COLUMBIA RIVER TREATY
HYDROMETEOROLOGICAL COMMITTEE

2012 ANNUAL REPORT

Stephanie Smith	BC Hydro, Canada, Canadian Chair
Adam Gobena	BC Hydro, Canada, Member
Ann McManamon	Bonneville Power Administration, U.S., U.S. Co-Chair
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JANUARY 2013

COLUMBIA RIVER TREATY HYDROMETEOROLOGICAL COMMITTEE

2012 ANNUAL REPORT

Introduction

The Columbia River Treaty Hydrometeorological Committee (CRTHC) was established in September 1968 by the Entities. The CRTHC is responsible for planning and monitoring the operation of the hydrometeorological data collection network in accord with the Columbia River Treaty (CRT). It also assists the Entities in matters related to hydrometeorological and water supply forecasting.

This report summarizes CRTHC activities during the 2012 water year (October 1, 2011 – September 30, 2012). The Annual Report focuses on:

- action taken on proposed changes to the hydrometeorological monitoring network
- updates to CRT communications and data storage systems
- updates to data exchange requirements
- updates to forecasting procedures
- review of the 2012 CRT water supply forecasts
- other activities of the Committee

The CRTHC began issuing regular Annual Reports in 2001. General background information on CRTHC activities contained in the 2001 and 2002 annual reports is now presented in a separate supplemental document. The supplement contains general information that does not typically change from year to year. Appendices in the supplemental document include:

2012 ANNUAL REPORT

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See 2012 Supplemental Report for a list of acronyms used in this report

COLUMBIA RIVER TREATY
HYDROMETEOROLOGICAL COMMITTEE

2012 ANNUAL REPORT

2012 Annual Summary

The Columbia River Treaty Hydrometeorological Committee (CRTHC) was established in September 1968 by the Entities and is responsible for planning and monitoring the operation of hydrometeorological data collection network in accord with the Treaty and otherwise assisting the Entities as needed. The Committee consists of four members as follows:

UNITED STATES SECTION	CANADIAN SECTION
Peter Brooks, USACE Co-Chair	Stephanie Smith, B.C. Hydro, Chair
Ann McManamon, BPA Co-Chair	Adam Gobena, B.C. Hydro, Member

The CRTHC met two times in the 2012 operating year:

Meeting 69: March 7, 2012 at BC Hydro

Meeting 70: July 24, 2013 at the Corps of Engineers

In addition, the CRTHC members participated in discussions with CRTOC members and others regarding the results of climate change studies conducted by both BC Hydro and the River Management Joint Operating Committee (RMJOC).

The 2011 CRTHC Annual Report was completed in January 2012, in advance of the annual Permanent Engineering Board Meeting.

Stations

The CRTHC process for reviewing proposed changes to the operation of stations within the hydrometeorological network is described in Appendix C of the 2012 Supplemental Report. The process is intended to ensure that changes made to the network do not negatively affect the monitoring, planning, and operations of Treaty facilities.

There were no reported changes to the station network in 2012. In the 2011 CRTHC Annual Report, it was reported that the CRTHC was working on an updated listing of all Treaty stations. The CRTHC, during the two meetings this year, has decided to take advantage of what was written in the original Treaty language. The CRTHC has begun to create a record of the stations with the highest relevance to the Treaty. The station hierarchy reflects those stations which are most critical to current Treaty operations and those which support that effort. The CRTHC agreed that stations used directly in regression-based water supply equations for the Treaty projects and those monitoring reservoir levels and key streamflow points are placed in the highest tier. Stations used in daily operations or not used directly in forecast procedures are classified in a lower tier. The tiered approach will permit better monitoring of those stations critical to the operation of the Treaty. As the work progresses, the CRTHC will determine the best way to report on the ongoing availability of these stations to the Operating Committee and Permanent Engineering Board.

