THE ECONOMIC BENEFITS OF COMPLETING RECLAMATION SUCCESSFULLY THE FIRST TIME FOR OIL & GAS SITES

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Lindsey Kruckenberg, John Rizza and Bryan Whiteley

BIOGRAPHICAL SKETCH

David Chenoweth

Mr. Chenoweth, a Certified Professional Soil Scientist, started his career with ARCO Coal Company as a soil and environmental scientist completing work on surface and underground mines in the western U.S. Mr. Chenoweth founded Western States Reclamation. Inc. in 1983. He has over 31 years of experience in soil science, revegetation planning/construction, land restoration, land use planning, and environmental permitting. He has written revegetation training manuals and conducted stormwater management training seminars. Mr. Chenoweth has provided expert witness reports and testimony on cases involving natural resource damages including fire restoration erosion control evaluation. He has just completed a three year term as President of the American Society for Mining Reclamation.

David Holland

Mr. Holland is currently the Environmental and Regulatory Manager, Rockies Asset Team for Pioneer Natural Resources USA, Inc. in Denver, Colorado. He is responsible for the environmental and regulatory compliance programs involving the company's oil and gas exploration and production in the Rockies. Mr. Holland currently oversees all reclamation and stormwater compliance activities in the Rockies. Prior to joining Pioneer, Mr. Holland was the Natural Resources Program Director for SWCA Environmental Consultants' in Salt Lake City, Utah focusing on environmental permitting and compliance services for the highway construction and oil and gas industries. Mr. Holland received his B.S. and M.S. degrees in Forest Management from Utah State University.

Gerald Jacob

Mr. Jacob, Ph.D. is an Environmental Advisor to the senior management of Pioneer Natural Resources Inc. in Denver, Colorado. Previously he was the Environmental-Regulatory Manager responsible for all aspects of environmental monitoring and compliance for Pioneer's oil and gas operations in the Western U.S. and, prior to it's acquisition by Pioneer, served in a similar capacity with Evergreen Resources Inc. He has extensive experience in coalbed methane as well as conventional oil and gas operations. Dr. Jacob has degrees from the University of Chicago, Utah State University and the University of Colorado-Boulder.

Lindsey Kruckenberg

Ms. Kruckenberg works for EnCana Oil & Gas as a Coordinator within the Surface Management team. The Surface Management team maintains disturbances created by EnCana in the Piceance Basin. The team maintains environmental compliance with regards to Reclamation, Stormwater, SPCC, Weed control, Pit/Net inspection, etc. Lindsey is involved in all phases of planning, implementation, interaction with regulatory agencies, monitoring, and reporting. She graduated from the University of Colorado with a Bachelors degree in Geology and has previous experience with remediation of soil and groundwater along with chemical analysis of soil, water, and air.

John Rizza

John Rizza, is a Certified Arborist and Estimator for Western States Reclamation Inc. He has conducted research in relation to obtaining his Masters degree on reclaiming strip mine spoils in eastern Tennessee. John received his B.S. degree at Colorado State University where he focused on Forestry and Forest Reclamation. He has experience working in a variety of ecosystems throughout the U.S. John's innovative ideas have helped improve reclamation practices and promote healthy establishment of native vegetation on drastically disturbed sites.

Bryan Whiteley

Bryan Whiteley, Landscape Architect, has been recognized for his thoughtful construction, operations and maintenance cost management while delivering outstanding design solutions on many interdisciplinary design teams for major projects including *Leadership in Energy and Environmental Design* certified projects involving site selection, protection and restoration; water efficient landscaping and planting design, non-potable irrigation; stormwater management and construction activity pollution prevention plans. In 2005, Bryan founded LandStewards™ and set new precedence in reclamation, stormwater and VRM within the energy industry. Bryan's topsoil conservation strategies have been adopted by the BLM for oil, gas and geothermal development. In 2009, Bryan accepted a new position with EnCana as their Piceance Basin Surface Management Coordinator managing 900,000 acres of development.

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ABSTRACT

Environmental Managers employed by energy companies are often plagued with the lack of adequate cost data to support appropriate budgets for successful initial reclamation programs. Insufficient budgeting and improper initial reclamation for drill pads and access roads can result in higher overall operating cost and lower net profits over the life of the well. Pioneer Natural Resources and EnCana Oil and Gas Inc. have provided actual cost data for this case study and information from operations in the Piceance Basin and Raton Basin of Colorado. Minimizing reclamation and maintenance costs over the life of the well by properly budgeting and planning initial reclamation activities is essential to ensure cost savings. Reclamation failures can result in a 50% cost increase over initiating proper reclamation techniques from project implementation. The economic impacts associated with the direct costs of additional earthwork for sediment clean up and regrading, importing topsoil or applying soil amendments when poor soil conditions generate initial revegetation failures, re-seeding, re-installation of erosion control products, and weed control are significant. Operators can expect to spend upwards of $20,000 on sites where initial reclamation programs have failed. Additionally, hidden indirect costs, which are difficult to quantify, include environmental manager and consultant time to coordinate reclamation work that needs to be redone, potential agency fines for storm water management violations, and potential lost opportunity cost due to poor agency and landowner relationships that delay mineral extraction. Developing more effective programs to track these reclamation and stormwater management costs would benefit operators in the long term. Providing reasonable estimates for reclamation activities on sites to be capitalized up front would ensure resource protection.

