

CAKN Stream Monitoring Program

2014 Field Season Report



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On the cover: Waterfall on an unnamed stream in the East Fork Basin of the Little Bremner River, WRST. The CAKN Stream Monitoring Program sampled two streams in this area in 2014

Summary

During the 2014 field season, the Central Alaska Network (CAKN) Stream Monitoring Program made 58 sampling visits to 37 unique stream sites across the network (Figure 1), with each site being sampled one to two times from early May through late September. High water prevented sampling during a number of additional site visits. Field work was scaled back in comparison to previous years to allow more focus on management and analysis of data collected in previous years. The data collected included instantaneous water chemistry, stream flow, water chemistry samples, macroinvertebrates, stable isotope samples, habitat data and environmental DNA (eDNA) samples. We successfully used eDNA to detect the presence of multiple fish species at several sites in the network. Continuous year-round temperature monitoring at 22 sites across the network is ongoing, and is now in its 7th year at some sites. A number of temperature dataloggers were replaced during 2014. Active layer depth and continuous soil temperature data were collected for the 6th year at 2 CALM plots in WRST. A time-lapse camera installed in 2012 at Jack Creek in WRST to monitor flow, turbidity and the timing of freeze-up and break-up failed again over the winter, but new high-performance batteries should solve this problem going forward. Four site visits were made to the stream gage on the Nabesna River just outside of WRST to perform station maintenance and collect discharge and water chemistry data. This gage has been operated as a cooperative effort between CAKN, The US Fish and Wildlife Service and the NOAA River Forecast Center since 2012. 8 years of continuous discharge and temperature data have now been collected. Logistical problems led to the cancellation of most data collection in YUCH, although water chemistry and environmental DNA samples were collected from 2 sites. We collaborated with Matt Nolan at UAF to test the utility of high-resolution photogrammetry to detect channel change in rivers. A final version of the CAKN Stream Monitoring Program 2011 Annual Report will be available as a Natural Resources Technical Report by the end of the calendar year (Annual Reports for 2006-2010 are available at the CAKN website - <http://science.nature.nps.gov/im/units/cakn/reportpubs.cfm>). The Stream Monitoring Protocol, including a Protocol Narrative and 19 Standard Operating Procedures, is in peer review; a final version should be in publication as a Natural Resource Report within several months.

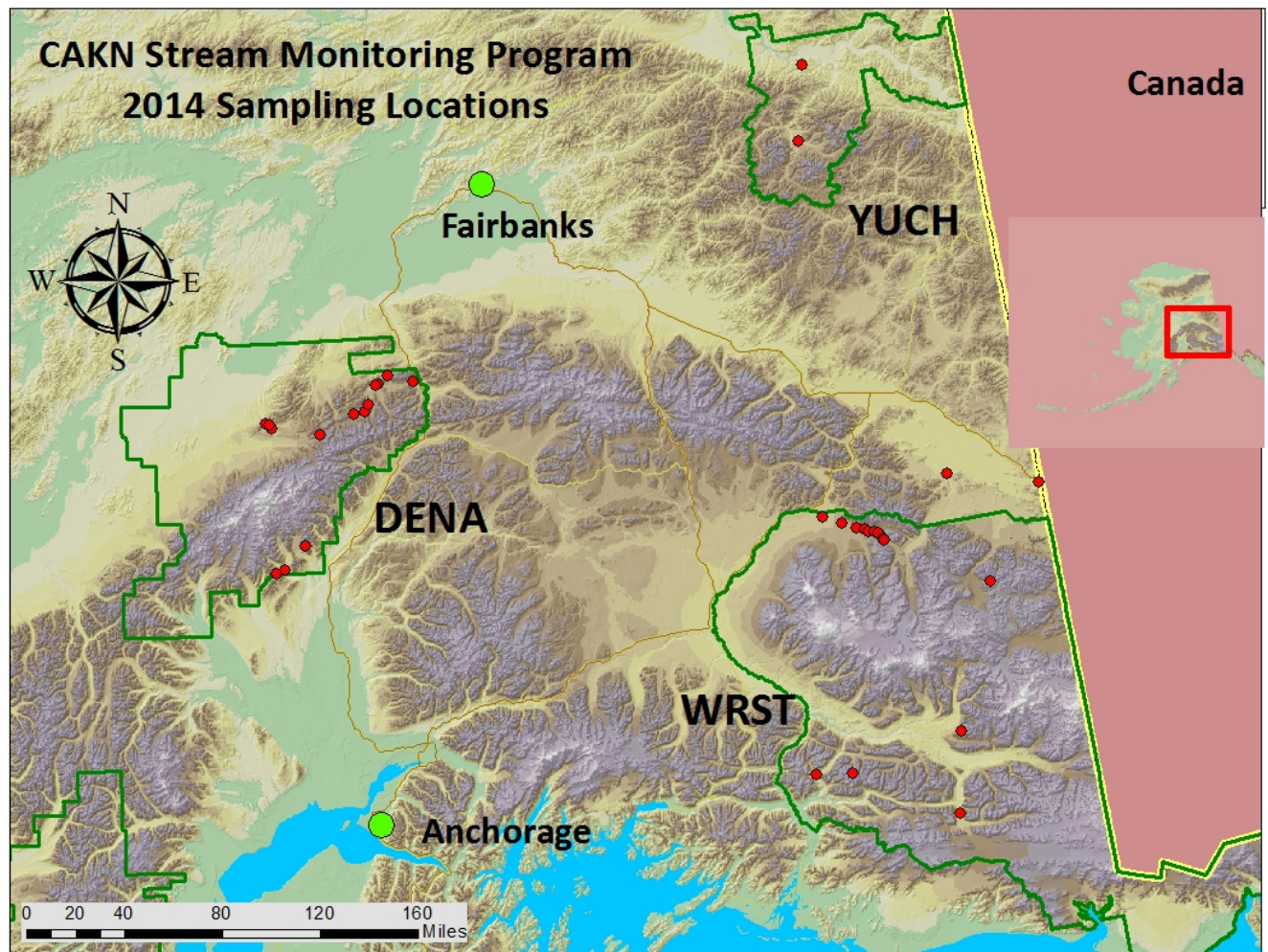


Figure 1. Locations of sites sampled by the stream monitoring program during 2014. Individual sites were sampled one to two times from May through September.

