Twelve Mile Coulee Pipeline Topsoil Handling Soil Research Project

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By

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TABLE OF CONTENTS

TABLES

FIGURES

APPENDIX

EXECUTIVE SUMMARY

Companies installing pipelines seek economical, practical and environmentally responsible methods of soil handling during pipeline construction to ensure successful soil reclamation.

The objectives of the Twelve Mile Coulee Soil Research Project are to evaluate the impact of pipeline construction on Solonetzic soil quality and salt movement in the Brown soil zone. This research addresses soil handling practices on actively grazed native prairie in a landscape dominated by Brown Solonetz soils developed on till. Topsoil overstripping with a stepblade versus no stripping of trenchline (for small lines) is compared. Several important findings two years after summer construction are:

- A step blade is effective in overstripping topsoils to re-establish fair surface soil quality as compared to poor quality on no strip plots. The native soils have a 10 cm Ah over an Ae and Bnt horizon sequence. Overstripping to 20-25 cm salvages the Ah to upper B horizons. Upon reclamation, the capability of overstripped soils is slightly better (about half a class) than that of no stripped soils.

- There is increased topsoil salinity in both overstripped and no stripped treatments, but higher salinity in the latter. In overstripped treatments topsoil salinization occurs during topsoil replacement rather than during stripping.

- In this prairie landscape dominated by Brown Solonetz soils, vegetation is responding well on both the overstripped and no stripped treatments.

- No topsoil stripping is a viable alternative on straight lines, but is not viable on road and pipeline crossings or other major disturbances.

1.0 INTRODUCTION

Can-Ag Enterprises Ltd. was commissioned by NOVA Gas Transmission Division to conduct a research and monitoring study which compares topsoil overstripping with no stripping in Brown Solonetz soils. This report provides a description of baseline soil conditions prior to construction, and subsequent post-construction monitoring in the falls of 1993, 1994 and 1995. Initial vegetation cover and vegetation performance on the trenchline is also addressed.

The objectives are to evaluate the impact of pipeline construction on Solonetzic soil quality and salt movement in the Brown Soil zone. This research addresses soil handling practices on actively grazed native prairie in a landscape dominated by Brown Solonetz soils developed on till. Topsoil overstripping with a stepblade versus no stripping of trenchline (for small lines) is compared.

2.0 GENERAL DESCRIPTION OF STUDY AREA

2.1 Location and land use

The study is located in southeastern Alberta, west of the Town of Suffield (Figure 1). The legal locations are Sec 19-15-11-W4M and NE 18-15-11-W4M. The project is located in native grassland vegetation used for cattle grazing.

2.2 Bedrock geology

According to Green (1972), the route overlies the Oldman Formation. The Oldman Formation is nonmarine, and is below trench depth throughout the route.

2.3 Climate

Climatic characteristics for the area are representative of dry mixed grass Ecoregion of Alberta (Strong and Leggat, 1992). According to the Alberta Soils Advisory Committee (1987), the climatic limitation for agriculture is moisture deficiency (Climatic Moisture Index: -460), with an overall agroclimate rating of 3A (Moderate Moisture Limitation).

2.4 Soils and topography

The study area lies within the Brown Soil Zone of southeastern Alberta. The landscape is dominated (60%) by Brown Solodized Solonetz (Hemaruka Series) soils developed on till and on a discontinuous lacustrine veneer over till. Solonetzic Brown Chernozems (Ronalaine Series) and Brown Solod (Halliday Series) each make up about 20% of the landscape. The topography is undulating with very gentle slopes. From a pipeline construction perspective, the area is a 2-lift candidate based on the occurrence of Bnt and Bnt-like horizons being dominant. In terms of chemical criteria, EC and SAR levels are such that 3-lift handling would be necessary if Chernozemic soils were dominant.

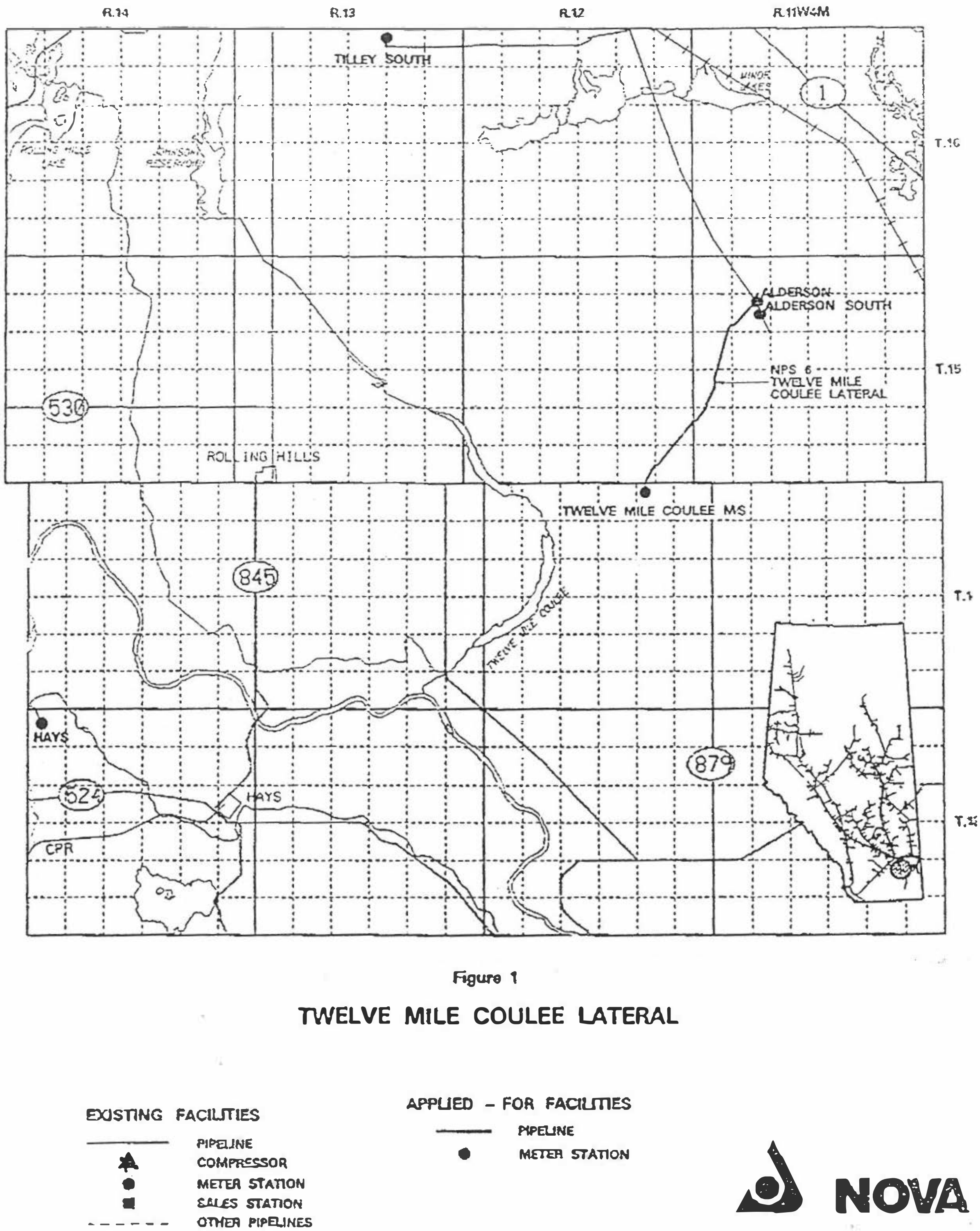

Figure 1. Study location.

3.0 STUDY DESIGN

3.1 Initial soil investigation

A pipeline soil survey was conducted in March, 1993, on a 1:10,000 scale photomosaic alignment sheet. The soils and landscapes were described in terms of landform, surficial materials, slope, texture, stoniness, topsoil thickness, drainage conditions, profile morphology and soil chemistry. Soils were examined to trench depth (1.2 m), at two or more sites per quarter section and to approximately 50 cm at four additional sites per quarter. Soils were classified and described according to the criteria established by the Agriculture Canada Expert Committee on Soil Survey (1987) and correlated with the Alberta Soil Series Working Group (1992). Areas of similar topsoil depth and topography were delineated and assigned soil-landscape units (Leskiw 1993).

3.2 Site selection and pre-construction characterization

A general area for the study was chosen based on information from the initial soil survey. This area is characterized by a dominance of Hemaruka soils, with an average topsoil depth of 10 cm, on class 2-3 topography and native rangeland. A specific site for the research plots was then found within this area. Criteria for site selection included relative uniformity in slope, landform and soil type.

Plot layout and characterization was completed in July, 1993. Eight plots 100 m long were selected in total, 4 plots for each of the topsoil strip and no strip treatments. An interval between the plots of 10 m or more was included (Figure 2). After selection, plots were sampled along the future trench-line at a single location within each plot. Adjacent control samples were also taken along the right-of-way (ROW) west boundary. Samples of A, B and C horizons were taken to 1m depth for salinity analysis.