As highlighted in the "Snow Pillow Project" section of the CRTHC's 2011 Annual Report, the CRTHC is continuing to address the question of adequacy of the network. As a result, an MOU between BPA and BCH was signed and funds will be made available to BC Hydro for site investigation, permitting and project management. So far only Keystone Creek is advancing to the permitting stage. A review of the physical environment at several other existing snow course sites has precluded them as possible sites for conversion to snow

pillows. This project is ongoing, and BCH and BPA are reviewing information from site assessments at several additional sites for consideration.

Computer Systems and Data Acquisition and Exchange

The Columbia Basin Telecommunications (CBT), other communication systems, and the Columbia River Operational Hydromet Management System (CROHMS) are described in Appendix E of the 2012 Supplemental Report. The CBT system, operated by USACE in Portland, is the primary communications system for transmitting project data throughout the Columbia River. There are 30 nodes (projects) that comprise the CBT system Agencies, including the Northwest River Forecast Center (NWRFC), USACE, and BCH. CROHMS is the central system for collecting and re-distributing hydrometeorological data used to support the operations of Treaty projects, although the Entities also use other communication systems to exchange data.

Appendix F of the 2012 Supplemental Report describes current data exchange procedures. Data exchanged among operational projects and entity agencies may be categorized according to the type of data and the frequency of transmission. Types of data include project data, weather and streamflow data, inflow forecasts, as well as reports and messages. The frequencies of transmission may be hourly, daily, or monthly.

The Corps Columbia Basin Water Management Water Control Data System (WCDS) was forced to migrate to updated servers as a result of the fallout from a Department of Defense (DoD) Information Assurance Audit on one of its districts. Four Corps WCDS staff spent 90 days completing the compliance activities, largely focused on the approved versions of the Solaris operating system and Oracle database software.

The Corps has issued a requirement to terminate anonymous and non-secure File Transfer Protocol (FTP) at a national level. Any data-reporting office must migrate to secure FTP

(sFTP). BC Hydro and BPA have adopted sFTP. A few regional data providers will need assistance to become compliant. An ongoing issue with the new sFTP is that the Corps has fielded a product called RepliWeb that works well for ad hoc file transfers internal to and external to the Corps. But automated FTP cannot be accommodated via RepliWeb, so a different national solution is being tested by the Corps. The Corps may stand up a single national sFTP server or another solution entirely. This issue is one in a series of efforts by DoD and Army to move to a more consolidated server environment.

BC Hydro made major changes to its data reporting infrastructure. They are now able to provide data with a finer temporal time step in an automated fashion and have been able to reduce or eliminate a number of manual processes and spreadsheets.

Forecasting

2012 was the first year that the new seasonal volume forecast procedure, Ensemble Streamflow Prediction, (ESP) was used by the Northwest River Forecast Center (NWRFC). This past year, the committee felt that an earlier forecast could be beneficial and recommended that the region use the forecast released on the 4th working day of the month. It was believed that this shorter period of time would still permit adequate time to incorporate automated and manual snow observations. At the beginning of the water supply season, the NWRFC was only able to make water supply forecasts available that included 10 days of a short term forecast. As the season progressed, they also provided forecasts with three and zero days of quantitative precipitation forecast (qpf). The CRTOC tasked the CRTHC to monitor and evaluate our original recommendation of which forecasts to use for treaty purposes.

While analyzing the information from the past water supply season, there were several issues that the committee took into account during our review. One component was to

balance the need to allow adequate time to permit the inclusion of hydrometeorological data including automated and manually measured snow information, while making the forecast available with an adequate amount of time to permit the Action agencies to compute the information necessary to operate the FCRPS and Treaty projects. It appears that on at least one occasion four days did not allow adequate time to incorporate the data from manually pulled snow observations. Late December and early January were times of particularly bad weather in British Columbia and staff members were unable to complete measuring the manual snow course data in the first few days of January. There was a significant increase in the January forecast from one forecast to the next in early January. Although only one more day might not have fixed this particular challenge, it was indicative that trying to shorten the forecast preparation period may have had a negative impact on the forecasts earlier in the season.

