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The Use of CIS in Environmental Planning

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ABSTRACT

Coalmine reclamation is a major component of mine planning. Reclamation planning of a mine starts at the inventory phase, where biophysical data from pre-disturbance surveys must be collected. Much of this data can be collected from satellite imagery, digital orthophotos, topographic maps, ground data collection as well as existing digital data provided by the related Provincial and Federal Government Ministries. Once this data is collected all of the data can utilized in a Geographic Information System to map the data as well as relate the database information to the spatial data and use this as the base for recording and analyzing pre-disturbance levels, biophysical information, reclamation objectives, monitoring successes, current status of the disturbed areas and to predict future responses.

The use of CIS in reclamation planning allows for quick, accurate, and precise management of data. CIS allows quicker and more convenient summaries of quantifiable data thus improving efficiency in appraising present plans to determine if they will meet with regulations and required reclamation standards (e.g. required amount of wildlife habitat to be replaced, areas, distances, etc.) The process of mining is not a single disturbance event; it encompasses an on-going disturbance of land necessitating the use of an on-going management. Updates to a CIS database can be accomplished quickly and accurately. Multiple scenario modelling can be undertaken by making small changes to the CIS model (e.g. a CIS model allows manipulation of data and what-if scenarios quicker, cheaper, and with less environmental disturbance than trials on real land). The ability to run predictive scenarios will also make it possible to plan ahead which is the most pro-active technique that can be done. Modelling can help support theories or plans for reclamation work before the work has actually started on the reclamation - i.e. an actual working model of a proposed reclamation plan will be accepted by government and public much easier than a plan that has only literature to back it up. A considerable reduction in reclamation costs may be noticed from enhanced pre-planning of reclamation and decreased uncertainty in the planning procedure.

INTRODUCTION

Geographic Information Systems - General Overview

In his book, *CIS: a Management Perspective,* author Stan Aronoff states "Geographic Information Systems are computer-based systems that are used to store and manipulate geographic information. This technology has developed so rapidly over the past two decades that it is now accepted as an essential tool for the effective use of geographic information." From its beginnings in the late 1960's to the present date, CIS technology has advanced in leaps and bounds and has, by and large, "crossed the chasm" and become mainstream technology. Even the novice user can now quickly

and easily perform mapping and analytic tasks that were previously done using manual methods. The range of available analytic complexity has been vastly increased by the use of CIS, and continues to grow as the technology matures, thus enabling the use of GIS in more diverse application areas. Unlike simpler CAD systems that mimic human engineering and design processes, CIS software packages attempt to model the more complex natural world.

Although a usable technical definition of CIS has escaped all who've tried, simply put, CIS is a tool designed "for the collection, storage, and analysis of objects and phenomena where geographic location is an important characteristic or critical to the analysis." A CIS integrates satellite data, aerial photographs, digital maps, and other data that can be linked to a location to analyze relationships and identify spatial patterns. Impediments to the early use of CIS - lack of digital data, complexity, and high cost - have largely disappeared, as more and more digital data is available. As social, geographical, environmental and natural resource issues increase, the need for a powerful tool for analyzing the inter-related systems involved in these types of problems increases. Geography deeply influences almost every decision we make, and CIS is changing the way we see and use geographic information. We need to answer which options would affect what areas in what ways, and what issues are tied to what areas. CIS helps examine spatial relationships between issues and options so we can fully understand the impacts.

The use of CIS in the natural resources and environmental application areas is long-standing. Governments and private companies involved in natural resources and environmental management were among the first users of CIS and other related technologies (such as remote sensing and global positioning systems). However, while CIS has been around for more than 30 years, it has yet to be accepted as a useful tool in the mining industry, despite its seemingly ideal fit. As the technology becomes easier to use and more mainstream, it is anticipated that more mining companies will use CIS, particularly in their reclamation efforts.

