International Conference on Hydroinformatics

2014

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8-1-2014

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11th International Conference on Hydroinformatics
HIC 2014, New York City, USA

EVALUATING ALTERNATIVE WATER ALLOCATION POLICIES AMONG COMPETING USERS IN THE BOW RIVER BASIN, ALBERTA, CANADA

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ABSTRACT

Demand for water from rivers and aquifers for consumptive use has grown greatly due to population and economic growth and changing lifestyle and dietary habits. Consequently, aquatic ecosystems, especially in semi-arid and arid regions across the world, suffer adverse environmental impacts of over-extraction. Historically, Alberta's water allocation system has been based on the first-in-time-first-in-right (FITFIR) system, granting the preference to the licensees based on the seniority of their licenses. In recent years, scientists, policy makers, and water users have raised questions whether FITFIR will continue to be the most appropriate allocation system to manage increasing scarce water resources in Alberta.

This study aims to investigate the current and proposed water allocation strategies in Alberta and their impacts on existing consumptive users employing risk-based evaluation performance indicators. These performance criteria are employed to compare the current allocation mechanism and four alternative scenarios proposed by the Bow River Project Research Consortium. This study has used the BROM model provided by the Consortium. The study concludes that the alternative scenarios improve all risk-based indicators in the entire Bow River Basin. Among all alternative scenarios, although the water bank 60 slightly decreases the sustainability of the BRID, it could contribute more than other alternatives to the consumptive uses and the environmental flows of the Bow River Basin.

INTRODUCTION

Demand for water from rivers and aquifers for consumptive use has grown greatly due to population and economic growth and changing lifestyle and dietary habits [1]. Consequently, aquatic ecosystems, especially in semi-arid and arid regions across the world, suffer adverse environmental impacts of over-extraction. Historically, Alberta's water allocation system has been based on the first-in-time-first-in-right (FITFIR) system, granting the preference to the licensees based on the seniority of their licenses [2]. In recent years, scientists, policy makers, and water users have raised questions whether FITFIR will continue to be the most appropriate allocation system to manage increasing scarce water resources in Alberta [3][4][5].

This study aims to investigate the current and proposed water allocation strategies in Alberta and their impacts on existing consumptive users employing four performance evaluation criteria: reliability, resilience, vulnerability and sustainability. These four performance criteria are used to evaluate the current allocation mechanism and four alternative scenarios proposed by the Bow River Project Research Consortium in the Bow River Basin.

STUDY AREA

The Bow River Basin (BRB) comprises about 25,000 square kilometers covering more than 4% of Alberta and about 23% of the South Saskatchewan River drainage area in Alberta. The Bow River originates in the Rocky Mountains and continues its journey through the foothills into the prairie and eventually confluences with the Oldman River and becomes the South Saskatchewan River [6]. The Bow River Basin consists of 22 urban municipalities, including Calgary, 12 rural or regional municipalities and 3 First Nations. It also comprises three major irrigation districts: Western Irrigation Districts (WID), Eastern Irrigation Districts (EID), and Bow River Irrigation Districts (BRID). With approximately 1.2 million people, the Bow River Basin is the most populous river basin in Alberta, comprising 95% of the urban, 4% of rural or regional municipalities and less than 1% of the first nation population [7]. The Bow River Basin is heavily allocated. The total allocations in 2005 were 2,601,465 dam3 [7]. In 2005, an overview of the allocation of surface and ground water shows that the agricultural sector accounts for 77% of total allocations, following by municipalities 20%, commercial 1%, industrial 1%, other 1% and petroleum less than 1%. By 2010 agricultural share of total allocations had declined to 71%. However, allocated water is not equal to consumed water. According to 2005 data, 1,124 million cubic meters were actually used in the Bow River Basin. Agriculture and irrigation accounted for about 89%, municipalities 5%, and commercial and industrial sectors each 2% of the estimated water use in the Bow River.

