CLIMATE CHANGE
ADAPTATION PROGRAM

Best Practices for On-Farm Management of Runoff, Drainage & Erosion

Project Report

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Regional Adaptation Program

BC Agriculture & Food Climate Action Initiative

Peace Region, British Columbia, 2020

Best Practices for On-Farm Management of Runoff, Drainage & Erosion

Project Summary

Peace Region — Best Practices for On-Farm Management of Runoff, Drainage & Erosion: Project Summary

Prepared by ***Forage Friendly Enterprises***,
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This report was prepared by ***Julie Robinson*** (Senior Agrologist) of Forage Friendly Enterprises, in association with ***Matthias Loeseken*** (Senior Agrologist) of Blackbird Environmental Ltd and ***Sandra Burton*** (Senior Agrologist) of First Resources, for BC Grain Producers Association in partnership with the BC Agriculture & Food Climate Action Initiative.

The Project Oversight Committee included:

- ***Talon Gauthier*** & ***Blair Hill***, Peace Region Forage Seed Association
- ***Garnet Berge***, ***Irmi Critcher***, ***Rick Kantz*** & ***Sharla Pearce***, BC Grain Producers Association
- ***Brian Stratuliak***, Peace River Regional Cattlemen's Association
- ***Darryl Kroeker***, Peace River Forage Association of BC
- ***Aaron MacKay*** & ***Lori Vickers***, BC Ministry of Agriculture
- ***Emily MacNair*** & ***Foster Richardson***, BC Agriculture & Food Climate Action Initiative

The cover photo by Foster Richardson.

The Peace Agricultural Adaptation Working Group included representatives representation from:

- Peace Region Forage Seed Association
- BC Grain Producers Association
- Peace River Regional Cattlemen's Association
- Peace River Forage Association of BC
- BC Ministry of Agriculture
- BC Agriculture & Food Climate Action Initiative

In addition, Forage Friendly Enterprises would like to thank the agricultural producers, agricultural organizations, Ministry of Agriculture staff, and all the other individuals and organizations in the Peace region who provided input and information during the project.

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1 Project Background

Best Practices for On-Farm Management of Runoff, Drainage and Erosion (the project) was initiated by the Peace Agricultural Adaptation Working Group in late 2018 to summarize the current state of knowledge and management practices with regards to the management of surface runoff, drainage and erosion improvements in the Peace region. A project oversight committee (POC) was established that selected Forage Friendly Enterprises Ltd. (Forage Friendly) to implement the project in early 2019. The project was administered by the BC Grain Producers Association.

Forage Friendly subsequently consulted with producer groups, individuals, and industry specialists on the subject matters, and completed a scan of other jurisdictions to identify management practices with potential applications in the Peace. This document summarizes the results of the engagement efforts and presents recommendations for the next steps in research, pilot projects and on-farm demonstrations.

Overarching project objectives include:

1. Assess the extent and nature of current runoff, drainage and erosion management practices currently in use in the Peace
2. Review and summarise relevant management practices that are not currently used in the Peace region (but have potential for greater adoption)
3. Identify the management practices with the greatest potential (high applicability and economic feasibility) for adoption in the Peace region
4. Deliver information to producers through effective knowledge transfer mechanisms

2 Consultation with Peace Region Producers and Industry Specialists

Consultations were planned and carried out with directors of the Peace Region Forage Seed Association, the BC Grain Producers Association, the BC Peace River Regional Cattlemen's Association, The Peace River Forage Association of BC and other agriculture producers at large between February and May of 2019. Please refer to Table 1 below for an overview of engagement efforts.

Table 1: Summary of events held for producer consultation

Event	Sectors Represented	Attendees
Soil Health Workshop Feb 14, 2019	Grain, Forage Seed, Forage, Livestock	37 producers + 5 industry specialists
BCGPA Directors Meeting Feb 22, 2019	Grain	6 producers + 1 industry representatives
PRFSA Directors Meeting Feb 22, 2019	Forage Seed	2 producers + 1 industry representative
PRFA Directors Meeting Mar 6, 2019	Forage	7 producers + 2 industry representatives
Peace River Regional Cattlemen May 8, 2019	Cattlemen	11 producers
Total		**71 producers 11 Industry specialists**

The producer consultations were conducted by reviewing a series of industry relevant images of runoff, drainage and erosion scenarios and collecting information from producers and industry specialists to determine:

1. The current state of practices related to the management of runoff, drainage and erosion
2. Potential practices to be employed going forward
3. Priority of practices, and factors that can be used to evaluate utility of practices

2.1 Consultation Results

1. Identify management practices that have been adopted and those that producers have considered/have awareness of, but have not adopted:

    a. Subsoiling (aggressive shearing tool) in luvisols or sandy soils has been utilised to some extent, however frequency and cost of using this tool has limited its use today.
    b. Highspeed tillage has increased in the last five years for producers, especially those with perennials in the rotation, the up to $130,000 initial purchase price has limited the uptake to some extent.
    c. Minimal tillage is the established standard for grass seed and grain farmers and has been since the early 2000.
    d. A lot of various reactive methods utilized once erosion has occurred, such as backfilling, placing bales of hay, infilling with rocks, grassing waterways, etc.

