# Under the Ice: Winter Conditions of Happy Creek Following Restoration

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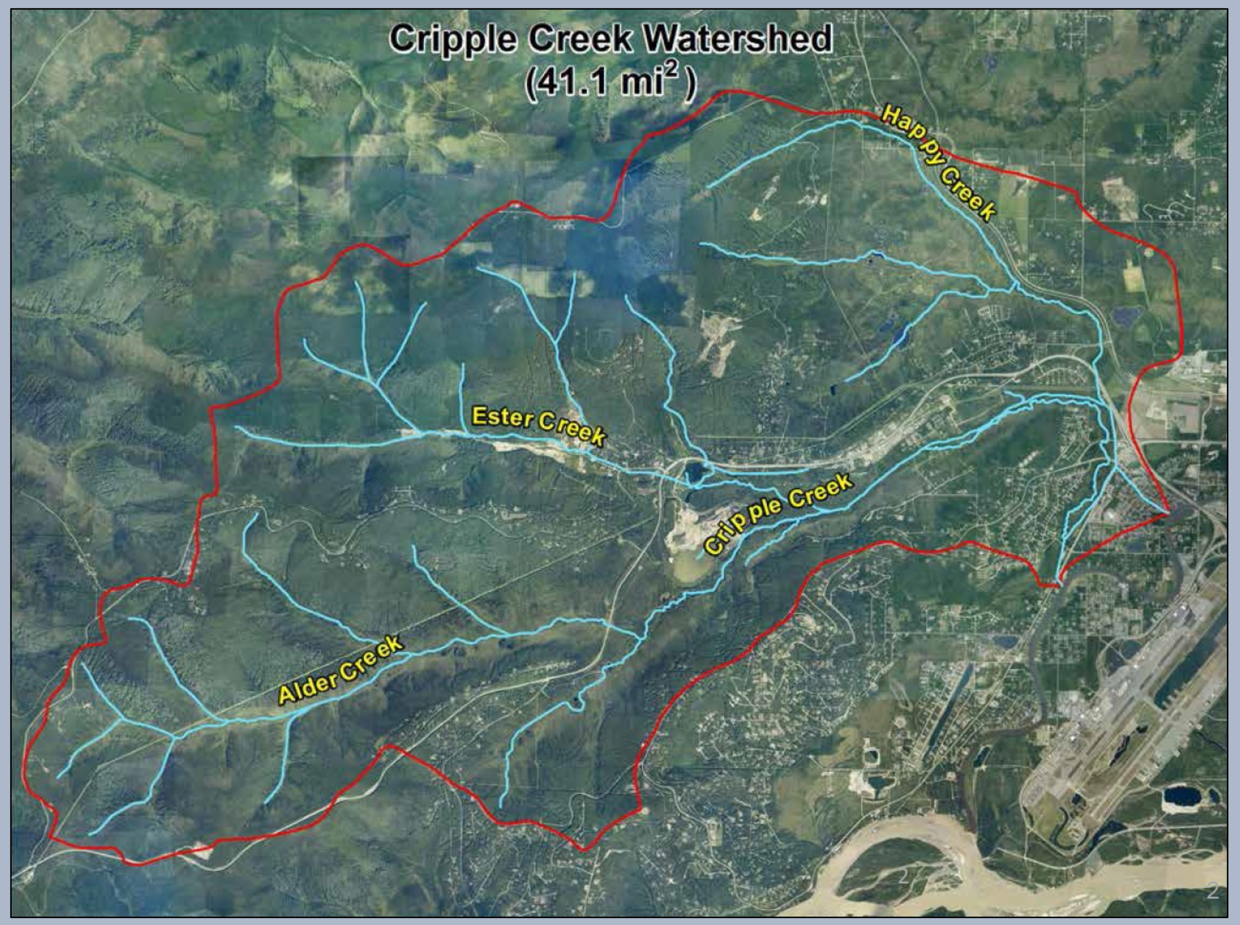
## Restoration for Salmon

Located in Fairbanks, Alaska, Cripple Creek is a tributary of the *Ch'eno'* (Chena River) near the confluence of the *Ch'eno'* and the *Tth'itu'* (Tanana River). Cripple Creek is undergoing restoration to create better habitat for juvenile *nulaghi* (chum salmon, *Oncorhynchus keta*) and *gath* (chinook salmon, *Oncorhynchus tshawytscha*).

In the 1930s, hydraulic mining cut off juvenile salmon from this vital habitat. Over the past decade, the Interior Alaska Land Trust and US Fish and Wildlife Service have been working with dozens of partners to give juvenile salmon to access this habitat once more. In summer 2023, flow was restored to the historic channel of Cripple Creek.




