This Report was posted prior to the completion of the Kettle River Watershed Management Plan.
Good luck finding the full KRWMP Report on the RDKB website.
Our own Critique of the Kettle River Watershed Management Plan can be found at:
https://www.boundaryalliance.org/krwmp_a_critique.pdf
or article link on our webpage www.boundaryalliance.org

Kettle River watershed analysis

Midway, British Columbia to stream headwaters

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Introduction

The Kettle River flows from its headwaters in the Christian Valley, located in the Southern Interior of British Columbia, Canada to the Columbia River in Washington State, USA. We have chosen the drainage upstream of Midway, BC as our sample segment. This is an ideal location for analysis for several reasons: First, the headwaters are located in this area, as are two notable tributaries, the West Kettle River and Boundary Creek; second, the Kettle is a trans-boundary river shared by both Canadian and American riparians and Midway, British Columbia is where the river first crosses the border, making it an important point internationally; third, there are a variety of land use and water quality issues; and finally, Environment Canada has available data sets for the Kettle River at Midway from 1972 to present (BWP Consulting, 2003).

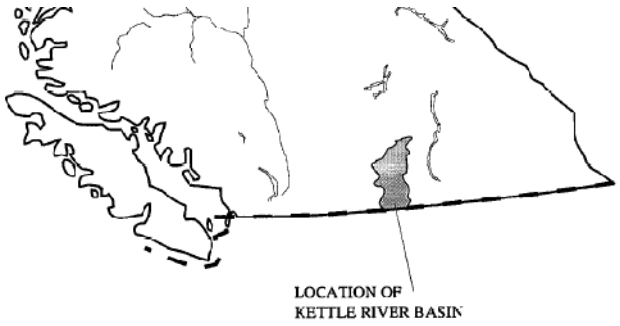
Before crossing into the United States, the Kettle River's resources affect both local riparians as well as visitors. The primary value of the river is irrigation for agricultural purposes. Although, water quality in the river is reported to be excellent, there are concerns of high fluoride levels and increasing levels of fecal coli form (BC Ministry of Environment, 1996). During the summer months the Kettle is used widely by locals and visitors alike for recreational purposes. A number of provincial parks in the West Boundary region offer unique rest stops for kayakers, bike riders, campers and fishermen who are following the Kettle Valley Railway or touring the river.