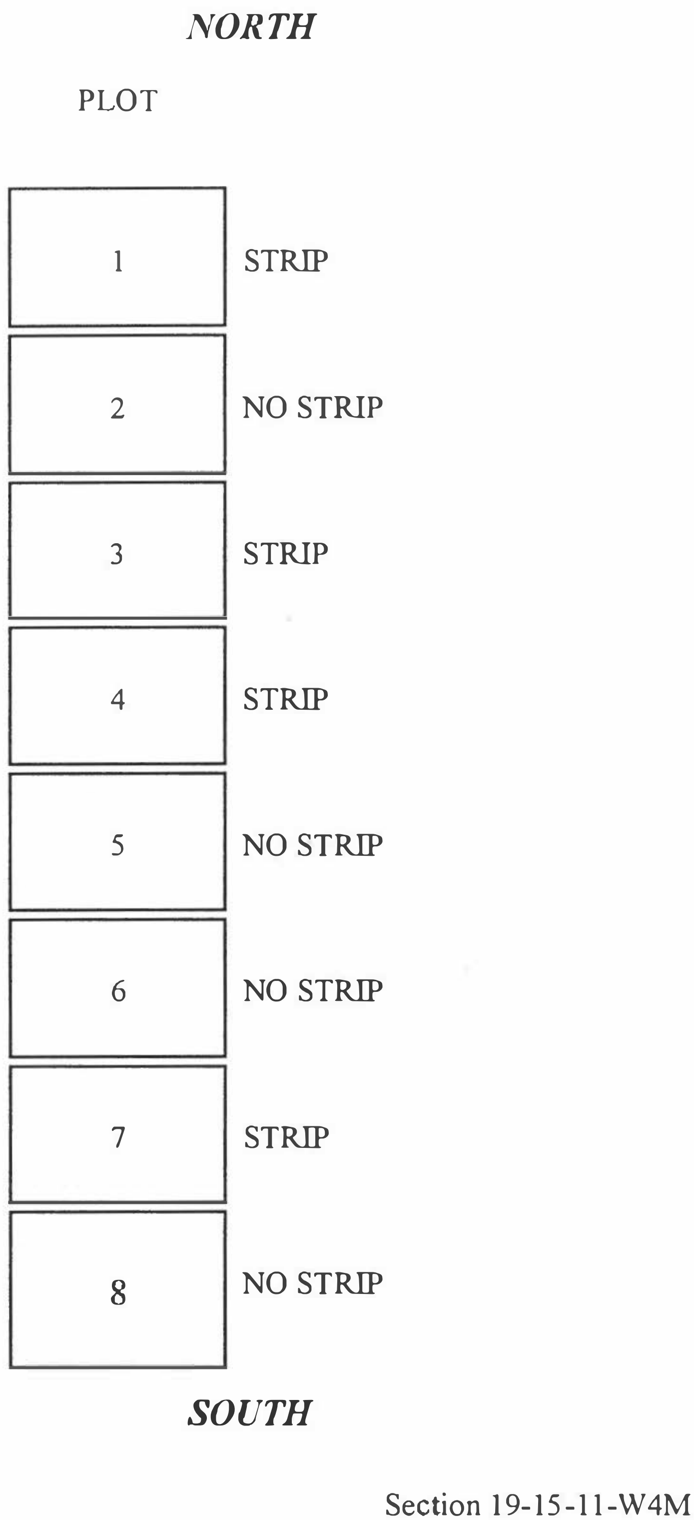

Figure 2. Site layout.

3.3 Pipeline construction and concurrent sampling

Pipeline construction and concurrent sampling occurred in mid-August, 1993 (Figures 3 and 4). Topsoil overstripping in the strip treatment was performed with a plate welded to the grader blade. This made a cut approximately 20-25 cm deep and 60 cm wide and pushed the topsoil to one side. A trencher excavated a 30 cm wide by 1.2 m (in places to 1.5 m) deep trench, piling the material on either side. After placing the pipe, the mix of lower B and C horizons were replaced and capped with the topsoil. It should be noted that the removal of 20-25 cm of topsoil entailed overstripping the topsoil which is about 10 cm. In no strip treatments the trencher was used to excavate the entire trench depth resulting in mixing of all horizons.

During construction further soil characterization and sampling was conducted. Ten sites were classified along the trench line, commencing 5 m into each plot and proceeding at 10 m intervals. Classification was completed after the topsoil had been removed in the strip treatments. The topsoil piles in the strip treatments were subsampled and composited for analysis (one sample per plot). Random subsoil samples during construction were taken from subsoils of a Hemaruka map unit, north of the plots.

3.4 Post-construction characterization

Post-construction investigation and sampling was initiated in mid-October, 1993. Sampling design involved taking samples from 0-20 cm (topsoil layer) and 25-40 cm (upper subsoil layer) at approximately the same 10 m interval locations previously investigated during pipeline construction. The 10 samples were combined, respectively, to make topsoil and subsoil composites for each plot.

Sampling was repeated in late November, 1994, and November, 1995. Vegetation descriptions and soil samples were taken at ten sites per plot, based on the construction sampling intervals. Soil sampling depths were similar to 1993. Samples were composited to provide one sample per depth for each plot. A soil sample was also taken in the middle of each plot at the 0-20 cm, 20-35 cm, 35-50 and 50-70 cm depths. In 1995 a "control" profile was also sampled 2 m west of the "trench" profile within each plot. The control profile was sampled by horizons to 1 m.

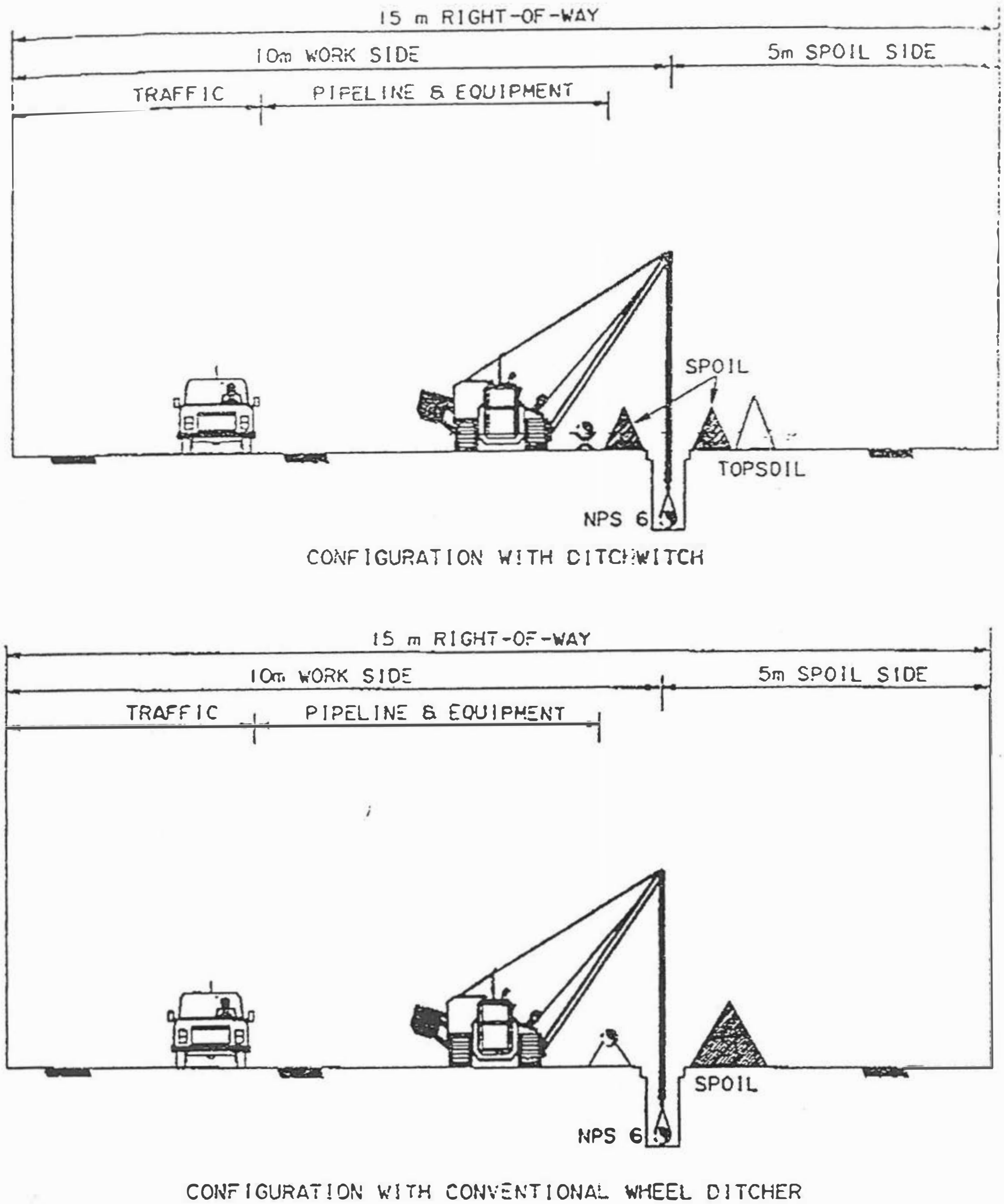

Figure 2
RIGHT-OF-WAY CONFIGURATIONS
NPS 6 TWELVE MILE COULEE

Figure 3. Right-of-way configurations.

