NORTHERN WATER
2010 WATER QUALITY REPORT

FLOWING SITES: STREAMS, RIVERS AND CANALS

A snapshot of water quality conditions in the C-BT and Windy Gap projects
& an assessment of any recent changes in water quality

THE REPORT

Analysis was done at 43 sites (14 in streams on the West Slope, 12 in streams on the East Slope and 17 in C-BT conveyance/canal system sites) from October 2000 to September 2009.

Basic statistical and graphical procedures were used to reveal spatial and temporal patterns and trends in the existing data. The statistical procedures used in the study are mostly nonparametric methods (not assuming a normal or any particular distribution shape) and are therefore "robust" or relatively uninfluenced by outliers. These procedures are particularly appropriate for use with environmental data, which tend to contain outliers.

RESULTS AND HIGHLIGHTS

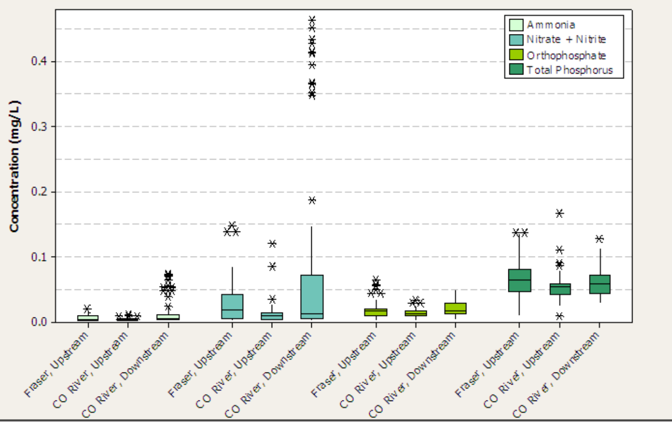
In general, water quality in the C-BT system is good. Most parameters are detected at low concentrations and in compliance with state water quality standards. Many sites are not impacted by anthropogenic activities such as wastewater effluent or agriculture, as evidenced by the low nutrient concentrations at these sites. However, nutrients remain of concern in this system; given the low concentrations and the dynamics of the C-BT system, small changes in concentrations can have a significant effect on overall water quality and ecosystems. Trends in water quality and inputs into the system from areas with higher concentrations should be closely monitored.

WINDY GAP SITES

Data shows the Fraser River has a significant impact on water quality in the Colorado River below Windy Gap Reservoir (Fig. 1). This is particularly true for nutrients, chlorophyll-a and pH, which are often elevated in the Fraser River, especially in late summer. Concentrations in the Fraser River drive concentrations downstream of Windy Gap Reservoir and in the water pumped from Windy Gap Reservoir into Granby Reservoir, which is a source of nutrient loading into the Three Lakes System.

Monitoring at Windy Gap sites will continue through the Baseline Monitoring Program, including weekly monitoring during pumping.

Fig. 1 - Nutrient Concentrations Above and Below Windy Gap



STILLWATER CREEK

Water quality in Stillwater Creek presents very different characteristics relative to the rest of the C-BT system and more specifically relative to the other inlets to the Three Lakes.

Orthophosphate (Ortho P), total phosphorus (TP), iron, alkalinity, total organic carbon, and to a lesser extent manganese, are remarkably elevated in this watershed in comparison to the rest of the system. Natural occurrences from geologic formations in the watershed are strongly suspected to be the cause.

Targeted monitoring in the Stillwater Creek watershed will help identify sources of nutrients and contributions from irrigation return flows.

Further investigation of the possible short-circuiting of Stillwater Creek flows directly into the Granby Pump Canal also needs to be done to understand whether it is a significant contributor to Shadow Mountain Reservoir algal productivity and overall nutrient loading.

ARAPAHO CREEK

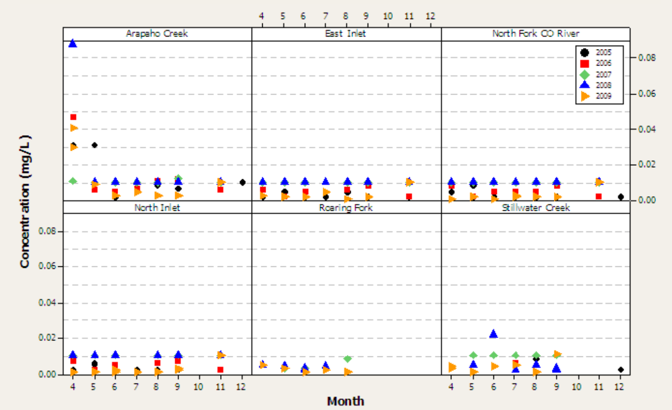
Elevated ammonia occurs in Arapaho Creek, a tributary to Granby Reservoir, in April and is at the highest ammonia concentrations in the C-BT (Fig. 2).