Watershed description

Location

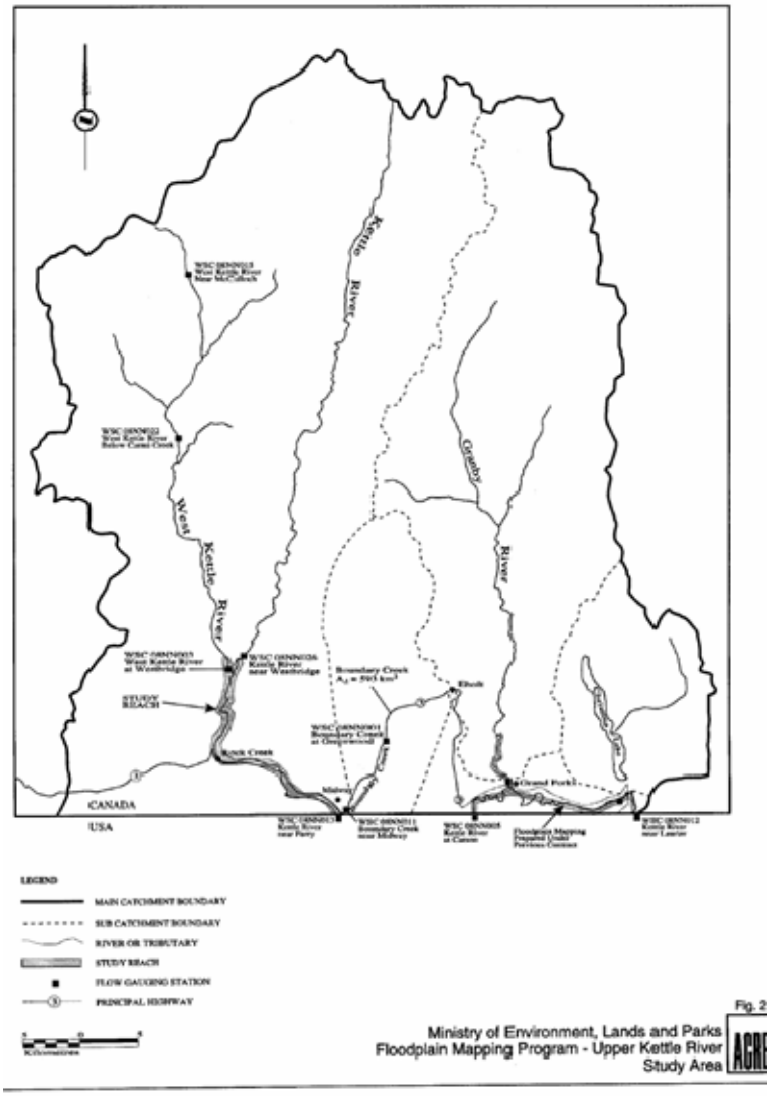
With its headwaters being Keefer Lake in the Monashee Mountains, the Kettle River drains an area of 9800 km^2 in the Okanagan region of Southern British Columbia and Northern Washington State (BC MOE, 2007[a]). It flows south until Rock Creek, BC and then turns East-Southeast and begins a series of large meanders. It crosses the international border at Midway, leaving Canada only to re-enter again near Grand Forks, BC and flow for another 45 kilometres before leaving Canada for a second time and joining the Columbia River in Washington. Of its 9800 km^2 drainage basin, 8300 km^2 are in Canada (BC MOE, 2007[a]). This assessment focuses on the 5157 km^2 (roughly 190 mainstream channel kilometres) upstream of Midway, BC. This section of the Kettle drains the Okanagan and West Kootenay Boundary regions of BC as can be seen in figure 2-2 below (BC MOE, 2007[a]).

Figure 2-1: Map showing the location of the Kettle River Basin



Source: BC MOE, 2007[d].

Figure 2-2: Map showing the Kettle River drainage area north of the 60th parallel.



Source: BC MOE, 2007[d] .

Physiography

The Kettle drainage comprises three distinct physiographic units; the Monashee Mountains, the Interior Plateau, and deeply incised river valleys (BC MOE, 2007[e]). The Midway Range of the Monashees occupies the east part of the drainage, and is characterized by moderate relief, steep slopes and extensive rock outcrops (BC MOE 2007[e]). The Interior Plateau occupies most of the

drainage basin. The relief and altitude of this part of the plateau is higher than most of the rest of the plateau in the province, with summits rising to 7 500 feet and slopes exceeding 50 degrees (BC MOE, 2007[e]). This could be considered a highland transition zone to the mountains to the East (BC MOE, 2007[e]). The Western area of the drainage is occupied by the Beaverdell mountain range. The rivers in this area are generally deeply incised and the valley bottoms they occupy are often several thousand feet below the average elevation of the region's land (BC MOE, 2007[e]).

The territory the Kettle drains covers a transition zone of the Okanagan Highlands, between the Okanagan Valley and the Monashee Mountains (BC MOE, 2007[a]). The drainage is dendritic, although the Kettle and West Kettle (the Kettle's largest tributary) flow down roughly parallel glacial valleys before meeting at Westbridge.

It is a free-flowing river. Other than Keefer Lake, there are no significant lake-fed tributaries.

Having a dendritic drainage pattern, slope aspect varies widely with no significant percentage of slopes facing in one direction.