Another forecasting issue was to determine how much of a short term forecast should be included in a seasonal forecast. The committee agreed that using some short-term forecast is more appropriate than using climatology (zero days of a short-term forecast). Therefore, our analysis included the comparison of the ESP forecasts containing 3-day and 10-day short-term forecasts. The committee determined that there was greater variability between subsequent forecasts which incorporated the 10-day short term forecast and found that this increased variability is less desirable for use in managing the large scale multi-purpose projects which make up the Columbia system. There was also a general sense that the meteorological science is still not adequate to have a reliable forecast out 10 days into the future, whereas, 3-day forecasts have been shown to have significant skill. Based on that evaluation, the CRTHC prepared a revised recommendation for the CRTOC of ESP forecast issue dates that will be the official ones for use in the Treaty Flood Control Operating Plan, the Actual Energy Regulation (AER) and the Treaty Storage Regulation. (TSR)

The dates will reflect the fifth working day of the month. At the October 2012 CRTOC meeting, these recommended forecast dates were adopted for the upcoming year. The dates are:

8 January 2013,

7 February 2013,

7 March 2013,

5 April 2013,

7 May2013,

6 June, 2013*,

8 July 2013.

* This date is actually the 4th working day in the month of June. Shortening the forecast preparation period by one day makes the TSR available about five days earlier (due to the way the calendar falls). By June, none of the agencies preparing water supply forecasts should be adjusting snowpack conditions based on ground observations.

Decision support model for declaring the onset of the Kootenay Lake Freshet

The annual declaration of the "commencement of the spring rise" on Kootenay Lake by the IJC International Kootenay Lake Board of Control (KLBC) has potential operational impacts on the management of Kootenay River system reservoirs as it can signal a relaxation in the operating restrictions. For this reason, the Columbia River Treaty Operating Committee (CRTOC) commissioned the CRT Hydrometeorological Committee (CRTHC) to undertake a study and provide the KLBC with an additional decision support tool for their annual deliberation of the declaration of the spring rise.

Frank Weber (BC Hydro) developed a model that uses as input observed and forecasted local Kootenay Lake inflows. Key characteristics of the model are its objectivity in declaring

the freshet onset, flexibility to accommodate year-to-year variations in hydroclimatic conditions, robustness of day-to-day flow variability caused by poor data quality and natural hydrologic processes, and the use of a four-day lead-time inflow forecast.

The procedure is not intended to replace human decision making, but provides guidance for declaring the start of the seasonal snowmelt freshet. It has been used unofficially in the water years since 2009 with success.

An updated version of the report and procedure were submitted to the KLBC in January 2011. The KLBC appreciated the input and will incorporate the additional decision support, along with other data and experience, to make its annual judgment on the declaration of the start of the spring rise.

In 2012, the spring rise was officially declared by the KLBC on April 20, 2012. This differs from the results of the Kootenay Lake Freshet tool which indicated the spring freshet started in the week of March 26th. A short upward surge of inflows driven by rainfall runoff pushed the indicator above the 2x winter low flow threshold on March 20th, but inflows quickly receded. The inflow increase at the end of March also appeared to be primarily triggered by rainfall runoff, but the indicator remained above the 2x winter low flow threshold afterwards despite the sharp decline of flows in early April. See the figure below for a snapshot of the 2012 season.