I. INTRODUCTION

At the onset of the Phase II Storm Water Quality Regulations enforcement by the Environmental Protection Agency (EPA) many energy companies found their storm water management and reclamation programs lacking compliance with the new laws. Numerous energy companies learned the hard way, through hefty fines, what non-compliance with the storm water regulations can mean. Environmental Managers were grappling with budget constraints as well as what the constituents of a reclamation and storm water management program that can comply with state and federal laws. Western States Reclamation has worked for both Pioneer Natural Resources and EnCana Oil and Gas Inc. as a reclamation and storm water management contractor. Western States has witnessed the growth curve that oil & gas companies have gone through in trying to develop storm water management and reclamation programs. In a time of low natural gas prices the cost of storm water management and reclamation programs are being scrutinized by upper management. Environmental Managers with energy companies need to establish budgets that are adequate for successful reclamation and meet the requirements of federal and state regulatory agencies. Inadequate unsuccessful reclamation programs can result in an exponential increase in the comparative cost to retrofit sites which may exceed the costs of implementing a more thorough and successful reclamation program the first time around.

The purpose of this case study is to compare the cost of successfully reclaiming a site at the outset compared to the cost to retrofit an unsuccessfully reclaimed site. Western States Reclamation encouraged environmental managers with both Pioneer and EnCana to compile costs for previous reclamation projects. These costs could then be evaluated to determine the cost of successful reclamation work against the costs associated with retrofitting inadequately reclaimed sites.

While the cost data provided in this case study can be considered subjective it still provides evidence that there are economic benefits to performing reclamation right the first time. This case study also shows the importance of Environmental Managers setting up a system for cost data collection to establish credible reclamation budgets. Poor quality reclamation programs could result in higher lease operating expenses – a critical metric in the oil & gas industry. Western States Reclamation, Pioneer, and EnCana established a list of several key factors that are needed for successful reclamation projects:

- Locate facilities and access roads to minimize slope and stormwater run-on.
- Identify areas for potential topsoil salvage and establish a replacement plan for interim and final reclamation.
- Properly grade pads and install terraces, berms, benches, etc. to reduce sediment loading during interim and final reclamation.
- Apply the proper types and amounts of soil amendments to the soil when topsoil is lacking or poor in quality.
- Perform proper soil tillage to loosen compaction.
- Design proper seed mixtures and application rates.
- Adequately install and maintain BMPs and erosion control devices until the desired vegetation achieves self sustaining cover.
- Complete mechanical and chemical weed control for as long as needed to control noxious weeds.
- Construction supervision & monitoring so that all parties have an understanding of how their work fits in the overall project design.

Poor quality reclamation work results in cost increases to reconstruct and reclaim these sites. Experience demonstrates that most reclamation failures can be traced back to three factors; the lack of available quality seedbed materials (topsoil), the lack of implementing proper storm water BMPs, and the lack of clear upfront project design and follow-up performance supervision. Poor quality soils are typically the most erodible. Poor quality soils typically support less final vegetative cover for long term erosion control and significantly more weed species growth than desirable grasses or forbs. Improperly implementing BMPs can result in undesirable protection for newly seeded or planted vegetation. This ultimately creates poor vegetative health and delays the establishment of a desirable self sustaining cover. Failure to address erosion and sediment issues in the design of any site reclamation and properly supervising their execution can greatly increase the cost of reclamation programs.

i. Commonly Associated Direct Costs

Direct costs for reclamation and stormwater management failures include the following:

- Retrieving sediment from erosion and sediment events, including off-site.
- Replacing sediment or other suitable materials in washout areas.
- Regrading
- Reseeding
- Replacing and possibly adding more BMPs to avoid future washouts.
- Extending the duration for weed management activities.
- Additional maintenance and inspection costs due to restarting the reclamation clock.

ii. Commonly Associated Indirect Costs

There are many indirect costs that energy companies often may not recognize as significant in the cost of reclamation and stormwater management failures which include:

- Increased staff and consultant time to deal with sediment and erosion issues and redoing reclamation work and inspections
- Tarnished Agency and Landowner relationships
- Potential regulatory non-compliance

The costs associated with reclamation may be a relatively small percentage of the capital cost to drill and develop an oil and gas well. However, reclamation can become a significant factor in the operating expenses associated with a well, particularly on older wells where less sophisticated reclamation measures were used. Often, issues in Lease Operating Expense (LOE), a metric commonly used in the oil and gas industry, are followed closely by managers and financial analysts as indicators of profitability. LOE per unit of oil or gas produced is often used as an indicator of an operator’s efficiency. Unexpected inputs and resource allocation can lead to some level of impact to profitability.