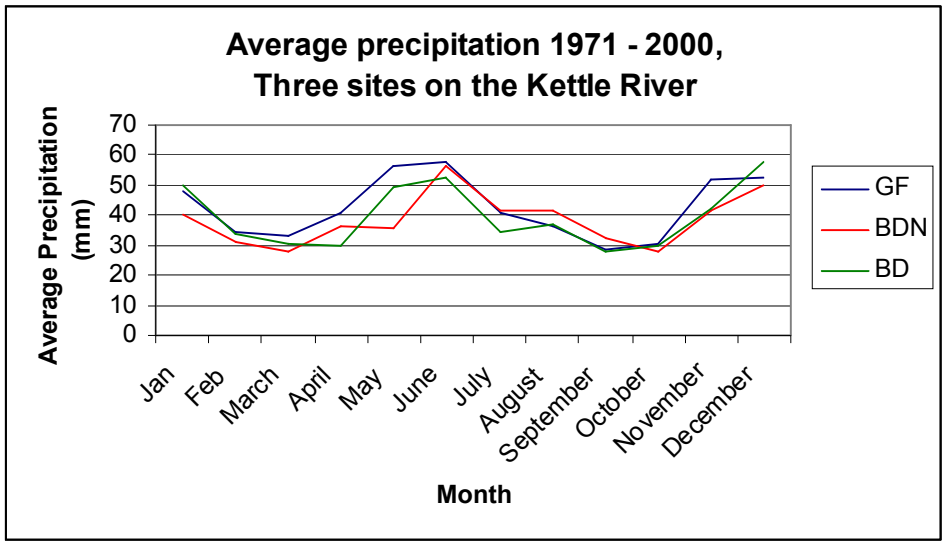
Climate

The lower elevations and valley bottoms in the Kettle River drainage comprise some of Canada's hottest and driest areas (with the exception of the arctic) (BC MOE, 2007[c]). However, the bulk of the drainage basin lies at

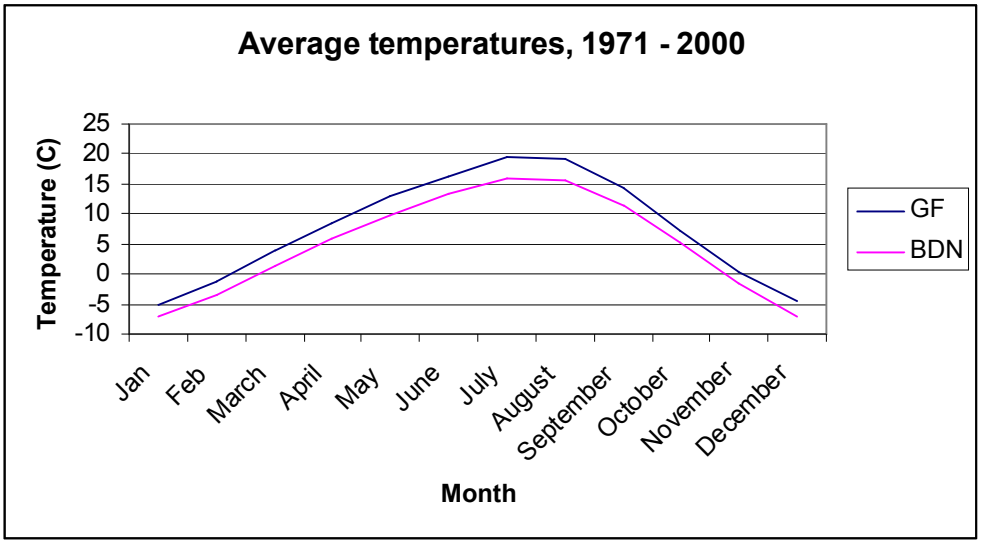
altitudes well above the valley bottom and gets more precipitation. The only weather stations within the drainage area are at near-river level elevations at Beaverdell and Midway, and therefore do not necessarily accurately represent the climate over the drainage system as a whole.

Significant rainstorms generally occur via two mechanisms in the drainage area, either through orographic precipitation by systems coming from the coast which are subjected to the high relief of ranges or by frontal low pressure systems coming from the Northwest, West or Southwest in early summer (BC MOE, 2007[d]). Convective events are localized and never enough to trigger mainstream flooding (BC MOE, 2007[d]). To illustrate climatic variations throughout the year, average monthly temperature and precipitation values have been collected and displayed in figures 2-1, and 2-2.