BOW RIVER OPERATIONAL MODEL

In May 2010, the Bow River Project Research Consortium (known as the Consortium) was formed to enhance management of the Bow River and to propose new operational rules and management policies within the Bow River Basin. The project was funded by Alberta Water Research Institute (AWRI), Environmental Hub, and some other stakeholders in the Bow River Basin. The consortium consisted of a number of stakeholders who control more than 90% of all allocated water and water use in the Bow River Basin. To evaluate changing management practices and operational rules in the Bow River Basin, the consortium developed the Bow River Operational Model (BROM). This study has used the BROM model provided by the Consortium (for more detail of the consortium research project, please see the Bow River Project Final Report prepared by The Bow River Project Research Consortium [8]). The OASIS software is utilized by the Consortium to simulate the entire Bow River Basin (for more detail of the OASIS model developed for the Bow River, please see the core paper by Sheer et al. [9]). Based on the data acquired from Alberta Environment and the irrigation districts on the Bow River, besides the current base allocation system, four alternative scenarios as the operational rules are implemented in the OASIS software by Hydrologics Inc. which was the member organization of the Bow River Project Research Consortium.

WATER ALLOCATION ALTERNATIVES

The Consortium proposed four major operational rules as alternate options for The Bow River (the Consortium, 2010). In all scenarios, excluding the current base scenario, the Langdon reservoir in the WID has been doubled up from 8,340 to 16,700 dam3 (6,750 to 13,500 acre feet). The project to double the Langdon reservoir has been funded and is in the final design stage. Therefore, it has been included in all alternative scenarios due to its ability to reduce the WID's water shortages. The first scenario is to stabilize lower Kananaskis Lake and Kananaskis River at 1663.5 meters with a fluctuation of +/- 0.5 meter-3.5 meters below the current 1667 meter full supply level. If the elevation rises above the full supply level, the reservoir will be allowed to use its spillway. The second scenario is to, in addition to stabilize Lower Kananaskis River and Kananaskis Lake, establish a water bank of 49,339 dam3 (40,000 acre feet) purchased from the TransAlta reservoir to improve the Bassano flows. The third scenario expands on the second scenario by increasing the water bank from 40,000 acre feet to 60,000 acre feet. The fourth scenario is called the integrated scenario: stabilizing Lower Kananaskis River and Kananaskis River, adding a water bank of 74,000 dam3 (60,000 acre feet), and adding another 75,200 dam3 (61,000 acre feet) of water to Spray reservoir to raise the full supply level of the reservoir.

RESULTS OF WATER ALLOCATION SIMULATION

The three risk-based performance indicator, known as R-R-V, (reliability, resilience, and vulnerability [10]) were employed to investigate the effects of the alternatives scenarios on the BRB and associated irrigation districts. These performance measures could be useful to help policy makers in the selection of water resource system capacities, targets, and operating policies during periods of drought and peak demands [10]. The sustainability index, proposed by Loucks (1997) [11], is the combination of these risk-based indicators to quantify the sustainability of the water resource system.

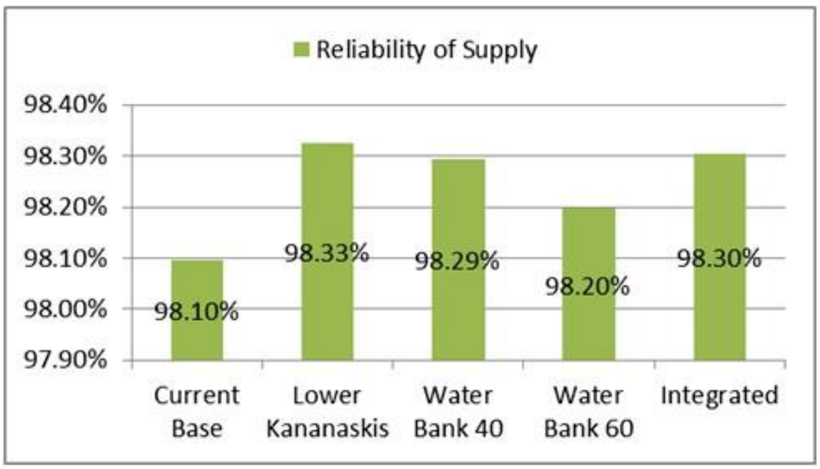


Figure 1. Reliability of supply in the entire basin

The reliability of supply defined as the percentage of time that demands are satisfied during the time period covered by the historical record (time series) shows that stabilizing the lower Kananaskis (Scenario 1) has the highest level of reliability of supply among the alternatives followed in order by Scenarios 4 (integrated scenario), 2 (water bank 40), 3 (water bank 60) and the current base system (Figure 1).

The indicator of resilience is defined as the strength of a system’s ability to bounce back from a state of not meeting demands to a state of meeting demand. The simulation result shows that the probability of recovering from failure conditions is the highest for Scenario 2 (water bank 40), followed in order by Scenarios 3 (water bank 60), 4 (integrated scenario), 1 (Stabilizing Kananaskis), and the current base system (Figure 2).