In December 2023, researchers measuring the ice where Happy Creek intersects the Cripple Creek restoration site (Fig. 1) reported a sulfurous smell coming from the water and saw discoloration of the ice (Fig. 6). This promoted my preliminary look into the water conditions below the ice.

Microbial processes can create sulfurous gases. Hydrogen sulfide ($H_2S$), dimethyl sulfide (DMS), and methanethiol (MeSH) are some of the most common. $H_2S$ and MeSH are released through decay of organic matter, and DMS typically originates from phytoplankton. Dissolved organic carbon (DOC) informs the makeup and source of the carbon present in the water.

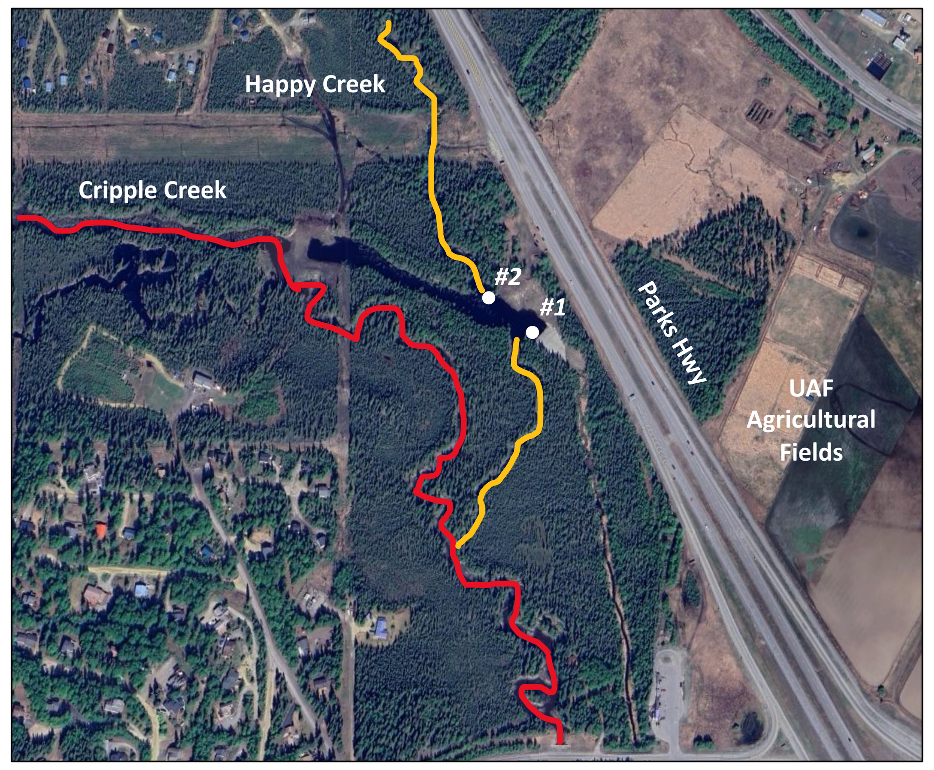
## Methods

Samples and data were collected in February 2024 from two sites where Happy Creek intersects the restoration. Site #1 is where the smell was first detected, in the pond seen in figure 2, and site #2 is over Happy Creek.

Water quality information was collected with a YSI ProDSS Sonde. Three surface water samples were collected at each site and promptly analyzed.

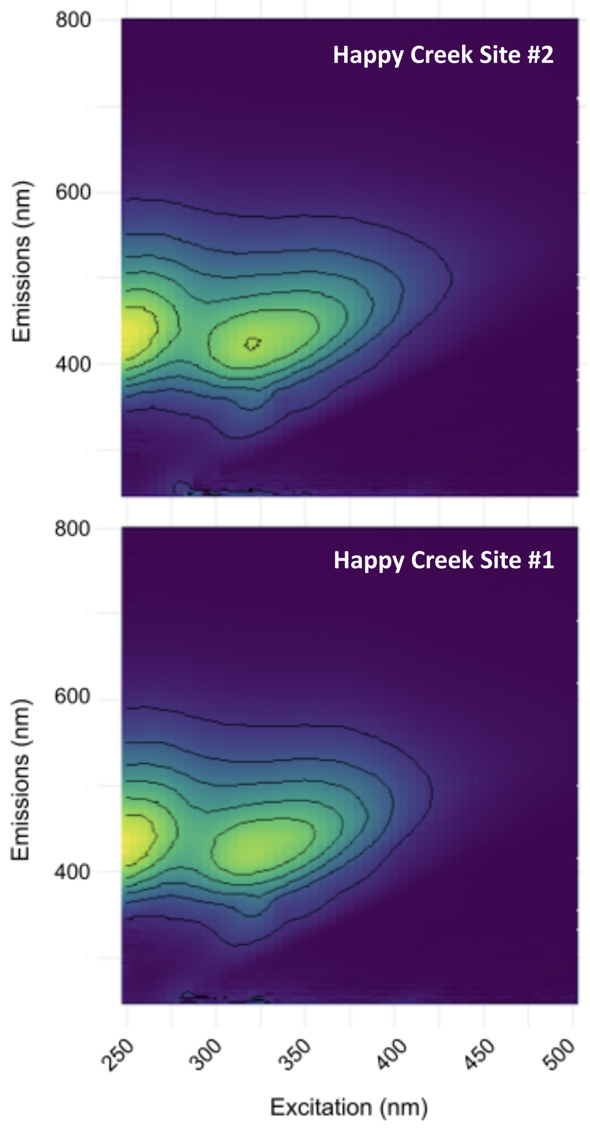
Each of the samples was initially filtered through a 1.2 µm glass microfiber filter washed with excess of the water sample. Bulk dissolved organic carbon was measured on a Shimazu TOC-L. Absorbance and fluorescence were measured on a Horiba Duetta.

