# MINE DEVELOPMENT: AN INTEGRATED APPROACH

by Malcolm K. Ross and W. Stuart Hunter

Good morning ladies and.gentlemen.

When Jim Lant, your persudsive program chairman, invited Malcolm and I to present a paper to you today, we accepted with the proviso that we would not restrict the paper to a particular facet of reclamation. Rather we would like to describe, as an example, reclamation as a single facet of overall mine development and operations.

Before defining the framework and objectives of the integrated approach to development, I would like to illustrate the evolution of project planning as we see it in Crows Nest. I must admit that the concept of the various stages of evolution and the "bubble" diagrams (which you will see) did not originate with us. Credit is due to Bert Webber of the Western Washington State University who has included them in a soon-to-be-published book on coal transportation. However, I have modified and added to the titles in the bubbles to reflect my understanding and, perhaps, biases (Figure I).

Stage I, then, describes the structure of project planning up to around the 1950's and early sixties. This stage could be equally well characterized by reversing the order of the "bubbles." It is also significant that this era was one in which large projects of a more political nature were committed for motives of national prestige, sometimes only having a tenuous link to economics, markets or the technical disciplines.

Stage II developed during the 1960's, partially due to the need to more efficiently manage the megaprojects.

As a result of the impacts of large projects specifically and the developed nation's increasing industrial activities, concern for the environment did begin to factor in project planning by the early 1970's but still more as a cosmetic afterthought and usually in operations (Stage III).

Stage IV (Figure 2) shows the process in vogue during the late 1970's, with the addition of public involvement reflecting increasing public pressure to have some say in projects impinging on their lifestyle. However, the process is still sequential. Lastly, Stage V represents the process towards which we are evolving in the 1980's with all components fully integrated from the earliest stages of the development process.

The interlocking of the three bubbles also implies that the project group is an interdisciplinary team of specialists who understand and "buy-in" to the concept of integrated mine development.

This team must serve two masters. The first is the company executive who must be convinced that, in the uncertain world of mining and selling coal, the project is soundly conceived and that future risks have been sufficiently accounted for to provide the degree of confidence that a decision can be made.

The second master is government who must also have sufficient information to assess the project and decide whether or not, on the basis of aggregate benefits and costs, society in general will benefit if the project proceeds.

Integrated development planning, then, is the task of identifying, measuring and understanding <u>all</u> of the resources, their constraints and interdependences. The objectives are to provide a rational and consistent framework for decision making and, in the successful cases, a basis for ongoing operational design.

Reclamation, incorporating elements of environment, engineering, geology, economics and public perceptions as to end use is an excellent example of how this approach works in practice. So I'll turn the presentation over to Malcolm Ross who will describe reclamation planning and activities which CNRL has carried out to date at our

Telkwa property near Smithers.

The concept of integrated development has been explained. Implicit in this concept is an understanding and committment by all members of the Planning and Development Team that they are coal miners. I am a coal miner with particular disciplinary skills which enable me to supervise, on behalf of the company, those aspects of coal mine development which are environmental in nature. This does not diminish my committment to the environment. On the contrary, it ensures that environmental matters are fully accounted for.

Let us then consider, as a practical example of integrated development, part of the 1983 development program on Crows Nest Resources Limited's Telkwa property. Since exploration commenced on this property in 1979, the successful reclamation of roads, trenches and drill sites has been well-documented, and considerable practical reclamation experience has been gained as a result. The development program included a bulk sample component as well as conventional exploration, environmental and socio-economic studies and community liaison. In the bulk sample sub-program, multi-seam coal samples were taken from two test pits which were excavated in a cleared area approximately 1,000 x 70 m.

The objectives of this program were to obtain coal samples for analyses for essential data on processing and utilization, and to maximize operational information on geology, mining and reclamation. This, as indicated earlier, will contribute to a more accurate assessment of conditions and facilitate more efficient planning of the proposed coal mine.

The area was cleared in June of 1983 and the predominently poplar vegetation cover removed. Topsoil from the cleared area was then removed and stockpiled. The decision to proceed with the two pit configuration instead of one large pit was made as a result of the structure of the sub-crop and as a method of reducing the overall surface disturbance and consequential cost reduction. The smaller, shallower east pit and the larger west pit were excavated sequentially from east to the west.

