Proceedings of the 7th Annual British Columbia Mine Reclamation Symposium in Victoria, BC, 1983.
The Technical and Research Committee on Reclamation

REVEGETATION OF PIPELINE RIGHT-OF-WAYS

Paper presented by
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Westcoast Transmission

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REVEGETATION OF PIPELINF RIGHTS-OF-WAY

The reclamation and revegetation of pipeline rights-of-way in British Columbia is discussed in the following paper under two major headings: (1) an introduction to the Westcoast Transmission pipeline system and the company's revegetation experience; and (2) the results of a field program which was designed to evaluate revegetation success.

PART 1

INTRODUCTION

Westcoast Transmission Company Limited constructed its mainline to transmit natural gas from the Peace River area of British Columbia to the Lower Mainland in 1955, 1956 and 1957. In the 25 years since it began operation, the Westcoast system has been expanded a number of times so that it now comprises some 1,395 km (867 miles) of main transmission lines, 935 km (581 miles) of loop lines, and 2,105 km (1,308 miles) of gathering lines. The company's gas supply comes largely from gas fields in British Columbia, augmented by supplies from Alberta, the Yukon Territory and the Northwest Territories. Westcoast, as a processor and wholesaler, supplies natural gas to residential, commercial and industrial consumers from northern British Columbia to California.

Westcoast[1]s Pipeline System

Westcoast's mainline follows a north-south alignment through central British Columbia from Taylor in the Peace River area through the Pine Pass and generally following the highway corridor southward, passing by Summit Lake, Prince George, Quesnel and Williams Lake then swinging eastward near 100 Mile House, Hihium Lake, Savona and Merritt and through the Coquihalla Pass to the Fraser Valley (Figure 1).

A branch of the main transmission line transports natural gas from the Fort Nelson area and from gas fields in the Territories, joining the Taylor line at Willow Flats near Chetwynd.

A network of gathering lines feeds gas from various areas into Westcoast's processing plants at Fort Nelson, Taylor and Pine River.

WESTCOAST TRANSMISSION COMPANY LIMITED

PIPELINE SYSTEM MAP

Pipeline Construction

Westcoast's pipeline system is designed and operated by Company personnel, with major additions to the system constructed by experienced pipeline contractors. In order to construct a high-pressure gas pipeline, the contractor is required to clear all trees and brush from a right-of-way which is of sufficient width to excavate a trench and lay the pipe. The pipeline right-of-way is graded and levelled only to the extent necessary to allow the pipe to be fabricated and lowered into the trench by heavy equipment, and the trench backfilled. Within certain limitations, joints of pipe are bent both vertically and horizontally to conform to the contours of the trench. A depth of cover of approximately 0.9 m is maintained over the pipeline when the trench is backfilled.

Right-of-Way Width

Westcoast's pipelines vary in size from small 88.9 mm (3 inch) diameter gathering lines to large 762 mm (30 inch) diameter and 914 mm (36 inch) diameter main transmission lines. To install and operate a small diameter gathering line, a right-of-way approximately 18 m wide is cleared and prepared; larger diameter lines require a greater width of working space to accommodate a wider trench, larger amounts of excavated soil, and bigger pipelaying equipment. Where the right-of-way is located in steep, sidehill locations, additional clearing must be done to prepare a bench on which to install the pipeline.

When the pipeline system is expanded by adding another parallel section of pipe (a "loop" pipeline), additional right-of-way is cleared for working space, and the two lines are installed some 9 m (30 feet) apart.

Westcoast's existing cleared rights-of-way, therefore, range from 18 m (60 feet) to 38 m (125 feet) in width.

Riqht-of-Way Cleanup

Following pipe installation and backfilling, the first critical stage in the reclamation process is right-of-way cleanup. This phase of a pipeline project is typically carried out to high standards as part of the main pipeline contract. As with other aspects of pipelining, strict quality control of the cleanup operations is maintained by Westcoast's own inspection staff. Slopes are graded to stable contours, and all debris and slash is removed. Surface drainage control berms are constructed across slopes to direct the runoff to the edge of the right-of-way and into natural vegetation to prevent downslope erosion.

