PPWB Water Quality Monitoring Review
Phase 3: Assiniboine, Battle, and Red Deer (at the Saskatchewan-Alberta) rivers

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1.0 INTRODUCTION

1.1 Background

The Prairie Provinces Water Board (PPWB) was formed in 1948 when the governments of Canada, Manitoba, Saskatchewan and Alberta signed the Prairie Provinces Water Board Agreement. In 1969 these same parties entered into the Master Agreement on Apportionment and in 1989, Schedule E of this Agreement defined the mandate of the PPWB Water Quality Program as being to *Afoster and facilitate interprovincial water quality management among the parties that encourages the protection and restoration of the aquatic environment@*. The primary objectives of the Water Quality Program (PPWB 1991) are to:

1. Promote a preventative and proactive approach to interprovincial water quality management.
2. Promote the protection and restoration of the aquatic environment.
3. Promote an ecosystem approach to the management of interprovincial waters.
4. Recognize the effect of quantity on the quality of water for the effective management of interprovincial waters.
5. Promote compatible water quality objectives for the effective management of interprovincial waters.

In order to satisfy these objectives the PPWB=s Committee on Water Quality (COWQ) established a Water Quality Monitoring Program on major interprovincial streams. The objectives of the Monitoring Program (PPWB 1991) form a subset of the larger water quality program. These objectives are to:

1. Describe the quality of the aquatic ecosystems at the interprovincial boundary and identify the presence, absence and abundance of toxic substances, and other physical, chemical and biological attributes of transboundary waters.
1. Provide evidence of changes in trends in the concentration of chemical and physical substances, and in the biological integrity of the aquatic ecosystem.
2. Assess the achievement of water quality objectives, other water quality indicators and other water quality goals.
3. Maintain a scientifically credible data and information base on the quality of transboundary waters.

Data collection was initiated in 1974 and, with the recent addition of the Cold River, the number of transboundary river reaches currently monitored has expanded to twelve (Figure 1). The COWQ annually reports to the PPWB on general water quality and excursions to specific objectives at each of the monitored reaches and, less frequently (approximately every five years), examines long-term trends in water quality variables (Dunn 1995a, b).

Figure 1. Location of PPWB Interprovincial Water Quality Monitoring Sites.

In light, of recent changes to the PPWB Water Quality Monitoring Program and because of changing funding pressures, the COWQ has chosen to undertake a comprehensive review of its current monitoring program. The purpose of this report is to provide background information and recommendations to facilitate the COWQ=s discussions. It is also hoped that this report will help to ensure that the PPWB continues to meet its mandate in the most cost effective manner possible and that the data collected provide ecologically relevant information allowing for a characterization and assessment of environmental trends and current condition within each of the PPWB=s twelve transboundary river reaches.

1.2 Objectives

This report builds on Cash (1998, 1999) which provided a general review of the PPWB Water Quality Monitoring Program and more specific recommendations regarding changes to the current monitoring programs along the Qu=Appelle and North Saskatchewan rivers (Cash 1998) and the Beaver, Red Deer (at the Alberta-Saskatchewan Boundary), South Saskatchewan, Churchill, Saskatchewan, and Carrot rivers (Cash 1999). The objective of this series of reports is to provide a starting point for discussions concerning a response to several important changes that have occurred since the establishment of the PPWB Water Quality Monitoring Program in the mid-1970s. First, recent and predicted changes in funding availability serve to emphasize the need to conduct environmental monitoring in the most cost effective manner possible and to ensure there is a high return of information for each dollar invested. Second, the field of environmental monitoring is a rapidly evolving one, and this review represents an opportunity to incorporate recent advances in the theory, practice and interpretation of aquatic monitoring into the PPWB Water Quality Program. Finally, and perhaps most importantly, the current PPWB database now spans a period of over two decades and provides an excellent foundation for the quantitative and statistically rigorous assessment of trends. This database further provides the context within which monitoring efforts can be reviewed and refocused so as to identify and concentrate on the most ecologically relevant components of the ecosystem. It can also be used to ensure that those components are monitored on the spatial and temporal scales most appropriate to satisfy the PPWB mandate.

The specific objective of this report is to expand on Cash (1998, 1999) and inputs received from COWQ members to expand the review to the final three PPWB monitoring sites which include the: (1) Assiniboine, (2) Battle, and (3) Red Deer (at the Saskatchewan-Alberta boundary) rivers.