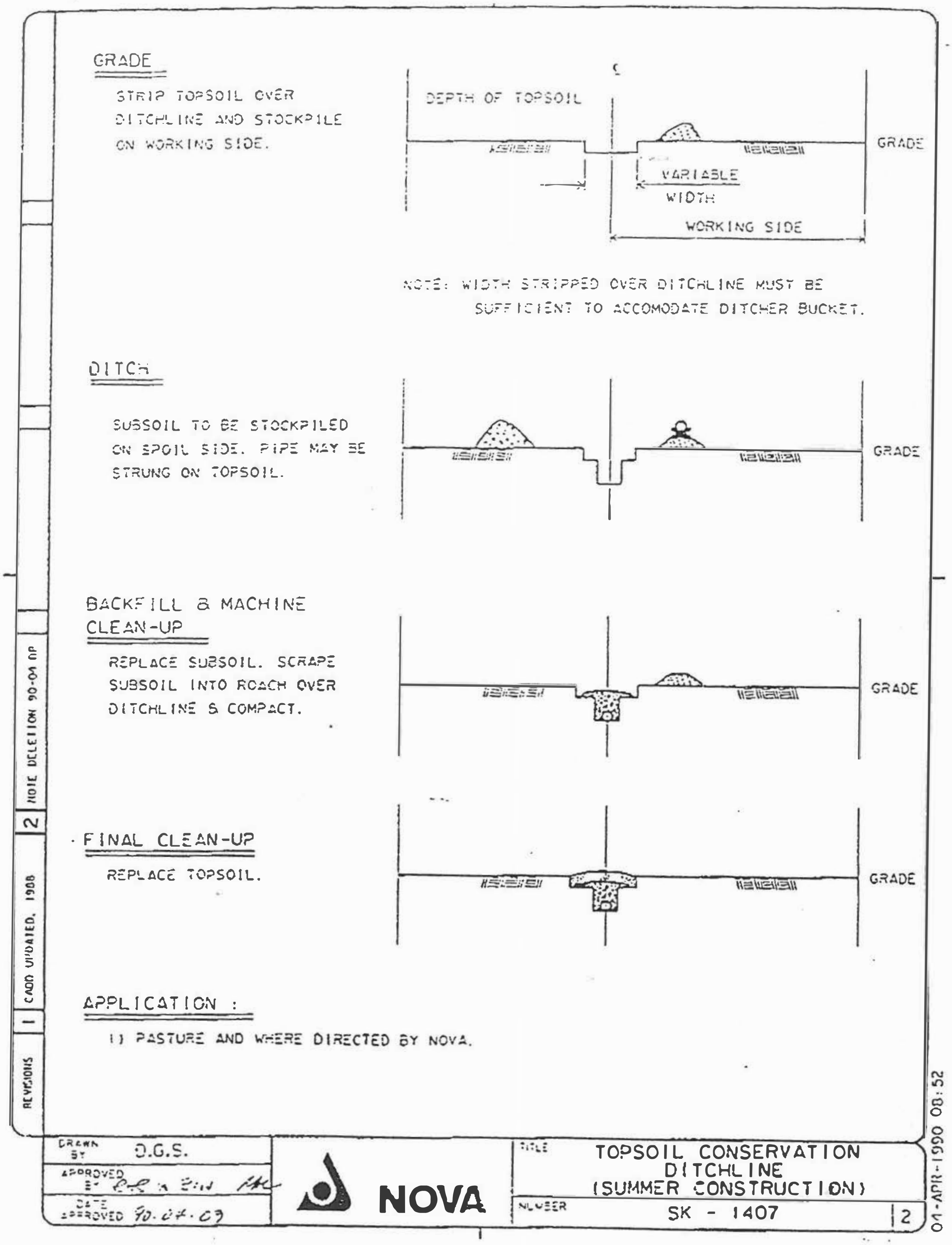

Figure 4. Topsoil conservation ditchline.

3.5 Soil chemical analysis

The soils were analyzed using standard soil investigation methods, as outlined by McKeague (1978), by Lakeside Research in Brooks. Electrical conductivity (EC), saturation percentage (SAT%), soluble cations, sodium absorption ratio (SAR), and soil reaction (pH) were determined for all subsoil samples collected. Percent organic matter (OM%) was determined for all A and B horizon samples collected in 1994 and all A horizons in 1995.

3.6 Soil capability analysis

Soil capabilities ratings were determined based on the *Land Reclamation: Agricultural Capability Classification* (Leskiw and Kutash 1993) for the pre-construction control and trench and post-construction 1993, 1994 and 1995 sample sites. Both Soil Index and Soil Capability Rating are reported in this study.

3.7 Vegetation characterization

Vegetative cover on the native range was inspected on controls (west of ROW) in the fall of 1993. Percent cover of different principal species was estimated at 10 m intervals, using a 0.1 m^2 frame. In fall of 1994 and 1995 the regrowth of vegetation on the trenchline was measured by counting the number of plants per meter length in a drill row at 10 m subsample intervals within each plot. The trenchline in 1994 and 1995 was overgrazed; nevertheless, vegetation appears to be developing satisfactorily.

4.0 STUDY RESULTS

4.1 Soil Classification

Soil classification based on trench examination during construction indicates three main soil types (Tables 1-3). Brown Solodized Solonetz is the dominant soil, found at 59% of the investigation sites. Solonetzic Brown Chernozems are found at 22% and Brown Solods are found at the remaining 19% of the investigation sites. All soils are developed on clay loam till or clay loam lacustrine veneer over till. Subsequent chemical analysis (SAR) implies that some of the Brown Solodized Solonetz soils may be classified as Solonetzic Brown Chernozems even though they have well developed Bnt-like horizons in terms of structure and consistence.

Table 1. Hemaruka (HUK) Series.

Soil Classification				Brown Solodized Solonetz	
Parent Material				till	
Texture (topsoil/subsoil)				loam / clay loam	
Topography/Percent Slope				nearly level to very gently undulating <5%	
Surface Stoniness				moderately	
Drainage Class				well	
Topsoil Depth/Relationship to Topography				10 cm (Ah)	
Land Use				native rangeland	
Sod Quality (good/poor)				good	
Colour Transition (good/poor) Topsoil / Subsoil				poor brown (Ah) / brown to dark brown (Bnt)	
PROFILE:					
Horizon	Depth (cm)	Color	Texture	Structure	Consistence
Ah	0-10	brown	loam	granular	friable
Bnt	10-30	brown, dark brown	clay loam	columnar, angular blocky	very firm
Ccasa	30-120	grayish brown	clay loam	massive	very hard

Representative chemistry of Series taken from Appendix 2.

Location	Horizon	Depth (cm)	pH	EC (dS/m)	SAT (%)	SAR	OM (%)	Texture
Plot 6	Ahe	0-8					5.7	fSL-L
Trench	Bnt	8-22	7.6	0.72	76.0	7.4	4.9	CL
	Ccasa	22-100	7.9	5.88	51.5	7.4		CL

COMMENTS: Review of trench inspection sites reveals topsoil (Ah) thickness ranges from 5-14 cm, with a mean of 8.4 cm, out of 41 sites. Four sites were "eroded" and had no Ah. The overstripping to 20-25 cm therefore includes Ae, AB and Bnt material.

Table 2. Halliday (HDY) Series.

Soil Classification	Brown Solod
Parent Material	till, lacustrine veneer over till
Texture (topsoil/subsoil)	loam / clay loam
Topography/Percent Slope	very gently undulating / <5%
Surface Stoniness	moderately
Drainage Class	well
Topsoil Depth/Relationship to Topography	10 cm (Ah)
Land Use	native rangeland
Sod Quality (good/poor)	good
Colour Transition (good/poor) Topsoil / Subsoil	poor brown (Ah) / brown to dark brown (Bnt)
PROFILE:	

Horizon	Depth (cm)	Colour	Texture	Structure	Consistence
Ah	0-12	dark brown	loam	granular	friable
AB	12-25	brown	clay loam	subangular blocky	firm
Bnt	25-45	dark brown	clay loam	angular blocky, columnar	very firm
Ccas	45-120	brown	clay loam	massive	hard

Representative chemistry of Series taken from Appendix 2.

Location	Horizon	Depth (cm)	pH	EC (dS/m)	SAT (%)	SAR	OM (%)	Texture
Plot 3	Ahe	0-8					5.2	L
Trench	Bnt	8-25	7.4	0.71	74.5	5.4	5.4	CL
	Ccas	35-100	8.1	2.34	50.5	8.7		CL

COMMENTS: Review of trench inspection sites reveals topsoil (Ah) thickness ranges from 6-12 cm, with a mean of 9.8 cm, out of 16 sites. The overstripping to 20-25 cm therefore includes Ae, AB and a small amount of Bnt material.

Table 3. Ronalaine (ROL) Series.

Soil Classification	Solonetzic Brown Chernozem
Parent Material	till
Texture (topsoil/subsoil)	loam / clay loam
Topography/Percent Slope	gentle slopes / 2-5%
Surface Stoniness	moderately stony
Drainage Class	well
Topsoil Depth/Relationship to Topography	10 cm (Ah)
Land Use	native rangeland
Sod Quality (good/poor)	good
Colour Transition (good/poor) Topsoil / Subsoil	poor brown, dark brown (Ah) / brown, dark brown (Bt, Btnj)

PROFILE:

Horizon	Depth (cm)	Color	Texture	Structure	Consistence
Ah	0-10	dark brown	loam	granular	friable
Btnj	10-30	brown	clay loam	subangular blocky	firm
Cca	30-120	grayish brown	clay loam	massive	hard

Representative chemistry of Series taken from Appendix 2.

Location	Horizon	Depth (cm)	pH	EC (dS/m)	SAT (%)	SAR	OM (%)	Texture
Plot 1	Ah	0-10					5.0	L
Trench	Bnt	10-30	7.2	0.35	44	0.3	3.2	CL
	Cca1	30-50	8.1	0.45	47.5	1.7		CL
	Cca2	50-100	8.8	1.17	56.5	9.1		CL

COMMENTS: Review of trench inspection sites reveals topsoil (Ah) thickness ranges from 6-15 cm, with a mean of 10 cm, out of 19 sites. The overstripping to 20-25 cm therefore includes Ae, AB and Btnj material.

Table 4. Soil descriptions of Twelve Mile Coulee research plots during construction.

Plot	Investigation Site Location (m) north									south	Soil Handling Treatment	Soil Type Ratio (BSS:BSO:SZB)
	5	15	25	35	45	55	65	75	85	95		
1	BSS*	BSO	erBSS	SZB	SZB	BSS	BSO	SZB	BSO	erBSS	Strip	4:3:3
2	SZB	BSS	SZB	erBSS	BSS	BSO	BSS	BSS	SZB	BSS	No strip	6:1:3
3	SZB	BSO	BSO	BSS	SZB	SZB	SZB	BSO	BSO	BSS	Strip	2:4:4
4	BSS	SZB	BSS	BSS	SZB	BSS	BSS	SZB	BSO	SZB	Strip	5:1:4
5	SZB	BSS	BSS	BSS	BSO	SZB	SZB	BSS	BSS	BSS	No strip	6:1:3
6	BSS	BSO	BSS	erBSS	BSS	BSO	BSS	erBSS	BSS	BSO	No strip	7:3:0
7	BSS	BSS	BSS	BSS	BSS	BSS	BSS	BSS	BSS	BSS	Strip	10:0:0
8	SZB	BSS	BSS	BSS	BSO	BSS	BSS	BSS	BSO	BSS	No strip	7:2:1

*Soil Classification: BSS - Brown Solodized Solonetz, BSO - Brown Solod, SZB - Solonetzic Brown Chernozem, er - eroded.

