landscape is. An important part of this process would involve educating society on ecology-based issues. Only then, she argues, will people begin to see beauty in the more modest, less visible aspects of our everyday landscapes. The result would be a landscape aesthetic that is capable of evoking an "intelligent tending of the land so that aesthetic decisions can become intrinsically ecological decisions." (Nassauer 1996, p. 72).

Similarly, in arguing his case for a new aesthetic of nature, Saito (1998) concluded that society needs to reassess its traditional notion of what is beautiful in nature. Saito suggests that by approaching nature in much the same way as a serious critic approaches art, we can avoid the trap of aesthetic deception.

Let us first examine the reason why it is inappropriate to experience a work of art incorrectly, even when doing so would provide the utmost enjoyment and entertainment. Our refusal to experience an art object on its own terms, that is, within its own historical and cultural context as well as by reference to the artist's intention, indicates our unwillingness to put aside our own agenda, whether it be an ethnocentric or present-minded perspective or the pursuit for easy pleasure and entertainment. (Saito 1998, p 102)

Similarly, when we engage in the appropriate appreciation of nature, our efforts to understand the origin, structure, and function of the natural world demonstrates our willingness to
recognize the intrinsic value of nature. Here again knowledge of the processes that sustain a healthy environment is seen as a necessary precondition for human efforts to create and/or preserve sustainable environments.

By placing such an emphasis on the importance of knowledge, does this necessarily mean that one must reject the picturesque when designing sustainable spaces? According to the conclusions drawn by Leopold, Berleant, Saito and others the answer is clearly no. When appreciating nature, as in art, one’s taste must be allowed to develop over time and this process must start from somewhere. That somewhere is thought to begin with the pretty. Though pretty art and pretty landscapes may catch the immediate interest of the viewer, what follows afterward depends on the ability of the piece to hold and sustain a person’s interest. In the case of landscape design, this means creating spaces that engage the viewer on many different levels. In characterizing his views on the subject, the landscape architect Laurie Olin (1997) wrote:

Landscape design can and should be responsible toward a community and the environment ... it can help to create an environment that is healthy and functional within a larger framework of natural systems, and it can help us to understand our environment through the use of traditional artistic strategies that have to do with meaning and expression.

(Olin 1997, p 117)

In simple terms, by creating beautiful landscapes that also work from an ecological perspective, the landscape architect is using his craft to heighten the environmental awareness of the local community. It also follows that given their greater environmental knowledge, the people who experience this site will now begin to find added beauty in the unscenic, yet invaluable elements of nature that are necessary for maintaining ecological function. With their perception of beauty so altered, the people now become open to new and ever bolder efforts to create positive
aesthetic values in our working landscapes. In responding to these desires, designers would now be free to create landscapes that reveal ever-greater aspects of the natural world.

Armed with this understanding of the relationship that exists between aesthetics and ecology, where does that leave us with respect to the problem of creating sustainable reclamation designs? What is being suggested here is that we apply the same iterative process to the debate on mine reclamation. By focusing on designs whose aims are as much pedagogical as they are environmental, the goal of every reclamation project would in part be to expand the aesthetic tastes of the local community. By adopting an approach that is evolutionary, as opposed to revolutionary, reclamationists would be part of a process that seeks to engage local people in resolving the environmental issues that directly impact their communities. As each successive reclamation project proceeds from the initial planning stages through to execution, the members of the affected communities would develop an ever-greater knowledge of issues relating to ecological function. As this environmental knowledge increases, it would have the concomitant effect of altering the public's aesthetic preferences with respect to the environment. This altered aesthetic would then be used by designers as a starting point for planning the next phase of the overall mine reclamation project. For such a system to work, mining companies would have to be willing to adopt measures that promote the active participation of local people in all decisions relating to mine development. Even though the time period between the initial planning phases and eventual mine close-out may extend decades into the future, members of the local community

3 Later in this thesis it will be argued that community participation is an essential component of most successful restoration projects.
must be encouraged by the company to participate in all stages of the mining development process. By allowing people to have a say in how the mine is to be developed, operated, and the land subsequently reclaimed, mine owners are creating the basis for sustainable mine development. The specifics of how it might be possible to facilitate this public involvement will be discussed in greater detail in the forthcoming section on mine reclamation.

PART III- RECLAMATION

Beginning in the early 1980's there has been a growing interest in reclamation as an effective technique for reversing the impact certain industrial processes have had on the environment (Cairns 1988, Jordan et al. 1988). Some see reclamation as the answer to the problem of biological conservation (Burton 1991, Jordan 1994, and Turner 1994), while others point out that there are still many technical issues that first need to be addressed before the true value of reclamation projects can be properly assessed (Barrett 1994; Medley). Allen & Hoekstra (1992) have characterized reclamation as nothing more than “gardening using wild species in natural mosaics.” Kirby (1994) described reclamation ecology as “an expensive self-indulgence for the upper classes, a New Age substitute for psychiatry. It distracts intelligent and persuasive people from systematic initiatives.” A further critique of the ‘reclamation thesis’ is that there are inherent properties of a natural landscape that simply cannot survive the reclamation process (Elliot 1982). As in art, the origin of a landscape is critical in our estimation of its true value. A fake is a fake no matter how perfect the copy. Understanding the true worth of reclamation may

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4 For this thesis the term reclamation is being used to describe an activity that others have variously described as restoration, rehabilitation, reallocation, or reconstruction. Since no one is yet able to agree on a common terminology, this author has agreed with Hobbs and Norton (1996) that it is enough to think of reclamation as occurring along a continuum with different activities merely representing different forms of reclamation.
lie in developing a clearer and more universal understanding of what the goals of reclamation should be (Hobbs 1996).

**Legislation Governing Surface Mine Reclamation**

Though the mining industry has been active in the province of British Columbia for over one hundred years, government legislation with respect to mine reclamation has only been in effect for thirty years (Binns 1995). In 1969 the B.C. *Mines Act* was amended so that large coal and hardrock mine operators were made responsible for reclaiming their sites upon closure. In 1973 the reclamation provisions of the Act were further expanded to include exploration activities, as well as sand and gravel operations and quarries. The Act underwent further revisions in 1984 with the inclusion of reclamation standards and the establishment of a formula for setting reclamation bonds to a maximum of $2500/ha. The latest revision to the Act came in 1990. The general provisions of the Act are laid out in greater detail in the *Health, Safety and Reclamation Code for Mines in B.C.* Part 10 of the Code governs reclamation and mine closure. Under the provisions of the code, mine operators are required to submit a tentative mine reclamation and closure plan as part of the initial permitting process. Included in the plan is an extensive environmental baseline report. This report was intended to form the basis for subsequent environmental monitoring programs that would take place both during the operating life of the mine, and after it has closed (BCMEM 1992). Part 10 also replaced the reclamation bond with a new system that required mine owners to post a security deposit as a condition for receiving the Reclamation Permit.
The intent of these guidelines is to provide reclamation standards aimed at addressing basic public concerns over possible threats to human health and safety, and the need to re-establish the natural ecological productivity of the site. Consistent with these concerns, the aim of most mine reclamation projects is motivated by four practical objectives: The long-term stability of the site, long-term control of soil erosion, control of water pollution, and matching the pre-mining land use and capability of the site (BCMEM 1992). Once these issues have been addressed to the satisfaction of government inspectors⁵, the security deposit is released back to the mine owners and their responsibility for the site has ended.

As a consequence of this approach to mine reclamation, there exist powerful incentives for the company to engage in ‘quick-fix’ solutions. For example, to solve the problem of erosion on mine waste dumps, the usual practice is to hasten the establishment of a vegetative cover (Lavkulich 1991). Often this involves the application of topsoil and fertilizer, an extensive program of seeding, and in some cases the extensive use of irrigation. Though in the short-term this can effectively ‘green’ the site, it is expensive to maintain, and the vegetation is subject to failure once the artificial inputs are withdrawn from the system. In such cases the reclamation effort fails because the cycle of succession cannot proceed under these circumstances because no attempt has been made to reestablish the pre-existing water and nutrient cycles (Dietrich 1992, and Lavkulich 1991).

What is needed instead is an alternative approach to mine reclamation that is focused not on short-term results, but rather on the reestablishment of natural processes that will lead to the

⁵ Though it is the expressed goal of mine reclamation, existing government regulations gives mine inspectors great latitude in determining the practicality of requiring the mine owners to reclaim a site to its pre-mined condition.
creation of more sustainable landscapes. Though true walk-away solutions may not be possible in all cases, to make mining a more sustainable use of the land it is the goal that mine reclamationists should be aiming for. Achieving this goal will require that all stakeholders reassess their role in the process. In order to avoid the mistakes of the past, government, industry, and members of the affected community will have to accept a new range of responsibilities. Only by embracing alternative goals for reclamation will the practice of mining be consistent with the goals of sustainable development.

**Linking Reclamation and Sustainability**

Reclamation ecology has been criticized by some researchers on the grounds that it is both restricted to one scale of activity, and that its end goals are often too narrow (Allen and Hoekstra 1992). Though there is some truth to this charge, it does not necessarily mean that reclamation is inherently so limited. Hobbs and Norton (1996) argue that such limitations need not be the case if one views reclamation as a "key component for the development of sustainable land-management systems." (p. 95). Here reclamation is seen from both the intimate dimensions of the local mine site, up to the landscape scale. Reclaiming the site in terms of our understanding of the greater landscape contains certain real advantages. First, it allows reclamationists to view the project in terms of how the site relates to the larger regional ecosystem. Detailed analysis may reveal the presence of regionally under-represented ecosystems that could, in part, be addressed by adjusting the goal of the reclamation to respond directly to these deficiencies. Second, because the formal legislative requirement to return the site to its pre-mined state would no longer be the driving imperative, the designer would have greater flexibility for involving the public in decisions relating to the intended long term goals of the project.
This second point has important implications in terms of linking mining to both our definition of sustainable development and our understanding of aesthetic preference. In terms of sustainable development, a more flexible approach to post mine operations is critical in making an industry based on mineral extraction sustainable. This argument for flexibility is, in part, based on the premise that reclamation intended strictly for the purpose of returning a site to its pre-mined state is unnecessarily short-sighted (Robertson et al. 1998). For instance, in Canada much of the land that has been taken over for mining is essentially undeveloped. By returning these sites to their pre-mining condition, in many cases this means reclaiming the land to a state where it is ecologically self-sustaining but unable to provide the potential for creating a sustained financial yield (Figure 8). The need to consider the potential for sustained financial yield is argued here to be one of the primary benefits reclamation has to making mining a sustainable industrial activity. The importance of designing for sustained financial yield becomes apparent when one examines what happens to a site after a mined has ceased operations. Working in accordance with its government approved mine closure plan, the company initiates a reclamation plan to bring the site up to the required standard. Once this standard has been met, the company is released from its custodial responsibilities for the property. At this point, anyone wishing to purchase the property would assume all future liability. Because even the most carefully crafted mine closure plan cannot guarantee that all possible environmental hazards have been accounted for, identifying custodians to take over the site has been increasingly difficult because they are unwilling to accept the liability risk. Even sites that have been deemed to pose no threat to the environment still often require an ongoing program of passive or active monitoring and maintenance. Since the site is no longer capable of generating a financial yield, the site becomes a drain on the resources of future owners.
An alternative to the above scenario is an approach to post mine reclamation whose aim is to create the conditions that would support the long-term sustainable use of the site (Figure 9). Usually this would involve reclaiming the land so that it could support agricultural, forestry, or industrial uses. In certain circumstances, this list could be further expanded to include recreational or tourism based activities. Therefore, by expanding the goals of our reclamation activities, we create the opportunity for the site to sustain its own ongoing program of rehabilitation.
Turning our attention back to the issue of aesthetics, the question that many reclamationalists have struggled with is how do we reconnect a degraded site with the local community? Many reclamationists have come to believe that best way to achieve this is to create a process that actively involve the community in the reclamation project (Barry 1998). This involvement would extend from the initial preparation of the closure design through to the final disposal of the site by the mine owners. At each stage in the process, company representatives and local stakeholders would jointly establish the ends and the means for reintegrating the site back into the everyday lives of the community.
By engaging in a process that is based on accommodation, not confrontation, the mining company would be able to establish important and long-lasting links with the community. While in the past such links were not seen as critical for the success of the mine, a more informed public has created a level of local awareness that has the potential to block the development of the mine. This change in public perception with respect to mining led David Humphreys, chief economist of the giant British mining company RTZ, to conclude that:

The bigger challenge now is not a technical one. Rather it lies in the development of interactive and lasting relationships with the communities, regions and countries in which the industry operates ... (the success of mining companies) will be their ability to align the interests of local communities with their own areas where they wish to operate and to develop mines within those communities on the basis of mature and respectful partnerships. (in Epps, 1997, p. 33)

Taken in conjunction with our earlier discussions on sustainable development and cultural landscapes, this community-based approach to mine reclamation is illustrative of how a non-renewable resource industry can be made sustainable.

Exploring Alternative Goals for Reclamation

In re-appraising the goals of reclamation, the issue may be simplified by viewing reclamation as a continuum with different activities representing different levels of restorative action (Hobbs & Norton 1996). As one approach for determining what the goals of reclamation

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\(^6\) In a survey conducted in 1989 by the International Environmental Monitor, far more people had a great deal of confidence in information supplied by scientists/experts (51%) than from government (12%), or the mining industry (3%).
can or should be, one could look for inspiration in the works of the early practitioners in the field. In his examination of the modern history of reclamation, the ecologist Marcus Hall (1997) found that the tradition of restorative land management dates back several centuries. Confronted in 1816 with the problem of rehabilitating the severely de-vegetated hillsides of central Italy, the Italian hydrologist Francesco Mengotti suggested a series of reclamation initiatives based on the restorative processes he had observed in nature. These initiatives involved a combination of human construction and the planting of native grasses and shrubs for the purpose of preventing soil erosion. For reclamationists, Mengotti's work deserves to be recognized for he may have been the first person in modern time to make the vital connection between vegetation and soil, and between human and natural elements in the landscape.

Hall's historical analysis also included a review of the work of early North American reclamationists such as Arthur Sampson and Aldo Leopold. While working for the US Forest Service's Great Basin Station in central Utah, Sampson developed many of the central concepts that are used by reclamationists today. One of the more important of these concepts being the belief that through the act of reclamation, land managers are capable of replicating natural processes. In his reclamation projects, Sampson generally emphasized the use of natural plant species over exotics. Through experience gained in the field, he found native species typically required less nutrients and moisture than exotics, and once they were established, they had a greater capacity to hold topsoil in place. His defense of the value of native species, though vigorous, was not absolute. He did not hesitate to experiment with exotics when site conditions called for unconventional solutions. In critiquing Sampson's methods one can conclude that his choice of plant material was based on the pragmatic requirements to provide a working landscape that would support intensive human use (e.g., the rigors of cattle and sheep ranching).
reasons for using native plants for reclamation did not include such objectives as creating greater aesthetic enjoyment for people, or the value of re-establishing a landscape's ecological integrity.