The report will not attempt to summarize or re-analyze data presented in PPWB excursion or trend reports. Rather, it will provide a general ecological assessment of the current Monitoring Program and provide recommendations where appropriate. Specific examples will be used to better illustrate the arguments provided. Cash (1998, 1999) provides the basis for the approach taken in this review as well as a more detailed discussion of certain key issues, including: (i) the ecosystem approach to environmental monitoring and the need for the development of ecosystem-specific monitoring programs; (ii) an overview of issues relating to the current PPWB Monitoring Program; and (iii) an overview of issues relating to statistical techniques for trend analysis in the PPWB Monitoring Program.

2.0 GENERAL ISSUES

As discussed in the previous section, Cash (1998, 1999) provides the basic rational employed in this review and the reader is directed to that report for a fuller justification of the recommendations provided here. It is also important to note that many of the recommendations in this report will be similar to those previously provided previously. This is to be expected given the nature of the PPWB Monitoring Program and the general similarity of many of the monitoring reaches. Although some recommendations (e.g., incorporation of benthic invertebrate sampling) are common to most or all monitoring reaches, the final decision to accept or reject the recommendation should be based on the results of pilot studies in some subset of reaches and the feasibility of applying it in any given reach.

In the following sections a brief update will be provided on specific issues raised in Phase 1and 2 of this review and identified by the COWQ as being important to the overall Monitoring Program.

2.1 Nutrients

The appropriateness of current nutrient objectives has been identified as perhaps the most important issue facing the PPWB Monitoring Program. Current PPWB nutrient objectives, where they exist, are based largely on objectives and guidelines from other jurisdictions and may not be appropriate for prairie rivers that naturally experience high levels of phosphorous. The situation is further complicated by the fact that while the response (in terms of changes in primary productivity) to nutrient additions is fairly well understood in many lentic systems the same is not true in lotic systems. This is the case not only in Prairie Canada, but on a global basis as well.

The development of appropriate nutrient objectives for the PPWB Monitoring Program involves two distinct steps: (1) The empirical relationship between nutrient availability and primary production must be defined. In other words, the measurement endpoint (e.g., total phosphorous) should be predictive of the ecological consequence (e.g., algal production). (2) Decisions must be taken as to what constitutes Aacceptable@ levels of primary production within the monitoring reaches. This is partly an ecological issue but must also incorporate the public=s aesthetic sense of what levels of primary productivity are deemed acceptable.

To address the first step the COWQ approached Dr. Patricia Chambers of Environment Canada=s National Water Research Institute to review spatial and temporal patterns in nutrients and algal abundance in Alberta rivers (Carr and Chambers 1998). The study was constrained by the availability of both nutrient and primary productivity data collected at that same time and at several sites along a length of river. However, the available data suggests that total phosphorous levels below 0.012mg/L will limit periphyton growth to Amodest@ (< 50mg/m^2 chlorophyll *a*) levels and that levels >0.030mg/L were often associated with periphyton chlorophyll *a* concentrations > 150mg/m^2. The authours point out that this empirical relationship should be tested further, and refined before it is used to set objectives and that public consultation should be undertaken to determine what constitutes Aacceptable@ levels of periphyton.

Despite these caveats, and despite the observed spatial (basin to basin) and temporal (season to season) variability in the empirical relationship, this approach holds a great deal of promise in so far as it attempts to relate directly nutrient objectives to levels of primary production. The challenge is to better define the relationship between total phosphorous and primary production and to determine what constitutes an acceptable level of periphyton growth.

2.2 Rapid Bioassessment of Benthic Invertebrate Community Structure

In the first phase of this review it was recommended that the PPWB evaluate the benthic macroinvertebrate community present at the Qu=Appelle and North Saskatchewan river monitoring sites on annual basis using rapid bioassessment techniques. Worldwide, benthic invertebrates are the most widely studied and employed biological indicator of aquatic systems and the advantages of using benthic macroinvertebrates have been well documented (see summaries in Plafkin *et al*. 1989; Rosenberg and Resh 1993) and include the fact that: (i) they are a diverse and widely distributed group that can be found in virtually all aquatic ecosystems; (ii) because they are relatively sessile, they integrate, and are representative of, conditions present in the area in which they are sampled; (iii) they are sensitive to a wide variety of environmental stresses (both natural and anthropogenic) and show a wide variety of responses to such stress; (iv) with some notable exceptions (e.g., Chironomidae, Oligochaeta) the taxonomy of benthic macroinvertebrates is generally well understood.