4.2 Soil Quality During Construction

Pre-construction samples indicate that natural topsoils are nonsaline and nonsodic. The subsoil salinity ranges from 0.35-9.42 dS/m while SAR ranges from 0.3-11.9 (Appendix 2). The Salinity generally is not limiting plant growth since most values 0-100 cm are below 4 dS/m

Organic matter levels in the topsoil are typical for the Brown soil zone, with content ranging from 3.7-6.0 %. Baseline levels between the control and the trench are generally similiar.

Topsoil stockpiles sampled during pipeline construction are nonsaline (Table 5). Topsoil salinity affected was as subsoil was mixed into the topsoil during overstripping. The depth of topsoil stripping is approximately 20-25 cm, while the average topsoil depth is 10 cm. Table 5 also presents levels from subsoils excavated from the trench.

Table 5. Topsoil and subsoil composites taken during construction.

Plot	pH	EC (dS/m)	SAT (%)	SAR
		Topsoil from construction piles		
1	7.2	1.05	55.5	3.0
3	6.4	0.67	52.0	2.3
4	7.2	1.17	56.5	3.3
7	7.5	0.95	69.5	4.8
		Subsoil from random samples		
*	7.6	5.61	54.5	6.3
	7.6	5.58	53.5	6.2
	7.6	6.93	52.0	8.3
	7.8	7.03	52.5	9.7

* These samples taken from spoil pile in Hemaruka soils north of plots.

4.3. Soil Quality After Reclamation, 1993, 1994 and 1995

4.3.1. Composite Sampling of Topsoils and Subsoils in Plots

In the strip treatment, samples taken after reclamation (October, 1993) indicate that the topsoil had increased EC levels compared to the control (Table 6). Subsoil may have been mixed into the topsoil during stripping or subsoil being included with the topsoil during reclamation. The reclaimed subsoil also had higher EC levels relative to the control. Deeper, more saline subsoil may have been brought closer to the surface as a result of construction. Topsoil organic matter levels decreased compared to the control in the strip treatment. Subsoil was likely mixed into the topsoil during stripping or subsoil was being included with the sample in post-construction sampling. Organic matter levels in the subsoil appear higher than would be expected. Organic residue may have been scraped into the trench during spoil replacement.

In the no strip treatment, samples taken after reclamation (October, 1993) also show that the topsoil and subsoil had increased EC levels compared to the control (Table 7). Material from the lower subsoil may have been brought closer to the surface with the mixing action of construction. Organic matter levels in the topsoil and subsoil appear higher than would be expected. Organic residue may have been scraped into the trench during spoil replacement.

Table 6. Soil quality at strip plots after reclamation (October, 1993).

Plot	Depth*	EC (mS/cm)	Percent Saturation	SAR	pH	OM (%)	Soil Quality**
1	TS	2.15	53.5	1.9	7.2	3.1	F
	SS	4.84	56.0	4.6	7.7	2.2	F
3	TS	3.95	52.0	3.9	7.3	3.9	F
	SS	4.47	52.5	1.9	7.7	1.9	F
4	TS	3.54	53.5	4.0	7.1	4.0	F
	SS	3.61	57.5	1.9	7.7	1.9	F
7	TS	3.65	54.0	3.1	7.5	3.1	F
	SS	5.07	57.0	2.5	7.8	2.5	P
MEAN	TS	3.32	53.25	3.23		3.5	F
	SS	4.50	55.75	2.73		2.1	F

* TS = Topsoil (0-20 cm), SS = Subsoil (25-40 cm)
** G = Good, F = Fair, P=Poor, U = unsuitable (ASAC, 1987)

Table 7. Soil quality at no strip plots after reclamation (October, 1993).

Plot	Depth*	EC (mS/cm)	Percent Saturation	SAR	pH	OM (%)	Soil Quality**
2	TS	4.61	59.0	3.7	7.6	2.9	P
	SS	5.22	54.0	4.7	7.8	2.0	P
5	TS	4.72	52.5	4.6	7.6	2.3	P
	SS	4.38	55.0	3.8	7.5	3.6	F
6	TS	4.46	49.5	3.7	7.4	2.5	P
	SS	4.44	57.0	3.8	7.7	2.2	F
8	TS	4.09	54.0	2.4	7.2	3.3	P
	SS	4.09	64.0	2.8	7.7	1.8	F
MEAN	TS	4.47	53.80	3.60		2.8	P
	SS	4.53	57.50	3.78		2.4	F

* TS = Topsoil (0-20 cm), SS = Subsoil (25-40 cm)
** G = Good, F = Fair, P=Poor, U = unsuitable (ASAC, 1987)

Mean values of EC and organic matter were used to determine statistically significant differences (Table 8). Salinity and organic matter content were significantly different between the topsoil and subsoil in the strip treatment. The differences were not significant in the no strip treatment. This can be expected since topsoil is set aside for future replacement in the stripped treatment, while the original topsoil and subsoil are mixed together before replacement in the no strip treatment.

Salinity and organic matter content in "topsoil" (surface layer) were significantly different between the strip, and the no strip treatments. The differences were not significant for the subsoil. Again, this can be expected since topsoil is set aside for future replacement in the strip treatment. In the no strip treatments, the original topsoil and subsoil are mixed together before replacement.

Post reclamation values for 1994 sampling indicate that EC and SAR values are generally decreasing in the topsoil for the strip treatment (Table 9). The decrease is likely the result of downward salt movement due to leaching. We can see this in the SAR values of the subsoil, i.e., they have generally increased with the addition of sodium from the topsoil. Similiar trends are occurring in the no strip treatment (Table 10). Results for 1995 sampling are presented in Tables 11 and 12, and these are very similar to 1994 results.

Table 8. Statistical comparisons of treatments and soil depths in 1993.

Treatment/ Depth	**Electrical Conductivity (dS/m)**		**Organic Matter (%)**	
	Topsoil vs Subsoil			
	Mean	Probability	Mean	Probability
Strip	3.32 v 4.50	0.0619 *	3.53 v 2.13	0.0027 **
No Strip	4.47 v 4.53	0.8295	2.75 v 2.40	0.4797
	Strip v No strip			
Topsoil	3.32 v 4.47	0.0351 **	3.53 v 2.75	0.0579 *
Subsoil	4.50 v 4.53	0.9334	2.13 v 2.40	0.5486

** - significant at $p \leq 0.05$
* - significant at $p \leq 0.10$

Table 9. Soil quality at strip plots one year after reclamation (November, 1994).

Plot	Depth*	EC (mS/cm)	Percent Saturation	SAR	pH	OM (%)	Soil Quality**
1	TS	2.01	52.0	2.0	7.3	3.6	F
	SS	4.51	57.0	3.6	7.4		F
3	TS	3.38	51.0	1.3	7.1	4.5	F
	SS	4.18	52.0	2.7	7.4		F
4	TS	3.43	52.0	1.4	7.3	3.8	F
	SS	4.55	51.5	4.0	7.5		F
7	TS	3.32	54.0	2.1	7.5	3.4	F
	SS	4.75	57.0	4.0	7.6		F
MEAN	TS	3.03	52.25	1.70	7.3	3.8	F
	SS	4.50	54.40	3.60	7.5		F

* TS = Topsoil (0-20 cm), SS = Subsoil (25-40 cm)

** G = Good, F = Fair, P = Poor, U = unsuitable (ASAC, 1987)

Table 10. Soil quality at no strip plots one year after reclamation (November, 1994).

Plot	Depth	EC (mS/cm)	Percent Saturation	SAR	pH	OM (%)	Soil Quality**
2	TS	4.08	52.0	2.6	7.5	3.7	P
	SS	4.22	56.0	3.2	7.6		F
5	TS	3.92	50.0	2.5	7.5	3.2	F
	SS	4.44	51.0	3.7	7.5		F
6	TS	4.61	55.0	4.1	7.5	2.8	P
	SS	4.68	57.5	4.6	7.5		F
8	TS	4.07	52.5	2.3	7.5	2.7	P
	SS	4.61	58.0	3.9	7.5		F
MEAN	TS	4.17	52.40	2.90	7.5	3.1	P
	SS	4.49	55.60	3.80	7.5		F

* TS = Topsoil (0-20 cm), SS = Subsoil (25-40 cm)

** G = Good, F = Fair, P = Poor, U = unsuitable (ASAC, 1987)

Table 11. Soil quality at strip plots two years after reclamation (November, 1995).

Plot	Depth*	EC (mS/cm)	Percent Saturation	SAR	pH	OM (%)	Soil Quality**
1	TS	2.58	47	2.0	7.1	3.8	F
	SS	4.42	52	3.6	7.4		F
3	TS	3.21	52	1.4	6.8	4.5	F
	SS	4.19	48	2.7	7.3		F
4	TS	3.96	48	2.5	6.9	4.5	F
	SS	4.82	47	4.6	7.2		F
7	TS	3.56	54	1.8	7.1	4.6	F
	SS	4.54	53	2.6	7.3		F
MEAN	TS	3.32	50	1.9	7.0	4.3	F
	SS	4.49	50	3.4	7.3		F

* TS = Topsoil (0-20 cm), SS = Subsoil (25-40cm)
** G = Good, F = Fair, P = Poor, U = unsuitable chemical parameters (ASAC, 1987)

Table 12. Soil quality at no strip plots two years after reclamation (November, 1995).

Plot	Depth	EC (mS/cm)	Percent Saturation	SAR	pH	OM (%)	Soil Quality**
2	TS	4.37	49	3.2	7.4	3.4	P
	SS	4.52	50	3.8	7.5		F
5	TS	3.69	50	2.0	7.4	3.6	F
	SS	4.25	48	3.2	7.5		F
6	TS	4.33	50	2.6	7.2	3.8	P
	SS	4.34	54	3.3	7.4		F
8	TS	4.09	50	2.2	7.3	3.6	P
	SS	4.72	52	3.7	7.5		F
MEAN	TS	4.12	50	2.5	7.3	3.6	P
	SS	4.46	51	3.5	7.5		F

* TS = Topsoil (0-20 cm), SS = Subsoil (25-40 cm)
** G = Good, F = Fair, P = Poor, U = Unsuitable chemical parameters (ASAC, 1987)

Statistical comparisons for 1994 data confirm differences established in 1993 (Table 13). EC values in the topsoil, decreased while EC in the subsoil remained constant. The difference in salinity between topsoil and subsoil in the strip treatment is statistically significant. The difference in salinity between soil depths in the no strip treatment also increased, but was not statistically different. The difference in topsoil EC between strip and no strip was also more significant in 1994. Subsoil salinity was not significantly different between the two treatments.