Leopold too was a great advocate of the restorative value of native plants, but unlike Sampson, his approach to reclamation was not entirely based on pragmatism. His work on the University of Wisconsin Arboretum with the landscape architects Jens Jensen and Frank Waugh is evidence of the fact that despite his understanding of ecological systems, Leopold was willing to allow considerations such as aesthetics to influence his design decisions. In his defense, it has been argued that Leopold's conception of reclamation rightfully included both ecological and human components (Hall 1997).

Biodiversity as a Goal of Reclamation

In critiquing the short-term objectives of current mine reclamation projects, Phillip Burton (1991) suggested that ecosystem restoration should focus specifically on increasing local biological diversity. In arguing his case for the value of increased biodiversity, Burton provided a comprehensive overview of current research on the subject. His findings are summarized as follows:

- Economic value of products from wild species. These range from the pharmaceutical potential of local flora, through to the value of exploitable species such as mink, moose, and bear. Also included under this heading is ecotourism whose economic value has only recently been recognized in the province of BC.
• The importance of indicator species. By monitoring the relative health and abundance of certain plant and animal species, it is possible to then deduce the overall health of the local ecosystem;

• Biodiversity as insurance against future uncertainty. By creating conditions that will support the widest possible range flora and fauna, the reclamationist is hedging against the possibility of unforeseen changes in either the environment, or in societal values; and

• The aesthetic and ethical connection to biodiversity. It is clear from our earlier discussions on aesthetics and ethics that there are a number of strong arguments to suggest that issues of beauty and morality do influence our land use decisions. By altering the public's aesthetic and ethical position in favour of landscapes that support greater biodiversity, this change will necessarily affect how society chooses to develop its natural resources.

In designing for biodiversity there are a number of general rules that have been developed. One of these rules is based on the rich habitat possibilities that occur along shorelines. It has been observed that in these environments there typically existed an animal species ratio of 8:3:1 between the shore area, a body of water, and land (Dietrich 1992). Therefore whenever possible it is highly advantageous to maximize the amount of area given over to shoreline. A more detailed description of other generalized methods of reclamation for increased biodiversity has been included in Appendix VI. Where appropriate, these rules will form the basis for a number of design decisions that are being proposed for the Telkwa Project Area.
Designing for biodiversity in the context of a reclamation plan for an open pit mine carries with it a number of difficulties. Currently, the individuals that are involved in the reclamation of highly degraded sites simply lack the requisite knowledge of environmental systems that is needed to completely re-establish 'natural' ecosystems (Burton 1991, Lavkulich 1991). In the absence of this knowledge it is predictable that designing for increased biodiversity will entail a certain degree of risk. If ecosystem restoration with an emphasis on biodiversity is to become one of the goals of mine reclamation in the future, stakeholders at all levels will have to change their current mode of thinking. If the goal is to design sustainable landscapes, there is a need to rely less on rigid standards and more on an approach that encourages experimentation and risk taking (Figure 10). Though this approach creates the conditions for failure at the site specific level, it is the belief of this author and others (Burton 1991, Lavkulich 1991, Dietrich 1992), that the long-term rewards more than offset the perceived risks. As each new reclamation project proceeds through the cycle, the result is greater knowledge and experience of ecosystem restoration.

Figure 10 - Systems Model for the Practice of Reclamation (adapted from Lavkulich 1991)
Another difficulty of designing for biodiversity is that it is often hard for the untrained eye to assess the biological health of a site using just visual cues alone (Carlson 1998, Nassauer 1989 and 1997, and Shannon et al. 1995). From our earlier discussion on the relationship between aesthetics and sustainability, it was argued that biological knowledge on the part of the viewer is critical in creating sustainable landscapes. Because even experienced observers of the environment will not always correctly connect a site's visual quality with its biological health, it is necessary to provide visual cues that are clear and unambiguous. Therefore when designing for biodiversity it is important to select key indicator species that are readily identifiable to people living in the local community. In this way, a community can gauge for itself the relative success or failure of the reclamation effort.

**Ecosystem Restoration as a Goal of Reclamation**

Based on the conclusions drawn by Burton (1991), Lavelle (1991), Dietrich (1992), and Hobbs and Norton (1996), the goal of a sustainable reclamation project should be to hasten the establishment of sustainable natural processes. Though complex in theory and in practice, the goal of ecosystem restoration can be simplified by characterizing an ecosystem as containing the following elements:

1. Composition: species that are present and their relative numbers.
2. Structure: the vertical layering of vegetation and soil.
4. Heterogeneity: a variable consisting of composition, structure, and pattern.
5. Function: performance characteristics of the basic ecological functions (water, energy, and nutrient cycles).

6. Dynamics and Resilience: successional process, and recovery from disturbance.

Looking at an ecosystem in this way, we can establish a set of design intentions based on the specific goal of the restoration project. Depending on whether our goal is the restoration of the productive capability of a degraded mine site, or preserving native species, the essential processes remain the same. As long as the designer remains cognizant of how each element is interrelated, the ecosystem should function naturally. This approach also has the advantage that it considers the impact changing societal values can play in influencing the intended goals of a reclamation project (Allen in Hobbs and Norton 1997).

Methods for Measuring the Effectiveness of Ecosystem Management

If an institution purports to have adopted an ecosystem-based approach to resource management decisions, it is important to know what criteria they are using to guide their decision-making. Armed with this knowledge, outside observers are then in a position to effectively critique how a particular landscape is being managed. In his research in this area, Grumbine (1994, cited in Perley 1998) was able to identify a number of different criteria that can be used to successfully evaluate the management of forest ecosystems. These themes included:

- Hierarchical Context. Management decisions based on only one measure of biodiversity are inadequate. It is important to adopt a systems perspective that takes into consideration the connections that take place between all levels of a healthy ecosystem;
• Ecological Boundaries. Consideration of appropriate scale is an important in effective ecosystem management. Resource managers must look beyond artificial barriers - such as property lines and political boundaries – and place their decisions within the appropriate ecological boundaries;

• Ecological Integrity. This focuses efforts to preserve viable populations of native plants and animals, the management of natural disturbance patterns, and the reintroduction of indigenous extirpated species where possible;

• Monitoring. An effective system of monitoring allows for the collection of accurate and timely information on the success or failure of a project to meet its management objectives. Information is fed back into the decision-making system for the purpose of effecting a pattern of ongoing improvement;

• Adaptive Management. This concept accepts the legitimacy of the idea that knowledge is provisional, and that resource management should be looked upon as a continuous learning process;

• Inter-agency Cooperation. Resource management decisions should derive from a process that includes all the relevant stakeholders;

• Organizational Change. The existing system of top down decision-making should be replaced with one that is more responsive to the specific needs of local communities; and

• Humans Embedded in Nature. Ecological resource management accepts the notion that "humans are fundamental influences on ecological patterns and processes and are in turn affected by them." (Perley 1998, p 6).
Grumbine was able to amalgamate these eight themes into a single definition of ecosystem management: “Ecosystem management integrates scientific knowledge of ecological relations within a complex socio-political and values framework towards a general goal of protecting ecosystem integrity over the long term.” (Grumbine 1994, quoted in Perley 1998). In the context of the Telkwa Project Area, these themes for assessing ecosystem management can be used to guide the formulation of a reclamation design that addresses the needs of the company and local community in a sustainable manner.

PART IV- LEARNING FROM THE PAST: CASE STUDIES ON RECLAMATION

The following case studies have been selected based on their ability to illustrate some of the successes and failures of recent reclamation projects. For each example, a brief explanation of the project will be followed by an analysis of the important lessons to be learned. It is intended that these lessons will be applied, where possible, to the Telkwa Project Area.

Case Study #1 - The Chicago Controversy

Though this first case study does not deal with mine reclamation per se, the Chicago controversy - as it is referred to by reclamationists - is illustrative of the critical importance public opinion can play in determining the success of a reclamation project.

For over two decades volunteer reclamationists and the Cook County Forest Preserve District had collaborated on a plan to return a badly degraded piece of scrub forest back into a high-quality prairie and oak savanna. Over the years hundreds of volunteers had succeeded in
transforming as much as 2500 ha back to native prairie. However, as a result of some of their practices an aggressive anti-reclamation campaign was started by a group of environmental activists from outside the county. What initiated the controversy was the plan by the reclamationists to cull the local deer herd. In the absence of natural predators, the expanding deer population was threatening to destroy the newly re-established native prairie. Alarmed by the plans to shoot the deer, an outside group of animal-rights activists succeeded in convincing both the politicians, and the local community that the reclamationists were an elitist organization who were using public lands in a manner that was not in public interest. As local opinion shifted against the reclamationists, Cook County politicians decided to impose a moratorium on all prairie reclamation projects that were taking place on public lands. While the moratorium has since been partially lifted, new bureaucratic controls governing future reclamation projects have made the entire process cumbersome, confusing and expensive for everyone involved.

Looking back at the roots of the controversy reclamationists from across North America concluded there are a number of important lessons reclamationists can learn from what occurred in Chicago (Meekison et al. 1998, Siewers 1998, and Shore 1997). These lessons can be grouped under the following headings:

- **The importance of developing a real grass-roots movement.** Though they thought of themselves as being a grass-roots organization, the Chicago restoration movement in fact represented only a small minority of the local population. In addition the reclamationists had also formed a number of important links with corporate sponsors which, in retrospect, had the effect of making the movement vulnerable to charges that they were elitist organization whose goals were determined by forces outside of the local community. In looking back at the roots of the controversy, it is clear that greater
effort should have been taken to involve the affected communities in decisions on issues that are of primary importance to their everyday lives;

- **The need for a strong institutional framework.** The Chicago controversy demonstrated that reclamation efforts generally take place in the absence of a strong institutional framework. Once criticisms began to be directed at the reclamationists, they lacked the organizational structures necessary to offer an effective counterattack. In part this deficiency can be attributed to two factors: First, the links between local reclamationists and institutions such as universities remain undeveloped. As a result, the pro-reclamation side lacked the credibility that is typically afforded those who are viewed as ‘experts’. A second problem relates to the lack of an institutional network for the education of the local community on the goals of reclamation. Given the seemingly conflicting, and often brutal methods that were employed in some reclamation projects, public education and consultation is seen as critical to public acceptance of the project;

- **The need to integrate reclamation into our cultural traditions.** An increasing number of reclamationists believe that for it to become part of our popular culture, reclamation “must include a conscious renegotiation of the relationship between nature and culture, and that art, ritual and performance are means for effecting that.” (Meekison et al. 1998, p. 73). In the case of what was happening in Cook County, not one of the fifty local and national organizations that make up the reclamation consortium was a member of an arts organization; and

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7 The application of herbicides, tree girdling and deer culls are methods commonly used by reclamationists to meet their project objectives. Given the likelihood that these methods will evoke strong public opposition, it is necessary for reclamationists to engage in a proactive campaign to educate the public on why such methods are necessary.
• The need to restore for the local community the site’s sense of place. One of the important contributions of reclamation is its ability to re-establish, on a degraded site, its sense of place. In Chicago, little effort was invested in reintegrating the reclaimed prairie with the people living in the surrounding communities. Because too few people had the opportunity to experience the beauty of the site first-hand, once the controversy erupted local support for the continued work of the reclamationists was not forthcoming.

For ease of presentation and to remove unnecessary duplication, the lessons learned from case studies 2, 3 and 4 have been grouped together under a single heading.

Case Study #2 - The Henderson Mine and Mill  A molybdenum mine and mill located approximately 100 miles west of Denver, Colorado, the site is situated within the Colorado Front Range. This area of the state is of prime scenic importance as it supports intensive year-round outdoor recreational activities. Treated mine wastewater is directed into nearby streams that support a self-sustaining brook and brown trout populations. Because both the mine and mill are located within the Denver watershed, water flowing off the site eventually passes into the City’s main municipal reservoirs (Todd 1997).

Case Study #3 - The McLaughlin Mine  The McLaughlin Gold Mine is situated in California’s Coast Range, approximately 70 miles north of San Francisco. Local environmentalists, government regulators, and members of the mining industry regard it as a model of environmental friendly mining. Its success in this regard is based on a combination of proactive planning, management, and the use of appropriate pollution control technologies. Located in an area of the
state that has been greatly disturbed by past mining practices, reclamation planners at the McLaughlin Mine are looking to redress the effects of the accumulated history of mining on the site. Once the mine has ceased operations, the plan is to transfer the site, and its associated buffer lands to the University of California where it will be used as a wildlife preserve and environmental research station (Todd 1997).

Case Study #4 - The Flambeau Mine This mine is located partially within the city limits of Ladysmith, Wisconsin. It uses an advanced water treatment technology to process the highly acidic water that is pumped from the main pit. The effectiveness of the treatment technology to prevent contamination of the surrounding environment is reflected in the diversity and health of wildlife living downstream of the mine’s effluent discharge point. In terms of its socio-economic impact on the local community, city officials credit the mine for being the catalyst for the town’s recent economic resurgence. In addition to providing hundreds of direct jobs, the mine has evolved into one of the county’s foremost tourist attractions (Todd 1997).

Taken as a group, the important lessons that can be learned from the Henderson, McLaughlin, and Flambeau mines can be summarized as follows:

- **With appropriate planning, a mine can be successfully located in areas of high sensitivity.** These include areas that contain high scenic values, environmentally sensitive floral and fauna, or are close to human habitation; and

- **The importance of forming partnerships with post-mine users.** Because the life span of a mine is measured in decades, or even years, planning for closure is an integral part of most concepts of sustainable mining. Working in close cooperation with local
community leaders, the company can produce a post mine plan that successfully integrates the reclaimed site back into the community’s long-term vision for the area.