Once incorporated into the PPWB Monitoring Program temporal trends in community structure should be analyzed and related to general measures of water quality. Rapid bioassessment techniques have the advantage of being relatively inexpensive and can provide information on community structure in a timely fashion; however, changes in community structure detected using these techniques would have to be verified and further explored using more traditional methods

The recommendation was accepted by the COWQ in the final report and a pilot study to assess the feasibility of the approach was conducted in the fall of 2000. Results of this study have not yet been finalized.

2.3 Water Quality Index

In Phase 1 and 2 of this review it was recommended that the PPWB adopt the water quality index currently being developed by the CCME. The index is based on a consideration of three factors:

4. **F_1**, the number of excursions to the objectives
5. **F_2**, the frequency of excursions to the objectives
6. **F_3**, the magnitude of the excursions.

that are combined to produce a single value (between 1 and 100) that describes water quality.

In January 1997 the Canadian Council of Ministers of the Environment (CCME) Water Quality Task Group, in cooperation with the CCME State of the Environment Task Group undertook to examine and, if necessary, modify the BC index with a view to creating a national water quality index that could be adopted by all provinces and territories. That work is currently underway and is making use of some PPWB data in testing modified versions of the index. A final version of this report will be available in the spring of 2001. A variation of the BC index has already been employed by the Province of Manitoba in its State of the Environment Report (Manitoba Environment 1997) and more recently Alberta (Wright *et al*. 1998) has modified the index for use in agricultural streams and is currently interested in formally testing its utility in assessing long-term trends in larger river systems (K. Saffran, pers. comm.).

Unlike some earlier indices, the basic BC formulation captures all key components of water quality, is easily calculated, and is sufficiently flexible that it can be applied in a variety of situations. The index can be very useful in tracking water quality changes at a given site over time. However, because both the variables and objectives that feed into the index will vary across sites, it is not an appropriate tool for comparing among sites, except in so far as comparing their ability to meet a defined use (e.g., recreation, irrigation, protection of aquatic life, etc.).

The water quality index is a simple and powerful way to draw general conclusions concerning water quality and could greatly enhance the PPWB=s ability to communicate its results to both managers and the general public. Use of this index in the Prairie provinces as well as other Canadian jurisdictions would also serve to standardize the way in which the results of water quality monitoring could be communicated.

It must be stressed however, that the index is a technique used to report on water quality analyses and does not replace the need to analyze individual variables and trends. Any use of the index should be accompanied by narrative descriptions explaining the underlying causes of the calculated index values. It should also be noted that because the index is based on only those variables for which objectives exist, its utility to the PPWB will be largely constrained by the availability and appropriateness of such objectives.

In 1999 the COWQ authorized an evaluation of the WQI for the PPWB monitoring sites. That evaluation is now complete and will be submitted to the Committee shortly. The report will recommend the adoption of the WQI as a reporting mechanism for the PPWB.

3.0 PROPOSED CHANGES TO THE CURRENT MONITORING PROGRAM FOR THE ASSINIBOINE RIVER AT THE SASKATCHEWAN-MANITOBA BOUNDARY

3.1 Overview

The PPWB monitoring station on the Assiniboine River samples the reach from the Whitesand River to the outlet of the Shellmouth Reservoir. The gross drainage area measured at this point in the River is approximately 13,000 km^2 while the effective drainage area is approximately 4,324 km^2. A number of water storage projects in the Saskatchewan portion of the basin have the potential to effect the hydrology and ecology of this system.

The Assiniboine River Basin has been subjected to considerable agricultural development and its impacts on the hydrology and ecology of the Basin is currently the subject of a multi-sectoral study (the Upper Assiniboine River Basin Study). In addition to agriculture, the area has limited use for recreation and industry (see Dunn 1995b for a more detailed description of the river basin).