Continuous temperature data collection

Beginning in 2008, continuously recording temperature loggers have been deployed in streams along the Denali Park Road, and along the Nabesna and McCarthy Roads in WRST. At present, there are temperature loggers deployed at 22 sites in DENA and WRST (Table 1). There are currently no dataloggers deployed in YUCH, but I am planning on doing so starting in 2015. For the first two years, the dataloggers were deployed in late spring and removed in the fall, but are now left in place throughout the year. Currently the dataloggers are changed out approximately every 2 years, although because temperature data are recorded hourly, there is enough memory to leave them deployed for 3 years in cases where they cannot be retrieved after 2 years. In 2014, 4 recorders were changed out, and new ones were deployed at Little Stony Creek and Savage River in DENA, sites where the previously installed loggers had been lost. Continuous temperature data will allow us to detect changes in the temperature regimes of park streams over time. Exploratory analysis of data collected to date has revealed a variety of temperature regimes among network streams, and substantial variation among years at some sites, but no temporal trends.

Table 1. Locations of currently-deployed continuous temperature recorders in CAKN parks.

Site Code	Site Name	Park Unit	Notes
DENA-001	Rock Creek	DENA	Since 2009
DENA-008	Little Stony Creek	DENA	Since 2008
DENA-017	Tattler Creek	DENA	Since 2009
DENA-021	Hogan Creek	DENA	Since 2008
DENA-029	Lake Creek	DENA	Since 2008
DENA-033	Gorge Creek spring	DENA	Since 2009
DENA-034	Wonder Lake inflow	DENA	Since 2012
DENA-GRTS-010	Moose Creek	DENA	Since 2008
DENA-GRTS-014	E.F. Toklat tributary	DENA	Since 2009
DENA-GRTS-060	Savage River	DENA	Since 2008
DENA-GRTS-084	Igloo Creek	DENA	Since 2008
DENA-GRTS-104	Sanctuary River	DENA	Since 2008
WRST-004	Chalk Creek	WRST	Since 2008
WRST-006	Rock Creek	WRST	Since 2008
WRST-013	Gilahina River	WRST	Since 2008
WRST-015	Little Jack Creek	WRST	Since 2008
WRST-036	Rufus Creek	WRST	Since 2009
WRST-039	Caribou Creek	WRST	Since 2008
WRST-051	Long Lake Creek	WRST	Since 2008
WRST-060	Paco Creek	WRST	Since 2011, @ Mile 27 Nabesna Road
WRST-GRTS-032	Crystal Creek	WRST	Since 2010
WRST-GRTS-130	Jack Creek	WRST	Since 2008

Field data collection

Collection of field data during repeated visits to selected sites across the network is a critical component of the CAKN Stream Monitoring Program. Three types of sites are sampled – sentinel sites, GRTS sites, and judgment sites. Sentinel sites, all of which are currently located along the Denali park road and the Nabesna and McCarthy roads, are sampled approximately annually to maximize our ability to detect changes. Some of these sites are also sampled multiple times per year as a way to help quantify seasonal variability in ecological metrics. Many of the sentinel sites in DENA were originally part of the Long Term Ecological Monitoring (LTEM) program. Although at this point there are no sentinel sites in YUCH, because there are no road-accessible areas, we plan to identify at least one in the near future. GRTS sites are selected using a probabilistic algorithm (known as “Generalized Random Tessellation Stratified”, or “GRTS”). Sampling based on a probabilistic survey design allows us to use data collected at these sites to infer conditions at sites that have not been sampled. Although some of these GRTS sites are also sentinel sites (due to a coincident location with an existing sentinel site), most are in the backcountry and will be sampled approximately once every 10 years due to the high cost of accessing them. Judgment sites are selected on an *ad hoc* basis, and for a variety of reasons. For example, the so-called “Travertine stream”, located along the DENA park road near Stony Creek, has been sampled occasionally due to its unusual water chemistry. Lake Creek was selected to make sure that a lake outlet stream was included in the set of DENA sentinel sites, since their biogeochemistry and ecology are often quite different from other stream types. Similarly, in 2012 we sampled a tributary to Toby Creek in WRST because it was a small clearwater stream (sourced in a rock glacier) in a high-elevation glacial valley, and sampled Hidden Creek in WRST because it should be relatively ecologically isolated by the Kennicott Glacier. In both of these cases I was attempting to broaden the ecological scope of streams that have been sampled. This is a critical aspect of the overall

sampling approach of the Stream Monitoring Program, because probabilistic sampling schemes do not necessarily capture the full range of ecological conditions across a landscape, something that is important for ecological modeling. In 2014, we revisited and sampled two sites on the south side of the Alaska Range in DENA (upper Alder Creek and Bear Creek) that were part of the 1994-1996 parkwide water chemistry study. Judgment sites sampled in WRST in 2014 included White Creek, a high-gradient tributary of Chititu Creek, and the Sangaina River. In both of these cases, logistical considerations were paramount. White Creek was selected for its proximity to the Chititu climate station, in order to minimize flight time in a helicopter being shared with CAKN climate researchers. The Sangaina River site was sampled because the nearby target GRTS site in that valley did not have a safe landing zone; again an effort was made to minimize helicopter flight time.