- Figure 2-1: Monthly average precipitation 1971 - 2001:
(GF) Grand Forks; Climate ID 1133270; Elevation: 531.90 meters A.M.S.L.; By authors
(BDN) Beaverdell North; Climate ID 1130771; Elevation 838.20 meters A.M.S.L.; By authors
(BD) Beaverdell; Climate ID 1130770; Elevation 780.00 meters A.M.S.L.; By authors



Source: Environment Canada Weather Office, 2006
Figure 2-2: Monthly average temperatures (C°) 1971 – 2000, Data for Beaverdell station 1330770 was not available.



Source: Environment Canada Weather Office, 2006

Hydrologic characteristics

The Kettle River at Ferry, Washington has an average annual discharge of 41.3 m^3/s. With an average annual precipitation depth of 482.17 mm over the entire watershed, this works out to a runoff coefficient of 47% which is fairly typical, though slightly low for a heavily forested drainage basin (authors, BC MOE, 2007[d]) (Note- here we use data from Ferry, as discharge data is unavailable for the Kettle at Midway. Ferry is only a few kilometres downstream from Midway, and between Midway and Ferry, only one significant tributary, Boundary Creek, enters the Kettle. The Boundary Creek drainage is about ten percent the size of the Kettle drainage above Midway, and is very similar to the rest of the drainage physiographically. Therefore, the numbers quoted from Ferry are generally about ten percent higher than Midway).

The Kettle is a snowmelt dominated river; 78% of total yearly flow occurs in the three months of April, May and June (BC MOE, 2007[d]). The discharge of the Kettle during a 50 year flood event at Ferry is about 510 m^3/s; a 100 year flood event is about 600 m^3/s. While snowmelt alone can create high stream flow rates that exceed bank full discharge, severe floods usually require the addition of significant rainfall (BC MOE, 2007[d]).

Ecology

Indigenous tree species include Sub-alpine Fir, Coastal Western Hemlock, Ponderosa Pine, Douglas-fir, and Engelmann Spruce. The lower elevations of the drainage and valley bottoms consist of sparser vegetation and some grassland, but the drainage as a whole is heavily forested (BC MOE, 2007[d]). The river is home to a rare species of fish such as the Umatilla dace, and also supports populations of rainbow trout, bull trout, whitefish, suckers, northern pike minnow and brown trout, among others. Deer are the most prevalent ungulate in the drainage area, and are present along with moose, wolf, cougar, bobcat, and black bear (BC MOE, 2007[a]).

Land Use

Forestry is the most significant land use within the Kettle River basin (BC MOE, 2007[d]). The other most significant land uses within the Kettle River Valley are agriculture, rural homesteading, ranching, transportation, mining and quarrying. The river itself supports numerous water licenses for domestic use,

irrigation, and power generation (BC MOE, 2007[c]). There are highways closely paralleling most of the drainage.

Issues concerning quality

Political

Issues and concerns about forest-water interactions have developed directly from observations or perceptions of what constitutes a desirable or adverse situation. Many of these issues and concerns have been developed because of conflicting management responsibilities allocated between provincial and federal governments (Hetherington, 1987). The Kettle River watershed possesses not only provincial conflicts but also international dilemmas because of its location near the Canadian/U.S. border. Approximately 75 % of the Kettle River watershed lies within British Columbia with the other 25 % in Washington State (Moore & Dames, 1995). Since the Kettle River originates in the Okanagan Highlands and Monashee Mountains of southern British Columbia, any environmental impacts around and within the Kettle River watershed directly affect the water quality across the border (Moore & Dames, 1995). The Ministry of Environment (MOE), in an effort to minimize water quality conflicts between Canada and the United States, has placed monitoring stations where the Kettle River first crosses the Canada/U.S.A border located at the town of Midway, the Boundary Creek Station, and another one just down stream from Midway at the

point where the river crosses back into Canada, called the Carson Station. By placing monitoring stations in these locations both governments can measure the impacts to the river from each side of the border.