Reclamation - General Overview

Reclamation is the combined process of land treatment that minimizes water degradation, air pollution, damage to aquatic or wildlife habitat, flooding, erosion, and other adverse effects from

surface mining operations, including adverse surface effects incidental to underground mines, so that mined lands are reclaimed to a usable condition which is readily adaptable for alternate land uses and create no danger to public health or safety. The process may extend to affected lands surrounding mined lands, and may require backfilling, grading, resoiling, revegetation, soil compaction, stabilization, or other measures. The main environmental impacts of, for example, coal mining are surface disturbance and disposal of mining wastes.

Land reclamation can lead to habitat restoration when the intent of the reclamation project is to restore native vegetation and recreate wildlife habitat reflecting the biodiversity of the region. This goal can only be achieved when the natural processes required for a self-sustainable ecosystem are also restored to the reclaimed site. Mining reclamation plans frequently contain provisions for restoring native vegetation and wildlife habitat on part or all of the reclaimed site.

Largely in response to public concerns over the effects of mining on the environment, legislation has been enacted at both the Federal and Provincial level in Canada. The federal legislation consists of quality standards enforced on fisheries, air and water, which provide a framework for provincial agencies to base reclamation standards.

All mines are required to carry out programs of environmental protection and at closure, reclaim the land and watercourses to a condition equal to or better than existed before disturbance. Regulation is achieved through a permit system including company submission of mine plans, acid rock drainage management plans, and reclamation plans; review by an interagency committee of government; security bonding; inspections; and annual reporting and review.

Implementation of the Forest Practices Code of British Columbia Act also has significant implications for the mining industry, as protection of forest resources is given a very high profile. Primary concerns for the mining industry are ensuring that appropriate authorization is in place before felling trees, constructing, maintaining and deactivating roads and access trails to high standards, and conserving soil.

At the beginning of a mine's life, the ultimate reclaimed land use objective is set out, and the proposed Reclamation Plan is put before a regional multi-agency review. Reviewing agencies can

include the BC Ministry's of Environment, Lands and Parks, Forests, and Employment and Investment, as well as the Federal Government agencies Natural Resources Canada and Department of Fisheries and Oceans. The stated end land-use objective would be accepted or rejected based on the results of the review. In the early days of coal mining in British Columbia there was a lot of concern over displacement of wildlife due to changing habitat. A major goal of reclamation is to reduce that. Since then things have changed, and forestry as an objective is also common. Of course, the end reclamation objectives vary depending on the original state of the undisturbed land. The reclamation results themselves are the subject of many topical debates - what does productivity mean? - how do you know when you've achieved your objective?

RECLAMATION AND GIS

Reclamation of disturbed lands is a critical, on-going part of the operation of an open-pit coalmine. Reclamation includes a range of activities ranging from the collection and compilation of large amounts of geographical data from a range of sources, through the building of an spatial environmental dataset, to analyzing and reporting upon the data collected and mine activities. Government legislation and regulations governing mining activities mandate much of the analysis and monitoring, and maps and reports are produced to accompany this analysis.

Mine reclamation at Line Creek focuses on returning a habitat for both wildlife and vegetation that resembles, as closely as possible, the land's pre-disturbance state. In order to accomplish this, data must be kept and managed that describes the land base prior to mining, and that reflects current land disturbance throughout the life of the mine.

CIS can be a laborsaving tool for analyzing land-data and presenting the types of results required during on-going reclamation processes. The accuracy, speed, and quality of this analysis and output will be increased through the effective use of a CIS. To describe the types of analyses performed in support of reclamation, one can generally say that the state of the land before mining activities is compared to the state of the land during and after disturbance, and graphical, tabular, and statistical output is generated to illustrate this change. These output can then be used for planning the mine's reclamation activities. In addition to collecting and using the data strictly for reclamation purposes,

the flexibility of a digital data base means that the information can be used for other purposes, such as avalanche prediction and monitoring, forest-land management around the mine site, and mine-site planning.