Case Study #5 - Equity Silver Mine

The Equity Mine was an open pit operation that ran from 1980 to 1994. Located in Bulkley River Watershed, acid rock drainage (ARD) originating from three large waste dumps contains highly toxic concentrations of heavy metals (Wilkes 1997 and Miningwatch 1998). If left untreated, these contaminants could potentially impact the region in three important ways:

- **Fisheries.** The Bulkley River is an important regional source of trout and salmon habitat. For salmonid species the river provides a route for migration, spawning, and over wintering areas. For certain species of fish (e.g., trout and coho) that spend significant portions of their lives in the Bulkley and/or its tributary streams, the effect on mortality from heavy metal contamination can be particularly severe. In addition to the environmental damage, the potential economic costs associated with ARD are equally high. Included as Table 7 is an estimate of the value of the fishery to the local economy. Based on the best estimates of provincial fisheries biologists, the release of untreated ARD into the Bulkley River would have the effect of eliminating, at least seasonally, salmonid populations as far as 250 km down river from the mine.
Table 7 - Estimated Value of the Bulkley River Fishery (X $1000) (adapted from Wilkes 1987)

<table>
<thead>
<tr>
<th></th>
<th>Net</th>
<th>Gross</th>
<th>Present value discounted at 8% over 60 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sport Fishery</td>
<td>$1300</td>
<td>$3000</td>
<td>$20845</td>
</tr>
<tr>
<td>Food Fishery</td>
<td>$104</td>
<td>$239</td>
<td>$2205</td>
</tr>
<tr>
<td>Commercial Fishery</td>
<td>$131</td>
<td>$301</td>
<td>$3340</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$1535</strong></td>
<td><strong>$3540</strong></td>
<td><strong>$26400</strong></td>
</tr>
</tbody>
</table>

- **Recreation Values.** The sport fishery is a significant contributor to the local economy. In addition to direct jobs for fishing guides, the indirect economic spin-offs to local businesses are worth over a $1 million annually.

- **Drinking Water.** The Bulkley is a source of drinking water for several communities. The exact nature of the risk to human health from the release of untreated ARD from the mine is still to be determined.

To understand the full dimensions of the potential ARD problem posed by the Equity Mine, it has been estimated by staff from the BC Ministry of the Environment that contaminates from the site could continue to be generated for the next 150,000 years (Wilkes 1987). According to the existing legislation governing mine reclamation, the company was required to post a performance bond of $25 million to cover the cost of ARD cleanup in perpetuity. In 1997 the bill for collection and treatment of ARD exceeded $1.5 million. At this level of expenditure, the bond will be exhausted in less than 15 years.

For reclamationists who are interested in creating the conditions for post mine sustainable land use opportunities, the Equity Mine is important because it is illustrative of the extreme
case the government and company response to the problem of ARD management, as expressed in the performance bond system, is clearly inadequate to respond to the specific demands of the site. This author would argue that in the case of the Equity Mine, the concept of reclaiming to equivalent land use is clearly inconsistent with the philosophy of sustainable development. A more flexible legislative framework, one that allows the company and the local community to delineate a long-term land use plan for the site, could potentially lead to design responses that address the conditions of the site.

**Case Study #6 - Treating Coal Mine Drainage Using Constructed Wetlands**

Under certain conditions, the mining of coal can lead to the formation of ARD. Coal mine drainage becomes acidic as a result of the oxidation of pyrite. Pyritric material can be found in either the coal itself, in the overburden, or in the material underlying the deposit. Once pyrite is exposed to atmospheric oxygen and water, an oxidation reaction is initiated. Water that is subsequently drained from the site is characterized by low pH and high levels of iron. When in contact with other rock material, the acidic water initiates additional chemical reactions that lead to the dissolution of heavy metals (Hellier 1999). If left untreated, ARD has the potential to cause severe environmental and economic damage to both local and regional watercourses.

Pennsylvania has a long history of coal mining activity. Though it has generated significant economic benefits for the state, an enduring legacy of the coal mining industry has been ARD contamination of a significant proportion of the state’s network of streams and rivers. In part due to strict US federal environmental regulations, mine owners are now required to meet very high standards with respect to the release of toxic materials into the environment. One response of the
industry has been to explore options that involve the use of constructed wetlands to treat ARD. Though research is still ongoing, in a number of field studies constructed wetlands have been found to provide the following benefits:

- **Economic benefits.** Constructed wetlands are cheaper to build and operate when compared to conventional systems. These cost savings are possible because constructed wetlands rely upon energy that is freely supplied (e.g., sunlight, wind), as well as using plants and soil to trap and store contaminants (Kadlec et al. 1995);

- **Flood and runoff control.** Wetlands perform as natural sponges that soak up rainwater and melting snow and then release it gradually back into the environment over an extended period of time. This gradual release helps lesson the damaging effects caused by excessive runoff during periods of flash flooding. An added cost benefit is that drainage ditches and other flood control infrastructure can be designed to handle reduced peak flow rates;

- **Pollution Control.** Wetlands have the ability to both treat ARD, and take up heavy metals contaminants that are in solution;

- **Increasing local biodiversity.** Through careful planning and design, constructed wetlands can offer a wide range of different habitat possibilities. For example, with the proper combination of open water areas, emergent vegetation, and the inclusion of islands, waterfowl populations can be encouraged to colonize a constructed wetland (Kadlec et al. 1995). Further adjustments to the design of the wetland can lead to conditions that encourage the establishment of reptiles, amphibians, fish, and both small and large mammals; and

- **Recreation and other human uses.** Humans attach value to wetlands, both in terms of its commercial and non-consumptive uses. Commercially, some
constructed wetlands have been purposely designed to support activities such as waterfowl hunting and sport fishing. The potential also exists to grow food products on these sites (Dinges 1982). The non-consumptive opportunities presented by constructed wetlands generally relates to their potential as aesthetic and/or recreational amenities. Increasingly wetlands are being designed intentionally to provide people with opportunities to learn about ecology, engage in bird watching, or as adjuncts to existing hiking trails. Included as Figure 11 is a conceptual plan for a constructed wetland that has been designed to support a range of human activities.

Figure 11 – A conceptual plan of a treatment wetlands showing ancillary benefits to the community (adapted from Kadlec et al. 1996).
The value of this case study has been to demonstrate the potential benefits offered by natural systems to control a potentially significant source of pollution resulting from the mining of coal.\textsuperscript{8} While it should not be considered as a panacea, when used appropriate constructed wetlands appear to offer a cost effect, environmental sound, and socially sustainable alternative to conventional approaches for handling ARD.

Case Study #7 - Slope Stabilization Using Bioengineering Methods

This case study was selected because in terms of climate, difficult soils, steeply sloping banks, and the need to address concerns relating to visual impact, this site is similar to the Telkwa Project Area. Located along Alberta’s Kananakis Highway, this site had resisted previous attempts to reestablish vegetation on its steeply sloped banks. Attempts to hydroseed the area failed, in part, because of the largely mineral soils and extreme micro climatic conditions that characterize the site. Because the highway is a major arterial connection for tourists visiting the area, allowing the site to naturally re-vegetate over time was not seen as a viable option. At that time of construction (1986), little was known about the bioengineering of slopes in a northern continental climate. As a result several different bioengineering techniques where applied with varying degrees of success. The important lessons learned from this project included:

- **The importance of correct plant selection.** Due to the extreme conditions of the site, plant mortality rates were in some cases as high as 80 - 90%. These figures point to the need to correctly choose plant material that is specifically adapted to the expected

\textsuperscript{8} In the case of the Telkwa site, the greatest single source of concern by local residents has centered on the company’s plan to prevent ARD from occurring on the site.
environmental conditions of the site. In addition, locally harvested plants, grasses and flowers generally proved to be more successful at surviving the rigors of transplant;

- **The effect of slope on plant mortality.** The extreme slope of the site (1:1) contributed significantly to the high initial plant mortality rate. It was believed that even minor reductions in slope would have contributed greatly to the chances of a successful transplant;

- **Effectiveness of bioengineering methods to address aesthetic, ecological, and engineering concerns.** In terms of addressing the specific engineering, environmental, and aesthetic concerns of the designers, the Kananaskis Highway project was a success. Thirteen years into the trial, the slope remains stable and it is beginning to be reintegrated into the surrounding visual landscape; and

- **Bioengineering as a sustainable method of slope stabilization.** Compared to conventional engineered solutions (e.g. concrete and/or steel retaining walls), bioengineered methods offer significant long-term cost advantages. As self-regenerating systems, their maintenance costs are minimal and they are not subject to the usual cycle of replacement that characterize man-made structures.

**PART V- STUDY METHODOLOGY**

In developing the final reclamation design for the Telkwa Project Area, the author selected a design methodology that was both systematic and flexible. Given the breadth of the subject matter, it was important to identify from the beginning a process that would keep the discussion focused on the original hypothesis. In addition, because design is inherently an iterative process it
is important to adopt a methodology that is compatible with the design process. Based on these two requirements, the author selected the methodology described in Figure 12.

Figure 12- Flowchart Describing Thesis Methodology
In reviewing the development of this thesis project, the chosen methodology permitted the author to move seamlessly from the science of modern reclamation practices, to issues of ethics, aesthetics, the concept of sustainable mining, and finally to a design proposal for the reclamation of the Telkwa site.

In terms of a theory base, in addition to developing the arguments raised by the authors cited in the literature review, the author plans to rely heavily upon case studies of different reclamation projects. By documenting the successes and failures of recent reclamation efforts, it is hoped that the experience of others will make this design a more credible product.

In light of the research that pointed out the importance of public involvement in all phases of the reclamation process, the author reviewed the proceedings from the company sponsored townhall meetings in order to understand some of the concerns of people living in the local area. Based on this review, the author was able to establish a program for the site that is compatible with the expressed aspirations of the community.

PART VI-TELKWA COAL PROJECT SITE ANALYSIS

Purpose of the Site Analysis

A site is composed of many complex elements, each of which is unique from the other in some degree. Falling rain creates a network of streams, soils influence vegetation, human settlement patterns impact upon wildlife migratory routes. While at one level each element is separate, on another they are all highly interrelated. Understanding this interrelationship becomes
critical if the designer wants of lessen the negative impacts of development on a site. Careful analysis can also reveal the latent potentialities of a site. Thus the site analysis forms the basis for environmental conservation.

Understanding the Telkwa Site

As part of BC's environmental assessment process, a mine operator is required to provide the government with a detailed site inventory covering the area of the proposed development. In the case of the Telkwa Coal Mine, Manalta Coal Ltd. (subsequently purchased by Luscar Ltd) handed over to the government an extensive two hundred page report dealing with issues ranging from possible effects to the environment, to socio-economic impacts, to First Nations concerns. That report formed the basis of the site analysis that is contained in Appendix 2. The site information described below is only intended to provide the reader with general description of the Telkwa Project Area.

General Project Description

The proposed Telkwa Coal Mine is located in the central interior of British Columbia approximately six km southwest of the Village of Telkwa, and 10 km south of Smithers (see Appendix I). The mine is planned to produce between 1-1.5 million tons of coal per year over a twenty-five period (Table 8).
Coal will be extracted entirely from four different open pits using conventional truck and shovel methods (Figures 13 and 14). Once processed the clean coal will be transported by road to a rail loadout on the CN mainline located approximate to where Hubert Creek joins the Bulkley River. The coal will then be loaded onto unit trains and shipped some 400 km to the port facility at Prince Rupert.

<table>
<thead>
<tr>
<th>PIT AREA</th>
<th>RAW COAL RESERVES (MT)</th>
<th>YEARS MINED</th>
<th>SIZE OF DEVELOPMENT (HA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tenas Pit</td>
<td>20</td>
<td>0 - 14</td>
<td>650</td>
</tr>
<tr>
<td>Pit 3</td>
<td>15</td>
<td>14 - 20</td>
<td>550</td>
</tr>
<tr>
<td>Pit 7 &amp; 8</td>
<td>11</td>
<td>20+</td>
<td>500</td>
</tr>
<tr>
<td>TOTAL</td>
<td>46</td>
<td></td>
<td>1700</td>
</tr>
</tbody>
</table>

Figure 13. Illustration of Terrace Pit Mining System.
Source: Fung, R. 1981
The project timeline and construction plan is as follows:

- Commence On-site Construction April, 1999
- Commence Overburden Removal November, 1999
- Commission Preparation Plant March, 2000
- First Coal Shipment May, 2000

DISCUSSION

This section of the thesis is devoted to expressing, through design, the theoretical concepts discussed in the previous chapter. The objective is to provide the reader with a graphical representation of what these concepts would look like if applied to the reclamation of the Telkwa site. Though the drawings themselves are enclosed as Appendix VII of the thesis report, included
here is an accompanying brief written description of the principle design concepts which directed
the form of these designs. To further assist the reader in interpreting these drawings, their
description has been organized under the following main headings:

- Aesthetics
- Ecological Function
- Long-term Sustainability

Because the design being presented in this thesis is intended as a conceptual prototype, it
was decided to focus attention on a single pit only. After due consideration Pit #3 was selected,
both because it represented conditions found in the other pit areas, as well as presenting design
challenges that were unique to the project area. Because Pit #3 will not developed until
approximate year 14 of the project, there is an opportunity for Luscar to weigh the costs and
benefits of amending its existing reclamation design to reflect the results of this thesis report.

AESTHETICS

Given the research on the importance culture plays in influencing aesthetic preference, the
design sought to address issues of aesthetics from two perspectives: First, the dominant aesthetic
color of the area was determined. This allowed the designer to estimate what impact, if any,
the mine would have at a regional scale on the existing landscape as seen by off-site observers.
Second, by narrowing the focus to the scale of the area directly affected by mining, the designer
sought to address issues of aesthetics that would be encountered by people who directly access
the site. Unlike most reclamation projects where people are not encouraged to re-enter the
affected area, one of the key goals of the alternative design was to encourage people to explore the site.

With its relatively undeveloped landscape, the dominant aesthetic character of the area is the picturesque wilderness. In determining the possible visual impact the mine would have on this landscape, a series of viewshed maps were plotted from several locations outside of the project area. These locations were determined based on a review of public and government visual impact concerns as expressed in Luscar's Project Application Report that was released in 1997 (refer to map of Key Observation Points located in Appendix 3 of the thesis report). Given the topography of the Pit #3 area, the spoil dumps represent the dominant alteration to the existing landscape (refer to 3D computer plots of the site found in Appendix 1). Luscar's conceptual design proposes that the dumps be re-contoured to form a series of flat benches extending up the hillside to the pit area. This decision was based on the objective to reclaim large portions of the dump area for use by local cattle ranchers. Re-contouring of the dumps to meet specific aesthetic objectives for the site were not identified by the company as an important design consideration. The alternative design suggests a less uniform, more heterogeneous re-contouring of the dumps so that they more closely resemble the surrounding landscape (refer to L-2 and L-3). Given the requirement to re-contour the dumps upon closing, these alterations to the final dump profile would represent little, if any, additional cost to the company.