Quality Issues

The USA has been monitoring the water quality of the Kettle River at the Ferry Station since 1972 through 2002 (Environment Canada, 2003). This data, and that from the other water quality monitoring stations at Carson, Gilpin and Boundary Creek show that the water quality of the Kettle River has generally been in compliance with B.C. Ministry of Environment guidelines. Substances found in the Kettle River are outlined in figure 3-1.

Figure 3-1: Naturally occurring substances found in the Kettle River

Substances found in Kettle River	
Arsenic	Rubidium
Barium	Silica
Boron	Silicon
Bromide	Silver
Dissolved organic carbon	Strontium
Fecal coliforms	Sulphate
Cyanide	Thallium
Gallium	Uranium
Lanthanum	Vanadium
Lithium	
Magnesium	
Molybdenum	
Nickel	
Nitrate/Nitrite	
Nitrogen	
Phosphorus	
Potassium	

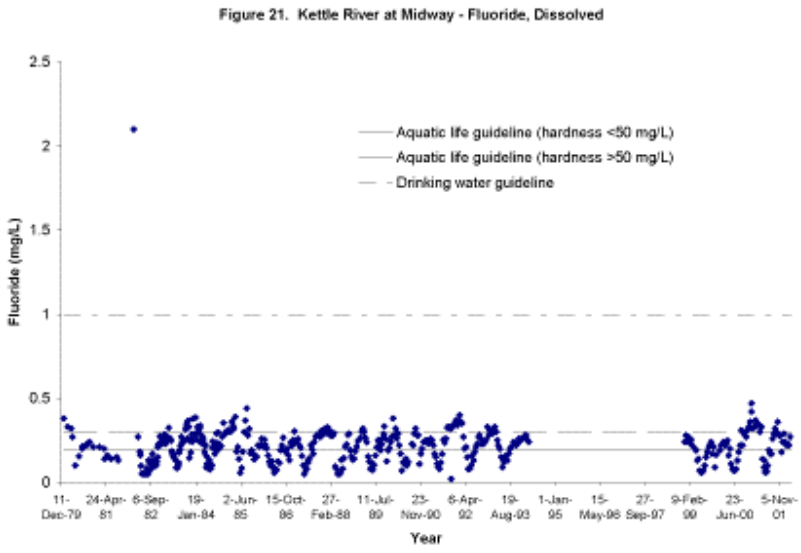
Other major ions, trace elements, nutrients, colour, dissolved and suspended solids, and temperatures are monitored once every two weeks since 1980 just upstream from Boundary Creek and monitored continuously just downstream from Boundary Creek at Midway (Environment Canada, 2006). According to Environment Canada, the greatest concern for water quality in the Kettle River watershed is negative effects on sensitive uses such as: drinking water, aquatic life and wild life, recreation, irrigation, and livestock watering. Agriculture, ranching, and rural homesteading account for most of the out-of-stream use of water. Many stretches of the Kettle River are adjacent to roads, making the river accessible for picnicking and other shoreline activities. This has made the Kettle River watershed popular recreation destinations where water supply must be high enough quality for drinking water use and to support fish habitat and wildlife. Moore & Dames state that "At the same time, water quality may depend on preserving large quantities of clean water to reduce the adverse effects of existing pollutants and maintain proper water temperature for fish" (1995).

Within the West Boundary region there are at least 2 major point source pollution discharge locations on the Kettle River including effluent from the City of Grand Forks and the Village of Midway sewage treatment facility. The effluent from both sources has fallen under the required guidelines of Environment Canada and has not significantly impacted the water quality of the Kettle River (Dames & Moore, 1995). In 2003 the west boundary watershed up stream from Midway was reported to be relatively pristine, with no ecologically damaging

anthropogenic impacts other than forestry (Environment Canada, 2003). Other non point source pollutants that could potentially affect the water quality of the Kettle River include agriculture, livestock grazing, septic systems, storm water and road surface run off, landfills and mining.