DATA

Baseline Biophysical Data

Biophysical data was collected during Environmental Impact Assessments (EIA) at the time that the mine was originally proposed and planned. This data includes inventory information describing various wildlife and vegetation habitats at the mine site and in the area surrounding the mine. Among this information are maps showing areas of fisheries importance, sensitive fluvial and terrain areas, and wildlife habitat eco-regions that highlight and classify winter and summer ranges of elk, goats, mule deer, whitetail deer, moose, and sheep. Also included are specific features such as migration routes, mineral licks, important 'habitat requisites' and traditional ungulate crossings. These data attempt to portray the pre-disturbance habitat of the mine site and the area surrounding the mine upon which mine activity will have indirect or direct impact. The pre-disturbance vegetation has also been inventoried. The result of this data compilation is a comprehensive data set that includes habitat inventories, and bio-physical data that is pertinent to the presence and re-creation of the wildlife habitat.

Operational Data

In addition to the broader, baseline information required to define reclamation goals, the CIS includes a number of operational data layers that describe in detail the mine area and disturbance. These maps are updated frequently to reflect: current mine activity.

- original ground, including 3M contour lines
- present pits
- present dumps
- 'reclaimed to date'
- yearly reclamation
- yearly flat
- yearly re-sloping
- roads
- ponds

Supplementary Data

There are a variety of data that can be accessed through public and private sources, or which can be derived from information collected for other processes. Most provinces in Canada have undergone significant digital data-collection initiatives resulting in a supply of data including cadastral and land-ownership information, hydrographie data, and infrastructure data detailing roads and other man-made features. Also common are datasets compiled by organizations such as the British Columbia Ministry of Forests which delineate and provide information on forest cover, or the BC Ministry of Environment, Lands, and Parks thematic mapping exercises which contain baseline land-use information. Private companies, such as forest lessees, may be a source of digital land-use data.

The BC MOELP 'TRIM' (Terrain Resource Information Management) files, collected at 1:20,000 scale, were purchased and incorporated into the Line Creek dataset to provide entire study area elevation and base map data. The Line Creek mine plans included 3 metre contour lines, which were used to derive additional information in the CIS. Using PAMAP GIS's 3-D modelling capabilities a 'Digital Elevation Model' (DEM), a slope map, and an aspect map were produced. One of the key advantages of using a CIS is the availability of functions that automatically produce new, and required data - such as the slope cover - from existing data, in this case a set of contour lines.

ANALYSIS

The production of Annual Reclamation Reports reviews the degrees to which the overall reclamation objectives are being met require that the mine disturbance be analyzed in comparison to baseline bio-physical data. In Line Creek's case, the establishment of year-round habitat ranges for Elk and Moose in lower elevations and spring through fall habitat for Bighorn Sheep in the upper elevations form the reclamation objective. Secondary objectives include rehabilitation simulating the surrounding topographic features, geo-technical stability, and pleasing aesthetic qualities. Virtually all of the reporting produced for the Annual Reclamation Reports can be quickly and easily generated using the CIS. In addition, the level of effort required for producing the information using the CIS means that the progress of reclamation can be summarized more frequently if required at little additional cost.

PAMAP CIS provides a comprehensive suite of tools that are used in producing information for supporting the Environmental Department's decision making, and in generating summary information and maps for presentation in an Annual Reclamation Report. Some of this summary information and the techniques by which they were generated are discussed below.

Generation of Summary Statistics

The entire mine site has been planned and mapped for operational planning purposes using Line Creek's existing Computer Assisted Drafting (CAD) system. This provides detailed, high-accuracy information about the present state of the mine. The data was imported into the CIS via DXF, an industry-standard format, and converted into a *polygon cover.* A polygon cover, in PAMAP CIS, contains discrete, homogeneous areas with associated attribute information contained in a database. Each polygon, representing an individual area such as a dump, has an automatically generated area (measured in hectares) and perimeter (measured in metres), as well as descriptive information such as the age of the dump, the type of habitat, and other user-definable data. Additional polygon covers in the map contained the baseline habitat information, and historic disturbance information (each year's mine plan forms a separate polygon cover, so the change between years can be evaluated). Using the 3 metre contours, secondary information describing the terrain was produced: a digital elevation model, which is a continuous surface cover containing elevation information about every point in the terrain, a cover indicating the slope of each point in the map, and a cover indicating the aspect of the slope (i.e. The compass direction in which the slope faces).