Seeding Programs

Prior to 1971, Westcoast did not generally undertake extensive seeding programs on Crown Lands. Rangelands along the right-of-way were frequently seeded by the range permittees or by livestock associations, with Westcoast[1]s encouragement and financial support. Private landowners were compensated for any crop losses which occurred as a result of pipeline construction, and for undertaking any soil rehabilitation or seeding required.

In the early 1970's however, there was a renewed interest in land reclamation. Westcoast, together with other energy and mining companies in British Columbia, initiated seeding programs for new rights-of-way.

For some 12 years, therefore, Westcoast has undertaken to seed pipeline rights-of-way and other facility sites on Crown Lands following construction. As with other types of developments, such as surface mining, it is recognized that prompt revegetation is of considerable assistance in controlling erosion, and in restoring disturbed areas to productive growth as wildlife habitat or grazing for domestic animals, as well as improving the appearance of the right-of-way.

In certain high value sites, Westcoast has also undertaken more intensive planting programs involving shrub and tree planting and sodding to restore rights-of-way following construction.

Westcoast usually does not include seeding or tree planting in the general pipeline construction contract, but carries out the work using specialist contractors working directly for the Company and supervised by Westcoast staff. Smaller areas are seeded or planted by Westcoast operations crews after minor construction projects are completed.

Seeding of very large sections of right-of-way is the reclamation procedure most frequently undertaken. Seed mixtures are formulated for the climatic conditions of the area to be seeded. Westcoast relies on the experience of seedsmen who are familiar with B.C. growing conditions to select the types of grasses and legumes most suitable for revegetation purposes. Regional staff of Federal and Provincial government ministries also provide advice and direction on appropriate seed mixtures.

Westcoast[1]s pipeline rights-of-way extend the full length of the province, therefore a very wide range of climate and terrain conditions are encountered. A revegetation program has been developed to adapt to the various regions. Some typical seed mixtures made up of agronomic grasses and legumes which have been used successfully on various sections of right-of-way are shown in the following table (Table 1).

TABLE 1

WESTCOAST TRANSMISSION COHPANY LIMITED

STANDARD REVEGETATION

SEED MIXTURES FOR

RIGHTS-OF-WAY

PRINCE GEORGE, PEACE RIVER AND NORTHERN FOOTHILLS AREA:

(MIX 2A.)	Smooth Brome	(25% by weight)
	Climax Timothy	(25%)
	Boreal Creeping Red Fescue	(30%)
	Aurora Alsike	(10%)
	Mixed Blossom Sweet Clover and	(5%)
	Redtop	(5%)
(MIX 2B.)	Smooth Brome	(25%)
	Climax Timothy	(20%)
	Boreal Creeping Red Fescue	(35%)
	Aurora Alsike	(5%)
	Mixed Blossorr, Sweet Clover	(5%)
	Rhizomatous Alfalfa	(10%)

Note: Mixture B is used in preference to A where greater nitrogen-fixing capability is desirable.

CARIBOO AREA & SOUTHERN INTERIOR

(MIX 3.)	Smooth Brome	(30%)
	Climax Timothy	(20%)
	Creeping Red Fescue	(15%)
	Rambler Alfalfa	(10%)
	Single-cut Red Clover	(10%)
	Crested Wheat grass	(10%)
	Alsike Clover	(5%)

TERRACE AREA OF NORTHWESTERN B.C.

Orchard Grass	(25%)
Creeping Red Fescue	(20%)
Canary Grass	(15%)
Alsike	(10%)
Crown Vetch	(10%)
Rhizomatous Alfalfa	(10%)
Redtop	(5%)
Lupin	(5%)

SOUTHERN COAST MOUNTAINS

Creeping Red Fescue	(30%)
Alsike	(15%)
Tall Fescue	(10%)
Orchard Grass	(10%)
Climax Timothy	(10%)
Mixed Blossom Sweet Clover	(10%)
Flemish-type Alfalfa	(10%)
Kentucky Bluegrass	(5%)

Seeding Methods

Westcoast has utilized aerial seeding methods with excellent success. Experienced contractors are employed to carry out the work using fixed-wing aircraft equipped with seed bins calibrated to apply the seed at the rate desired. Fixed-wing aircraft are normally the most effective and economical means of applying the seed, but helicopter application has also been used in mountainous terrain. Aerial seeding has the advantage of broad coverage in a short space of time, low cost, and effective application at a season when over-the-ground travel may be restricted.