2. Gauge producer interest in new practices; taking an interest in determining the threshold of impacts that would lead to management changes

    a. Minimal ditching in fields. In general, questions about newer ditching tools, about GIS tools, and building and implementing drainage plans on field or farm basis were raised.
    b. Minimal field drainage plans other than field edge ditching, it seemed unclear if concentrating flow of water, or improving infiltration and mitigating erosion causes, such as speed of water, would be a more beneficial approach.
    c. Some producers shared proactive measures they were implementing, such as grassed waterways, or annual maintenance of trouble areas, while others struggled with rental land agreements and investing in erosion repair when the landowner did not place a value on the maintenance of good soil health.
    d. Forage industry has minimal uptake of minimal tillage practices, and virtually no utilization of high-speed tillage implements to date.

3. Understand the economic considerations that inform management decisions and how future climate conditions might shift the balance of the cost/benefit to producers.

> “Wind and water erosion are major threats to the long-term sustainability of farming on much of the Canadian Prairies. Since the 1930s, cropping practices using tillage and use of fallow have greatly accelerated the process of erosion.

> Erosion reduces the soil productivity via its effects on soil qualities.[1] Eroded soils generally are coarse, have high bulk density, poor tilth, reduced organic matter, low nutrient availability and reduced water holding capacity, these all result in reduced crop yields.[2] The average annual soil loss due to wind erosion on the Canadian Prairies is estimated to be about 160 million tonnes per year.[3] The Research Council of Canada (1986), indicated that annual losses associated with soil degradation cost $1.3 billion ($50.00 - $62.00 per acre of agricultural land) in Canada, and this figure would increase to $2.0 billion a year by 2000, as of writing, this estimate has not been substantiated in any reports. Also, in western Canada, Rennie (1986) estimated the annual on-farm costs of soil erosion to be $430 million."[4]

In 2000 using *The Universal Soil Loss Equation* (USLE) and its derivatives there was a predicted average annual soil loss rates by water erosion on the Canadian Prairies and according to this model, in 1996, the Prairie Provinces had 87% of cropland area at a tolerable water erosion risk.[5] This was an improvement of 22% in water erosion risk since 1981, and this shift of cropland into the tolerable risk class from the higher risk classes can be attributed to a combination of reduced tillage, less intensive crop production, decreased summer fallow, and removal of marginal land from production.[6]

In simulated erosion studies at six Alberta sites, erosion drastically reduced crop productivity.[7] These authors showed that only 1 cm of soil loss could result in a 2 - 8% yield reduction in spring wheat, and after 20 cm soil loss, crop yields would be reduced by 5 - 40%. They also found that the addition of fertilizer and manure didn't restore productivity. In addition, they found that treatment effects at an irrigated site followed the same trends as at dryland sites, indicating that topsoil loss cannot be offset by adequate soil moisture. [8]

In another simulated rainfall study, Nolan et al (1997) showed that for a 1 in 2-year storm in the Peace River region, reduced tillage and no-till reduced soil losses by 50 - 80 % as compared with conventional tillage.[9]

a. Based on the above research a 5% yield assuming 50-bushel wheat crop average with $5.00 per bushel value could mean $12.50/ac loss in yield. An average BC Peace grain farm size of approximately 2,500 acres would experience a $31,000 loss in yield. In more severe soil erosion sites of 40% yield losses resulting in $100/ac and $250,000 annually in yield. These values make it clear what the value of preserving topsoil is and how it relates to production costs. If high-speed-tillage is an implement that helps minimize the risk of

1 (Coote 1984, Sparrow 1984)
2 (Dormaar et al 1986)
3 (Sparrow 1984)
4 (Baig and Gamache 2011)
5 (Shelton et al 2000)
6 (Baig and Gamache 2011)
7 (Larney et al 1995)
8 (Baig and Gamache 2011)
9 (Baig and Gamache 2011)

soil loss in an operation like perennial grass seed farming, saving a 5% loss in yield in an annual creeping red fescue stand would be valued at about $30/ac. This would mean a less than four-year return on investment on a $150,000 implement if the farm is over 2,500 acres.

b. Rental agreement amendments, education for landowners on erosion issues and costs of repairs as well as information about the mitigation practices that producers regularly implement, such as residue management, minimum till, contour farming may help.
c. Climate change modeling predicts more frequent extreme weather events increasing the risk of soil loss from water erosion. The more frequent occurrence of extreme weather events paired with a projected slight increase in temperature could result in greater heat stresses for Peace Region crops. This amplifies the importance of soil health and soil organic carbon which are tools that will help mitigate these stresses.

4. Document other external factors that impact farm runoff, drainage and erosion management (oil & gas industry, highways/roads)

    a. External factors are anecdotally the leading cause of gully type erosion on agriculture land in the BC Peace. Quantifying this information is difficult, although many site visits where erosion was noted were associated with new culverts, roads, or overflowing ditches.
    b. Within the ALR the oil and gas industry are developing most of the new roads and pipelines in the region. Often new linear features such as roads and culverts have some detrimental effect on water movement on adjacent land within the first couple of years of installation.
    c. In the North Peace currently BC Hydro's land clearing is a major contributor to disruption in water movement within the Peace Valley.
    d. Major fires in 2016 also affected soil stability in previously forested areas, this increases the land's vulnerability to water erosion for the next two to three years.