Using the information in one or more level in the map, summary information can be generated. Three such scenarios are discussed here:

1. Change in reclamation areas between years

By 'overlaying' the mine plan polygon covers for different years, a new map can be created showing thematic information such as how much previously reclaimed area has been affected by this year's mining activities.

2. Report on the amount and percentage of given habitat that has been affected by mine disturbance and reclamation activities.

By overlaying the mine plan on baseline data, summary statistics and maps showing the following can be generated:

- the percentage and total amount of habitat that has been affected by mine disturbance for a given year's activities and for the total mine area. This was repeated for each of the habitat ranges forming the reclamation goals.
- Using the information generated in Step 1 (above), the change in habitat between years can be calculated.

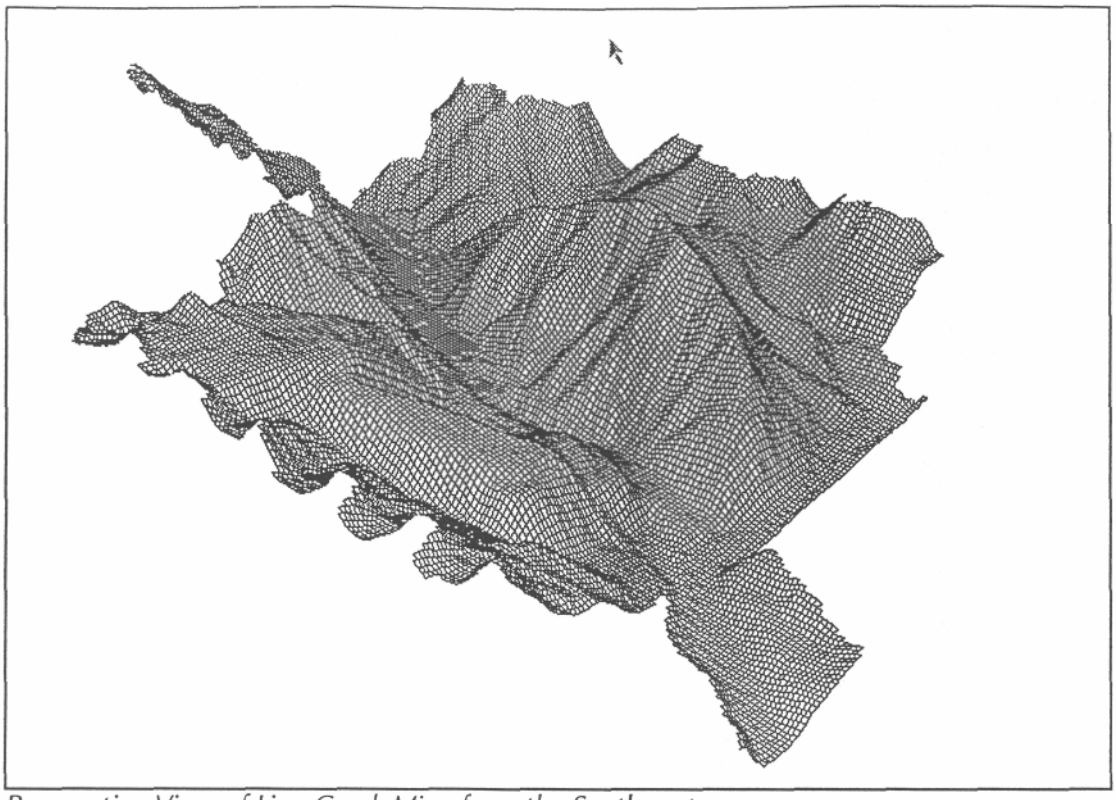
Future Applications

One of the advantages of holding complex land information in a CIS is the ability to use that data for a number of applications that may not be evident or planned for at the time the data is collected, but which may easily be done at a later stage. In the case of the Line Creek mine, a number of potential applications were exposed:

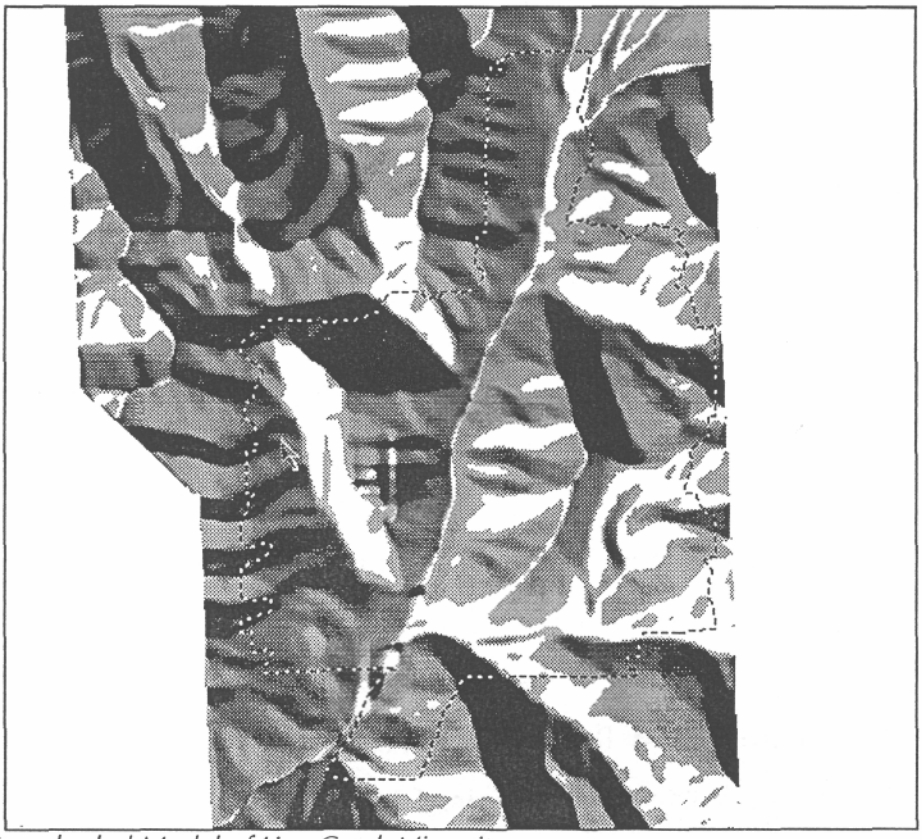
- **Site planning:** using the CIS a map can easily be prepared which would show locations for future site features. For instance, if a new tipple was required, parameters such as 'must be at least 100ha in size and on a slope between O and 10%' could be fed the CIS and a map showing potential sites would be generated.
- **Avalanche potential:** because the system allowed a slope map to be generated, potential avalanche sites could be predicted.
- **Forest management:** the harvestable timber available on the mine site can be monitored and managed using the CIS.
- **Viewscape Modelling:** using the CIS and the 3-D data, 'perspective views' showing what a piece of terrain would look like from given viewpoints. The visual impacts of new mine pits or the land following reclamation can be estimated. The software can also simulate a live 'fly-through' of the terrain.

SUMMARY

Increasing legislative and public pressures on natural resource companies are necessitating the use of CIS technology. The ability to analyze and forecast reclamation processes, to generate visability models, to model and predict environmental problems before they occur, are available through the power of CIS. In the case of Line Creek Mine, the CIS will significantly reduce the time required to generate annual and site-specific Reclamation Plans, and will aid in day to day activities.



Perspective View of Line Creek Mine from the Southwest



Sun-shaded Model of Line Creek Mine site

Sensitive Area model of Line Creek Mine site

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