For some difficult slopes, or special areas such as river crossings or highway crossings, hand-seeding equipment is utilized.

Seeding Time and Rates of Application

Where lack of moisture is a problem, late winter application of seed has been found to be most effective. Seed is applied while some snow cover remains. The seed then has the moisture of spring run-off to encourage early germination. Where there is ample moisture, seed has been applied in either spring or fall with good success.

A seeding rate of 25 to 35 kg per ha (22 to 26 lbs per acre) is the seeding rate normally specified.

Fertilization

Fertilizing at the time of seeding would assist in establishing the grasses and legumes but, because of the high additional cost, and undetermined overall gain, Westcoast does not generally apply fertilizer, except in certain difficult sites.

Coated Seed

For one project in the northeast coal area, the Grizzly Valley Pipeline, a coated seed mixture (Special Mix 2B) was applied to the entire 150 km right-of-way. The seed coating supplied an initial burst of N-P-K for the emerging seedling. No specific evaluation studies were carried out to determine the benefits of the coated seed, however, from a visual inspection it would appear that establishment of a ground cover was somewhat better in the first year.

Costs for the coated seed were approximately double that of uncoated seed. Costs of application increased somewhat because the coated seed is heavier, thus the aircraft was able to apply fewer seeds with one hopper load. Overall costs for the project were only fractionally

greater, on a per hectare basis, because a lower seeding rate was used, based on actual seed count per hectare (Refer to Table 2).

Seeding Costs

Some estimated costs of seeding rights-of-way are shown in Table 2. A very general formula for calculating the area to be seeded is used: a 20 m wide right-of-way is approximately 2 hectares per kilometer. The total area, estimated at 2 hectares per kilometre, is increased somewhat to allow for sections where the right-of-way is wider, for example, river crossings, shoofly roads and borrow areas. Using recent air photo coverage and/or construction experience, the seed quantities can be calculated fairly accurately in this manner. The pilot of the seeding aircraft also uses air photo mosaics to estimate the approximate number of overflights necessary to complete the operation.

The costs of fixed-wing aerial seeding are very much influenced by the location of the area to be seeded relative to a suitable landing strip where seed can be loaded. Most of the sites seeded have been in relatively accessible areas, therefore there has been little difficulty in using fixed-wing aircraft. Seeding remote sites would, in all probability, be done by helicopter; however, costs per helicopter flying hour are approximately 3% times greater than for fixed-wing aircraft.

Regulatory Requirements for Reclamation and Revegetation

Westcoast Transmission Company Limited is a federally-incorporated pipeline company regulated by the National Energy Board. The NEB, as part of a certificate to construct a pipeline, requires Westcoast to stabilize and revegetate the surface of the land which has been disturbed by construction.

Several provincial agencies also specify that rights-of-way through Crown Lands be seeded. The B.C. Ministry of Forests, for example, recommends seeding mixtures for rangelands and forested areas within each Forest District, and the local Forest officer generally inspects a project upon completion of clean-up and seeding. The Ministry of Lands, Parks and Housing also specifies seeding of Crown Lands as a condition of a Grant of Right-of-Way for pipeline purposes.

Post-Construction Monitoring of Revegetation Success

The National Energy Board requires that Westcoast submit periodic reports on the success of reclamation and revegetation for major projects. These reports may include specifics on the seed and seeding method employed, percentage ground cover (on a kilometer by kilometer basis) and a general evaluation of the success of revegetation programs.

