Fig. 1 Sampling sites at Isdammen, Gruvedalen and Endalen. Svalbard

The water supply to Longyearbyen: understanding the present system and future uncertainties

By Aga Nowak and Andy Hodson

Longyearbyen is a growing Arctic community whose water supply is directly dependent upon a sensitive and to a large degree, climatically controlled resource: glacial and snow meltwater. We believe that implementation of a new monitoring programme in the Isdammen watershed is essential for future water supply planning due to the pressures imposed by a growing, transient population, climate change and the influences of coal mining and glacial sediment transfer upon water quality.

Establishing the best practice for managing water supply to Longyearbyen is a multidisciplinary problem that requires interaction among engineering, glaciological, geomorphological and hydrological expertise. Such a programme was funded by Longyearbyen Bydrift (the institution responsible for the water supply to Longyearbyen) and undertaken in Gruvedalen and Endalen catchments between May 2012 and April 2013 by Aga Nowak and Andy Hodson (The University of Sheffield) in cooperation with Hanne Christiansen (The University Center in Svalbard).

LONGYEARBYEN LOKALSTYRE
Bydrift KF

The University Of Sheffield.

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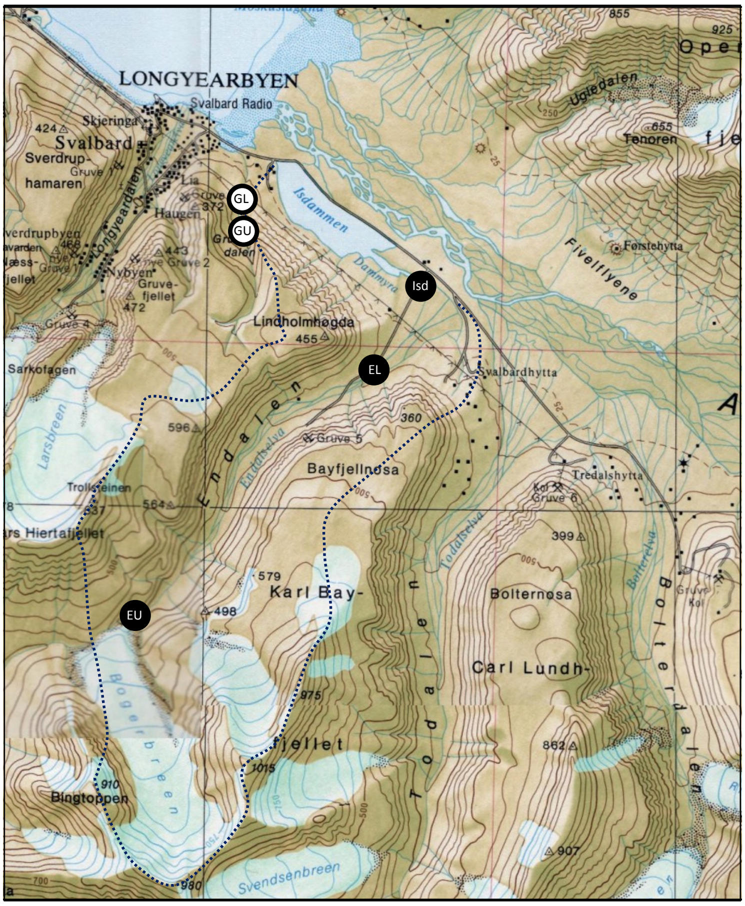
A snow survey was performed in Gruvedalen watershed (that supplies drinking water to Longyearbyen during summer) to establish snow accumulation and the volume of snow available for melt throughout the melt season.

We were also monitoring summer meltwaters at five locations (Fig. 1 and 3) from the beginning of snowmelt (5th June) until cessation of icemelt and significant decrease in water discharge (30th August) to establish seasonal changes in a broad range of water quality parameters (such as pH, dissolved ions, nutrients and contaminant metals) and to better understand the controls upon their variability. Furthermore, river monitoring stations were installed at every sampling site to collect hourly records of river runoff, electrical conductance and water temperature.

This was supplemented with a suspended sediment transport monitoring programme in Endalen that we have designed to help reveal the sedimentation characteristics of Isdammen (Longyearbyen's only winter water source). Therefore, we have installed automatic pump samplers at "EL" and "ISD" for the duration of the summer and programmed them to collect samples three times a day. A further turbidity sensors installed at "EL", "EU" and "GL" allowed us to establish the relationship between suspended sediment and turbidity. The turbidimeters were also used to construct hourly average estimates of sediment concentration from the averages of 30 second readings.