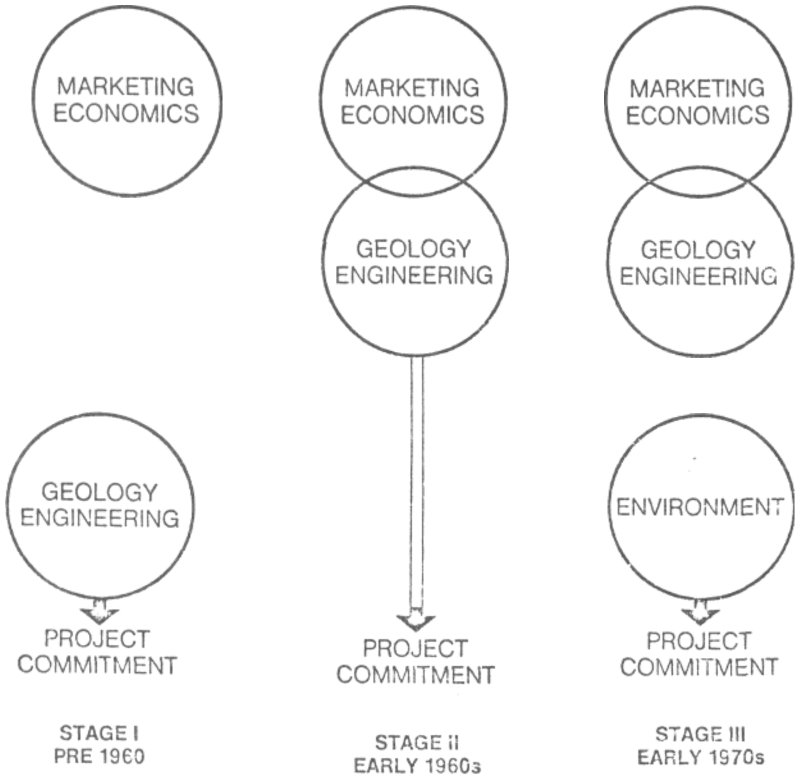
Not all of the initial objectives of the program were able to be met. For example, in keeping with Crows Nest Resources Limited's desire to maximize operational information from the bulk sample pit, it had been proposed to leave part of a pit open for a predetermined period of time to determine the geotechnical stability of the highwall. This was contingent on the highwall being suitable for such studies. This did not eventuate, and both pits were completely backfilled following coal removal. Poor weather conditions enabled an assessment of equipment capability under all conditions. While the pits were open, every opportunity was taken to collect operational information. The waste materials produced from such a bulk sample extraction are similar to those which would be produced during actual mining. Information was collected on the swell factor of overburden materials, and samples were taken at intervals along the pit walls for chemical characterization. Channel samples also were taken from the footwall and hanging wall of each seam. These latter samples in particular were collected for analyses for potential acid mine water production. Pit water was pumped to a settling pond and sampled for quality.

Coal samples were taken sequentially from the higher to the lower seams and sampling was followed by progressive backfilling. The deeper west pit was still open when the shallower east pit had been backfilled. Backfilling of the west pit then commenced from the eastern end. At the eastern end of the western, deeper pit, that is, roughly in the centre of the bulk sample site, the backfilled spoil was levelled at approximately I meter below the original surface level. This area, 12Om x 20 m, was used as the location to construct a series of replicated treatments investigating the growth capabilities of various combinations of spoil and overburden material (Figure 3).

These investigations were designed to <u>contribute</u> to the development of the most appropriate materials-handling methods to

**Figure I**

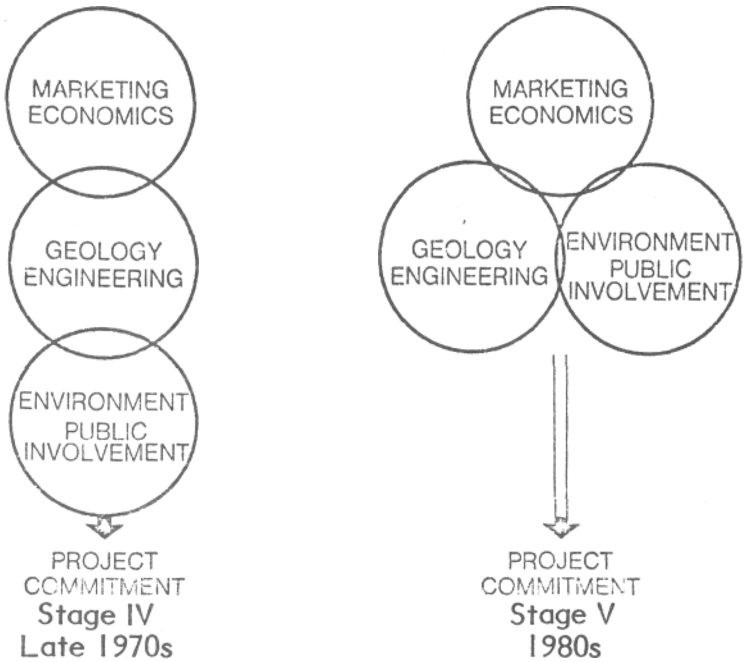
EVOLUTION OF INTEGRATED DEVELOPMENT PLANNING




Source: Webber et al.