TABLE 2

ESTIMATED SEEDING COSTS - PIPELINE RIGHTS-OF-WAY

WESTCOAST TRANSMISSION COMPANY LIMITED

PROJECT	SEEDING TIME	AREA SEEDED	METHOD OF APPLICATION	COSTS FOR HECTARE (SEED & APPLICATION)
Grizzly Valley Pipeline	fall 1978 & spring 1979	405 ha	fixed-wing	$111 ($1979)*
Coquihalla Valley	fall 1979	107 ha	fixed-wing	$107 ($1979)
Coquihalla Valley- steep hillsides	fall 1979	12 ha	hand-seeding	$225 ($1979)
Looping and upgrading – Summit Lake 100-Mile House 108-Mile Ranch	spring 1980	57 ha	fixed-wing	$105 ($1979)
Pipe Upgrading Chetwynd	spring 1980	10 ha	hand-seeding	$ 88 ($1980)
Access Road to Pine River Plant -	spring 1980	16 ha	fixed-wing	$145 ($1980)
Looping - Pine Pass	spring 1981	44 ha	fixed-wing	$119 ($1981)
Looping - Hixon	fall 1981	36 ha	fixed-wing	$142 ($1981)
Looping - Williams Lake & Hihium	fall 1981	40 ha	fixed-wing	$115 ($1981)
Junior-Sierra Pipeline Fort Nelson	spring 1981	81 ha	fixed-wing	$145 ($1981)
Grizzly Valley Replacement	fall 1982	105 ha	fixed-wing	$ 75 ($1982)

* Costs are based on coated seed mixture seeded at 34 ka press weight per hectare (equivalent to 18 kg per hectare of seeds and 16 kg per hectare of coating material).

No specific guidelines are issued by the National Energy Board concerning the methods to be used in assessing revegetation success.

To assist in preparing post-construction reports, and to evaluate our revegetation efforts over a 12-year period, Westcoast conducted a systematic field program during the summer of 1982. A bio-resource engineering student, under UBC's Co-op Program, was employed to review the literature on revegetation and develop a workable method for assessing and reporting revegetation success.

The methods used, and the results of the 1982 field program are discussed in Part 2 of this paper.

PART 2
EVALUATING REVEGETATION SUCCESS

Westcoast's evaluation program was based on standard procedures used in other British Columbia industries, and was structured specifically for evaluating linear developments in the climate and terrain of northern and central British Columbia. The emphasis of the program was evaluation of revegetation on a practical basis rather than a research level, and evaluation which was relevant to post-construction land use objectives.

Part 2 of this report discusses (1) the background information on which the evaluation program was based, (2) details of the evaluation program, and (3) 1982 field work results.

Literature Review

There are no current reclamation guidelines for rights-of-way in British Columbia, as was the case in the mining industry some 10 years ago. In 1974, mining legislation was unclear as to what constituted adequate reclamation (Dick, 1974a) and only two mining companies were attempting to assess reclamation results in quantitative terms (Dick, I974b). There is no single established method for evaluating pipeline revegetation and few standards for success which consider post-construction land use objectives. Blanket standards for British Columbia are not reasonable given the variation in elevation, climate, and terrain (Dick, 1974a).

Range inventory methods are applicable to revegetation research, mine site revegetation studies, and pipeline revegetation studies. Revegetation inventories generally include a system for study area stratification, site selection and use of sample plots or transects for

data collection. The B.C. Ministry of Environment manual "Describing Ecosystems in the Field" (MOE, 1980)has standardized collection of data including species lists, numbers lists, plant density, percent ground cover, and qualitative characteristics. The complexity and objectives of any project determine which information is most relevant. Many aspects of the B.C. Ministry of Energy, Mines and Petroleum Resources program for monitoring mine site reclamation progress are based on this manual (MEMPR, 1982).

Evaluation Program for Rights-of-Way

The program, as developed for Westcoast's rights-of-way in central and northern British Columbia, took into consideration some constraints in selecting representative sites for evaluation. Unlike highways or railways, in which steep grades and rough terrain are generally avoided or are modified for vehicular access, pipelines in British Columbia are constructed through rugged and remote terrain. Temporary access roads are generally impassable after construction is complete. Frequent creek and river crossings, where the pipe is buried in the river bed, are usually not fordable. In general, four-wheel drive vehicles or helicopters must be used to revisit many locations. The problem of accessibility is compounded by the large distances involved. Climate and elevational changes are constant, and revegetation study sites are difficult to select in a manner which provides representative sampling.

The following method of site selection was developed, taking into account the above factors:

(1) Sections of right-of-way were stratified into units, based on date of construction, date of seeding and seed mix used.

(2) In areas with good ground access to and along the right-of-way, five plots were chosen at even intervals along the pipeline section.