2.2 Summary of Current Practices

Through interviews with local producers and industry experts it was established that:

1. Conservation tillage practices have been adopted by over 80% of the annual and perennial seed farmers in the BC Peace.
2. High speed tillage implements are starting to be utilized in the region, mostly over the past five years. Producers in the region have utilized subsoiling, especially deep tillage or soil shearing in the past, but it is not currently a regular practice.
3. Field edge drainage ditches have been utilized; in the 80s and 90s there was some large-scale drainage implemented to improve arability of some areas.
4. Grassed waterways are common for all sectors.
5. Crop Rotation is being utilized in some cases to deal with residue and disease risks
6. Offsite watering systems are moderately common in the livestock industry.
7. Reduction in summer fallow acres.
8. Conservation fallow, where producer are trying to reduce the timeframe that fields are left bare and tilled.

9. Utilization of shelterbelts, diversion structures and treed areas to manage water flow.
10. Residue management is being utilized to provide armour on soil surface for annual producers.

2.3 Summary of Potential Practices

Forage Friendly's extensive outreach and engagement efforts yielded a wide range of ideas and suggestions from producers regarding runoff drainage and erosion:

A. Tillage practices
    a. Vertical tillage
    b. High speed tillage
    c. Subsoiling
    d. Aerway

B. Livestock watering
    a. Platform options

C. Soil Health
    a. Role of organic matter, levels of organic matter
    b. Interpreting soil type, aggregate stability and erosion risks
    c. Determining on-farm erosion risk
    d. Understanding infiltration
    e. Understanding compaction

D. Tire compaction

E. Livestock trail issues

F. Erosion cutbacks into fields and solutions

G. Culvert related erosion challenges and solutions

H. Drainage
    a. Farm-level
    b. Regional scale
    c. Concentration or distribution: what is best?

I. Cropping – perennial cropping on high risk sites, crop rotations

J. Monitoring
    a. soil health
    b. erosion
    c. runoff
    d. infiltration
    e. compaction

K. Surface residue management

L. Rental agreements, impact on erosion management

M. Water Sustainability Act and its impacts to drainage management on farms

N. Basic erosion runoff drainage vocabulary to enable better understanding of issues

2.4 Prioritization of Practices

Discussions with industry and industry experts yielded some relatively easy to implement, yet potentially rewarding opportunities regarding runoff, drainage and erosion. Each sector contributed a wide range of ideas and suggestions. Upon conclusion of the project, Forage Friendly recommends the topics below as a starting place for extension and knowledge transfer in the region.

1. Drainage, Runoff and Erosion 101 Fact Sheet, to enable better understanding and in-depth discussions about erosion. It was decided that this fact sheet was to include a break down of basic terminology and risk parameters as they relate to runoff, drainage and erosion issues.

2. Tillage Practices – Fact sheet and field day to increase awareness around the tools and what field level challenges they may help address.
    a. Vertical tillage
    b. High speed tillage
    c. Agro-plow
    d. Subsoiling

3. Livestock watering – Field day, with fact sheet follow-up.
    a. Platform options

4. Soil Health – Field day, many fact sheets are available on this, there was an initial plan to write articles for magazines.
    a. Understanding the role of organic matter, levels of organic matter
    b. Interpreting soil type, aggregate stability and erosion risks
    c. Determining on-farm erosion risk
    d. Understanding infiltration
    e. Understanding compaction

3 Regional Erosion Risk Map

There are twenty-nine watersheds in the BC Peace with ALR land in them as depicted in Figure 1: BC Peace Watersheds

Each watershed is then broken down in many more sub-watersheds. Nine of the watersheds have more than forty percent of the land base with ALR status and are highlighted in green in table 2.

An initial soil risk mapping exercise was completed in a pilot area that the contractors were familiar with utilizing RUSLE variables.