This case history assesses the varying successes of reclamation and storm water management efforts experienced by Pioneer Natural Resources environmental staff operations in southeast Colorado. Also investigated is the Piceance Basin operation near Rifle, Colorado managed by EnCana environmental staff. These case study examples will demonstrate the financial advantages of reclamation planning in the early stages to ensure long term success. Evidence suggests that improper reclamation, storm water management, and associated budget programs could significantly reduce company profits over time. Properly designing and implementing BMPs, site monitoring, and progressive management will enable managers to successfully reclaim surfaces which will reduce waste and costs.

II. CHALLENGES AND PROPOSED SOLUTIONS FOR INCREASING RECLAMATION SUCCESS ON DRILL PADS AND ACCESS ROADS

i. Initial Planning and Site Surveys

An initial site survey conducted by environmental and engineering personnel should be the first step in the reclamation process to determine optimum routing of access roads and pad location for successful interim and final reclamation. Degree of slopes to be encountered, watershed size, exiting vegetation species inventory, and soil resources present should be evaluated and considered in the planning process. Operators have found that proper site selection is essential to avoid costly site development and reclamation issues.

Many of the challenges related to site selection are due to topographic variation including slope, drainage features, and subsurface material composition. Often, operators must implement a variety of techniques to address site concerns. Whenever practical, benching or terracing should occur on steep slope areas. Every effort should be made to retrieve viable topsoil during road and pad construction. Often, operators and engineers feel they have ample knowledge of what topsoil is by simply looking at soil color. However, proper identification of possible topsoil materials requires collecting and sampling an adequate number of sample sites. The sample data has to be evaluated for suitability as topsoil by rating the material according to standards that have been published by the U.S. Department of Agriculture and State Agencies such as Department of Environmental Quality. Currently, managers are modifying their practices to conduct their activities within the new Colorado Oil and Gas Conservation Commission (COGCC) rules. Background samples are an important part of conducting development activities. Program managers are continually adding sampling parameters for measuring soil vitality. Soil samples are typically rated by parameter as to good, fair, or unsuitable material. Any indication of unsuitable soil ratings may be cause for a soil scientist to reject material as topsoil for salvage. When seedbed quality material does not exist on site for use in reclamation, a variety of soil amendments may be utilized to build a suitable soil from local materials. Amending soil located in close proximity of the work site to create suitable growth media should be compared to the cost of importing topsoil. Management teams are implementing programs which utilize perimeter windrowing for topsoil conservation. The windrow is seeded and hydraulic erosion control mulch is applied almost immediately after its construction. The windrow minimizes the slope length facing the exterior edge of the disturbed area. Ideally this maximizes the topsoil surface area which helps to maintain its viability. This technique reduces the overall quantity of erosion control BMPs utilized for a well site, contains and diverts stormwater within the disturbance, and maintains topsoil adjacent to its previous position. Suitable quality seedbed material is the most critical building block to achieving successful reclamation on the first attempt.

ii. Topsoil Placement and Site Regrading

The sites encountered in this case study often lack salvageable topsoil material. Operators are faced with thin soils which are often poor in nutrient content and lacking in organic matter. The significant amount of course fragments occurring on these sites also impedes the ability to salvage soils. Operators must account for the creation of adequate topsoil or topsoil substitute materials early in the planning process. Seedbed quality material placement followed by site regrading of disturbed areas should be completed in a manner which limits water run-on and runoff. Geomorphic landforming and earthen hydrological controls are utilized to manage water run-on, runoff, to reduce slope potential for erosion, and contain sediment. Terracing and berming on disturbed areas are a few methods utilized to effectively control water erosion. Channelizing flow from disturbed areas and routing through adequately sized detention ponds are also effective methods of treating water flow to prevent sedimentation and reduce the need for regrading operations. When these landforms and drainage controls are properly constructed with suitable subsoils to achieve proper grade and sediment containment, they are then ready for topsoil spreading. When utilizing perimeter windrows for topsoil conservation, the topsoil is easily placed on the adjacent subsoils limiting compaction and potential losses.

iii. Seed Mixture Design

Seed mixtures, seeding rates, and seeding methods are all very important elements for successful reclamation practices. Considerations for the actual seed mixture should include species of grasses, forbs, and shrubs that are common to the area. Also, the intended land use after final reclamation is completed should be considered and related to vegetative species selection. For example, if managers choose livestock grazing as the future land use, the vegetative cover mix should focus on a balance of warm season and cool season grasses which are palatable. Wildlife habitat should include native forbs and shrubs for browse and cover. Forb species are important for game birds such as pheasants, turkey, quail or grouse. These native species will attract insects as a food source for young chicks and in turn benefit overall site establishment. Selecting the appropriate seeding rates represents both an art and a science. Educating landowners to the timeline for vegetative establishment and addressing their concerns during the planning process is imperative to creating a cooperative working environment.

