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THEME: "RECLAMATION AND DECOMMISSIONING"
THEME: "RÉHABILITATION ET MISE HORS DE SERVICE"

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PLAN DE RÉHABILITATION, CARRIERE DE GYPSE, FALKLAND, C.B.

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ABSTRACT:
In 1993 our landscape architect firm planned the reclamation of former, actual and future mining sectors of the Falkland Gypsum Quarry. A global and progessive approach was selected to enable a better visual and functional cohesion throughout the mining site and its evolution. Given its location in the Rockies and its extreme topography, the material being extracted, the proximity of the town and the site's glaring visibility, the Falkland Quarry offered a unique reclamation challenge.

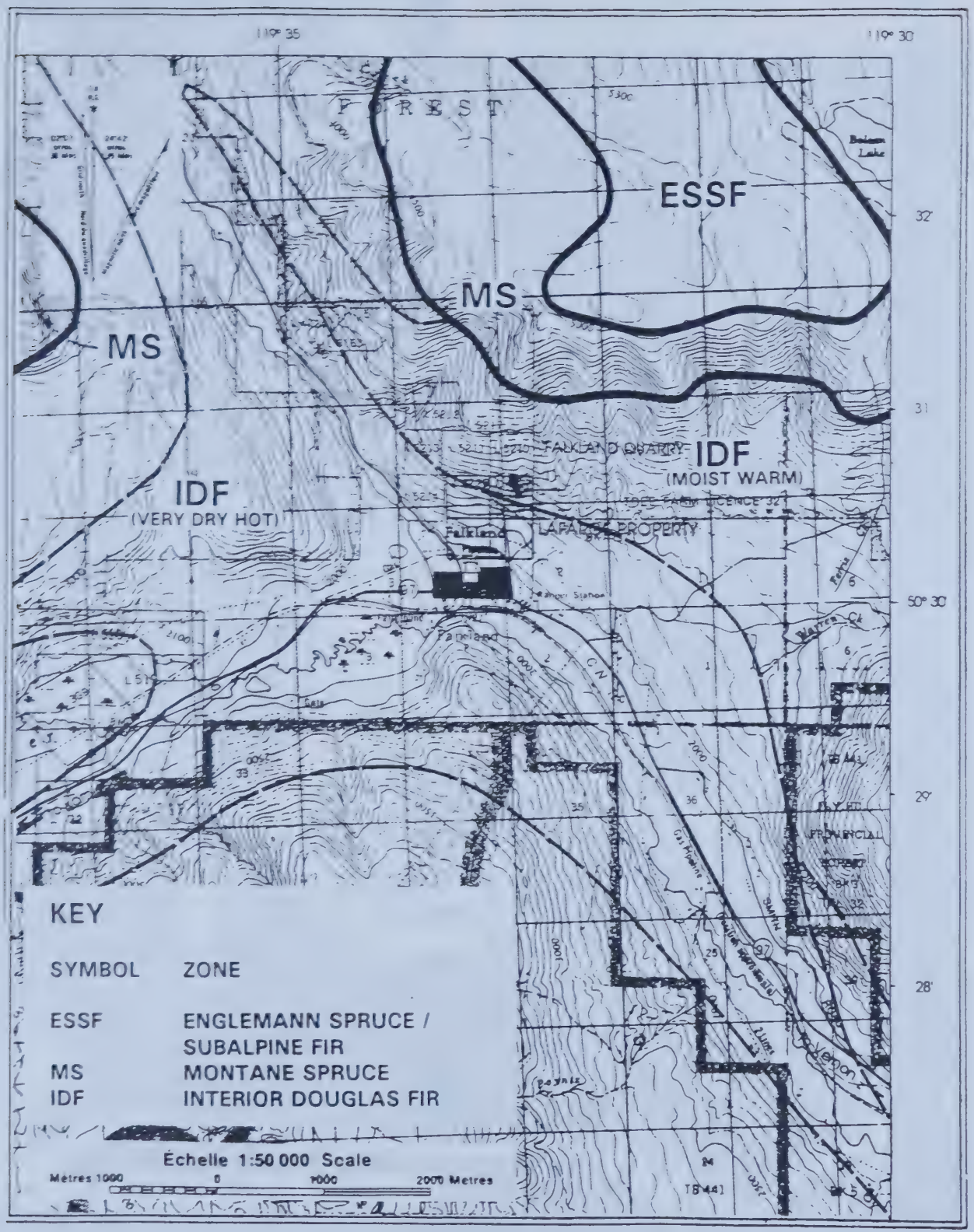
Biophysical, visual and human factors were studied along with the detailed mining schedules and operations. Reclamation strategies were to produce an efficient and environmentally sound mining site with regards to its sociological context. The two main foci of the project were to create a responsive reclamation plan for the proposed quarry and to be open to the site's genius.

RÉSUMÉ:
En tant qu'architectes paysagistes, nous avons élaboré un plan de réhabilitation progressif pour l'ensemble de la Carrière de Gypse de Falkland. Une approche globale de la problématique a permis de générer des stratégies d'aménagement offrant une bonne cohésion visuelle tout en assurant une logistique efficace entre les travaux de réhabilitation et le développement de l'exploitation minière. La topographie escarpée, la proximité de la ville et la grande visibilité du gypse, ont contribué à la complexité du projet. L'étude des composantes du site (biophysiques, visuelles, socio-économiques) et de la dynamique des plans miniers et leur développement pour les trente prochaines années ont permis de dégager les objectifs du projet:

1. Etre conformes à la section 10 du Code des mines de la Colombie-Britannique;
2. Stabiliser et renaturaliser les espaces ouverts existants et les futures aires de dépôts;
3. Minimiser les impacts visuels des carrières présente et future ainsi que les impacts visuels des aires de dépôts de mort-terrain;
4. Renaturaliser la présente carrière et les routes de hâlage existantes;
5. Créer un aménagement paysager permettant, à certains endroits, le développement d'activités récréatives extensives.

Définies selon les phases de développement de la carrière et la gestion de mort-terrain, les stratégies de réhabilitation sont flexibles pour permettre une meilleure répartition annuelle des budgets de réhabilitation. Les plans produits illustrent les phases de la réhabilitation et les stratégies d'aménagement, en corrélation avec le plan minier. Présenté avec un accueil très favorable en 1993 à la Municipalité de Falkland, la réussite de ce projet repose sur sa sensibilité à l'environnement et son ouverture envers le génie du lieu.