Within the Pit #3 project area itself, the alternative design proposes that both the pit area and the spoil dumps be both visually and physically accessible to people (refer to L-3, L-4, L-6 to L-13). In association with ecologically based interpretative signage, this accessibility is intended to promote increased public awareness of the relative ecological health of the areas affected by
mining. Based on the earlier literature review that argued the importance culture plays in shaping a community's understanding of beauty, it is critical that the means for communicating the relative ecological functioning of the site be given a high priority. Accepting the notion that knowledge is a key component underlying human aesthetic preference decisions, this increased level of understanding forms the basis for altering the existing public preference for landscapes unaffected by human processes. Even in a landscape that has been subject to intensive human use (as in the case of the Telkwa site), humans can be made to recognize the beauty that is possible following reclamation.

To allow for this increased accessibility to the site, the design proposes that the user be allowed access to the many contrasting features of the reclaimed site. This would include running a trail along portions of the pit highwall (refer to L-6, L10, and L-11). To accommodate this, it is recommended that the highwall be modified in areas to provide both a safe, and visually interesting environment. Though existing reclamation guidelines do not require that highwalls be reclaimed, it is thought that relatively minor modifications to the highwalls would provide trail users with greatly enhanced viewing opportunities of the site and surrounding area (refer to Viewshed Map #5 in Appendix 3), as well as greatly increased opportunities to interpret the mine's history.

ECOLOGICAL FUNCTION

To assist them in understanding the ecological functioning of the site, the habitat requirements of three easily identifiable key indicator species have been selected for the reclamation of Pit#3. Because of local concerns over the mine's possible impact on the water quality of local fish
bearing creeks, restoration and/or creation of salmon and trout habitat is an objective of the alternative reclamation design (refer to L1, L-3, L-13). Because both of these fish species are acutely sensitive to the effects of pollution, their presence is seen as an indicator of an ecologically healthy creek. The ability to construct stream habitat to the level that they can meet the habitat requirements of salmon has been successfully demonstrated in several stream restoration projects conducted in the State of Washington.

While there is some concern about the effects of ARD on local fish stocks, the high acid neutralization potential (NPR = 2.4) of the geology of the coal deposits in Pit #3 area suggests that the threat from ARD is minimal. The proposal to create a series of wetland areas through the Pit#3 area is based on the ability of these systems to provide high quality habitat for aquatic organisms (refer to L-3). Relatively simple and inexpensive re-contouring of submerged land can transform relatively unproductive areas into highly productive wetlands (refer to L-1 and L-8). For those areas where the potential for ARD is a problem (e.g., Pit #7), these wetlands would also function as natural ARD treatment areas.

Moose was selected as the other key indicator of the site's ecological health. Moose is the principle big game species hunted in the Bulkley Valley. It is valued both as an important source of food for people living in the area, as well providing economic benefits by attracting hunters from outside of the region. Presently the local moose population is under threat from human encroachment on their critical winter range habitat. Moose require sheltered, mixed deciduous forests during the winter, and presently these forests are found on a significant portion of the Pit #3 area (refer to Sensitive Area Network map in Appendix 3). The alternative design recommends
that the reclaimed forest be specifically targeted toward accommodating the winter range
requirements of moose (refer to L-3, and L-12). Maintaining the quality of this habitat would be
accomplished through specific silviculture practices, including selective harvesting of the mixed
forest.

LONG-TERM SUSTAINABILITY

While the actual operating life of the Telkwa mine is estimated at only 20 years, the mine's
physical influence on the site will be much more long lasting. One of the goals of the alternative
design was to enable the site to be more sustainable on a long-term basis. To attain this goal,
consideration was made to reclaim the site to meet the following land use objectives:

- Increase the percentage of land reclaimed for forestry versus grazing land;
- Reclaiming the site for the purpose of providing a recreational amenity; and
- Reclaiming the site for the purpose of supporting the region's resource-based
economy.

In terms of direct costs to the mining company, reclaiming a site to support forestry is
substantially less costly when compared to reclaiming a site to support animal grazing (Berger et
al 1998). Forestry also has the potential to provide far more economic benefits to the community
at large than is possible through agriculture. Using the community forest concept as a model,
economic benefits from the site flow back to the community through the involvement of local
people in the planting, on-going maintenance, and eventual harvesting of the forest (Drushka
1999). Reclaiming for forestry also has the added benefit of employing more people when
compared to cattle grazing. Such benefits are important when measured against the region's
traditionally high level of unemployment. Because most of Pit#3 falls within the ALR (refer to the land use map in Appendix 3), it would be necessary to get an exemption from the provincial government to take the land out of agricultural use. Given the intended use of the land, and the fact that the agricultural capability of the site is low (refer to the agricultural capability map in Appendix IV), the case should be made to the government that this exemption is in the best interests of the local community.

Economic benefits to the local community are also possible through adoption of a reclamation program that aims to address certain deficiencies in the existing recreational opportunities available to those living and/or visiting the region (refer to recreational capability map in Appendix V). Large, readably accessible lakes are not common in the area, but as a result of the flooding of the pits there is an opportunity to satisfy this deficiency. Through the development of an on-site camping area (L-4), an extensive trail system\(^{10}\) (L-3 and L-4), a day recreation area (L-7), together with provisions for interpretative information, Pit #3 has the potential to provide a significant recreational amenity to the area.

With the emphasis on the creation of fish and moose habitat, the reclaimed portions of the Pit #3 area will contribute to the region's existing resource based economy. Whether this includes hunting and fishing, or simply the viewing of these species in the wild, properly managed these activities can be sustained indefinitely into the future.

\(^{10}\) Placement of trails was based in part on issues of aspect, slope, connectivity with the existing trail network, and local points of interest. Refer to maps enclosed in Appendix 3.
CONCLUSIONS AND RECOMMENDATIONS

Mining is an industry whose history dates back to the beginning of human civilization. As the global economy consumes minerals at an ever-increasing rate, it is inconceivable to think of a time when mining will no longer form the foundation upon which all other forms of economic activity is based. Given the rising tide of societal concern over the declining state of the planet's ecological health, it is also inconceivable to think that the mining will be allowed to occur in the absence of strict controls on how the mine is developed, operated, and eventual reclaimed.

In this thesis the author has explored a number of ethical, aesthetic, and sustainability issues that those working in the mining sector ought to consider when confronted with the question of how best to reclaim a former mine site. Miners themselves now acknowledge that social, and not technical issues are the biggest challenge facing the industry in the coming century. Mines simply will not be developed if members of the affected community are unwilling to accept the consequences of the mine. If this acceptance is to be forthcoming, the public needs to believe that the mine will be capable of contributing long-term positive values to the community after mining has ceased. Also, members of the public must be given a forum for expressing their views on how the mine should be developed. Landscape architects, working as members of a multi-disciplinary team of professionals, can propose more sustainable mine reclamation designs, but the community must be willing to be involved in the process. With their commitment to a design process that embraces public involvement, landscape architects are uniquely suited to the task of addressing the concerns of both the industry and public. The question that remains to be answered is this: Are landscape architects willing to take up the challenge? This author believes that with the current trend in the profession to move beyond traditional areas of work and pressure on the
mining companies to "look to be green", this suggests that the next generation of practicing landscape architects will take on a more influential role in the field of mine reclamation.

Based on the results of the literature review and the alternative design proposal, recommendations for future action fall under two main headings:

- **Actions to be taken by Luscar.**

  1. The management at Luscar should consider the possible benefits accruing to the company from increased public participation in the development of a new conceptual reclamation plan for the Pit #3. The design ideas presented in this thesis could be used to demonstrate to the community some of the potential long-term benefits that are possible through reclamation. The public would then be encouraged to propose a reclamation design that is consistent with their understanding of what the landscape character of the reclaimed area should be. Though reopening the process may lead to some addition costs for the company, the potential for the creation of goodwill between the company and the local community could more than offset these added costs. This spirit of goodwill could prove decisive given Luscar's tentative plans to expand the mine beyond the four pits currently envisioned for the site.

  2. As an operator of eleven mines throughout Western Canada, has an opportunity to use the Telkwa mine as a test case for developing alternative methods for involving the public in the mine development process. Given the recent public rejection of its proposed Cheviot mine near Jasper Alberta, it is clear that it is in the company's long-term interest to explore alternatives to the way it currently develops its mine sites.
• Actions to be taken by the engineering and landscape architecture professions.

1. Within the university setting, much more could be done to encourage the flow of information between different faculties. Sustainable development is only one area where professors and students from engineering and landscape architecture could benefit from a more open exchange of ideas. While the creation of a number of common core courses may not be a practical idea, there are other less formal venues that could be utilized to open the lines of communication\textsuperscript{11}.

2. Professional engineers must demonstrate a greater willingness to accept the legitimacy of non-traditional approaches to the mine development process. Though certain members of the engineering community have come to realize the need for change, in general engineers are reticent to surrender a measure of their authority in a field that they have come to dominant. Conversely landscape architects must be more proactive in their efforts to establish themselves in the field of reclamation. Though initially this process may prove difficult, the profession as a whole has much to gain from broadening the existing scope of its activities.

\textsuperscript{11} These could be as simple as monthly brown bag lunches where graduate students are encouraged to present their research findings to students from other faculties.
LITERATURE CITED


LIST OF APPENDICES

APPENDIX I
Map of British Columbia
3 D Map of Telkwa Area
Aerial Photograph of Project Area
Map of Pit #3 Area

APPENDIX II
Environmental Baseline Information for the Telkwa Project Area

APPENDIX III
Site Analysis Maps
- Elevation Map
- Contour Map
- Slope Map
- Aspect Map
- Watercourses
- Historic Resources
- Land Use Map
- Key Observation Points
  - Viewshed Map #1
  - Viewshed Map #2
  - Viewshed Map #3
  - Viewshed Map #4
  - Viewshed Map #5 (Regional Points of Interest)
- Views from the Road
  - Viewshed Map #6
  - Viewshed Map #7
  - Viewshed Map #8
- Landscape Flows - People
- Trail Network
- Landscape Flows - Fish
- Fisheries Resources Map
- Landscape Flows - Moose
- Sensitive Area Network

APPENDIX IV
Soils and Agriculture Capability Map

APPENDIX V
Recreation and Tourism Capability Map

APPENDIX VI
General Methods of Reclamation for Increasing Biodiversity

APPENDIX VII
Alternative Design Drawings
APPENDIX I

MAP OF BRITISH COLUMBIA
Geology

During the Jurassic and Cretaceous periods, much of the land that we now know as British Columbia was formed by the collision of several terrains with the main North American craton. The Bowser Basin, where the Telkwa coalfield is located, was formed as the Stikine Terrane moved into contact with the main continental land mass. Over millions of years, thick layers of sediments were deposited in the basin. In the Telkwa study area the deposition of sediments has resulted in the formation of coal seams whose average thickness is 85m.

The project site is underlain by a coal-bearing sedimentary sequence containing a blend of siltstone, sandstone, mudstone and shale. Underneath this sedimentary layer are undifferentiated volcanic rocks consisting of andesite, trachyte, and basalt. The bedrock in the Project Area is highly faulted. These faults effectively subdivide the area into fairly discrete blocks. Glaciation has resulted in till thicknesses of between 1 m and 43 m. The till is mainly composed of silty clay with only trace amounts of sand.
Forest Resources

Forest Cover and Capability

The site is located within the borders of the Bulkley Forest District in an area where timber harvesting has historically occurred. The predominant tree species in the area include lodgepole pine (Pinus contorta), white spruce (Picea glauca), subalpine fir (Abies lasiocarpa), and quaking aspen (Populus tremuloides). Stand heights vary between 19m and 28m, with the area covered by canopy ranging between 26% to 45% over the entire site. The index classification of forest capability rates the site between poor and good.

Impact of Construction

In addition to the pits, it will be necessary to clear some forested land in order to allow for the construction of the coal preparation plant, mine service buildings, train loadout area, and vehicle access roads. The location chosen for the buildings contains mature stands of spruce, aspen and pine. The area identified for road and rail construction has in general been already cleared for cultivation.

Vegetation

The Project Area falls within the area defined as the Sub-Boreal Spruce biogeoclimatic zone. This zone is composed of the White Spruce subzone at lower elevations, and the Subalpine Fir subzone at elevations above 750m. Lodgepole pine and aspen comprise the climax forest in
the White Spruce subzone, while subalpine fir, spruce, and lodgepole pine form the climax forest for the Subalpine Fir subzone.

Cover Types

Some sixteen vegetated and five non-vegetated cover types are found on the site. These can be grouped into five main categories: Coniferous Forest, Deciduous Forest, Natural Meadow, Brushland, and non-vegetated types. When broken down by the percentage of area covered, Forested types (67%) and Natural Meadow and Brushland (13%) dominate the site. In the Forested areas, conifers (38%) take up more of the site than deciduous types (30%). The lower elevation areas consist mainly of spruce/lodgepole pine forests in various successional stages. On flat, drier sites lodgepole pine occur as pure stands. In wetland areas black spruce dominates.

Plant Communities

The Spruce subzone contains the following plant communities:

- Mesic Maturing Hybrid Spruce-Lodgepole Pine-Purple Peavine
- Mesic Seral Trembling Aspen-Highbush Cranberry
- Alluvial Black Cottonwood-Hybrid Spruce-Shrub
- Black Spruce-Hybrid Spruce Swamp
- Willow-Scrub Birch Swamp
- Black Spruce Bog
- Dry Lodgepole Pine-Moss
- Scrub-Steppe-Meadow
The Subalpine Fir subzone contains:

- Mesic Maturing Hybrid Spruce-Subalpine Fir-Black Huckleberry
- Mesic Seral Trembling Aspen-Thimbleberry
- Upland Black Cottonwood-Black Twinberry
- Black Spruce Fen

**Rare Plant Communities**

The Scrub-Steppe-Meadow is rare both on the site and in the region as a whole. It is limited to steep south to west facing slopes on the north bank of the Telkwa River.

**Rare Plants**

Only two designated rare plant species - Carex trisperma and Rubus arcticus spp. stellata - were found to occupy the site. They were identified on one occasion growing in a wetland area. No endangered plant species have been identified in the study area.

**Habitat and Wildlife**

The relative numbers of wildlife in the area was determined by winter surveys of large ungulates, small mammals, and seasonal bird counts.
Ungulates

In terms of numbers, the principle ungulate species found wintering on the site are moose and mule deer. White-tailed deer only occasionally forage on the site. Caribou and mountain goat are typically found in the more mountainous regions south of the Project Area.