Seed mixture designs must take into consideration items such as ease of establishment of individual species, number of seeds per pound per species, and aggressiveness of individual species. Grass species can vary greatly in their number of seeds per pound. For example, Buffalo Grass has 56,000 seed per pound and Sand dropseed has 5,298,000 seeds per pound. A targeted goal for planting seeds per square foot according to most revegetation experts ranges from 75 seeds per square foot up to

140 seeds per square foot. Regulatory agencies often specify required minimum seeds per square foot depending on site conditions and seeding type. Increasing the number of seeds per square foot is based on the risk of loosing seed to water erosion on steep hill sides or wind erosion in high wind prone areas.

To promote species diversity and sustainability, managers should design seed mixtures containing 4 to 10 different native species. The number of pounds of individual species should be based on a relatively equal number of seeds per square foot while taking into consideration ease of establishment and interspecies competition. Having a number of species in the mixture will promote diversity in the final vegetative cover and will reduce the risk of revegetation failure. The amount of time needed for certain species to establish can play a significant role in site stabilization. Often, native species take 2 to 3 growing seasons to achieve an adequate amount of cover. Managers need to account for this and recognize the increased risk associated with utilizing native species. Any expert in the revegetation industry knows that there are no absolutes in designing a seed mixture.

A seed mixture at a minimum will consist of native grasses and forbs. As previously mentioned at least three grass species should be in any revegetation seed mixture. The operator (such as EnCana), landowner (either private landowner or federal agencies such as the Forest Service or BLM), and Revegetation Specialist typically consult with one another to determine what the seed mixture should contain. These individuals or organization will determine if the seed mixture should contain only grasses or whether shrub and forbs seed should be added to the seed mixture as well. Typically cost of seed is a driving factor on deciding if these species are added to a seed mixture.

iv. Seeding Methods

Common options for seeding methods include drill seeding, hand and machine broadcasting, and hydroseeding. Drill seeding is considered the most reliable method of seeding since there is more control over seed depth placement and seed covering with soil (Figure 1). However, drill seeding is not always possible on drill pads and access roads since steep slopes and rocky terrain prohibit access with equipment. Hand broadcasting or hydroseeding are typically used where drill seeding is not practical. However, these methods are often costly and exhibit limited success. Sources of water for hydroseeding operations can be difficult to obtain and increase the cost of reclamation. Managers need to be aware of the costs and benefits related to each method of seeding to make an informed decision. Regardless of which of these practices are used, it is important that the seed is properly covered with soil by hand raking, slope chaining, or harrowing.

Figure 1: Proper reclamation of access roads in the Raton Basin before (2005) and after (2008)

Drill seeders should be calibrated for use on a small area before all seeding is completed. Most manufacturers of drill seeding equipment can provide general guidelines as to the amount of seed output by seed box for flowable seeds versus trashy seeds. Calibration will help ensure that the proper amount of Pure Live Seed (PLS) is planted. All drill seeding should be completed parallel to slopes or on the slope contour. Drill seeding up and down a slope can result in accelerating erosion after rainfall since the indentations from the drill rows help to concentrate flow and accelerate soil movement down hill. It is recommended to plant most native grass and forbs species to a depth of ¼ inch for optimal germination.

Broadcast seeding is typically done where seeding areas prohibit safe operation of a farm tractor, access is limited, scope of work is small or the soil surface is covered with large rock that cannot be economically removed. Hand seeding may be needed in small, tight access areas where machinery cannot effectively operate. Broadcast seeding is performed using hand seeders or tractor mounted spreaders. Broadcast spreaders typically spread an even swath of seed onto the soil surface. Broadcast seeding by hand or machine alone will not typically provide good results unless the seed is covered with soil. Broadcast seeding with a tractor should be followed by using a flex harrow to cover the seed with soil. Hand broadcast seeding should be followed by hand raking with a hard tine rake. In both cases the seed should not be raked deeper than ½ inch into the ground. And in all cases, the chance for broadcasted seed germination is greatly increased when followed by mulch application.

Often operators utilize hydraulic applications of seed on pads and roadways. The operator will mix the seed, amendments, required tackifiers, and hydromulch in the tanker. The objective of using the hydraulic pressure of the machine is to use enough force to shoot or push the seed into the ground. If the seed is not adequately covered with soil, hand raking of the area or slope harrowing should be employed.

v. Mulch and Erosion Control Fabrics

Surface mulch and erosion control blankets are needed to conserve soil moisture and serve as BMPs to control erosion. Lack of proper erosion control can result in seed being washed away before it germinates. Mulch materials also promote increased moisture infiltration from rain and snow, cool the soil surface, and provide valuable soil organic matter to increase soil structure. Mulch considerations include conventional hay/straw mulch and hydromulch. Innovative products being applied to meet the needs of challenging sites include Bonded Fiber Matrix (BFM), and Flexible Growth Medium (FGM). These products tend to be more expensive and create application difficulties on certain sites. Experienced operators must employ techniques to ensure adequate seed germination and soil stabilization. In many circumstances, erosion control blankets can be an effective way to control sediment movement. On the sites investigated by this case study, operators have determined that these blankets are most useful when used in place of mulches on steep uniform slope areas, drainage areas, and constructed diversion channels. These products come in a number of different fabric ratings to control erosion. Some examples include excelsior blankets, straw blankets, straw coconut blend blankets, coconut blanket, and geotextile blankets for more permanent erosion control. Mulches and blankets need to be complemented with other BMPs to ensure proper erosion control and comply with state and local agency requirements for disturbed construction sites.