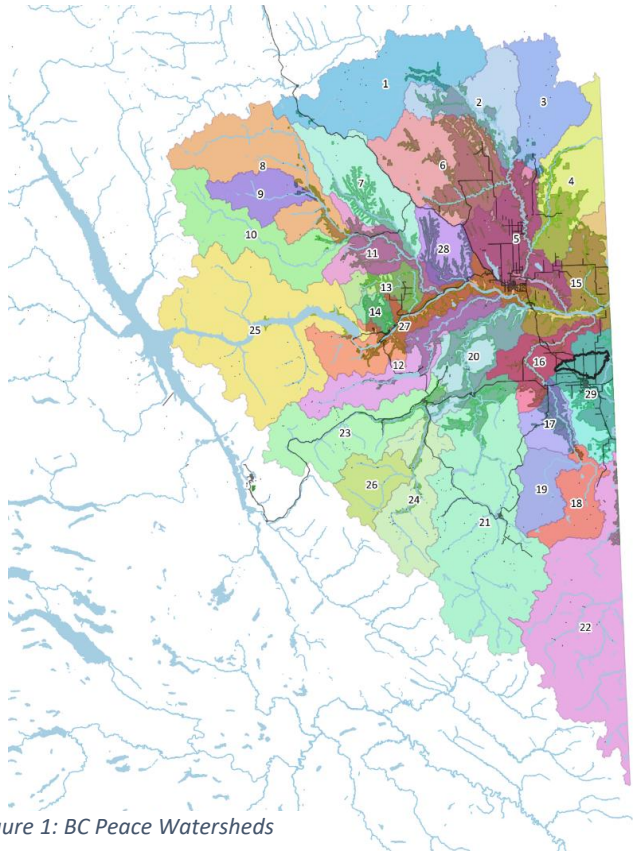


Figure 1: BC Peace Watersheds

Table 2: BC Peace Watersheds with ALR acres

Watershed ID	Basin Name	Land in ALR (ac)	Land in ALR (%)
1	Upper Beatton River	20035	2
2	Middle Beatton River	97036	22
3	Milligan Creek	8431	2
4	Doig River	167441	32
5	Lower Beatton River	438268	83
6	Blueberry River	312464	43
7	Cameron River	73138	14
8	Upper Halfway River	29448	4
9	Chowade River	3548	1
10	Graham River	6094	1
11	Lower Halfway River	163630	56
12	Moberly River	155034	33
13	Farrell Creek	88908	56
14	Lynx Creek	47617	60
15	Lower Peace River	310285	74
16	Lower Kiskatinaw River	243265	81
17	Middle Kiskatinaw River	62952	33
18	East Kiskatinaw River	3845	1
20	Lower Pine River	192072	49
21	Murray River	107367	7
22	Smoky River	13895	1
23	Upper Pine River	31560	5
24	Sukunka River	27999	6
25	Peace Arm	8303	1
26	Burnt River	563	0
27	Upper Peace River	211341	42
28	Cache Creek	74361	32
29	Pouce Coupe River	286185	71

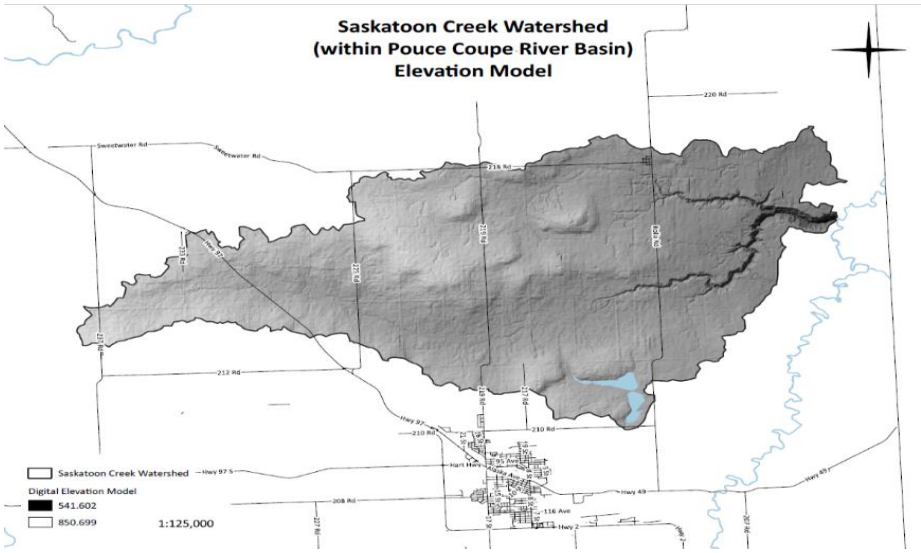


Figure 2: Elevation Modeling Saskatoon Creek Watershed

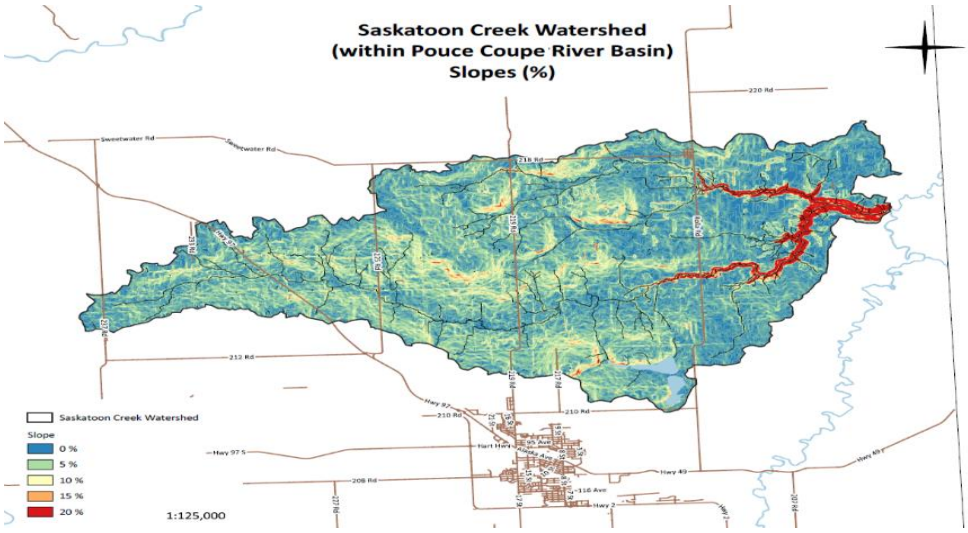


Figure 3: Slopes in Saskatoon Creek Watershed

The elevation modeling (Figure 2) tied to percent slope (Figure 3) drives most of the soil loss potential illustrated in Figure 4. This can be further impacted by individual farm practices that affect the crop management factor ("C") in the soil loss modeling and that is where understanding RUSLE and how to estimate soil loss from water erosion becomes crucial to mitigate.

