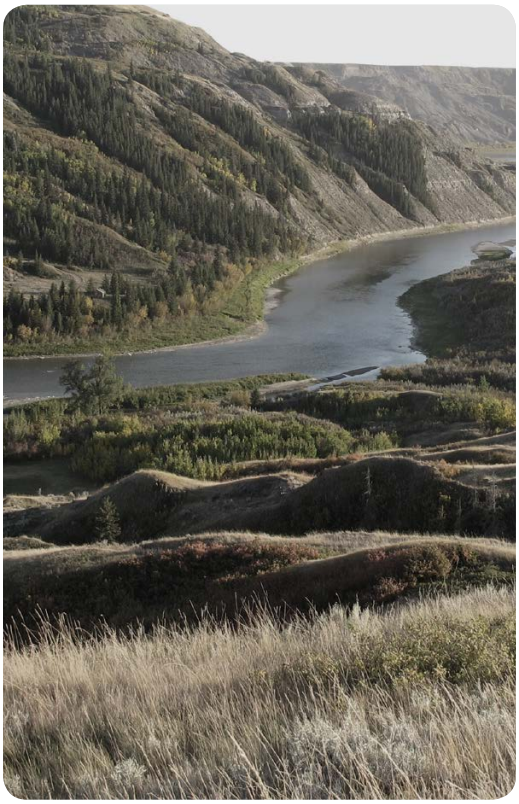
Blueprint

An Integrated Watershed Management Plan for the Red Deer River Watershed

Phase 1: WATER QUALITY

Red Deer River Watershed Alliance



Our Vision

The Red Deer River watershed will be healthy, dynamic and sustainable through the efforts of the entire community.

Acknowledgements

This plan was completed as a collaborative effort. The Red Deer River Watershed Alliance (RDRWA) would like to acknowledge the efforts of the Project Management Unit for their significant contribution in leading the development of the Integrated Watershed Management Plan (Phase One) over several years, including support from lead author Josée Méthot.

In addition, the process to develop this plan would not have been successful without the contributions of the RDRWA Board of Directors, staff, the Technical Advisory Committee and teams, the RDRWA Education & Outreach Committee, and past Board, staff, and committee members. Several consultants, including Alan Dolan & Associates, Dr. Anne-Marie Anderson, BPS Consulting, and O2 Planning + Design, laid much of the groundwork for this plan.

We would like to thank all the individuals who participated in RDRWA workshops and forums throughout the development of this plan. The input and ideas shared at these events was instrumental in leading to where we are now.

The RDRWA received funding for this work through project funds and support provided by Alberta Environment and Parks as well as support from numerous provincial, municipal, business, and industry organizations.

About the Red Deer River Watershed Alliance

The Red Deer River Watershed Alliance (RDRWA) is a multi-sector, not-for-profit organization that promotes the good use and proper management of water in the Red Deer River watershed. The RDRWA was created in September 2005 and is one of 11 Watershed Planning and Advisory Councils (WPACs) which partner in the delivery of Alberta's *Water for Life* Strategy[1] in watersheds across Alberta.

WPACs have five key responsibilities:

1. Lead in watershed planning,
2. Foster stewardship activities,
3. Report on the state of the watershed,
4. Educate users on the importance of water resources, and
5. Develop beneficial management practices.

Importantly, the RDRWA and other WPACs do not have legislative or regulatory authority around watersheds. Instead the RDRWA works to educate the community on the value and importance of watersheds, coordinate watershed planning processes, facilitate collaborative relationships among stakeholders, and advise stakeholders on watershed planning.

Message from the RDRWA

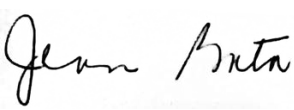
Welcome to *Blueprint: An Integrated Watershed Management Plan for the Red Deer River Watershed* (Phase One, Water Quality). It is with great pleasure that we share this plan as a signal of our shared commitment to improving watershed health and the wellbeing of our communities.

We all have a role to play in protecting watershed health, and the creation of this plan is a testament to the power of working together. It has taken a lot of hard work from many committed people to get us to where we are now. We thank all those that have contributed along the way.

We were unanimous in approving *Blueprint*. We hope it acts as a decision-support tool for anyone looking to make a positive difference in the watershed, that it will contribute to regional planning efforts, and that you see **yourself** as an important part of that.

Blueprint respects the progress that has already been made and addresses the challenges ahead. Now we need to roll up our sleeves and get to work. Please join in.

Thank you,



Jean Bota
on behalf of the RDRWA Board of Directors

Table of Contents

Watersheds 6

Water Quality 18

Goals & Targets 22

11 Recommendations 24

Conclusions 54

Executive Summary

The Red Deer River Watershed is home to approximately 300,000 people and covers an area of 49,650 km^2 in Central Alberta.

In alignment with Alberta's *Water for Life* Strategy (2003) and the product of extensive community engagement and research, *Blueprint: An Integrated Watershed Management Plan for the Red Deer River Watershed* (Phase One: Water Quality) presents a set of goals, targets, and recommendations to maintain and improve surface water and groundwater quality in the Red Deer River watershed. The plan is written for three audiences: individuals, groups/ organizations, and governments.

The fundamental principle underlying this plan is that water quality must be maintained and improved. Goals are presented for both surface water and groundwater, which in turn are supported by targets. Targets for surface water quality are presented as site-specific water quality objectives. Water quality objectives are included for four of the six reaches of the mainstem of the Red Deer River (Reaches 3-6) and for 11 different water quality parameters. Quantitative targets for groundwater quality have yet to be developed.

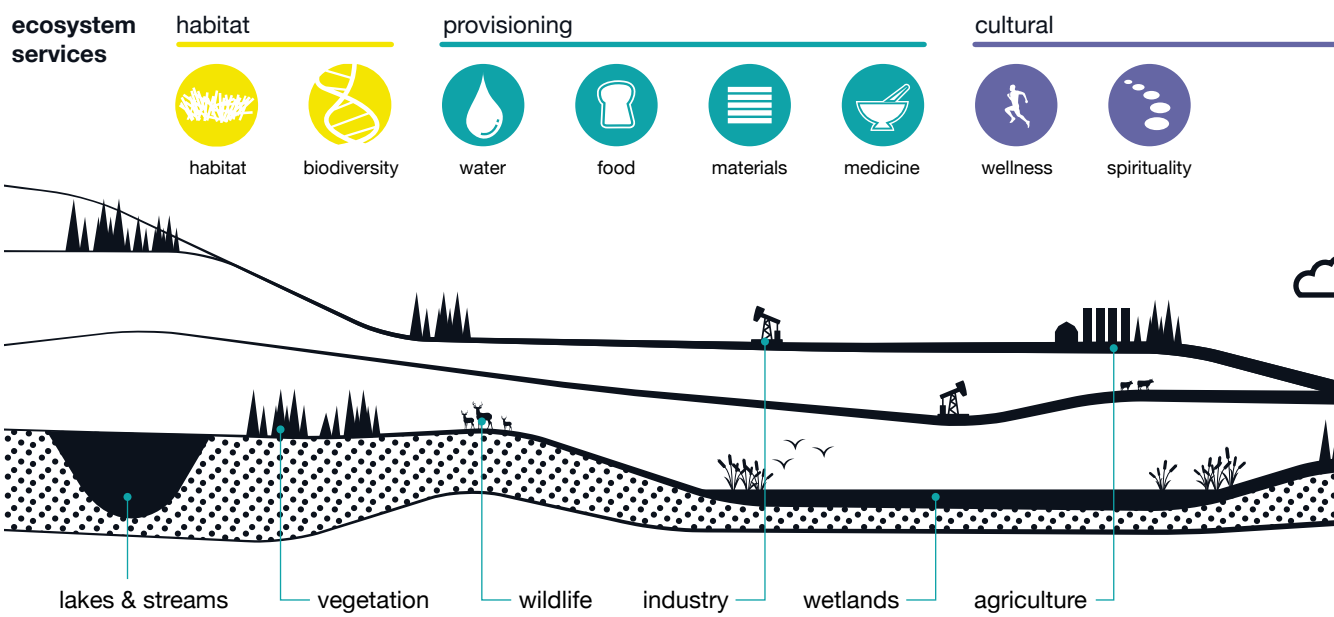
Blueprint is a decision-support tool and the implementation of the 11 recommendations in the plan will rely on the commitment and goodwill of a network of diverse partners. The plan serves as advice to all watershed stakeholders to guide future decision-making and activities in their respective areas of responsibility and interest. A living document, the plan will be updated as the process continues on to subsequent phases that address land use, riparian areas, wetlands, biodiversity, and water quantity in the Red Deer River Watershed.

Watersheds

Water is our livelihood and is the engine of Alberta's economy. Many of our jobs – from farming and oil and gas to forestry and tourism – rely directly on water. We simply cannot have healthy communities, prosperous economies, and resilient ecosystems without clean water.

Freshwater comes from watersheds. A watershed is the area of land that drains water into a body of water such as a stream, river, lake, wetland, or ocean. People tend to think of only water bodies, such as rivers, lakes, and wetlands, as being part of their watershed. However, any land – whether it is park, farm, forest, parking lot, or the ground we build our towns on – is also included. A watershed actually includes the air, land, water, people and animals within a defined area, as well as water beneath the surface of the earth. Think of a watershed as a funnel – collecting the water within a specific area and draining it to a common point. The word "watershed" is often used interchangeably with the word "basin".

We are all part of a watershed, connected to the land and water that surrounds us. Given the importance of water to our livelihoods, our health, and overall wellbeing, communities should have a say in the decisions that affect our home waters. This is really what *Blueprint: An Integrated Watershed Management Plan for the Red Deer River Watershed* is all about. We should all have a say, because we all have a role to play.



A source of well-being and prosperity

Healthy watersheds provide:

Health: Water is life. We drink it, it keeps us clean, and it supports our food chain. Unsafe drinking water is linked to roughly 90 deaths and 90,000 illnesses annually in Canada[2].

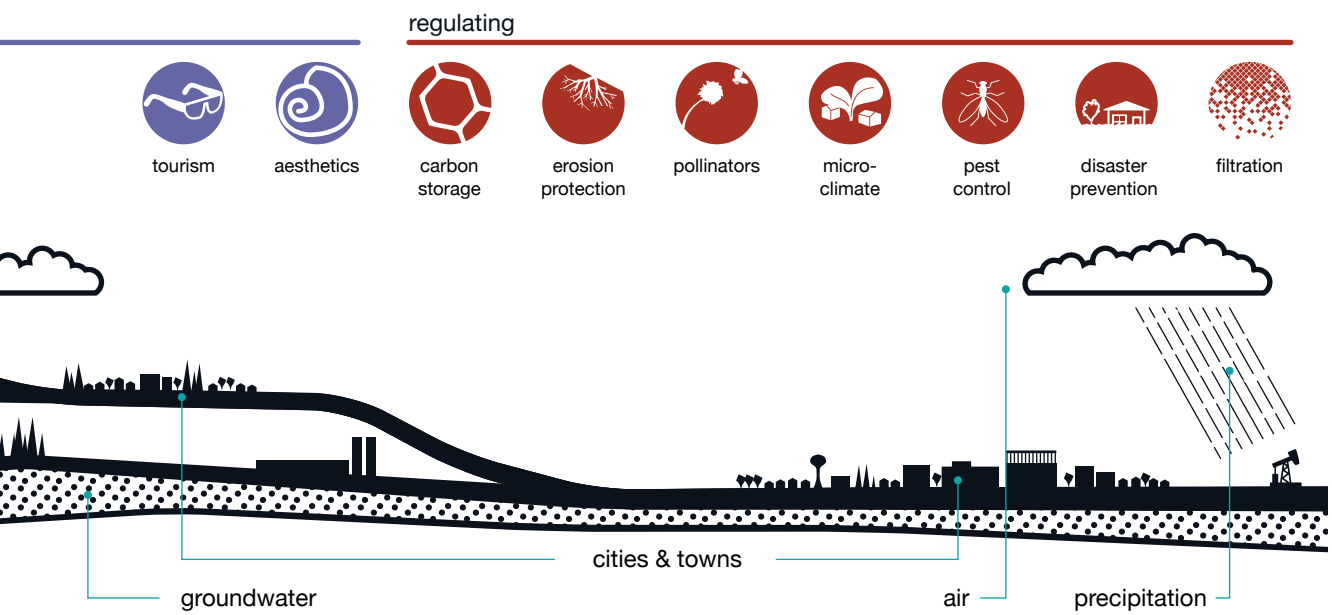
Wealth: We need an ample supply of clean water to grow our economy. Estimates of water's contribution to the Canadian economy range from $7.5 to $23 billion annually, all the way up to priceless[3].

Ecosystem services: Watersheds provide "ecosystem services" that humans benefit from. Beyond food and fiber, watersheds can naturally purify water, supply water, mitigate floods and droughts, provide soil fertility, and more.

Security: Clean, plentiful water keeps us safe. Declines in water quality and quantity are the #1 threat to our global communities in the next decade[4]. By protecting our watersheds, we can be more resilient in the face of global instability.

Recreation: Watersheds are our playgrounds for fishing, paddling, hunting, skiing, and many of our most cherished activities.

Watersheds provide a range of ecosystem services that support our communities.



Why do we need a plan?

An investment in our future

"Planning is bringing the future into the present so that you can do something about it now." – Alan Lakein

A watershed is a complex place and there is a lot going on. There are natural processes like flooding, erosion, droughts, and changing weather and climate. There are industrial activities, farming, new housing developments, municipal water withdrawals, and sewage treatment outfalls. There are different governments overseeing different issues (e.g., land use, pollution, emergency response, air quality) as well as a variety of stewardship and education groups helping people understand the value of our natural resources. If you add to this all of the plants and animals living in a watershed – well, it's a lot to think about.

If we want to understand all the issues and all the players, we need to look at the full scope of these activities and envision a way forward. We need a common reference point for action – a blueprint.

Pressures are intensifying

People across the Red Deer River Watershed have a long history of working to maintain and improve water quality conditions. Whether it is a municipality investing in water treatment plant upgrades, a farmer using environmentally friendly practices, or a citizen educating their neighbour about the safe disposal of household chemicals – all of these decisions can add up to a brighter future. It is important to acknowledge that, everyday, there are people working on a groundswell of projects to protect water quality across the Red Deer River watershed. Continuing to support, connect with, and learn from these individuals and groups will be crucial for reaching our watershed management goals.

Having honoured the actions of the past and present, however, it is also clear that we have a ways to go.

In surface waters in various parts of the watershed, we face ongoing challenges relating to issues such as nutrient enrichment, erosion and sedimentation, pathogen contamination, increasing salinity, and pesticide contamination[5]. We also have much to learn about the quantity and quality of our groundwater, particularly given concerns that human activities are influencing groundwater quality at local or potentially regional scales.

Ecosystems are complex and rarely follow simple, predictable, linear changes through time[6]. In the future, the Red Deer River Watershed will not look like it does today. Social, ecological, and economic conditions will change – sometimes predictably and sometimes surprisingly. In either case, we

Times are changing and we must act now

need to be ready. Important factors to consider include:

- **Population growth**: Some forecasts indicate that the watershed's population could increase by as much as 40% between 2008 and 2031[6]. While this estimate may be high, population is still expected to grow and will bring new development.
- **Climate change**: Climate change is very likely to increase in severity as the 21st century progresses[7]. Climate extremes – such as droughts and flooding – may become more frequent and more severe in Alberta[8], and there is concern that the driest parts of the watershed may face increasing water stress and risk of drought (e.g., lower reaches downstream from Drumheller in the Berry, Kneehills, and Rosebud sub-watersheds)[9].
- **Cumulative Effects**: Cumulative effects are caused by the addition or accumulation of impacts from different activities over time. One activity or impact by itself may not be a cause for much concern, and may even seem insignificant on a project-by-project basis. However, when the density (or intensity) of activities increases, the resulting cumulative effect on water resources can be significant[9].
- **Water quantity**: Water quality and water quantity are highly linked. In 2015, low water levels in the Red Deer River sparked concern about high water temperatures and the potential for harmful effects to aquatic life. To manage water quality, we will also need to manage for water quantity and rising demands for water.
- **Policy, planning, and regulation**: In recent years, there has been a shift toward more regional approaches to manage the long-term cumulative effects of development on the environment. Through the Government of Alberta's *Land-use Framework* (2008)[10], there is a renewed focus on the need to coordinate activities across scales.

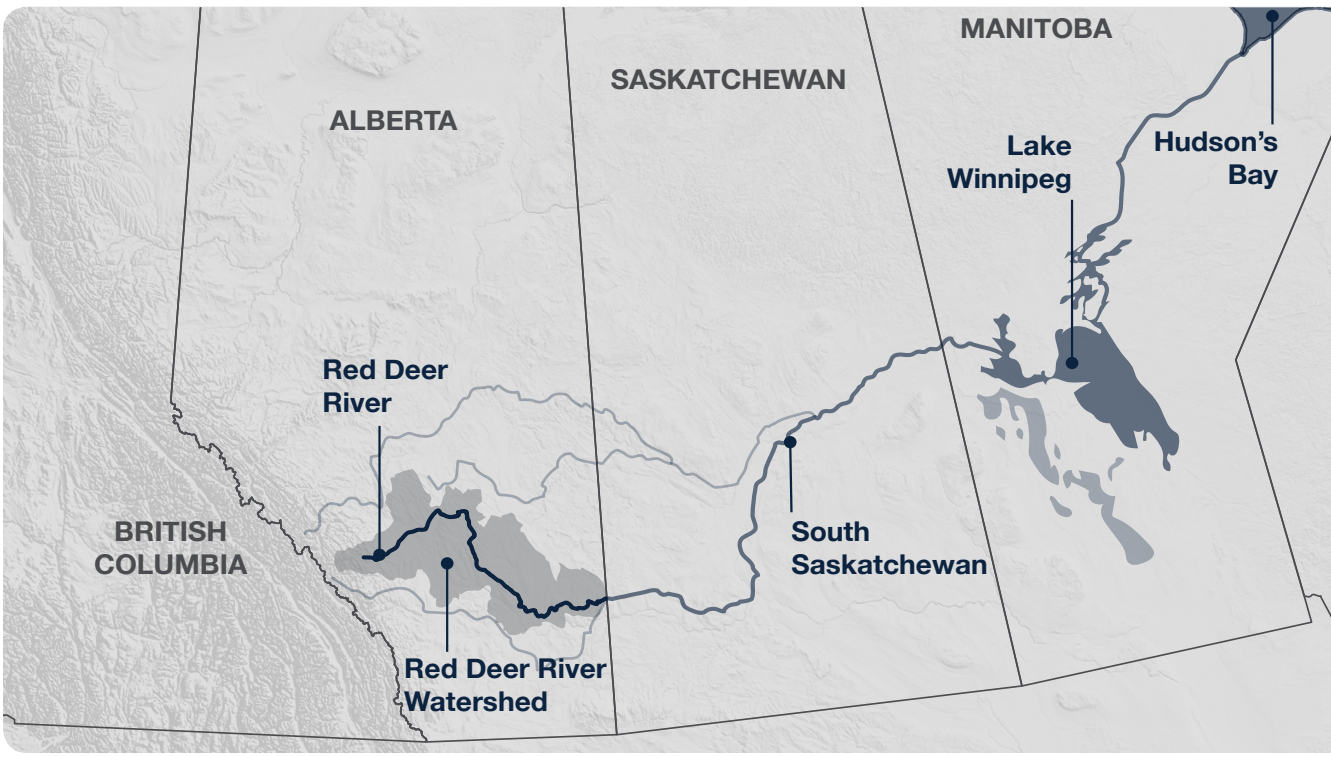
The Red Deer River Watershed

Watersheds are like Russian nesting dolls: a small one fits into a bigger one, which fits into a bigger one. The Red Deer River watershed is part of the larger South Saskatchewan watershed, which is itself part of the larger Hudson's Bay watershed. The Red Deer River watershed is also made of 15 smaller sub-watersheds – or "bite-sized" areas that nest within the larger watershed. These sub-watersheds include a rich diversity of lakes, wetlands, creeks, tributaries, and the lands that surround them.

Some watersheds are just a few hectares in size, while others can sprawl over thousands of square kilometres.

The Red Deer River watershed is 49,650 km^2 – an area home to 300,000 people and bigger than Denmark. The river's headwaters* are in the Skoki Valley of Banff National Park and the river then flows over 724 kilometres to join the South Saskatchewan River in Saskatchewan.

* The term "headwaters" refers to the source of a river, i.e., the set of tributaries that feed into a river's beginning.



A mosaic of human and natural interaction

The South Saskatchewan River then continues through the Saskatchewan river system to Lake Winnipeg, en route to Hudson's Bay.

Land uses and natural areas in the Red Deer River watershed form a mosaic of interacting landscape elements. Land uses within the watershed include urban and rural development, agriculture, forestry, recreation and tourism, linear developments (e.g., roads, pipelines), and industry (e.g., oil and gas, aggregate mining). As our footprint in the Red Deer River watershed has grown, we have, however, begun to learn that not all land uses are created equal. Different lands uses pose varying risks to water quality, depending in part on the density, intensity, and location of a given land use. While any land use activity can pose local water quality risks, we must also consider cumulative effects. To learn more about the relationship between each of these land uses and water quality and ecosystem health, please see O2 Planning + Design[6].

The watershed, Aboriginal peoples, and treaty rights

It is important to acknowledge that the Red Deer River watershed spans the ancestral and traditional territories of Aboriginal peoples, including First Nations and Métis peoples. The watershed is part of both Treaty 6 and Treaty 7 territory. Watershed management must respect the constitutionally protected rights of First Nations and Métis peoples and must not adversely impact treaty rights or traditional land uses.

Groundwater is nature's hidden treasure

Groundwater is also part of the watershed. A common myth about groundwater is that it is found in underground rivers or massive open spaces. In reality, groundwater is water found beneath the earth's surface in gaps and pore spaces between rocks and soil. These underground water-bearing materials are called aquifers. Aquifers vary in size, groundwater quantity and quality, rate of flow, the materials they are made of, and depth from the surface (e.g., from a few metres to several kilometres).

Zones of the Red Deer River Watershed

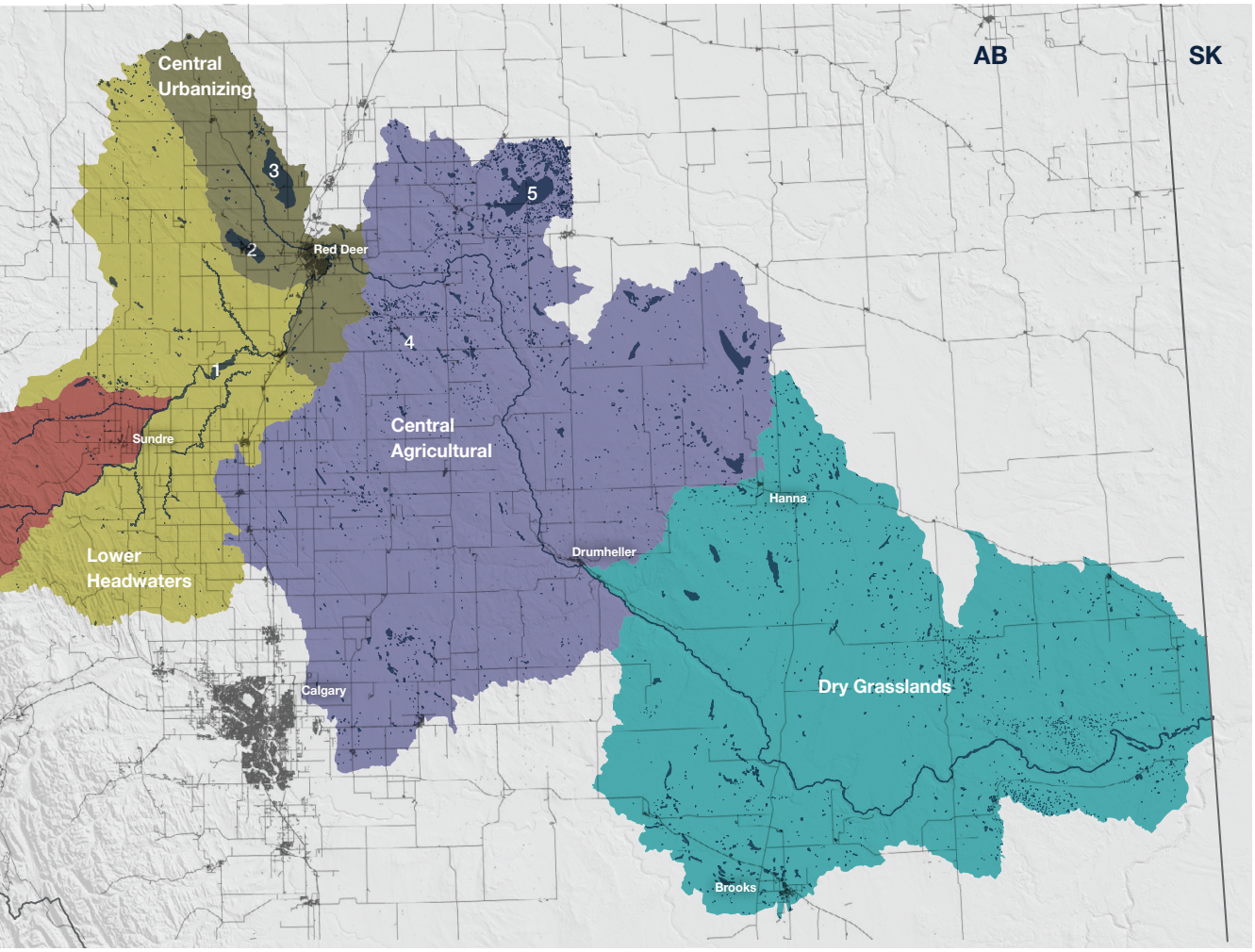
The Red Deer River watershed includes five distinct zones. These five zones – Upper Headwaters, Lower Headwaters, Central Urbanizing, Central Agricultural, and Dry Grasslands – vary in terms of geography, land use patterns, and natural ecosystems – and also contain smaller sub-watersheds. Water management is not necessarily "one size fits all" across these five zones. See Appendix A for more information on each zone.

Fast Facts about the Red Deer River Watershed

- Occupies 8% of Alberta or approximately 49,650 km^2.
- Originates in the Canadian Rocky Mountains in Banff National Park.
- Is part of the larger South Saskatchewan River basin.
- Is home to four large recreational lakes (Buffalo Lake, Gull Lake, Pine Lake, and Sylvan Lake), and numerous small lakes and reservoirs.
- Traverses 5 Natural Regions: Rocky Mountains, Foothills, Boreal, Parkland, and Grassland.
- 56% of the watershed's land cover area is developed, disturbed, or agricultural.
- The watershed includes over 55 urban centres and 18 rural municipalities.
- Approximately 43% of the watershed is used to grow crops on about 13,000 farms.
- There are over 130,000 oil and gas wells in the watershed, and pipelines cover a total length of 78,000 km.
- There are over 220 sand and gravel pits in the watershed, with a total area of greater than 14 km^2.
- Hydraulic fracturing activity has been concentrated in the Lower Headwaters and Central Urbanizing Zones.
- Approximately 3.1% of the watershed consists of parks and protected areas, including 57 provincial parks.

Sources: O2 Planning + Design, 2013a, 2014[6,9]

Drivers of water quality vary across zones



1. Gleniffer Reservoir
2. Sylvan Lake
3. Gull Lake
4. Pine Lake
5. Buffalo Lake

What is this plan about?

Phase One of *Blueprint* addresses two key areas: surface water quality and groundwater quality, recognizing that the two are fundamentally interconnected.

Built over years of collaborative effort, this plan lays out goals, targets, and recommendations that provide a foundation for moving forward with strategic actions.

An Invitation

We all have a role to play in protecting watershed health and there is a compelling need to act now to protect water quality.

This plan is written for three types of audiences.

First and foremost, this plan is for **you**. An individual who wants to make a difference in the watershed.

This plan is also for the various **groups and organizations** that can contribute to reaching the targets and implementing the recommendations. For example: schools, businesses, industry, and stewardship groups – all have a role to play.

Finally, this plan serves as advice to **local and provincial governments**. The plan can be used as a decision-support tool by municipalities. Its contents should also inform the future development of a Red Deer Regional Plan under the Government of Alberta's *Land-use Framework*[10].

While the contents of this plan are not legislated, the Red Deer River Watershed Alliance calls on all parties to participate in the forthcoming phases of work with good will and with a commitment to a "healthy, dynamic, and sustainable watershed".

Where do you fit in?

As you read through *Blueprint*, please ask yourselves:

Individuals

What am I most passionate about?

What am I already working on?

Where can I contribute?

What do I commit to doing?

Groups and Government

What are we responsible for?

What are we already working on?

What are we most passionate about?

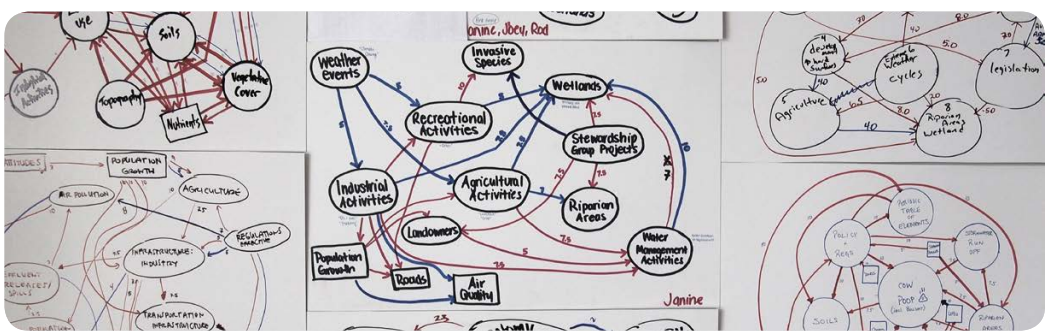
What do we commit to doing?

A decision-support tool to protect water quality

Creating the plan

This plan is the product of extensive community engagement and research. Since beginning in 2010, the process to develop the plan has included approximately 900 participants, 28 workshops, 4 background technical reports , and countless emails, phone calls, and meetings. A Steering Committee, a Technical Advisory Committee, and several consulting groups have guided the process forward.

Since this process began, we have heard a rich diversity of opinions, concerns, questions, and critiques related to watershed management from a variety of individuals and groups – government officials, landowners, scientists, industry and business leaders, environmental and stewardship groups, and more. The Red Deer River Watershed Alliance believes that, to the extent possible, the recommendations in this plan are an accurate representation of the input received. For those looking for more scientific information, the four background technical reports[6,9,11,12] developed through this process are available at www.rdrwa.ca.



Building momentum

As a living document, the IWMP will expand and evolve after Phase One to address a broader range of watershed health issues. Phase Two will begin in 2016 and will look holistically at watershed health. If you have ideas for how to improve watershed management moving forward or would like to participate in any way, please visit our website (www.rdrwa.ca) or reach out to the RDRWA directly. Opportunities to get involved are listed at the back of this plan.

How does this plan come to life?

Putting ideas to work

This plan, *Blueprint*, will do little good gathering dust in a drawer somewhere. It will take commitment, collaboration, and action to bring this plan to life. As we work together, here are a few things to keep in mind:

Collaboration and Partnerships

This plan is a decision-support tool and the recommendations should be taken as advice. There is no specific statutory framework yet in place to require the adoption and implementation of integrated watershed management plans (IWMPs) in Alberta.

For this reason, the recommendations in this plan will only be achieved through the voluntary actions of individuals, groups and organizations across sectors, and governments. Businesses, homeowners, and landowners: we must all do our part.

A Living Document

The recommendations included in this plan are just some of the steps that can be taken to maintain or improve surface water and groundwater quality. No plan for such a complex issue can pretend to be exhaustive, nor should it be static.

Additional phases of work will see this IWMP expand to include recommendations related to land use, riparian areas, wetlands, biodiversity, and water quantity. Future phases of the plan will also review this plan (Phase One) to determine if any updates or course corrections are required.

Evaluating Progress

The RDRWA commits to reporting back periodically about progress made toward the recommendations and lessons learned.

Action and Innovation

The road ahead is about much more than implementing a written plan – it is about connecting with one another to make improvements over the long haul. A range of partners will support the implementation of these recommendations. For some recommendations, work is already underway. In other cases, a concerted and collaborative effort will be needed to get the ball rolling.

To accelerate the implementation of *Blueprint* while fostering creative solutions to water quality challenges, the Red Deer River Watershed Alliance and Alberta Ecotrust have also partnered to launch **Project Blue Thumb: Action on Water Quality Issues** (see over).

A catalyst for action

How can we work together to maintain and improve water quality?

Introducing *Project Blue Thumb*: *Action on Water Quality Issues*, Alberta's first social innovation lab dedicated to addressing water issues.

Recognizing that watersheds are complex systems – with a range of individuals and groups having different needs – *Project Blue Thumb* brings together a diverse (and growing) team of people to design, test, and iterate solutions to water quality challenges.

Project Blue Thumb is led by the Red Deer River Watershed Alliance and the Alberta Ecotrust Foundation, with support from pioneers of the social lab approach, Reos Partners. The lab team includes approximately 30 committed individuals from government, industry, the non-profit sector, academia, and the public.

Labs are a useful approach for working on complex issues in changing times[13], and are designed to be creative, collaborative, and systems-based. The key idea is that we can work smarter and faster if we pool our efforts.

Since launching in Spring 2015, the lab team continues to meet regularly and is actively working on a range of initiatives aimed at improving watershed management and water quality. Through a focus on "learning by doing", the lab team is already implementing aspects of *Blueprint*, while simultaneously helping to advance new and innovative ideas.

This hybrid approach to watershed management seeks to get the better of two worlds: a focused plan, supported by strong relationships across the watershed, and ongoing, flexible implementation.

PROJECT BLUE THUMB
ACTION ON WATER QUALITY ISSUES

Water Quality

Understanding water quality

Water quality can be thought of as a measure of the suitability of water for a particular use. In Alberta, how we evaluate whether water quality is "good" depends in part on its intended use. Water full of dirt might be fine for watering the plants, but would you want to drink it?

Water quality guidelines are established for specific water uses (e.g., drinking water supply, recreation, protection of aquatic life). For example, we typically have more stringent guidelines for the protection of aquatic life because aquatic life can be sensitive to poor water quality.

Water quality is measured using a variety of methods and a combination of measurements reflecting the physical, chemical, biological, and radiological characteristics of water. Examples include:

Physical: temperature, colour, turbidity, and suspended solids.

Chemical: nutrients (nitrogen, phosphorus), metals, oxygen, and a wide range of pollutants (e.g., pesticides, pharmaceuticals).

Biological: bacteria, parasites, algae, invertebrates, and plants.

Drivers of water quality

Watershed health is a function of ecosystem processes in combination with human activities. Water bodies are in constant flux and this is reflected in changing water quality over time. Some differences in water quality are due to natural causes (e.g., different bedrock geology), while others are due to human causes (e.g., nutrient runoff from agricultural land).

When changes are part of a natural disturbance– such as when a forest fire adds sediment to a river – the changes are not typically considered pollution. However, human-caused changes that lead to degradation are considered pollution. There are two key types of pollution:

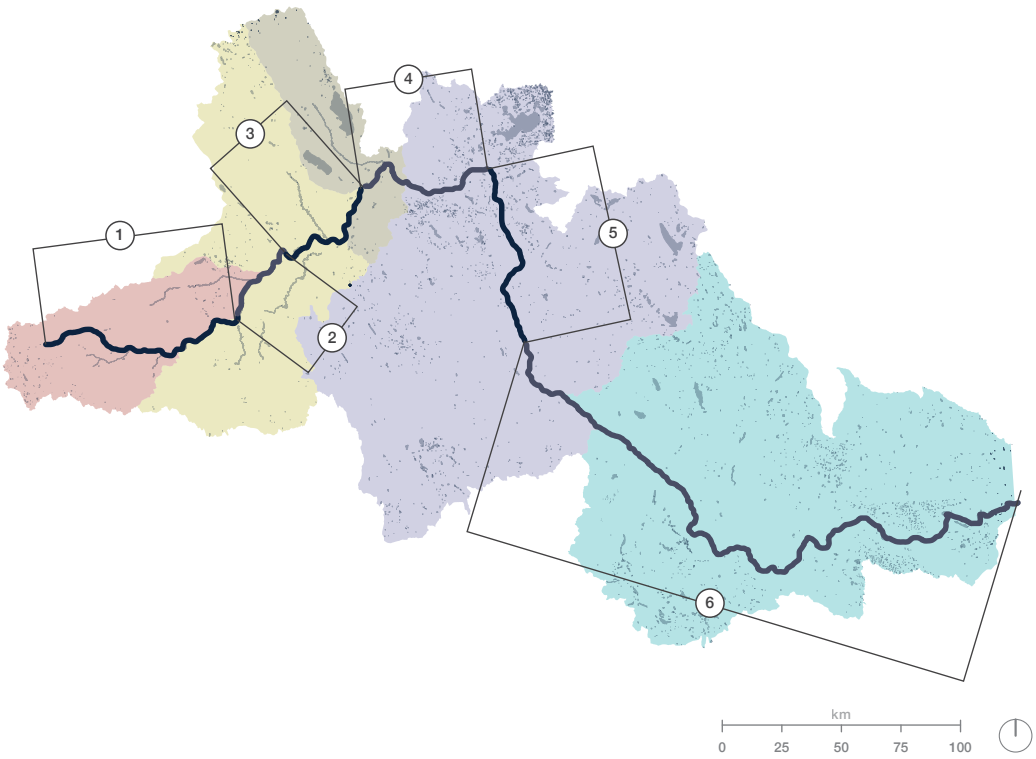
Point source pollution is pollution that comes from a single, discrete place, such as from a pipe (e.g., effluent from a wastewater treatment plant). This type of pollution is typically managed through regulation.

Non-point source (NPS) pollution is contamination that enters a water body from diffuse points of discharge and has no single point of origin[14]. Understanding the sources and quantities of NPS pollution is a big challenge, yet is considered to be an important priority moving forward[14].

A report card for how we live on the land

Quality varies from west to east

The mainstem of the Red Deer River can be thought about as a series of six different sections, or reaches. In general, water quality conditions in the Red Deer River mainstem deteriorate from upstream (west) to downstream (east)[6]. See Appendix B for a description of water quality conditions in these six reaches.



Reach 1. Headwaters to Sundre

Reach 2. Sundre to Gleniffer Reservoir

Reach 3. Gleniffer Reservoir to Highway 2

Reach 4. Highway 2 to Nevis

Reach 5. Nevis to Morrin

Reach 6. Morrin to Alberta -Saskatchewan border

State of the Watershed

"The health of our waters is the principal measure of how we live on the land." – Luna Leopold

- The story of water quality in the Red Deer River watershed is a story that is still unfolding. The RDRWA's 2009 *State of the Watershed* report systematically looked at watershed health across all 15 sub-watersheds of the watershed[5]. The report considered 20 different indicators, and for each sub-watershed, indicators were rated "good", "fair" or "poor" based on existing scientific data. Each of the sub-watersheds was then given an overall grade.
- In the report, five sub-watersheds received a poor watershed health grade, eight received a fair grade, and two received a good grade (Table 1). The Medicine, Blindman, Buffalo, Michichi, and Kneehills sub-watersheds received poor grades, with surface water nutrient levels, land cover, linear developments, and oil and gas activity being the indicators of most concern[5].
- More specifically, water quality in the sub-watersheds and associated tributaries ranges from poor to good, depending on the indicator assessed[5]. Water quality nutrient variables are poorest in the central region of the Red Deer River watershed.
- Importantly, the results of the 2009 *State of the Watershed* Report were based on a limited data set and many knowledge gaps still exist[5]. Moving forward, a key focus for watershed management should be improving the quality and quantity of water quality data collected across sub-watersheds and major tributaries.

For more information on the health of the Red Deer River Watershed, please see the 2009 *State of the Watershed* Report[5] and the four background technical reports[6,9,11,12] developed to support this plan. These reports are available online at www.rdrwa.ca.

Table 1. Condition assessment of watershed health across sub-watersheds[10], including the status of five key indicators of water quality (phosphorus, nitrogen, bacteria – *E.coli*, parasites, and pesticides).

Zone	Sub-watershed	Overall State of Sub-watershed*	Water Quality Condition				
			Total Phosphorus	Total Nitrogen	Bacteria	Parasites	Pesticides
Upper Headwaters	Panther	A	Fair	Fair	-	-	-
	James	B+	Fair	Good	Good	-	-
Lower Headwaters	Raven	B+	Good	Good	-	-	-
	Little Red Deer	B	Fair	Good	Poor	-	Good
	Medicine	C-	Poor	Fair	Poor	Poor	Good
Central Urbanizing	Blindman	C-	Poor	Poor	Poor	-	Good
	Waskasoo	B-	-	-	-	-	-
Central Agricultural	Buffalo	C+	Poor	Poor	Good	-	Good
	Threehills	B-	Poor	Poor	Good	-	Good
	Kneehills	C	Poor	Poor			
	Michichi	C+	Poor	Poor	-	-	Good
	Rosebud	B-	Poor	Fair	Good	-	Good
Dry Grasslands	Berry	B	Fair	Poor	Good	-	-
	Matzhiwin	B	Fair	Good	Poor	-	-
	Alkali	A-	Good	Good	Good	-	-

*State of the watershed grades are based on an assessment of 12 different risk and condition indicators relating to water quality, water quantity, land use, and biology[5]. Ratings are shown as “good” (green), “fair” (orange), and “poor” (red).

Goals & Targets

Maintaining and improving water quality

When you go to a river to fish or swim, you expect the water to be clean and safe. You expect that the fish can breathe and would be safe to eat. And whether you use water to grow crops, brush your teeth, flush out waste, or for another industrial or commercial purpose, you expect that clean and adequate water will be available.

Our water must be potable, swimmable, fishable. Our communities expect it for their daily living. Our downstream neighbours – from Lake Winnipeg to Hudson's Bay – do too.

Water is used for many purposes - drinking water, irrigation, industry, and the protection of aquatic life, among others – and for each of those uses, there is a desirable state of water quality.

While water quality guidelines have been established to describe the desired state of water quality for many uses[15,16], there has been a distinct need to develop goals and targets specific to the Red Deer River watershed.

Goals	Targets	Details
Surface water quality in the Red Deer River Watershed is maintained and improved.	Targets for surface water quality are presented as Water Quality Objectives (WQOs). WQOs are science-based targets that protect water uses and form a cornerstone of aquatic ecosystem and water quality management. WQOs are developed for specific monitoring locations in the mainstem of the Red Deer river.	Site-specific WQOs for 11 water quality indicators have been developed for four monitoring locations along the Red Deer River: the Highway 2 site (Reach 3), Nevis site (Reach 4), Morrin site (Reach 5) and Bindloss site (Reach 6). See Appendix C for detailed targets.
Groundwater quality in the Red Deer River Watershed is maintained and improved.	Quantitative targets for groundwater quality have yet to be developed.	See Recommendation 9 for more information on the development of targets for groundwater quality.

Water quality objectives as early warning signals

Water quality objectives are important measures to determine whether surface water quality is meeting the needs of the aquatic environment and requirements for human uses.

- WQOs were developed using a scientific approach guided by best practices set by the Alberta Government[17]. WQOs were determined based on historical water quality conditions at a given site. In that sense, past water quality monitoring results (values) provide the basis for establishing desired future water quality conditions. More information on the development and scientific validation of these WQOs is available in the report "Draft site-specific water quality objectives for the Red Deer River Basin with emphasis on the mainstem"[11].
- WQOs were developed for four of the six reaches of the Red Deer River (Reaches #3-6). Owing to data limitations, WQOs were not developed for Reaches 1 and 2 (the headwaters) or for tributaries. See Recommendation 3 for more information on future WQO development for these locations.
- The RDRWA envisions that these water quality objectives will be considered during the development of a regional plan for the Red Deer Region under the Government of Alberta's *Land-use Framework*[10]. While the WQOs as presented are in alignment with the goal of "maintaining and improving surface water quality in the Red Deer River watershed", they have not been subject to analyses of socio-economic feasibility.

Applying Water Quality Objectives (WQOs)

If future water quality conditions at a given site are found to be better than what is required through the established WQOs, then we should strive to maintain these superior conditions. However, if future water quality conditions fall below the established WQOs, measures should be taken to improve the instream water quality to meet the objective. Regular water quality monitoring and data analysis should be conducted in order to detect changes or trends that might indicate a decline in water quality.

11 Recommendations

1 Water literacy & participation

Improve the understanding and strengthen the commitment of watershed users to protect water quality.

2 Surface water quality monitoring network

Establish a robust monitoring program for surface water quality.

3 Water quality objectives

Develop and implement a management-response framework for the Red Deer River and major tributaries.

4 Beneficial management practices

Encourage and promote the implementation of beneficial management practices across municipalities, industry, and agriculture.

5 Emerging Issues

Research, curate, and share information on emerging issues that impact water quality (e.g., pharmaceuticals, pesticides).

6 Source water protection

Identify and address risks to source waters, including water used as a source of drinking water.

7 Monitoring and measuring lakes & reservoirs

Fill information gaps to improve lake monitoring and inform the development of lake watershed management plans.

8 Groundwater monitoring network

Establish a robust monitoring program for groundwater quality.

9 Integrated monitoring and reporting framework

Establish an integrated monitoring, evaluation, management, and reporting framework for groundwater quality.

10 Mapping groundwater resources

Expand efforts to map and characterize groundwater resources across the Red Deer River Watershed.

11 Sustainable management of groundwater quality

Incorporate the sustainable management of groundwater quality, including the protection of recharge areas, into land-use planning and resource management.

Recommendation_01:

Water literacy & participation

Core message

Improving water literacy equips our communities with the knowledge and tools required to understand the complexity of watershed issues and to effect change. Water literacy requires understanding how our activities on the landscape influence water quality.

What's the issue?

- Water literacy is a foundation for community efforts to protect watersheds. One who is "water literate" will think, plan, and act with water in mind.
- Albertans have identified the need to raise water literacy levels[18]. There is a particular need for decision-makers to be water literate.
- Groups working on watershed issues often work independently and miss opportunities to collaborate. While many partnerships have been strengthened through Alberta's *Water for Life* Strategy[1], we can do better.
- Connecting with others, encouraging learning, and broadening participation have all been identified as key principles for building resilience in our communities[19].
- As we seek to enhance collaboration and build stronger networks around water issues, there is also a distinct need to strengthen relationships with First Nations and Métis communities, beginning with a focus on the links between Traditional Ecological Knowledge and improved watershed management.

Improving water literacy

The Alberta Water Council has formed a team to recommend ways to improve water literacy across Alberta. The recommendations of this team will be released in Spring 2016.

Improve the understanding and strengthen the commitment of watershed users to protect water quality.

Specific actions

1.1 Develop and implement a program to enhance water literacy and counter common water myths for people who live, work, and play in the watershed.

1.2 Encourage and support collaboration among individuals and groups working on common thematic issues.

1.3 Explore avenues to address and incorporate Traditional Ecological Knowledge (TEK) in watershed management activities.

Key partners

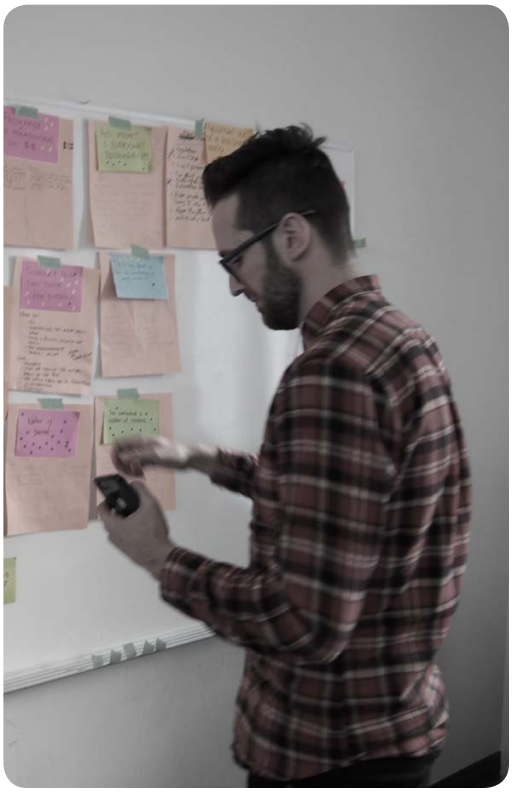
All

Resources

Alberta Water Council Water Literacy Project Team link
RBC Canadian Water Attitudes Survey (2008 - 2015): link
Alberta Council for Environmental Education: link
Project Blue Thumb: *Action on Water Quality Issues*: link
Alberta Urban Municipalities Association (AUMA): link

Did you know?

The Red Deer River watershed spans the ancestral and traditional territories of Aboriginal peoples, including First Nations and Métis peoples. The watershed is part of both Treaty 6 and Treaty 7 territory.

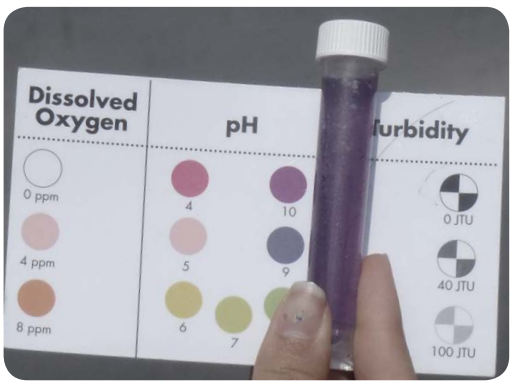


Recommendation_02:

Surface water quality monitoring network

Core message

By collecting data and information on the condition of water quality, people can understand trends and changes over time. There is a need to expand surface water quality monitoring efforts across the Red Deer River watershed to fill existing knowledge gaps and inform decision-making that affects land use.



What's the issue?

- Important gaps exist in water quality monitoring, evaluation, and reporting across the watershed, and these are key tools needed to inform watershed management[5,6].
- There is a need for increased routine water quality monitoring in the headwaters and in major tributaries.
- Impacts to water quality can come from both point and non-point sources, however quantification of non-point source pollution across the watershed remains a challenge.
- There is a need to identify point and non-point sources of pollutants and to quantify significant loads in tributaries and the river's mainstem. This can enable more focused management efforts through the future establishment of pollutant load limits and allocations.
- In 2015, high water temperatures stressed fish populations in the river. Concerns about climate change and recent drought conditions have highlighted the need for increased real-time monitoring of water temperature.
- Multiple groups monitor surface water quality conditions at select locations, however there is a need for enhanced coordination of efforts, a sustainable funding model that will support monitoring over the long-term, and clear support for citizen science.

Establish a robust monitoring program for surface water quality.

Specific actions

2.1 Continue monitoring at long-term river network (LTRN) monitoring stations along the Red Deer River. Ensure that the medium-term river network monitoring station at Sundre becomes a LTRN site.

2.2 Establish a long-term river network monitoring site for Reach 2 (Bowden).

2.3 Expand monitoring efforts to include regular sampling at the mouths of major tributaries, to support the future development of site-specific water quality objectives and pollutant load allocations for these sites.

2.4 Expand monitoring efforts to include the real-time monitoring of surface water temperature in major tributaries and the Red Deer River.

2.5 Conduct synoptic surveys on the river to describe longitudinal changes in river quality and the influence from point sources and non-point sources on aquatic ecosystems. Surveys should capture critical seasonal and flow-related features such as spring and summer runoff, and winter and open water low flows.

2.6 Expand monitoring efforts to enable the calculation of total loads and fluxes by ensuring access to data on concentrations and discharge at all long-term river network sites on the mainstem and tributaries.

Monitor, Evaluate, Report

The Alberta Environmental Monitoring, Evaluation and Reporting Agency (AEMERA) was recently established as an arms-length provincial organization responsible for leading monitoring, evaluation, and reporting efforts for key environmental indicators, including water quality indicators.

Key partners

AEMERA; Watershed Stewardship Groups; Municipalities

Resources

Alberta Environmental Monitoring, Evaluation & Reporting Service (AEMERIS): an online portal for Alberta environmental data link

Alberta Water Council, Recommendations to Improve Non-Point Source Pollution Management in Alberta link

Recommendation_03:

Water quality objectives (WQOs)

Core message

In order to maintain and improve surface water quality, it is necessary to have a clear framework for how we can work together that is proactive, fair, and science-based.

What's the issue?

- As the watershed's population grows and land use intensifies, cumulative effects may pose an increasing risk to water quality[6].
- Because no single agency or level of government is solely responsible for instream water quality protection, we must all work together to establish water quality targets, monitor and evaluate trends, and implement appropriate protection and mitigation strategies.
- A Surface Water Quality Management Framework that involves all key stakeholders – with legal authority under the *Alberta Land Stewardship Act* - is needed for the Red Deer Region (see box). This framework should be part of the future development of a regional plan for the Red Deer Region under the *Land-use Framework*[10].
- This framework must specify water quality objectives (i.e., targets), establish an agreed-upon trend evaluation process, define roles, and outline the management responses to take in the event of acute or chronic exceedances of targets[11].
- Municipalities have a key role to play in informing the development of a management framework to ensure that land use decisions protect water quality while meeting municipal needs.

Key partners

Government of Alberta; Municipalities; Prairie Provinces Water Board

Resources

Environmental Management Frameworks link

The Prairie Provinces Water Board Agreement on Water Quality link

Develop and implement a surface water quality management framework for the Red Deer River and major tributaries.

Specific actions

3.1 Utilize the water quality objectives (WQOs) presented in this plan to inform the future development of a *Red Deer Region Surface Water Quality Management Framework*. Site-specific Water Quality Objectives have been developed for four of the six reaches of the Red Deer River (Reaches 3-6), as presented in this plan.

3.2 Develop WQOs for the headwaters (lower portions of reaches 1 and 2) once sufficient data is available.

3.3 Develop WQOs for the mouths of major tributaries (i.e., tributaries designated as sub-watersheds in *Blueprint*) once sufficient data is available.

Regional planning matters

Under the Government of Alberta's *Land-use Framework*[10], the development of regional plans is a key opportunity to ensure that we are managing the long-term cumulative effects of development and all activities on the environment at a regional level.

In other parts of Alberta, regional planning has been complemented by the development of management frameworks to manage surface water quality and groundwater in each region.

These management frameworks seek to manage cumulative effects by establishing targets and limits for certain indicators that prompt management actions by various groups. Once complete, these frameworks have legal authority under the *Alberta Land Stewardship Act*.

Recommendation_04:

Beneficial management practices (BMPs)

Core message

There are many proactive measures – or beneficial management practices (BMPs) – that can be taken to maintain or improve water quality, and that go beyond current legislation. To improve water quality at a watershed scale, extensive adoption of BMPs is required by municipalities, industry, forestry, agriculture, and even individuals.

What's the issue?

- Many BMPs have already been, or are being, implemented, in parts of the watershed as a result of improving technology, growing awareness of human impacts, evolving industry standards, and the recognition that water is a critical resource for all. Nevertheless, cumulative impacts to watershed health indicate a need for increased BMP adoption across sectors[5].
- While many resources and guides to BMPs have been developed, less is known about the relative effectiveness of different BMPs for improving water quality and the best avenues to increase adoption rates in different sectors and regions. There is a need to better leverage existing information rather than reinvent the wheel.
- Efforts to increase BMP adoption should prioritize areas that have the largest influence on water quality. Recognizing that the Red Deer River watershed is 49,650 km^2, there is a need to identify key areas for BMP adoption.
- There is a growing interest in the potential for peer-to-peer sharing of information on BMPs and finding ways to creatively incentivize their adoption.

Encourage and promote the implementation of beneficial management practices to improve water quality.

Specific actions

4.1 Identify areas in the watershed that would benefit from targeted efforts to increase BMP adoption.

4.2 Create and encourage funding programs to incentivize BMP adoption with a focus on experimentation and learning.

4.3 Enhance the use of demonstration sites and peer-to-peer sharing of information to promote the use of BMPs.

4.4 Research the effectiveness of BMP adoption on water quality at the sub-watershed scale.

County support for BMPs

Many counties offer information and funding to help landowners implement BMPs that benefit the environment and water quality. Check with your County office to see if they can help.

Key partners

All

Resources

Many resources and guides to BMPs have been developed for various sectors. The list below includes a few examples but is not meant to be comprehensive:

Alberta Phosphorus Watershed Project: a project to evaluate the effectiveness of implementing different agricultural BMPs on reducing phosphorus link

Synergy Alberta BMPs: a compilation of BMPs relevant to oil and gas development link

Sustainable Forestry Initiative (SFI) 2015-2019 Forest Management Standard: promotes sustainable forestry practices to protect water quality and ecosystem health link

The Alberta Urban Municipalities Association (AUMA) website shares many tips about municipal watershed management link

Recommendation_05:

Emerging issues

Core message

Human activities and watershed conditions are changing, and we need to make sure that we are managing for this change.

What's the issue?

- Research is documenting with increasing frequency that chemical and microbial constituents that have not historically been considered as contaminants are present in the environment on a global scale. These "emerging contaminants" are commonly derived from municipal, agricultural, and/or industrial wastewater sources.
- Emerging contaminants are important because the risks they pose to human health and the environment is not fully understood. Pharmaceuticals, personal care products, and endocrine disrupting compounds are among the prime examples of emerging contaminants.
- Community members in the Red Deer River Watershed have highlighted several concerns related to a range of issues that are already impacting water quality in the watershed or have the potential to, including among others: emerging contaminants, pesticides, hydraulic fracturing, bacteria, and sedimentation.
- More research will be needed to understand the science behind these issues and any risks posed to the watershed and our communities. Research results should be clearly communicated to those concerned about particular issues and used to inform management.

People across the watershed have expressed a range of concerns about our water resources. While some of these concerns are addressed in Phase One of *Blueprint*, others will be addressed in later phases. Examples:

Drought	Pipeline spills	Heavy metals
Lake shoreline development	Loss of farmland	Wetlands & riparian areas
Pesticides	Floods	Pharmaceuticals
Hydraulic fracturing	Sand & gravel development	Climate change

Research, curate, and share information on emerging issues that impact water quality (e.g., pharmaceuticals, pesticides).

Specific actions

5.1 Follow the *Environmental Quality Guidelines For Alberta Surface Waters*[20], which include updated surface water and aquatic ecosystem guidelines for a range of nutrients, metals, petroleum hydrocarbons, and emerging contaminants.

5.2 **Pesticides**: Compare pesticide use patterns in the Red Deer River watershed[21] to the pesticides commonly monitored by the Government of Alberta to ensure that monitoring captures pesticides that are in high use and/or likely to enter surface waters and cause adverse effects. Explore the potential application of the Alberta Pesticide Toxicity Index[22] as an index of pesticide contamination and as a basis for deriving WQOs for pesticides.

5.3 **Hydraulic fracturing**: Report on the research of the possible effects of hydraulic fracturing on surface and groundwater quality in the Red Deer River watershed, particularly in areas with high hydraulic fracturing activity.

5.4 **Emerging contaminants**: Report on the research regarding individual and cumulative effects of man-made chemicals, such as pharmaceuticals, personal care products, flame retardants, and plasticizers on aquatic ecosystems.

5.5 **Bacteria**: Report on the research regarding the occurrence and risks associated with *Cryptosporidium* and *Giardia* in Alberta surface waters.

5.6 **Solids**: Quantify the sources of total dissolved solids and total suspended solids to determine the relative importance of natural and man-made disturbances.

Key partners

All

Resources

Environmental Quality Guidelines For Alberta Surface Waters[18]: includes guidelines for surface water quality (to protect aquatic life, agricultural, and recreational uses), sediment quality, and tissue residue (to protect wildlife consumers).

Recommendation_06:

Source water protection

Core message

Source water protection is a strategy by which municipalities and/or water providers can identify risks and implement actions to reduce risks to water used as a source of drinking water.

What's the issue?

- Protecting water sources can reduce the costs of drinking water treatment, reduce public health risks, increase the recreational value of the area, and enhance natural ecosystems.
- Source water can be threatened by various contaminants depending on local conditions (e.g., nutrients, metals, viruses, bacteria, salts, pesticides, radioactive contaminants).
- Source water protection involves reducing risks to local water sources by: 1) identifying existing and potential risks to source water quantity and quality, and 2) developing and implementing strategies to minimize, control, or prevent those risks.
- While many municipalities within the watershed have already completed Drinking Water Safety Plans, integrating source water protection considerations into these plans and municipal decision-making remains a challenge.
- As interest in source water protection increases, the Red Deer River Municipal Users Group (RDRMUG) has also begun work on a *Municipal Water Quality Protection Action Plan* to identify shared concerns and priorities for water quality among 35 municipalities in the watershed. Moving forward, opportunities to coordinate and enhance source water protection planning across stakeholders should be explored, recognizing that both the development of regional plans and Integrated Watershed Management Plans can support source water protection through the establishment of water quality objectives.

Identify and address risks to source waters, including water used as a source of drinking water.

What is source water?

Source water is untreated water that is used to provide public drinking water, and may come from surface water (e.g., lakes, rivers, streams) or groundwater. Source water protection is part of a multi-barrier approach to protect the quality and quantity of water sources within watersheds and aquifers.

Drinking water safety

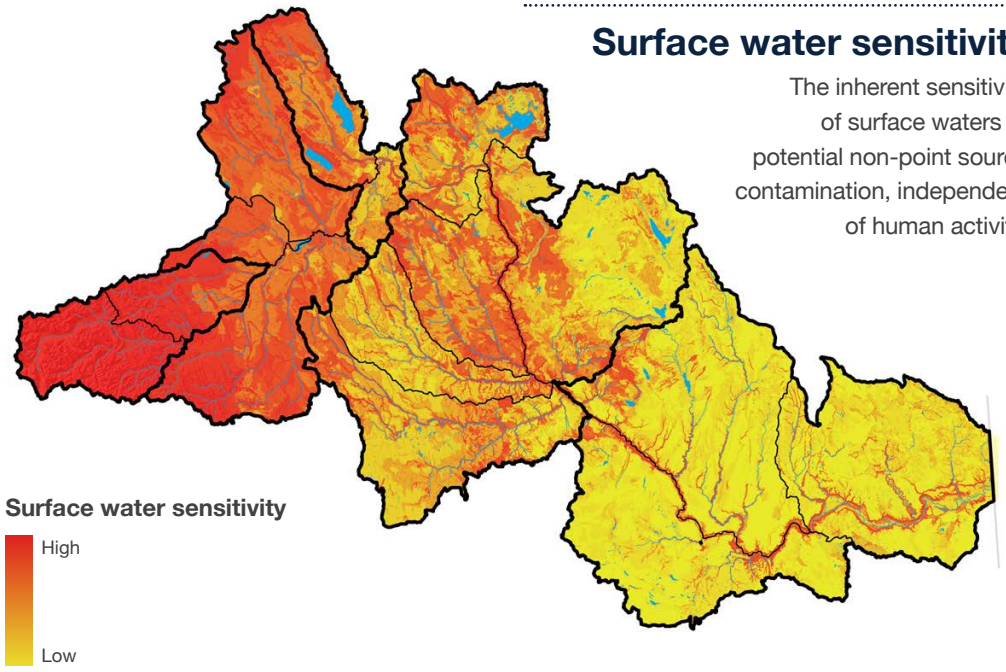
As of 2013, municipalities in Alberta are required, under the *Environmental Protection and Enhancement Act*, to develop Drinking Water Safety Plans.

Drinking Water Safety Plans are a proactive method of assessing risks to drinking water, which ultimately helps to protect public health. The process follows a multi-barrier approach based on an assessment of risks that could adversely affect the source, treatment, storage and distribution of drinking water.

In 2015, Alberta Environment and Parks initiated a project to develop a regional approach and tools to support source water protection planning.

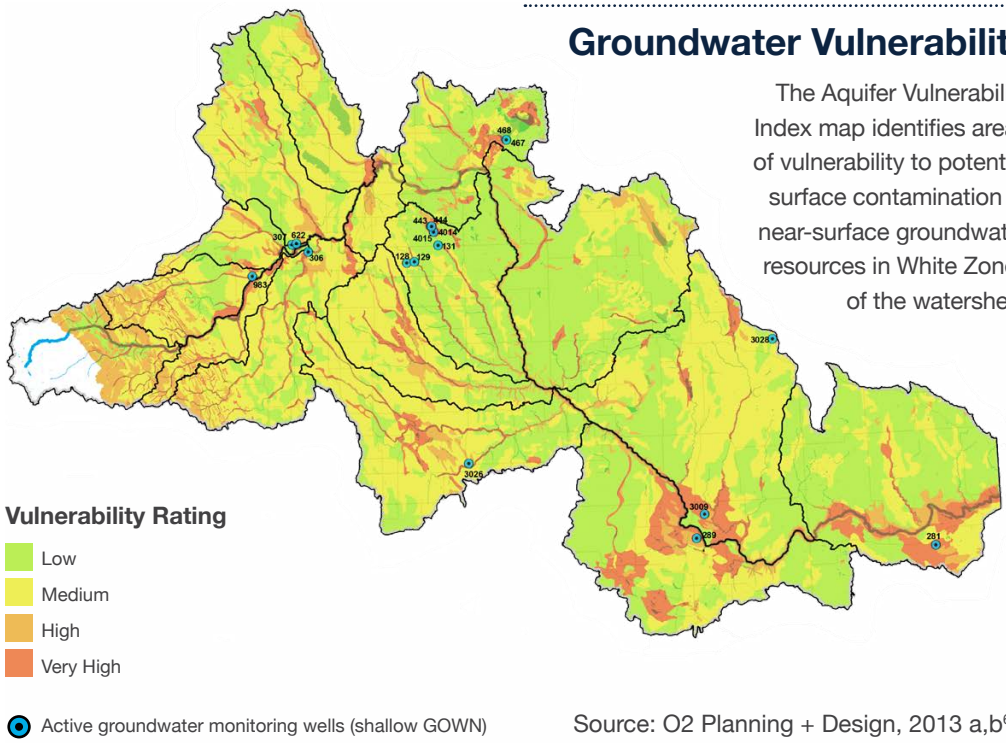
Surface water sensitivity

The inherent sensitivity of surface waters to potential non-point source contamination, independent of human activity.



Groundwater Vulnerability

The Aquifer Vulnerability Index map identifies areas of vulnerability to potential surface contamination of near-surface groundwater resources in White Zones of the watershed.



Source: O2 Planning + Design, 2013 a,b[6,9].

Specific actions

6.1 Provide education and training opportunities about source water protection, Drinking Water Safety Plans, and source water protection strategies at the municipal level (for both municipal officials and staff).

6.2 Enhance participation, communication, and collaboration among municipal staff and officials in the creation and regular review of Drinking Water Safety Plans and share lessons learned across municipalities.

6.3 Include information and recommendations to support source water protection planning by municipalities in the forthcoming RDRMUG *Municipal Water Quality Protection Action Plan*, and ensure that source water protection planning efforts at the local scale support integrated planning across the watershed.

6.4 Secure funding to assist municipalities to better address source water protection, in partnership with other groups.

Avoiding fragility

- 67% of Albertans agree that a tragedy similar to Walkerton could happen again in Canada. In 2000, municipal water supplies in Walkerton, Ontario were contaminated by *E.coli* bacteria, causing 7 deaths and more than 2,300 people to become sick[23].
- 62% of Albertans agree that extreme weather events in Canada will become more commonplace in the future[24].

Key partners

Municipalities; Government of Alberta

Resources

The American Water Works Association (AWWA) has prepared a standard and a supporting guidebook that describe the essential requirements for the effective protection of source waters (AWWA, 2007, 2010).

CCME. 2003. Canadian water quality guidelines for the protection of aquatic life. Guidance on the site-specific application of water quality guidelines in Canada: Procedures for deriving numerical water quality objectives. Winnipeg.

The Government of Alberta recently developed a Guide to Source Water Protection Planning in the South Saskatchewan Region, December 2015 (Draft).

The Alberta Urban Municipalities Association (AUMA) has compiled several resources on source water protection for municipalities link

The Battle River Watershed Alliance has developed a series of guidance documents on source water protection link

Recommendation_07:

Monitoring & management of lakes and reservoirs

The Red Deer River watershed is home to several important lakes in Central Alberta, including the popular summer destinations of Sylvan Lake, Pine Lake, Gull Lake, and Buffalo Lake. Other sizeable lakes and reservoirs include: Burnstick Lake, Chain Lakes, Gleniffer Reservoir, Crawling Valley Reservoir, Blood Indian Creek Reservoir, Bigelow Reservoir, and Little Fish Lake.

A lake's water quality reflects not only the physical features (soils, land cover) of the landscape, but also climate and, more recently, changing land use in lake watersheds. The nature of a particular lake depends not only on its physical setting, but also on changing inputs from the surrounding watershed (e.g., soil, nutrients, household products). As such, each lake's water quality reflects the contribution of all of these inputs, and the influence of sunlight and wind energy.

The complex aquatic ecosystem within a lake is affected by changing inputs (human or natural) and this influences the lake's character and water quality. For this reason, comparing lake water quality (see over) across lakes is difficult. Instead, evaluating and understanding a specific lake's water quality requires looking at its location in the region, the history of land use change, as well as the internal drivers (such as fish populations) that affect water quality. More specific information for a range of water quality indicators is available for many of these lakes through the Alberta Lake Management Society, the Alberta Environmental Monitoring, Evaluation, and Reporting Agency (AEMERA), or through local watershed stewardship groups (see next page).

Lake water quality is the cumulative result of the people and their activities within a lake's watershed, and is intricately tied to land use. In Alberta, current projections indicate that population growth and development around many lakes will continue to increase, as people are attracted to lake communities and recreational opportunities[25]. Understanding the cumulative effects that these changes, and other land use trends within a lake's watershed may have on lake water quality and aquatic health is an important avenue for future watershed management.

Lake water quality ratings

Buffalo Lake	Fair
Gull Lake	Good
Pine Lake	n/a
Sylvan Lake	Good
Chain Lakes	Poor

Source: State of the Environment in Lacombe County, 2013[26].

Fill information gaps to improve lake monitoring and inform the development of lake watershed management plans.

Core message

To protect our lakes, there is a need for increased water quality monitoring, enhanced lake watershed research, and the development of lake watershed management plans with all stakeholders.

What's the issue?

- Human population growth and changing development patterns in lake watersheds are putting pressure on lake water quality and aquatic ecosystem health. Risks of eutrophication, sedimentation, acidification, contamination, and invasive species must be addressed at the watershed scale.
- The two major challenges for effective lake management in Alberta include: 1) ensuring there is sufficient lake monitoring and research to support management actions; and 2) clearly defining management responsibilities and roles across sectors.
- Because no single agency or level of government is solely responsible for lake water quality protection, we must all work together to establish water quality targets, monitor and evaluate trends, and implement appropriate protection and mitigation strategies.
- Increasingly, people are calling for the development of lake watershed management plans that clearly define roles and responsibilities for lake water quality protection. While previous lake planning efforts are laudable, there is a distinct need to establish clear roles and responsibilities for lake protection in Alberta, backed by multi-stakeholder planning efforts under the *Land-use Framework*[10].

Risks to lakes

Eutrophication: Algae Takes Over.
Sedimentation: The Lake Fills In.
Acidification: Air Pollution Affects Lakes.
Toxic Contamination: Chemicals Contaminate.
Invasive Species: Out-compete native species.

Specific actions

7.1 Develop lake watershed management plans for Sylvan Lake, Gull Lake, Pine Lake, Buffalo Lake, Chain Lakes, and the Gleniffer Reservoir, informed by emerging best practices for lake watershed planning.

7.2 Fill information gaps to improve lake monitoring, evaluation, and reporting. Priority monitoring and reporting needs include:

- Establish a consistent and clear approach for the regular monitoring and reporting of lake water quality information to the public and decision-makers.
- Assess temporal trends in water quality and the potential for sudden shifts in lake eutrophication status (e.g., through sediment loading)
- Detect the quantity and sources of non-point and point source loadings.
- Model lake dynamics to predict future states based on development, restorations and/or management scenarios.

7.3 Provide expert support to watershed stewardship groups in order to enhance local stewardship capacity in areas of lake monitoring and citizen science (e.g., through the development of custom lake monitoring protocols).

7.4 Research the economic implications of changes to lake water quality and factor these values into local and regional decision-making.

7.5 Develop quantitative lake water quality objectives for phosphorus and nitrogen.

Key partners

Alberta Lake Management Society; AEMERA; Municipalities; Watershed Stewardship Groups; Government of Alberta

Lake governance

The Water Conversations[18] led by the Government of Alberta in 2013 identified the need for enhanced lake governance systems supported by improved lake monitoring.
The Alberta Water Council has since established a project team to issue recommendations on how lake management can be improved. Their findings will be released in 2016.

Resources

Workbook for Developing Lake Management Plans in Alberta (2013): a guide for those interested in developing lake watershed management plans, developed by the Alberta Lake Management Society link

ALMS LakeWatch reports include lake water quality monitoring results link

Many people in the Red Deer River watershed are passionately working to protect their local lakes, driven in part by concerns about cumulative impacts to lake resources. These groups – sometimes referred to as "watershed stewardship groups" – are leading many lake management efforts. Examples:

- Buffalo Lake: Buffalo Lake Naturalist Club
- Gull Lake: Gull Lake Watershed Society
- Sylvan Lake: Sylvan Lake Watershed Stewardship Society
- Pine Lake: Pine Lake Restoration Society
- Chain Lakes: Friends of the Chain Lakes Society

Recommendation_08:

Groundwater monitoring network

People often think of groundwater and surface water as separate types of water, but in reality they are connected in complex ways. Groundwater contributes to surface water, and vice versa, although the degree of connectivity can vary based on geology and groundwater depth.

Groundwater can be young or old, ranging in age from several months to millions of years old. Because groundwater can be very old, pollutants that enter groundwater can linger much longer than they do in streams or rivers, making contamination potentially irreversible.

Groundwater comes from rainfall, snowmelt, or surface water that percolates into the ground. This is called groundwater recharge. Groundwater is also an important source of water for surface waters like streams, lakes, and wetlands. As groundwater moves out of an aquifer or into surface water, it is called groundwater discharge.

Groundwater can naturally be fresh (non-saline) or salty (saline). As groundwater travels, it dissolves minerals from the rocks and soils it encounters, increasing its salinity. Saline groundwater in Alberta is defined as any water that possesses a mineralization (as total dissolved solids - TDS) in excess of 4,000 mg/L.

Groundwater quality is often assessed based on the total dissolved solids present. In general, groundwater becomes more saline with increasing depth. Geologists distinguish between groundwater in surficial sediments and groundwater in bedrock formations.

Groundwater quality is influenced by the kinds of rock and soil formations through which groundwater flows, by the speed of groundwater flow, and by temperature and pressure conditions underground. Human activities may also influence groundwater quality, particularly in areas where groundwater is shallower and under the direct influence of surface water.

Groundwater quality is highest in the RDRW's headwaters. In the eastern areas of the basin, groundwater quality conditions decline somewhat due to increased mineralization and the presence of notable concentrations of constituents like sulphate[9].

The Alberta Energy Regulator and the Alberta Geological Survey have mapped groundwater quality (based on TDS concentrations) for the portion of the watershed in the Edmonton to Calgary corridor and for both surficial sediments[27] and bedrock formations[28]. The Edmonton-Calgary Corridor Groundwater Atlas is a great resource to learn more.

Groundwater monitoring network (cont.)

Core message

We need to know more about the quality of our groundwater resources. A robust groundwater monitoring network is key to understanding local and regional groundwater quality and cumulative effects.

What's the issue?

- Risks to groundwater quality across the watershed are rising, tied to the increasing intensity of land use, non-point source pollution, and the potential for cumulative effects[8].
- Although some aquifers have been mapped and studied, we do not have a full understanding of the quality of groundwater resources across the watershed, and the impact that land use activities are having on non-saline groundwater quality.
- Despite some recent additions to the provincial groundwater monitoring network, there remain gaps in the current monitoring infrastructure, for example in locations with a higher intensity of activity, in areas with higher vulnerability to impacts from surface or subsurface developments, and in areas where important groundwater-surface water interactions occur (e.g., streams, lakes)[8].
- Strategic improvements to groundwater monitoring infrastructure are needed to enhance our ability to understand cumulative effects to groundwater quality on a regional basis as well as localized impacts to groundwater quality in priority areas of concern.

Establish a robust monitoring program for groundwater quality.

Specific actions

8.1 Evaluate existing and future groundwater monitoring needs in terms of where monitoring occurs, what is monitored (e.g., nutrients, pathogens, contaminants), and who is responsible. O2 Planning + Design[9] have developed a proposal for an enhanced regional monitoring network with additional monitoring locations that could be further refined to support this stream of work.

8.2 Secure funding to support an enhanced groundwater observation well network (GOWN).

8.3 Streamline and centralize access to: i) data on groundwater quality, and ii) groundwater use patterns for large license holders (e.g., location of wells, actual amounts used, purpose of use, etc.).

Key partners

AEMERA; Government of Alberta

Resources

The data from AEMERA's Groundwater Observation Well Network are publicly available link

O2 Planning + Design, et al. Background Technical Report: Surface Water Quantity and Groundwater Resources link

Modern groundwater

Just six percent of the world's groundwater is replenished and renewed within a "human lifetime" of 50 years. This "modern" groundwater is a more renewable resource than older "fossil" groundwater, yet is also more vulnerable to land use change and surface contamination[29].

Recommendation_09:

Integrated monitoring and reporting framework

Core message

In order to maintain and improve groundwater quality, it is a necessary to have a clear framework for how we can work together that is proactive, fair, and science-based.

What's the issue?

- The Red Deer River watershed is experiencing rapid municipal and industrial growth, as well as ongoing agricultural development and possible climate shifts. All of these influences have the potential to affect groundwater resources[9].
- Managing cumulative effects to groundwater will require a coordinated approach to track, evaluate, and report groundwater quality against established indicators and targets, and to trigger appropriate management responses (see O2 Planning + Design, 2013b for more information).
- This framework should help assess changes in groundwater quality over time and space, and help determine the causes of any changes that occur.
- Under the Government of Alberta's *Land-use Framework*[10], the development of regional plans and associated Groundwater Management Frameworks will be important cornerstones for the future management of groundwater resources.

Establish an integrated monitoring, evaluation, and reporting framework for groundwater quality.

Specific actions

9.1 Define quantitative targets for groundwater quality for select indicators.

9.2 Develop a groundwater management framework with a robust evaluation process (e.g., control charting) to analyze trends in important groundwater quality parameters, assess causality, and trigger management responses as appropriate (see O2 Planning + Design 2013b for more information).

Intersecting frameworks

Under the Government of Alberta's *Land-use Framework*[10], regional plans are being developed to manage the long-term cumulative effects of development and all activities on the environment at a regional level.

The Red Deer River watershed overlaps with the South Saskatchewan Regional Plan (completed), the North Saskatchewan Regional Plan (in development), and the Red Deer Regional Plan (to be developed).

Management frameworks for groundwater quality are typically developed to support the regional plans. These management frameworks seek to manage cumulative effects by establishing triggers and limits for certain indicators that prompt management actions by various groups. Once complete, these frameworks have legal authority under the *Alberta Land Stewardship Act*.

Resources:

Overview of Groundwater Management by the Government of Alberta link

Example of a groundwater management framework: Lower Athabasca Region Groundwater Management Framework link

Key partners

Government of Alberta, Municipalities

Recommendation_10:

Mapping groundwater resources

Core message

Improving our understanding of the spatial distribution of groundwater resources – including flows, recharge and discharge patterns, and usage patterns – is fundamental to watershed management moving forward.

What's the issue?

- High quality scientific information is needed to inform the protection of groundwater sources and areas that replenish water. Groundwater mapping and modelling can tell us how much groundwater is available, its' quality and flow, and can show the shapes and locations of aquifers (sources of groundwater) and aquitards (underground barriers to water movement).
- The Edmonton-Calgary Corridor Groundwater Atlas (see box) and the Alberta Geological Survey Groundwater Program are important steps toward improving our knowledge of groundwater resources. Through the AGS Groundwater Program, a regional groundwater model has been developed as a foundation for more site-specific research and analysis into groundwater quantity and quality in the future.
- Despite recent work, there is still a need to expand mapping and modelling efforts, especially in areas of priority concern and potentially high human impact on groundwater. Results should be shared to improve the groundwater literacy of key stakeholders and to inform land use decision-making.

Key partners

Alberta Geological Survey; Alberta Environment and Parks; Academic partners, Municipalities.

Expand efforts to map and characterize groundwater resources across the Red Deer River Watershed

Specific actions

10.1 Identify key geographic areas of concern within the watershed to focus future groundwater mapping, modelling, and research.

10.2 Research the distribution of aquifers, groundwater volumes, and sustainable yields in the Red Deer River watershed, particularly in high-use aquifers (e.g., Paskapoo Formation).

10.3 Map regional groundwater flows to determine groundwater catchments and potential influences from development activities occurring in neighbouring basins.

10.4 Identify and map recharge and discharge zones, and characterize and quantify the contributions to groundwater inventories and surface waterbodies (i.e., streams, rivers, lakes, and wetlands).

10.5 Document the deep well injection of industrial wastes (e.g., location, amount, chemistry) and identify high-risk areas related to groundwater resources.

10.6 Conduct comprehensive groundwater risk mapping (by major aquifer type) to identify groundwater at greatest risk of contamination from current and future development (e.g., key recharge areas) and target these for protection or other management efforts.

A groundwater atlas

The Edmonton-Calgary Corridor Groundwater Atlas is an example of a detailed study that maps fresh (non-saline) groundwater across a large portion of the watershed. Led by the Alberta Geological Survey and Alberta Environment and Parks, the Atlas is an important step toward improving our knowledge of groundwater resources. The Edmonton-Calgary corridor has the most water wells in Alberta.

Resources

Edmonton-Calgary Corridor Groundwater Atlas: an atlas reporting on the state of groundwater resources in the Edmonton-Calgary Corridor, prepared by the Alberta Geological Survey link

Gull Lake Watershed Aquifer Project: This initiative mapped aquifers that are hydraulically connected to Gull Lake to inform municipal decision-making link

Regional groundwater assessments: prepared for counties and municipal districts across Alberta by Hydrogeological Consultants Ltd. link

Recommendation_11:

Sustainable management of groundwater quality

Core message

Groundwater is often overlooked and undervalued in decision-making. Any important land use decision should consider the potential impact on the sustainable management of groundwater quality.

What's the issue?

- The vulnerability of shallow groundwater to potential surface contamination varies across the watershed (see map on page 38), depending on factors including depth to the aquifer and the types of geological materials between the surface and the first aquifer encountered[9]. In general, the western portion of the watershed exhibits higher vulnerability to surface activities than the eastern part, because of the lower containment ability of overlying sediments.
- Thorough planning is needed to ensure that communities have enough quality groundwater in the future and to avoid contamination of shallow groundwater by various land use activities.
- Because groundwater flows underground and crosses jurisdictions, there is a need to strengthen regional partnerships to ensure a coordinated approach to groundwater management.
- Municipalities have an important part to play in the protection of groundwater. Responsible land use is required to prevent contamination of groundwater used as a source of drinking water and groundwater that is hydrologically connected to surface water.

Key partners

Government of Alberta; Municipalities; Alberta Geological Survey.

Resources

The Working Well program provides well owners with workshops, information, and tools to help with the proper care for wells link

Incorporate the sustainable management of groundwater quality, including the protection of recharge areas, into land-use planning and resource management.

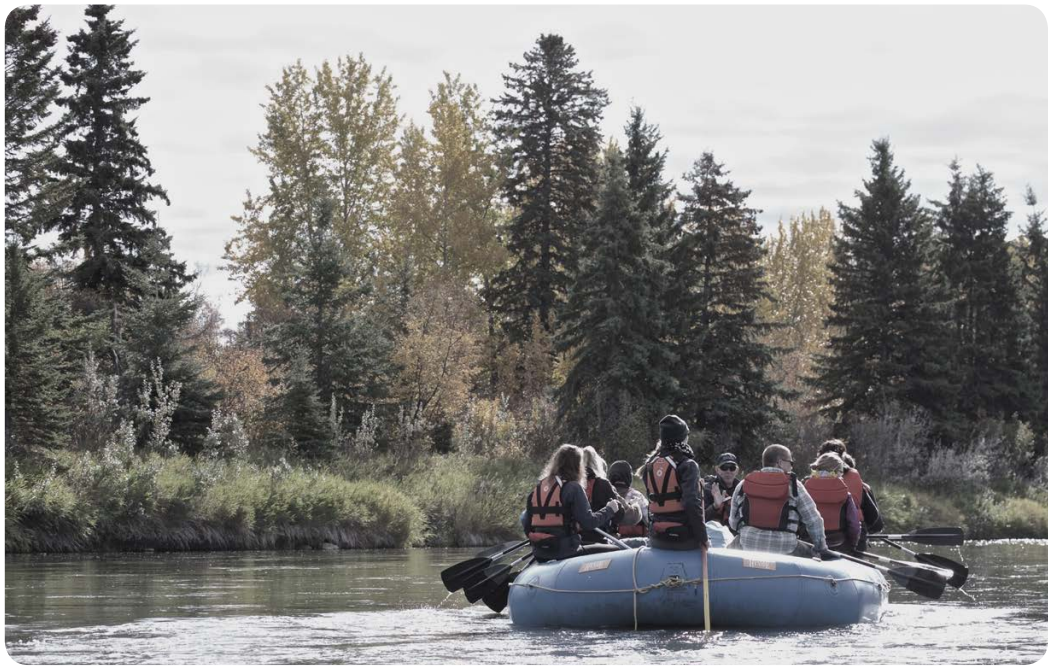
Specific actions

When conducting land use planning, it is important to understand the type, distribution, quantity, quality, and connectivity of groundwater resources. Land use planning activities should attempt to:

11.1 Characterize local and/or regional groundwater resources and their relationship with planned land use activities.

11.2 Assess the role of climate variability and climate change on groundwater level fluctuations, quality, and storage volumes.

11.3 Identify aquifer/groundwater management areas and associated plans that include aspects such as forecasting effects (through modeling) and sustainable yields.



Notes

We all have a role to play in maintaining and improving water quality. Please use these pages to reflect on the questions below and jot down any notes and ideas.

Individuals

What am I most passionate about?

What am I already working on?

Where can I contribute?

What do I commit to doing?

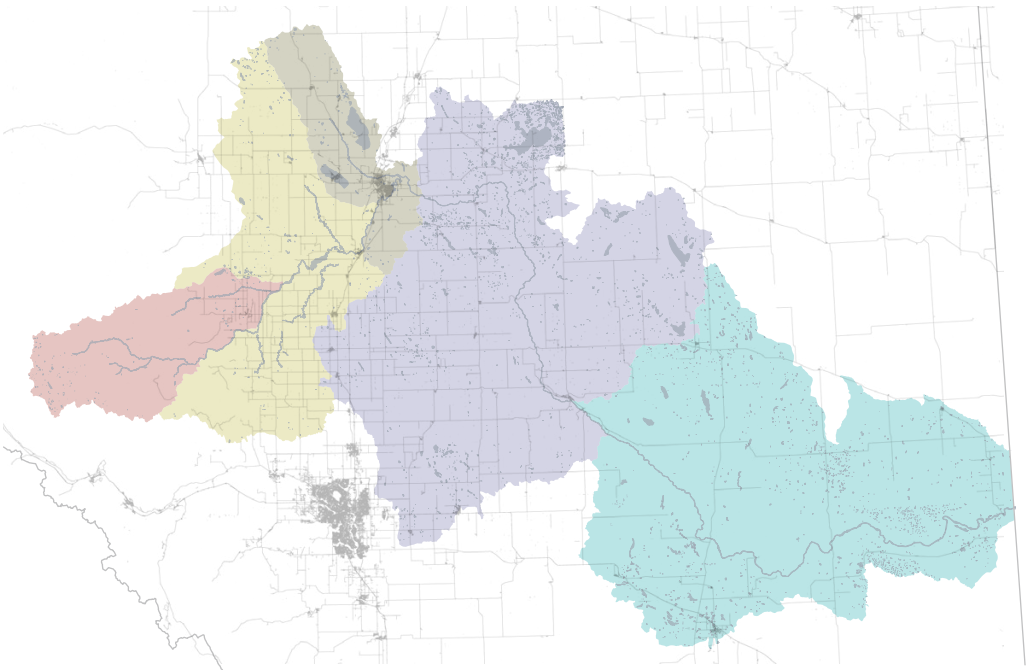
Groups and Government

What are we responsible for?

What are we already working on?

What are we most passionate about?

What do we commit to doing?



Conclusions

Blueprint: An Integrated Watershed Management Plan for the Red Deer River Watershed (Phase One) presents goals, targets, and recommendations to maintain and improve water quality in the Red Deer River Watershed. We hope that this plan will be an important catalyst and touchstone to maintain and improve water quality in the coming years.

A decision-support tool, the implementation of the recommendations in this plan will rely on the commitment and goodwill of a network of diverse partners. From individual actions and targeted projects to large-scale multi-stakeholder commitments, this plan will come to life at many scales and on many timelines.

Of course, one of the most exciting things about this plan is thinking beyond it. While the plan covers a lot, there is always more to do. Such is the nature of working to transform a watershed. Social, ecological, and economic conditions change, and as they do, our management approaches will need to be flexible and adaptive. Despite our best intentions and efforts, some of these recommendations may stay on the "to do" list. Our challenge is to stay rooted in our goal of maintaining and improving water quality while continually seeking strategic approaches to getting there.

References

1. Government of Alberta. 2003. Pub No.1/955: ISBN No. 0-7785-3058-2 Water for Life: Alberta's strategy for sustainability. Edmonton, AB: Alberta Environment.

2. Environment Canada. 2001. "Waterborne Pathogens," in Environment Canada, ed. Threats to Sources of Drinking Water and Aquatic Ecosystem Health in Canada. Burlington, ON: National Water Research Institute. By: T. Edge, J.M. Byrne, R. Johnson, et al.

3. Blue Economy Initiative. 2011. Running through our fingers: How Canada fails to capture the value of its top asset. By: S. Renzetti, D.P. Dupont, and C. Wood.

4. World Economic Forum. 2015. Global Risks 2015, 10th Edition.

5. Aquality. 2009. Red Deer River State of the Watershed Report. Red Deer, AB: Aquality Environmental Consulting Ltd. Report prepared for the Red Deer River Watershed Alliance, Red Deer, Alberta, Canada.

6. O2 Planning + Design Inc. (O2), LimnoLogic Solutions Ltd & A Dolan & Associates. 2013a Background Technical Report on Riparian Areas, Wetlands and Land Use. Last accessed February 16, 2015 from: http://www.rdrwa.ca/sites/rdrwa.ca/files/pdf/ReportRiparianAreasWetlandsLandUse.pdf

7. IPCC, 2014. Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp.

8. Government of Alberta. 2010. South Saskatchewan Regional Plan: Water Quantity and Quality Modelling Results. By: Alberta Environment. ISBN: 978-0-7785-9004-0.

9. O2 Planning & Design Inc (O2), Integrated Sustainability Consultants Ltd, LimnoLogic Solutions Ltd & A. Dolan & Associates. 2013b. Background Technical Report: Surface Water Quantity and Groundwater Resources. Last accessed February 16, 2015 from: http://www.rdrwa.ca/sites/rdrwa.ca/files/2013/IWMP-BTRs/RDRWASurfaceWaterGroundWater21Nov20131FINAL.pdf

10. Government of Alberta. 2008b. Pub No. I/321. ISBN No. 978-0-7785-7714-0. Land-use Framework.

11. AM Anderson & A Dolan & Associates. 2012. Draft Site Specific Water Quality Objectives for the Red Deer River Basin with the emphasis on the mainstem. Online: Red Deer River Watershed Alliance <http://www.rdrwa.ca/sites/rdrwa.ca/files/pdf/WQO-RDR-IWMP-July-16-2012.pdf>.

12. O2 Planning & Design Inc (O2) & A. Dolan & Associates. 2014. Background Technical Report: Terrestrial & Aquatic Biodiversity. Last accessed February 16, 2015 from: http://www.rdrwa.ca/sites/rdrwa.ca/files/2014/O2_TerrestrialAquaticBiodiversityTechnicalReportFINAL_20140825_LO.pdf

13. Hassan, Z. 2014. The Social Labs Revolution: A new approach to solving our most complex challenges. Berrett-Koehler Publishers, Inc. San Francisco.

14. Alberta Water Council (AWC). 2013. Recommendations to Improve Non-Point Source Pollution Management in Alberta .

15. AENV. 1999. Surface water quality guidelines for use in Alberta. Environmental Sciences Division, Alberta Environment, Edmonton, Alberta. Pub. No.: T/483. ISBN: 0-7785-0897-8. 20pp.

16. CCME. 2003. Canadian water quality guidelines for the protection of aquatic life. Guidance on the site-specific application of water quality guidelines in Canada: Procedures for deriving numerical water quality objectives. Winnipeg.

17. Alberta Environment and Water. 2012. Guidance for deriving site-specific water quality objectives for Alberta rivers. Version 1.0. Water Policy Br., Policy Div., AEW. Edmonton. 32pp.

18. Government of Alberta. 2014. ISBN No. 978-1-4601-1890-0. Our Water, Our Future. A Plan for Action.

19. Stockholm Resilience Centre. 2015. Applying resilience thinking. Seven principles for building resilience in social-ecological systems.

20. Alberta Environment & Sustainable Resource Development (ESRD). 2014. Environmental Quality Guidelines for Alberta Surface Waters. Water Policy Branch, Policy Division. Edmonton. 48pp. ISBN: 978-1-4601-1524-4.

21. Byrtus, G. 2011. Overview of 2008 pesticide sales in Alberta. Alberta Environment, Edmonton.

22. Anderson, A.M. 2008. Development of an aquatic pesticide toxicity index for use in Alberta. Alberta Environment, Environmental Assurance Division, Edmonton, Alberta. http://www.environment.gov.ab.ca/info/library/7973.pdf

23. RBC. 2015. RBC Canadian Water Attitudes Study. By: RBC Blue Water Project.

24. RBC. 2014. RBC Canadian Water Attitudes Study. By: RBC Blue Water Project.

25. Alberta Lake Management Society. 2013. Workbook for developing lake watershed management plans in Alberta.

26. State of the Environment in Lacombe County, 2013.

27. Barker, A.A., Moktan, H., Huff, G.F., and Stewart, S.A. 2013a. Maps for fresh groundwater chemistry, Edmonton-Calgary Corridor. Alberta: I – surficial sediments aquifer. Alberta Energy Regulator. AER/AGS Open File Report 2013-07, 17p.

28. Barker, A.A., Moktan, H., Huff, G.F, and Stewart, S.A. 2013b. Maps of fresh groundwater chemistry, Edmonton-Calgary Corridor, Alberta: II – Paskapoo aquifer. Alberta Energy Regulator, AER/AGS Open File Report 2013-08, 17p.

29. Gleeson, T., K.M. Befus, S. Jasechko, E. Luijendijk, and M.B. Cardenas. 2015. The global volume and distribution of modern groundwater. Nature Geoscience. DOI: 10.1038/NGEO2590

Appendix A

Watershed zones at a glance

The five watershed zones were first delineated by O2 Planning + Design[6] and described as “watershed-based landscape units”. Zones were determined based on sub-watershed boundaries, natural regions and sub-regions, primary land management issues and land use patterns, and the location of water quality monitoring stations.

	Upper Headwaters	Lower Headwaters	Central Urbanizing	Central Agricultural	Dry Grasslands
Sub-watersheds	Panther, James	Raven Little Red Deer Medicine	Blindman Waskasoo	Buffalo, Threehills, Kneehils, Michichi, Rosebud	Berry, Matzhiwin Alkali
Cities and towns (population > 1,000 people)	Sundre	Bowden, Carstairs Olds, Eckville	Red Deer, Bentley Blackfalds, Rimbey Sylvan Lake Penhold, Innisfail	Bashaw, Threehills Trochu, Crossfield Didsbury Drumheller, Irricana Strathmore	Hanna, Brooks Bassano, Oyen
Major tributaries	Panther River, James River,	Raven River, Little Red Deer River, Medicine River, Fallentimber creek Dogpound creek	Blindman River	Rosebud River, Three Hills creek, Kneehills creek, Ghostpine creek	Berry Creek, Blood Indian creek, Alkali creek
Major lakes and reservoirs	Burnstick Lake	Gleniffer Reservoir	Gull Lake Sylvan Lake	Buffalo Lake Pine Lake Chain Lakes Sullivan Lake	
Primary land uses	Forestry, Recreation	Agriculture, Oil and gas, Recreation	Urban development, Agriculture, Petrochemical industry	Agriculture	Oil and gas, Pasture/ native prairies, some irrigated agriculture
Red Deer River mainstem reach (#)	1,2	1,2,3	3,4	4,5,6	6

Appendix B

State of water quality

Water quality in the mainstem of the Red Deer River

The Alberta River Water Quality Index (RWQI) is a useful tool to summarize water quality conditions in a specific location. The RWQI provides ratings for water quality based on a wide range of water quality variables, including metals, nutrients, bacteria, and pesticides. The RWQI mathematically combines all of these variables into one easily understood value between 0 (poor water quality) and 100 (excellent water quality). These values are then ranked into five categories of water quality: poor, marginal, fair, good, excellent.

According to the RWQI, water quality conditions in the Red Deer River mainstem generally deteriorate from upstream (west) to downstream (east). Although some of these changes are natural, some are the result of human activities in the basin[11]. The RWQI Index ratings for 1996-2004 indicate that, in general, water quality conditions in the Red Deer River mainstem deteriorate from upstream (west) to downstream (east)[6]. It is important to remember that RWQI values are influenced by a number of natural factors (e.g., volume of river flow, local geology) and human factors (e.g., development along river, non-point sources of runoff).

Water Quality in the six reaches of the Red Deer River

Reach 1.Headwaters to Sundre

There is limited historical data on water quality in this reach, although regular water quality sampling at Sundre began recently. Existing data suggests that water quality is high, although bacterial counts and total phosphorus levels can be high during runoff periods. Oil pipeline spills (2008 and 2012) have also spurred concerns about hydrocarbon contamination in this reach and in downstream reaches.

Reach 2.Sundre to Gleniffer Reservoir and Reach 3.Gleniffer Reservoir to Highway 2

Water quality conditions in Reaches 2 and 3 are typically “good” to “excellent”. There are occasional guideline exceedances for phosphorus (particularly in the spring), bacteria, and heavy metals (e.g., copper, lead). Significant deteriorating trends for dissolved oxygen and bacterial indicators have been detected in these reaches[11], and pesticides have been detected. Total phosphorus has increased over time, likely due to agriculture, wastewater inputs, and urban stormwater.

Reach 4.Highway 2 to Nevis

Water quality conditions in Reach 4 are generally "good". However, while RWQI sub-indices for bacteria and metals typically range from "good" to "excellent", the nutrient and pesticide sub-indices range from "fair" to "good" with some guideline exceedances for nutrients. Significant deteriorating trends for *E.coli*, Total Nitrogen, and ammonia-N for the period 1987-2010 have been detected in this reach[11], prior to major upgrades at the Red Deer Wastewater Treatment Plan. Exceedances of guidelines for Al, Cu, Fe, Hg, and Zn have occurred and hydrocarbons have been detected.

Reach 5.Nevis to Morrin

Water quality conditions are generally considered "good" to fair". Sub-index values for nutrients range from "poor" to "good" and the pesticides sub-index ranges from "fair" to "good". Significant decreases in TP and TDP were reported at Morrin although reasons for improvements have yet to be investigated. Some exceedances of guidelines have been reported for Al, Cu, Fe, and Hg at Nevis and for Al, Fe, Mn, Cr, and Ni at Morrin[5,11].

Reach 6.Morrin to Bindloss

a. Morrin to Jenner (includes Drumheller): Water quality conditions in the uppermost section of this reach are considered "good". A long-term river monitoring station was recently installed at Jenner. Available data shows that total suspended solids (TSS), total dissolved solids (TDS), total nitrogen (TN), and total phosphorus (TP), and several metal concentrations begin to increase in this reach. This reach traverses the highly erodible Badlands, which may contribute suspended solids and associated contaminants to the river. Irrigation return flows from the Western and Eastern Irrigation Districts also enter this reach of the river.

b. Jenner to Bindloss: Water quality conditions are mostly "fair", although compliance with guidelines decreases for all sub-indices. The nutrient sub-index is considered "marginal", and concentrations of TN and TP are higher at Bindloss compared to upstream. The trophic status of the river changes from mesotrophic to eutrophic. While DO levels are relatively high, low winter levels have dropped below chronic and acute guidelines in the past. Exceedances in several metals have occurred (Fe, Mn, Al, Cd, Cr, Cu, Pb, Ag, and Zn). Higher suspended solid levels (TSS) occur in this reach. Significant deteriorating trends have been detected for TN, ammonia-N, TDS, and NO2+NO3-N [11].

*Source: O2 Planning + Design[6].

Appendix C

Water quality objectives

The Water Quality Objectives (WQOs) included below were developed by Anderson et al. in the report "Draft site-specific water quality objectives for the Red Deer River Basin with emphasis on the mainstem"[11]. WQOs were developed using a scientific approach guided by best practices set by the Government of Alberta[17].

In early 2012, the key points in Anderson et al.'s report[11] were presented to the public and stakeholders through a series of stakeholder workshops and an online response form. In Fall 2015, two additional workshops and an online survey were conducted to seek public and stakeholder input on the draft Integrated Watershed Management Plan, Phase One, Water Quality. This history of public and stakeholder engagement, coupled with scientific expertise provided by Anderson et al. and the RDRWA's Technical Advisory Committee, lend confidence to the process used to develop these WQOs.

Water Quality Objectives were developed for 11 water quality indicators: dissolved oxygen, total phosphorus, dissolved phosphorus, total nitrogen, ammonia, nitrite, (nitrite+nitrate)-nitrogen, total dissolved solids, total suspended solids, fecal coliform bacteria, and *E.coli*. These indicators were selected based on advice from the RDRWA's Technical Advisory Committee. While other indicators were considered, in many cases data and knowledge on these indicators was insufficient to draft objectives.

WQOs were developed for four of the six reaches of the Red Deer River (Reaches #3-6). Owing to data limitations, WQOs were not developed for Reaches 1 and 2 (the headwaters) or for tributaries. As a result, Recommendation #3 in this plan explicitly calls for the future development of WQOs at these locations:

3.1 Develop WQOs for the headwaters (lower portions of reaches 1 and 2) once sufficient data is available.

3.2 Develop WQOs for the mouths of major tributaries (i.e., tributaries designated as sub-watersheds in *Blueprint*) once sufficient data is available.

WQOs serve as "early warning signals", helping to illuminate if water quality conditions are within a desirable range. If a trend indicates that water quality is being degraded close to or beyond a WQO, then further investigation and evaluation will be required to determine an appropriate management response. No single actor or group is responsible for meeting a WQO; instead we must all play our part in ensuring that water quality conditions do not deviate significantly from historical values. By seeking to "maintain and improve water quality", we recognize that our river system, rich with aquatic biodiversity, is specially adapted to a specific range of water quality conditions. To protect river health and function, water quality conditions should remain within this range of historical natural variation.

The RDRWA envisions that these water quality objectives will be considered during the development of a regional plan for the Red Deer Region under the Government of Alberta's Land-use Framework[10], and specifically during the development of a Surface Water Quality Management Framework for the Red Deer Region. While the WQOs as presented are in alignment with the goal of "maintaining and improving surface water quality in the Red Deer River watershed", they have not been subject to analyses of socio-economic feasibility.

Additional Considerations

In 1969, the governments of Alberta, Saskatchewan, Manitoba and Canada signed the Master Agreement on Apportionment (MAA), which dealt primarily with the sharing of water in eastward flowing streams that cross interprovincial boundaries. Despite an initial focus on water quantity, the MAA was amended in 1992 to include the Agreement on Water Quality (Schedule E). Schedule E provides a framework for protecting transboundary water quality, and includes water quality objectives for the Red Deer River flowing eastward into Saskatchewan. The Prairie Provinces Water Board (PPWB) is the organization tasked with supporting Schedule E and is thus involved in the protection of water quality at the Alberta-Saskatchewan border.

In 2015, the interprovincial water quality objectives in Schedule E were updated for the Bindloss monitoring location in Reach 6. Recognizing the desirability of having consistent WQOs for the Bindloss site, the RDRWA conducted a comparison of the WQOs herein and those developed by the PPWB. Key findings include:

- The WQOs developed by the PPWB at Bindloss are more stringent for three parameters (*E.coli*, TSS, Ammonia-N).
- The WQOs developed by the PPWB at Bindloss are less stringent for five parameters (TDP, TP, TN, TDS, fecal coliform bacteria).
- The PPWB did not develop WQOs for three parameters that are included in this plan (DO, Nitrite-N, Nitrite-Nitrate-N).

While the overall methodology used to develop the WQOs in both plans was quite similar, potential reasons for the discrepancies include: 1) differences in the historical data used (i.e., time period), and 2) the decision to use either a background approach or a guideline-based approach to establish a WQO.

Recognizing that the WQOs included in this plan are designed to inform the development of a Surface Water Quality Management Framework for the Red Deer River Watershed under the Land-use Framework, the RDRWA recommends that any process to develop this framework review the two sets of objectives in favour of adopting a consistent set for Reach 6 (Bindloss).

Water Quality Objectives for the Red Deer River (Reaches 3 to 6).

E.coli	WQO count/100mL			
	Ice Cover		Open Water	
	Median	90%ile	Median	90%ile
Reach 3 – Hwy 2	**2**	**9**	**13**	**62**
Reach 4 - Nevis	**11**	**67**	**9**	**78**
Reach 5 – Morrin	**3**	**31**	**6**	**80**
Reach 6 – Bindloss	**10**	**12**	**21**	**400**

Total Suspended Solids	WQO mg/L			
	Ice Cover		Open Water	
	Median	90%ile	Median	90%ile
Reach 3 – Hwy 2	**4**	**5**	**4**	**51**
Reach 4 - Nevis	**4**	**4**	**4**	**120**
Reach 5 – Morrin	**L4 a**	**14**	**14**	**322**
Reach 6 – Bindloss	**8**	**68**	**101**	**820**

Total Dissolved Phosphorus	WQO mg/L			
	Ice Cover		Open Water	
	Median	90%ile	Median	90%ile
Reach 3 – Hwy 2	**0.003**	**0.0123**	**0.006**	**0.027**
Reach 4 - Nevis	**0.011**	**0.037**	**0.008**	**0.041**
Reach 5 – Morrin	**0.005**	**0.016**	**0.009**	**0.028**
Reach 6 – Bindloss	**0.005**	**0.02**	**0.01**	**0.034**

"L" indicates value less than the method detection limit.

Source: Anderson et al., 2012.

Fecal Coliform Bacteria	WQO count/100mL			
	Ice Cover		Open Water	
	Median	90%ile	Median	90%ile
Reach 3 – Hwy 2	**5**	**16**	**18**	**100**
Reach 4 - Nevis	**18**	**90**	**13**	**100**
Reach 5 – Morrin	**7**	**59**	**12**	**100**
Reach 6 – Bindloss	**5**	**20**	**34**	**100**

Total Dissolved Solids	WQO mg/L			
	Ice Cover		Open Water	
	Median	90%ile	Median	90%ile
Reach 3 – Hwy 2	**251**	**262**	**210**	**231**
Reach 4 - Nevis	**280**	**311**	**208**	**247**
Reach 5 – Morrin	**274**	**292**	**202**	**234**
Reach 6 – Bindloss	**315**	**369**	**238**	**310**

Total Phosphorus	WQO mg/L			
	Ice Cover		Open Water	
	Median	90%ile	Median	90%ile
Reach 3 – Hwy 2	**0.005**	**0.016**	**0.018**	**0.126**
Reach 4 - Nevis	**0.019**	**0.047**	**0.017**	**0,17**
Reach 5 – Morrin	**0.007**	**0.033**	**0.027**	**0.182**
Reach 6 – Bindloss	**0.017**	**0.062**	**0.095**	**0.524**

Total Nitrogen	WQO mg/L			
	Ice Cover		Open Water	
	Median	90%ile	Median	90%ile
Reach 3 – Hwy 2	**0.248**	**0.637**	**0.341**	**0.848**
Reach 4 - Nevis	**0.626**	**0.974**	**0.381**	**1.066**
Reach 5 – Morrin	**0.69**	**0.979**	**0.458**	**1.279**
Reach 6 – Bindloss	**0.490**	**0.755**	**0.530**	**1.476**

Nitrite + Nitrate-N	WQO mg/L			
	Ice Cover		Open Water	
	Median	90%ile	Median	90%ile
Reach 3 – Hwy 2	**0.085**	**0.186**	**0.008**	**0.097**
Reach 4 - Nevis	**0.366**	**0.474**	**0.003**	**0.157**
Reach 5 – Morrin	**0.340**	**0.477**	**L0.003 a**	**0.194**
Reach 6 – Bindloss	**0.277**	**0.463**	**0.005**	**0.243**

Ammonia-N	WQO mg/L			
	Ice Cover		Open Water	
	Median	90%ile	Median	90%ile
Reach 3 – Hwy 2	**0.02**	**0.06**	**0.01**	**0.01**
Reach 4 - Nevis	**0.05**	**0.22**	**0.02**	**0.09**
Reach 5 – Morrin	**0.05**	**0.22**	**0.01**	**0.09**
Reach 6 – Bindloss	**0.02**	**0.08**	**0.01**	**0.04**

Nitrite-N	WQO mg/L			
	Ice Cover		Open Water	
	Median	90%ile	Median	90%ile
Reach 3 – Hwy 2	**L0.003 a**	**0.005**	**L0.003 a**	**0.004**
Reach 4 - Nevis	**0.005**	**0.012**	**L0.003 a**	**0.007**
Reach 5 – Morrin	**0.004**	**0.011**	**L0.003 a**	**0.005**
Reach 6 – Bindloss	**No Data**		**No Data**	

Dissolved Oxygen	WQO mg/L			
	Ice Cover		Open Water	
	Median	90%ile	Median	90%ile
Reach 3 – Hwy 2	**12.0**	**10.9**	**10.5**	**9.5**
Reach 4 - Nevis	**10.2**	**8.3**	**10.4**	**8.6**
Reach 5 – Morrin	**9.9**	**6.5**	**10**	**8.3**
Reach 6 – Bindloss	**9.9**	**6.5**	**9**	**7.4**

Acknowledging our funders

Over the years, our integrated watershed management planning has been supported by various community members and funders. We wish to thank all those who supported the early stages of this work, including the development of the four background technical reports.

The RDRWA has also received funding specifically for the development of Phase One of *Blueprint: An Integrated Watershed Management Plan for the Red Deer River Watershed (Water Quality)*. We gratefully acknowledge funding from the following partners:

Alberta Government

NOVA Chemicals

PLAINS MIDSTREAM CANADA

ConocoPhillips Canada

ROCKY VIEW COUNTY
Cultivating Communities

Cover image taken near Drumheller, Alberta. Photo courtesy of RDRWA.

All images courtesy of RDRWA and partners.

Graphic design, illustration, icons, and select maps (pages 10, 13, 19, and 53) by kilometre design.

Map data and maps (page 38) courtesy of O2 Planning + Design Inc.

How to get involved

Want to plug into shared efforts to protect water quality and watershed health? Whether you have an issue to discuss, a project in mind, or are filled with questions, there are many ways to get involved. Check out the opportunities below and be sure to stay connected as we work to bring *Blueprint* to life.

1. **Become a member of the Red Deer River Watershed Alliance.**
    - Membership is free and is a simple way to stay up to date through our monthly e-newsletter.
    - Sign up at www.rdrwa.ca.
2. **Learn more about watersheds and how to take action.**
    - Take a look at materials on our website (www.rdrwa.ca) to get your feet wet.
3. **Use your voice to advance ongoing conversations.**
    - Participate in RDRWA events with partners across the watershed (see www.rdrwa.ca for more information).
4. **Contact us to get involved in education and stewardship programs.**
    - From school presentations to citizen science programs – the RDRWA and our partners offer a range of programs to schools, stewardship groups, and any group looking to learn more.
    - Email outreach@rdrwa.ca.
5. **Follow us on social media or contact our office directly.**

    Facebook: Red Deer River Watershed Alliance

    Twitter: @RDRWA

    Phone: 403.340.7379

    Email: info@rdrwa.ca
6. **Consider taking action to advance *Blueprint*.**
    - The recommendations and actions in this plan require support and leadership from individuals, groups, and governments. Please contact the RDRWA if you see a good fit for you or your organization.