Erosion Control Mulch (ECM) is hydraulically-applied, flexible erosion control blanket composed of long strand, thermally refined wood fibers, crimped, interlocking fibers and performance enhancing additives. Operators utilize ECM that requires no curing time and when applied forms an intimate bond with the soil surface to create a continuous, porous, absorbent, and erosion resistant blanket that allows for rapid germination and accelerated plant growth. Many applicators have determined specifications for the ECM application rates and techniques on a site specific basis to ensure soil and vegetation stabilization.

vi. Structural BMPs

Some of the structural BMPs that are available on the market include erosion logs, straw wattles, silt fence (including wire backed fence), erosion bales, and rock socks. Constructed physical devices can include wood logs placed perpendicular to the slope, wood slash piles in drainages to slow water flow, diversions, terraces, rock check dams, and many others. On disturbed sites, these products can create significant maintenance challenges when failures occur. Combining different techniques is an effective way to utilize the benefits of structural devices. Areas with concentrated flows created by landforming can receive erosion control blanket with wattle check dams. Riprap can also be applied to containment outlets to limit impacts caused by concentrated flows. These types of stabilization techniques are very effective methods for reducing soil loss and they are also cost effective due to low initial cost and reduced maintenance requirements.

VII. MAINTENANCE AND MONITORING

The objective of surface management programs is to utilize a wide range of tools and management practices to establish a diverse self sustaining mosaic of vegetation cover that exceeds regulatory agency compliance requirements and provides a new precedent for the visual resource, stormwater management, revegetation, and productive land use. Establishment successes are often achieved by early planning for the long term. Maintenance and monitoring programs developed from project implementation will benefit site establishment and sustainability. Maintenance of seeded areas includes weed control, erosion control, and touch up seeding. Most newly seeded sites require these maintenance operations during the first growing season to help insure successful revegetation. Observing the site in regularly scheduled intervals and evaluating changes will allow proactive management to reduce the need for unexpected repairs and erosion control additions.

i. Weed Control

Managers must address weed control concerns by treatment consisting of mechanical methods such as hand cutting and removal, weed eating, and bush hog mowing. Ideally, operators should mow or cut weeds when twenty percent (20%) canopy cover for any surface area is achieved. Mechanical weed control is typically used the first growing season and often needs to be completed twice per year. If weed species continue to be a problem for the native grasses after a 12 month grow-in period control techniques shift to use of approved herbicide applications

ii. Touch-up Seeding

A consensus among local ecologist has shown that two healthy seedlings per square foot after one growing season are typically adequate for successful reclamation. Thus, any areas not containing at least two seedlings per square foot should be evaluated and reseeded. Most surface management programs are performance based. Revegetation results are directly related to the quality of the site design, earthwork, seeding, mulching and stormwater applications. A lack of attention to detail during earthwork and soil preparation adversely affects the quality of the visual resource, stormwater management, revegetation and ultimately lengthens the maintenance cycle. Each phase of site activities can adversely affect the following phase if implemented poorly.

iii. BMP Repairs, Regrading, and Additions

Inspections and maintenance are an extremely important part of the stormwater management process. Inspectors ensure controls are constructed or applied in accordance with governing specifications or good engineering practices. The goal is to minimize the potential for inadvertent removal or disturbance of BMPs and to prevent the off site transport of sediment and other pollutants. Maintenance activities will ensure that all control measures are functioning at optimum levels and that all procedures and techniques will be in proper working order during a runoff event or spill condition.

When inspections determine that repairing areas where rill or gully erosion has occurred, immediate action is required. These repairs will increase financial and resource inputs long past well construction completion. When channel erosion is severe enough to warrant regrading, the vegetative cover will also have to be repaired. Seeding steep slopes and waiting to achieve the desired amount of cover increases the likelihood of additional site repairs. These reworked sites need to be inspected after every rainfall event or every two weeks. In certain situations, regrading and reseeding have to be completed on a semiannual or annual basis as needed to make sure that the vegetative cover is progressing towards a self sustaining cover and 70% of background cover. These repairs can prove costly and will add to the time for site recovery.

IV. LESSONS LEARNED

i. Cost of Proper Reclamation Programs as Completed by EnCana and Pioneer Natural Resources

Both EnCana and Pioneer have experienced the learning curve of using less adapted reclamation techniques versus their site-specific reclamation practices that are currently on-going. Costs were compiled from EnCana and Pioneer Environmental staff for each major technique related to proper site reclamation activities (Table 1). These operators provided average costs by slope category for drill pads and access roads on a per acre basis for comparison. Steeper slopes accounted for an increase of approximately 25% over gentile grades for both operators.