An analysis of long-term trends in water quality in the Assiniboine River suggests that the majority of measured variables show few systematic trends over time. Parametric (linear regression) and non-parametric (Kendall Tau, Spearman Trend, Van Belle) tests revealed that concentrations of four water quality variables significantly increased over the period of measurement. These variables included: boron, dissolved sodium, dissolved chloride, and total alkalinity. (Dunn1995b). The same statistical trend analysis revealed that ten variables, NO3+NO2, total nitrogen, NFR, dissolved magnesium, a-BHC, total copper, total zinc, total coliforms, fecal coliforms, and daily discharge showed a significant negative trend in concentration over the same period.

Regardless of trend direction, rates of change were low and excursions to objectives rare. For these reasons, none of the detected trends were considered to be of management concern.

In addition, to the trends described above, dissolved oxygen, total phosphorous and dissolved manganese, have been consistently identified as deserving special attention in recent PPWB Excursion Reports. Although no trend is apparent, for any of these variables dissolved manganese and total phosphorous exceed PPWB objectives in the majority of samples. Fecal and total coliforms were issues of concern historically but excursions to these objectives have not been observed in recent years.

In summary, the Assiniboine River is currently (1997-2000) monitored on a monthly basis. Monitored variables include nitrogen, phosphorous, carbon, NFR, pH, temperature, conductivity, dissolved oxygen, major ions, boron, heavy metals, mercury, and aluminum and pesticide. Fish samples are collected every five years to measure concentrations of metals, phenolics, and Ocs/PCBs. The variables currently identified as being of potential concern in this reach include total phosphorous, dissolved manganese and dissolved oxygen.

3.2 Recommendations

The following recommendations are based on an examination of available data and a consideration of the issues discussed in earlier sections of this report and Cash (1998,1999). Any changes to the Monitoring Program should be carefully evaluated and, if necessary, adapted based on new information and internal Afeedback loops@

3.2.1 **It is recommended that the PPWB undertake a review of current objectives associated with water quality variables measured in the Assiniboine River and that, where objectives are needed, they be developed.** As discussed in Cash (1998,1999), the lack of objectives is a major impediment to the interpretation of the collected data and to the assessment of overall health or condition. Objectives also form the basis of any water quality index that might be applied to the PPWB data.

3.2.2 **It is recommended that the PPWB consider the need to control for other influences (e.g., discharge, hardness, sediment load, diurnal variability, etc.) when analyzing trends and establishing objectives.** Such a consideration may necessitate the control of certain covariates in trend analysis or the development of a number of condition-dependent objectives for some variables.

3.2.3 **It is recommended that (contingent upon the results of a pilot study) the PPWB evaluate the benthic macroinvertebrate community present at the Assiniboine River monitoring site on an annual basis using the rapid bioassessment techniques outlined in this report.** Worldwide, benthic invertebrates are the most widely studied and employed biological indicator of aquatic systems and should be incorporated into the PPWB Monitoring Program. Trends in community structure should be analyzed and related to general measures of water quality.

3.2.4 **It is recommended that the PPWB continue monitoring fish condition and tissue contaminant levels in the Red Deer River on a five year cycle**. Fish collected for contaminant analysis should also be assessed for general condition. Fish captured, but not collected for contaminant analysis, should also be assessed for general condition prior to release

3.2.5 **It is recommended that the PPWB examine the feasibility of measuring primary productivity (periphyton and/or epiphyton) measured at the Assiniboine River monitoring site.** Measures of primary productivity, though not feasible in all locations, would link directly measured nutrient levels and their immediate affect on biota. This data would also assist efforts to improve nutrient objectives and should be directly linked to the work being conducted by Dr. P. Chambers (NWRI) in Western Canada and the Great Lakes Basin.

3.2.6 **It is recommended that the PPWB explore the possibility of measuring sediment quality within the Assiniboine River monitoring site.** Sediments can serve as important sinks for a variety of contaminants. Sediments form an important compartment within the aquatic ecosystem and can have a strong influence on aquatic quality.

3.2.7 **It is recommended that the PPWB continue to periodically (every five years) analyze trends in water quality and biota measured at the Assiniboine River**

monitoring site. Trend analysis is essential to the Monitoring Program but given the data already collected, an analysis every five years should be sufficient to detect changes in trends and identify potential concerns. Where appropriate, advances in statistical trend analysis and related software should be incorporated in this exercise.