One of the major concerns for water quality in the Kettle River is the fluoride levels found at certain times of the year that exceed the guideline to protect aquatic life (Environment Canada, 2006). However, according to Water Quality Assessments of the Kettle River by MOE, there are no known effects on the local fish population and it is suspected that the fish population may have adapted to the higher levels of fluoride (Environment Canada, 2003). These levels of fluoride are naturally occurring and there are no known anthropogenic sources of fluoride in the watershed. Fluoride levels at Midway can be observed in figure 3-2.

Figure 3-2:
Water Quality Assessment of the Kettle River at Midway, 1972-2000



Source: Environment Canada, 2003

Land use Conflicts

Land use conflicts on the Kettle River have caused concerns about water rights on both sides of the international border. Examples include a proposed hydroelectric dam on the Kettle River in British Columbia called the Cascade Falls dam, and the development of the Battle Mountain Crown Jewel gold mine in Washington State.

The Cascade Falls dam would include an inflatable rubber dam about 1.5 miles north of the Laurier, Washington border crossing and would take all of the unclaimed upstream British Columbia water rights in the river except spring runoff (Craig, 2003). Opposition to the project include First Nations with cultural ties to the Kettle River and Cascade Falls who fear that the project would degrade the river and its fishery. U.S concerns include fears that the dam would limit water availability, harm fish stocks by raising downstream water temperatures and change the downstream movement of sand and gravel (Craig, 2003). Economic concerns in tourism-dependant communities such as Christina Lake create further opposition to the idea of diverting much of the water from Cascade falls to a powerhouse below the falls. The Cascade falls are a tourist attraction that entices visitors to the local area.

Issues concerning quantity

Water Quantity

As Bosch & Hewlett (1987) state “areas with over 450 mm of annual precipitation, clearing at least 20% of a watershed will result in an increase in water yield that is proportional to the annual precipitation but which is highly variable”. By taking the average of total annual precipitation of three stations surrounding the Kettle River watershed we were able to predict the total annual precipitation for the west boundary watershed see chart 2.

Figure 4-1: Annual precipitation at select stations in the Kettle River Watershed

Location	**Total annual precipitation mm**
Grand Forks	509.8
Beaverdell north	461.9
Beaverdell	474.8

Kettle River watershed estimated total annual precipitation: **482.17 mm**

Source: Environment Canada, 2006

Environment Canada Climate Station MIDWAY (#1135126) indicates that 3.69% of the total land use is either recently logged or selectively logged. Therefore we can conclude that logging in this area has not significantly impacted total water yield within the watershed.

Timing and Flow

Even though the permitted annual withdraws are small compared to the average annual flow in the Kettle River, withdrawals during low flow periods in

the river can be critical. Low flow records from 1930 to 1993 and recent records of increased water use from 1966-1993 were compared with Kettle River stream flows. The average low flow for all time periods were lower in the recent record than in the full period of record suggesting increased recent (1966-1993) water usage is impacting the average low flow (Moore & Dames, 1995). During the summer months when stream flow in the Kettle River is extremely low, water demand and usage is highest. This will create more problems in the future as water demand increase in the area.

Recommendations

Although the water quality of the Kettle River meets human and wildlife use guidelines, several monitoring measures are recommended to determine if any long-term trends can be observed. The Midway site serves as an ideal location for continued monitoring due to its location relative to the American border and its comprehensive data history. The collection of water quality data at this site is important for regional and international concerns related to resource development within the watershed. Continued monitoring of the Kettle at Carson, B.C., where the river re-enters Canada, is also recommended. This is critical for not only sustainable development of the resource, but for Canada-U.S. relations, as there are dependent riparians on both sides of the border.

Regarding physical in-channel and riparian impacts and issues, we recommend the use of softer environmental management techniques, such as bioengineering. The West Kettle River Watershed Restoration Demonstration Site serves as an excellent example for future projects. After suffering bank damage during a fish habitat restoration project due to the use of heavy machinery, the location has since become known for its lower-impact, hands-on remediation techniques (Little, 2001).