- Moose. These animals are by far the most common of the large ungulates found in the area. Throughout the year moose generally will move across many different cover types to forage. Areas designated as “true winter range” for moose include the area occupied by pits 7 & 8, as well as along the banks of area creeks and rivers.

- Mule Deer. The distribution pattern for mule deer is directly related to snow depth. They favour the area of thick pine located near the Telkwa River and Tatlow Road.

- Other Big Game Species. The area is known for the high quality of its black and grizzly bear habitat. In the spring bears move down from the high country and occupy the south-facing slopes and benches. They later move on to the mesic and wetland areas in summer and fall. No winter denning sites are known to exist in the Project Area.

Birds

Counts have revealed that over 140 different species presently nest in the study area. Because of a lack of suitable habitat, waterfowl typically do not nest on the site. Migratory
waterfowl will use the larger lakes in the region, none of which is expected to be affected by this development.

**Rare and Endangered Species**

No rare or endangered mammals have been identified on the project site. Bird species with high conservation value such as Peregrine falcon, osprey, and mountain bluebird are known to nest in the area. The high cliffs located along the Telkwa River have the potential to serve as falcon nesting sites.

**Biophysical Classification for Wildlife Capability**

In 1983 the Ministry of Environment produced a wildlife capability map for the area. This map indicated that there is a moderate capability (Classes 2 to 4) for moose winter range along the major watercourses. High accumulations of snow limit the use of most habitats for ungulate species. A common limiting factor is the presence of upland forest soils that promote the formation of very dense coniferous forest. Other large ungulates seldom use the area for overwintering.

Interestingly, biologists have noted the presence of far more moose than would be expected from the area’s capability class rating. This could mean that the rating was either under reported, or that losses of preferred habitat (i.e., from agriculture or urban development) has forced moose to move into the area.
Resource Use

• Forestry. Historically forestry has been the primary resource-based activity in the Smithers area. Most of the study area has at some time in its past been logged. This includes the area identified as Pit 7 & 8, and large sections of the site along the Telkwa and Bulkley Rivers.

• Non-consumptive Wildlife Uses. The popularity of wildlife viewing has grown to become an important outdoor recreational activity. The small herd of caribou that occupies the area around the Telkwa mountains has been identified as a regionally significant wildlife viewing resource. The known eastern limit of the herd’s range does not extend into the Project Area. However the existing road that provides the most direct vehicular access to the main viewing area of the caribou passes through the Tenas Pit area.

• Hunting and Trapping. In general the pressure on wildlife from hunting is very great throughout the Telkwa valley. In terms of big game animals, moose is the most widely hunted. Also important are black bear, deer, and grizzly bear. The majority of hunters are local residents. Trapping presently occurs in the area identified as Pit 3. Animals taken include marten, beaver, fisher, weasel, wolverine, lynx, mink, and otter.

Fisheries and Aquatic Habitats

Fisheries Base Data

The most recent fisheries study covering the Project Area was conducted in 1996. In general the amount of fisheries related data for the Telkwa River drainage area is quite extensive.
With respect to the Project Area itself however, data gaps begin to become apparent. While some detailed records exist for the area along the southern perimeter of the site, as one moves north (i.e., Pine Creek) little specific information exists.

Fisheries have historically been an important resource for people and wildlife living in the Telkwa Valley. Salmonid species native to the Project Area include pink, coho and chinook salmon, as well as cutthroat trout and Dolly Varden char. The presence of rare (Blue Listed) bull trout has also been documented on the site.

Fish Distribution and Fish Abundance

- Coho salmon. Three helicopter surveys performed in 1994 and 95 confirmed the presence of coho in the Telkwa system. A more detailed survey conducted in 1983 found that adult and juvenile coho could only be identified in the waters of Helps and Hubert Creeks.
- Pink salmon. In terms of overall numbers, pink salmon are the most abundant of the Pacific salmon species using the Telkwa system. Adult pink salmon have been sighted on all of the Telkwa River (below Pine Creek), Pine and Howson Creek, and below the 600m elevation mark of Goathorn Creek.
- Steelhead. No studies have been conducted to determine the numbers of steelhead using the Telkwa River. Juvenile fish have been sighted in Goathorn and Tenas Creeks, and the lower Telkwa River.
- Chinook Salmon. Recordings of Chinook salmon in the Telkwa system have been few in number. It is thought that only the lower portion of Hubert Creek is used for spawning purposes.
• Dolly Varden Char and Bull Trout. Dolly Varden char are found throughout the Telkwa system. They are particularly numerous in the waters of Goathorn Creek where they have been sighted up to the headwaters. Bull trout also favour Goathorn Creek. The number of trout identified using the creek make it the highest populated of all the watercourses that make up the Skeena watershed. Because bull trout have been listed as rare or uncommon both globally and provincially, this area is of particular concern for those wishing to preserve the species.

• Other Species. Other important fish species in the area include cutthroat trout, mountain whitefish, and peamouth chub. No studies have been conducted to determine their numbers.

Fish Habitat

The following provides a brief description of the fish habitat provided in each of the primary watercourses found in the Project Area. A summary of the types of habitat associated for each watercourse has been included as Table 1.

• Goathorn Creek. In the early 1980's an extensive fish habitat survey was carried out in the Telkwa Project Area. It was reported that very little (<1%) of the lower nine km of Goathorn Creek could be used by coho for spawning. This same area is also poorly suited for providing rearing habitat due to the limited number of back and side channels. Circumstantial evidence suggests that steelhead likely spawn in the creek. A survey of the benthic invertebrate community in Goathorn Creek found that species diversity was greatest at the headwaters, and lowest approximately 1 km downstream of Four Creek. No attempt was made at the time to establish if the presence of the mine site was causing this reduction.
• Tenas Creek. It is thought that Tenas Creek is primarily used by spring spawners (i.e., steelhead) due to the presence of spring high flows allowing easy access to the spawning areas. The numbers of benthic invertebrates in this creek were consistently higher than in Goathorn Creek or the lower Telkwa. Tenas Creek also recorded the highest juvenile fish density of all the local watercourses sampled in the study.

• Pine Creek. The suitability of the substrates for coho spawning was <1% for the lower 13 km portion of Pine Creek. In addition, a 4 m barrier is located just 2.5 km upstream of the Telkwa River. Gradients below this barrier were estimated to be greater than 2%.

• Howson Creek. This creek provides substantially better habitat value for coho than other creeks in the area. Steelhead, Dolly Varden and bull trout were seen spawning in the lower reaches of the creek.

• Telkwa. Due to the presence of lower gradient streams and an abundance of suitable substrate, the upper Telkwa (near Elliott Creek) is an important coho spawning and rearing area.

• Hubert and Helps Creek. Low gradients and several ponded sections, both of which are favoured by coho, characterize the lower portion of Hubert Creek. The middle portion of the creek mainly supports a resident population of cutthroat trout and Dolly Varden char.
Table 1 - Summary of Types of Habitat Present in the Area’s Primary Watercourses (adapted from Telkwa Coal Project 1997)

All salmonids known to use the watercourse are listed.

U = Unknown
✓ = Habitat is present
X = Habitat is not present

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<td>Likely</td>
<td>Likely</td>
<td>Likely</td>
</tr>
<tr>
<td><strong>CABINET CREEK</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dolly Varden or Bull</td>
<td>U</td>
<td>Likely</td>
<td>U</td>
</tr>
<tr>
<td>Trout</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>PINE CREEK</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coho Salmon</td>
<td>X</td>
<td>✓</td>
<td>N/A</td>
</tr>
<tr>
<td>Pink Salmon</td>
<td>✓</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Cutthroat Salmon</td>
<td>Likely</td>
<td>Likely</td>
<td>Likely</td>
</tr>
<tr>
<td>Dolly Varden or Bull</td>
<td>Likely</td>
<td>Likely</td>
<td>U</td>
</tr>
<tr>
<td>Trout</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mountain Whitefish</td>
<td>Likely</td>
<td>Likely</td>
<td>Likely</td>
</tr>
</tbody>
</table>

110
Table 1. "Continued"

<table>
<thead>
<tr>
<th>HOWSON CREEK</th>
<th>SPAWNING</th>
<th>JUVENILE REARING</th>
<th>OVERWINTERING/HOLDING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coho Salmon</td>
<td>✓</td>
<td>✓</td>
<td>N/A</td>
</tr>
<tr>
<td>Pink Salmon</td>
<td>✓</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Steelhead Trout</td>
<td>✓</td>
<td>✓</td>
<td>U</td>
</tr>
<tr>
<td>Dolly Varden or Bull Trout</td>
<td>✓</td>
<td>Likely</td>
<td>U</td>
</tr>
</tbody>
</table>

Hydrology and Water Quality

In terms of water resources, the Project Area encompasses the lower portion of the Telkwa River, portions of Pine Creek, Goathorn Creek (and its network of tributary streams), Hubert Creek, and a small section of the Bulkley River.

The Telkwa River forms part of the Skeena Watershed. The river runs for approximately 50km, draining an area of 1120 square kilometers. Its headwaters begin above 2000m, and it ends when it joins with the Bulkley River at the village of Telkwa. A major tributary of the Telkwa is Goathorn Creek (Table 2).

Table 2 - Flow data at Bulkley River, Telkwa River, and Goathorn Creek (adapted from Telkwa Coal Project 1997)

<table>
<thead>
<tr>
<th>Station Name</th>
<th>Bulkley River @ Quick</th>
<th>Telkwa River @ Tsai Creek</th>
<th>Goathorn Creek</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drainage area (sq km)</td>
<td>7360</td>
<td>368</td>
<td>132</td>
</tr>
<tr>
<td>Mean flow (cubic meters/sec)</td>
<td>134</td>
<td>13.9</td>
<td>1.75</td>
</tr>
<tr>
<td>Max. daily discharge</td>
<td>957 (Jun. 13, 1972)</td>
<td>156 (Nov. 1, 1978)</td>
<td>40.8 (May 20, 1968)</td>
</tr>
<tr>
<td>Min daily discharge</td>
<td>11.38 (Feb. 25, 1980)</td>
<td>0.680 (Apr. 2, 1982)</td>
<td>0.052 (Feb. 22, 1986)</td>
</tr>
</tbody>
</table>
Water Quality

Due to the naturally unstable soils found throughout the watershed, area creeks and rivers contain a high amount of sediment loading. In the Telkwa River itself, a long stretch of unstable river bank just upstream of where the river joins with Howson Creek is a major contributor of natural sediment. Naturally caused erosion is also quite evident along the lower reaches of both Goathorn and Tenas Creek. In addition to the natural sources of sediments in these two watercourses, logging in the area has resulted in a number of slides following extensive rainfall events.

Water quality monitoring for the area has been going on for several decades. Historically, surface water quality over the entire Telkwa Watershed has exceeded both federal and provincial guidelines for drinking water and aquatic environments in the following areas:

- total iron
- dissolved aluminum
- manganese
- pH
- chromium
- mercury zinc

In addition, the individual creeks and rivers in the Project Area may contain localized concentrations of some chemical elements not included in this general list. The source of this pollution is attributable to a combination of natural weathering of surface rock and the improper disposal of tailings from past mining operations.
While the concentration of metals in area creeks and rivers may appear high, the quality of the water is not atypical of surface water flows in a pristine aquatic environment. Progressive weathering of rocks result in the surface water being naturally high in iron, manganese, dissolved aluminum, and calcium. In general the natural buffering capacity of the soils is good and the pH in the area is usually basic.

Consumptive Uses of Water

The source of most of the potable water in the Telkwa area comes from underground wells drawing on the alluvial deposits located along both the Telkwa and Bulkley Rivers. In the Project Area, several homes are supplied by wells located near the confluence of Goathorn Creek and the Telkwa River. The Village of Telkwa also has water rights in the area.

Groundwater Flow

Field studies have indicated the movement of groundwater through the project site is controlled by topography with the flow moving in a generally southern direction toward the Telkwa River. It is estimated that the linear velocity of ground water flows is between 10 and 100 m/year. This great variability in range is the result of the highly faulted and fractured nature of the Project Area's underlying bedrock.
Groundwater Quality

Groundwater temperatures fall within a range of 5.0 to 10.0 °C. Groundwater pH was measured between 6.73 to 9.50. Concentrations of total dissolved solids (TDS) were between 175 to 3790 mg/L. Of the samples taken, only TDS were found to exceed the standard for drinking water set down in the Canadian Drinking Water Quality Guidelines.

Climate and Air Quality

The project site is situated in an upland area containing large tracts of forest and some grassland. Compared to the southern areas of the province, the valleys in the area are more open and the changes in elevation more gradual. The coastal mountain ranges greatly influence regional weather patterns. Despite being relatively close to the Pacific Ocean, the mountains tend redirect offshore winds away from the area. The result is a climate that is very much continental in quality. Winters are typically long and cold, and summers short and cool. Rainfall is light when compared to more coastal regions. For a more detailed description of the area's climate please refer to Table 3.

Temperature

Due to its continental climate, the Telkwa area is given to experience a wide range of temperature variation. Meteorological records kept for Smithers show a temperature range of 34.4 °C from the mean monthly maximum to the mean monthly minimum. The range between maximum and minimum temperatures is just under 80 °C. This great variation is possible given
the severity of the winters in this part of the province. It is not uncommon for overnight lows to drop well into the minus 30s C.