(3) In areas with poor access, the location of representative plots was dictated by .ground accessibility. Helicopter time was not available for this study.

(4) At each site, a vegetation plot 10 x 10 metres was chosen. A representative location was selected off any roadway or other unusual feature. Each site was marked on air photo mosaics for future reference, and colour photographs were taken as a permanent record of site conditions and vegetative cover.

At each study location, a standardized evaluation procedure was followed, based on a set of guidelines, as follows:

(1) A general information sheet was completed for each unit outlining seeding details and general results.

(2) A detailed data sheet was completed for each site compiling physical, vegetative, and photographic information.

Examples of the general information sheet, detailed data sheet, and guidelines for data collection are inserted in the Appendix of this report. (Appendix A.)

This evaluation program proved very workable in field studies. Four of fourteen units studied in 1982 were surveyed by two different people. Responses to each question were comparable, indicating that the results are objective and repeatable.

1982 Field Studies

Sixty-nine plots on fourteen right-of-way sections were surveyed during July and August, 1982. Ten sections were located between Prince George and Fort St. John in northern B.C., and the remaining four were located between Hihium and Prince George in central British Columbia. Section 1 was the northernmost, and Section 14 the southernmost (Table 3).

This survey was the first detailed review of the Westcoast revegetation program. While general cover and good visual appearance had been noted prior to 1982, little was known about the relative success of the agronomic species seeded over the previous 12 years.

Table 3 summarizes some of the key data gathered. Physical site information collected included growth material, moisture, slope, aspect, presence or absence of erosion channels, and elevation. As well, vegetation data such as percent ground cover, species present, relative abundance, height, vigor, flowering status, and overall appearance of the right-of-way was reported.

Table 4 lists the right-of-way sections in order of increasing percent ground cover. Humus cover, vegetation cover, and total cover were lowest for the most recently seeded sections, and generally increased with the number of years since seeding. Percent cover was also influenced by elevation, climate, growth material, and moisture. These factors account for some variation between sites of similar age. Cover of greater than 50% on some of the older sections would appear excellent when compared with some literature values for evaluating northern pipeline restoration (Johnson, 1981).

TABLE 3

SUMMARY OF DATA FROM 1982 REVEGETATION INVENTORY

PIPELINE SECTION	AVERAGE ELEVATION (FEET)	CONSTR-UCTION YEAR	SEEDING YEAR	SEEDING METHOD	SEED MIX	% AVERAGE COVER (TOTAL)	SPECIES DOMINANT	SPECIES MISSING	COMMENT
1	2790	1977	1978	AIR	2B	75	BROME ALFALFA TIMOTHY	-	EXCELLENT GROWTH
2	2500	1979	1980	HAND	2B	73	ALFALFA	SWEET CLOVER	EXCELLENT GROWTH
3	2400	1957	-	-	-	93	N/A	N/A	TREES & NATIVE HERBS DOMINANT
4	2400	1978	1978/79	AIR/AIR	SPECIAL	88	-	-	EXCELLENT GROWTH
5	2300	1971/72	1972	AIR	2A	91	BROME FESCUE TIMOTHY ALSIKE	-	DANDELION ABUNDANT
6	2400	1973	1973	AIR	2A	78	BROME TIMOTHY ALFALFA* FESCUE	-	ALFALFA PRESENT
7	2600	1980	1981	AIR	2B	33	TIMOTHY FESCUE SWEET CLOVER ALSIKE	-	EXTREM.VARIABLE; BROME & ALFALFA RARE
8	2700	1971/72	1972	AIR	2A	65	REDTOP	SWEET CLOVER	SHRUBS COMMON
9	2400	1973	1973	AIR	2A	90	-	-	WEEDS & SHRUBS COMMON
10	2400	1971/72	1972	AIR	2A	70	-	SWEET CLOVER	WEEDS COMMON
11	2500	1980	1981	AIR	2B	12	RED CLOVER	SWEET CLOVER	AGRONOMICS RARE; CHANNELS
12	2500	1980	1981	AIR	2B	12	ALSIKE TIMOTHY FESCUE BROME	SWEET CLOVER	WEEDS COMMON; CHANNELS
13	3000	1980	1981	AIR	3	12	-	-	REDTOP*; HEAVILY GRAZED WEEDS COMMON
14	4500	1980	1981	AIR	3	9	-	-	REDTOP*; VIGOROUS GROWTH