The source of ammonia is not known although decaying organic matter in the winter in Monarch Lake (a very small lake upstream of the sampling site) could be the source. Low dissolved oxygen occurs under the ice causing anoxic conditions and can release ammonia from sediment. Cold temperatures also slow down nitrification processes, which remove ammonia from the water column by converting it to nitrate.

Although no winter data were collected for this site, potentially elevated concentrations throughout the winter months may impact nutrient loading into the Three Lakes System, even at low flows.

Winter data has been collected at this site since 2011 and a streamflow gage was installed on Arapaho Creek to help assess the magnitude of nutrient loading on the Three Lakes system from this watershed.

Fig. 2 - Ammonia in Arapaho Creek Compared to Three Lakes Inlets



THE NORTH FORK OF THE COLORADO RIVER

Data show an increase in total phosphorus in the past ten years in the North Fork of the Colorado River.

A breach in the Grand Ditch in spring 2003 flushed a significant amount of sediments into the North Fork. This may be an important contributing factor to the observed increase as sediments are often phosphorus laden.

The influx of sediments and debris was most significant in 2003 but has continued to a lesser extent.

Beyond the 2003 breach, erosion and sedimentation are known issues in the North Fork of the Colorado River that, over time, have led to the formation of a delta in Shadow Mountain Reservoir.

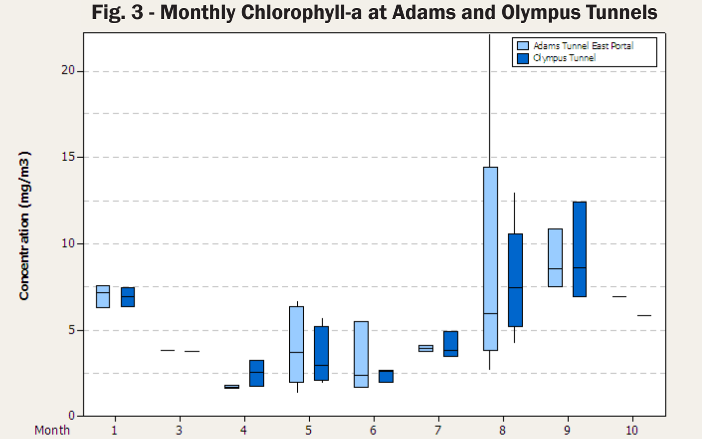
They will be part of the Three Lakes Nutrient Study to better characterize sediment and nutrient loading associated with this watershed and the impact in Shadow Mountain Reservoir and Grand Lake.

ADAMS TUNNEL AND OLYMPUS TUNNEL

As water moves from the West Slope to the Front Range via Adams and Olympus Tunnels, the water quality remains generally good and concentrations are low, reflecting the water quality of the Three Lakes System. The exception is chlorophyll-a. Chlolorophyll-a is noticeably higher at Adams and Olympus Tunnels in August and September coinciding with peak algal productivity in Grand Lake and Shadow Mountain Reservoir (Fig. 3). Algal productivity in these water bodies and the subsequent movement of water to the East Slope needs to be monitored closely since some species, especially blue-green algae, can cause taste and odor issues in drinking water supplies and increase the risk of algal toxins.

There is a general decline in water quality as water moves from the Adams Tunnel into the Olympus Tunnel. This is due to mixing of transmountain water with both the native inflows of the Big Thompson River and wastewater treatment plant effluent in Lake Estes. Monitoring at the tunnels will continue through the Baseline Monitoring Program.

Fig. 3 - Monthly Chlorophyll-a at Adams and Olympus Tunnels



TOTAL ORGANIC CARBON

Temporal trend analysis shows an increase in total organic carbon from 2000 to 2009 at many East Slope canal sites, particularly in the Hansen Feeder Canal. Temporal trend analyses at the Adams and Olympus tunnels from 2005 to 2009 also show an increase in total organic carbon concentration over time. This indicates that West Slope water contributes to the increases in total organic carbon in the Hansen Feeder Canal.