Table 2. List of sites sampled by the CAKN Stream Monitoring Program in 2014

Site Code	Site Name	Park Unit	Notes
DENA-001	Rock Creek	DENA	Sampled annually, first LTEM site
DENA-008	Little Stony Creek	DENA	Sampled annually, LTEM site
DENA-017	Tattler Creek	DENA	Sampled annually, LTEM site
DENA-021	Hogan Creek	DENA	Sampled annually, LTEM site
DENA-029	Lake Creek	DENA	Sampled most years
DENA-034	Wonder Lake inflow	DENA	Sampled annually
DENA-035	Eureka Creek	DENA	Legacy mining impacts
DENA-045	Tokositna trib	DENA	Clearwater stream adjoining glacier
DENA-GRTS-010	Moose Creek	DENA	Sampled annually, GRTS site, LTEM site**
DENA-GRTS-014	E.F. Toklat tributary	DENA	Sampled annually, GRTS/LTEM site, [Coal Cr.]
DENA-GRTS-027	E.F. Toklat River	DENA	Sampled annually, GRTS site, LTEM site**
DENA-GRTS-060	Savage River	DENA	GRTS site, sampled annually
DENA-GRTS-084	Igloo Creek	DENA	Sampled annually, GRTS/LTEM site
DENA-GRTS-104	Sanctuary River	DENA	Sampled annually, GRTS/LTEM site
DENA-WQ-100	upper Alder Creek	DENA	Resample of site from 1994-96 WQ study
DENA-WQ-101	Bear Creek	DENA	Resample of site from 1994-96 WQ study
NABA2	Nabesna River	Tetlin NWR	Site of the cooperative gaging station
WRST-004	Chalk Creek	WRST	Sampled annually
WRST-006	Rock Creek	WRST	Sampled annually
WRST-011	Rock Creek tributary	WRST	Sampled annually
WRST-015	Little Jack Creek	WRST	Sampled annually
WRST-036	Rufus Creek	WRST	Sampled most years
WRST-060	Paco Creek	WRST	Sampled annually, at Nabesna Road mile 27
WRST-069	Trail Creek	WRST	Sampled annually
WRST-070	Lost Creek	WRST	Sampled annually
WRST-071	Boyden Creek	WRST	Sampled annually
WRST-074	White Creek	WRST	Judgment site
WRST-077	Sangaina River	WRST	Judgment site
WRST-GRTS-021	Caribou Creek	WRST	GRTS site, sampled most years
WRST-GRTS-130	Jack Creek	WRST	GRTS site, sampled annually
WRST-GRTS-136	Glacier Creek	WRST	GRTS site
WRST-GRTS-160	Beaver Dam Creek	WRST	GRTS site
WRST-GRTS-372	Tana Glacier trib	WRST	GRTS site
YUCH-001	Copper Creek	YUCH	Judgment site
YUCH-002	Beaton Pup	YUCH	Judgment site

"GRTS sites" are sites that were selected using an algorithm that generates a probabilistic, spatially-balanced list of potential sampling locations to maximize inference to conditions at unsampled sites.

Logistical challenges prevented active sampling in Yukon-Charley Rivers NP (YUCH) in 2014. However, water chemistry and eDNA samples were collected in cooperation with the climate research team from 2 locations (Copper Creek and Beaton Pup). The Stream Sampling Program intends to focus more effort specifically on sampling streams in YUCH beginning in 2015.

Overall in 2014, 58 sampling visits were made to 37 unique sites in the network (Figure 1, Table 2). Data collected during these sampling visits included instantaneous water chemistry, habitat characteristics and stream flow, as well as water chemistry samples, stable isotope samples, benthic invertebrate samples and environmental DNA (eDNA) samples. Analysis of eDNA using next-generation sequencing technology will be used to detect the presence of fish species and other aquatic organisms (see below). These data are used to evaluate status and trends in water quality, biodiversity and ecological integrity in park streams.

Benthic invertebrate and basin descriptor data (derived from GIS) have been used to construct several empirical predictive biological assessment models (RIVPACS models) for the Central Alaska Network. These models allow us to quantify the ecological condition of stream ecosystems, and hence their water quality, based on the degree to which the observed macroinvertebrate species composition conforms to the expected composition (as predicted by the model). The precision of the latest iteration of the RIVPACS model we have developed (as quantified by the standard deviation of derived reference site scores) is comparable to other large-scale models developed in the lower 48. These constitute the first set of RIVPACS biological assessment models ever developed for Alaska.

One potential use of this approach is to monitor the success of stream restoration projects. In 2014, the CAKN stream ecologist cooperated with Robin Henderson, a graduate student from Washington State University, in developing a sampling program that will be used to evaluate the ongoing Eldorado Creek restoration project in DENA using this RIVPACS modeling approach.

Kantishna Hills Flood

An unusual rain event occurred in the Kantishna Hills in late June. The Wonder Lake climate station recorded nearly 3 inches of rain in less than 24 hours. However, it is likely that local accumulations were significantly higher than this. The precipitation resulted in substantial flooding in Eureka Creek, and large amounts of sediment were transported down the valley and across the park road. Sediment transport was probably exacerbated by extensive historic gold mining in the catchment, which among other effects resulted in a paucity of riparian vegetation. The CAKN Stream Monitoring Program started collecting biological and chemical data from Eureka Creek in 2012. This presents an opportunity to monitor recovery of the stream ecosystem from this large disturbance event. Data were collected on two occasions in 2014 after the flood in cooperation with Robin Henderson, a graduate student from Washington State University. We plan to continue to collect data at least once a year moving forward. Figure 2 shows the extent of changes to Eureka Creek. Note that much of the valley was reworked by a bulldozer shortly after the flood. Both the location and shape of the channel have been substantially altered. In addition there is almost no riparian vegetation remaining in this section, which is likely to have a significant effect on the ecology of this section of the stream and may slow the recovery of the ecosystem.