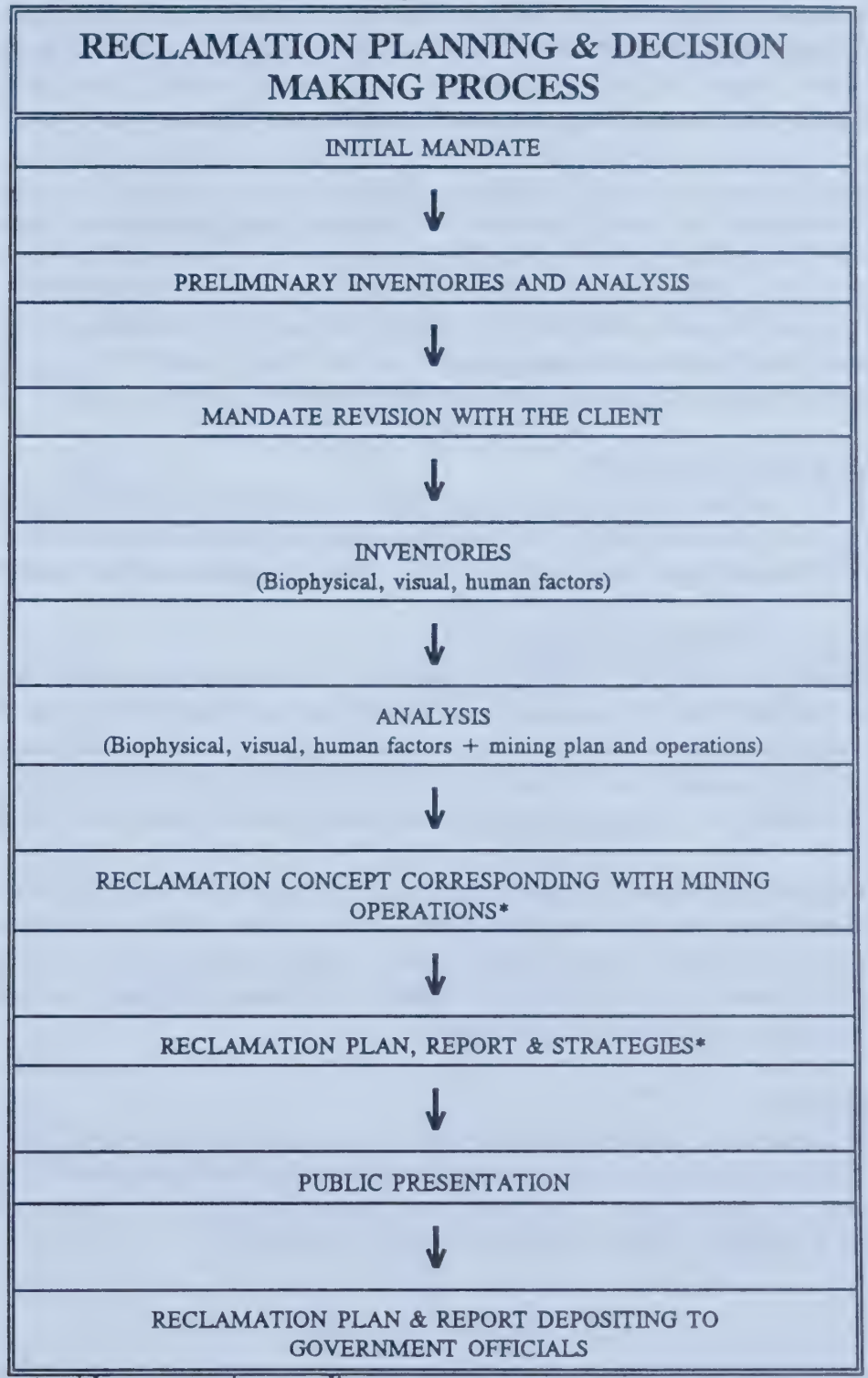

AERIAL PHOTOGRAPH
OF FALKLAND GYPSUM QUARRY
(Scale 1:12000 approx.)
ACTUAL MINE
PREVIOUS MINE
609938 SQM SURROUNDING NATURAL FOREST
SLIGHTY SPOILED NATURAL FOREST
106163 SQM CLEARED FOR PREVIOUS HAUL ROADS AND MINING TESTING
2606 SQM CLEARED FOR FUTURE SPOIL DUMP
62046 SQM ACTUAL MINE AND PREVIOUS MINE
SRS 4658 -18



BIOGEOCLIMATIC ZONES

FROM LLOYD ET AL (1989)

Following reception of the initial mandate to reclaim the former quarry, preliminary site inventories and analyses were done. Necessity to adopt a more global approach by reclaiming the whole site of the quarry including former, actual and future quarries and there impacts on surrounding land became the obvious and logical choice.



** with presentation to client*

SITE INVENTORIES AND ANALYSIS

1. GEOGRAPHICAL & CULTURAL CONTEXTS

Falkland is located in the recess of an elbow-shaped valley with an approximative population of 600. This Town has a resource and tourism economy base and canadian patriotism is clearly indicated by a huge flag at the summit of the former quarry. The quarry spreads over approximatively 45 hectares, between elevations 609 and 853m.

2. GEOLOGY

The Falkland deposit, originally known as the Salmon River deposit, was discovered sometime before 1889. The gypsum deposit occurs as a series of lenses extending for two kilometers along the hillside on the northeast side of Bolean Creek valley just north of Falkland. The slope of the mountain side in this area averages 30° (33%). Its major exploitation started in 1926 upon completion of the Kamloops-Kelowna branch of the CNR. Until 1956, 1.3 million tons were extracted. Two mining companies succeedly bought and exploited the site.

3. LOCAL MICROCLIMATE

Falkland is in a wet sub-zone of the interior dry belt. Most of the normal microclimatic changes related to higher elevations are offset by quarry solar exposure. Rock exposure likely increases reflection of heat and light, contributing to drier, warmer conditions that would normally occur.

4. SOILS & SURFICIAL GEOLOGY

Coarse-textured morainal and colluvial blankets of venners over rocks form parent materials of soils in the Falkland area. Surface soils are thin and consist of silty loams, sandy loams and clay loams. Surface drainage is expected to be good to very good. Existing original surface soils are a mixture of Gray Luvisols and Dystric and Eutric Brunisols. Dystric Brunisols, typically found at higher elevations, are more acidic and moist making them better suited for reforestation.

Bedrock overburden, beneath the surface soil, is composed of shale, gypsum-based roak and some argilites. These materials make up most of the volume of the quarry waste dumps. Long-term physical weathering of these materials will most probably produce fine particles suitable for plant growth and soil developement. Chemical weathering of these materials is not expected to create harmful by-products for plant growth.

5. DRAINAGE

Because of the site's climatic conditions, southern exposure and geology, there is no stream on the site. Visible drainage lines on topographic maps, but invisible on the site, do not collect enough water to sustain humid environement plants. Lack of water will be counteracted by establishing a drainage line at the base of the new spoil dump.

6. VEGETATION

The area has a canopy largely composed of mature Douglas Firs. Crown closure is of 50% to 70% depending on slope gradients. Natural forest of the site matches the surrounding forests. Forest is much thinner closer to exploitation areas and non-existent in cleared or deforested surfaces. These type of surfaces act as a form of buffer zone. They are in the process of self-naturalization and it is recommended that this reclamation plan does not intervene in these areas.

Selection for tree, evergreen and deciduous shrub plantings was done according to the B.C. Ministry of Environment inventory, the characterestics of an IDF zone, the particular conditions of the site along with regards to future public amenities. Here is a summary of the vegetation species to be used through reclamation:

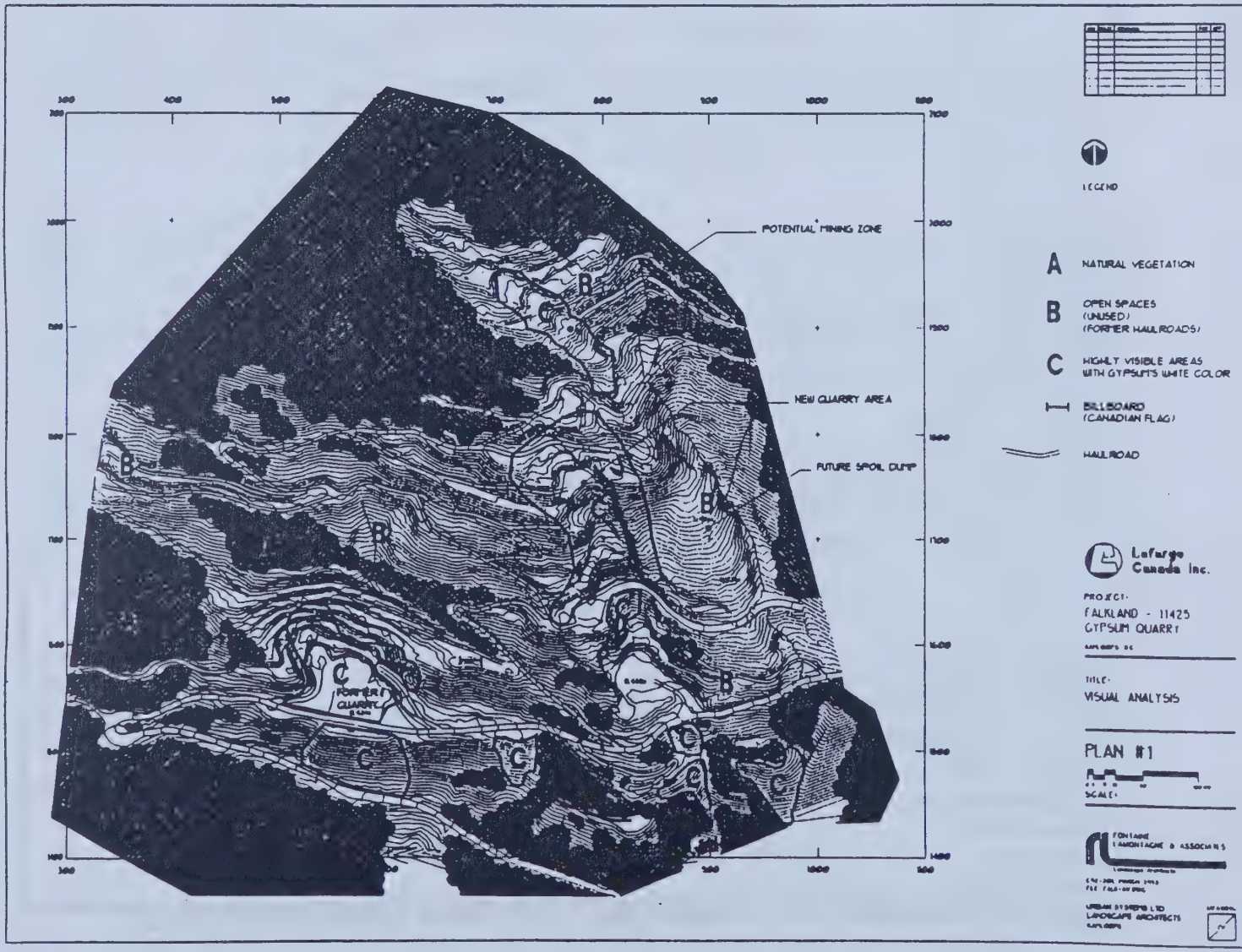
botanical names	*english names*	
TREES		
Pseudotuga menziesii	Douglas Fir	n,*
Pinus contorta	Lodgepole Pine	n,*
Pinus Ponderosa	Ponderosa Pine	nn,*
EVERGREEN SHRUBS		
Juniperus Scopulorum	Rocky Mountain Juniper	nn,*
TALL SHRUBS		
Acer glabrum	Rocky Mountain Maple	n
Alnus Tenuifolia	Mountain Alder	nn
Amelanchier Alnifolia	Common Sakatoon	n,*
Rhus Typhina	Staghorn Sumac	nn,*
Rhus glabra	Smooth Sumac	nn,*
Shepherdia Canadensis	Soopalallie	nn
LOW SHRUBS		
Spirea betufolia	Birch-leaved Spirea	n,*
Paxistima myrsinites	Oregon Boxwood	n,*
Mahonia aquifolium	Tall Oregon-grape	n,*
Symphoricarpos albus	Snowberry	nn,*
Rosa gymnocarpa	Dwarf Rose	nn,*
Ribes cereum	Squaw Currant	nn
GRASSES	Pine Grass	n
Calamagrostis rubescens	Showy Aster	n
Aster conspicuus	Racemose Pussy Toes	n
Antennaria racemosa	Yarrow	nn
Achillea millefolium		
Additional plants for diversification in touristic areas:		
Shepherdia argentea		
Rosa acicularis		
Rosa rugosa		
Juniperus Sabina		

*(n=indigenous, nn=non-indigenous, *=commonly found in B.C. nurseries specializing in native plants)*

7. VISUAL ANALYSIS

The Falkland Gypsum quarry is a highly visible feature in the otherwise lush green surrounding landscape. Numerous reasons contribute to this visibility:

1. the Town of Falkland sits in the elbow joint of the mountains, making it a pivotal axis which visually emphasizes on the quarry;
2. travellers heading to Falkland on Highway 97 are bound to have the quarry as a focal point;
3. steep slopes and large deforested areas of haul roads hairpin bends increase visibility;
4. gypsum's unique glaring white color makes its exploitation visible and its presence in overburden waste used for road foundations create extremely visible areas on the mountain's hillside;
5. a huge billboard with the Canadian flag has been set up within those very visible areas, on the summit of the former quarry at level 666. It is a regional symbol of reference and pride.



8. POTENTIALS & CONSTRAINTS

Located in a lush green mountain and valley landscape, the Falkland Gypsum Quarry is composed of unique wildlife, vegetation and visual qualities. These elements contribute to make tourism a local economy key factor, along with mineral resources. Therefore, it is of outmost importance that reclamation designing take into consideration human factors as well as environmental factors. This reclamation plan puts emphasis on integrating these two issues into the reclamation plan.

Steepness of the topography, quarry and quarrying activities, views of the valley, of the Town of Falkland and of the surrounding mountains are all factors of great interest.

The view of Falkland and the valley at the Canadian flag, the future first belvedere;

RECLAMATION PLANNING PROCESS

1. RECLAMATION GOALS

The following goals were established to develop the reclamation strategies and designs.

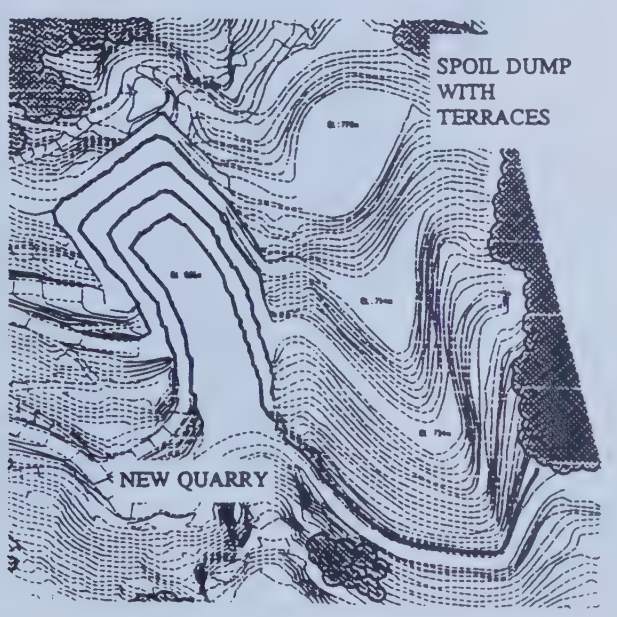
1. Comply with section 10 of the B.C. Reclamation Code.
2. Stabilize and revegetate existing open spaces and future disposal area.
3. Minimize the visual impacts of the existing and future quarries and of the overburden disposal areas.
4. Renaturalize the former quarry site and the clear-cut areas of existing hauling roads.
5. Create and manage a landscape allowing for recreational development in certain areas.

2. MINING SCHEDULE

An important part of the reclamation planning process included modifying the mining plan in order to address the overburden placement design in the new spoil dumps. Working with the client, we recommended alternatives to their extraction schedule and handling of waste material or overburden.

The Falkland Gypsum Quarry mining plan will use a basic multiple bench/open quarrying strategy. Five phases of soil deposition will form terraces across the dump to provide stability, reduce erosion and facilitate reclamation. This method creates lesser visual impact than the method used in the former quarry. The future quarry's new orientation combined with the perpendicular excavation and use of spoil dump terraces will greatly abate visual impacts as opposed to the former method which spread throughout large visually sensitive areas.

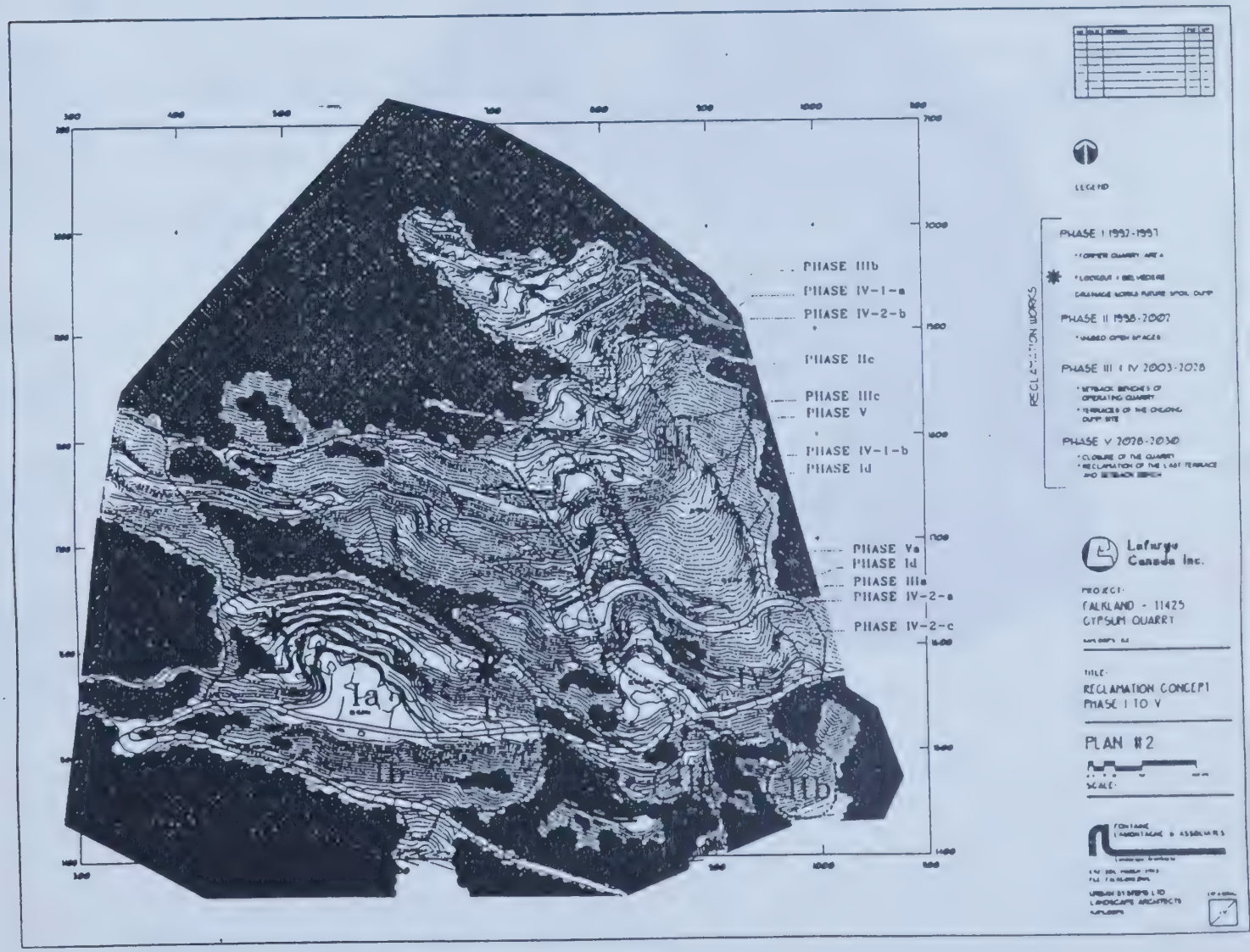
Thourough management of overdurden waste material produced by the future quarrying is a key factor of this Reclamation Plan. Overburden quantity will be significant and surrounding dump areas are relatively small and have steep slopes. Following figure shows the unreclaimed final layout of the future quarry and its spoil dump.

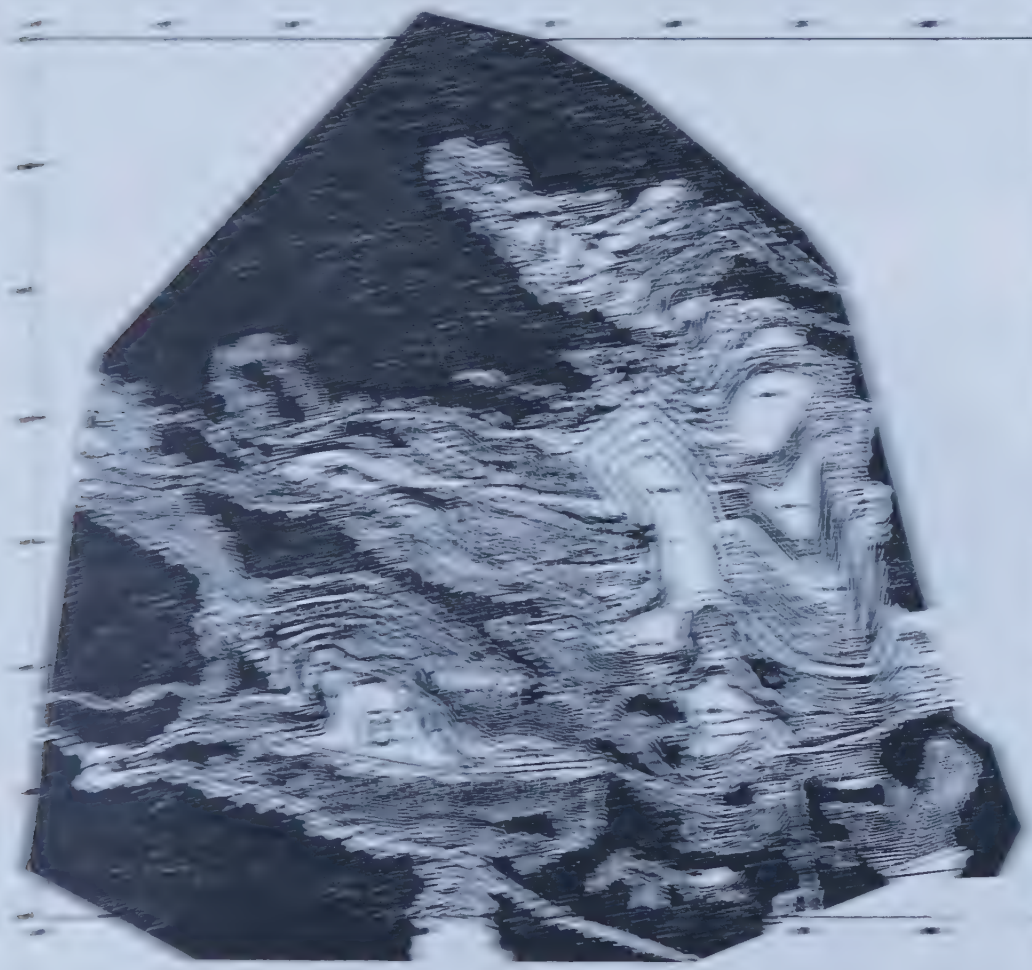


3. RECLAMATION CONCEPT

The reclamation concept is evolutionary and puts forward interchangeable reclamation interventions. It is to be applied according to exploitation development, granular material and/or plants availability and budget yearly distribution. Divided into five reclamation work phases, the concept corresponds with mining plan operations.

Phases I and II pertain to the reclamation of the former quarry, the present unused open spaces and the new haul roads. To highlight community spirit and develop tourism, recreational activity is developed around the Canadian Flag Landmark and revolve around a geological theme. **Phases III and IV** pertaining to future mining plan works include reclamation of dump site and setback benches of the quarry. Final **Phase V**, to occur at the end of mining operations, includes completion of reclamation work and a new layout for recreational activities enhancing recreational and touristic activities of Phase I.





4. RECLAMATION PLAN

Reclamation of large areas deforested for hairpin bends of haul roads and mining tests is of an outmost importance and is to be performed within Phases 1 and 2. Steep gradients of areas to be planted and renaturalized, command cautious planting operations. Planting strategies were developed to deal with this aspect.

The former quarry will be reclaimed during Phases 1 and 2. The actual quarry and its future spoil dump are the object of this reclamation plan and will be reclaimed over the next 30 years.

In realizing this reclamation plan, the Falkland Gypsum Quarry will first of all comply with the British Columbia Reclamation Code. Renaturalization and revegetation of open spaces (previous quarries and haul roads), future quarry and its spoil dump will abate visual impacts and raise the ecological value of the site. These measures are also planned, along with other landscaping improvements, to offer recreational activities.

Site revegetation, which follows a parallel thirty years schedule, includes a number of strategies ranging from straight and basic renaturalization to highly orchestrated ornemental planting. All these strategies are necessary to reduce the visual impact of the quarry and insure the safe integration of our proposed recreational activites.