**Figure 2**

EVOLUTION OF INTEGRATED DEVELOPMENT PLANNING




Source: Webber et al.

Figure 3

TELKWA RECLAMATION PLOTS

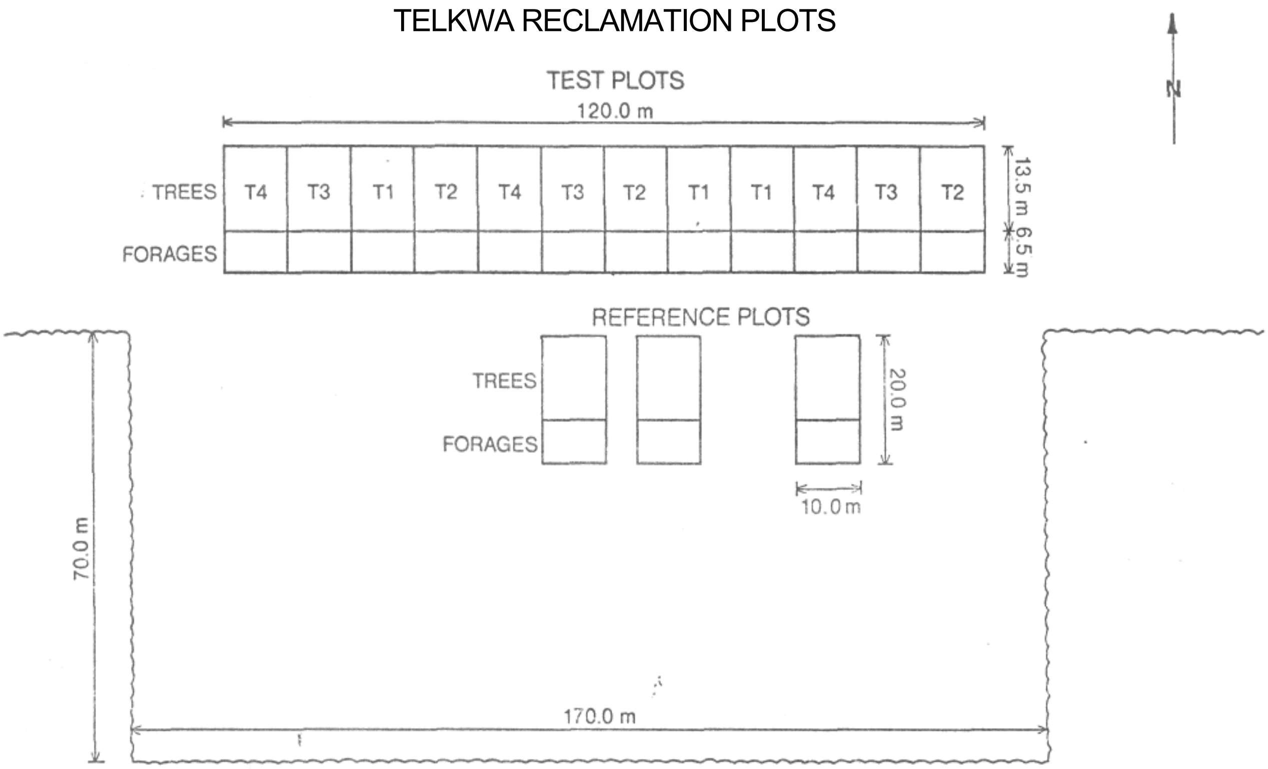
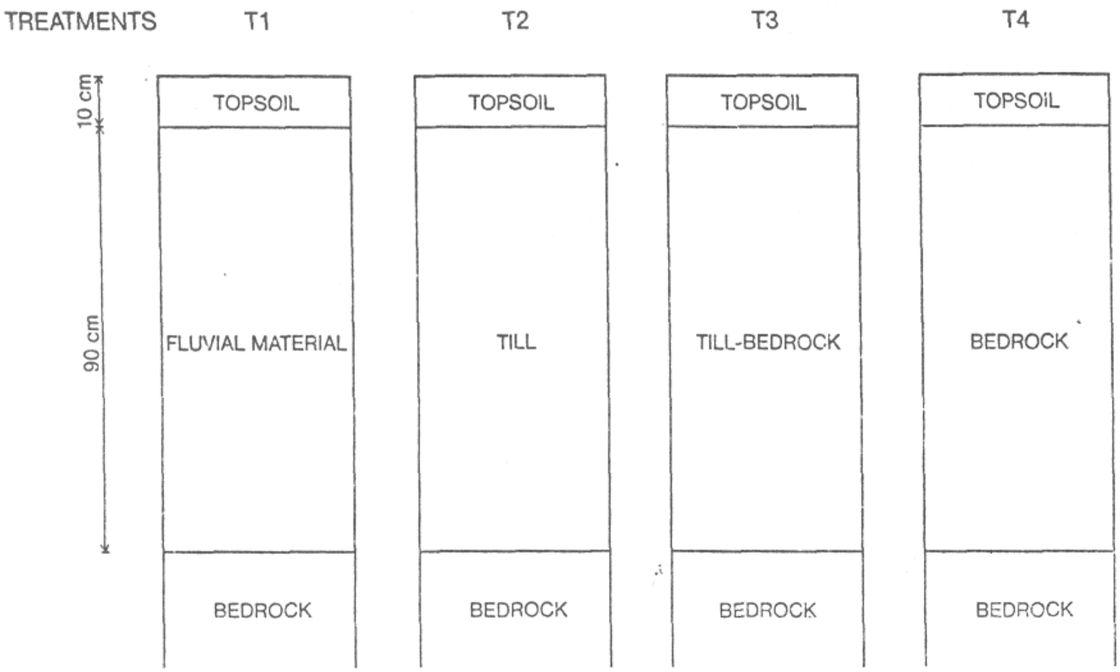


**Figure 4**

RECLAMATION PLOT DESIGN



ensure operational reclamation success, not to provide a definitive method. It is important to grasp the conceptual difference between theoretical and applied, or operational, reclamation research. Operational research does not, and should not, investigate the relative performance of new species or cultivars or different modes of propagation of these species. The vegetative species to be used in mine reclamation are qualified in the operational objectives of the reclamation plan by the pre-determined post mining land uses. These land uses may be forestry, agriculture, wildlife habitat, watershed management or other specified uses either singly, or in combination. The most successful, and most appropriate species to meet the operational reclamation objectives are known on a site specific basis: they are the species which are present already, the local ecotypes, provenances and cultivars. The problem, then, is how to provide the best possible growth medium, or seedbed, for the establishment, survival, and self-sustaining productivity of these species.

Three replicates of each treatment were included (Figure 4). The four treatments, each 20 x 10m, were subsoil manipulations, each of which was topsoiled. The treatments were: topsoil over till, which in effect was a reconstituted soil profile; topsoil over raw spoil; topsoil over a fluvial material which occurs over a significant portion of the property; and topsoil over a mixture of till and spoil. The latter is the combination of material which is most likely to occur on the surface following mining. As a control, 3 replicate comparison plots were laid down on nearby undisturbed soil, each 20 x 10m. The area cleared for the comparison plots was calculated with an understanding of the need for similar light regimes on treatments and controls. Two scrapers, a large dozer, and a small dozer were used to spread the subsoil treatments. These treatments were determined following discussion with engineering and geology staff, following a 1:5,000 soil survey which was conducted over the project area, and following analyses of overburden and parting quality and quantity. After the subsoil treatments were put in place and levelled, the major construction was complete, and the area was ready for topsoil ing. Prior to topsoiling, soil samples were taken from each subsoil treatment down the center line of the plots. As a result of working in a confined area, the excess travel by scrapers compacted the treatments, particularly the raw spoil treatment. As a result, this latter treatment was ripped prior to top soiling. This would not be required in an operational mining sequence. Topsoiling then took place to a predetermined thickness.

During and after test plot construction, the rest of the bulk sample area was backfilled and levelled. The surface was surveyed to determine variance from original contour. As well, a drainage line which traversed the site prior to operations was replaced.

One-third of each of the treatments was planted to a forage mix which was recommended by the local district agriculturalist. The remaining two-thirds of the areas of the reclamation plots will be planted to commercial tree species, spruce and pine, in the spring of 1984. Arrangements are being made to obtain local provenances from the district office of the Ministry of Forests. The same forage mix and trees will also occur on the comparison plots. The remainder of the surface of the sample site was seeded to the forage mix in the fall of 1983. The completed sample area, on the eastern side, indicates the blending with local topography that is possible with contouring. On the western end, the surface was contoured in a manner that directed surface flow into the surrounding bush and not directly towards Goathorn Creek. These plots will provide information on the crucial stages of establishment and early growth for approximately 8 years prior to their being mined during operations.

The completed program produced a site which can be used as a demonstration of the success of integrated development planning to the local community and to the Provincial Government. It must be emphasized that every effort was made to maximize information available. As a further example, the trees cleared from the area used for comparison plots were sectioned and analyzed. From this information a series of site index curves for merchantable tree species were developed. Incremental costs of these plots represented 2 days of machine time plus consultant time.

Consideration of all aspects of the bulk sample program allows an early assessment of the relative magnitude of potential environmental and reclamation problems, both technical and financial. Early identification of potential areas for specialized materials handling methods is one of the numerous advantages which accrues from the integration of geology, engineering and the environment.

When all disciplines are incorporated into the mine design and cost studies, an objective, balanced assessment of the technical and financial viability of the project results. This is a real assessment, not a laboratory study, a paper study or a computer simulation.