Figure 2. Photos of Eureka Creek taken before (Aug 2012) and after (Aug 2014) the 2014 flood event. Upper left (before) is looking upstream from the bottom of the sampling reach. Upper right (after) is looking upstream from approximately the same location. Note the landslide in the upper left corner. Bottom left (before) is looking downstream from the bottom of the sampling reach. Bottom right (after) is taken from the same location, but the angle is slightly different.

Active-layer monitoring in WRST

2014 marked the 6th year of data collection at the Circumpolar Active Layer Monitoring (CALM) plots established in 2009 at two sites along the Nabesna Road in cooperation with the USGS. These sites were originally established as part of a 2-year project to examine the effects of ATV use on wetland hydrology in WRST, but we have continued to collect data at the sites. The global CALM network, established in 1991, is part of the NSF Arctic Observing Network (AON). The CALM network is an international effort containing more than 150 sites from 15 countries around the globe where long-term responses of the active layer and near-surface permafrost are observed. The two CALM plots in WRST are among the southernmost plots in North America. Each September, at the time of maximum thaw, 121 active-layer depth measurements are made in a grid overlaid on the one-hectare CALM plots in WRST. In addition, dataloggers deployed near the center of each plot record continuous soil

temperature data at depths of 0.1, 0.5, 1 and 1.5 meters. The data are submitted annually to the CALM network and are publicly available.

Use of high-resolution photogrammetry to detect channel change

Another goal of the CAKN Stream Monitoring Program is to monitor changes in stream channel morphology. Traditional cross-section based methods can be effective, but are time intensive, and provide only limited inference regarding reach-scale change. Although the CAKN Stream Monitoring Program has periodically collected channel data based on cross sections at all sentinel sites in the network, we have been looking for a better approach. In 2014, the CAKN Stream Monitoring program teamed up with Matt Nolan at UAF to test the utility of high-resolution photogrammetry for quantifying reach-scale channel change in rivers. The technique, which Dr. Nolan refers to as “Fodar”, uses a large number of overlapping aerial photographs to create a digital elevation model (DEM) with sub-meter resolution. Draping a photo mosaic onto the resulting DEM generates a detailed 3-dimensional view of the landscape (Figure 3). Subtraction of DEMs generated from aerial photos

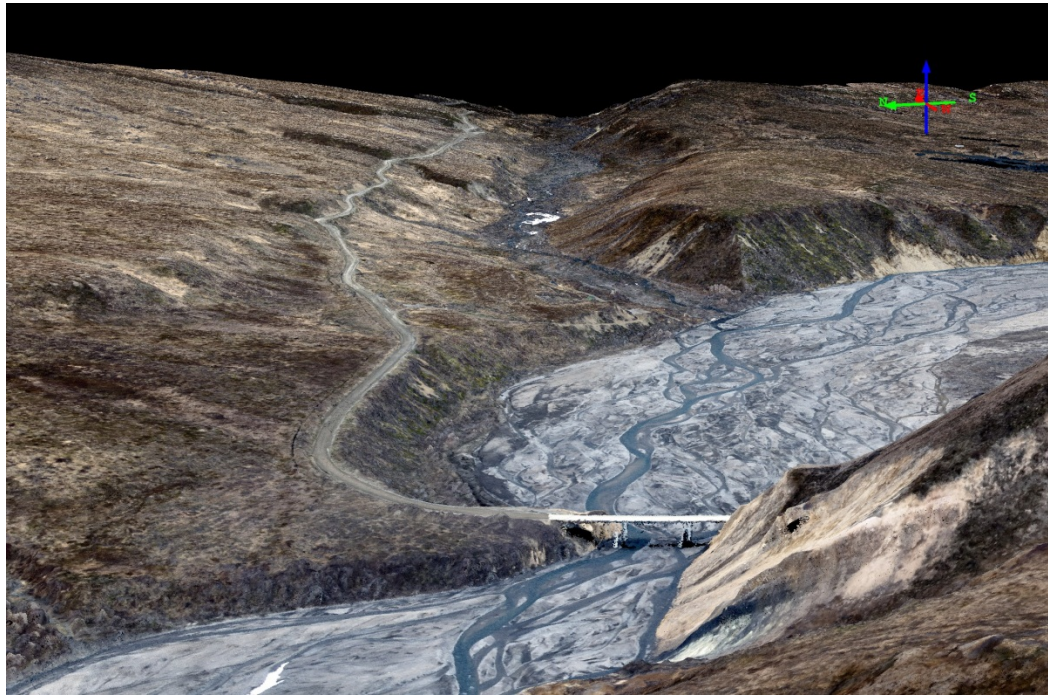


Figure 3. Oblique view of a Fodar-derived photomosaic-draped DEM of the East Fork of the Toklat River, looking southeast.

collected on different dates provides a way to detect and quantify any elevational changes that have occurred in the intervening time. We elected to test this approach for assessing channel change using the East Fork of the Toklat River in DENA. The East Fork Toklat was selected for this pilot project because it is a very dynamic system, so we expected significant change to occur over the course of a single season. Figures 4 and 5 show the results of the pilot effort. Visual inspection of Figure 4, which represents data collected in early June and late August, respectively, reveals a number of changes in the size and location of river channels. Figure 5 is a map of the resulting elevational differences over an approximately 1-kilometer river reach between the data collected on these two dates. These preliminary results suggest that this could be a viable approach to mapping and quantifying channel change in

network rivers. One challenge will be to figure out how to deal with water surfaces, which although mapped, are not accurately represented, and so generate “false” elevations. We are currently working on methods to mask out water surfaces to minimize this effect. We are planning to move forward in 2015 with additional mapping, including sites in all 3 network parks if possible.