Table 1 - Estimated Costs of Proper Reclamation Practices on Drill Pads

	EnCana - Piceance Basin		**Pioneer - Raton Basin**	
	(2.1:1 to 3:1)	**(1:1 to 2:1)**	**(2.1:1 to 3:1)**	**(1:1 to 2:1)**
Treatments	Cost per Acre	Cost per Acre	Cost per Acre	Cost per Acre
Lifespan Planning	$950 to $1,150	$950 to $1,150	$1,250 per acre	$1,500 per acre
Topsoil Conservation	$525 - $1,142	$450 - $1,101	$750	$1,000
Topsoil Replacement	$1,100 - $1,060	$950 - $1,020		
Pad Regrading	$1,224 - $1,632	$1,224 - $1,632		
Landforming	$9,500.00	$9,900.00	All Inclusive, Drill Seeding w/ straw mulch, tackifier, BMPs $14,000	All Inclusive, Hydroseed w/ Flexterra hydromulch, BMPs $17,000
Soil Preparation	All Inclusive, Drill Seeding & Crimped Straw $2,620.00	All Inclusive, Broadcast Seeding & Flexterra Mulch $7,015.00		
Soil Amendments				
Seeding				
Mulching				
BMP's	$900.00	$900.00		
Weed Control	$125.00	$200.00	$125	$200
Total Costs	**$16,944 to $18,129**	**$21,589 to $22,921**	**$16,125**	**$19,700**

ii. Estimated Costs of Low Budget Reclamation Practices on Drill Pads

In past times, operators often reclaimed sites with minimal inputs and disregarded revegetation standards and erosion control BMPs (Table 2). Sites were often reclaimed without adding any type of soil amendments or any type of tilling activities to create quality seedbed materials. Seeding was often conducted using aggressive forage species including perennial rye that were not drought tolerant but could be purchased at a relatively low cost and quickly achieve densely vegetated stands. Operators could spend as little as one to two percent of capital on reclamation activities under the old regime. That is compared to 5-8 percent of capital that is currently spent on reclamation.

Table 2 - Estimated Costs of Low Budget Reclamation Practices on Drill Pads

	EnCana - Piceance Basin		**Pioneer - Raton Basin**	
Treatments	**(2.1:1 to 3:1)** Cost per Acre	**(1:1 to 2:1)** Cost per Acre	**(2.1:1 to 3:1)** Cost per Acre	**(1:1 to 2:1)** Cost per Acre
Initial Planning	$520 to $570	$520 to $570	$1,000	$1,000
Topsoil Stockpiling	$775	$625	none	none
Topsoil Replacement	$1,350	$1,250	none	none
Pad Regrading	$1469 to $2122	$1469 to $2122	$1,000	$2,000
Subsoil Contour Grading	$11,100	$10,750	none	none
Soil Preparation	none	none	minimal	minimal
Soil Amendments	none	none	none	none
Seeding	$500	$500	$500	$500
Mulching	none	none	none	none
BMP's	minimal non-structural	minimal non-structural	minimal non-structural	minimal non-structural
Weed Control	$250	$400	$250	$400
Total Costs	**$15,964 to $16,667**	**$15,514 to $16,217**	**$2,750**	**$3,900**

iii. Costs Associated with Unsuccessful Reclamation Programs

EnCana and Pioneer Environmental staff compiled costs associated with reclamation work that required redo treatments (Table 3). While redo cost can be very subjective, expert opinion and costs compiled by the three different companies (EnCana, Pioneer, and Western States) added to the credibility of the results. Redo work on these sites often ranges from $20,000 to $40,000 depending on the severity of site degradation and need for regrading and reseeding. The addition and reworking of BMPs on these sites is another significant area of economic and resource input.

Table 3 - Costs Associated with Reclamation Failures				
	EnCana - Piceance Basin		**Pioneer - Raton Basin**	
Redo Treatments	**(2.1:1 to 3:1) Cost per Acre**	**(1:1 to 2:1) Cost per Acre**	**(2.1:1 to 3:1) Cost per Acre**	**(1:1 to 2:1) Cost per Acre**
Sediment Clean Up	$500 to $1000	$500 to $5,000	$500 to $1,000	$1,000 to $5,000
Fill Placement	$500 to $1000	$500 to $5,000	$500 to $1,000	$1,000 to $5,000
Regrading	$11,100 to $13,100	$10,750 to $13,750	$5,000 to $10,000	$8,000 to $15,000
Reseeding and Mulching	Drill Seeding & Crimped Straw $2,620	Broadcast Seeding & Flexterra Hydromulch $8,017	Drill Seed, Straw Mulch w/Tackifier $2,000	Hydroseed, Flexterra Hydromulch $8,000
Fix BMP's and Add More	$5,000	$5,000 to $10,000	$5,000	$10,000
1 Year Extended Weed Control	$350	$450	$250	$400
Total Costs	**$20,070 to $23,070**	**$25,217 to $42,217**	**$13,250 to $19,250**	**$28,400 to $43,400**