Table 3 - Environment Canada Data for Smithers Area
Averages for 1942 to 1990 period (adapted from Telkwa Coal Project, 1997)

<table>
<thead>
<tr>
<th>Temp C</th>
<th>JAN</th>
<th>FEB</th>
<th>MAR</th>
<th>APR</th>
<th>MAY</th>
<th>JUN</th>
<th>JUL</th>
<th>AUG</th>
<th>SEP</th>
<th>OCT</th>
<th>NOV</th>
<th>DEC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daily Max</td>
<td>-5.2</td>
<td>-0.1</td>
<td>4.8</td>
<td>10.3</td>
<td>15.3</td>
<td>19.0</td>
<td>21.4</td>
<td>21.0</td>
<td>15.7</td>
<td>9.0</td>
<td>0.6</td>
<td>-4.4</td>
</tr>
<tr>
<td>Daily Min</td>
<td>-13.0</td>
<td>-9.6</td>
<td>-5.7</td>
<td>-1.5</td>
<td>2.6</td>
<td>5.9</td>
<td>8.3</td>
<td>7.8</td>
<td>4.0</td>
<td>0.3</td>
<td>-5.7</td>
<td>-11.7</td>
</tr>
<tr>
<td>Daily Mean</td>
<td>-9.0</td>
<td>-4.8</td>
<td>-0.4</td>
<td>4.4</td>
<td>9.0</td>
<td>12.5</td>
<td>14.9</td>
<td>14.4</td>
<td>9.8</td>
<td>4.7</td>
<td>-2.5</td>
<td>-8.0</td>
</tr>
<tr>
<td>Extreme Max</td>
<td>15.6</td>
<td>11.9</td>
<td>16.0</td>
<td>24.3</td>
<td>35.8</td>
<td>33.9</td>
<td>34.4</td>
<td>35.2</td>
<td>31.1</td>
<td>24.4</td>
<td>15.6</td>
<td>11.5</td>
</tr>
<tr>
<td>Extreme Min</td>
<td>-43.9</td>
<td>-35.6</td>
<td>-33.3</td>
<td>-18.3</td>
<td>-7.2</td>
<td>-4.1</td>
<td>-1.1</td>
<td>-2.2</td>
<td>-6.7</td>
<td>-22.0</td>
<td>-32.4</td>
<td>-36.7</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Precipitation</th>
<th>JAN</th>
<th>FEB</th>
<th>MAR</th>
<th>APR</th>
<th>MAY</th>
<th>JUN</th>
<th>JUL</th>
<th>AUG</th>
<th>SEP</th>
<th>OCT</th>
<th>NOV</th>
<th>DEC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precip (mm)</td>
<td>57.8</td>
<td>29.3</td>
<td>22.3</td>
<td>18.0</td>
<td>33.3</td>
<td>42.2</td>
<td>45.7</td>
<td>42.1</td>
<td>53.7</td>
<td>62.3</td>
<td>54.5</td>
<td>48.0</td>
</tr>
<tr>
<td>Rain (mm)</td>
<td>11.6</td>
<td>6.3</td>
<td>5.8</td>
<td>12.1</td>
<td>32.7</td>
<td>42.2</td>
<td>45.7</td>
<td>42.1</td>
<td>53.5</td>
<td>55.5</td>
<td>22.3</td>
<td>7.5</td>
</tr>
<tr>
<td>Snow (cm)</td>
<td>60.7</td>
<td>29.7</td>
<td>19.7</td>
<td>6.9</td>
<td>0.9</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.2</td>
<td>7.3</td>
<td>39.2</td>
<td>51.9</td>
</tr>
<tr>
<td>Max Daily Precip (mm)</td>
<td>61.0</td>
<td>18.0</td>
<td>22.6</td>
<td>24.6</td>
<td>52.3</td>
<td>42.6</td>
<td>40.1</td>
<td>30.4</td>
<td>46.8</td>
<td>42.7</td>
<td>59.7</td>
<td>29.0</td>
</tr>
<tr>
<td>Max Daily Rain (mm)</td>
<td>26.7</td>
<td>13.2</td>
<td>15.5</td>
<td>24.6</td>
<td>52.3</td>
<td>42.6</td>
<td>40.1</td>
<td>30.4</td>
<td>46.6</td>
<td>41.7</td>
<td>59.7</td>
<td>23.6</td>
</tr>
<tr>
<td>Max Daily Snow (cm)</td>
<td>61.0</td>
<td>22.1</td>
<td>21.1</td>
<td>15.7</td>
<td>6.4</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>2.5</td>
<td>15.5</td>
<td>43.7</td>
<td>36.8</td>
</tr>
<tr>
<td>Month-end Snow Cover (cm)</td>
<td>39</td>
<td>32</td>
<td>12</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>12</td>
<td>26</td>
<td></td>
</tr>
<tr>
<td>Max Temp &gt; 0°C</td>
<td>8</td>
<td>16</td>
<td>27</td>
<td>30</td>
<td>31</td>
<td>31</td>
<td>31</td>
<td>30</td>
<td>31</td>
<td>18</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Measurable Precip</td>
<td>17</td>
<td>13</td>
<td>12</td>
<td>8</td>
<td>11</td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>14</td>
<td>17</td>
<td>16</td>
<td>17</td>
</tr>
<tr>
<td>Measurable Rain</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>6</td>
<td>11</td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>14</td>
<td>15</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>Measurable Snow</td>
<td>16</td>
<td>11</td>
<td>9</td>
<td>4</td>
<td>*</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>*</td>
<td>3</td>
<td>12</td>
<td>16</td>
</tr>
<tr>
<td>Freezing Precip</td>
<td>1</td>
<td>*</td>
<td>*</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Fog</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>*</td>
<td>*</td>
<td>2</td>
<td>3</td>
<td>6</td>
<td>12</td>
<td>7</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Thunderstorms</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>*</td>
<td>*</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>*</td>
<td>*</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Hours of Sunshine</td>
<td>43.8</td>
<td>78.6</td>
<td>124.4</td>
<td>179.5</td>
<td>223.9</td>
<td>241.4</td>
<td>254.8</td>
<td>227.7</td>
<td>140.1</td>
<td>90.6</td>
<td>41.3</td>
<td>33.3</td>
</tr>
<tr>
<td>Wind Speed (km/h)</td>
<td>8</td>
<td>8</td>
<td>7</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Max Hourly Speed (km/h)</td>
<td>66</td>
<td>56</td>
<td>55</td>
<td>61</td>
<td>51</td>
<td>46</td>
<td>50</td>
<td>46</td>
<td>56</td>
<td>58</td>
<td>64</td>
<td>51</td>
</tr>
<tr>
<td>Wind Direction</td>
<td>SW</td>
<td>SW</td>
<td>W</td>
<td>SW</td>
<td>NW</td>
<td>SE</td>
<td>SE</td>
<td>SW</td>
<td>SW</td>
<td>SE</td>
<td>SW</td>
<td>SW</td>
</tr>
<tr>
<td>Max Gust Speed (km/hr)</td>
<td>114</td>
<td>120</td>
<td>81</td>
<td>93</td>
<td>100</td>
<td>74</td>
<td>78</td>
<td>74</td>
<td>81</td>
<td>87</td>
<td>106</td>
<td>111</td>
</tr>
<tr>
<td>Wind Direction</td>
<td>SW</td>
<td>W</td>
<td>W</td>
<td>SW</td>
<td>SW</td>
<td>SW</td>
<td>SW</td>
<td>NE</td>
<td>N</td>
<td>S</td>
<td>W</td>
<td>E</td>
</tr>
</tbody>
</table>
Precipitation

The Telkwa Valley is situated on the leeward side of the both the Coast and Hazelton Mountain Ranges. As moisture laden ocean air is forced up over these ranges, much of the water is released in the form of rain or snow. Thus while the coast side of the range typically receives in excess of 2500 mm of precipitation annually, the lee side may receive only 20% of that amount.

Records for the Smithers region shows that the area can expect approximately 500 mm of precipitation annually: 300 mm falling as rain and 200 mm as snow. The two wettest months are October and January. Spring tends to be relatively dry. Since the Project Area is 320 m higher than the weather station in Smithers, climatic conditions are expected to vary slightly from the data presented in Table 3.

Wind

Wind conditions are generally calm throughout the Smithers area. The prevailing wind direction is from the west. Wind speed tends to decline during the summer months. Given the differences in local topography between Smithers and the Project Area, it is likely that wind speed and direction will be somewhat different. With respect to wind speed, this difference should not be significant since it is the product of the same general weather system.
Air Quality

The poor quality of the air in the Bulkley Valley is of primary concern to area residents. Air pollution in the valley is the result of three factors: Inadequate wind dispersion, natural topography, and numerous sources of local and regional sources of airborne particulate matter. The sources of this pollution are as follows:

- prescribed burning 40%
- wildfires 28%
- point source burning (beehive burners) 17%
- road dust 7%
- internal combustion engines (7%
- area burning (wood stoves) 2%

The topography of valley allows for temperature inversions to occur during the winter months. These inversions serve to trap within the valley any locally produced pollutants.

Soils and Terrain

The soils and terrain for the Project Area were extensively mapped in 1984. Maps at a scale of 1:5000 were produced for the areas where the main mine buildings are to be situated. The remainder of the site was mapped at 1:20000, with the exception being the area around Tenas Creek and Pits 7 & 8. At the time of the soil survey these pits were not included as part of the original mining plan.
Agricultural Capability

Soils were rated for their agricultural capability using the guidelines set out in the Land Capability Classification for Agriculture in British Columbia. This system groups soil into seven different categories based on the soil’s potential for agricultural use. A description of these seven categories and an agricultural capability map for the Project Area is enclosed as Appendix IV.

Soil Suitability for Reclamation

Within the Project Area, native soils were categorized, evaluated and classified according to their potential for reclamation. The different soil categories are as follows:

- Subsoil. The B horizon.
- Buffer. The parent material usually to a depth of 3 m.

Soil evaluation was performed using the Soil Suitability for Reclamation Guidelines produced by Alberta Agriculture in 1981. The guidelines provide a methodology for classifying the reclamation potential of soils (Good, Fair, Poor, and Unsuitable) according to their physical, chemical and morphological properties.

Soil Descriptions

Given the continental character of its climate, the Project Area contains mainly Luvisolic and Brunisolic soils. Less important in terms of the degree to which they occupy the site are
Regosolic and Humisolic soils. These four soil orders have developed from a wide range of differing parent material. These include fluvial, glaciofluvial, lacustrine, and colluvial deposits, moraine and organic materials.

Luvisolic Soils

These generally consist of Orthic Gray Luvisols whose A and B horizons are between 30 - 50 cm in depth. This layer is typically composed of loamy or silty sand overlaying a parent material of clay loam to silty clay loam. These soils are most likely to be found on the upper portions of hills or ridges with slopes of between 2 to 40%. They are well to imperfectly drained. In terms of their agricultural capability, the Luvisolic soils found on the Project Area have been given a rating of between Class 4 and 6. The major limitation of the soil for agriculture being stoniness, topography, and erosion potential. The reclamation suitability of Luvisols is high owing to the quality of the material in the A and B horizons. Due to problems related to texture and consistency, the parent material of this soil is rated fair to poor.

Brunisolic Soils

Eluviated Dystric and Orthic Dystric are the primary Brunisols found on the site. The sandy loam of the A and B horizon is a yellowish brown and extends 20 to 40 cm below the surface. The underlying parent material can range from silty clay loam to gravelly sand and can be some 3 m in depth. Brunisols of this type are well to imperfectly drained and are often found on wet, north facing slopes of between 2 to 50%. The agricultural capability of these Brunisols is between Class 4 and 6. Stoniness and moisture content are the principle limiting factors. The
reclamation suitability of these soils varies from good (A horizon), to fair to poor as one moves down through the soil. Because the A horizon material has the highest reclamation value of all the soils in the Project Area, great care will have to be taken when the time comes for salvaging this material.

Regosolic Soils

Regosolic soils on the site are classified as either Orthic or Cumulic Regosols. These soils are typically very weakly developed. This may be the result of slope instability. These soils can be found on both the flood plain areas, and on steeply sloped hillsides. These soils tend to be relatively shallow (between 10 to 15 cm), and consist of loose sands overlying gravelly sand or cobbles. Drainage is highly variable owing to location. Slopes range from 0 up to 100%. The agricultural capability of these soils varies from Class 6 (on floodplains) to no classification on extremely sloped sites. These soils are rated as unsuitable for reclamation owing to their unfavourable location.

Organic Soils

Organic soils in the Project Area consist of either Mesisols or Fibrisols. The degree of organic matter decomposition, and the height of the water table will determine which form the organic soil will take. These soil occur in the poorly drained depressional areas of the site. These soils have been rated as Class 4 to 6 in terms of agricultural capability, with the prime limiting factor being wetness. Not enough is known about the organic soils on the site to permit a reclamation suitability rating.
Terrain Analysis

The British Columbia Terrain Classification System was used to classify the surficial geologic features of the Project Area. Based on data drawn from aerial photography and on-site excavations, the Project Area was subdivided according to soil texture, parent material, landforms, and recent influences on the land surface.

Surficial Geology

The landforms and surficial material in the Project Area are generally the by-product of alternating periods of deposition and erosion that took place during the period known as the Fraser Glaciation. Following the retreat of the glaciers, colluvial materials as well as organic sediments have also contributed to the surficial geology of the area.

The following identifies the different types of surficial material, along with their principle physical characteristics, that have been found in the Project Area. The description of each material is taken from Manalta’s Project Application report.

- Moraine. The regional basal till of the area has a dense, compact matrix of sand and silt which is slightly to moderately calcareous and contains rock and mineral fragments of various shapes and rock types. Thickness ranges from a thin veneer to depths greater than 6 m.
• Fluvial. Materials consisting of gravel, sand and/or silt and are often moderately to well sorted and stratified. These sediments occur as channel or flood plain deposits, terrace deposits, alluvial fans and gravelly, sandy veneers deposited on upland slopes.

• Glaciofluvial. Materials consisting mainly of gravel and sand that ranges from non to well sorted. These sediments occur as large gravel outwash plains, irregular terraces along valleys, hummocks and ridges, and gravelly and sandy veneers over upland moraines.

• Lacustrine. Sedimentary materials consisting of fine sand, silt, and clay deposited on lake beds.

• Glaciolacustrine. Sediments of silt and fine sand but may contain coarse sand and gravel.

• Organic. Materials that result when the accumulation of dead vegetative matter exceeds the rate of decay. May also be classified as bogs, fens, or swamps.

• Disintegrated Bedrock. Naturally weathered (e.g., frost heaving) rock debris that originates from the underlying bedrock.

• Colluvium. Materials that are the result of mass wastage and whose location is the direct result of gravitational forces.

• Decomposed Bedrock. Weathered and decomposing rock resulting from chemical processes acting on bedrock.

• Bedrock. Bedrock outcrops or rock covered by less than 10 cm of unconsolidated material.

• Anthropogenic. Substrate materials built by man or natural materials so affected by human activities that their physical properties, structure, etc., has been profoundly
altered. Commonly used to describe topography and/or surficial material that have been altered as a result of mining.

The mapping and categorizing of surficial materials is a critical first step in the process of conducting a terrain analysis. The next step in the process is interrupting the data in order to access the capability of the land to support a particular type of activity.

**Terrain Constraints**

Using the Terrain Classification System, limitations on the use of a site can be classified either as natural hazards or as land constraints. Natural hazards refer to events that are either impossible, or unfeasible to prevent (e.g. mass movement). Land constraints refer to things that are of concern, but through the proper application of engineering methods they can be overcome (e.g. poor drainage). The main terrain constraints for this site are:

- Frequent flooding
- Occasional or rare flooding
- Potential mass movement and surface erosion
- Gully and bank erosion
- Active mass movement
- Organic deposits
- Potentially poor foundation conditions.