KOOTENAY LAKE INFLOW FRESHET

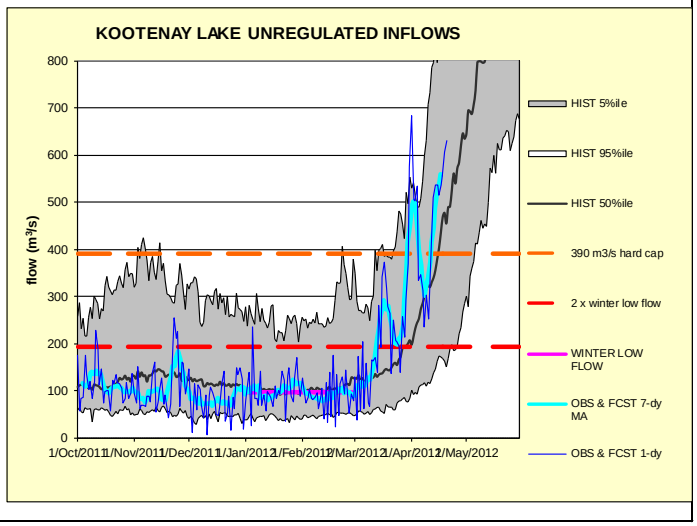
Issue date: March 26, 2012
BC Hydro

The Kootenay Lake freshet has started!

The 7-day average inflow is 276 m3/s, which exceeds the 194 m3/s threshold.

		inflows			
		1-day		7-day average	
		m^3/s	ft^3/s	m^3/s	ft^3/s
observed	24-Mar-12	138	4871		
	24-Mar-12	250	8826		
	24-Mar-12	207	7299		
	24-Mar-12	204	7218	222	7853
	25-Mar-12	195	6871	256	9040
forecast	26-Mar-12	262	9253	276	9763
	27-Mar-12	301	10630		
	28-Mar-12	373	13183		
	29-Mar-12	393	13889		

winter baseflow (Jan 1- Feb 28)	97 m^3/s	
	3429 ft^3/s	
threshold 1	194 m^3/s	2 x winter low flow
	6857 ft^3/s	
threshold 2	390 m^3/s	hard cap
	13773 ft^3/s	



In 2012, the KLBC determined, at the request of the Operating Committee, and later confirmed by the IJC that it did not have the authority to dictate the operations of projects upstream of Kootenay Lake. The KLBC further determined that as long as the Cora Linn project was on free-flow, the Kootenay Lake Order (Order) was not being violated or otherwise not being complied with. The implication of this decision is that the operations of either Libby or Duncan are always in compliance with the Order, thereby placing no restrictions on the projects' releases during their respective winter drawdowns. So if the Libby and Duncan releases are not constrained by the Order, then the date of the spring rise has no effect on those releases, and the declaration of the spring rise is no longer needed. Therefore the CRTHC will no longer report on the declaration of the of the spring rise nor on the performance of its decision support tool.

Forecast Verification

The water supply forecasts and information on the hydrometeorology for the year are presented in the 2012 Annual Report of the Columbia River Treaty by the Entities (Section IV), and will not be repeated here. This section gives a brief overview of the forecasts and

focuses on the results of the verification of the Treaty project forecasts and any lessons learned.

Canadian Projects

The Arrow local drainage is defined as the sum of the Arrow, Revelstoke, and Whatshan basins, while the Arrow total drainage is defined as the sum of the Arrow, Revelstoke, Whatshan, and Mica basins. Arrow local and total forecasts are aggregates of sub-basin forecasts.

Columbia River Treaty forecasts for Mica, Revelstoke, Arrow local and Duncan are based solely on statistical forecast model (i.e., principal component regression). For early-season (December) forecasts, total Feb-Jul forecast volumes are disaggregated into monthly volumes using the monthly runoff distribution from the 71-year mean. For consecutive forecast dates, total Feb-Jul volumes, or the residual thereof, are calculated by aggregating BC Hydro's monthly forecast volumes and disaggregated using the monthly runoff distribution from the 71-year mean. January forecasts are naïve (climatology, 71-year mean) forecasts. August forecasts are the difference between Apr-Aug forecasts and the Apr-Jul volume of the disaggregated Feb-Jul forecasts.

2012 Highlights

- 2012 water supply forecast year was characterized by another La Niña episode. Despite the moderate La Nina signal, winter started warmer and drier than average, and snow accumulation was only slightly above average by the end of February. By the end of the snow accumulation season however, snowpack across the region was above average thanks to a wetter and cooler spring, which also caused a delay in the spring freshet.