We suggest that the following variables affecting the water flow and quality of the river be considered for continued monitoring:

- Dissolved minerals: To determine the influence on aquatic species
    - Fish stock assessment, in addition to water quality/quantity assessment, is recommended to determine any abnormalities within the species of the region
- Nitrate and nitrite: to determine if there are long term trends associated with changes in agricultural practices and the affect on water quality
- Fecal coliforms: To determine trends associated with wildlife migration and changes in range management practices
- Low flows: To determine if the amendment of future land use plans are needed should allocation of the resource exceed availability during low flow periods
- Peak flows: To determine the effect of peak flows on water quality, in addition to any trends associated with climate change, that may be applicable to flood prevention measures and other natural disasters

- Turbidity: To determine the relationship between peak and low flows, variations in data over time, and the effect on aquatic ecosystems

Monitoring

In order to guarantee the accurate and thorough identification of the nature and cause of change in the Kettle, several monitoring measures are suggested. Post-decision-monitoring can be generalized into three types: Compliance monitoring, used to determine compliance with regulations; progress monitoring, which helps to confirm project advancement; and monitoring for understanding, which is designed to provide insight into understanding multi-system interactions – environmental, economic, and social (Noble, 2006).
A break down of sub-monitoring practices of the three types previously mentioned can be seen below.

- Suggested compliance monitoring strategies:
    - Inspection monitoring: The purpose is to ensure compliance with operating procedures and data accuracy.
    - Monitoring of agreements: Important for tracking changes in trends to assign costs related to the study.

- Suggested progress monitoring strategies:
    - Monitoring for management: The purpose is to evaluate alterations to the environmental, economic, and social variables of the study.

Important to implementing solutions to environmental concerns that arise from the project.

- Cumulative effects monitoring: The purpose is to measure the accumulated influences of regional anthropocentric development on physical and biological river processes.

- Suggested monitoring for understanding strategies:
    - Experimental monitoring: The purpose is to develop knowledge about local environmental systems through hypotheses specific testing.
    - Monitoring for knowledge: The purpose is to collect data for future management purposes (Nobles, 2006)

Although there are significant supplies of fresh water in the Pacific Northwest, and the Kettle River boasts excellent water quality, cross-border conflicts between local and federal governments may arise, especially during annual low flow periods. We therefore recommend an independent environmental monitoring agency (IEMA) be hired due to the nature and scope of the project. This will ensure the accurate and bipartisan collection and presentation of data. This is critical for developing future policies concerning water rights, as well as water quality in the Kettle River.

Regular reports should be produced by the selected IEMA, local forest companies and Environment Canada. These reports should incorporate all

progress and compliance monitoring issues. As well, general public meetings concerning water issues throughout the river basin should be held a minimum of twice a year or more pending any increasing public concerns. These meetings should include river riparians, the IEMA, government officials and ministry representatives, forest companies, and the British Columbia Cattlemen's Association. With close observation and diligent testing, future sustainable fresh water resource development goals will be attainable.

Summary

This report analyzes both natural and anthropocentric variables that impact the Kettle River Watershed. The Kettle River flows from its headwaters in the Monashee Mountains, across international boundaries into Washington State, U.S.A., at the village of Midway, B.C., and then traverses back across into Canada at Carson, BC, before flowing south once more into the U.S., and into the Columbia River and ultimately the Pacific Ocean. No significant water rights issues have arisen, however, given the widely accepted theory of human enhanced climate change, the possibility of future conflicts are probable.

Although the drainage area of the Kettle spans international borders, we have focused our report on the area from where the border is first crossed at Midway, to the headwaters in the West Boundary region. This has served as an ideal site due to its relative location to the U.S. border, in addition to its pristine water quality given the variety of land uses in the watershed. Specific stake

holders within the drainage basin include individual riparians, forestry companies, Environment Canada, the B.C. Cattlemen's Association, and possibly an independent environmental monitoring agency. The successful resolution of future conflicts regarding the quantity and quality of the Kettle River on both sides of the border will depend on a collaboration of ideas, and cooperation of all stakeholders involved.

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