Left: Fig. 2 The areas of coal mining (Endalen) influencing water quality and a rusting due to poor water quality water monitoring station (Gruvedalen). August 2012



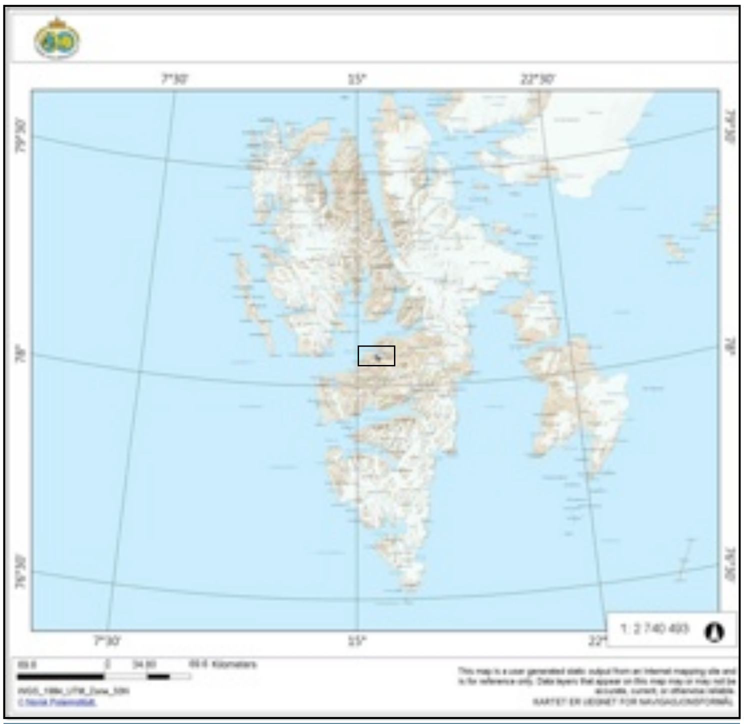


Fig. 3 Sampling sites: Left: The Isdammen watershed (dotted line) and the data logging sites referred to in the text (GL: Gruvedalen Lower; GU: Gruvedalen Upper; ISD: Isdammen inflow; EL: Endalen Lower; EU: Endalen Upper); Upper: The location of Svalbard

Left: Fig. 5 The frozen waterfall formed on Bogerbreen moraines at Endalen Upper. June 2012

Bottom right: Fig. 6 Vegetation at floodplains near the meltwater inflow into Isdammen. August 2012

Our study of water quantity in Gruvedalen and Endalen watersheds indicated the importance of rainfall on sustainable runoff. The relative significance of rain and snow is likely to become more variable from year to year, and our recent work elsewhere suggests that winter rainfall might be a major characteristic of this variability (Nowak & Hodson, 2013). Endalen has an additional glacial influence upon runoff that was a very important contributor to the water balance of Isdammen.

Our study of water quality indicated the influence of acid mine drainage on drinking water supply to Longyearbyen. We found that, in Gruvedalen, waters were concentrated in heavy metals derived from waste rock, but the reactions did not produce water quality issues to the same extent as seen in waste rock effluent in Bjørndalen and in certain parts of Longyeardalen. The poor water quality can be expected at the beginning and at the end of summer. In the first case, contaminants are leached from both the snowpack and the underlying mine waste rock. The high concentrations at the end of summer, are caused by low discharge and high duration of rock-water contact. Furthermore, there was no dilution of the seepages from hillslopes surrounding the mine.

Endalen is a snow, icemelt and rainwater-fed, mining influenced watershed with a moderate mining influence. Glacial input waters to Endalselva are important for buffering and diluting the contaminants. However, as in Gruvedalen, the contamination was most pronounced at the end of summer when the glacier ablation was low and therefore unable to dilute inputs from the area influenced by mining activity. Water quality was also influenced by the end of summer rainfalls that, when heavy, deliver contaminants form hillslopes.

Water quality issues were also associated with suspended sediment concentrations. We found a high sediment yield (like former researchers) and a sediment transfer system that operates like in other small cold-based glacier basins. There was no sediment delivery from beneath the glacier as a result of their cold-based temperature structure. Therefore the high concentrations were triggered by high water discharge and heavy rainfalls. The other processes of sediment delivery were ground thaw and moraine mass movements responding to summer warming. Since the glaciers in the valley were almost certainly more active at the turn of the 20th Century than they are now, the present day sediment transfer system is probably still adjusting to the changes that have occurred after 1900s.

Although high concentrations of suspended sediment were recorded at "EL" during high flows and heavy rainfalls, a notable feature of our work was that the concentration dropped markedly between this site and the "ISD" site. This implies that the storage of sediment in the Isdammen delta is important and equivalent to 20% of the sediment influx to Isdammen during our study. The resuspension of sediment from the delta was also observed, causing concentrations at "ISD" to exceed those at "EL" during low flows.

Therefore thanks to our work we were able to present to Local Council of Longyearbyen a set of recommendations that can improve the use and planning for the future use of surface runoff as a water source.

Additionally, we were able to indicate crucial periods when poor water quality can be expected and therefore another source of water should be used. Furthermore, we were able to show the importance of glacial melt as a freshwater source and suggest that it should be considered in any future planning for change in water supply to Longyearbyen.

Also, our monitoring of suspended sediment concentrations indicated spatial and temporal patterns in sediment transport as well as crucial present and future areas of sediment sources, which can be used to improve management of water storage in Isdammen.

Lastly, thanks to our observations and research on hydrology and biogeochemistry of glacial meltwaters and groundwaters in neighbouring valleys, we were also able to suggest a possible future sources of freshwater contamination with saline waters and present the possibilities for future investments that will ensure good quality, sustainable water supply to Longyearbyen.

Fig. 7 Panorama of Longyearbyen, Svalbard. Source: http://en.wikipedia.org/wiki/File:Longyearbyen_panorama_july2011.jpg