The pine beetle epidemic on the West Slope is suspected to be a contributing (although not confirmed) cause of increases in total organic carbon since dead trees provide organic matter inputs into the system.

Recent data analysis conducted by the City of Fort Collins indicates that inputs from the Big Thompson River contribute significant total organic carbon into the Hansen Feeder Canal as well.

Although the calculated changes in total organic carbon concentrations are all very small from a stream water quality perspective, this should be re-evaluated in the next report including new data collected at the Three Lakes Inlet sites. Increasing total organic carbon concentrations are of significant concern for drinking water treatment plants because higher total organic carbon in raw water results in higher disinfection byproducts (regulated compounds) in finished water.

Total organic carbon trends need to continue to be monitored closely. UV254 analysis was added to the Baseline Monitoring Program in 2012 to help characterize sources of total organic carbon in the C-BT system (terrestrial humic sources vs. algal sources).

EAST SLOPE CANALS

On the Hansen Feeder Canal, inputs of Big Thompson River water at the trifurcation via the Dille Tunnel can degrade the canal water quality. The report showed Big Thompson water to be a source of total nitrogen, orthophosphate, iron, pH and most significantly, chlorophyll-a and total organic carbon. Chlorophyll-a and total organic carbon both have important implications from a drinking water standpoint.

In general, the quality of water is degraded as it moves downstream and through developed areas. The most noticeable degradation occurs as water moves south from Carter Lake toward Boulder Reservoir.

The water moving north from Flatiron Reservoir through the Hansen Feeder Canal is less impacted by development and is generally higher in water quality.

EAST SLOPE STREAMS

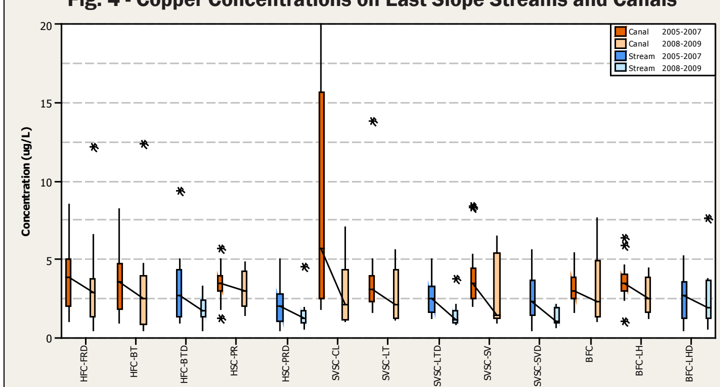
In general, water quality in the canals is better than that of the South Platte tributaries, and canal inputs into the streams improve water quality through dilution.

The exception is copper, used as an algaecide in the form of copper sulfate in canals before 2008. During this period, both the canals and the receiving streams were subjected to an influx of copper, a significant but not sole factor for most of the stream segments listed as impaired for copper.

The use of copper sulfate was discontinued in 2008, and since then there has been a decline in copper concentrations as evident in the median concentration in both canals and receiving streams (Fig. 4).

There are occurrences of elevated pH in the Saint Vrain River below the Saint Vrain Supply Canal in the late summer. This may be related to periphyton growth. Currently this stream segment is not listed as impaired for pH on the 303d list but pH should be closely monitored in the future as this could become an issue.