The main areas of concern within the Project Area relate to the series of floodplains that extend along the Telkwa River, Tenas and Goathorn Creeks. Another concern is the scarp slopes
adjacent to these watercourses. These slopes are subject to the effects of mass movement and surface soil erosion. On the upland portions of the site terrain constraints are less of a problem. Here the terrain constraints are mainly problems related to poor surface drainage.

SOCIO-ECONOMIC CONDITIONS

Recreation and Tourism Resources

This section of the site analysis identifies the tourism and recreational opportunities that presently exist within the surrounding Bulkley Valley. A recreation and tourism capability map is enclosed as Appendix V.

Outdoor and adventure recreation is an important contributor to the local economy. These activities include hunting, fishing, hiking, walking, bird and game viewing, downhill and cross-country skiing. The following area attractions and/or annual events are meant to showcase the areas natural scenic beauty.

Area Attractions

- Telkwa High Road: A scenic drive that runs parallel to the Yellowhead Highway between the Village of Telkwa and Moricetown
- Moricetown Falls.
- Hudson Bay Mountain: Summer hiking trails
- Perimeter Trail: All season hiking trail that runs the perimeter of Smithers.
- Community Forest: An interpretive nature trail running through a variety of local habitats.
- Babine Mountain Recreation Area: All season recreational area.
- Ski Smithers: Downhill ski area.
- Tyhee Provincial Park. All season recreational area.
- Aldermere Ridge: Hiking.
- Driftwood Canyon Provincial Park
- Telkwa Barbecue and Demolition Derby

An example of the scenic resources that are available in the area.

Annual Events

- Smithers Mexican Mountain Top Festival.
- Smithers Mid-Summer Festival.
- Smithers Winter Festival.
- Smithers Air Show.
- Pleasant Valley Days.
- Discovery Days.
Social Considerations

The following information pertains to the socio-economic conditions of the people living in the general vicinity of the Project Area. This area extends north to Moricetown and south to Houston.

Moricetown

Estimated population is 1437. Census data from 1991 showed that 26% of the population 15 years and older had less than a Grade 9 education, and only 34% had a post-secondary education. This compares to the provincial average of 87% and 63% respectively. Fishing, forestry and the provision of government are the main sources of employment in the town. Unemployment runs at just over 52%. Water services for the town comes from an infall pipe in the Bulkley River. Sewage is treated in single lagoon. Solid waste is dumped at a local landfill site.

Smithers

Estimated population is 5800. Similar to other resource towns, census data reports that Smithers has a population that is younger than the provincial average. Main industries are retail trade, manufacturing (in support of the wood processing and pulp and paper sector), transportation, and government services. Unemployment rate 9.3%. Three underground wells supply water to the town.
Telkwa

The census of 1991 reported a population of 959. Average age of residents is 35 and the level of education obtained is comparable with the provincial average. Main industries include manufacturing, mining, forestry, agriculture and tourism. The unemployment for the village is 13.7%. Village is serviced by community water and sewer systems.

Houston

The population was 3707 in 1993. The population profile of Houston is similar to that of Smithers. The town is home to some of the largest sawmills in BC. The rate of unemployment is 10.5%. Water is provided by three underground wells. Over half the town is serviced by sewer.

Cultural and Heritage Resource Assessments

Early History

In response to different attempts at developing the Project Area in the early 1980's, a number of industry sponsored historical and cultural assessment studies have been conducted. These studies indicate the existence of a major trade route and trail system that once connected the First Nations peoples living in the Bulkley Valley with communities on the coast. A few artifacts from this period in history have been discovered in an isolated portion of Pit 3.
Coal Mining History

Following the discovery of coal in the area of the project site in the late 1890’s, numerous attempts have been made to exploit this resource. In connection with these earlier mines, four historic sites have been identified in the Project Area. Three of these sites are remnant underground operations and the fourth is possibly an old bridge or mining camp. A heritage resource inventory map is enclosed as Appendix 3 (refer to Historical Resources Map).

LAND MANAGEMENT

Land Ownership

The combined land area required for the Telkwa Coal Project is just over 4630 ha. Of this total, only 46% will be used in direct support of mining operations. The rest of the site will remain undeveloped for reasons of public and worker safety, noise and dust reduction, and to mitigate viewscape impacts.

Currently Manalta Coal Ltd. holds title over only 14% of the required land base. The Crown (55%) and private owners (29%) control the bulk of the land. As development in the Project Area proceeds, private land will be purchased by the company. Crown land is presently limited to supporting the grazing activities of local ranchers.
Land Zoning

Municipal Land Zoning

The Regional District of Bulkley Nechako has zoned the area that encompasses the project site as rural land use with the exceptions of those areas that are part of the Bulkley Forest. The Tenas Pit area falls within the jurisdiction of the Bulkley Forest, as do small portions of Pit 7 & 8, and Pit 3. The area that has been designated for the loadout and access road right-of-way is zoned agricultural.

The Agricultural Land Reserve

Major portions of the Project Area have been included as part of the Agricultural Land Reserve (ALR). Table 4 contains a detailed breakdown of ALR holdings within the Project Area. While the mining of coal is not normally permitted on ALR lands, there are special use permits that can be obtained for this purpose. The required permits are issued on the basis of a government approved reclamation plan. Such a plan requires that the company reclaim the land, where possible, to an equivalent agricultural capability.

<table>
<thead>
<tr>
<th>Project Sub-Area</th>
<th>Total Area (ha)</th>
<th>ALR Lands (ha)</th>
<th>% Project Area in ALR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tenas Area</td>
<td>1368</td>
<td>nil</td>
<td>0</td>
</tr>
<tr>
<td>Pit 3, Main Plant and Tailings Area</td>
<td>1943</td>
<td>660</td>
<td>34%</td>
</tr>
<tr>
<td>Pit 7 &amp; 8</td>
<td>1230</td>
<td>842</td>
<td>68%</td>
</tr>
<tr>
<td>Loadout Area</td>
<td>63</td>
<td>63</td>
<td>100%</td>
</tr>
<tr>
<td>Rights-of-Way</td>
<td>34</td>
<td>32</td>
<td>94%</td>
</tr>
<tr>
<td>Totals</td>
<td>4638</td>
<td>1597</td>
<td>35%</td>
</tr>
</tbody>
</table>
The Bulkley Valley Forest Reserve

The Tenas Pit, and small sections of Pit 3, 7 and 8 are located within the Bulkley Valley Forest Reserve (BVFR). Development activities within the BVFR are subject to prior approval by the BC Ministry of Forests.

The Smithers Community Forest

A 130 ha strip of landing running along the southern perimeter of Pit 7 and 8 falls within the jurisdiction of the Smithers Community Forest (SMF). The SMF maintains several important cross-country ski trails within the region.

The Bulkley Long Range Management Plan

The Bulkley Long Range Management Plan (BLRMP) is intended to provide an integrated approach to resource management in the Bulkley Forest District. The Plan’s authors have divided the District up into discreet management zones. In each zone a set of management directions has been written for the purpose of limiting the negative impacts from development. These management directions range from issues like biodiversity, to preserving visual quality. Major portions of the Project Area fall within some of the proposed BLRMP zones.
Landscape Corridors

The BLRMP has designed certain portions of the Bulkley Valley as landscape corridors for the purpose of:

- maintaining connectivity within the region
- reducing the effects of habitat fragmentation
- permitting the free movement of plant and animal species
- preserving, within the confines of a managed forest, forests that contain the structure, function, microclimate, and biota that are associated with old growth forests.

Portions of Tenas Pit, Pit 3, the loadout area, the mine access road, and the bridge leading to Pit 7 & 8 are located in areas identified as landscape corridors. A map of the landscape corridors both within the site and the surrounding area is enclosed as Appendix 3 (Sensitive Area Network Map).

FIRST NATIONS PEOPLE

First Nations peoples have lived in the area for millennia. The Project Area straddles land that once belonged to several different clan organizations. It is the stated intention of the company to respect these territorial divisions in terms of who will benefit from and participate in the Project.
First Nation peoples have in the past, and continue today to use the land as a major source of food. Preservation of access to traditional hunting and fishing areas, as well as protecting the quality of this habitat are prime concerns of local aboriginal leaders.
APPENDIX III
GIS MAPS OF TELKWA PROJECT AREA

- Elevation Map
- Contour Map
- Slope Map
- Aspect Map
- Watercourses
- Historic Resources Map
- Land Use Map
- Pit Area #3
- Key Observation Points
  - Viewshed Map #1
  - Viewshed Map #2
  - Viewshed Map #3
  - Viewshed Map #4
- Viewshed Map #5 (Regional Points of Interest)
- Views from the Road
  - Viewshed Map #6
  - Viewshed Map #7
  - Viewshed Map #8
- Landscape Flows – People
  - Trail Network
- Landscape Flows – Fish
  - Fisheries Resources Map
- Landscape Flows – Moose
  - Sensitive Area Network
HISTORIC RESOURCES
POINTS

KEY OBSERVATION POINTS

- Minor Roads
- Yellowhead Highway
- Teikwa High Road
- Major Area Roads
- Village Boundary
- Teikwa Area
- Pine Tree Boundary
- Teikwa Project Area
- Major Creeks
- Major Rivers
- Marshall
- Twin Falls
- Teikwa Airport
- Teikwa
- Spruce Camp
- Smithers
- SKI Hill
- Minor Campsite
- Mackey Park
- Key Observation Points
#2
VIEWSHED MAP
NETWORK
SENSITIVE AREA
APPENDIX IV

SOILS AND AGRICULTURAL CAPABILITY MAP
(adapted from Canada Land Inventory - Soils and Agricultural Capability, 1969)

Glacial till, glaciofluvial, colluvial, recent fluvial, and glacio-lucustrine deposits are the main surficial materials in the area. Exposed bedrock and associated colluvium predominate in mountainous regions. Glaciation has modified the landscape, as evidenced by cirques, spur truncation, and U-shaped valley formations.

Well drained clay loam textured glacial till is the dominant soil parent material on which agriculture occurs. Soils vary from Dark Gray Luvisols on dry, exposed lower valley slopes to Bisequa Humo-Ferric Podzols on the more moist upland slopes. Agriculture capabilities vary greatly, ranging from Classes 3 to 7. Smooth, flat lands have been rated Class 3, and lands limited by stoniness and topography have been rated Classes 4 and 5.

Silty and sandy fluvial deposits of recent origin are often imperfectly drained and are commonly found along rivers and streams. Regosolic soils on fluvial deposits have been rated Class 3 where limitations are chiefly climatic, Class 4 where low moisture-holding capacity is the chief limitation, and Class 5 where inundation is an additional limitation. Capability Classes 6 and 7 occur on Gleysolic soils where wetness and inundation are severe limitations.

Dystic Brunisol and Humo-ferric Podzol soils occur on rapidly drained glaciofluvial deposits. They have been rated Classes 4 and 5, with severe limitations of stoniness and low moisture-holding capacity.

Orthic Gray Luvisol soils occur on glaciolacustrine deposits along the lower benches of the Bulkley River. These soils are found in scattered locations and are associated with flat topography. They have a capability rating Class 3, with slight limitations of poor structure and low permeability.

Many mountain valleys are dominated by colluvial deposits. The soils are predominantly Humo-Ferric Podzols, which are associated with Regosols on unstable slopes. These soils are variable in texture depending on type of bedrock, are well to rapidly drained, and are limited by topography, stoniness, and climate. They are rated predominantly Class 7, and a few locations have been rated Class 6.

DESCRIPTIVE LEGEND

The classes are based on intensity, rather than kind, of their limitations for agriculture. Each class includes many kinds of soil, and many of the soils in any class require unlike management and treatment.

Class 1
Soils in this class have no significant limitations in use for crops. These soils are deep, well to imperfectly drained, hold moisture well, and in the virgin state were well supplied with plant nutrients. They can be managed and cropped without difficulty. Under good management they are moderately high to high in productivity for a wide range of field crops.

Class 2
Soils in this class have moderate limitations that restrict the range of crops or require moderate conservation practices. These soils are deep and hold moisture well. The limitations are moderate and the soils can be managed and cropped with little difficulty. Under good management they are moderately high to high in productivity for a fairly wide range of crops.

Class 3
Soils in this class have moderately severe limitations that restrict the range of crops or require special conservation practices. The limitations are more severe than for Class 2 soils. They affect one or more of the following practices: timing and ease of tillage; planting and harvesting; choice of crops; and methods of conservation. Under good management they are fair to moderately high in productivity for a fair range of crops.
Class 4  Soils in this class have severe limitations that restrict the range of crops or require special conservation practices, or both.

Class 5  Soils in this class have very severe limitations that restrict their capability to producing perennial forage crops, and improvement practices are feasible. The limitations are so severe that the soils are not capable of use for sustained production of annual field crops. The soils are capable of producing native or tame species of perennial forage plants, and may be improved by use of farm machinery. The improvement practices may include clearing of bush, cultivation, seeding, fertilizing, or water control.

Class 6  Soils in this class are capable only of producing perennial forage crops, and improvement practices are not feasible. The soils provide some sustained grazing for farm animals, but the limitations are so severe that improvement by use of farm machinery is impractical. The terrain may be unsuitable for use of farm machinery, or the soils may not respond to improvement, or the grazing season may be very short.

Class 7  Soils in this class have no capability for arable culture or permanent pasture. This class also includes rockland, other non-soil areas, and bodies of water too small to show on the map.

O  Organic soils (not placed in capability classes)

SUBCLASSES

Excepting Class 1, the classes are divided into subclasses on the basis of kinds of limitation. The subclasses are as follows:

Subclass C  Adverse climate. The main limitation is low temperature or low or poor distribution of rainfall during the cropping season, or a combination of these.

Subclass D  Undesirable soil structure and/or low permeability. The soils are difficult to till, absorb water slowly or the depth of the rooting zone is restricted.

Subclass I  Inundation. Flooding by streams or lakes limits agricultural use.

Subclass M  Moisture. A low moisture holding capacity, caused by adverse inherent soil characteristics, limits crop growth.

Subclass P  Stoniness. Stones interfere with tillage, planting, and harvesting.

Subclass R  Shallowness to solid bedrock. Solid bedrock is less than a meter from the surface.

Subclass T  Adverse topography. Either steepness or the pattern of slopes limits agricultural use.

Subclass W  Excess water. Excess water other than from flooding limits use for agriculture. The excess water may be due to poor drainage, a high water table, seepage or runoff from surrounding areas.