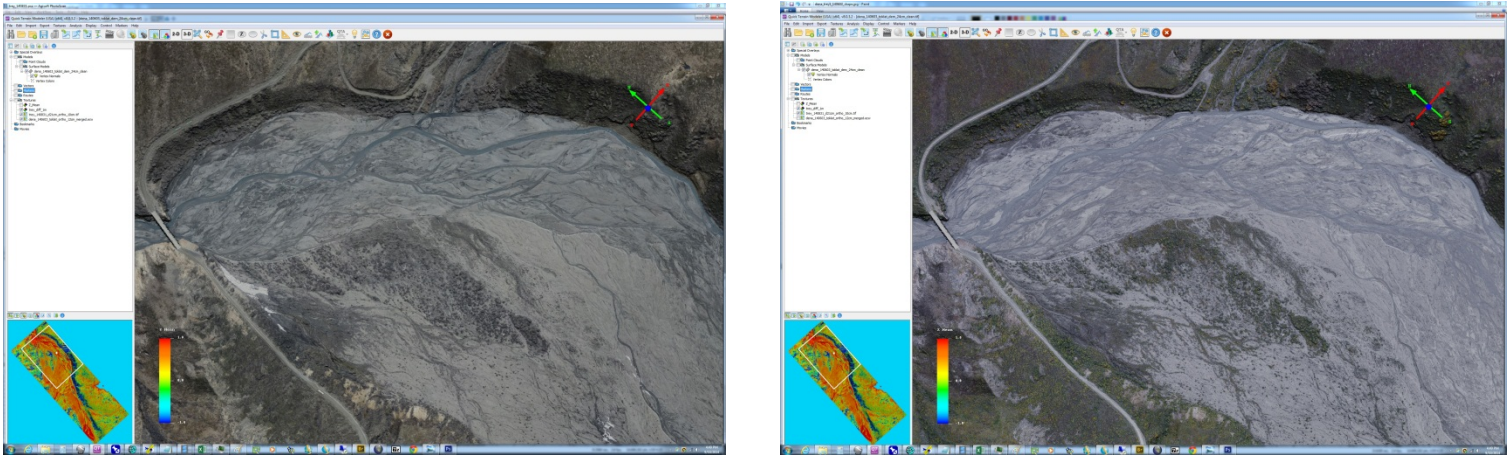


Figure 4. Photo mosaics of the East Fork Toklat River. The mosaic on the left was generated from photos taken on June 1 2014. The mosaic on the right was generated from photos taken on August 31, 2014.

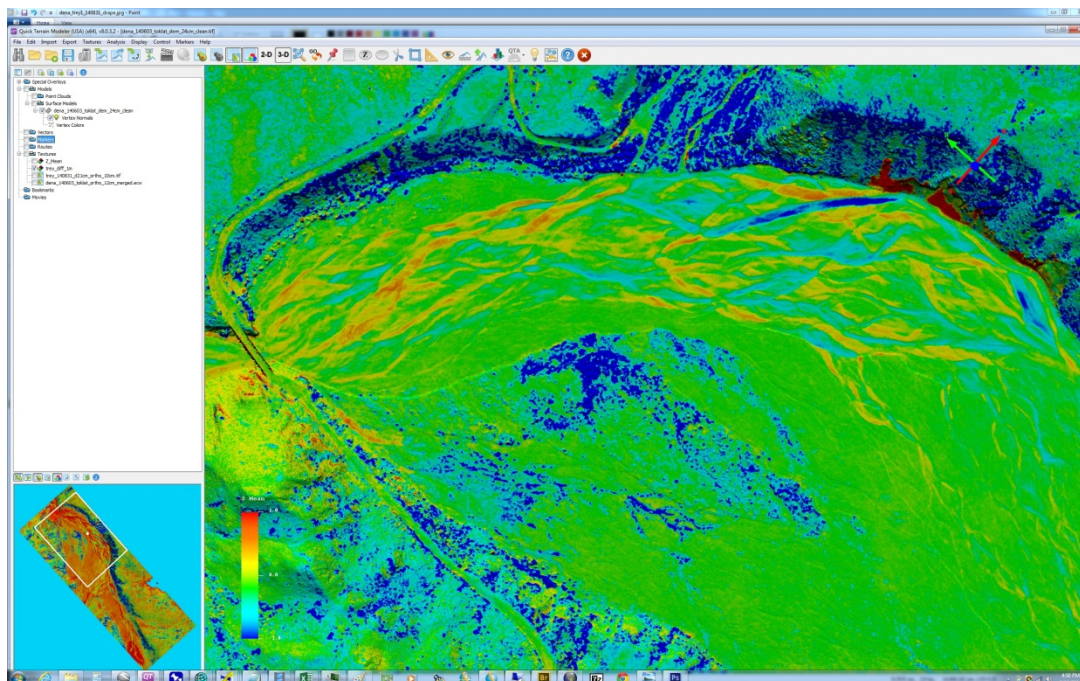


Figure 5. Elevation difference map of the East Fork Toklat River. The map was created by subtracting the DEM created from data collected on Aug 31 2014 from the DEM created from data collected on June 1 2014. Red colors indicate a net decrease in elevation, while blue colors indicate a net increase in elevation. Note that much of the “increase” that can be seen on the terraces and upland areas is a result of leaf-out on vegetation.