Table 13. Statistical comparisons of treatments and soil depths in 1994.

Treatment/ Depth	**Electrical Conductivity (dS/m)**		**Organic Matter (%)**	
	Topsoil vs Subsoil			
	Mean	Probability	Mean	Probability
Strip	3.03 v 4.50	0.0068 **	N/A	--
No Strip	4.17 v 4.49	0.1327	NA	--
	Strip vs Non strip			
Topsoil	3.03 v4.17	0.0230**	3.8 v 3.1	0.0705 *
Subsoil	4.50 v 4.49	0.9511	N/A	--

N/A - sample not taken which would pennit comparison
** - significant at $p \leq 0.05$
* - significant at $p \leq 0.10$

Statistical comparisons in 1995 are similar to those for 1994 in terms of soil salinity (Table 14). In fact, there is no significant change in soil salinity between 1993 and 1995 (Table 15). However, in 1995 there is a pronounced and significant increase in organic matter content, in both strip and no strip treatments. This rapid increase in organic matter probably reflects increased rooting as such a rapid increase in stable organic matter is unlikely.

Table 14. Statistical comparisons of treatments and soil depths in 1995.

Treatment/ Depth	Electrical Conductivity (dS/m)		Organic Matter (%)	
	Topsoil vs Subsoil			
	Mean	Probability	Mean	Probability
Strip	3.32 v 4.49	0.0109 **	N/A	--
No Strip	4.12 v 4.46	0.1220	NA	--
	Strip vs No strip			
Topsoil	3.32 v 4.12	0.054 **	4.35 v 3.60	0.0109 **
Subsoil	4.49 v 4.46	0.8310	N/A	--

N/A - sample not taken which would permit comparison
** - significant at $p \leq 0.05$
* - significant at $p \leq 0.10$

Table 15. Statistical comparisons of treatments and soil depths between 1993 and 1995.

Treatment/ Depth	Electrical Conductivity (dS/m)		Organic Matter (%)	
	1993 vs 1995			
	Mean 1993	Probability	Mean	Probability
TS Strip	3.32 v 3.32	0.99230	3.53 v 4.35 **	0.0366
TS No Strip	4.47 v 4.12	0.2284	2.75 v 3.60 **	0.0481
SS Strip	4.50 v 4.49	0.9910	NA	--
SS No Strip	4.53 v 4.46	0.8010	NA	--

** - significant at $p \leq 0.05$.

4.3.2 Profile Sampling of Plots and Controls.

Results from samples taken in the center of the plots in 1994 and 1995 indicate that there is considerable variability in EC values with values ranging from 0.49-7.85 dS/m (Table 16). This is likely the result of natural variability in the soil and can be correlated with soil classification. An example of this is seen in Plot 3. Soil classification of the plot center (Table 1; Plot 3; Location 45, 55 and 65) is Solonetzic Chernozem, which is the best soil in terms of agriculture capability. These soils correlate with the lowest EC values in the plots (Table 16). Values from Table 16 also show the vertical variability within an individual profile, indicating that trenching does not create a homogenous spoil pile and post-construction soil profile. The post-construction upper 50 cm of the root zone is more saline in the trench than in the control.

Table 16. Summary of soil profile salinity (1994 and 1995).

Strip		1994 Plot Center		1995 Plot Center		1995 Adjacent Control		
		EC	Quality	EC	Quality	Horizon Depth	EC	Quality
1	D1*	5.07	P	4.95	P	Ah 0-9	0.73	G
	D2	2.56	G	1.95	G	Bt 9-40	0.80	G
	D3	2.15	P			Cca 40-70	0.79	F
	D4	4.84	P	5.17	P			
3	D1	2.45	F	1.68	G	Ah 0-15	0.77	G
	D2	0.62	G	1.27	G	Bt 15-40	0.66	G
	D3	0.49	G			Cca 60-90	0.92	G
	D4	0.59	G	0.70	G			
4	D1	3.95	F	3.83	F	Ah 0-9	0.48	F
	D2	4.47	F	5.47	P	Bnt 9-50	0.96	F
	D3	3.54	G			Ccas 40-70	3.58	P
	D4	3.61	G	3.23	F			
7	D1	1.08	G	2.64	F	Ah 0-8	0.84	G
	D2	4.28	F	5.36	P	Bnt 8-30	0.73	G
	D3	3.65	P			Casa 50-70	6.32	P
	D4	5.07	P	4.39	F			
No Strip								
2	D1	3.63	F	3.47	F	Ah 0-12	0.60	F
	D2	3.91	F	3.70	F	Bnt 20-50	0.68	F
	D3	6.49	P			Ccas 60-80	2.22	P
	D4	4.08	F	4.49	F			
5	D1	4.60	P	1.49	G	Ah 0-12	0.64	G
	D2	4.78	F	2.01	F	Bnt 20-35	0.66	G
	D3	4.35	P			Cca 50-70	0.70	F
	D4	4.51	F	3.76	F			
6	D1	4.12	P	3.13	F	Ah 0-11	0.64	G
	D2	5.56	P	2.04	G	Bnt 11-30	1.40	G
	D3	7.85	P			Ccas 30-70	4.15	F
	D4	7.49	P	2.13	G			
8	D1	4.40	P	3.78	F	Ah 0-12	0.91	F
	D2	5.11	P	4.94	F	Bnt 12-30	1.24	F
	D3	5.54	P			Ccasa 40-70	6.05	P
	D4	5.66	P	5.65	P			

Source: Appendix 3. Tables 3.1 to 3.6
* D1 = 0-20 cm, D2 = 20-35 cm, D3 = 35-50 cm, D4 = 50-70 cm

4.4 Soil Capability

Soil, indices and capabilities are shown in Table 17. A comparison of soil indices and capabilities are the most meaningful as landscape (Class 2) and climate (Class 3A) ratings do not change. Soil capability ratings show the same trends as soil quality ratings. Soil capability has improved very slightly from 1993 to 1995 based on composite sample results. The strip treatment plots average about 5 index points better than no strip plots. Strip treatment soils are comparable to BSO and BSS soils, but not as good as SZB soils. The no strip soils are similar to BSS soils.

Table 17. Comparison of soil capability ratings.

Soil	Mean Index Value	Soil Capability
SZB	50	3
BSO	45	4
BSS	34	4
Strip 1993 comp*	41	4
No strip 1993 comp*	34	4
Strip 1994 comp*	44	3
No strip 1994 comp*	36	4
Strip 1995 comp*	41	4
No strip 1995 comp*	37	4
Strip 1994 profiles**	40	4
No strip 1994 profiles**	34	4
Strip 1995 profiles **	44	4
No strip 1995 profiles **	39	4

* Based on composites of 10 subsamples at two sample depths of 0-20 and 25-40 (extrapolated to 100 cm)

** Based on profiles with sample depths of 0-20, 20-35, 35-50 and 50-70 (extrapolated to 100 cm)

4.5 Vegetation

Results of vegetation surveys, plant counts on the trenchline, are summarized in Tables 18 and 19. The results indicate that vegetation on no strip plots are slightly better than strip plots in both years, and there has been and improvement from 1994 to 1995. Original vegetative cover data is appended (Appendix 4). As of 1995, there is much more bare ground on the trenchline than on native range, nevertheless, the new growth appears to be stable and is thickening. Short term results do not indicate an advantage to topsoil stripping even though soil quality of stripped plots is better.

Table 18. Number of plants per 1 m row on trenchline (November, 1994).

	Strip Plots				No Strip Plots			
Position	**1**	**3**	**4**	**7**	**2**	**5**	**6**	**8**
5 m	3	8	5	8	9	13	9	4
15 m	3	13	7	6	8	14	7	2
25 m	3	4	8	6	12	15	7	4
35 m	4	11	9	3	7	21	6	14
45 m	5	4	16	3	13	10	6	2
55 m	2	13	12	5	13	11	7	3
65 m	4	7	9	4	3	10	10	6
75 m	3	2	10	4	3	10	10	6
85 m	1	4	9	2	5	13	8	13
95 m	1	5	2	5	2	10	2	4
MEAN	3	7	9	5	8	13	8	6
	Mean strip plots = 6				Mean no strip plots = 9			

Table 19. Number of plants per 1 m row on trenchline (November, 1995).

	Strip Plots				No Strip Plots			
Position	**1**	**3**	**4**	**7**	**2**	**5**	**6**	**8**
5 m	9	7	8	10	9	7	3	8
15 m	7	10	8	10	21	11	5	10
25 m	7	9	9	9	14	7	9	11
35 m	11	7	6	8	10	15	11	9
45 m	10	11	9	9	9	13	6	8
55 m	9	8	10	6	9	6	8	5
65 m	9	8	10	6	9	6	8	5
75 m	5	9	8	10	9	22	7	9
85 m	6	16	11	7	9	9	10	8
95 m	9	12	6	6	9	21	8	8
MEAN	9	10	8	8	11	12	7	8
	Mean strip plots = 8				Mean no strip plots = 10			

5.0 CONCLUSIONS AND RECOMMENDATIONS

Results of soil analysis two years after pipeline construction indicate that, in a Brown Solonetz, native prairie landscape, overstripping with a stepblade to include upper subsoil material is superior to no stripping.

Overstripping is superior as evident by the significantly lower topsoil EC levels in the strip vs no strip treatments for 1993, 1994 and 1995. Topsoil EC values were lower for strip compared to nostrip (3.32 vs 4.47 dS/m in 1993, 3.03 vs 4.50 dS/m in 1994, and 3.32 vs 4.49 dS/m in 1995). Topsoil organic matter concentrations were also higher in the strip vs no strip treatments (3.53 vs 2.75 in 1993, and 4.35 vs 3.60 in 1995). Overstripping had higher soil quality index values compared to no stripping (41 vs 34 in 1993, 44 vs 36 in 1994, and 41 vs 37 in 1995, respectively).

Examination of soils before, during and after construction indicates that topsoil salinization occurs as a result of mixing of topsoil and subsoil during topsoil replacement.

Salinity comparisons between 1993 and 1995 suggest little or no salt movement in the upper profile. EC levels for 1993 and 1995 are similar and greater than 1994 levels, although the differences are not statistically significant. Organic matter in topsoils is gradually increasing. EC levels in the topsoil and upper subsoil are expected to decrease with time.

A comparison of soil index values indicates that the overstripped treatment is generally comparable to the pre-construction Brown Solodized Solonetz (BSS) and Brown Solod (BSO) soils, but not as good as the Solonetzic Chernozem (SZB). BSS, BSO and SZB soils has mean index values of 34, 45 and 50, respectively. The overstripped soils has values of 41, 44 and 40 for 1993, 1994, and 1995, respectively. The initial landscape is approximately 60% BSS, 20% BSO and 20% SZB. Based on these values 80% of the post-construction landscape with topsoil stripping is as good as or better than before construction, while 20% is slightly poorer. A comparison of soil capability ratings indicates similiar trends. The no strip soils are similar to the pre-construction BSS soils.

The EC values indicate that narrow trenching in small diameter pipe does not create a homogeneous subsoil mix. There is considerable lateral and vertical variation that is slightly moderated compared to that within the original soil landscape.

Vegetative growth on overstripped and no stripped plots is similar to slightly better on the no strip plots after two years. Therefore, vegetative growth does not show any advantage to soil stripping and to the better soil quality at this time.

There are several important implications to pipeline construction (6 inch or smaller lines) on native rangelands with Solonetz soils:

- No stripping is a viable soil handling practice on straight lines on Brown Solonetz soils. This is not recommended on road and pipeline crossings where there is considerable disturbance beyond the trenchline.

- Without stripping there is a slight deterioration in soil quality and capability compared to overstripping but the difference is minor (about half a capability class).

- After two years there is no marked difference in vegetation reestablishment although the no-stripped treatments average slightly better. Vegetative cover in 1995 was better than in 1994 on both treatments.

- From a range management perspective, minimum disturbance with no stripping is preferable.

- These findings apply to summer construction. We speculate that no stripping would be an attractive method for winter construction.

Additional research is suggested to examine four issues related to this study;

- Further vegetation monitoring regarding species diversity, productivity, compatibility, etc.

- Optimum depths of overstripping.

- Effects of larger diameter pipelines and wider trenches.

- Fertilizer trials to determine what fertilizer mixes and amounts would be beneficial, if so.

6.0 REFERENCES

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7.0 APPENDICES

Appendix 1. Selected climatic data for weather stations near project site.

Suffield A

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Year
Daily Mean Temp (°C)	-11.6	-7.6	-2.0	6.0	12.0	16.7	19.4	18.7	12.8	7.2	-2.6	-9.5	5.0
Degree-Days above 5°C	0.9	2.0	12.5	80.6	221.4	350.5	448.2	425.4	238.5	109.6	13.6	1.7	1905
Precipitation (mm)	19.5	11.5	16.1	26.6	39.1	59.2	35.8	32.3	35.9	14.9	15.0	18.9	325.0

Medicine Hat A

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Year
Daily Mean Temp (°C)	-10.7	-6.8	-1.2	6.3	12.4	17.1	19.8	19.2	13.0	7.3	-2.1	-8.6	5.5
Degree-Days above 5°C	1.0	2.8	15.0	86.4	233.1	362.1	458.7	438.7	244.7	111.3	14.9	2.4	1971
Precipitation (mm)	17.3	10.3	16.0	26.0	42.3	56.4	40.9	30.6	36.3	15.5	14.8	16.2	322.6

Brooks A HRC

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Year
Daily Mean Temp (°C)	-12.5	-8.2	-2.7	5.1	11.4	15.9	18.4	17.5	11.6	6.4	-3.6	-10.2	4.1
Degree-Days above 5°C	0.6	1.5	8.4	61.9	202.1	328.3	414.6	387.2	204.8	87.8	10.7	1.1	1709
Precipitation (mm)	18.4	11.9	17.0	27.2	39.1	65.5	38.1	36.4	38.8	16.0	14.9	18.3	341.6

Appendix 2. Soil characteristics at pre-construction.

Site/ Soil	Horizon	Depth (cm)	pH	EC (dS/m)	SAT (%)	SAR	OM (%)	Texture
				Plot 1				
Trench	Ah	0-10					5.0	l
SZB	Btnj	10-30	7.2	0.35	44	0.3	3.2	cl
	Ccal	30-50	8.1	0.45	47.5	1.7		cl
	Cca2	50-100	8.8	1.17	56.5	9.1		
Control	Ah	0-10					4.4	l
SZB	Btnj	10-30	6.5	0.39	37.5	1.9	2.9	cl
	Ccal	30-50	8.1	0.59	51.5	4.6		cl
	Cca2	50-100	8.5	1.32	59.5	9.8		cl
				Plot 2				
Trench	Ah	0-15					4.2	l
BSS	Bnt	15-45	7.5	0.45	47.0	3.5	3.4	cl
	Cca	45-100	8.3	1.31	49.5	4.0		cl
Control	Ah	0-12					5.9	l
SZB	Bnj	12-35	7.3	0.36	45.5	0.4	3.0	cl
	Ccas	35-100	8.0	3.52	48.5	4.6		cl
				Plot 3				
Trench	Ahe	0-8					5.2	l
BSS	Bnt	8-25	7.4	0.71	74.5	5.4	5.4	cl
	Ccas	35-100	8.1	2.34	50.5	8.7		cl
Control	Ah	0-10					3.7	l
BSO	Bnt	20-35	6.8	0.41	56.0	3.0	4.3	cl
	Cca	35-100	7.9	1.97	74.5	3.6		cl
				Plot 4				
Trench	Ah	0-10					4.7	l
BSS	Bnt	10-25	7.5	0.50	44.5	1.6	3.4	cl
	Ccasa	25-100	8.0	5.81	53.5	7.2		cl
Control	Ah	0-10					5.4	l
BSS	Bnt	10-25	7.1	0.57	64.0	0.3	5.1	cl
	Ccas	25-100	7.9	4.57	62.0	4.0		cl

Appendix 2 cont'd

Site Plot	Horizon	Depth (cm)	pH	EC (dS/m)	SAT (%)	SAR	OM (%)	Texture
				Plot 5				
Trench	Ah	0-10					4.7	l
BSS	Bnt	10-20	7.5	0.44	47.0	0.3	3.6	cl
	Ccas	20-100	8.3	2.65	52.5	9.9		cl
Control	Ah	0-10					4.8	l
BSS	Bnt	10-25	7.7	0.94	70.5	9.6	4.2	cl
	Ccasa	25-100	8.1	9.42	63.0	11.9		cl
				Plot 6				
Trench	Ahe	0-8					5.7	fsl-l
BSS	Bnt	8-22	7.6	0.72	76.0	7.4	4.9	cl
	Ccasa	22-100	7.9	5.88	51.5	7.4		cl
Control	Ahe	0-12					4.1	l
BSS	Bnt	12-25	7.4	0.56	47.0	2.1	3.4	cl
	Ccas	25-100	7.9	2.43	61.0	6.2		cl
				Plot 7				
Trench	Ahe	0-10					4.8	l
BSS	Bnt	10-25	7.5	0.64	62.0	5.6	4.5	cl
	Ccasa	25-100	7.8	5.31	54.5	6.1		cl
Control	Ahe	0-8					6.0	l
BSS	Bnt	8-20	7.3	0.63	68.0	1.7	5.2	cl
	Cca	20-100	8.0	0.65	52.5	5.6		cl
				Plot 8				
Trench	Ahe	0-15					4.3	l
BSS	Bnt	15-30	7.3	0.62	52.0	3.0	3.2	cl
	Cca	30-100	8.3	0.99	49.0	7.6		cl
Control	Ahe	0-18					4.1	l
BSS	Bnt	18-40	7.3	0.42	48.5	3.9	3.0	cl
	Cca	40-100	8.3	1.20	50.5	6.2		cl

Note: These sample sites were selected to characterize a range of soil types across the plots, these profiles were not sampled as "representative" of each respective plot.

Appendix 3. Laboratory results.

Appendix 3.1. Soil quality in strip treatment at plot center in 1994.

Plot	Depth (cm)	EC (mS/cm)	Percent Saturation	SAR	pH	OM (%)	Soil Quality
1	0-20	5.07	54.5	4.3	7.6	2.7	P
	20-35	2.56	48.0	1.4	7.6		G
	35-50	2.15	57.5	5.1	7.7		P
	50-70	4.84	57.0	4.9	7.8		P
3	0-20	2.45	46.5	0.5	6.9	4.1	F
	20-35	0.62	41.5	0.6	6.8		G
	35-50	0.49	44.0	1.3	7.4		G
	50-70	0.59	46.5	3.0	7.9		G
4	0-20	3.95	55.0	1.2	7.0	4.7	F
	20-35	4.47	48.0	3.3	7.5		F
	35-50	3.54	49.5	0.8	7.5		G
	50-70	3.61	36.5	0.9	7.9		G
7	0-20	1.08	57.0	2.7	7.9	3.1	G
	20-35	4.28	60.0	3.0	7.4		F
	35-50	3.65	58.5	6.3	7.7		P
	50-70	5.07	57.5	7.7	7.9		P
MEAN	0-20	3.86	53.30	2.20		3.7	F
	20-35	3.01	49.40	2.00			F
	35-50	3.56	52.40	3.40			F
	50-70	3.35	49.40	4.10			F

* G = Good, F = Fair, P = Poor, U = unsuitable (ASAC, 1987)

Appendix 3.2. Soil quality in no strip treatment at plot center in 1994.

Plot	Depth	E.C. (mS/cm)	Percent Saturation	SAR	pH	OM (%)	Soil Quality*
2	0-20	3.63	56.5	1.5	7.5	3.1	F
	20-35	3.91	54.5	1.9	7.5		F
	35-50	6.49	52.0	1.7	7.6		P
	50-70	4.08	48.0	2.5	7.7		F
5	0-20	4.60	54.0	4.0	7.8	<1.5	P
	20-35	4.78	54.0	4.6	7.6		F
	35-50	4.35	50.5	3.9	7.6		F
	50-70	4.51	49.5	4.2	7.7		F
6	0-20	4.12	56.5	3.1	7.6	2.3	P
	20-35	5.56	67.5	6.2	7.7		P
	35-50	7.85	62.5	8.7	7.9		P
	50-70	7.49	53.5	8.5	7.9		P
8	0-20	4.40	54.0	3.2	7.6	3.3	P
	20-35	5.11	58.5	4.7	7.7		P
	35-50	5.54	55.0	5.5	7.8		P
	50-70	5.66	54.5	5.6	7.9		P
MEAN	0-20	4.19	55.30	3.00			P
	20-35	4.84	58.60	4.40			F
	35-50	6.06	55.00	5.00			P
	50-70	5.44	51.40	5.20			P

** G = Good, F = Fair, P = Poor, U = unsuitable (ASAC, 1987)

Appendix 3.3. Soil quality in strip treatment at plot center in 1995.

Plot	Depth	EC (mS/cm)	Percent Saturation	SAR	pH	OM (%)	Soil Quality*
1	0-20	4.95	52.0	4.0	7.5	2.7	P
	20-35	1.95	52.0	1.7	6.7		G
	50-70	5.17	53.0	4.6	7.7		P
3	0-20	1.68	50.0	1.2	7.2	4.2	G
	20-35	1.27	47.0	0.9	7.1		G
	50-70	0.7	46.0	0.8	7.4		G
4	0-20	3.83	55.0	2.3	7.1	5.0	F
	20-35	5.47	48.0	6.0	7.5		P
	50-70	3.23	51.0	3.9	7.6		F
7	0-20	2.64	57.0	2.2	7.3	4.9	F
	20-35	5.36	56.0	4.6	7.5		P
	50-70	4.39	69.0	4.1	7.6		F
MEAN	0-20	3.28	54.00	1.90	7.3		F
	20-35	3.51	51.00	3.30	7.2		F
	50-70	3.37	55.00	3.40	7.6		F

* G = Good, F = Fair, P = Poor, U = unsuitable (ASAC, 1987)

Appendix 3.4. Soil quality in no strip treatment at plot center in 1995.

Plot	Depth (cm)	E.C. (mS/cm)	Percent Saturation	SAR	pH	OM (%)	Soil Quality*
2	0-20	3.47	52.0	1.3	7.3	4.3	F
	20-35	3.7	49.0	2.0	7.5		F
	50-70	4.49	48.0	3.3	7.6		F
5	0-20	1.49	52.0	2.3	7.6	3.6	G
	20-35	2.01	52.0	4.3	7.4		F
	50-70	3.76	51.0	4.3	7.8		F
6	0-20	3.13	48.0	1.2	7.0	3.4	F
	20-35	2.04	58.0	1.3	7.2		G
	50-70	2.13	61.0	3.0	7.8		G
8	0-20	3.78	52.0	1.8	7.3	4.1	F
	20-35	4.94	53.0	4.4	17.6		F
	50-70	5.65	52.0	5.5	7.7		P
MEAN	0-20	2.97	51	1.80	7.3	3.8	F
	20-35	3.17	53.00	3.00	7.4		F
	50-70	4.01	53.00	4.00	7.7		F

* G = Good, F = Fair, P = Poor, U = unsuitable (ASAC, 1987)

Appendix 3.5. Soil quality in no strip treatment at control in 1995.

Plot	Depth	E.C. (mS/cm)	Percent Saturation	SAR	pH	OM (%)	Soil Quality*
	Solonetzic Brown						
1	Ah 0-9	0.73	46.0	0.1	7.0	3.2	G
	Btnj 9-40	0.8	48.0	0.7	6.9		G
	Cca 40-70	0.79	48.0	6.4	8.4		F
3	Solonetzic Brown						
	Ah 0-15	0.77	50.0	0.3	6.5	4.4	G
	Btnj 15-40	0.66	43.0	0.5	6.5		G
	Cca 60-90	0.92	46.0	2.0	7.4		G
4	Brown Solodized Solonetz						
	Ah 0-9	0.48	57.0	3.3	6.1	6.1	F
	Bnt 9-40	0.96	64.0	6.6	7.6		F
	Ccas 40-70	3.58	57.0	11.7	8.2		P
7	Brown Solodized Solonetz						
	Ah 0-8	0.84	64.0	1.7	7.0	5.1	G
	Bnt 8-30	0.73	68.0	2.4	7.7		G
	Ccasa 50-70	6.32	54.0	7.0	8.0		P
MEAN	A	0.70	54.00	1.40	6.6	4.7	G
	B	0.79	56.00	2.60	7.7		G
	C	2.90	51.00	6.80	8.0		F

* G =Good, F = Fair, P = Poor, U = unsuitable (ASAC, 1987)

Appendix 3.6. Soil quality in no strip treatment at control in 1995.

Plot	Depth	E.C. (mS/cm)	Percent Saturation	SAR	pH	OM (%)	Soil Quality*
	Brown Solodized Solonetz						
2	Ah 0-12	0.60	61.0	0.4	6.0	6.1	F
	Bnt 20-50	0.68	48.0	5.2	7.5		F
	Ccas 60-80	2.22	52.0	9.3	8.2		P
5	Brown Solod						
	Ah 0-12	0.64	58.0	0.6	6.6	4.8	G
	Bnt 20-35	0.66	50.0	0.6	6.6		G
	Cca 50-70	0.70	48.0	48.0	0.7	7.7	F
6	Brown Solodized Solonetz						
	Ahe 0-11	0.64	46	0.8	6.8	3.5	G
	Bnt 11-30	1.40	58	2.8	6.9		G
	Ccas 30-70	4.15	54	6.5	7.8		F
8	Brown Solodized Solonetz						
	Ahe 0-12	0.91	42.0	3.5	7.3	2.4	F
	Bnt 12-30	1.24	59.0	7.0	7.3		F
	Ccasa 40-70	6.05	60.0	8.2	8.0		P
MEAN	A	0.70	52.0	1.30	6.7	4.2	G
	B	1.00	54.0	3.90	7.1		G
	C	3.28	54.0	6.20	7.9		F

* Good = Good, F = Fair, P = Poor, U = Unsuitable (ASAC, 1987)

Appendix 4. Vegetative cover off right-of-way, 1993.

Vegetative cover on the controls, west of trenchline, was examined in the fall of 1993. A 20 x 50 cm frame was used to estimate cover and principal species at 5 m intervals along the length of each plot. Results are presented in the eight tables following.

Data indicate that Lichens and June Grass each make up about 50% cover; followed by Reindeer Moss and Slender Wheat Grass each providing about 10 to 20% cover. Other species generally provide less than 10% cover each. This information indicates approximate conditions on the ROW prior to construction.

VEGETATION DATA OF 12 MILE COULEE

PLOT # 1

5 m Intervals	Percent Cover (%)								
	RM	LI	JG	PS	GG	SW	SG	Ground Cover (%)	Comments
1	10	80	20	5	10	20		90	Dip
2	10	40	40	10	5	15		70	Flat
3	5	70	60	5		30		95	Flat
4	5	70	70	5	5	30		95	Flat
5	5	10	1			5		80	Dip
6	30	60	70			20	2	95	Flat
7	10	60	50	10	2	25		90	Flat
8	5	70	70	10	3	30		90	Flat
9	5	70	70	10	5	30		90	Flat
10	5	10	2			5		50	Flat
11	5	50	50	5		25		95	Flat
12	30	70	70			20	2	95	Flat
13	25	70	70			30	2	95	Flat
14	20	20	20			10		70	Flat
15	20	15	15		5	5		70	Dip
16	30	20	20		10	30	2	85	Flat
17	30	40	10			20		85	Flat
18	30	50	10			5		75	Flat
19	30	60	10		5	10		75	Flat
20	15	45	15		2	5		60	Flat
Average	16.3	49.0	37.2	7.5	5.2	18.5	2.0	82.5	
Mode	5	70	70	5	5	30	2	95	

Legend :

RM - Reindeer Moss
LI - Lichen
JG - June Grass
PS - Pasture Sage
GG - Gramma Grass
SW - Slender Wheatgrass
SG - Spear Grass

VEGETATION DATA OF 12 MILE COULEE

PLOT # 2

5 m Intervals	Percent Cover (%)								
	RM	LI	JG	PS	GG	SW	SG	Ground Cover (%)	Comments
1	10	80	30	10	2	5		90	dip
2	1	40	50	2	20	30		80	flat
3	1	70	10	2	15	25		70	flat
4	1	70	60	5	15	30		80	flat
5	40	80	20		5	40		80	flat
6	1	80	20	10	15	40	2	80	flat
7	10	80	30	2	10	30		80	flat
8	30	80	15	5	10	30		70	flat
9	5	70	50	5	2	30		60	flat
10	5	60	50	5	1	20		60	flat
11	5	60	70	10	15	20		80	flat
12	30	60	50	15	10	40	2	65	flat
13	25	70	60	10	10	30	2	80	flat
14	20	80	60	20		20		80	flat
15	20	40	80	20	10	15		90	flat
16	30	40	70	30	20	10		90	flat
17	30	40	60	40		5		70	dip
18	30	70	50	1	5	5		85	dip
19	30	70	60			5		70	dip
20	15	50	60	5		30		65	dip
Average	17.0	64.5	47.8	10.9	10.3	23.0	2.0	76.3	
Mode	30	80	60	5	10	30	2	80	

Legend:

RM - Reindeer Moss
LI - Lichen
JG - June Grass
PS - Pasture Sage
GG - Gramma Grass
SW - Slender Wheatgrass
SG - Spear Grass