Subclass X  Minor cumulative limitations. Soils having a moderate limitation due to the cumulative effect of two or more adverse characteristics which individually would not affect the class rating.

CONVENTIONS

Large arabic numerals denote capability classes.
Small arabic numerals placed after a class numeral give the approximate proportion of the class out of a total of 10.
Letters placed after the class numerals denote the subclasses, i.e., limitations.
EXAMPLES

An area of Class 4 land with topography and stoniness limitations is shown thus:

An area of Class 2 with topographic limitation, and Class 4 with stoniness limitation, in the proportions of 7:3 is shown thus:
APPENDIX V

RECREATION AND TOURISM CAPABILITY MAP
(adapted from Canada Land Inventory - Ability for Recreation 1968)

There are three large lakes in the Smithers map area; Morice, Francois, and Babine; the latter is the largest natural inland water body wholly contained in British Columbia. Sand and gravel beaches can be found on all lakes, but cold summer water temperatures severely limit family bathing.

Glacial till and rocky shores predominate. Scenic viewing, fishing, and boating are the most important aspects of Morice Lake with its distinctive blue glacial cast. Cottaging, picnicking, boating, fishing, and camping capabilities are found principally at Francois and Babine lakes. The latter’s large size, variable shoreline and frequently protected bays and islands make it particularly suitable for pleasure cruising.

The rivers within the Smithers area are its most important recreation feature. Their banks are suitable for camping, picnicking, and collecting of rocks and fossils. Viewing opportunities from valleys that penetrate the Hazelton Mountains are frequent and rewarding. A number of streams within a pastoral setting, background mountains, and small glaciers combine to make Smithers and the Bulkley Valley an outstanding scenic area for recreational travel.

DESCRIPTIVE LEGEND

<table>
<thead>
<tr>
<th>Class</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class 1</td>
<td>Lands of this class have very high capability for outdoor recreation. Class 1 lands have natural capability to engender and sustain very high total annual use based on one or more recreational activities of an intensive nature. Class 1 land units should be able to generate and sustain a level of use comparable to that evident at an outstanding and large bathing beach or a nationally known ski slope.</td>
</tr>
<tr>
<td>Class 2</td>
<td>Lands in this class have a high capability for outdoor recreation. Class 2 lands have natural capability to engender and sustain high total annual use based on one or more recreational activities of an intensive nature.</td>
</tr>
<tr>
<td>Class 3</td>
<td>Lands in this class have a moderately high capability for outdoor recreation. Class 3 lands have natural capability to engender and sustain moderately high total annual use based usually on intensive or moderately intensive activities.</td>
</tr>
<tr>
<td>Class 4</td>
<td>Lands in this class have moderate capability for outdoor recreation. Class 4 lands have natural capability to engender and sustain moderate total annual use based usually on dispersed activities.</td>
</tr>
<tr>
<td>Class 5</td>
<td>Lands in this class have moderately low capability for outdoor recreation. Class 5 lands have natural capability to engender and sustain moderately low total annual use based on dispersed activities.</td>
</tr>
<tr>
<td>Class 6</td>
<td>Lands in this class have low capability for outdoor recreation. Class 6 lands lack the naturally quality and significant features to rate higher, but have the natural capability to engender and sustain low total annual use based on dispersed activities.</td>
</tr>
<tr>
<td>Class 7</td>
<td>Lands in this class have very low capability for outdoor recreation. Class 7 lands have practically no capability for any popular types of recreation activity, but there may be some capability for very specialized activities with recreation aspects, or they may simply provide open space.</td>
</tr>
</tbody>
</table>
SUBCLASSES

Subclasses indicate the kinds of features which provide opportunity for recreation. They are, therefore, positive aspects of land and do not indicate limitations to use.

The subclasses are:

Subclass A  Land providing access to water affording opportunity for angling or viewing of sport fish.
Subclass B  Shoreland capable of supporting family beach activities. In high class units this will include family bathing. In Class 4 and 5, the activities may be confined to dry land due to cold water or other limitations.
Subclass C  Land fronting on and providing direct access to waterways with significant capability for canoe tripping.
Subclass E  Land with vegetation possessing recreational value.
Subclass F  Waterfall or rapids.
Subclass G  Significant glacier view or experience.
Subclass J  Area offering particular opportunities for gathering and collecting items of popular interest.
Subclass K  Shoreland or upland suited to organized camping, usually associated with other features.
Subclass L  Interesting landform features other than rock formations.
Subclass M  Frequent small water bodies or continuous streams occurring in upland area.
Subclass N  Land (usually shoreland) suited to family or other recreation lodging use.
Subclass O  Land affording opportunity for viewing of upland wildlife.
Subclass P  Areas exhibiting cultural landscape patterns of agricultural, industrial or social interest.
Subclass Q  Areas exhibiting variety, in topography or land and water relationships, which enhances opportunities for general outdoor recreation such as hiking and nature study or for aesthetic appreciation of the area.
Subclass R  Interesting rock formations.
Subclass S  A combination of slopes, snow conditions and climate providing downhill skiing opportunities.
Subclass U  Shoreland fronting water accommodating yachting or deep water boating opportunities.
Subclass V  A vantage point or area which offers a superior view relative to the class of the unit(s) which contain it, or a corridor or other area which provides frequent viewing opportunities.
Subclass W  Land affording opportunity for viewing of wetland wildlife.
Subclass Y  Shoreland providing access to water suitable for popular forms of family boating.
Subclass Z  Areas exhibiting major, permanent, non-urban man-made structures of recreational interest.

CONVENTIONS

Large arabic numerals denote capability classes.
Upper case letters denote subclasses.

EXAMPLE

An area of Class 1 shoreland with very high capability to generate intensive family bathing and beach activities, fronting and providing access to a water body suited to family boating, and with a backshore suited to organized camping is shown thus:
APPENDIX VI

GENERAL METHODS OF RECLAMATION
FOR INCREASED BIODIVERSITY
(Adapted from Green 1987 and Nener et al. 1997)

1. CONCEPTS OF HABITAT RECLAMATION

Basic Needs of Wildlife
These needs are food, water, cover, and space on a seasonal or year-round basis.

Habitat Diversity and Edge
Habitat diversity is a goal of ecosystem reclamation.
Edge/border areas provide important sources of cover, food and water.
Maximize diversity for wildlife through changes to landforms, bodies of water, and vegetation.

Select Key Indicator Species
Should be native to region.
Should be representative of other desired wildlife species in the area.

2. DEVELOPING & ENHANCING WATER BODIES

A. Watercourses
Construction and enhancement of watercourses for habitat should consider the following:
1. Proper location and design of the watercourse.
   • Placement of the watercourse is determined primarily by landform.
   • Design of the watercourse should allow for shallow gradients, sinuous channels, pools, riffles, oxbow lakes and wetlands.

2. Methods for stabilizing and enhancing the stream bank. Following their construction, stream banks are susceptible to erosion and therefore need to be stabilized using natural vegetation and/or inert materials. Examples of these materials include:
   • Rip-rap
   • Gabions
   • Wood cribbing
   • Erosion fabrics
   • Plant material

B. Lakes and Ponds
Highly productive water bodies are characterized by the following:
1. Placement of the pond should allow for water losses to be naturally replaced.
   Ideally there should be at least one feeding and one outlet stream.
2. Depth of water should be >3 m for between 25 - 75% of the waterbody.
3. The amount of open water should be > 80% of total ponded surface area.
4. Bottom contours should be of irregular design to promote a diversity of bottom types. These types should include:
   - Gradually sloping (11-22%) shoreline shelves with depths between 0.5 - 1.5 m. Variations in depth will encourage greater vegetative diversity along the shoreline.
   - Steeply sloping (44 - 67%) shoreline areas to limit vegetative growth and facilitate deep water access.

5. To add habitat value and decrease erosion, shorelines should be designed to be irregular in form.

C. Wetlands

Wetlands are generally defined as small bodies of water whose average depth is < 1.5 m over 80% of its area. Wetlands are important for habitat restoration because they provide a ready source of water for plants and animals, recharge ground water supplies, provide edge habitat, and have the potential to treat certain types of water-borne pollutants. When creating wetlands the following factors should be considered:

1. Location.
   - Areas where periodic flash flooding occurs should be avoided.
   - Areas where annual recharging of wetlands occurs.
   - Areas that allow for partial drainage to occur over a period of 3 - 10 years. This will permit for the exposed area to reseed itself as well as promote the rapid decomposition of built-up organic matter.

2. Size.
   - Minimum recommended area is 0.2 ha. Preferred area is between 0.4 - 2.0 ha.
   - In the case of larger wetland areas, designers should include the provision of islands and complex shoreline forms to increase its wildlife value.

3. Substrate.
   - Bottoms should be composed of impervious materials to minimize water losses due to infiltration.
   - Topsoil (20 cm) and mulch (2 cm) should be added to support initial establishment of plant material on newly constructed wetlands. When possible soils from wetlands slated for destruction should be salvaged for use in constructed wetlands.

4. Water Depth.
   - Typical depth of water of between 0.5 - 1.5 m. Water >1.5 m should be limited to < 20% of total wetland area.
   - Optimal habitat value occurs when there is a 50:50 mix of open water to vegetative areas, and when depth of water is highly variable.

5. Bottom Contours.
   - Side and bottom slopes should range between 11 - 22%.
   - Side slopes in deep water portions of the wetland should range between 44 - 67%.
• Design should attempt to include irregularities to increase variability between shoreline, shallows, and areas of deep water.

6. Shoreline Shape.
   • Irregular shorelines are preferred.
   • Where possible attempts should be made to include peninsulas, bays, shoals and islands into the design.

D. Riparian Areas
Riparian areas are identified as the ribbon of land located along lakes, rivers, streams, and wetlands. Their importance to the health of local ecosystems can be summarized as follows:
1. They support a diversity of plant species which in turn translates into habitat for a diverse range of wildlife.
2. They provide a buffer area between watercourses and the surrounding uplands. In this way they help sustain healthy aquatic habitat by stabilizing banks from the effects of water erosion.
3. Riparian areas provide important physical links that connect otherwise dispersed habitat areas.
4. Riparian vegetation acts to trap the overland flow of sediments before they can reach local streams.
5. Overhanging trees, shrubs, and large woody debris provide shelter and cover for aquatic organisms.
6. Overhanging trees and shrubs provide protection from the sun. Certain species of fish such as salmon and trout are particularly vulnerable to the effects of increased water temperature.
7. Riparian vegetation and the animal life that feeds off them are important components of the food chain for higher order animals.

E. Island Development
Islands can provide important sources edge habitat for nesting birds, as well as adding to the aesthetic value of the water body. Some important considerations for the design of islands include:
1. Location.
   • Placement of islands should be between 20 - 50 m from shoreline and a minimum of 100 m apart. Depth of water should vary between 0.3 - 1 m in depth.
   • Islands should be sited in areas protected from the effects of prevailing winds.
   • Emergent vegetation should be planted around island parameter to protect against the erosive effects of wave action.
2. Size.
   • Islands > 100 m are sufficient to suit the habitat needs of most waterfowl.
   • Preferable to have many smaller islands rather than one large island for water bodies > 20 ha.
3. Substrate.
   • Any stable fill material will suffice.
   • To facilitate vegetative growth, a layer of topsoil to a depth of 20 - 40 cm should be placed on top of fill.
To attract waterfowl, vegetation should include grasses and low shrubs. Trees should be avoided as they attract raptors.

4. Shape.
- As a general rule, the larger the island the more complex its shape.
- The top of islands should be flat, and average 1 m above the spring high water line. The sides of the island should slope to the water < 45%.

3. BIOENGINEERING

Bioengineering involves the use of live plant materials as a means to achieve slope stabilization through a combination of engineering practice and ecological principles. While bioengineering has been around for centuries, interest in the technique has recently undergone a resurgence as people look for alternatives to traditional engineered solutions. The prime advantages of bioengineering is that it is aesthetically pleasing, environmental friendly, inexpensive to build and maintain, and it is self-sustaining (Johnston et al. 1995). Some of the basic design principles of bioengineering include:

- The application of live plant material for the purpose of controlling soil erosion.
- The reliance upon local plant material as a means to increase biological diversity.
- Harvesting native soil to ensure that soil organisms and seed stock are compatible with the local climate.
- Trees removed from other construction operations should be reused, either as tree stock or as components of revetment structures.

Table 1 has been included to demonstrate the versatility of bioengineering methods to respond to many different soil and site conditions.
Table 1 - Bioengineering Methods Based on Differing Soil and Site Conditions (adapted from Sotir 1999)

<table>
<thead>
<tr>
<th>Factor or Failure Process</th>
<th>Soil Condition</th>
<th>Intensity of Type of Condition</th>
<th>Soil Bioengineering Methods</th>
<th>Live Slope Grading</th>
<th>Vegetated Geogrid</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Live</td>
<td>Fascine</td>
<td>Brush-layer</td>
<td>Branch-packing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Staking</td>
<td>N/A</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Slope Gradient</td>
<td>High</td>
<td>N/A</td>
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It is clear from Table 1 that bioengineering methods, when properly matched to the specific demands of the site, can effectively address issues of slope stabilization. In addition, however, bioengineering methods also offer the added benefit of providing strong aesthetic and habitat values. When compared to traditional engineered solutions involving concrete, broken rock, and/or corrugated metal, bioengineered solutions perform the same functions but rely instead on the use of woody plant material. Once established, these plants provide both habitat value as well as hastening the visual reintegration of the site with the surrounding environment. Table 2 compares the habitat and aesthetic values associated with different bioengineering methods.
Table 2 - Bioengineering Methods Rated Against Aesthetic and Ecological Goals (adapted from Sotir 1999)

<table>
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<th>Goals and Benefits</th>
<th>Live Staking</th>
<th>Live Fascine</th>
<th>Branch-packing</th>
<th>Live Cribwall</th>
<th>Live Slope Grating</th>
<th>Vegetated Geogrid</th>
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<td>Wildlife Habitat</td>
<td>Negligible to Very Good</td>
<td>Good to Excellent</td>
<td>Fair to Good</td>
<td>Fair to Good</td>
<td>Good to Very Good</td>
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<tr>
<td>Aesthetic Values</td>
<td>Good to Very Good</td>
<td>Good to Very Good</td>
<td>Fair to Good</td>
<td>Fair to Good</td>
<td>Very Good</td>
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</tr>
</tbody>
</table>

Soil Bioengineering Methods
APPENDIX VII

DESIGN DRAWINGS FOR RECLAMATION OF PIT #3