Fig. 4 - Copper Concentrations on East Slope Streams and Canals



INFLOWS & OUTFLOWS, EAST SLOPE RESERVOIRS

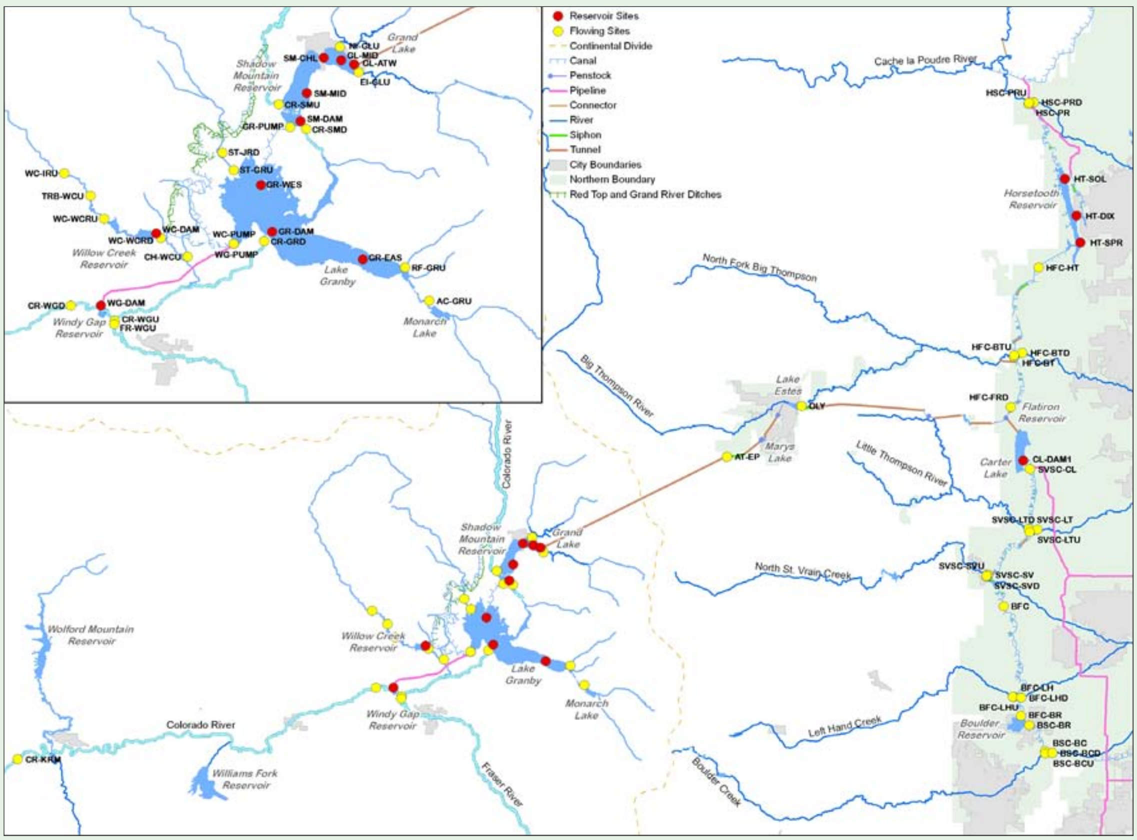
All three reservoirs on the East Slope (Horsetooth, Carter and Boulder) display differences in water quality between the inflows and the releases. For most constituents, concentrations decrease from inflow to outflow indicating that the constituent is accumulating in the sediment in the reservoir or taken up by biological processes. Nitrogen may be removed from the system entirely by de-nitrification. In a few cases, concentrations increase from inflow to outflow as a result of additional sources, releases from sediment, or biological processes.

Water quality changes within a reservoir are the result of many physical, chemical, and biological processes including flow dynamics, thermal stratification, mixing by wind, turnover, biological oxygen addition and removal, and many others. These processes will be discussed in a separate report that specifically addresses water quality in the lakes and reservoirs of the C-BT system.

SPECIFIC CONDUCTIVITY

As shown in the 2007 water quality report, there is a continuing trend of increased specific conductivity over time at many of the sites in the C-BT system. The magnitudes of the trends are small, and there are no impairments to existing uses as a result of current or projected salinity levels. The trends will be monitored and evaluated in future reports.

Northern Water's Water Quality Monitoring Program



As the Northern Front Range population continues to increase, ownership of C-BT Project water allotment contracts increasingly shifts from the agricultural to the municipal and industrial water users. This trend parallels an increased public awareness of water quality and environmental issues and a strengthening of the regulatory framework both at the federal and state levels.

The CB-T Project is a major drinking water supply source for most municipalities it serves, therefore protection of the watersheds associated with the project has become of particular concern as drinking water treatment requirements get tighter.

In response to these developing needs, Northern Water has continuously expanded its water quality related activities over the past 20 years. The backbone of the Water Quality Program is the Baseline Monitoring Program, which started in 1991. As new water quality challenges surface, new monitoring programs are developed to target specific areas of concern and studies are carried out to address identified water quality issues.

The objectives of the Baseline Monitoring Program are to:

- Monitor trends and changes in water quality in lakes and reservoirs and flowing sites: streams, rivers and canals
- Assess potential water quality changes in receiving streams, upstream and downstream of where C-BT Project and Windy Gap Project water releases
- Assess compliance with state water quality standards

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QUESTIONS?

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