# Victoria Creek Fish Overwintering Study, Mount Nansen Project

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## EDI PROJECT NO.:


PROJECT # 11-Y-0344
DATE JULY 19, 2012


2012 ENVIRONMENTAL EMPLOYER OF THE YEAR

EDI ENVIRONMENTAL DYNAMICS INC.

# EXECUTIVE SUMMARY

EDI Environmental Dynamics Inc. (EDI) was retained by Assessment and Abandoned Mines (AAM) in 2011 to conduct a fish overwintering study on Victoria Creek, with a focus on Arctic grayling. While fish use has been documented during the open water season, it was unknown whether grayling overwinter in Victoria Creek or whether they migrate downstream to the Nisling River or to lakes in the watershed.

EDI established ten monitoring stations in deep pools with overwintering potential, along a 4.2 km length of Victoria Creek. Water temperature loggers were installed at each monitoring station in September 2011. Temperature logger data was supplemented with mid- and late-winter surveys to document ice and open water conditions along the creek and to monitor dissolved oxygen levels at each station. An underwater video camera was also deployed at each station to confirm fish presence or absence in potential overwintering areas.

Average water temperatures from September 2011 to May 2012 ranged from 0.21 to 0.38 °C, with the coldest average temperature found at DL 3 and DL 4 and the warmest at DL 2. Generally, water temperatures dropped to near zero degrees at the end of September or mid-October and started warming around May 10. Some stations warmed earlier in the spring, particularly DL 5, 6, 8 and 9.

Dissolved oxygen levels ranged from 7.95 to 14.58 mg/L through both winter surveys and appeared to decline from mid to late winter as ice thicknesses increased over that period. Open water areas were documented at several locations along the creek, including sections downstream of the road crossing, around the Minnesota Creek confluence, and up and downstream of the Back Creek confluence. These areas are likely subject to groundwater influences year round. Fish were documented at a total of seven out of ten stations and all species were identified as Arctic grayling except for one fish that could not be identified.

While fish were documented at numerous locations along Victoria Creek, grayling appeared to select the larger deep pools (DL 5, 6, 7 and 8) that also warmed up earlier in the spring. Fish were observed in these pools during both winter surveys, and these pools also had the highest number of fish documented during the study. Open water areas did not appear to correlate with fish presence or absence during the study.

## ACKNOWLEDGEMENTS

EDI would like to thank the AAM staff who provided edits and comments during the draft stage of this report. Special thanks to Danny Skookum of the Little Salmon Carmacks First Nation (LSCFN) for assisting with field work and to Sheila Garvis of the LSCFN Lands Department for coordinating Danny's involvement.

## AUTHORSHIP

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Field work was completed by Meghan Marjanovic, Laura Grieve, and Joel MacFabe.

# TABLE OF CONTENTS

# LIST OF TABLES



# LIST OF FIGURES

# 1 INTRODUCTION

EDI Environmental Dynamics Inc. (EDI) was retained by the Yukon Government Assessment and Abandoned Mines Branch (AAM) in 2011 to conduct a fish overwintering study on Victoria Creek. To date Arctic grayling, slimy sculpin and burbot have been documented in Victoria Creek during the open water season (Norecol 1989; Osbourne 1995), but there have been no studies that confirm overwinter use.

The purpose of the 2011/2012 study was to identify potential fish overwintering locations in Victoria Creek, with a focus on Arctic grayling. Past observations of the creek indicate that winter conditions are variable depending on location. For example, some locations are known to freeze to the bed substrate and are subjected to severe overflow ice conditions, while other areas can maintain open water and flow for most of the winter.

In general, Arctic grayling require access to deep pools, spring areas, or lakes during the winter (Ford *et al.* 1995; West *et al.* 1992). Grayling overwintering behaviour is variable across their range (McPhail 2007). Most grayling are known to migrate through various stream and/or lake habitats for different parts of the year (West *et al.* 1992), commonly spending their summer feeding in smaller tributary streams, and migrating downstream in the fall to the lower reaches of larger river systems or lakes to overwinter (Ford *et al.* 1995). Other grayling may complete their entire life cycle in one stream or lake habitat (West *et al.* 1992). In the case of Victoria Creek, it was unknown whether grayling overwinter in the creek or whether they move downstream to the Nisling River or to lakes in the watershed.