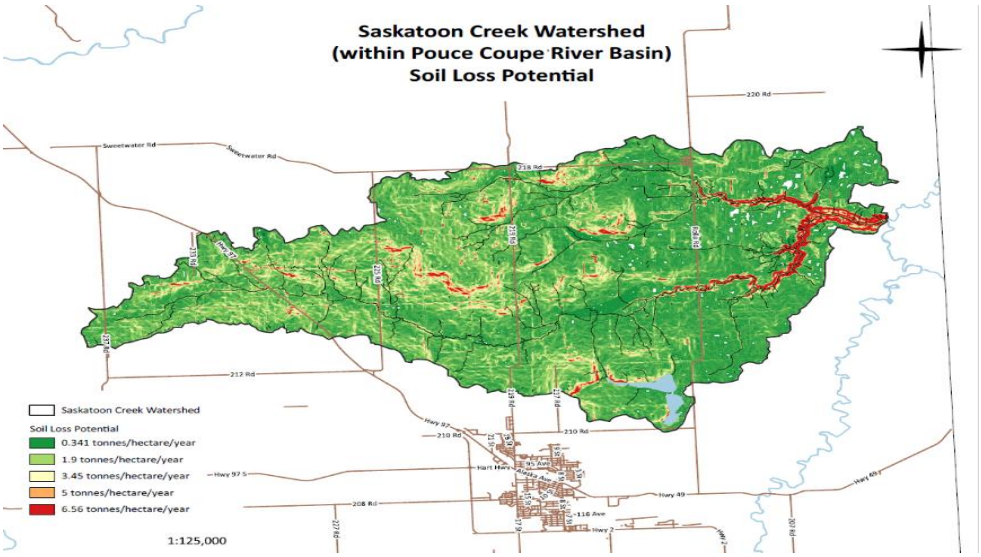


Figure 4: Soil Loss Potential Saskatoon Creek Watershed

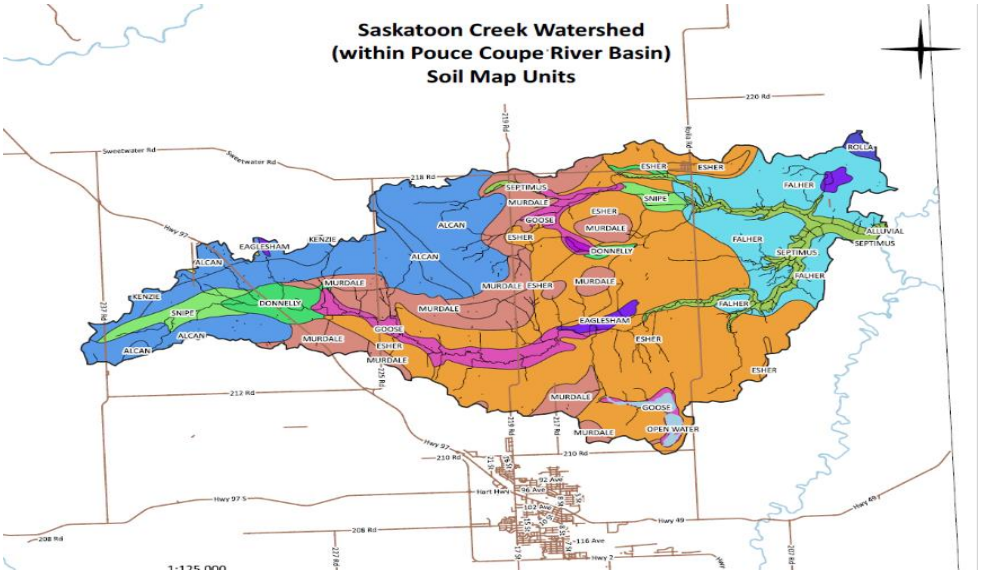
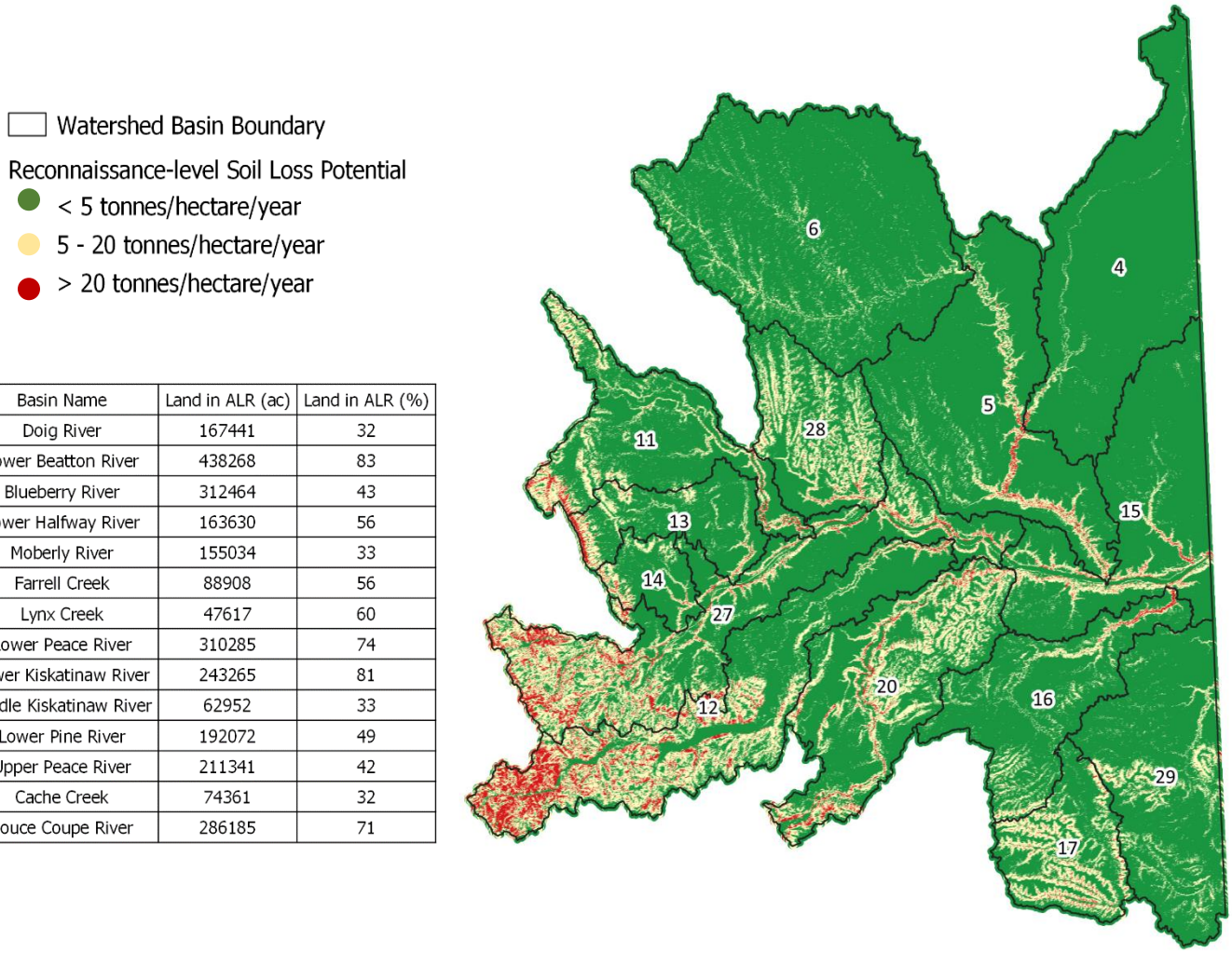


Figure 5: Soil map units in Saskatoon Creek Watershed



Watershed ID	Basin Name	Land in ALR (ac)	Land in ALR (%)
4	Doig River	167441	32
5	Lower Beatton River	438268	83
6	Blueberry River	312464	43
11	Lower Halfway River	163630	56
12	Moberly River	155034	33
13	Farrell Creek	88908	56
14	Lynx Creek	47617	60
15	Lower Peace River	310285	74
16	Lower Kiskatinaw River	243265	81
17	Middle Kiskatinaw River	62952	33
20	Lower Pine River	192072	49
27	Upper Peace River	211341	42
28	Cache Creek	74361	32
29	Pouce Coupe River	286185	71

Figure 6: Reconnaissance-level soil loss estimate for Peace area watershed basins containing significant portions of ALR land

Figure 6: Reconnaissance-level soil loss estimate for Peace area watershed basins containing significant portions of ALR land illustrates high risk of erosion loss soils. As a regional map of erosion risk this map is limited in its accuracy as slope is the variable that is driving most of the erosion risk. Erosion risk mapping is more meaningful at field scale.

4 Relevant Management Practices Not Currently Used in the Peace

4.1 Immediate opportunities with low cost and/or high returns

1. Plant growth regulators

Currently market access for crops treated with growth regulators is limiting the utilization of the tool the grains and forage seed sectors. For example, chlormequat chloride or "Manipulator," a plant growth regulator was first registered in Canada in 2015. It was legal to use but most grain buyers refused to accept wheat treated with Manipulator until the U.S. established a maximum residue limit for it in 2018. As of the date of this report, there are still feed market limitation for it in Canada until the Canada Food Inspection Agency provides the necessary approvals.

The opportunity here is to reduce the volume of residue produced by grain and forage seed crops in wet years. Taller plants are more vulnerable to lodging from heavy rains or strong winds. Manipulator and Palisade contain the active ingredients that help regulate plant height it is also commonly thought to reduce the volume of straw. There is older research that demonstrates both an increase and reduction in the volume of straw. The Peace region would benefit from research on the reduction of residue production as it its related to plant growth regulators in the near future as these products become more utilized in the seed production industries in Canada.

2. Variety selection for reduced straw production

Peace producers are utilizing variety selection for other key attributes, but it was not brought up by producers as a residue management tool. The BC Grain Producer Association has diligently engaged in variety trials in the Peace region for over 30 years and they have been doing the research that supports adoption of some semi dwarf varieties of Canadian Western Red Spring wheat for example. Semi dwarf varieties have been demonstrated to produce both more and less straw and more current research is needed in northern regions like the Peace in relation to this topic. Many varieties are tested in the region for yield and maturity perhaps residue production would be a variable added to some trials.

3. Application of soil amendments to aid with breakdown of crop residue

There are several products that recently, in the last 10 years, entered the marketplace that are said to improve soil health and aid in the breakdown of crop residue. The third-party research to provide the data on the impacts of these products in very limited. There may be some benefits from utilizing these tools, but more research and extension needs to be done in the northern dry and cool climates. Fall application is often recommended for such products but the conditions also need to be moist and above freezing for a couple weeks for the soil micro organism to have time to break down plant residue. For Peace farmers there may not even be a viable window for this kind of a product, more research is needed.

4. Improving soil organic matter

Organic matter management, protection and improvement is a goal of all agriculture sectors considered in this project. Livestock and forage producers have the fastest opportunities for improvements with livestock winter feed and summer grazing practices. Organic matter is a key factor when considering water infiltration in the soil and the effective water utilization by plants. This will continue to be an area for opportunity for all sectors. Very few people related soil stability to organic matter content and many producers did not know their soil organic matter levels.

5. Contour farming

This describes practices where cultivation and planting are done following topographic contours. Is there a return on this practice for producers when this increases the number of turns by equipment during field activities? This has been an effective tool in reducing erosion risk by 10 to 50%, providing almost complete protection against moderate intensity storms.

6. Strip farming

This describes crops grown in a systematic arrangement of strips or bands across the slope, alternating higher erosion risk crops with lower erosion risks crops like perennial forages or forage seed. This can reduce erosion by 10 to 75% and is more effective than contour farming alone. This may have particular application to fields with long slopes, which are common the Peace.

7. Crop rotations

This describes the concept of managing crop rotations with considerations to residue management, soils aggregate stability, maintaining crop cover on high risk area possibly by using perennials of cover crops for fast cover establishment during rejuvenation. This involves maximizing the years between tillage events and possible introducing perennial crops or legume into the rotation.

8. Plant cover maintained

This is related to both living and dead plant material providing soil protection. Currently producers are managing the crop residues to leave as much as possible evenly distributed on the soil with tools like straw choppers and blowers, however this continues to be a challenge for forage seed producers as straw and residue cover often limits sunlight exposure to plants crowns and growing points affecting seed yields, more work is needed around this topic for the forage seed sector. Forage producers are still struggling with long rejuvenation processes often involving several tillage practices leaving the soil uncovered for extended periods of time.

4.2 Limited opportunities high investment or low returns

9. Drainage tile & Laser Leveling

On large acres with lower value crops and limited irrigation options the return on drainage tile is limited with today's technologies.

Cost breakdown

- Custom Installation: $800-$1,000/ac

- Farmer self-installs initial cost: $70,000 to $100,000 (including tile plow, RTK-GPS control system, a backhoe and tile trailer) plus $400 to $600 per acre materials depending on the field.
- Annual maintenance costs.
- Life span - systems can last indefinitely depending an installation, materials used and diligence in maintenance and soil type. Fine and silty textures decrease lifespan of system.

Assuming 25-year replacement on $900/acre installation costs, a $36 per acre per year return must be realized to cover the cost of the installation. Ideally, a five-year return on investment would mean $180 per acre per year increase. For canola at $9.00/bu the field would need to see a 20-bushel yield increase per year or more. If installation of drainage enables an increase in acres in production, it pencils out a bit differently. If you assume 40-bushel yield on $9/bu canola resulting $360/ac potential revenue and if you assume $200 fixed input expenses, there is a resulting $160/ac revenue. If drainage only has to be done on 1 acre to add the acre to production, it could be possible to have a return on investment in 6 years. However, if 160 acres has to be drained to access new acres it only pays if the project depreciates over 10 years on 90 new acres.

Benefits of drainage can include: improved plant performance, improved crop yield and quality, more rapid warming of soils in spring, improving germination, improved environment for soil organisms, better access to water and oxygen for plant roots, better crop uptake of soil mineral nitrogen, better access to land, reduced duration/risk of autumn waterlogging, quicker accessibility of fields following any period of wet weather, crop inputs more likely to be applied at optimum time, an extended growing, improved speed of work and fuel use, better traction, fewer cultivation passes, educed wear and tear, fewer wet areas to avoid, benefits to soil structure and the environment, less structural damage to soils, better water infiltration, reduced surface run-off and erosion, reduced phosphorus and pesticide losses to water.

10. Drainage Ditch – Regional Drainage Plans

In Saddle Hills County to the east of Dawson Creek in the 1960's and 1970's drainage ditches were installed in the county to increase arable acres in the region. This had a tremendous benefit to producers in the region. However, under todays water legislation and environmental expectations it would take extraordinary effort and regional leadership to endeavour on this level of planning and implementation of drainage. Although let it be said, some level of regional drainage should be discussed and prioritized in regions were producers are implementing farm level drainage without collaborating with neighbouring property landowners. There is so much more opportunity in capturing moisture in the soil profile then speeding up the rate it leaves the field. Implementing ditching even at a local field level has often led to greater on-site erosion with the long slopes in the BC Peace.

11. Terrace farming

This describes practices of implementing large soil ridges across the slope at regular intervals, to divide the slope length, reducing erosion risk 10 to 90%. This reduces sheet and rill erosion on the terrace intervals however his is relatively expensive and would have serious implications to equipment size.

5 Knowledge Transfer Plan

5.1 Factsheets

Based on Industry Consultation:

1. Erosion, Runoff and Drainage 101 Factsheet, to enable better understanding and discussion about erosion. This fact sheet was to include a break down of basic terminology and risk parameters as they related to runoff, drainage and erosion.