* NOT PRESENT IN SEED MIX

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TABLE 4

SECTIONS RANKED FROM LONEST TO HIGHEST TOTAL COVER

PIPELINE SECTION	AVERAGE % COVER	YEAR SEEDED
14	9	1981
11	12	1981
12	12	1981
13	12	1981
7	33	1981
8	65	1972
10	70	1972
2	73	1980
1	75	1978
6	78	1973
4	88	1978-1979
9	90	1973
5	91	1972
3	93	1957 (UNSEEDED)

Field Observations

All agronomics originally seeded were observed on each section, with the noticeable exception of sweet clover. Unseeded agronomics were sometimes observed. Agronomic occurrence and abundance varied with site age and growth material. Grasses, legumes or a mixture of grasses and legumes dominated at each site, with no clear pattern. On newer sites, agronomic population roughly reflected percentage composition by number of seeds in the mixture used. Brome, sweet clover and alfalfa were generally infrequent on more recently-seeded sites, and timothy and fescue more common. These relative compositions changed with age of the site, with brome and alfalfa becoming more common on older sections.

Trees, shrubs and native herbs were commonly observed on older sections as well as over the original pipeline adjacent to the newer loop lines. Trees and shrubs are undesirable as they eventually prevent access for pipeline maintenance but it remains unclear whether seeding of grasses and legumes has helped to reduce tree and shrub invasion on the right-of-way.

The occurrence of weeds was variable. On some sections seeded in 1981, weeds were rare, while on others they were abundant. On most older sites weeds were common, with one or two (such as dandelion) being particularly abundant. Weed occurrence appeared related to moisture and grazing conditions on the right-of-way.

Species height, vigor and flowering status generally reflected nutrient and soil conditions. Areas having higher percentage ground covers supported healthier, taller, more mature plants. These were generally older sites where organic matter and nutrients are more plentiful.

No slumping was observed at any sites. Minor erosion channels were present on some hills, particularly on newer sections.

As has been mentioned, physical details of the site were found to influence vegetation performance. Growth material had the most noticeable influence. Rocky, dry sites with little organic matter supported fewer, less vigorous plants than sites with more organic soil. Elevation also influenced growth. Less vigorous immature plants with a lower germination rate were observed on 1981 Section 14 at elevation 1370 m than on 1981 section 7 at 820 m. However, climate may also be an important factor in this case since Section 14 is in a considerably drier climate zone.

No clear relationship was observed between slope, aspect, and plant growth. In more protected areas at the sides of the right-of-way and at locations where moisture could accumulate, growth was accelerated.

None of the 14 sections studied had been fertilized, except Section 4 on which N-P-K coated seed was used. Therefore, the effectiveness of fertilizer for providing good long term cover with reduced tree repopulation cannot be assessed, based on 1982 field work.

CONCLUSIONS

The revegetation evaluation program was well suited to collecting data relevant to the reclamation objectives of Westcoast Transmission Company Limited. Much was learned about the progress of revegetation, and some basic field techniques were developed which can be used in future years.

Results of 1982 field work indicate that post-construction objectives of erosion control, improved aesthetics and enhanced animal forage are attainable through reseeding. The effectiveness of reseeding for tree and brush control remains uncertain.

Further monitoring could help to determine the costs and benefits of fertilizing over the long term, and the effects of grass and legume seeding on tree invasion.

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APPENDIX A

WESTCOAST TRANSMISSION COMPANY LIMITED

PIPELINE RIGHT-OF-WAY REVEGETATION INVENTORY

GUIDELINES FOR DATA COLLECTION

These guidelines are to assist the pipeline right-of-way revegetation inventory. They are based on the "Reclamation Inventory Handbook", B.C. Ministry of Mines and Petroleum Resources (Inspection & Engineering Division) and "Describing Ecosystems in the Field", B.C. Ministry of Environment, Resource Analysis Branch. The following points apply specifically to the revegetation inventory to be undertaken by Westcoast Transmission, commencing July 1982. For greater detail, refer to the above references.