- The February-through-July observed inflow volumes to Columbia region projects were all above average. Mica was 130% of the 71-year mean; Arrow was 129% and Duncan was 128%.

- The evolution of the water supply predictions reflected the month to month variation in the hydroclimate of the region. December forecasts were slightly above average owing to wetter than average antecedent conditions, but the January forecast dropped to near average as December turned out to be abnormally dry throughout the region.

- January saw above average precipitation resulting in an uptick in the February forecast. Forecasts also went up by early April in response to heavy snow accumulation in March. The largest month to month change in the forecast was encountered in July where high snowpack and record precipitation in June resulted in an over 10% increase in forecasts relative to the previous month.

- The June precipitation carries a negative weight in the July statistical equations for Mica. Under normal circumstances, this is plausible because heavy rain in June would for instance enhance snowmelt and reduce the residual water supply forecast. This year however, assessment of antecedent hydrometeorological conditions at the time of the forecast suggested that the residual forecast would be too low if the relationship was to be maintained. With the approval of the CRTOC, the June precipitation for two stations used in the Mica equation was set to the 1981-2010 normal to increase the residual forecast.

Despite the manual intervention, observed inflow volumes for all three projects fell above the +2 SE prediction bound for most forecast dates. The primary reason for the under-prediction error is believed to be the progressive wetting observed through the spring season that culminated with near record high flows in June and July.

Libby

The 2012 water year was classified as a weak La Niña year. The precipitation through the winter was below average but the snowpack was 110% of average through February. March was the biggest snow-building month of the winter and early spring with precipitation for the month above 300% of average at some gages; and the snowpack increased to 120% of average. The largest inter-month forecast increase was from March to April when the April-issued forecast rose by 1.2 MAF over that of March. The spring saw average temperatures in April and May with the freshet beginning earlier than it had in each of the previous three years. The month of June brought record-setting precipitation throughout the Kootenai Basin. The following section goes into more detail on the June precipitation. The observed April-August seasonal average snowpack was 156% of average. As seen in the table below, Libby Dam was significantly under-forecasted for the seasonal volume forecasts issued from December through June (a positive value for number of standard errors indicates an under-forecast). The under-forecasting was due mainly to the heavy precipitation in the Kootenai basin from June through mid-July. The following section goes into some detail on the June precipitation.

Month of Forecast	First-of-Month Apr-Aug Volume Forecast (KAF)*	Model Standard Error (KAF)	Number of Standard Errors Different Than Observed	End-of-Month Flood Risk Management Target (FT)
Dec	5876	947	3.5	2412
Jan	5524	841	4.4	2410
Feb	5714	564	6.2	2408
Mar	5635	527	6.8	2402
Apr	6872	532	4.4	2390
May	7159	487	4.2	
June	7240	418	4.7	