The vulnerability indicator is measured as the average volume of shortage in each failure events computed by dividing the volume of shortages (CDM) by the number of failure events. The lowest level of vulnerability is achieved under Scenario 3 (water bank 60), followed in order by scenarios 4 (integrated scenario), 2 (water bank 40), 1 (stabilizing Kananaskis), and the current base system (Figure 3).

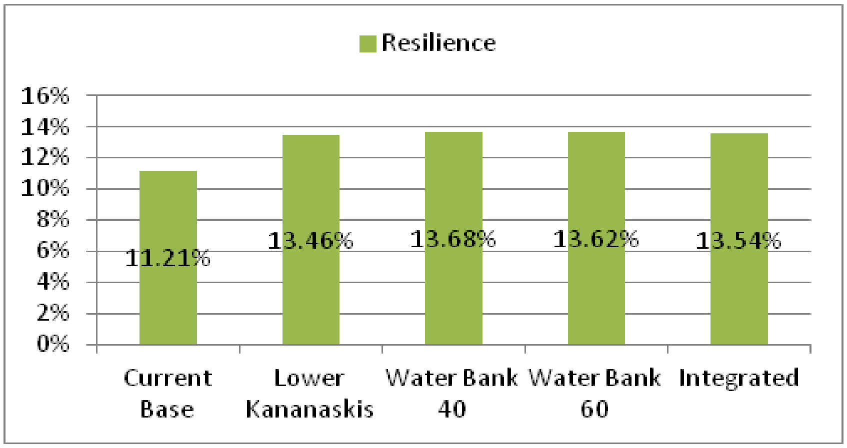


Figure 2. Resilience in the entire basin

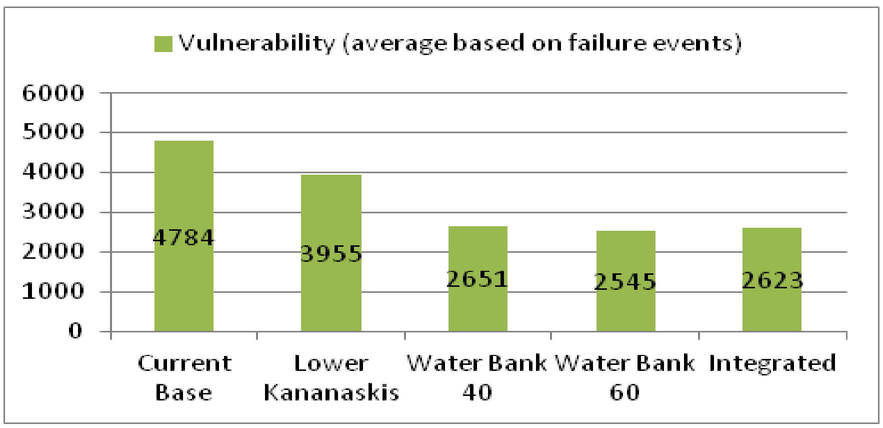


Figure 3. Vulnerability of the Alternatives in the entire basin

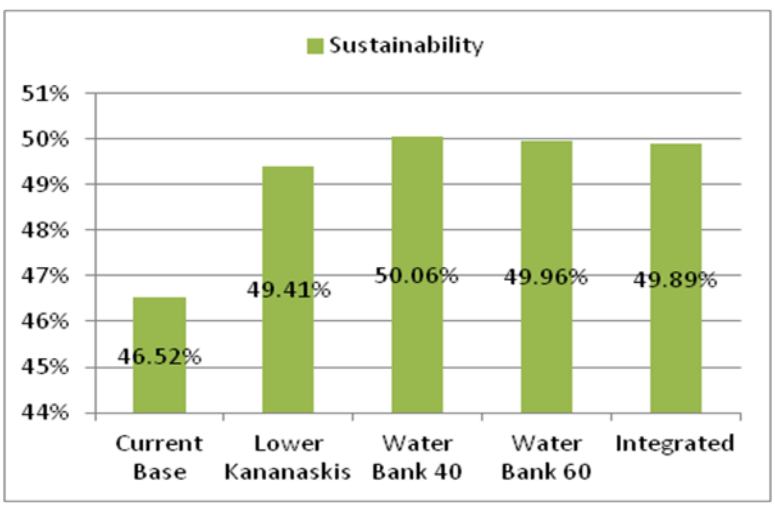
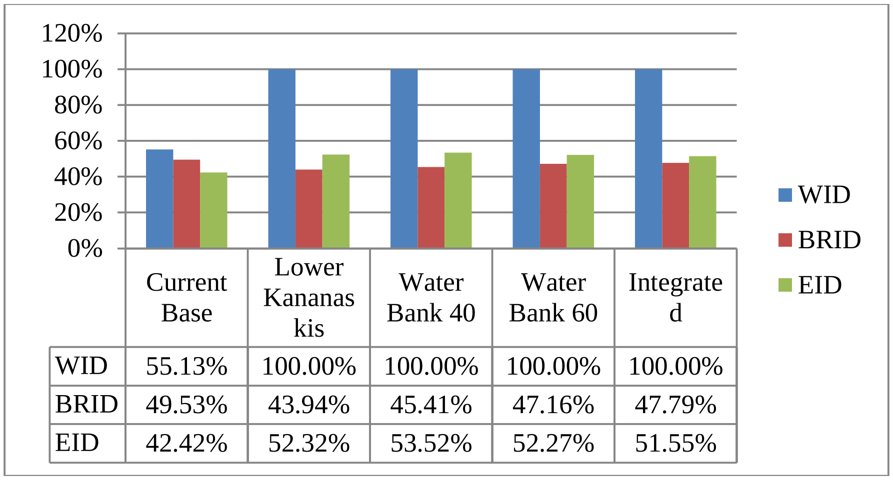


Figure 4. Sustainability of the alternatives in the entire system



	Current Base	Lower Kananaskis	Water Bank 40	Water Bank 60	Integrated
WID	55.13%	100.00%	100.00%	100.00%	100.00%
BRID	49.53%	43.94%	45.41%	47.16%	47.79%
EID	42.42%	52.32%	53.52%	52.27%	51.55%

Figure 5: Sustainability of the alternatives in the irrigation districts

The sustainability of Scenario 2 (water bank 40) is the highest among all alternatives, followed by Scenarios 3 (water bank 60), 4 (integrated scenario), 1 (stabilizing Kananaskis), and the current base system (Figure 5).

In irrigation districts, Sustainability of WID jumps to 100% from 55.12% by applying the alternative options. In EID, water bank 40 has the highest level of sustainability followed in order by the stabilizing Kananaskis, water bank 60, integrated, and the current base scenario. This result in EID shows that by increasing the volume of the water bank from 40,000 acf to 60,000 acf, the sustainability of the EID does not improve. In the BRID, the current base scenario has the highest percentage of the sustainability among the alternative options. This result implies that the alternative scenario deteriorate the sustainability of the BRID.

DISCUSSIONS AND CONCLUSIONS