A. DATA SHEET

One data sheet is completed for each site where observations are taken along the right-of-way unit.

1. Date - self explanatory.
2. Inventory Performed By - write name of surveyor.
3. Loop Name/Mile-Post Marker - constitutes one unit, or file, in the inventory program.
4. Site Number - number beginning from one, for each loop which refers to locations at which data is collected.
5. Site Location - free format information to aid another person in re-visiting the site. Used in conjunction with air photo mosaics on which loop name and site number are marked.
6. Vegetation Plot Size - usually 10 x 10 m for vegetation description.

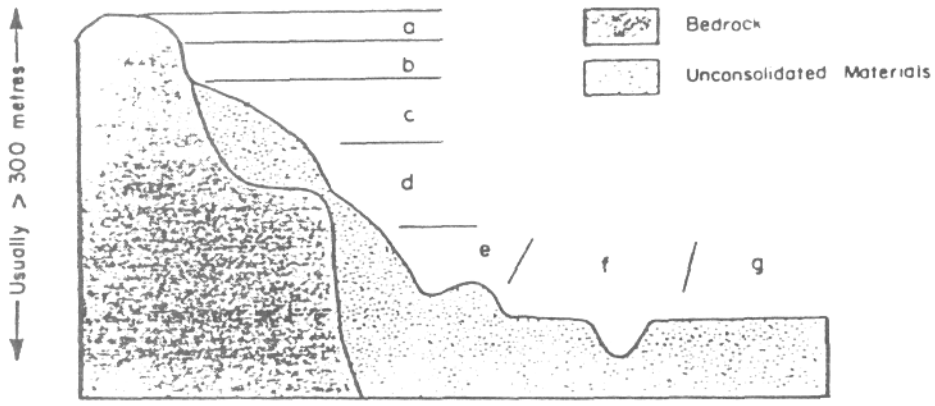
7. Plot Location; Plot Representing - note factors for which the plot location was chosen to be representative on the site; i.e. off roadway, revegetation representative, drainage or slope typical, etc.

8. Elevation - determine from topographic maps.

9. Slope - measure with a clinometer and express in degrees.

10. Aspect - measure orientation of slope face with a compass and express in degrees from North. Level ground has no aspect. Set compass declination to correct for local magnetic variation.

11. Site Position Macro - site position ranging from mountain top to plain or plateau. Use the following illustration and guide lines to circle the appropriate position:



a. Apex - the uppermost portion of a mountain. Surface shape is often convex.

b. Face - the vertical rock wall with steep exposed bedrock.

c. Upper Slope - the generally convex upper portion of the mountain slope immediately below the apex and, if present, the face.

d. Middle Slope - the area of a mountain between the upper slope and the lower slope where the general slope profile is not distinctly concave nor convex.

e. Lower Slope - the area toward the base of the mountain slope where the broad slope profile is generally concave.

f. Valley Floor - lower part of the valley system, bounded on both sides by mountain ranges, and more or less horizontal in cross section. -Valley floors generally have level to moderate slopes.

g. Plain - the area in which gravitational forces and confinement of water bodies by mountainous topography (30Cm difference between mountain tops and valley floors) are not major factors in the processes of landscape formation. Plateaus are considered as elevated plains. Plains may occur at any elevation.

12. Surface Shape - refer to diagram below and circle appropriate shape. Surface of site will be concave, convex, straight or flat. Microtopography is smooth if mounds are less than 1m high, over 7m apart and irregular if mounds are from .3 to greater than Im high, less than 7m apart. (See p.32 of "Describing Ecosystems in the Field", p.19 of "Reclamation Inventory Handbook").

concave - the surface profile is predominantly "hollow" in one or several directions.

convex - the surface profile is predominantly steepening in one or several directions away fron the highest point.

straight - the surface profile is linear, either flat or sloping in one direction.

13. Exposure Type - degree to which the site experiences climatic stresses in excess of the typical zonal climate of the area. Circle appropriate category. Consider wind, insulation, frost, cold air drainage, water spray, atmospheric toxicity, snow accumulation. Note contributing factors.