2. Tillage Practices to increase awareness around the tools and what field level challenges they may help address.
    a. Vertical tillage
    b. High speed tillage
    c. Agro-plow
    d. Subsoiling

3. Livestock watering platform options - summary of field day

4. Article on Soil health for newsletters and magazines

5.2 Field Days

The initial goal was to hold seven smaller half day sessions that get more regional coverage

1. Tillage Practices to increase awareness around the tools and what field level challenges they may help address. October 2 events goal is 6-10 people
    a. Vertical tillage
    b. High speed tillage
    c. Agro-plow
    d. Subsoiling

2. Soil Health – Field days planned in September and October 2019, 3-4 events goal is 6-10 people
    a. Role of organic matter, levels of organic matter – actual on farm sampling
    b. Interpreting soil type, Aggregate stability and erosion risks
    c. Determining erosion risk on farm level
    d. Understanding infiltration
    e. Understanding compaction

3. Livestock watering platform options – summary of field day – October 1-2 events goal is 6-10 people

Due to weather conditions the planned extension events the events were cancelled with the substitution of a webinar to be held in March of 2020. Factsheets were compiled based on POC and producer feedback including:

1. R.D.E #1 Runoff, Drainage & Erosion Project – 2 pages
2. R.D.E #2 Erosion Risk Mapping – 4 pages
3. R.D.E #3 Conversations About Runoff, Drainage & Erosion - 4 pages

4. R.D.E #4 Soil, Water & Residue Management Tools – 12 pages

The livestock and forage sectors have several of their industries' runoff, drainage and erosion concerns addressed in fact sheet R.D.E. # 4 where management tools for reducing tillage in relation to rejuvenating forage stands.

6 Recommendations for Further Research, Piloting and Demonstrations

1. Future agriculture erosion projects targeting watersheds with greater than 40 percent agriculture land reserve land base including:
    a. > 70 % ALR
        i. Lower Beatton River (83 %)
        ii. Lower Kiskatinaw River (81 %)
        iii. Lower Peace River (74 %)
        iv. Pouce Coupe River (71 %)

    b. 40 %-70 % ALR
        i. Lynx Creek (60 %)
        ii. Farrell Creek (56 %)
        iii. Lower Halfway River (56 %)
        iv. Lower Pine River (49 %)
        v. Blueberry River (43 %)

Please note that there may be some specific and significant reasons to focus outside the above nine areas in terms of critical land and land features that may merit focus on erosion in those areas in the future.

2. Water management plans at farm level, this would involve a "Qualified Professional" working with individual producers to develop an integrated water management plan. Areas of focus in the report may include:
    a. Identification of watersheds that land holdings are in.
    b. Volume of water flow inside the farm boundaries.
    c. Cover types.
    d. Slope assessments.
    e. Soil health report card, including measurements of infiltration, compaction/bulk density, organic matter, aggregate stability.
    f. Access to lidar or drone imagery to do detailed elevation modelling.
    g. Return on investment map, illustrating where greatest opportunity for return from water management may be realized.

3. Soil Health and Erosion Knowledge transfer events: this would support working in sub-regions to discuss specific erosion issues and solutions, as well as working with producers to develop methods of monitoring soil loss.

4. Soil health monitoring, this would involve sharing tools for monitoring soil health with tools such as penetrometer, turbidity sampling with secchi disk, bulk density samplers. It would also include

soil organic carbon or organic matter sampling. Long term monitoring in the region at benchmarks sites would allow for better understanding of soil losses over time.

5. Installation of soil moisture monitoring probes: this could be done in affiliation with existing weather stations. Soil moisture probes would provide a tool for awareness and prevention of soil compaction as well as accurate information for infiltration and factors relating to soil loss. These should be tied to cover types and geography.

6. Forage industry needs support to deliver research and knowledge transfer to producers to:
    a. Reduce fallow and the amount of time a field is vulnerable to soil loss especially reducing tillage and the soil's exposure during rejuvenation. One of the barriers to this is the availability and economics of custom operators for small acres of rejuvenation (less than 150 ac/year). Conservation tillage and minimal tillage in forage operations requires herbicide use. Currently in the Peace access to rental equipment for small acres at an affordable rate is limited and cost prohibitive.
    b. Increase longevity of stands through continued improvement in variety selection relevant to the Peace region, reducing the time between rejuvenation events.
    c. Soil organic matter improvements in strategic areas can help address issues arising from overgrazing and information is still needed to ensure the improvements stay on the land base and do not move with the runoff water in the spring.

7. Forage Seed Industry needs continued support around research and knowledge transfer relating to:
    a. Crop rotation - this would continue to build on the research being completed in Beaverlodge with the Peace Region Forage Seed Association.
    b. Strip farming – increasing the awareness of the cash value of forage seed crops and their value as soil protectors and how this may fit in landscape level crop rotation planning.
    c. Contour farming,
    d. Plant growth regulators as they relate to residue management and improving the rejuvenation process.
    e. Rejuvenation continues to be an activity that exposes the land to increased risk of soil erosion for several months.
    f. Plant breeding and genetics may be another area where residue production could be reduced, this would mean an assessment of how this trait would affect markets of the forage seed.

8. Grain production sector needs continued support around research and knowledge transfer related to:
    a. Residue management and mitigation of soil compaction,
    b. Growth regulators,
    c. Variety selection,
    d. Crop rotations,
    e. Maintaining soil cover,
    f. Strip farming,

g. Contour farming,
h. Soil amendments to aid in the breakdown of crop residue, and
i. Improving soil organic matter.

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