3.2.8 **It is recommended that the PPWB undertake a review of all nutrient objectives with a view to establishing objectives more appropriate for rivers in Prairie Canada.** The importance of nutrient levels in determining ecological function in these systems has long been recognized by the PPWB, as has the possible inappropriateness of current nutrient guidelines. These issues are the subject of ongoing study conducted by Dr. P. Chambers (DOE) and sponsored, in part, by the PPWB.

3.2.9 **It is recommended that the PPWB cease routine monitoring of dissolved oxygen at the Assiniboine River monitoring site.** Statistical analyses do not suggest a trend in dissolved oxygen concentrations at this site. However, excursions from the PPWB guideline (6.0 mg/L) are routinely observed. More importantly, dramatic diurnal variation in dissolved oxygen values are common in these systems and single monthly measures probably hold little value. If measures of dissolve oxygen are required during certain periods, they should be collected on a temporal scale (e.g., hourly, every ten minutes) adequate to characterize the variation.

3.2.10 **It is recommended that the PPWB cease monitoring mercury and chromium in the water column at the Assiniboine River site.** Mercury and chromium levels in the water column are difficult to measure and interpret. The PPWB now monitors these variables in a more appropriate medium (i.e., fish tissue).

3.2.11 **It is recommended that the PPWB cease monitoring dissolved boron at the Assiniboine River site.** Long-term trend analyses indicate a slight positive trend in boron concentration. However these concentrations have never approached the PPWB objective (2.0 mg/L) suggesting there is little value in continuing to monitor boron at this site.

3.2.12 **It is recommended that the PPWB cease monitoring total coliforms in favour of monitoring fecal coliforms and *Escherichia coli*.** Because total coliforms is a poor indicator of sewage contamination it has been replaced in many jurisdictions by fecal coliforms. *E. coli* possess the added advantage of being a superior indicator of gastrointestinal illness. A shift toward monitoring fecal coliforms and *E. coli* would also make PPWB data more comparable to that collected downstream in Manitoba.

3.2.13 **It is recommended that the PPWB adopt the water quality index currently being developed by the CCME and employed by the provinces of Alberta and Manitoba as a means by which the results of water quality assessments can be communicated to managers and the general public.** As discussed above, the index is already in use, or is being tested, by each of the Prairie Provinces. Adoption of the index would improve the PPWB=s ability to report on water quality trends and facilitate the exchange of information among agencies.

4.0 PROPOSED CHANGES TO THE CURRENT MONITORING PROGRAM FOR THE BATTLE RIVER AT THE ALBERTA-SASKATCHEWAN BOUNDARY

4.1 Overview

The Battle River originates in the Battle and Pigeon Lake area of Alberta and flows south-easterly for 800 km before crossing the Saskatchewan boundary. The PPWB monitoring site for the Battle River is just downstream of the Alberta-Saskatchewan Boundary and at this point the river has a gross drainage area of 25,062 km^2 and an effective drainage of 10,842 km^2. Water supply in the Battle River is partially controlled by small reservoirs in Alberta.

The majority of the basin within Alberta has been developed for agriculture while the remainder is primarily used for pasture or as wildlife habitat. There are no major water users that withdraw water from the Battle River, but flow is a major issue (see Dunn 1995a for a more detailed description of the river basin). The PPWB Water Quality Monitoring site on the Battle River is located at Unwin, Saskatchewan.

As with other PPWB monitoring sites, an analysis of long-term trends in water quality in the Battle River suggests that the majority of measured variables show few systematic trends over time. Parametric (linear regression) and non-parametric (Kendall Tau, Spearman Trend, Van Belle) tests revealed that concentrations of six water quality variables significantly decreased over the period of measurement. These variables included: total nitrogen, alpha-BHC, dissolved manganese, dissolved iron, total copper, and total coliforms (Dunn1995a). The same statistical trend analysis revealed that turbidity, pH, dissolved chloride, and fecal coliforms showed a positive trend over the same period.

Regardless of direction, rates of change for all significant trends were low and with the exception of total copper and fecal coliforms, both of which had significant negative trends, excursions to objectives were rare. For these reasons, none of the detected trends were considered to be of management concern.

Although no trends were identified as being of particular management concern, total copper, fecal coliforms, dissolved manganese, sodium and total dissolved are consistently identified as exceeding objectives in recent PPWB Excursion Reports. The underlying causes of these excursions have recently been examined by Alberta Environment and are being evaluated by the COWQ.