14. Erosion - self explanatory. Circle appropriate category.

15. Growth Material, Soil - comment generally on substrate. Note size and extent of rocks, soil, soil colour.

16. Moisture, Drainage - comment generally on moisture, dryness, or drainage of the site.

17. Photographs - record number of film and negative and note briefly the photo content. Photos of upstream and downstream views, vegetation plot, and closeups showing % cover should be included.

18. % Humus Cover - percentage of surface area within the plot that is covered by humus, including dead plant material and litter.

19. % Vegetation Cover - percentage of the ground area covered by a vertical projection of vegetation onto the ground surface. This is estimated visually, looking down. See comparison charts, p. 134-135, in "Describing Ecosystems in the Field". Take some photographs indicating what the surveyor has considered to be the various percentage covers.

20. % Total Cover - percentage of the ground covered by either humus or vegetation; will not necessarily be the sum of 18 and 19.

21. Vegetation Details -

a. Species - identify and list.

b. Abundance - specify relative species' abundance using the following terms:
   - dominant
   - abundant
   - common
   - infrequent
   - rare.

c. Height - average height of each species.

d. Vigour - describe appearance generally as weak, normal or strong. Refer when possible to the following criteria:

   Criteria
   a) normal
   b) feeble
   c) vegetative propagation
   d) eaten as forage
   e) water stress
   f) chlorosis and mottling on leaves
   g) red colouring on leaves
   h) yellow leaves
   i) purple leaves.

e. Comments - expand on a) through d). or add any other remarks if necessary.

22. Remarks - use this space for any additional comments or unique information on the site.

B. GENERAL INFORMATION SHEET

The information sheet is completed after all data is collected for a given loop. This sheet is completed once for each loop or specific pipeline right-of-way. Construction and seeding information is obtained from Westcoast Lands & Right-of-Way Division files.

Remarks summarize the overall impression of revegetation and reclamation success or failure. Note any correlations of success/failure with physical or environmental factors found in the site descriptions.

General comments include any additional or unique information related to the right-of-way unit. Use back of page if necessary.

WESTCOAST TRANSMISSION COMPANY LIMITED

PIPELINE RIGHT-OF-WAY REVEGETATION INVENTORY

DATA SHEET

1. Date of Inventory _____ 2. Inventory Performed by _____

3. Loop/Interval _____ 4. Site Number _____

5. Site Location _____

_____

6. Vegetation Plot Size _____

7. Plot Location, Plot Representing _____

_____

SITE DESCRIPTION

8. Elevation _____ 9. Slope _____ 10. Aspect _____

11. Site Position Macro

a apex
b face
c upper slope
d middle slope
e lower slope
f valley floor
g plain

12. Surface Shape

a smooth convex
b irregular convex
c smooth straight
d irregular straight
e smooth concave
f irregular concave
g smooth flat
h irregular flat

13. Exposure Type

a sheltered
b normal
c exposed
d contributing factors
_____
_____
_____

14. Erosion

a no channels
b channels - 10cm deep
c channels - 10-20cm
d channels - 20-30cm
e greater than 30cm

comments: _____ _____ _____ _____

15. Growth Material, Soil _____

_____

16. Moisture, Drainage _____

_____

VEGETATION DESCRIPTION

17. Photographs: Film-Frame Number Content

_____ _____

_____ _____

_____ _____

_____ _____

18. % Humus Cover_____ 19. % Veg. Cover_____ 20. % Total Cover____

21. Vegetation Details

	a. Species	b. Abundance	c. Height	d. Vigor	e. Comments
TREES					
SHRUBS					
NATIVE HERBS					
WEEDS					
AGRONOMICS Grasses Legumes Weeds					

22. Remarks_____

WESTCOAST TRANSMISSION COMPANY LIMITED

PIPELINE R.O.W. REVEGETATION INVENTORY

GENERAL INFORMATION SHEET

Dates of Inventory _____

Loop Name/Mile-Post Interval _____

Site Numbers _____

Photo Numbers _____

Pipeline: _____ Construction Year: _____

_____ _____

_____ _____

Date Seeded _____

Seed Mix _____

Method of Seeding _____

REMARKS:

1. Overall impression of right-of-way revegetation and reclamation success.

2. General Comments: