Oil and Gas Well/ Facility Site Erosion Management

(Year 1 Summary)

A 2 year project of the
Science and Community Environmental Knowledge (SCEK) Fund

Charlie Lake Conservation Society
November 2005

Summary

The Charlie Lake Conservation Society (CLCS)[1] is a non-profit group of volunteers who are interested in maintaining or enhancing water quality in Charlie Lake. In 2004, CLCS published *A Long-Term Strategic Plan for the Improvement of Water Quality in the Charlie Lake Watershed*. The strategic plan identified erosion caused by oil and gas activity as one of the land-uses potentially contributing to degradation of water quality. 79 wells and access roads were assessed for erosion problems in June-August 2005. Types of erosion found were rills, gullies and scour from dyke drains and road culverts. Regulations regarding erosion on oil and gas leases are not well defined. Oil and gas companies are willing to mitigate erosion problems, but are having difficulty finding best management methods that work well with local environmental conditions, particularly high clay and silt content of local soils. Various management techniques are available including traditional hard engineering, soil bioengineering and the use of geotextiles and synthetic drainage systems. Partnerships between government agencies, oil and gas producers and landowners are important in solving erosion problems in the watershed.
This report summarizes the activities done in the first year of a 2 year project. Primary funding was obtained through the Science and Community Environmental Knowledge (SCEK) fund established by the BC Oil and Gas Commission.

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Table of Contents

Summary ... ii

Table of Contents ... iii

List of Figures ... iv

List of Tables ... iv

Introduction ... 1

Study Area ... 2

Project Rationale ... 5

Methods ... 6

Results and Discussion ... 7

Regulations ... 13

Management Options ... 14

Conclusion ... 20

References ... 21

Appendix I – Primer on Erosion and Watershed Impacts ... 22

Appendix II –Photos from the Strategic Plan Supporting Project Rationale ... 23

Appendix III – Assessment ... 25

Appendix IV – Letter to Landowners ... 29

Appendix V – Relevant Acts and Regulations ... 31

Appendix VI – Basic Steps to Consider When Developing An Erosion and Sediment Control Plan ... 32

Acknowledgements ... 33

About the Author ... 33

List of Figures

Figure 1 – Charlie Lake Watershed 2
Figure 2 – Oil and gas activity in the northwest corner of the Charlie Lake Watershed 3
Figure 3 - Ownership of active wells in the Charlie Lake Watershed 4
Figure 4 – Rating wellsite erosion conditions..7
Figure 5 - Gully erosion from drainage pipe scour – 1.5m width (approx).............8
Figure 6 - Riprap placed in drainage pathway to mitigate scouring caused by dyke drain 8
Figure 7 – Successful use of riprap and geotextile fabric at dyke drain outflow. ...9
Figure 8 – Gullying, scouring and cracking on roadside near culverts 10
Figure 9 – Scouring and resulting gullying from perched culverts.......................11
Figure 10 – Crushed and broken culverts 11
Figure 11 – Gullies around lease and in roadside ditch exacerbated by cattle access 12
Figure 12 - Cross-ditch installation across an intact road (Ministry of Forests, 2002) 16
Figure 13 - Waterbar installation..16
Figure 14 – Rilling and gullying on road surfaces and ditches, possibly benefit from waterbars..17

List of Tables

Table 1 – Erosion issues observed June-August 2005 9

Introduction

The Charlie Lake Conservation Society (CLCS) is a non-profit volunteer group that is interested in the conservation and remediation of the Charlie Lake watershed ecosystem, so that it can better meet the needs of the natural and human communities. In 2004, CLCS published *A Long-Term Strategic Plan for the Improvement of Water Quality in the Charlie Lake Watershed*. This plan focused on improving water quality and habitat in the watershed and improving aesthetic and recreational potential of the watershed as a whole. Through the strategic planning process, CLCS is designing specific projects and community-level initiatives that will address the watershed level factors that are thought to be affecting perceived deterioration in water quality in Charlie Lake. The strategic plan identified erosion[2] caused by oil and gas activity as one of the land-uses potentially contributing to degradation of water quality.

The primary objectives of the project were to identify and document erosion issues on wellsites and access roads in the watershed and to raise awareness of the impact of erosion and sedimentation on Charlie Lake water quality among oil and gas companies, landowners and the general public (see Appendix I – Primer on Erosion and Watershed Impacts). Following the assessments, CLCS will encourage partnerships with landowners, oil and gas companies and government agencies to develop restoration plans for high priority sites. This report describes the methods and results of the summer 2005 portion of the oil and gas erosion assessment project.

[2] Appendix I – Primer on Erosion and Watershed Impacts

Study Area[3]

Charlie Lake is located in northeastern British Columbia, approximately 9 km northwest of the City of Fort St. John, The Charlie Lake watershed is valued for its natural beauty and residential suitability, angling , hunting and boating opportunities, fertile soils that support a thriving agricultural industry and substantial oil and gas reserves. In addition to supporting a wide range of recreational and industrial endeavours, Charlie Lake is the backup water supply for the City of Fort St. John (about 17,500 people) and surrounding areas.

Charlie Lake has a watershed area (Figure 1) of approximately 281 km^2 (surface area of the lake not included). Having a length of 15 km, a shoreline perimeter of 38 km, a surface area of 19 km^2 and a base volume of about 136,800 dam^3, Charlie Lake is considered to be a medium-sized lake. As are most naturally eutrophic lakes (i.e., lakes characterized by high biological productivity, particularly in terms of algae) of glacial-scour origin (Rawson, 1955; Hutchinson, 1957), Charlie Lake is comparatively shallow, having mean and maximum depths of 7 and 15 m. Charlie Lake has 21 direct tributaries. Most of these tributaries are ephemeral and typically only carry flows during spring melt and rainy periods. The two largest tributaries (Stoddart Creek that drains 171 km^2 and Coffee Creek that drains 25 km^2) enter from the north and together, drain nearly 80% of the watershed area.

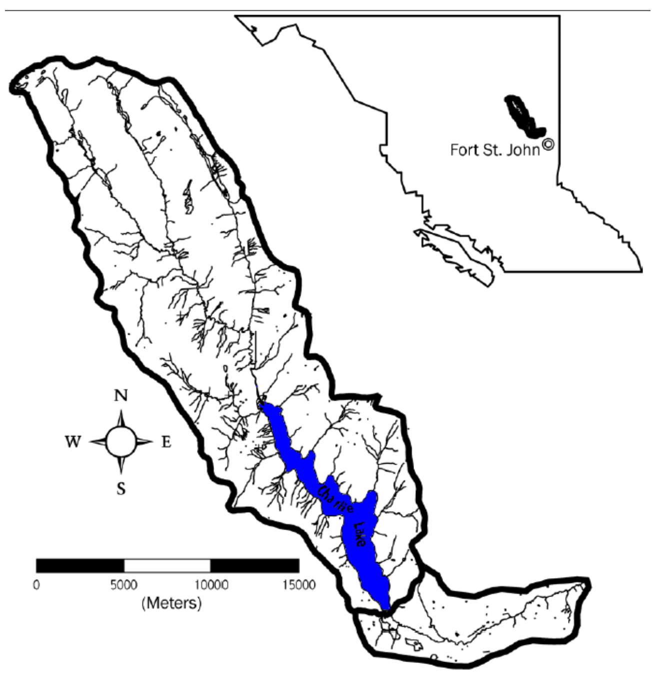

Figure 1 – Charlie Lake Watershed

[3]Most information from French and Booth, 2004, unless otherwise referenced.

Data provided by the Oil and Gas Commission (OGC) in May 2005 showed that there are a total of 239 wellsites in the watershed - 138 are active (Figure 2). Most of the active wells are operated by six companies (Figure 3). These numbers fluctuate regularly, due to the continual dynamic growth of the oil and gas industry.

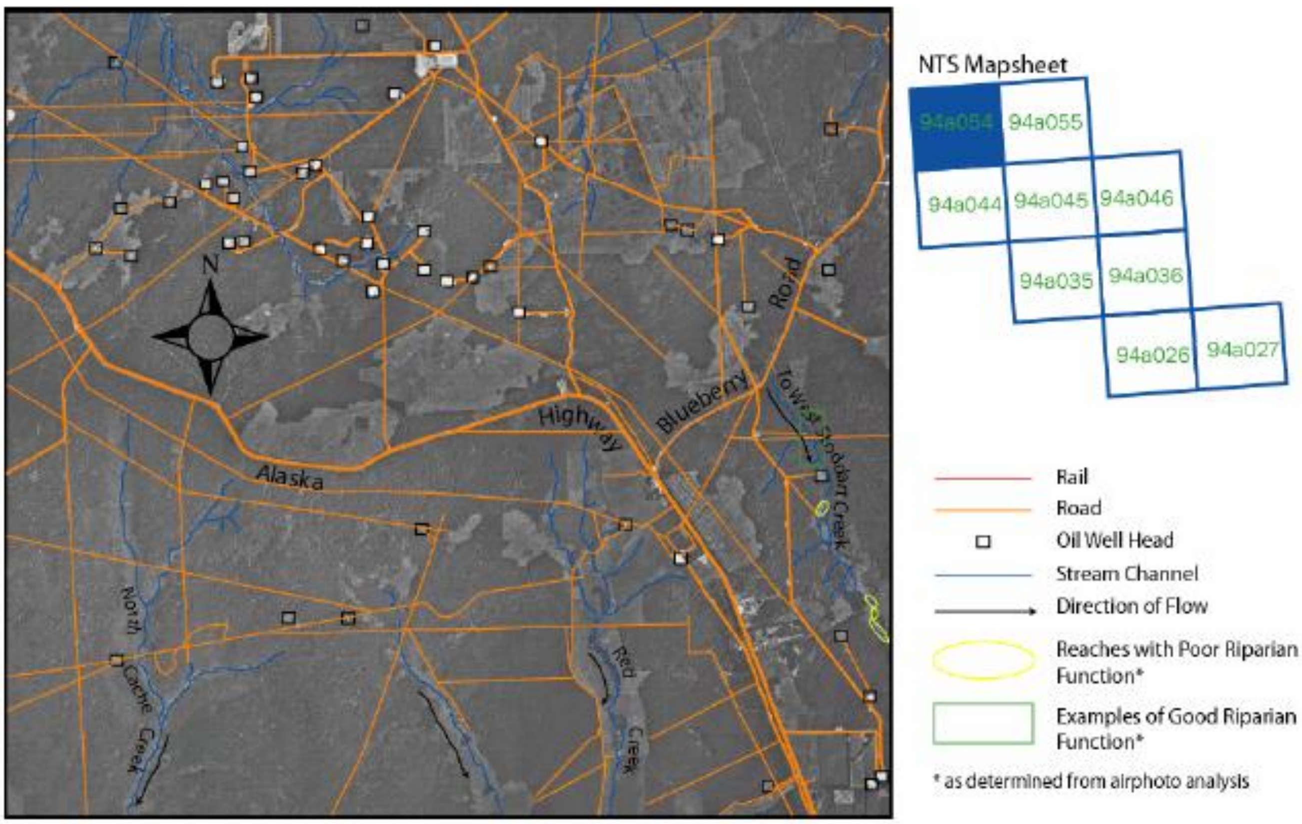

Figure 2 – Oil and gas activity in the northwest corner of the Charlie Lake Watershed

(Note that the region west of the Alaska Highway and north of Blueberry Road is not within the Charlie Lake Watershed.)

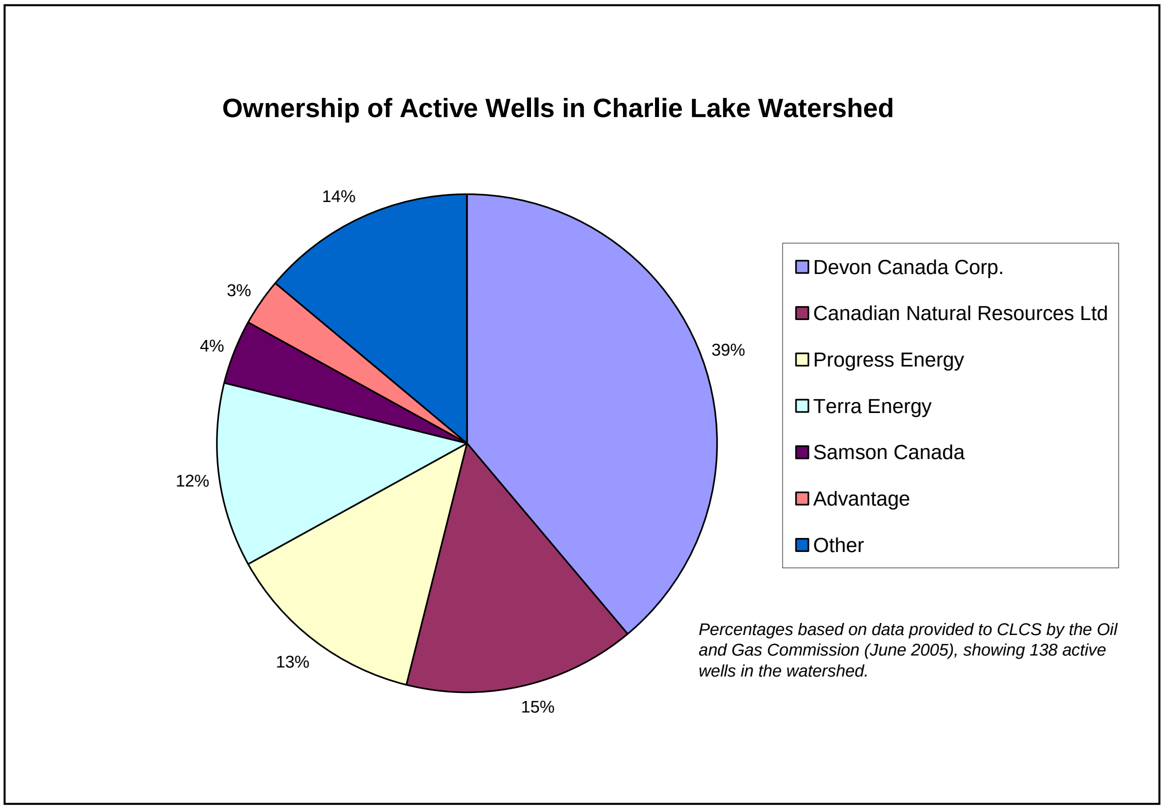

Figure 3 - Ownership of active wells in the Charlie Lake Watershed

Project Rationale

The strategic plan identified a number of human activity related factors contributing to sediment loading and consequently affecting water quality in Charlie Lake and its tributaries. These included shoreline erosion caused by high water levels, bridges/culverts, riparian land clearing, livestock access to streams, residential development, domestic wastes and oil and gas road and wellsites. Potential for eroded soil from wellsites and access roads to reach Stoddart and Coffee Creeks and ultimately be transported downstream to Charlie Lake is an issue of concern.

Wellhead sites in the Charlie Lake watershed characteristically have very little vegetation cover. Dust particles blown off dry exposed soils on wellhead sites can settle in stream channels and the lake. Of greater issue, however, was the management of surface water on some of these sites.

Some wellhead sites had water collection areas on their down-slope perimeter berms (Appendix II – Photos from the Strategic Plan Supporting Project Rationale, Plate 11). During snowmelt and rainy periods, substantial amounts of water can collect in these areas. In some cases, small diameter pipes were put through the down-slope berm to permit drainage (Appendix II, Plate 12 and13)**.** The pressure of water moving through such cross-ditch drain pipes appears to cause substantial sediment erosion (Appendix II, Plates 12-14) and has the potential to eventually make its way into stream channels and into Charlie Lake.

There also appeared to be erosional problems in the ditches of private roads that provide access to wellsites (Appendix II, Plate 15). In many cases, it appeared that roads were not constructed to minimize the erosion of the extremely fine watershed soils, with this being particularly evident in sloped regions of the watershed. In general, ditch-line erosion was prevalent in the Charlie Lake watershed wherever roads were constructed on sloped ground.

A plan for an oil and gas site erosion assessment project (the Project) was developed by CLCS board members and volunteers following the completion of the strategic plan. The Project was implemented in the summer of 2005, with a follow-up review to occur in the spring/summer of 2006.

Methods

The project began in May 2005. Steps taken prior to completing the actual erosion assessments included:

- Identification and listing of landowners and oil and gas producers (oil and gas companies) and their contact information for planned audit sites.
- Completion of an initial survey of literature on soil erosion as it relates to access roads, other linear development, oil field leases and lake shores.
- Gathering maps of the Charlie Lake area for navigational use and assess the distribution of wellsites in the watershed.
- Creating an erosion assessment form (Appendix III – Assessment Form)
- Mailing an information letter to landowners in the watershed to give them background information on the project (Appendix IV – Letter to Landowners)

Field visits to oil and gas wellsites and access roads were undertaken over the period June to August 2005. Visits involved a qualitative assessment of erosion problems using the assessment form and photographs.

After site assessments were compiled, wellsites were rated with a subjective grade on a scale from A to F, with A for excellent and F for poor. Grading was intended to help companies prioritize their efforts in managing sites Types of erosion problems observed were tabled, along with any observed attempt to mitigate erosion issues.

As part of the project, an erosion control workshop was held in August 2005, to raise awareness of erosion problems and to examine possible ways of mitigating problems. The outcomes of the workshop will be discussed briefly because of the linkages to the erosion assessment project.

Results and Discussion

Seventy-nine (79) wellsites and their access roads were assessed. Fifty-four (54) sites (78%) were considered to be in relatively good condition, rated A+ to B- (see figure 4). Most of the sites that received an A or A+ were suspended or abandoned and were mostly overgrown with vegetation. Erosion on these sites was minimal. Just over half the sites received a B grade, where erosion issues were apparent, but not as serious or extensive as a C or D rating.

Twenty-six (26) sites (32%) typically had usually had serious scouring and gully erosion and/or were within close proximity to Charlie Lake, Stoddart Creek, Coffee Creek or their tributaries and therefore have the potential to impact Charlie Lake within a relatively short period of time.

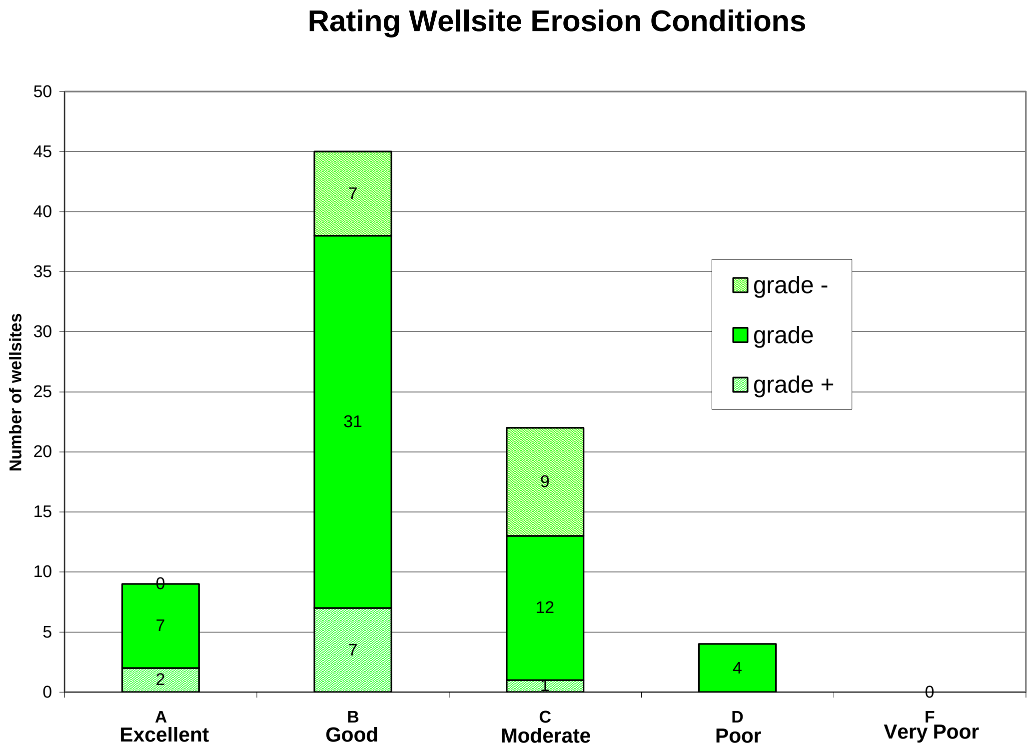

Figure 4 – Rating wellsite erosion conditions

The most common erosion problem observed on both the lease site and access roads was rilling (Table 1). Rills varied in severity from very minor, to large rills that were progressing towards gullying. Dyke drains, especially perched drains, frequently caused scouring at the outflow end and caused gullies to form in some cases (Figure 5).

Figure 5 - Gully erosion from drainage pipe scour – 1.5m width (approx)

Many sites with dyke drain problems showed some attempt to remedy the situation, often with the use of riprap alone (Figure 6), or in conjunction with some geotextile fabric (Figure 7).

Figure 6 - Riprap placed in drainage pathway to mitigate scouring caused by dyke drain

Figure 7 – Successful use of riprap and geotextile fabric at dyke drain outflow.

Both the OGC and operators in the watershed mentioned that the use of dyke drains is now being discouraged. One operator in particular has planned to remove all dyke drains from wellsites in the watershed, instead opting to pump collected water off. A major reason for this is to further reduce the potential for any contaminated water from escaping the wellsite and entering the natural drainage system, however, if performed diligently, pumping water off should also reduce scour and gullying problems. The downside of this method for operators is that pumping water off leases is likely far more expensive and time consuming than simply using a dyke drain.

Table 1 – Erosion issues observed June-August 2005

Wellsite Location	**Type of Erosion**	**Locations (%)**
Lease site	Rills	81
	Gullies	35
	Scour around dyke drain outflow	32
	Erosion outside dyke perimeter	11
Access Road	Rills	51
	Gullies	16
	Scour around culverts	16

Permanent and non-permanent roads usually cause a higher potential for erosion in areas that were previously undisturbed and covered with a protective vegetative layer. Several factors contribute to the increased erosion potential of forest roads: removal of surface cover, concentrated flow in ditches, interception of surface flow, destruction of the natural soil structure, increased slopes and compaction (Grace, 2002). Erosion and sedimentation from roads vary depending on soil characteristics, climatic factors and watershed hydrology (Grace, 2002). Soils in the Fort St. John area are prone to mass failure and are very erodible, especially at high moisture contents (Brady and Weil, 2002) (Severin, 2004). Specifically, roadside ditches are considered a major area of concern in mitigating erosion losses, because they serve as a zone of water flow concentration. An increased erosion potential results due to large volumes of water moving through at high velocities (Grace, 2002). Observations in the Charlie Lake watershed showed that erosion in road ditches can often be a serious issue.

The most common erosional processes observed on lease roads included rills and gullies. Scouring was also a problem on access roads, at the mouths of culverts. Similarly to dyke drains, a number of culverts were perched, causing gullies that could threaten lease road and livestock fence integrity (Figures 8, 9).

Figure 8 – Gullying, scouring and cracking on roadside near culverts

Figure 9 – Scouring and resulting gullying from perched culverts

In some cases culverts were broken or crushed and showed signs of being clogged with sediment and/or vegetation (Figure 10).

Figure 10 – Crushed and broken culverts

On a few sites, livestock access to lease sites and road ditches seemed to exacerbate erosion problems. One site in particular had serious gullying problems that looked to be exacerbated by cattle accessing water pooled in the roadside ditches and around the perimeter of the lease (Figure 11).


Figure 11 – Gullies around lease and in roadside ditch exacerbated by cattle access

Also of interest is that 11% of sites had erosion occurring outside the lease berm. This is likely caused by runoff from adjacent agricultural fields or forested lands encountering the berm and flowing around it, resulting in significant scour. Discussions with OGC staff indicated that so long as water does not run onto the lease site, companies are not clearly responsible for managing its impacts. Current regulations do not cover this type of water issue.

Regulations

Site inspections of oil and gas wellsites are conducted by compliance and enforcement inspectors from the OGC. Inspection guidelines for OGC Compliance and Enforcement include very little regarding erosion control and mitigation (OGC, 2005). Erosion issues related to oil and gas activity are not covered adequately in current regulations (Gilbert, 2005) (see Appendix V – Relevant Acts and Regulations). Guidelines for compliance inspectors reporting erosion issues are therefore quite vague and lead to inconsistencies. A number of operators expressed some frustration with these inconsistencies, as they are not always certain of what is expected of them with regards to erosion control and mitigation. Revision of current regulations or creation of new ones may be necessary to remedy this problem.

Management Options

Erosion Control Strategies

A basic approach to developing an erosion control strategy was presented by OGC (Gilbert) and Aurora Engineering (McDonald) at the CLCS Erosion Control Workshop (Appendix VI – Basic Steps to Consider When Developing An Erosion and Sediment Control Plan). Erosion control strategies can involve reducing water volume, reducing water energy and improving resistance to erosion.

Wellsites and associated roads can often interfere with natural drainage patterns. This was observed to be an issue in some cases, causing both berms and roads to be washed out by spring freshet every year. Not only is the sediment transported potentially detrimental to the watershed ecosystem, but constant repair of berms and roads is costly. Water volumes reaching infrastructure can be reduced in some cases by restoring the water channel to its natural location and geometry and diverting flow around critical structures (MacDonald, 2005). Water energy can be reduced by reducing flow gradient and widening the channel to remove constriction influences of the channel banks. Constricted flows move at much higher velocities.

Aurora Engineering identified a number of ways to improve resistance to erosion. These included armouring (rock riprap), the construction of weirs, ensuring a strong vegetation catch for drainage and installing culverts of an appropriate size. Inappropriately sized culverts and dyke drains (those that are too small for the large volumes of water that need to pass through them), cause a lot of scouring problems. Often the use of geotextiles and other synthetic drainage products[4] can significantly reduce erosion. Grace (2002) found that treatment of a road side-slope with an erosion mat resulted in increased vegetation and relatively insignificant sediment production over two years of study. The erosion mat aided in the establishment of vegetation and was more successful than applications of a native species vegetative mix seed and an exotic species vegetative seed mix alone.

[4] see www.nilex.com

Roads

There is little information on oil and gas road specific design guidelines for the Province of British Columbia. Resource road guidelines often used are the Ministry of Forests' *Forest Road Engineering Guidebook*.

According to this guidebook the best way to minimize soil erosion is to cover all exposed soils with vegetation immediately following road construction. This not only aids erosion control, but also helps prevent the spread of noxious weeds in the road ditches. The guidebook suggests the following sediment control techniques to minimize sediment transport away from the road prism:

- apply grass seed as soon as practical following completion of an area of construction
- install silt fencing, hay bales, or erosion control revegetation mats[5]
- install rock check dams or place rip rap to reduce water velocity and scour potential and to provide for temporary sediment retention
- install sediment catchment basins
- confine sensitive operations to periods of dry weather, minimize traffic through these areas and select equipment that will create the least disturbance (e.g. rubber-tired or rubber-tracked machinery)
- for stream culvert installations, use temporary diversion or impoundment of stream flow to reduce the exposure of disturbed soil to flowing water (but obtain prior agency approval if required).

Confining work and use of roads to periods of dry weather is not feasible in the oil and gas industry because of safety and production concerns. Wells must be checked regularly regardless of weather conditions. Temporary diversion of stream flow may not always be an option either, due to the semi-permanent nature of oil and gas roads. Extended periods of stream diversion may cause more problems both for infrastructure and the environment.

Other methods of sediment control on forestry roads involve water management techniques such as cross-ditches and waterbars (Figures 12, 13).

[5] For an extensive description of erosion control products see www.nilex.com. Available in the Fort St. John area through the Nilex office in Grande Prairie, AB.

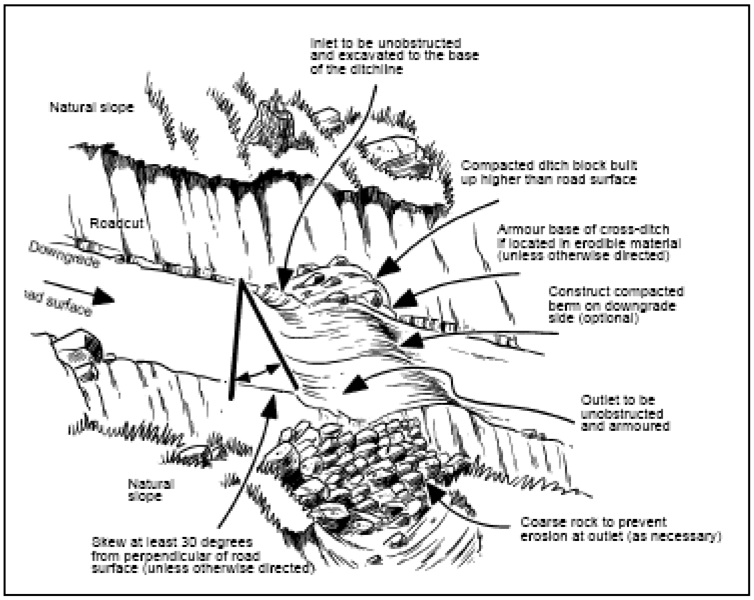

Figure 12 - Cross-ditch installation across an intact road (Ministry of Forests, 2002)

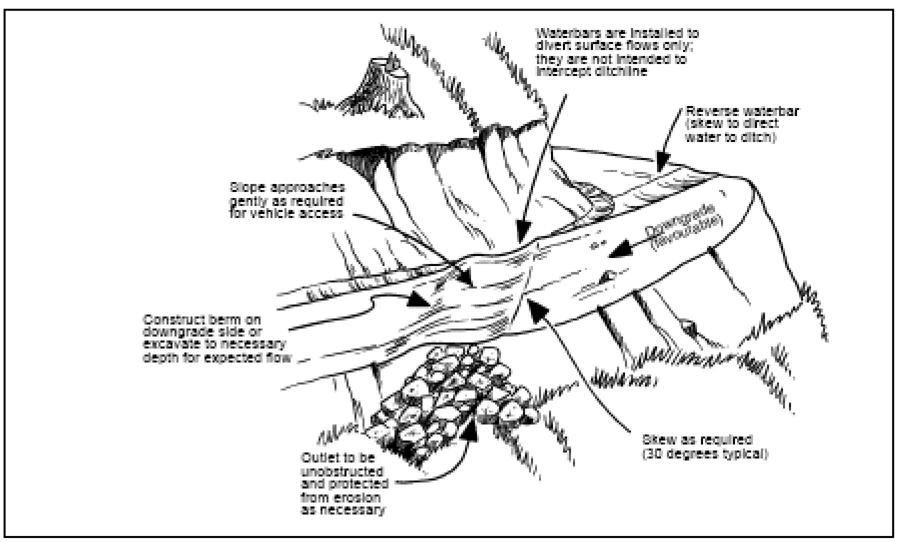

Figure 13 - Waterbar installation

The purpose of a cross-ditch is to intercept road surface and ditchline water and convey it across the road onto stable, non-erodible slopes below the road. Waterbars are meant to intercept surface water on the road and convey it across the road onto stable slopes below the road. They can also be used to reduce flow energy across the slope grade. Reverse waterbars direct flow off the road into the drainage ditch. Many of the lease roads assessed had low grades of 0-2%, so these methods may not be applicable to them. However a few roads on steeper grades of 4 to 6% showed extensive rilling and gullying problems either on the road surface or the ditch. These locations may potentially benefit from installation of waterbars or reverse waterbars (Figure 14).

Figure 14 – Rilling and gullying on road surfaces and ditches, possibly benefit from waterbars

Roads and Wellsites

Revegetation

Observed erosion was likely enhanced where there was a lack of vegetation, especially on steeper slopes. This was an issue for both lease berms and road ditches. The blackening of leases for wellsites and clearing for access roads leaves bare soil to be exposed to potentially degrading environmental conditions (French and Booth, 2004). Blackening of leases is required by law[6] to prevent fire

[6] Regarding flare stacks, section 62(n) of the *Drilling and Production Regulation* states that "a blackened area, free of vegetation and with a radius of at least 1.5 times the stack height, must be maintained around the base of the flare stack or the end of a flare line to the following minimum distances: 10 m in cultivated areas and 30 m in forested areas." In addition to this, the

hazards. Because of these requirements, many of the dykes on the wellsites had been sprayed with herbicide on the lease side and the backside, which prevented any vegetation from growing, thereby exposing soil. Communication with OGC staff indicated that some vegetating of the berms is permissible, with legumes or other plants which match neighbouring agricultural crops, or do not threaten the natural forest vegetation. OGC staff suggested oil companies could work with landowners to determine appropriate plants.

According to the *Forest Road Engineering Guidebook* (Ministry of Forests, 2002), seeding with a grass and legume seed mixture on exposed soil is the most common and usually the most cost-effective means of treating forestry roads to prevent erosion. There is a variety of erosion seed mixes available that provide for rapid germination and long-term growth to provide a solid sod layer. It suggests application of seed to all exposed soil that will support vegetation. For example, seed areas of road cuts, ditchlines, fill slopes, inactive borrow pits, waste areas and other disturbed areas within the clearing width. Dry-broadcast seeding immediately following construction works is the most common means of applying seed in the forest industry, whether by hand using a handheld cyclone-type seeder or by machine such as a vehicle-mounted spreader or a helicopter-slung bucket. In most cases, a light application of fertilizer will assist in initial establishment and growth. Hydroseeding (i.e., a mixture of seed, fertilizer, mulch, tackifier and water applied as a slurry mix) can be used for revegetation of roads. It is more costly than dry-broadcast seeding, but it is the most effective method of obtaining growth on steep or difficult sites.

At the CLCS Erosion Control Workshop (August 2005), Peace Country Seeds[7] discussed appropriate seed mixes for use in vegetating berms and road ditches. One problem mentioned was that oil companies in the Peace Region often use pre-made “reclamation mixes” from sellers in Alberta, that are designed for the loamy soils in central and southern Alberta, not for the silty clays often found in this area. These mixes often don’t grow well in local conditions and he suggested purchasing a custom mix from knowledgeable seed growers in the BC Peace Region. Creeping red fescue was one forage crop mentioned which develops a root mass that is excellent at holding soil in place.

OGC Compliance Guidelines state that “all dikes and firewalls must be maintained in good condition and the area kept free of grass, weeds, or other extraneous combustible materials.”

[7] For more information contact Peace Country Seeds, Glen Mielke, RR 1 Site 1 Comp 1, Dawson Creek, BC, V1G 4E7, Phone: (250) 782-8684, email: mielke@uniserve.com

Soil Bioengineering

Soil bioengineering uses live plant materials to provide erosion control, slope and streambank stabilization. It combines expertise from the professions of soil science, landscape architecture, civil, hydrological and geotechnical engineering and horticulture (Washington Department of Transportation). Less heavy machinery is required than traditional engineering methods, resulting in lower costs and environmental impacts. Erosion problems can be mitigated while they are still at a small scale. Once plants are established, root systems reinforce the soil mantle and remove excess moisture from the soil profile.
Willow is frequently used in soil bioengineering (the use of plants to stabilize soil) applications (Polster, 2001). Planting of willow may be an option for slope stabilization, as they also develop an excellent root mass. Live-staking with willows has been very successful at maintaining integrity of shoreline properties along Charlie Lake (Blair, 2005). Staking with willows could be applied to the backside of berms around lease sites and road ditches, if regulations allow. Future projects could include applications of live staking to wellsite berms and roadside ditch banks to determine the effectiveness of willow in oil and gas management situations.

There are some limitations to soil bioengineering and it may not be suitable for all sites. For example, certain sites may just need simple distribution of seed mixes, rather than extensive bioengineering treatments (Washington Department of Transportation, 2002).Geotechnical engineers from Duke Energy and Ministry of Transportation expressed some reservations with regards to effectiveness of soil bioengineering applications, especially on very steep grades where there is existing or potential mass wasting. A combination of bioengineering and “hard” engineering applications (traditional engineering, using machinery and rip-rap etc.) can work well.

There are a number of benefits to soil bioengineering. Usually less heavy machinery is required, which lowers cost and environmental

Conclusion

Erosion and sedimentation from oil and gas activity may contribute to water quality issues in the Charlie Lake watershed. The majority of problems were related to a lack of vegetation, interruption of natural drainage channels, or concentration of flow which resulted in scouring. However, the erosion assessment undertaken during this project was qualitative in nature. A quantitative study would be necessary to determine the degree of impact.

Oilfield operators and others having a role in monitoring the industry could benefit from increased knowledge in recognizing indications of erosion and erosion control technology. Early identification will keep sediment out of Charlie Lake, help maintain infrastructure integrity and potentially reduce maintenance costs of constantly repairing berms and roads. Oil and gas companies showed a willingness to fix the problems identified in the erosion assessment project. The main issue now is determining management techniques appropriate to the environmental conditions in the watershed. The clay soils are particularly challenging to work with. Based on information gathered, a combination of management techniques will be most effective.

The CLCS Erosion Control Workshop, held as part of the project, was a good start with regards to sharing knowledge and educating producers. Many participants suggested holding the workshops on an annual basis and making them available to oil and gas producers operating in areas outside the watershed.

Relationship building was the most important aspect of the project. Success in mitigating erosion and sedimentation contributing to poor water quality in Charlie Lake can happen if the oil and gas producers, landowners and government agencies work in partnership to solve the problems.

Customized company-specific reports with wellsite assessments will be issued to cooperating oil and gas companies in 2005. In the second year of this Project, follow-up field assessments and discussion of action plans will be conducted.

References

Blair, Allan. Technical Supervisor and Past President, Charlie Lake Conservation Society, Fort St. John. *Personal Communication, 2005.*

Brady and Weil. 2002. The Nature and Properties of Soils: Thirteenth Edition. Prentice-Hall: New Jersey.

French, T.D. and B.P. Booth, 2004. A Long-Term Strategic Plan for the Improvement of Water Quality in the Charlie Lake Watershed. Charlie Lake, BC,

Gilbert, K. Regional Compliance Manager – South, Oil and Gas Commission, Fort St. John, *Personal Communication 2005*.

Grace, J.M. 2002. *Control of Sediment Export from the Forest Road Prism.* Transactions of the American Society of Agricultural Engineers. 45(4).

Grace, J.M. 2000. *Forest road sideslopes and soil conservation techniques.* Journal of Soil and Water Conservation. 55:96-101.

MacDonald, Dusty, P.Eng, Aurora Engineering, Fort St. John. 2005. *Strategies to Mitigate Soil Erosion in the Oil and Gas Industry: A Northeastern BC Perspective.* Presentation to CLCS Erosion Control Workshop. August 2005.

Ministry of Forests. 2002. *Forest Road Engineering Guidebook.* Available at http://www.for.gov.bc.ca/tasb/legsregs/fpc/FPCGUIDE/Road/FRE.pdf

Oil and Gas Commission, 2005. B.C Oil and Gas Commission Inspections and Compliance Operations Manual. Government of British Columbia.

Polster, David F. 2001. *Soil Bioengineering For Land Restoration and Slope Stabilization.* Polster Environmental Services. Duncan, BC: A22-A23.

Severin, Jordan M. 2004. *Landslides in the Charlie Lake map sheet (94-A), Fort St. John.* University of British Columbia. Dept. of Earth and Ocean Sciences. Thesis. M.Sc.

Washington State Department of Transportation. 2002. *Soil Bioengineering.* http://www.wsdot.wa.gov/eesc/design/roadside/sb.htm

Appendix I – Primer on Erosion and Watershed Impacts

Definitions[8]

***Erosion* –** in the context of freshwater ecology, the term erosion most often refers to the movement of sediment (soil) by moving water and/or wind, machinery and livestock. Sediment is particularly susceptible to erosion when it is exposed to wind and moving water, i.e. when not stabilized by rooted vegetation.

***Sedimentation* –** the process through which solids suspended in the water column of rivers, streams and lakes settle, or deposit, to or towards the bottom. While the term sediment most often refers to inorganic solids, sedimentation refers to the sinking of both organic and inorganic solids from the water column towards the bottom. The term sedimentation also refers to the sinking of dead organisms (e.g., plankton, fish, etc.). It is the process through which materials suspended in the water column become incorporated into the bottom sediment matrix.

***Rills Erosion*–** process in which numerous small channels of only several centimeters in depth are formed

Gully Erosion – process whereby water accumulates in narrow channels (rills) and over short periods, removes the soil from this area to considerable depths, ranging from 1 to 2 ft to as much as 23 to 30m.

***Riprap* –** broken rock, cobbles, or boulders placed on earth surfaces for the protection against the action of water.

Soil erosion is a naturally ongoing process that occurs at a slow rate (MacDonald, 2005). When erosion and sedimentation are accelerated they can be destructive and can cause detrimental effects to watershed ecosystems. Erosion of soil can be caused by wind or water, but the water is the dominant force of soil erosion in the Charlie Lake watershed. Soil washed from eroding areas is subsequently deposited elsewhere, in nearby low landscape sites, in streams and rivers; or in downstream reservoirs and lakes. These displaced soil materials can lead to major water pollution problems, resulting in both economic and social costs to society.

[8] Adapted from French and Booth, 2004. and Brady and Weil, 2002.

Appendix II –Photos from the Strategic Plan Supporting Project Rationale

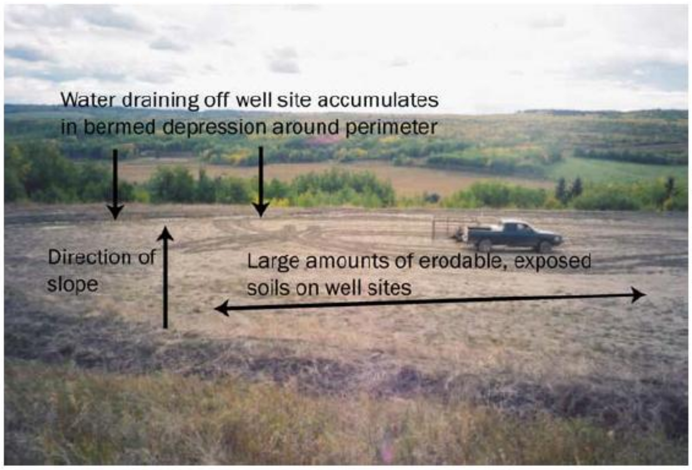

Plate 11. Exposed soils on oil and gas wellhead site. Note water retention ditch surrounding down-slope perimeter.

Plate 12. Small-diameter pipe used to drain water collection ditch on oil and gas wellhead site. Note extensive erosion down-slope of pipe resulting from the force of water through the pipe.

Plate 13. Small-diameter pipe that drains retention ditch on down-slope perimeter of oil and oil and gas wellhead. Note extensive sediment erosion resulting from the force of water through pipe.

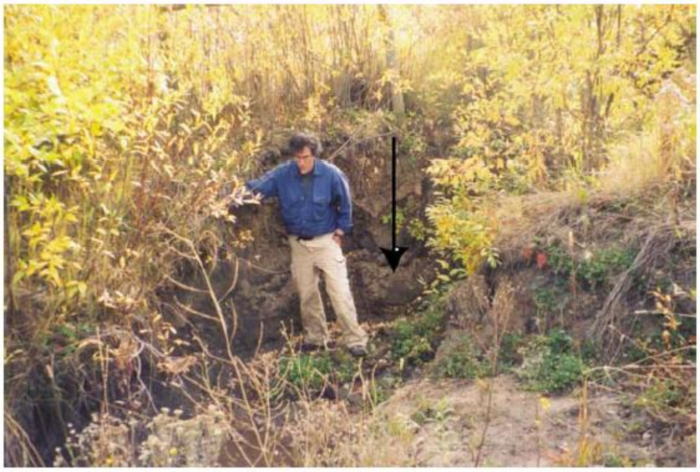

Plate 14. Sediment erosion down-slope of wellhead drainage pipe continues for considerable distance.

Plate 15. Ditchline erosion observed on private oil and gas road. Ditchline erosion is a common occurrence in the Charlie Lake watershed, particularly where there is any sort of slope (fine sediment is highly erodable, and likely contributes to stream channel sediment loads).

Appendix III – Assessment Form

WELLHEAD SITE ASSESSMENT FORM

GENERAL SITE DESCRIPTORS

Site Inspection Number (1-100):

Site Identification Number (WA# or Map Location):

Date of Inspection:

Time of Inspection:

Name of Inspector:

Weather at time of Inspection:

GPS Coordinates:

Lease Ownership:

Site Photographs Taken (ID #)____

1. WELLSITE

Location and Wellhead Site Description:
____
____
____
____
____
____
____
____
____
____
____

Surface Soil
Texture:____

Vegetation Cover (%):________________________________

Description of Vegetation Cover:

____
____
____
____
____

Proximity to watercourse / drainage ditch (m):

____

Evidence of Erosion:

Raindrop / Rainsplash

Sheet erosion / slope wash

Rill erosion

Gully erosion

Streambank / Stream Channel

Mass Movement

Description:____
____
____
____
____
____

Potential Causes:

____
____
____
____
____

Other notes:

2. ACCESS ROAD AND DITCHES

Slope (%):
____

Aspect:____

Surface Soil
Type____

Vegetation Cover (%):______________________

Description of Vegetation Cover:
____
____
____

Proximity to watercourse / drainage ditch (m):
____

Evidence of Erosion:

Raindrop / Rainsplash

Sheet erosion / slope wash

Rill erosion

Gully erosion

Streambank / Stream Channel

Mass Movement

Description:____
____
____
____
____
____

Potential Causes:
____

3. EROSION CONTROL

Are any past attempts at erosion control apparent?

4. OTHER

Evidence of wildlife:

Do livestock have access to lease site?

Does livestock access appear to be contributing to erosion on site?

Other notes/observations:

Some parts of form were developed using Polster, 2001 and French and Booth, 2004 as guidance.

Appendix IV – Letter to Landowners

Charlie Lake Conservation Society
Box 720
Charlie Lake, BC
V0C 1H0
(250) 262-0181
clcsoc@telus.net
www.charlielakeconservationsociety.ca

Dear __________;

RE: Permission to access your property for soil erosion assessment (oil and gas activity)

The Charlie Lake Conservation Society (CLCS) is a volunteer group that is interested in the conservation and remediation of the Charlie Lake watershed ecosystem, so that it can better meet the needs of the natural and human communities. In 2004, CLCS developed a long-term strategic plan for the improvement of water quality and habitat in the Charlie Lake watershed and to improve the aesthetic and recreational potential of the watershed as a whole. Through the strategic planning process, CLCS is designing specific projects and community-level initiatives that will address the watershed level factors that are thought to be affecting perceived deterioration in water quality in Charlie Lake.

Soil erosion and sedimentation are two factors which can cause detrimental effects to the watershed. Impacts include reduction in water clarity, which affects the ability of predatory fish to hunt successfully. Pollutants such as herbicides, pesticides and metals can bind to fine sediments and can then be carried through tributary flows to Charlie Lake. Nutrients such as phosphorus are also able to bind to fine sediments and fuel algal growth in the lake. Consequently the algal bloom problem in Charlie Lake is increased by the influx of sediments resulting from erosion.

This summer, CLCS would like to conduct an assessment of soil erosion at selected wellhead sites and associated access roads in the Charlie Lake watershed. The assessments will be taking place from June through to early-August 2005. Following the assessments, CLCS would like to work in partnership with landowners and oil and gas companies to develop restoration plans for high priority sites. A report will be compiled describing the results of the assessments at the end of the summer. Assessments and report writing will be carried out by Lindsay Sahaydak, a UNBC environmental sciences student. This project is funded by the Science and Community Environmental Knowledge (SCEK) fund administered by the provincial Oil and Gas Commission and the Peace River Regional District. A number of cash and in-kind donations have been made by local Fort St. John businesses.

CLCS is also planning a workshop on sedimentation and soil erosion issues which will be held in Fort St. John in August. The workshop is still in the planning stages and further information will be provided to you when the schedule is finalized.

If you have any questions or concerns regarding the oil and gas erosion assessment project, please contact Lindsay Sahaydak – Summer Watershed Technician at 250-262-0181. The CLCS Long-Term Strategic Plan for the Improvement of Water Quality in the Charlie Lake Watershed is available for viewing in CD-ROM format. If you would like more general information about CLCS, please visit our website at www.charlielakeconservationsociety.ca.

Kind Regards,

Lindsay Sahaydak
Summer Watershed Technician

Appendix V – Relevant Acts and Regulations

The following are Acts and Regulations that apply to the oil and gas industry in British Columbia[9]:

Agricultural Lands Commission Act;

Drilling and Production Regulation (under the Petroleum and Natural Gas Act);

Environmental Management Act;

Forest Act;

Freedom of Information and Protection of Privacy Act;

Geophysical Exploration Regulation (under the Petroleum and Natural Gas Act);

Heritage Conservation Act;

Land Act;

Oil and Gas Commission Act;

Petroleum Natural Gas Act;

Pipeline Act;

Pipeline Regulation (under the Pipeline Act);

Sour Pipeline Regulation (under the Pipeline Act); and

Water Act

[9] Oil and Gas Commission Inspections and Compliance Manual

Appendix VI – Basic Steps to Consider When Developing An Erosion and Sediment Control Plan[10]

Determine what you are trying to accomplish

- Preventive
- Temporary control
- Permanent control
- Biotechnical slope stabilization

What is the cause of the problem?

- water diversion
- water interception
- erode-able soils
- Unstable slopes

Costs and Scheduling

- Right people and equipment available
- Possibility of temporary measures (prior to implementing permanent measures) depending on available resources

[10] Summarized from presentation by Ken Gilbert, Regional Compliance Manager – South, Oil and Gas Commission, Fort St John, BC, August 2005.

Acknowledgements

This project would not be possible without generous funding from the Oil and Gas Commission's Science and Community Environmental Knowledge (SCEK) fund and the Peace River Regional District. Funding and in-kind donations were also provided by Ministry of Transportation, Mike and Pat Smith, Greywest Office Centre, Falkenburg Agencies, Murray Chev-Olds, Smith Fuel Services (Husky), Hamilton Stationary, McElhanney, Urban Systems, Duke Energy and Canadian Tire.

Cooperation of landowners and oil companies was also greatly appreciated. Charlie Lake Conservation Society would like to thank the many staff from the Oil and Gas Commission, Ministry of Environment, Ministry of Agriculture and Lands, Devon Energy, Samson Canada, Progress Energy, Terra Energy, Canadian Natural Resources Ltd and Advantage Oil and Gas who assisted with the completion of this project. Thanks also to Meridian Environmental for support for technical and other questions.

About the Author

Lindsay Sahaydak is a 4th year Environmental Sciences student specializing in Terrestrial Systems from the University of Northern British Columbia. The position of Watershed Technician with Charlie Lake Conservation Society was the final co-operative education work term for Lindsay's degree. Lindsay's work was directed by Allan Blair, P.Ag, a volunteer with the Charlie Lake Conservation Society.

Editing of final report was completed by Allan Blair, Edward Stanford and Bruce Kosugi.