Nabesna River cooperative gaging station

2014 marked the third field season for the collaborative operation of the Nabesna River gaging station. This is currently the only active gaging station located within or downstream of a network park unit. This station, located a few miles downstream of WRST in Tetlin National Wildlife Refuge (NWR), has been operated by the USFWS Water Resources Branch since 2007, but was scheduled to be removed in 2012. However, the CAKN Stream Monitoring Program has entered into a collaboration with the USFWS Water Rights Branch, Tetlin NWR and the NOAA River Forecast Center to maintain the station indefinitely. Under this agreement, the CAKN Stream Monitoring Program is responsible for field data collection and station maintenance, Tetlin NWR provides staff time and logistical support for field visits, and the Water Rights Branch and NOAA are responsible for data management and analysis and publication of the data. In 2012 the CAKN Stream Monitoring Program installed a new datalogger and GOES satellite transmitter to provide real-time river stage/discharge and air and water temperature data. Real-time stage/discharge and temperature data are available at the NOAA Hydrometeorological Automated Data System (HADS) website (<http://www.nws.noaa.gov/oh/hads/>). The NWSLI Identifier for the Nabesna River station is NABA2. The NESDIS Identifier is FED0E484.

In 2014, we made 4 visits to the gaging station. In March, an under-ice discharge measurement was made, which involved drilling 30 holes through the ice using an auger. During visits in May, July and September, discharge measurements were made using an acoustic Doppler current profiler, and routine station maintenance was performed. Discharge data from this station, the only currently operating gage within or downstream of a network park, will be used to assess hydrologic conditions upstream in WRST. As of 2014, we now have 8 years of discharge data, which is approaching the data record necessary to for detecting long-term changes in flow. Starting in 2013 we have also been collecting water chemistry and eDNA samples during each site visit.

Assessing fish distribution using environmental DNA

The CAKN Stream Monitoring Program has been working with the USGS Molecular Ecology Lab since 2012 to develop methods to detect the presence of multiple fish species and other aquatic organisms in streams and lakes by analyzing DNA present in the environment (eDNA). Currently we use a portable peristaltic pump that allows us to filter large volumes of water in a relatively short time. Shed skin cells, feces and other biological material containing DNA are retained on the filter, which is then preserved in a detergent buffer. The DNA is then isolated and purified in the lab. We have developed a set of 7 mitochondrial DNA markers that in combination allow us to distinguish all 37 species of freshwater fish found in Alaska. We use polymerase chain reaction (PCR) to specifically amplify these segments of DNA and then sequence them individually using next-generation sequencing technology. The methods were worked out using water samples from an aquarium, so that species composition was known. Importantly, we successfully detected all 5 species present in the aquarium, and there were no false positives (i.e. we did not “detect” any species that were not present). Preliminary results indicate that the method works well, and that we can accurately assess the fish species composition of a water body based on a water sample, although there are still challenges in accurately distinguishing salmonids.

We are now beginning to analyze a large number of samples collected from streams and lakes in both the Central Alaska and Arctic Networks. Three of the first sites we evaluated include Eureka Creek in DENA, and Grizzly Lake and the Gilahina River in WRST. At Eureka Creek we detected slimy sculpin, a salmonid that is most likely arctic grayling, and possibly longnose sucker. Presence of fish in

this creek, which at some point had been designated fishless by DENA, was confirmed in 2014 by Robin Henderson, who observed a salmonid upstream of the road crossing, most likely an arctic grayling based on the description. In Grizzly Lake, we detected slimy sculpin, whitefish, grayling and possibly ninespine stickleback. No burbot was detected in these initial experiments, which is interesting since burbot are known to inhabit the lake. The most likely explanation is that the sample was collected from the surface, while burbot are largely benthic. Similarly, lake trout, which might be expected to occur here, were not detected and are generally restricted to deeper water. In the future it may be necessary to collect lake samples from multiple locations and depths to ensure that all species present are detected. In the Gilahina River we detected slimy sculpin, whitefish, rainbow trout, Dolly Varden, sockeye salmon, and coho salmon. We expected to detect chinook salmon as well, but did not in this initial trial. We are currently reanalyzing the DNA from these sites using slightly modified methods, which may improve our ability to detect and distinguish species. Nevertheless, we are very encouraged by the results we have obtained so far. Although there is still much work to be done, we are fairly certain that this approach will allow us to assess fish species distributions across the network for a modest cost. In 2015 we will be collaborating with researchers from the Bureau of Land Management, the US Fish and Wildlife Service, the University of Alaska and the Wildlife Conservation Society to complete development of the method, including ground-truthing our eDNA results, optimizing the sampling approach, and estimating detection probabilities for a number of species.

Monitoring stream conditions with time-lapse cameras

In 2012 the Stream Monitoring Program launched an effort to monitor the dates of freeze-up and break-up, as well as obtain continuous qualitative estimates of flow and turbidity in streams and rivers in the CAKN using digital time-lapse cameras. The first camera was deployed on Jack Creek and initially recorded high-quality images once per hour. However, the batteries failed in December. In 2013 we installed higher-quality batteries and reduced the frequency of image collection to once every 4 hours, but again the batteries failed over the winter. In September 2014 we installed very high quality lithium batteries in hopes that image collection could be maintained through the winter. We plan to check on the condition of this camera in March, allowing battery replacement if necessary before river break-up. Once the method is worked out the program hopes to expand the network of cameras across all 3 CAKN parks. This constitutes a very low-cost method of recording qualitative river stage data, as well as monitoring river break-up and freeze-up.