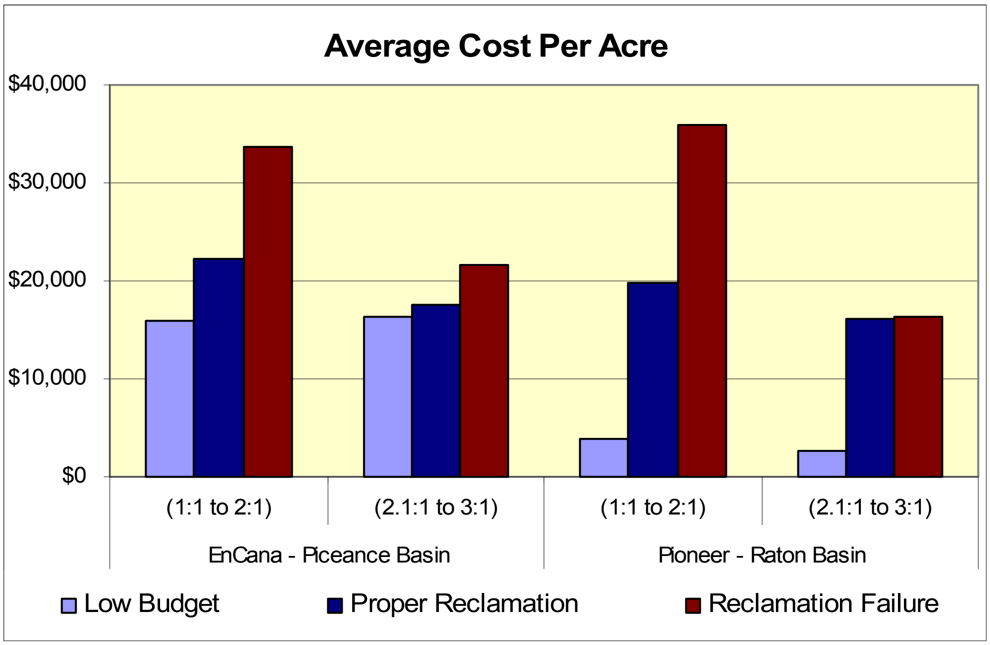
iv. Indirect Cost Estimates Resulting from Unsuccessful Reclamation

EnCana and Pioneer were asked by Western States to provide estimates of indirect cost to handle storm water management issues with state agencies and reclamation issues with individual land owners. The categories were divided into estimates of regulatory fines on a per acre basis, administrative time to deal with land owner and state agency issues, and finally what potential lost opportunity could be for delayed mineral extraction especially during the peak pricing periods of 2007and 2008.

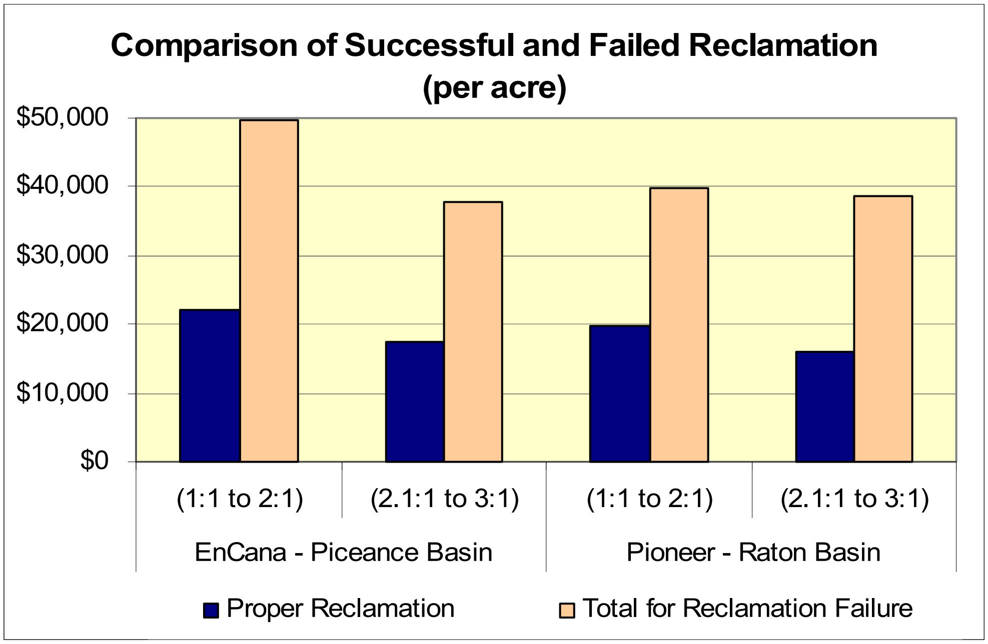
Calculating these costs proved to be very difficult since they were based on memory by EnCana and Pioneer Environmental staff. While the cost estimates are very subjective for indirect cost, they are conservative figures and have merit in being considered for illustrating to upper management the benefits of good reclamation programs. Upon further investigation of several example sites, we found that agency fines could range from $0.10 to $15 per acre depending on site conditions and other relevant factors. This is a significant total cost when considering both companies operate across several hundred thousand acres. We also found that a significant amount of time is spent by operators communicating with landowners or regulatory agency representatives about the deficiencies associated with poor reclamation. Administrative costs can range from $20,000 to $120,000 per year depending upon the amount and severity of conflicts. If effective initial site analysis and design are not adequately implemented environmental managers inherit additional-unneeded risk and additional cost over the lifetime of the asset. Again, although difficult to quantify, we can estimate the potential lost opportunity costs to be in the area of $1000 per acre in standard situations. Operators feel that linear disturbances after reclamation activities remains the highest surface management risk and most difficult to change.