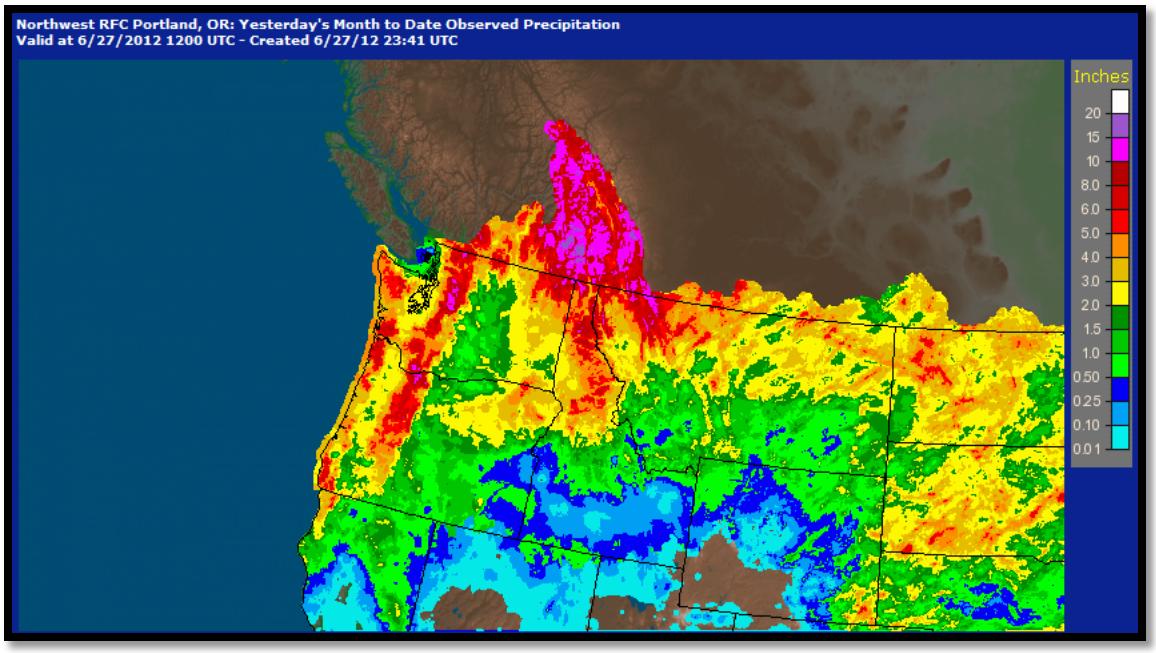
**Note that the Observed April-August Libby inflow volume was 9200 KAF*

June Precipitation in the Kootenai Basin

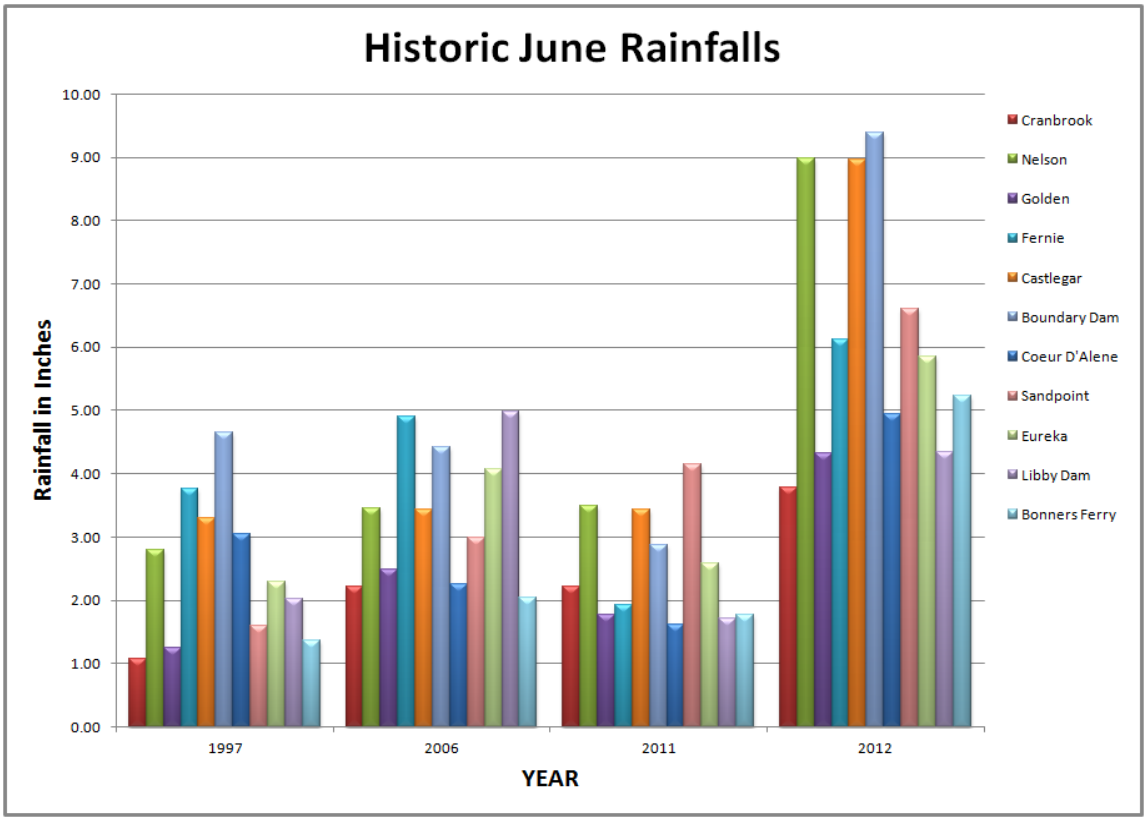
In June, the Kootenai Basin and surrounding areas received high amounts of precipitation from multiple strong rainstorms. The map on the following page shows the estimated totals as reported by the Northwest River Forecast Center and the geographic coverage of the June precipitation extending into the Kootenai Basin through the Upper Columbia Basin. The heavy precipitation was not restricted to a localized area. The figure on the next page shows monthly rainfall totals at several gages compared against recent years with high precipitation for the month of June. From the bar chart, 2012 precipitation in June nearly doubles previous totals for the month over the last 15 years. In the region, many of the