The following table shows how mining operations and site reclamation relate in time.

MINING OPERATIONS & SITE RECLAMATION PARALLEL SCHEDULES

MINING OPERATIONS	SITE RECLAMATION
BENCH 1: 1993-1995 - Excavation of Bench #1 (future quarry) - Filling of terrace #1 in spoil dump	*PHASE I: 1993-1997* Ia- Reclamation work at the former quarry Ib- Reclamation of slope between haul roads in front of former quarry Ic- Recreational Activities site work -Plantings in front of Canadian flag -Construction of parking area, staircases, geological interpretative trail, pavilion and belvedere near flag with service road Id- Preliminary site work of drainage at the future spoil dump
BENCH 2: 1996-2002 - Excavation and extraction of Bench #2 - Filling of terrace #2 in spoil dump	*PHASE II: 1998-2002* IIa- Reclamation of large open spaces IIb- Reclamation work on two abandonned sites at the south-east quarry limit IIc- Reclamation work of spoil dump terrace #1
BENCH 3: 2003-2013 - Excavation and extraction of Bench #3 - Filling of terrace #3 in spoil dump	*PHASE III: 2003-2013* IIIa- Construction of 1st bioengineered retaining wall at toe of terrace #3 IIIb- Reclamation of setback bench #1 IIIc- Reclamation work of terrace #2
BENCH 4: 2014-2020 - Excavation and extraction of Bench #4 - Filling of terrace #4a in spoil dump	*PHASE IV, STEP 1: 2014-2020* a- Reclamation of setback bench #2 b- Reclamation work of terrace #3
BENCH 4: 2020-2028 - Continuation, excavation and extraction benches #4-and #5 - Filling of terrace #4b in spoil dump	*PHASE IV, STEP 2: 2020-2028* a- Construction of 2nd bioengineered retaining wall b- Reclamation of setback bench #3 c- Reclamation work of terrace #4a
BENCH 4 - END OF OPERATION: 2028-2030 -In the eventuality of quarry closure, site will be cleaned up	*PHASE V: 2028-2030* Va- Reclamation work of terrace #4b Vb- Reclamation of setback bench #4 Development of nature trails network, contruction of 2 belvederes (west side of quarry bench#3 and summit of future quarry)

RECLAMATION PLAN - PHASE I (1993-1997)

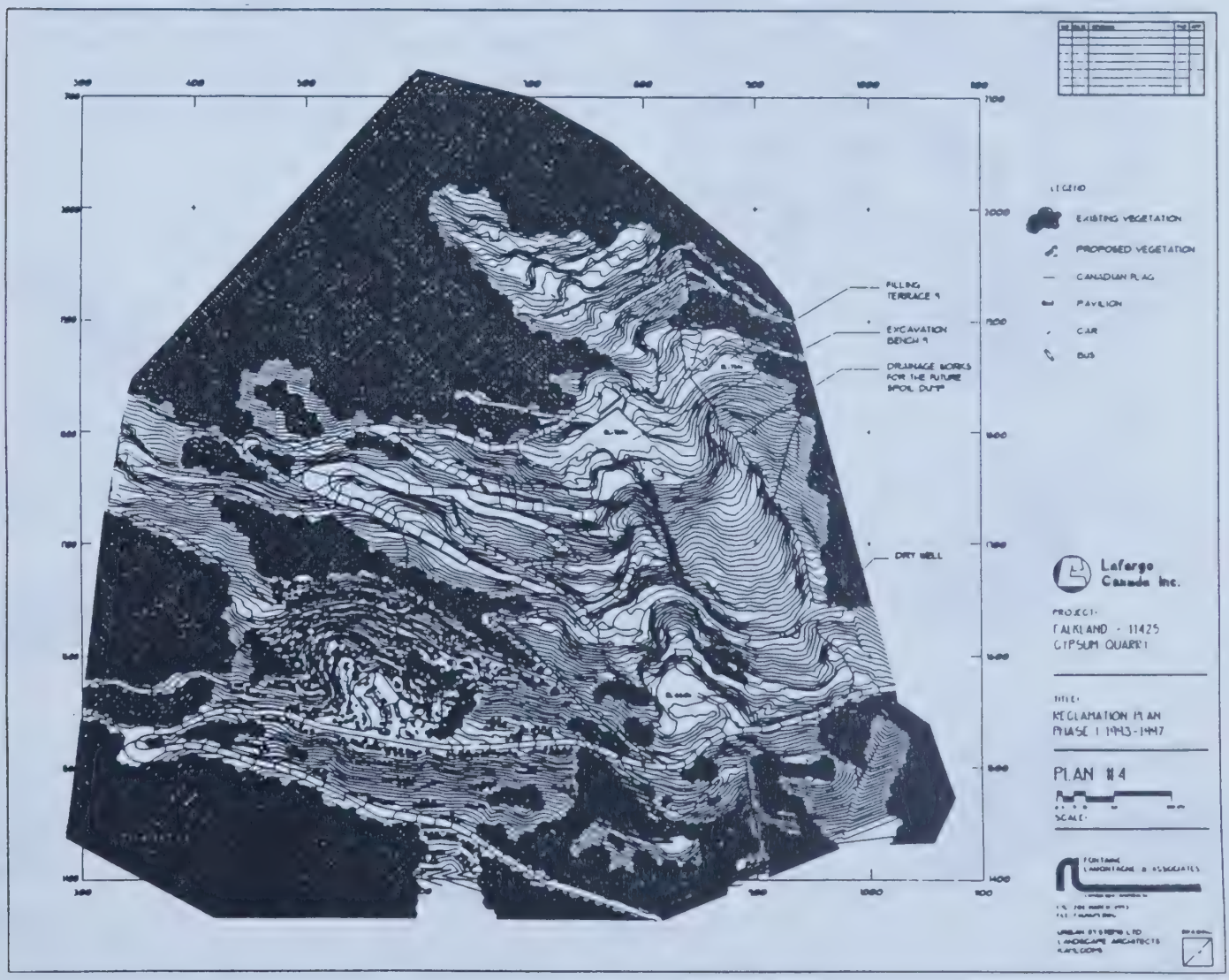
Reclamation work of the former quarry, reclamation of slope between haul roads in front of the former quarry, construction of the first belvedere at base of Canadian flag and preliminary work at the future spoil dump in order to improve drainage. Phase I roughly corresponds to the laying out period of Bench #1.

Summary of mining operations
Bench 1 1993-1995

The uppermost Bench #1 will produce no gypsum, but is designed to adjust the waste rock configuration and serve as the key layout of all the lower benches. The mixed gypsum and waste rock excavated between elevations 796 and 776 serve two purposes:

- *to create required catchment berm setbacks for the lower bench;*
- *to provide road access for the future waste generated from Bench #2 to the spoil dump.*

Bench 1 waste will be transported westward and the up and over top of lens to be deposited at top of dump starting at 794 elevation.