In summary, the Battle River is currently (1997-2000) monitored on a monthly basis. Monitored variables include nitrogen, phosphorous, carbon, NFR, pH, temperature, conductivity, dissolved oxygen, major ions, boron, heavy metals, mercury, and aluminum. Variables of potential concern include total copper, fecal coliforms, dissolved manganese, sodium, and TDSS. In all cases concerns relate to excursions rather than trends in parameter values.

4.2 Recommendations

The following recommendations are based on an examination of available data and a consideration of the issues discussed in earlier sections of this report and Cash (1998, 1999). Any changes to the Monitoring Program should be carefully evaluated and, if necessary, adapted based on new information and internal Afeedback loops@

4.2.1 It is recommended that the PPWB undertake a review of current objectives associated with water quality variables measured in the Battle River and that, where objectives are needed, they be developed. As discussed in Cash (1998, 1999), the lack of objectives is a major impediment to the interpretation of the collected data and to the assessment of overall health or condition. Objectives also form the basis of any water quality index that might be applied to the PPWB data.

4.2.2 It is recommended that the PPWB consider the need to control for other influences (e.g., discharge, hardness, sediment load, diurnal variability, etc.) when analyzing trends and establishing objectives. Such a consideration may necessitate the control of certain covariates in trend analysis or the development of a number of condition-dependent objectives for some variables.

1.1.3 It is recommended that (contingent upon the results of a pilot study) the PPWB evaluate the benthic macroinvertebrate community present at the Battle River monitoring site on an annual basis using the rapid bioassessment techniques outlined in this report. Worldwide, benthic invertebrates are the most widely studied and employed biological indicator of aquatic systems and should be incorporated into the PPWB Monitoring Program. Trends in community structure should be analyzed and related to general measures of water quality.

4.2.5 It is recommended that the PPWB examine the feasibility of measuring primary productivity (periphyton and/or epiphyton) measured at the Battle River monitoring site. Measures of primary productivity, though not feasible in all locations, would link directly measured nutrient levels and their immediate affect on biota. This data would also assist efforts to improve nutrient objectives and should be directly linked to the work being conducted by Dr. P. Chambers (NWRI) for Western Canada and the Great Lakes Basin.

4.2.6 It is recommended that the PPWB explore the possibility of measuring sediment quality within the Battle River monitoring site. Sediments can serve as important sinks for a variety of contaminants. Sediments form an important compartment within the aquatic ecosystem and can have a strong influence on aquatic quality.

4.2.7 It is recommended that the PPWB continue to periodically (every five years) analyze trends in water quality and biota measured at the Battle River monitoring site. Trend analysis is essential to the Monitoring Program but given the data already collected, an analysis every five years should be sufficient to detect changes in trends and identify potential concerns. Where appropriate, advances in statistical trend analysis and related software should be incorporated in this exercise.

4.2.8 It is recommended that the PPWB undertake a review of all nutrient objectives with a view to establishing objectives more appropriate for rivers in Prairie Canada. The importance of nutrient levels in determining ecological function in these systems has long been recognized by the PPWB, as has the possible inappropriateness of current nutrient guidelines. These issues are the subject of ongoing study conducted by Dr. P. Chambers (DOE) and sponsored, in part, by the PPWB.

4.2.9 It is recommended that the PPWB cease routine monitoring of dissolved oxygen at the Battle River monitoring site. Statistical analyses do not suggest any trend in dissolved oxygen concentrations and the PPWB objective for dissolved oxygen in this reach (6.0 mg/L) is rarely compromised. More importantly, dramatic diurnal variation in dissolved oxygen values are common in these systems and single monthly measures probably hold little value. If measures of dissolve oxygen are required during certain periods (e.g., late winter, under ice) they should be collected on a temporal scale (e.g., hourly, every ten minutes) adequate to characterize the variation.

4.2.10 It is recommended that the PPWB cease monitoring mercury and chromium in the water column at the Battle River site. Mercury and chromium levels in the water column are difficult to measure and interpret. The PPWB now monitors these variables in a more appropriate medium.