The 2011/2012 study at Mount Nansen involved a combination of fall and winter habitat investigations, underwater winter video monitoring and recording, and continuous winter water temperature monitoring. Methodologies are described in more detail in the Methods, Section 2.

## 1.1 STUDY AREA

The Mount Nansen site is located approximately 45 kilometres west of Carmacks, Yukon. The site lies within the Victoria Creek watershed, which is a tributary stream to the Nisling River, a medium sized river in the Donjek/White Rivers drainage basin. Victoria Creek is the receiving environment for all water leaving the Mount Nansen site via Dome and Pony creeks. Dome Creek flows from above the mill site, past the tailings facilities and into Victoria Creek. Pony Creek drains a small portion of the mine site north of the Brown-McDade Pit and eventually flows into Back Creek, a tributary to Victoria Creek, often heavily impacted by placer mining during the open water season.

# 2 METHODS

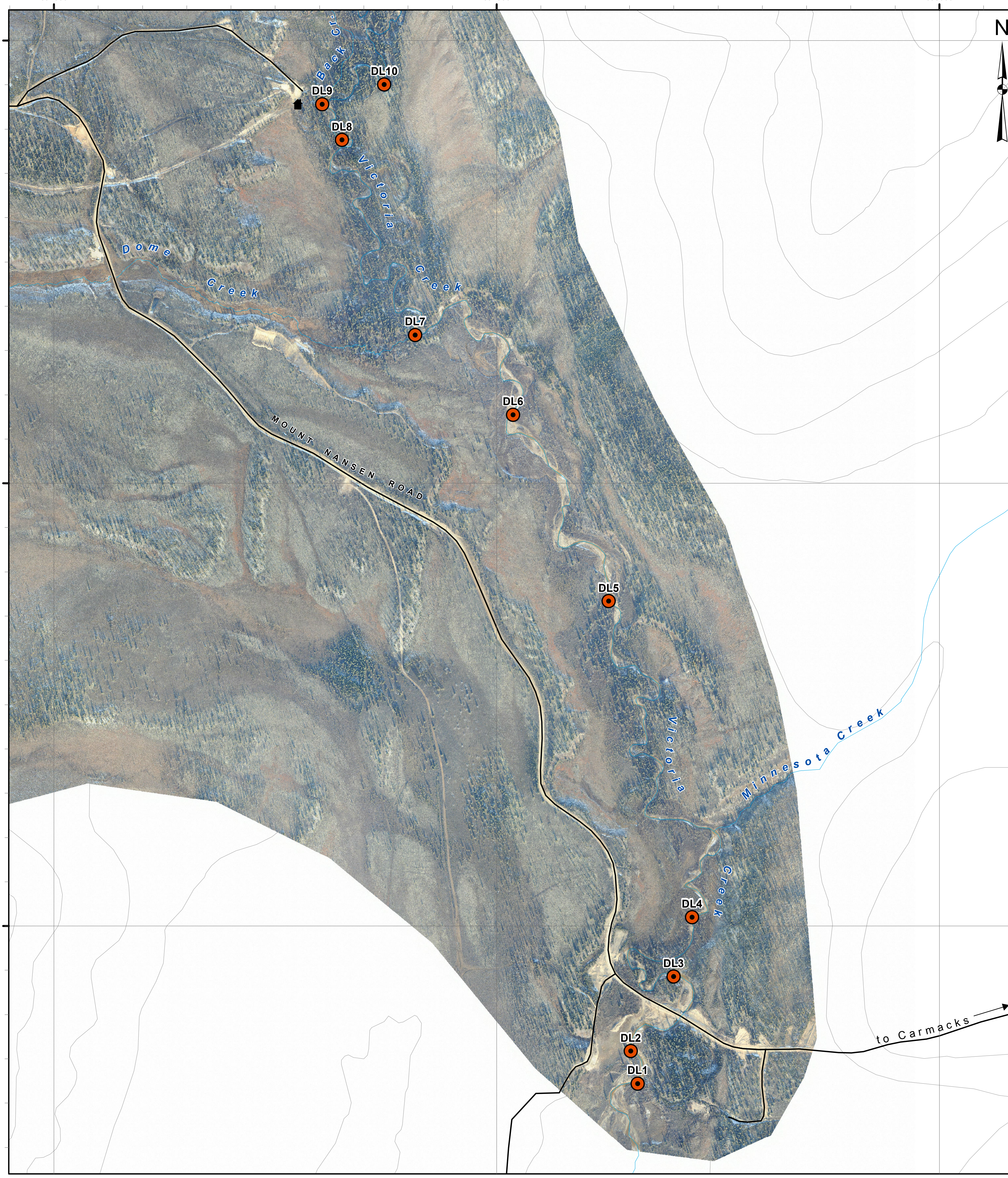
To determine if Victoria Creek supports fish throughout the winter, several approaches were undertaken. A fall reconnaissance trip was completed to identify potential overwintering areas and establish monitoring stations with water temperature loggers. Two follow-up winter surveys were completed to collect water quality measurements and document ice and flow conditions, in addition to documenting fish use through underwater video recording. These components are described in more detail below in Sections 2.1 and 2.2.