This paper has employed the different set of performance measures (risk-based indicators) compared with what are used by the consortium. By comparing the existing allocation mechanisms to the alternative scenarios, all four alternatives improve all four risk-based indicators in the entire Bow River Basin. Compared with the water bank scenarios (water bank 40, water bank 60, and integrated), the stabilizing Kananaskis scenario has only higher level in the reliability of supply indicator. Hence the sustainability of the water bank scenarios is higher than stabilizing Kananaskis scenario in the entire basin. Among the water bank scenarios, water bank 40 is slightly more sustainable than other scenarios in the entire basin.

In the WID and EID, alternative scenarios improve the sustainability of the system. On the contrary, in the BRID, all alternative scenarios decline the sustainability of the system. The study by the Alberta Water Research Institute (2010) shows that the water bank 60 scenario has the highest contribution to the environmental flows, followed by integrated, water bank 40, stabilizing Kananaskis and the current base scenario. Hence although the water bank 60 slightly decreases the sustainability of the BRID, it could contribute more than other alternatives to the consumptive uses and the environmental flows of the Bow River Basin.

ACKNOWLEDGMENT:

The authors would like to acknowledge the financial contribution from Alberta Innovates: Energy and Environment Solution, and the Canadian Social Sciences and Humanities Research Council's Water Economics, Policy and Governance Network. We would also like to acknowledge the significant contributions of Dr. Dan Sheer from Hydrologics Inc. and Professor Steward Rood from University of Lethbridge. Finally would like to acknowledge the ongoing work in this areas by the Bow River Consortium.

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