4.2.11 It is recommended that the PPWB cease monitoring dissolved boron at the Battle River site. Long-term trend analysis fails to suggest any trend in boron concentration and the fact that concentrations have never approached the PPWB objective (5.0 mg/L) suggest there is little value in continuing to monitor boron.

It is recommended that the PPWB cease monitoring total coliforms in favour of monitoring fecal coliforms and *Escherichia coli*. Because total coliforms is a poor indicator of sewage contamination it has been replaced in many jurisdictions by fecal coliforms. *E. coli* possess the added advantage of being a superior indicator of gastrointestinal illness.

4.2.13 It is recommended that the PPWB adopt the water quality index currently being developed by the CCME and employed by the provinces of Alberta and Manitoba as a means by which the results of water quality assessments can be communicated to managers and the general public. As discussed above, the index is already in use, or is being tested, by each of the Prairie Provinces. Adoption of the index would improve the PPWB=s ability to report on water quality trends and facilitate the exchange of information among agencies.

5.0 PROPOSED CHANGES TO THE CURRENT MONITORING PROGRAM FOR THE RED DEER RIVER AT THE SASKATCHEWAN-MANITOBA BOUNDARY

5.1 Overview

The Red Deer River is one of the smallest monitored by the PPWB. It originates at the confluence of the Barrier and Etomami rivers, and flows eastward, through the town of Hudson Bay and eventually into Manitoba. The portion of the Red Deer River contained within Saskatchewan has a gross drainage area of 11,000 km^2 and an effective drainage area of approximately 9,000 km^2. The Red Deer River is unregulated and thinly populated. Most of the drainage is covered with forest although there is also some mixed farming in the area. Recreation is also an important use within this basin. The PPWB Water Quality Monitoring site on the Red Deer is located near Erwood, Saskatchewan.

As with other PPWB monitoring sites, an analysis of long-term trends in water quality in the South Saskatchewan River suggests that the majority of measured variables show few systematic trends over time. Parametric (linear regression) and non-parametric (Kendall Tau, Spearman Trend, Van Belle) tests revealed that 14 water quality variables significantly decreased in concentration over the period of measurement. These variables included: NO2+NO3, total nitrogen, NFR, total dissolved phosphorus, total phosphorus, alpha-BHC, calcium, dissolved potassium, total copper, total zinc, total coliforms, fecal coliforms, total mercury, and daily discharge (Dunn1995b). Interestingly, trend analysis did not reveal a positive trend for any of the measured variables. Despite the large number of negative trends, rates of change for all were low and excursions to objectives rare. For these reasons, none of the detected trends were considered to be of management concern.

The only measured variable to routinely exceed the PPWB objective for this site is total phosphorous (local objective 0.05). But even in the case of total phosphorous excursions to the objective are rare and not thought to pose a risk to water quality.

In summary, the Red Deer River is now (as of 1999/2000) being sampled six times yearly. Monitored variables include nitrogen, phosphorous, carbon, NFR, pH, temperature, conductivity, dissolved oxygen, major ions, boron, heavy metals, mercury, and aluminum. Fish are sampled every five years for metals, chlorinated phenolics, and OC=s/PCBs. At this time, there are no variables of particular concern in the Monitoring Program for this site.

5.2 Recommendations

The following recommendations are based on an examination of available data and a consideration of the issues discussed in earlier sections of this report and in Cash (1998,1999). Any changes to the Monitoring Program should be carefully evaluated and, if necessary, adapted based on new information and internal Afeedback loops@

5.2.1 It is recommended that the PPWB monitor the Red Deer River on a quarterly basis. Although the Red Deer should remain as part of the PPWB monitoring program, the lack of trends in, or threats to, water quality suggests that quarterly sampling is sufficient to monitor this reach. Quarterly sampling is already the frequency at which the Qu=Appelle, Churchill and Cold River sites are being monitored.

5.2.2 It is recommended that the PPWB undertake a review of current objectives associated with water quality variables measured in the Red Deer River and that, where objectives are needed, they be developed. As discussed in Cash (1998, 1999), the lack of objectives is a major impediment to the interpretation of the collected data and to the assessment of overall health or condition. Objectives also form the basis of any water quality index that might be applied to the PPWB data.

5.2.3 It is recommended that the PPWB consider the need to control for other influences (e.g., discharge, hardness, sediment load, diurnal variability, etc.) when analyzing trends and establishing objectives. Such a consideration may necessitate the control of certain covariates in trend analysis or the development of a number of condition-dependent objectives for some variables.