precipitation gages recorded new records significantly greater than previously observed. In the bullets below, the amount of precipitation that occurred at three gages in June with previous records and number of observations.

- Boundary Dam – 9.38”
    - Wettest June on record (5.47” in 2005)
    - Wettest month on record (6.92” in Nov 1983)
    - Records back to 1965 = 47 years of observations
- Bonners Ferry – 5.23”
    - Wettest June on record (4.27 in 2010, 3.96” in 1981)
    - Not the wettest month on record (8.38” in Nov 1973)
    - Records back to 1907 = 105 years of observations
- Kalispell – 6.20”
    - Wettest June on record (5.66” in 2005)
    - Wettest Month on record (6.02” in Jul 1993)
    - Records back to 1899 = 113 years of observations



Map of June total estimated precipitation for 2012 by the Northwest River Forecast Center Portland, OR



June precipitation at regional gages compared to June of 1997, 2006 and 2011

Schedule 1 CRTHC Action Items

Meeting Source	Description	Notes/Updates	Assigned To	Due Date	Completed
OUTSTANDING ACTION ITEMS					
60.4.b	Establish a data working group to address ongoing data issues, document and improve data transfer protocols, and coordinate communication around changes and updates to data management systems.	NWS reps will be Harold Opitz and Kevin Berghoff Data group will be discussed in Feb 2011 CRTHC meeting. MTG 69: group has formed organically from BCH CROHMS redesign	All - with Corps as lead agency.	revisit in 2012	
60.4.c	Disaster Recovery plans - Stephanie to determine what, if anything, BC Hydro will do about data recovery in the event of a major system interruption	BCH working on in 2011. BCH has established a remote/backup site in Calgary Pushing data to CROHMS to happen in future	Stephanie Smith	ongoing	
64.2.d	Ensure that BPA and BCH data requirements addressed when CWMS v2.x is deployed	Deployment has been delayed and further delays are expected due to staffing and fiscal issues. CROHMS user survey is in progress to canvas for input.	Corps	Sep-2012	
69.3.e	review POP section 4.4.B and propose improved wording	Peter	Peter		
69.3.e	document specific components of how TSR forecasts are put together in CRTHC Supplemental Report		Peter	Sep-2013	
69.3.f	Document decision process for approving changes to water supply forecast inputs through CRTHC reps in CRTHC Supplemental Report. Alternates: Corps: Ron Malmgren; BPA: Steve Hughes, BC Hydro: Adam Gobena. Review each Fall.		Peter	Fall 2013	
69.5.a	Snow pillow site selection: 1. Keystone Creek moving to permitting. 2. Yoho Park Environment Canada site - BCH to discuss with Env Canada. Remaining 3 sites yet to be selected. BCH to send QC data to BPA for Canoe River, Mt Templeman, Field, Duncan Lake no. 2.	A work in progress. Only Keystone Creek is moving forward.	BCH/ BPA	2013	
69.5.c.	Present updates to Mica turbine curves to CRTOC	Possibly ready by October CRTOC [CHANGE DUE DATE?]	Stephanie Smith	Oct-2012	
69.5.d	Updates to Stations database: 1. Add columns for Start and End dates – Adam 2. Post Stations database spreadsheet to Sharepoint - Adam 3. Add LIB, DWO, HGH station lists - Peter	Items 1 and 2 done. New technician working for Peter to start soon. Peter's part moved to new item 70.2.c	Peter	2013	
70.2.c	Add Libby, Dworshak, and Hungry Horse station lists to database		Peter	Jun-2013	
70.4.d	Find individually archived CRTHC documents and upload to SP site		all		Ongoing