Cumulative stream sampling and additional data sources

Since 2006, the CAKN Stream Sampling Program has made 686 sampling visits to 176 unique sites across the network. Figure 6 shows the locations of all 176 sites. Individual sites have been sampled from one to 34 times over that period. Not all data types were collected at each visit, although the 4 core water chemistry parameters (temperature, specific conductivity, pH and dissolved oxygen) were collected every time unless the stream was waterless at the time of the site visit. Examination of Figure 6 reveals that some areas of the network are underrepresented, most notably in YUCH. This is partly due to the phased roll-out of the monitoring program, which initially focused on WRST, and then expanded gradually to include DENA and then YUCH. In addition, logistical complications and compliance issues have interfered with efforts to expand sampling in YUCH over the last several years. The program hopes to begin remedying this situation with an increased focus on sampling in YUCH in 2015. Other areas that remain underrepresented include the western half of DENA, as well as the far

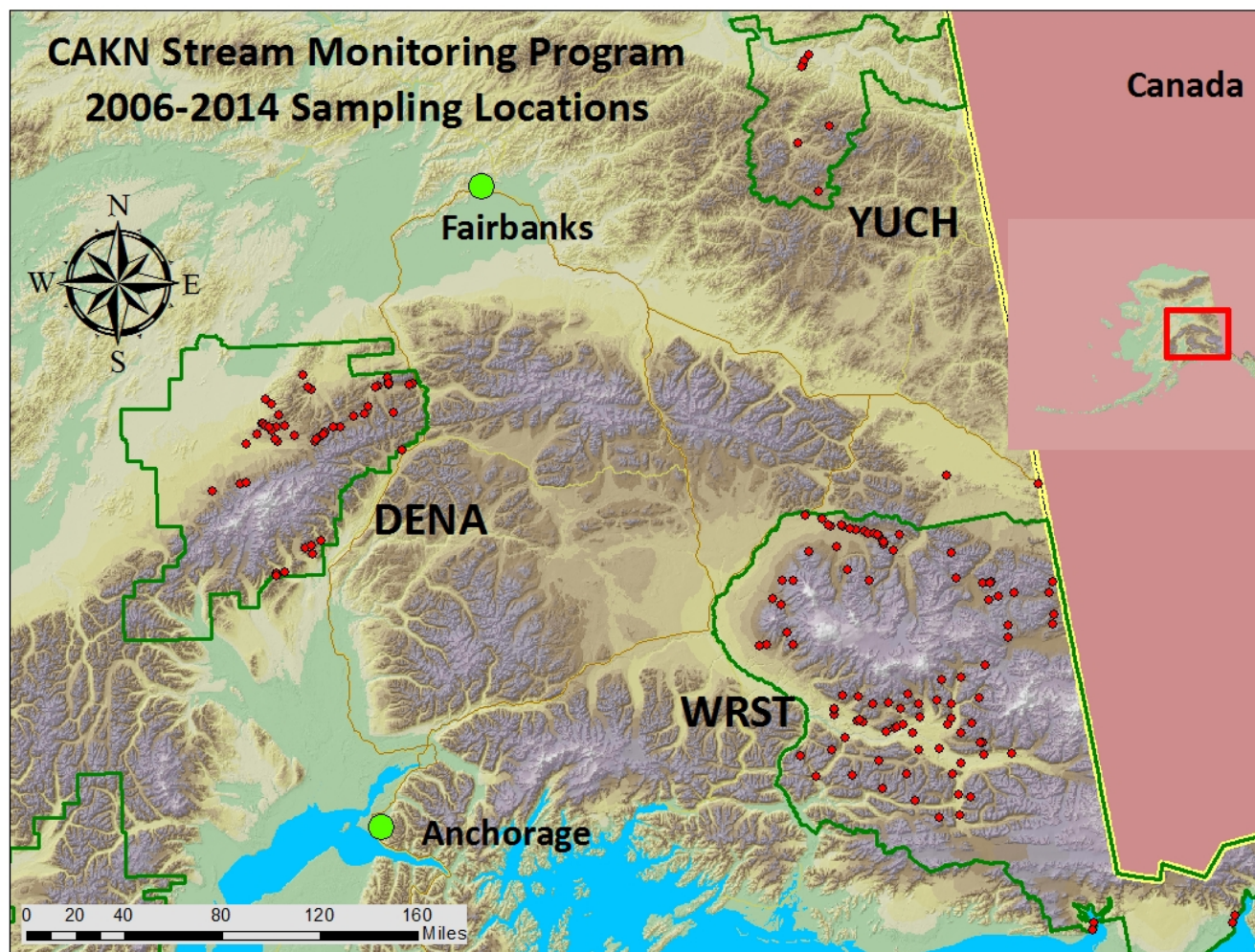


Figure 6. Locations of all sites sampled by the CAKN Stream Monitoring Program since 2006. The majority of sites have been sampled once, but some sites have been sampled as many as 34 times.

northeastern, southeastern and coastal areas of WRST. This is primarily due to the difficulty and high cost of accessing these areas by helicopter. Not shown in Figure 6 are 12 sites that were sampled in Tetlin National Wildlife Refuge in 2014 as part of a new cooperative effort with the US Fish and Wildlife Service. 12 sites in Tetlin NWR were sampled for eDNA, including both lakes and streams.