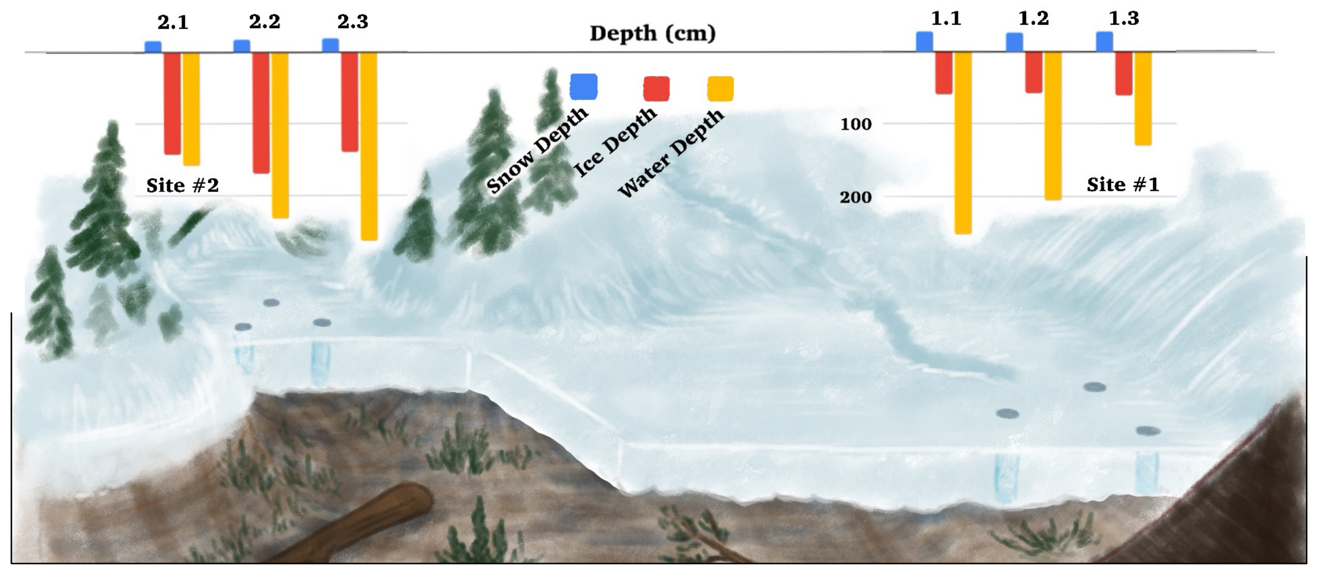
## Under the Ice…




*(Left) Figure 1: A map of the Cripple Creek restoration site, with the site locations (#1 and #2) showing where Happy Creek (in yellow) intersects the Cripple Creek restoration site, which restored Cripple Creek to its historic channel (in red).*

*(Above) Figure 2: Photographs from summer 2023 and winter 2024 overlooking Happy Creek site #1. Due to the restoration, this site was submerged beneath several feet of water, resulting in lots of plant matter beneath the surface.*




| | | Temp (°C) | DO% | DO (mg/L) | pH | ORP (mV) | DOC (mg/L) | Total N (mg/L) |
|---|---|---|---|---|---|---|---|---|
| Site #1 | Surface | 0 | 9.6 | 1.4 | 7.27 | -17.2 | 126.6 | 2.657 |
| | Depth | 0 | - | - | - | - | N/A | N/A |
| Site #2 | Surface | 0 | 6.8 | 0.99 | 7.12 | -50.7 | 49.27 | 2.375 |
| | Depth | 0 | 1.73 | 0.25 | 7.01 | -96.7 | N/A | N/A |