Table 1 Outstanding Action Items 2012

COLUMBIA RIVER TREATY
HYDROMETEOROLOGICAL COMMITTEE

Meeting Source	Description	Notes/Updates	Assigned To	Due Date	Completed
COMPLETED ACTION ITEMS					
66.6.e	Agree on a clear definition 'Treaty and Supporting Stations'		All		Will use original treaty Language
67.3	Update POP Appendix 7 with 2010 level Modified Flow information once adopted		Ann	Oct-2012	Done
68.5	Track NWRFC ESP generated forecast throughout the year and impact on treaty operations. Re-evaluate recommendation of 4th working day for forecast use for future years		All	Nov-2012	Done
68.6	Create MOU between BPA and BCHydro for installation and maintenance of new snow pillows		Erik Pytlak and Stephanie Smith	Jun-2012	Done
69.3.b	BCH to update distribution list for Kootenay Lake Freshet decision support reports – Dan Miller retired, Ann McManamon to be added		Adam	Mar-2012	Done
69.3.e	provide TSR spreadsheet to Barbara Miller at Corps		Ann	Mar-2012	Done
69.5.c.	Investigate issues with timeliness of Porthill and Bonners Ferry data getting to BCH		Ann	Oct-2012	Done
69.6.a.	Libby forecast performance discussion in 2011 Annual Report was inadequate. Peter to discuss with Seattle District forecasters what is expected in the forecast review discussion.		Peter	Aug-2012	Done
69.6.b	Stephanie to email out copy of the Supplemental report for editing. All edits to be returned to Stephanie		Stephanie	May-2012	Done
69.6.b	Appx D – list of agencies needs to be updated		all	Nov-2012	Done
69.6.b	Appx E – descriptions of data comms and storage systems – to be updated		all	Nov-2012	Done
69.6.b	Appx F – Data exchange reports – to be updated		all	Nov-2012	Done
69.6.b	Appx G – Add detail on how TSR numbers are produced (Peter); Update Water Supply forecasting section (Adam & Ann); Review Monthly section (Peter)		Peter, Adam, Ann	Nov-2012	Done
69.6.c	Ann still can't access CRTHC Sharepoint site. Peter to have Scott Keller contact Ann directly. Peter to set up access for Adam on Sharepoint site		Peter	Mar-2012	Done
70.3.b	Adam to review spring freshet email distribution list		Adam	Nov-2012	Done
70.5.b.2	Prepare draft of input to Treaty Annual report		Peter	Aug-2012	Done
70.5.b.3	Prepare draft slides for PEBCOM and PEB		Peter	Sep-2012	Done
70.5.b.4	Prepare draft CRTHC Annual and Supplemental Reports		Peter	Nov-2012	Done
70.3.d	Prepare recommendation to CRTOC for use of ESP				Done

Table 2 Completed Action Items 2012