v.	**Cost Comparison of Successful to Unsuccessful Reclamation Work**

Operators have found that any lack of attention to one detail adversely affects the others. Each component of the reclamation is interconnected and failure of one element causes failure of the entire reclamation program. Costs are significantly compounded when failures occur due to operators minimizing initial expenses for reclamation (Chart 1). Successful management of the landscape can only be achieved when planning for stormwater, revegetation, weed control, and reclamation over the lifespan of the assets. Poor stormwater design and topsoil conservation adversely affects revegetation which impacts future weed management. Poor reclamation design adversely affects operating and maintenance costs and public perception during the production lifespan of the asset.



When comparing the total cost of initial low budget reclamation and associated reclamation work due to site failure, we find that generally, the cost per acre is significantly higher than implementing adequate reclamation on the first attempt (Chart 2). Pioneer, being relatively youthful with respect to the data available for this case study, demonstrates similar trends as EnCana with respect to higher costs for steeper slope reclamation operations. EnCana has collected data on a much more intensive and larger area, approximatly three times the area of Pioneer's operations. These experiences represent the norm for operators as they have adjusted their approach over time based on better tracking of reclamation and stormwater maintenance costs.



vi. The need for Cost Data Through Annual Assessments of Reclamation and Stormwater Management Work

It became quite evident while preparing the case study that the previous years reclamation and storm water efforts needed to be evaluated on an annual basis to determine what practices were working the best and what redo work might be avoided in future efforts. In Pioneer's case cost allocation practices were recently altered to capture reclamation and stormwater efforts separately from traditional earthwork and well site construction costs.

Reclamation work has long been viewed as both an art and a science. There is no cookbook method to making sure that reclamation efforts are successful across a wide variety of sites found in company's area of operations. Site specific adjustments to reclamation and stormwater management programs should be expected since energy development covers a variety of different environmental factors and ecosystems that does not allow for a one practice fits all technique.

vii. Time Saving Areas for better use in Reclamation Project planning and budgeting

All environmental managers agreed that a significant percentage of their time and their staff's time was spent on problem solving old stormwater management and reclamation issues which could have been better spent on new well sites and increased production. Also, time could be utilized to continually determine through site evaluations where reclamation efforts could be improved to reduce the need and cost impact of redo work. While the authors feel that the cost data provided was useful, more accurate data would be beneficial in the future to pin down the cost of successful reclamation. Proper reclamation cost data will help establish better program budgets and select better adapted practices. More reliable economic forecasting will provide better credibility for planning and budgeting reclamation programs.

V. Conclusions

i. Findings

In conclusion, even with subjective cost data supplied in this case study the authors feel that by using conservative figures there is significant proof that there are many economic benefits to proper reclamation work completed the first time around. When either operator had utilized the minimal input reclamation procedures of the past, the opportunity for failure was significantly higher and in turn the cost of redo work ends up costing the company much more money. Reclamation failures can result in a 50% cost increase over initiating proper reclamation techniques from project implementation. This is related to many factors including the lost opportunity of advancing and moving on to more lucrative sites. EnCana's numbers represented a much larger area and demonstrated that in the big picture, the costs of reclamation failure is much higher on steep slopes due in particular to site regrading and seeding operations.

ii. Future developments

Environmental managers have found that the accounting department should be involved in assessing reclamation program success. At this time most operators are tracking the project costs on an individual pad and associated access road basis. For the future, it is essential to track out-of-house contractor costs for reclamation and stormwater management activities as well as in-house staff time for handling reclamation tasks. Separate project costing codes are needed to track costs for original reclamation efforts against any redo work. As reclamation and storm water management programs are steadily improved, project costing should help illustrate these reductions in direct and indirect costs for problem sites. Most contractors are utilizing a job cost based accounting software system that tracks costs and profitability on an individual job basis. Thus, reclamation contractors may be able to provide assistance to energy companies on how to set up project costing programs. Developments in technology and data collection should allow managers to create custom programs adapted to company accounting software for ease of analysis.