*(Left) Figure 3: The EEM (Excitation Emissions) graph for the two sites. (Above, Top) Figure 4: An illustration depicting the Happy Creek intersection with the Cripple Creek restoration site, along with a graph of the snow, water and ice depth at the two sites. Credit: Grace Veenstra. (Above, Bottom) Figure 5: Table with averaged water quality data for the two sites. Measurements at depth were collected at site #2, but not site #1.*

### A Sulfurous Stink…

*Figure 6: A picture of what Nate and Christi Buffington encountered in December 2023 after drilling through the ice at Happy Creek.*

All four individuals who collected data smelled a noxious sulfuric odor after drilling through the ice at both sites. Following this, it is noteworthy that:

1. All three compounds have a "sulfuric" smell, with $H_2S$ and MeSH being notably putrid.
2. $H_2S$ is highly toxic to marine life. At concentrations where it is detectable by humans, it is already at lethal levels to fish.
3. MeSH is toxic to humans but it and DMS are not recorded as having the same extreme toxicity as $H_2S$ to fish. However, they can still be hazardous.

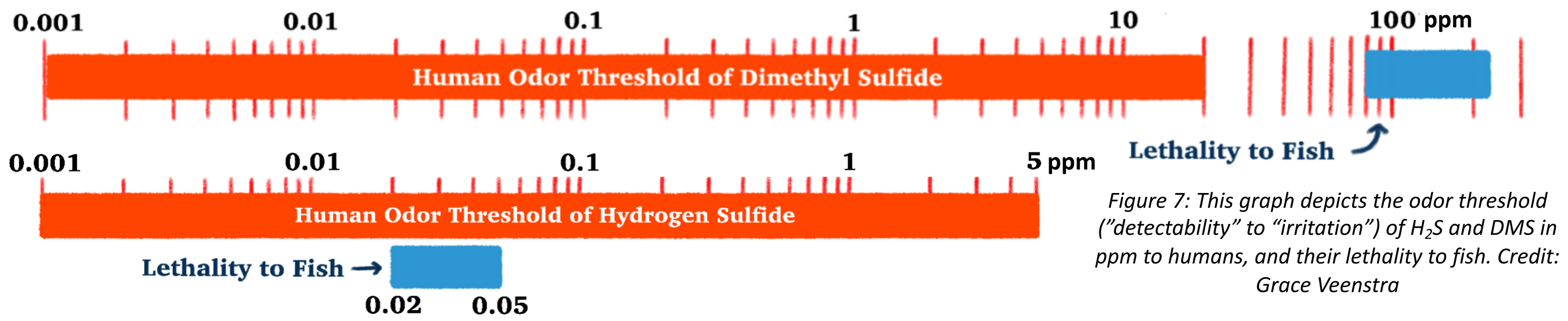



*Figure 7: This graph depicts the odor threshold ("detectability" to "irritation") of $H_2S$ and DMS in ppm to humans, and their lethality to fish. Credit: Grace Veenstra*

## What's it mean?

From our EEM data, we can conclude that the dissolved organic carbon (DOC) present is primarily sourced from terrestrial plants or soil organic matter. Furthermore, there is over twice as much DOC at site #1 than in site #2. This could be due to (a) more water flow beneath the ice at site #2 or (b) more plant carbon by volume at site #1.

Even close to the surface, conditions beneath the ice were hypoxic, with low levels of dissolved oxygen (DO). The pH is slightly more acidic, but still within typical bounds for freshwater. Based on our oxidation-reduction potential (ORP) values, it's probable that sulfide formation could be occurring ($H_2S$ formation occurs from -50 to -250 mV).

### Plants, Bacteria and Sulfur

Based on our results, the sulfurous gas smelled at both sites may have originated from anaerobic bacteria decomposing the terrestrial plant matter that was submerged during the restoration. We do not know what specific sulfur compound is present, but if it is hydrogen sulfide, it has the potential to be devastating to the marine population.

### What does this mean for fish?

Between the hypoxia and sulfur concentrations, the winter conditions beneath the ice are not conducive to fish survival. While winter hypoxia is not uncommon, the potentially lethal sulfur concentrations pose a serious threat. However, for migrating fish such as salmon, they may respond by moving to a different part of the stream with better conditions.

Going forward, I would like to take more water samples and run a nuclear magnetic resonance (NMR) spectroscopy to determine what sulfurous compounds are present in the water. It is recommended that water data and samples are taken with greater consistency over a longer interval to determine how the water condition is changing and these impacts to fish.

## Acknowledgements

This research was done on the ancestral lands of Dené people of the Lower Tanana River and Lower Tanana Dené place names are used in this poster. It was funded by a scholarship from the Biomedical Learning and Student Training program and the National Institute of Health. Thank you to Sarah Ellen Johnson's lab for providing their analytical tools and expertise.

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