5.2.4 It is recommended that the PPWB continue monitoring fish condition and tissue contaminant levels in the Red Deer River on a five year cycle. Fish collected for contaminant analysis should also be assessed for general condition. Fish captured, but not collected for contaminant analysis, should also be assessed for general condition prior to release.

5.2.2 It is recommended that (contingent upon the results of a pilot study) the PPWB evaluate the benthic macroinvertebrate community present at the Red Deer River monitoring site on an annual basis using the rapid bioassessment techniques outlined in this report. Worldwide, benthic invertebrates are the most widely studied and employed biological indicator of aquatic systems and should be incorporated into the PPWB Monitoring Program. Trends in community structure should be analyzed and related to general measures of water quality.

5.2.3 It is recommended that the PPWB examine the feasibility of measuring primary productivity (periphyton and/or epiphyton) **measured at the Red Deer River monitoring site.** Measures of primary productivity, though not feasible in all locations, would link directly measured nutrient levels and their immediate affect on biota. This data would also assist efforts to improve nutrient objectives and should be directly linked to the work being conducted by Dr. P. Chambers (NWRI) for the PPWB.

5.2.4 It is recommended that the PPWB explore the possibility of measuring sediment quality within the Red Deer River monitoring site. Sediments can serve as important sinks for a variety of contaminants. Sediments form an important compartment within the aquatic ecosystem and can have a strong influence on aquatic quality.

5.2.5 It is recommended that the PPWB continue to periodically (every five years) analyze trends in water quality and biota measured at the Red Deer River monitoring site. Trend analysis is essential to the Monitoring Program but given the data already collected, an analysis every five years should be sufficient to detect changes in trends and identify potential concerns. Where appropriate, advances in statistical trend analysis and related software should be incorporated in this exercise.

5.2.6 It is recommended that the PPWB undertake a review of all nutrient objectives with a view to establishing objectives more appropriate for rivers in Prairie Canada. The importance of nutrient levels in determining ecological function in these systems has long been recognized by the PPWB, as has the possible inappropriateness of current nutrient guidelines. These issues are the subject of ongoing study conducted by Dr. P. Chambers (DOE) and sponsored, in part, by the PPWB.

5.2.7 It is recommended that the PPWB cease routine monitoring of dissolved oxygen at the Red Deer River monitoring site. Statistical analyses do not suggest any trend in dissolved oxygen concentrations and excursions to the PPWB objective (6.0 mg/L) are very rare. More importantly, dramatic diurnal variation in dissolved oxygen values are common in these systems and single monthly measures probably hold little value. If measures of dissolve oxygen are required during certain periods (e.g., late winter, under ice) they should be collected on a temporal scale (e.g., hourly, every ten minutes) adequate to characterize the variation.

5.2.8 It is recommended that the PPWB cease monitoring mercury and chromium in the water column at the Red Deer River site. Mercury and chromium levels in the water column are difficult to measure and interpret. The PPWB now monitors these variables in a more appropriate medium (i.e., fish tissue).

5.2.9 It is recommended that the PPWB cease monitoring dissolved boron at the Red Deer River site. Long-term trend analysis indicate a slight positive trend in boron concentrations, however even the highest recorded concentrations fail to come within an order of magnitude of the PPWB objective (5.0 mg/L). These data suggest there is little value in continuing to monitor boron.

5.2.10 It is recommended that the PPWB cease monitoring total coliforms in favour of monitoring fecal coliforms and *Escherichia coli*. Because total coliforms is a poor indicator of sewage contamination it has been replaced in many jurisdictions by fecal coliforms. *E. coli* possess the added advantage of being a superior indicator of gastrointestinal illness. A shift toward monitoring fecal coliforms and *E. coli* would also make PPWB data more comparable to that collected downstream in Manitoba.

5.2.11 It is recommended that the PPWB adopt the water quality index currently being developed by the CCME and employed by the provinces of Alberta and Manitoba as a means by which the results of water quality assessments can be communicated to managers and the general public. As discussed above, the index is already in use, or is being tested, by each of the Prairie Provinces. Adoption of the index would improve the PPWB=s ability to report on water quality trends and facilitate the exchange of information among agencies.

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