As part of an ongoing effort to improve the performance and geographic scope of the RIVPACS biological water quality assessment models that the program is developing, as well as to improve modeling of water chemistry regimes across the network, we have been actively engaged in locating and incorporating stream data collected by other agencies and programs. As of 2014, we have begun to incorporate data from two additional sources, as shown in Figure 7. In 2004-2005, the Environmental Protection Agency (EPA) provided funds to the Alaska Department of Environmental Conservation to collect biological, chemical and habitat data from wadeable streams in the Tanana Basin. The field protocols used in this effort, known as the Alaska Monitoring and Assessment Program (AKMAP), were very similar to those that the CAKN Stream Monitoring Program uses (which are largely based on EPA methods), which greatly simplifies the process of combining data from the two data sets. AKMAP data were collected at 44 sites across the Tanana Basin. Only two of these sites are located within the

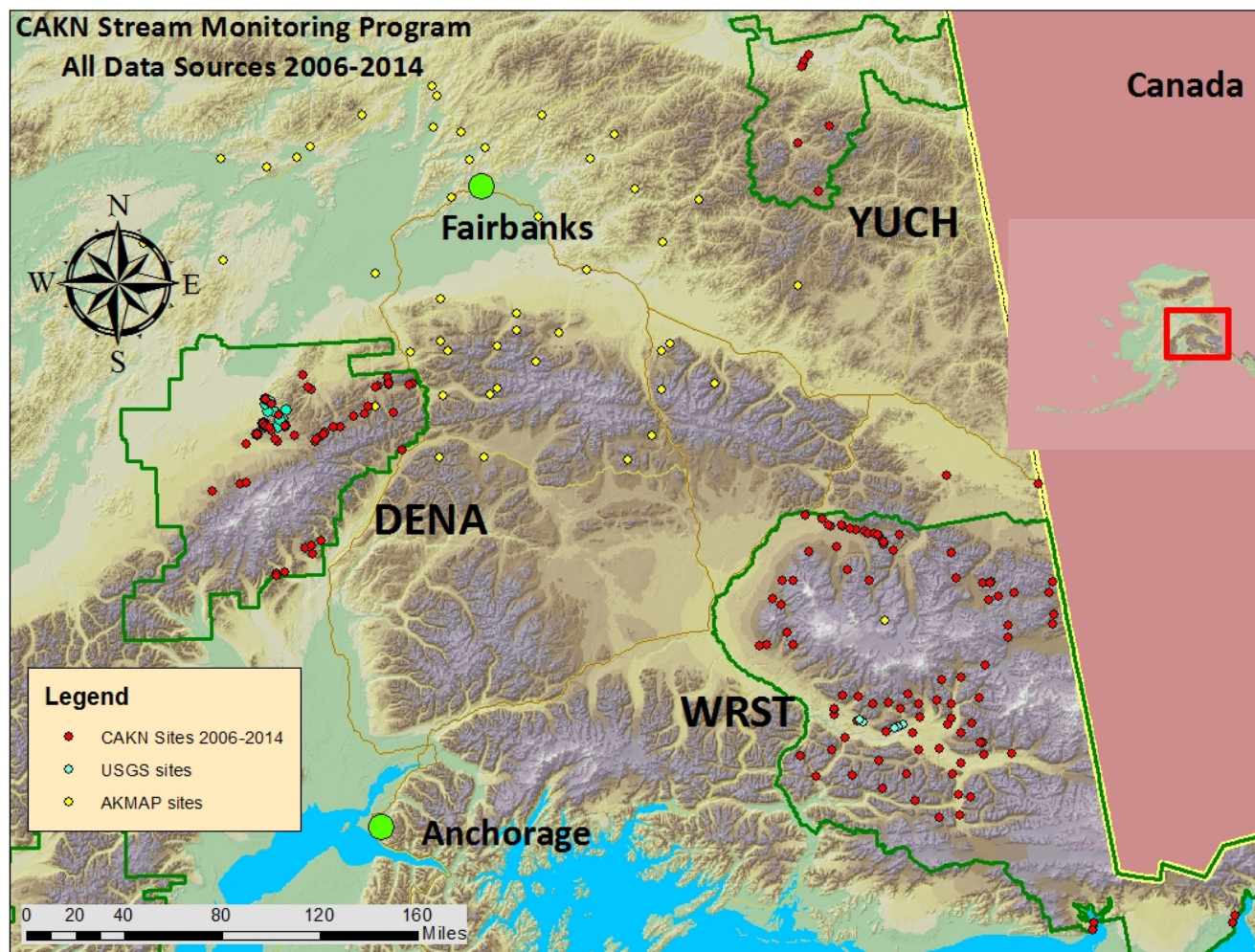


Figure 7. Locations of all data sources being incorporated into analyses for the Stream Monitoring Program through 2014. Sites shown in red are locations where the CAKN has collected data since 2006. Sites shown in blue are locations where data were collected by the USGS along the McCarthy Road and in the Kantishna Hills from 2007-2009. Sites shown in yellow are locations where data were collected as part of an EPA-funded pilot project (AKMAP) by the Alaska Department of Environmental Conservation in 2004-2005.

boundaries of CAKN park units. However, all 44 sites are located within the larger geographic scope of the network, meaning that data collected at these sites are ideal for improving modeling at the network scale. We have also obtained biological, physical and chemical data collected by the US Geological Survey (USGS) at 12 stream sites, 7 in DENA and 5 in WRST (Figure 7). These data were collected from 2007-2009 using protocols developed for the USGS National Water-Quality Assessment Program (NAWQA). Although NAWQA field protocols differ in some respects from protocols used by the EPA and CAKN, the resulting data are fundamentally compatible. Six of the sites in DENA are in streams affected by historical mining activity. Data from these sites will be used to test the sensitivity of the RIVPACS biological assessment models in detecting the effects of past mining on the current condition of stream ecosystems in DENA. As of December 2014, we are actively engaged with researchers from the Bureau of Land Management (BLM) and the Alaska Natural Heritage Program to obtain additional data from Tetlin NWR, Yukon Flats NWR and the upper Tanana River Basin.