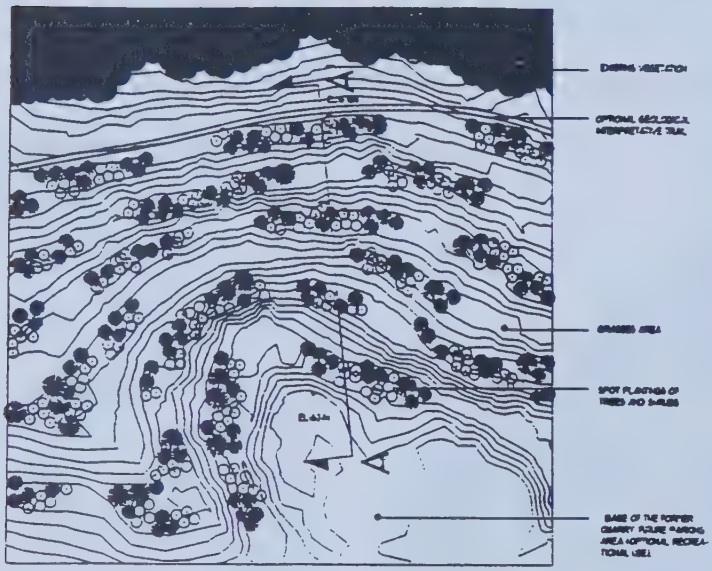


Reclamation work to be done in Phase I

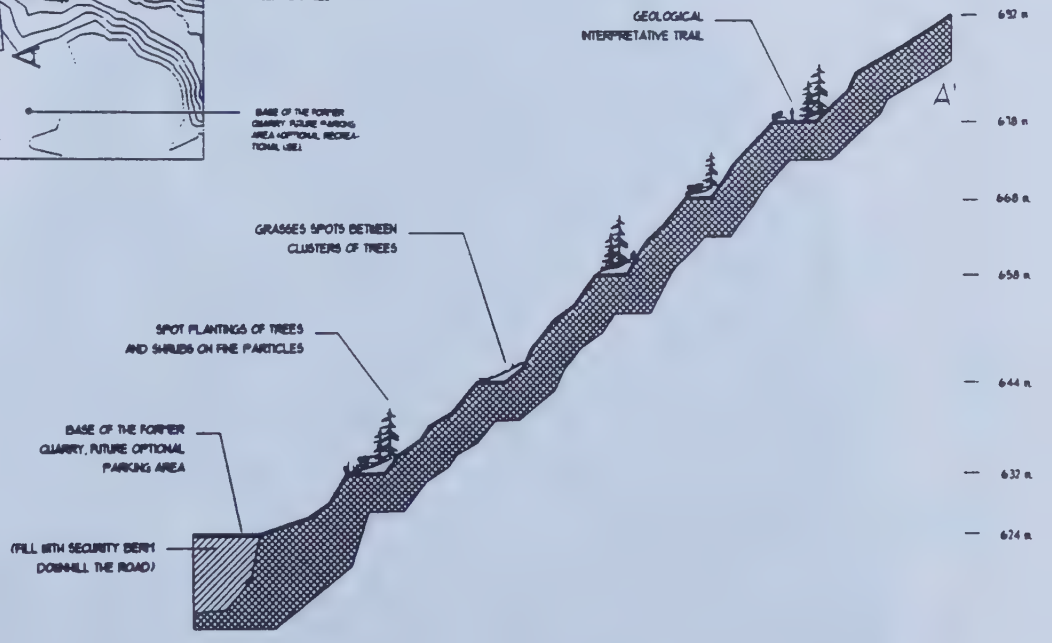
Ia- Former Quarry Reclamation : disused setback benches

The former quarry is already in the process of being revegetated. Fine particles are found on different setback benches. They are a key factor in the reclamation process and are hard to obtain on steep slopes impeding soil constitution. Width of setback benches is sufficent for small vehicular equipment managing.

Different setbak benches rehabilitation strategies were put forward. Spot planting of tree and shrub clumps with grassy areas between are directly grown on a setback bench embankment (old or new) by stripping other areas to obtain necessary growing medium in certain spots.



PHASE Ia
PLAN RECLAMATION OF THE FORMER QUARRY
FIGURE 5



PHASE Ia
SECTION A-A'
RECLAMATION OF THE FORMER QUARRY
FIGURE 6

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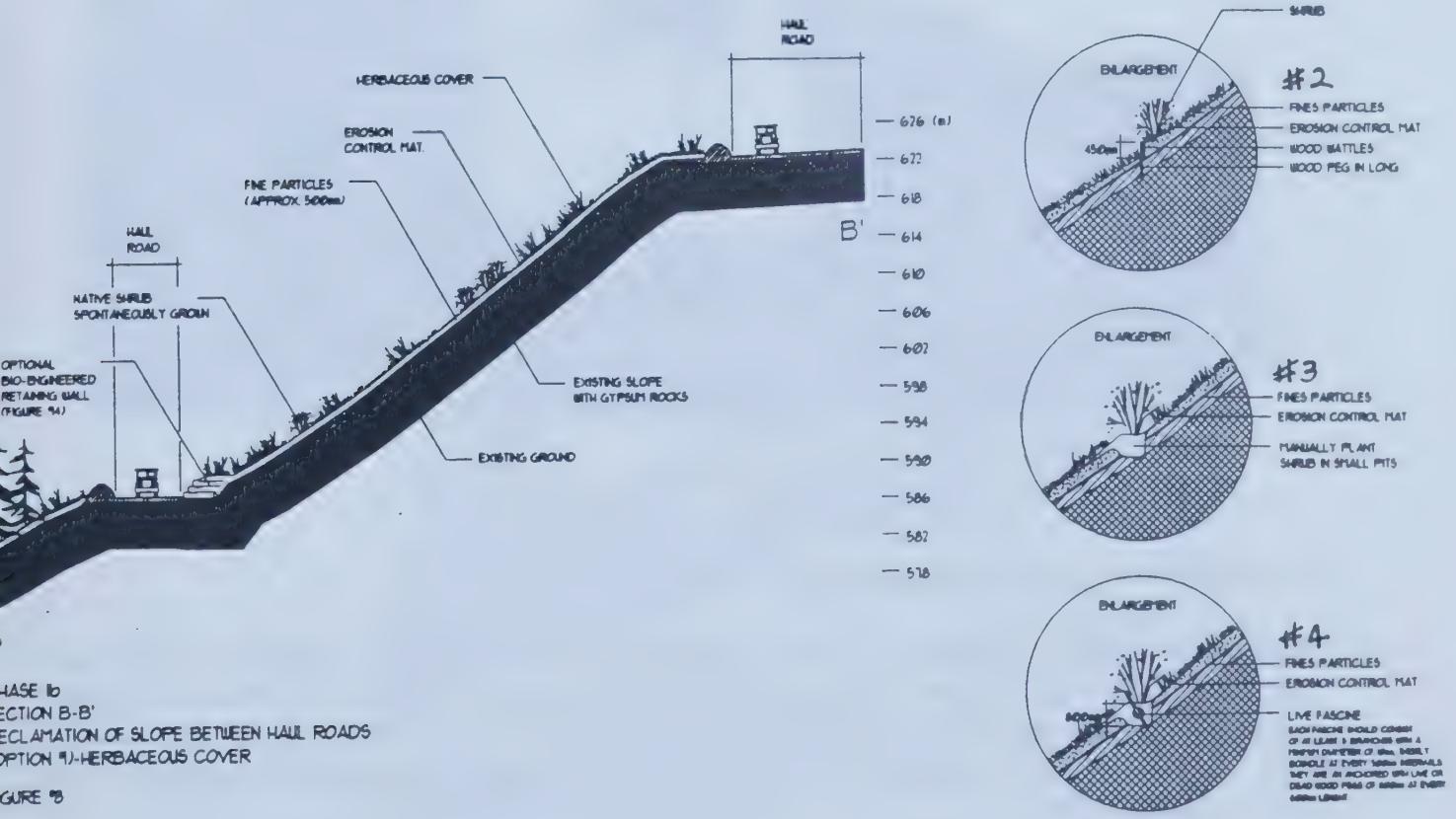
LANDSCAPE ARCHITECTS
KAMLOOPS

Ib- Slopes between haul roads, in front of former quarry

Rock fill to widen haul road in front of former quarry contains a significant proportion of gypsum, is bare and spreads on large areas. This fill has a high visual impact to be abated by the establishment of a simple herbaceaous cover in which native shrubs will eventually grow spontaneously. But slope steepness commands a variety of construction methods for enabling vegetation growth.

First, actual security berm downhill of road, near quarry, will be removed to allow for fine particule unloading. Then, after eliminating large gypsum rocks, a minimum layer of 400mm of fine particles is to be spread over the rock fill and left to filter through to enable natural revegetation to take place. Erosion control mats and seeding follows (Option 1).

Structures of wattle, wicker fences to lodge thicker layers of particles will sometimes be required (Option2). These structures are to be constructed where access is possible and must follow contour lines. Erosion control mat completes this option. Another strategie increases visual complexity of alluvial cone pattern rock fill with shrub and tree spot plantings (Option 3) hand planted in deeper layers of particles areas (found or previously prepared with option 2). Last planting and renaturalization strategie consists in implementing live fascines, again to retain fine particles and enable vegetation growth (Option 4).