VEGETATION DATA OF 12 MILE COULEE

PLOT # 3

5 m Intervals	Percent Cover (%)								
	RM	LI	JG	PS	GG	SW	SG	Ground Cover (%)	Comments
1	40	40	30	1		20		70	flat
2	20	30	40	30	5	20		80	flat
3	5	40	60	15	15	10		65	flat
4	40	40	30	15	10	15		75	flat
5	50	40	50	20		20		60	flat
6	30	50	35	5	5	15		70	flat
7	30	60	40	5	5	15		80	flat
8	15	60	40	5	2	10		80	dip
9	15	60	40	10	5	5		70	dip
10	50	70	40	5	5	10		60	dip
11	5	50	40	5	15	15		70	flat
12	10	50	60	1	10	20		80	flat
13	40	30	15	10		10		70	flat
14	40	30	80	5		5		90	dip
15	1	60	70	5		20		85	flat
16	5	70	50	2	5	15		90	flat
17	5	50	60	2	2	15	2	70	flat
18	20	50	60	5	2	15		80	dip
19	5	60	40	5	50	10		90	dip
20	5	50	40	15	5	50		95	flat
Average	21.6	49.5	46.0	8.3	9.4	15.8	2.0	76.5	
Mode	5	50	40	5	5	15	2	70	

Legend :
RM - Reindeer Moss
LI - Lichen
JG - June Grass
PS - Pasture Sage
GG - Gramma Grass
SW - Slender Wheatgrass
SG - Spear Grass

VEGETATION DATA OF 12 MILE COULEE

PLOT # 4

5 m Intervals	Percent Cover (%)								
	RM	LI	JG	PS	GG	SW	SG	Ground Cover (%)	Comments
1		60	30	10		5	5	95	dip
2		60	70	1		5		80	dip
3		60	70	1	1	5		90	dip
4	2	60	60	15	10	10		90	flat
5	10	60	50	5	5	50	5	90	flat
6	2	60	70	5	1	50		90	flat
7		60	30	10	1	5		90	dip
8	15	60	30	10	1	10		95	dip
9	30	50	30	5		10		90	flat
10	30	40	30	5		5		80	flat
11	10	50	60	1	10	15		95	flat
12	30	60	10	5	5	20		95	dip
13	40	30	70	5	1	10		100	dip
14	40	30	70	5		10		95	flat
15	40	50	60	5	10	20		95	flat
16	30	60	30	5	1	40		95	flat
17	30	60	30	5	20	20		100	flat
18	5	60	40	1	40	5		90	flat
19	10	50	30	5	20	10		95	flat
20	5	50	30	20	5	10	15	95	flat
Average	20.6	53.5	45.0	6.2	8.7	15.8	8.3	92.3	
Mode	30	60	30	5	1	10	5	95	

Legend :
RM - Reindeer Moss
LI - Lichen
JG - June Grass
PS - Pasture Sage
GG - Gramma Grass
SW - Slender Wheatgrass
SG - Spear Grass

VEGETATION DATA OF 12 MILE COULEE

PLOT # 5

5 m Intervals	Percent Cover (%)								
	RM	LI	JG	PS	GG	SW	SG	Ground Cover (%)	Comments
1	5	50	60	5	15	10		90	flat
2	5	60	50	5	15	10		80	flat
3	10	50	40	10	5	10		75	dip
4	5	60	40	5	5	15		80	dip
5	5	50	40	10	2	5		90	dip
6	5	65	40	2	10	5		75	dip
7	5	60	30	5	2	40		85	flat
8	2	65	35	5	10	20		85	flat
9	5	70	95	10	5	35		85	flat
10	5	70	65	10	5	20		80	flat
11	5	70	35	2	10	30		90	flat
12	5	60	50	1	10	15		90	flat
13	5	60	60	2	10	5		85	dip
14	30	50	25	2	5	35		80	flat
15	40	40	25		25	35		85	flat
16	30	40	25		25	35		90	flat
17	20	50	35		10	50		95	flat
18	10	70	50	5	2	50		90	flat
19	20	40	40			30		60	flat
20	10	50	50	5		30		95	dip
Average	11.4	56.5	44.5	5.3	9.5	24.3	0.0	84.3	
Mode	5	50	40	5	10	35	#N/A	90	

Legend :

RM - Reindeer Moss
LI - Lichen
JG - June Grass
PS - Pasture Sage
GG - Gramma Grass
SW - Slender Wheatgrass
SG - Spear Grass

VEGETATION DATA OF 12 MILE COULEE

PLOT # 6

5 m Intervals	Percent Cover (%)								
	RM	LI	JG	PS	GG	SW	SG	Ground Cover (%)	Comments
1		30	20	20		30	25	50	flat
2	20	30	20	10	10	15	5	80	flat
3	5	30	20	20	30	10		50	flat
4	20	40	10	5	10	5		80	flat
5	20	40	10	5	20	5		10	flat
6	15	40	15	5	5	5		90	dip
7	15	50	50	1	2	2		90	flat
8	15	60	60	5	5	5		95	flat
9	10	40	40	10	5	5		75	dip
10	40	30	40	10		2		70	dip
11	20	40	50	5	2	5		75	dip
12	10	40	30	12		10		75	dip
13	40	40	60			30		80	dip
14	40	30	40	5	10	10		85	flat
15	20	50	60	5		30		90	dip
16	5	70	70	5	5			95	flat
17	5	60	60	5	10	5		60	dip
18	10	60	70	10	2	5		95	flat
19	10	60	60	10	5	10		90	dip
20	5	60	50	5		10		90	flat
Average	17.1	45.0	41.8	8.1	8.6	10.5	15.0	76.3	
Mode	20	40	60	5	5	5	#N/A	90	

Legend :
RM - Reindeer Moss
LI - Lichen
JG - June Grass
PS - Pasture Sage
GG - Gramma Grass
SW - Slender Wheatgrass
SG - Spear Grass

VEGETATION DATA OF 12 MILE COULEE

PLOT # 7

5 m Intervals	Percent Cover (%)								
	RM	LI	JG	PS	GG	SW	SG	Ground Cover (%)	Comments
1	15	60	70	10		10		95	flat
2	10	50	70	20	5	1		75	flat
3	10	50	70	20	5	1		90	flat
4	15	60	70	5		10		85	flat
5	15	50	60	10	10	10		95	flat
6	15	60	60	2		15	5	75	dip
7	10	70	70	10		15		90	flat
8	10	70	70	10	2	15		95	flat
9	10	70	80	2	5	15		90	flat
10	5	70	65	10	5	20		80	flat
11	5	70	35	2	10	30		90	flat
12	5	60	50	1	10	15		90	flat
13	5	60	60	2	10	5		85	flat
14	30	50	25	2	5	35		80	flat
15	40	40	25		25	30		85	dip
16	30	40	25		20	30		90	flat
17	20	50	35		10	50		95	flat
18	10	70	50	5	5	50		90	flat
19	20	30	40	10	2	25		95	dip
20	20	50	40	5		30		90	flat
Average	15.0	56.5	53.5	7.4	8.6	20.6	5.0	88.0	
Mode	10	50	70	10	5	15	5	90	

<u>Legend :</u>

RM - Reindeer Moss
LI - Lichen
JG - June Grass
PS - Pasture Sage
GG - Gramma Grass
SW - Slender Wheatgrass
SG - Spear Grass

VEGETATION DATA OF 12 MILE COULEE

PLOT # 8

5 m Intervals	Percent Cover (%)								
	RM	LI	JG	PS	GG	SW	SG	Ground Cover (%)	Comments
1	20	70	60	5		10		60	dip
2	30	80	50	5	5	30		60	dip
3	10	80	60	1	2	10		80	dip
4		40	30	10		40		50	dip
5	5	60	40	30	10	60		70	flat
6	20	80	60	2	5	30		80	flat
7	5	60	80	15	5	10	1	60	dip
8	10	60	40	10		60		75	flat
9	70	40	40		5	50		80	flat
10	40	30	50		10	60		70	flat
11	30	60	40	2		30		80	flat
12	15	50	40	10	5	40		80	flat
13	30	60	30		10	40		80	flat
14	35	60	50	1	5	30		80	flat
15	5	70	60	1	1	40		85	flat
16	20	70	70	5		30		70	flat
17	10	70	80	10		50		75	flat
18	10	60	80	40		20		60	flat
19	10	50	50	40		30		60	flat
20	10	60	40	10		20		75	dip
Average	20.3	60.5	52.5	11.6	5.7	34.5	1.0	71.5	
Mode	10	60	40	10	5	30	1	80	

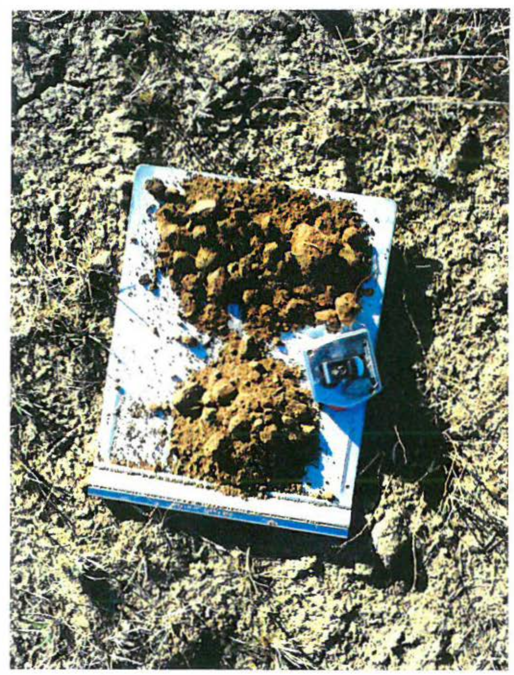
Legend :

RM - Reindeer Moss
LI - Lichen
JG - June Grass
PS - Pasture Sage
GG - Gramma Grass
SW - Slender Wheatgrass
SG - Spear Grass

Topsoil stripped, 1993.

Trencher

Reclaimed route, 1994.



Strip topsoil (upper); No Strip surface (lower)

Plot 1.

Plot 2, November 1995.

Plot 3, November 1995.

Plot 4, November 1995.

Plot 5, November 1995.

Plot 6, November 1995.

Plot 7, November 1995.