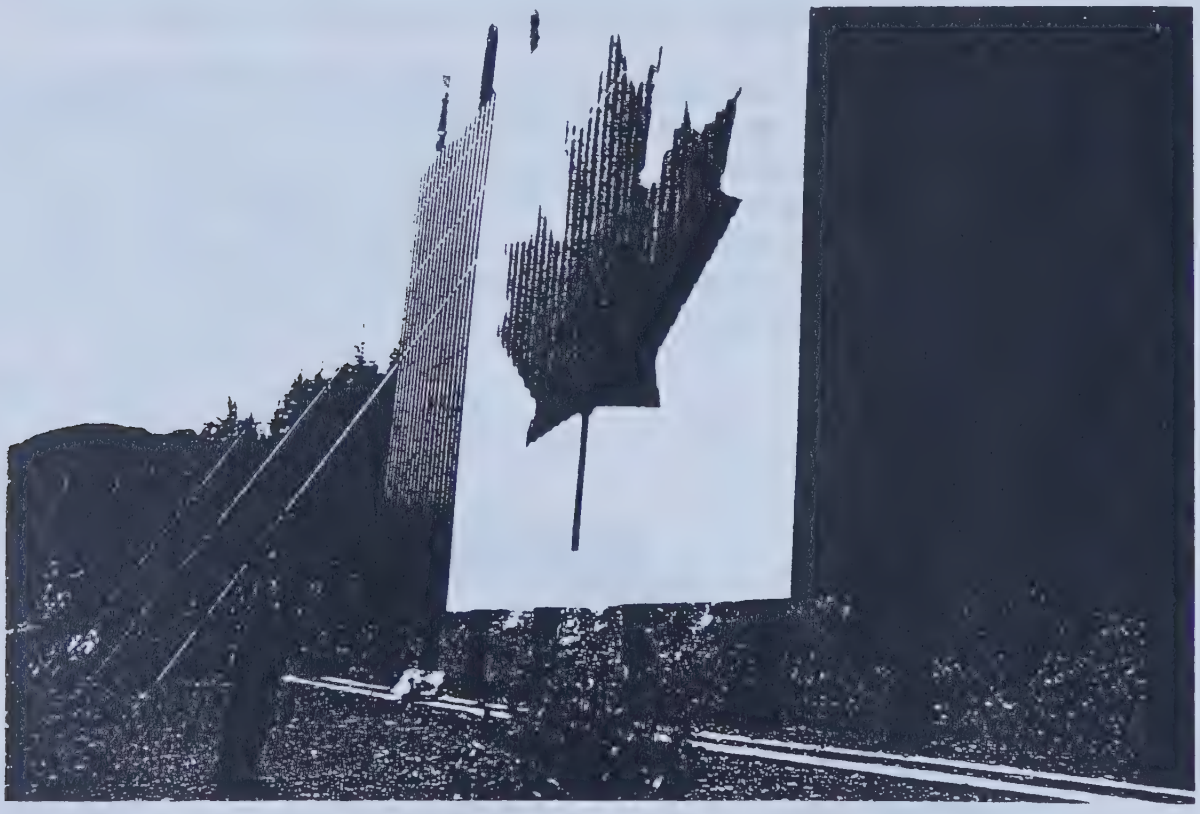


HASE Ib
ECTION B-B'
ECLAMATION OF SLOPE BETWEEN HAUL ROADS
OPTION 1)-HERBACEOUS COVER

GURE 9B

Ic- Reclamation of open spaces in front of Canadian flag with shrub planting and construction of first belvedere.

This area plays a key role in the recreational proposals. First, it will be revegetated in order to abate visual impact. Then access road will be converted for public use. A lookout will be designed on the small terrace with the flag to enjoy the panoramic and spectacular views. Mineralogical/geological interpretation trail will start at the lookout and put forward geological formations, quarrying activities and explain interesting related features. Parking areas, stairways and welcoming pavilion complete the recreational layout.



The Canadian flag;

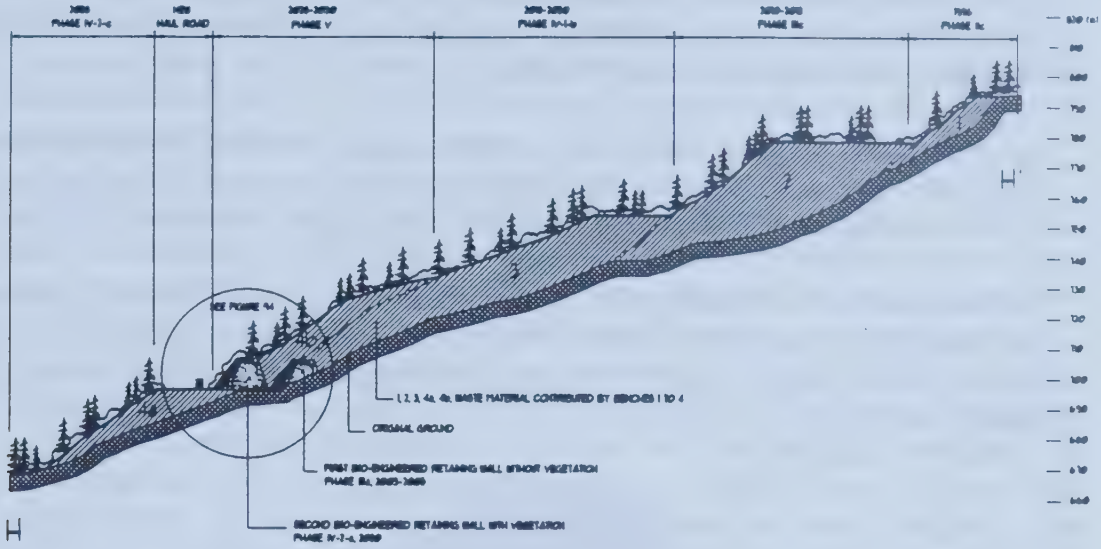
Id- Preliminary drainage work at the future spoil dump.

Preliminary work will be done at the base of the gully which will become the future spoil dump. This work will insure proper drainage on the future spoil dump and will maintain proper drainage on the present site while filling the spoil dump in the next 30 years. This riprap channel with a geotextile cover will drain water downhill and divert it into a road ditch. A dry well will soak up excess water.

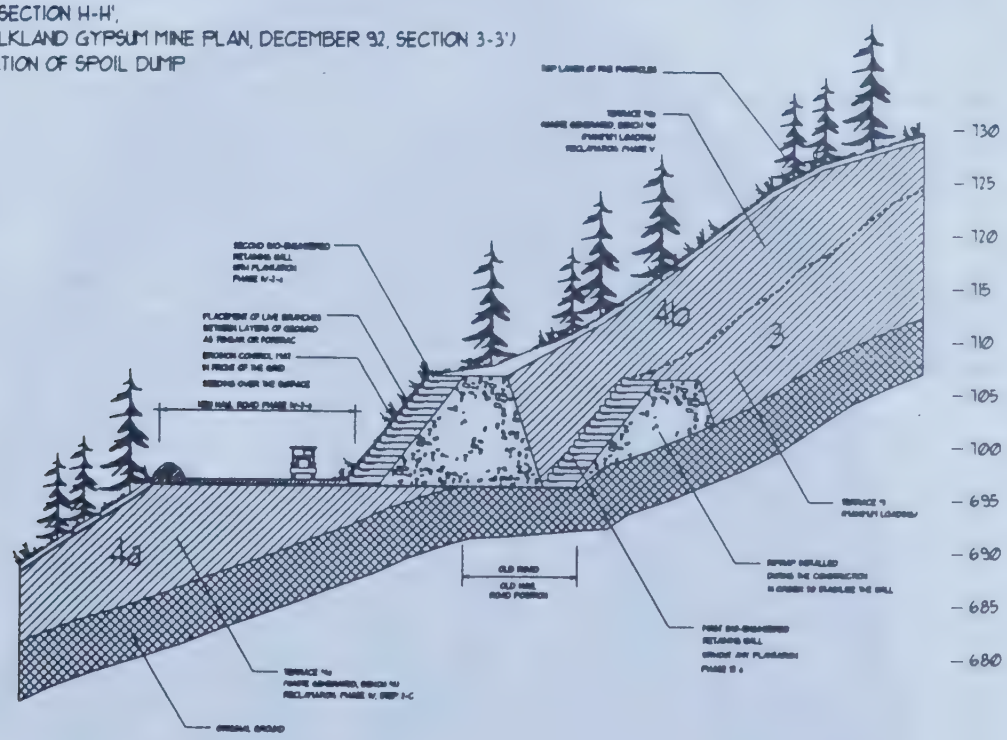
Following reclamation work examples were selected for their particular interest in this project.

RECLAMATION PLAN - PHASE III (2003-2028)

Construction of bioengineered walls will be required in order to lodge successive overburden dumping. They are built with geogrid reinforcement systems. These systems simply lay upon a compacted fondation layer of blasted stone.



TYPICAL SECTION H-H',
(FROM FALKLAND GYPSUM MINE PLAN, DECEMBER '92, SECTION 3-3')
RECLAMATION OF SPOIL DUMP



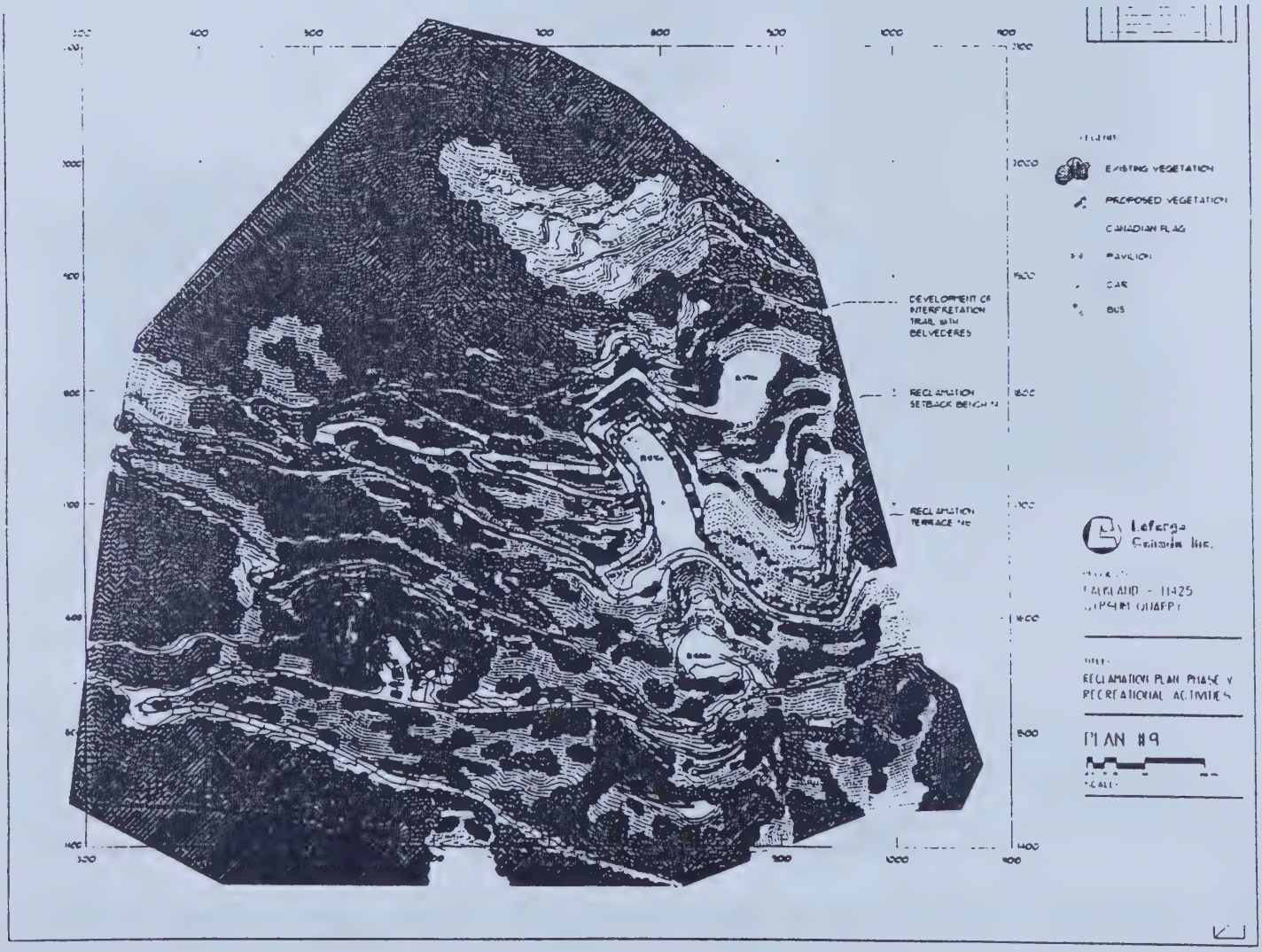
SECTION ENLARGEMENT
BIO ENGINEERED RETAINING WALL

RECLAMATION PLAN - PHASE V (2028-2030)
RECREATIONAL DEVELOPMENT COMPLETION

Reclamation of terrace #4b will occur when all waste material generated by bench #4 will have been put into place. This terrace will have to be reclaimed due to its large highly visible surface. Setback bench #4 will also be reclaimed at the end of mining operations. Recreational Phase V Plan will be performed once extraction operations are nearly completed or ended. It will pursue recreational development started in Phase I.

An observation platform located on a former loading platform, at intermediate level bench #3, will offer a sheltered place to contemplate the dramatic views of the gypsum lens exploitation and its recess plateaus. A pedestrian path links this platform to the Canadian flag lookout.

At the summit of the quarry site, another lookout is planned given the spectacular views onto the valley from this point. These views make a large part the genius of this landscape. Even treking up steep slopes is part of the genius. A network of trails links these features and recycles former haul roads.



CONCLUSION

The former quarry creates an unsightly gash in the otherwise lush green mountain and valley landscape. This is exacerbated by its southern exposure which sharpens the already bright white color of gypsum. Amazingly, the town had chosen to capitalize on this "eyesore". By installing a giant Canadian flag, they had already started the reclamation process and invested it with meaning. Our firm understood the significance of this gesture and was compelled to respond by developing a reclamation plan that included the actual and former quarry area and enhanced it for the benefit of the community.

The Reclamation Plan surpassed the mandate of both the Reclamation Code and the client on a number of levels. By broadening our focus beyond the site of the proposed quarry, we were able to introduce a significant recreational component. The plan itself is meant to be carried out over a thirty year period, yet our proposal does not wait for quarry closure to transform the site into a public amenity. At the onset of mining operations, a belvedere and an information pavilion along with geological interpretation trail will be the first interventions. In a later phase of work, a trail and look-out network will be built to allow visitors to view the quarrying operations. At the end of mining operations, a final belvedere will be constructed offering an exceptional view onto the surrounding valleys. As a result of the reclamation process, the site's ecological value will raise. Wildlife such as deers and other mammals and bird species, will be sustained by providing better nourishment.

Our firm was entirely responsible for the Reclamation Plan. With our sub-consultants in the region, we conducted the necessary inventories. We then proceeded to redifine the scope of intervention. In addition, our firm produced visual simulations as designing tools which became part of the presentation to the Town of Falkland.

The Falkland Gypsum Quarry owner is an acknowledged leader in environmentally sound mining and quarrying strategies. Commitment towards clients, employees, communities and shareholders have built our client's reputation. Goodwill underlays these commitments, and it extends to efficient cooperation while carrying out reclamation planning and site work.

BIBLIOGRAPHY*

**Please note that this article is based upon the Falkland Gypsum Quarry Kamloops Cement Plant Reclamation Planning Report, April 1993 prepared by J-G Levaque, Fontaine Bernard & Associates, Urban Syatems Ltd. The following Bibliography pertains to the aforementionned Report.*

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