## 2.1 FALL RECONNAISSANCE

EDI conducted an initial fish and fish habitat reconnaissance on September 13-14, 2011 to document deep pools with overwintering potential, as well as potential groundwater sources and fall congregations of Arctic grayling. During this assessment, ten monitoring stations were established along the creek in deep pools with the greatest overwintering potential (Figure 1). Areas with good cover, such as large woody debris were also incorporated into station selection. The overwintering study area extended approximately 250 m upstream of the confluence of Back Creek and 250 m downstream of the Mount Nansen Road crossing (Figure 1). This covers approximately 4.2 km of stream.

Hobo TidBit temperature loggers were installed at each station (Photo 1). Loggers were attached within a cement cinderblock which was anchored to a secure point on shore using plastic-coated wire. Loggers were set to collect data every 30 minutes. Stations were flagged and the location marked on a GPS.

**Photo 1. Temperature logger installation on Victoria Creek (September 13, 2011).**




General Project Features

- Overwintering Monitoring Station
- Pumphouse
- Road
- Contour
- Watercourse

# Overview Map of Victoria Creek Overwintering Fish Monitoring Stations, Mount Nansen Site.

Data Sources

1:50,000 Topographic Spatial Data provided by Geomatics Yukon - Yukon Government via online source (Corporate Spatial Warehouse) www.geomaticsyukon.ca.

Project data displayed is site specific. Data collected by EDI Environmental Dynamics Inc. (2011) was obtained using Garmin GPS technology.

Watercourse and Mount Nansen Road layers digitized / modified by EDI (2011) using orthophoto provided by Yukon Government, Energy, Mines and Resources (2011).

Disclaimer
This document is not an official land survey and the spatial data presented is subject to change.

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Map Scale = 1:9,000 (printed on 11 x 17)
Map Projection: North American Datum 1983 UTM Zone 8N

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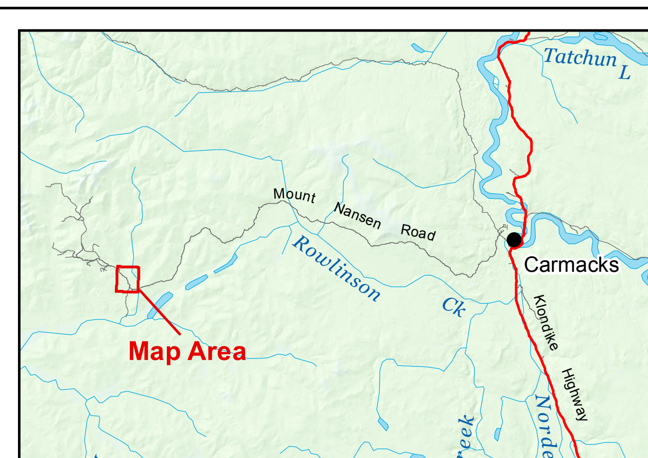


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## 2.2 WINTER SURVEYS

Temperature logger data was supplemented with surveys completed in mid and late winter. During each survey, field biologists walked the creek to document open water areas and general ice conditions. Each monitoring station was visited to measure water depth beneath the ice, ice thickness, dissolved oxygen (DO) and water temperature using a YSI Pro Plus multi-metre (Photo 2).

Winter is a critical time for DO levels, as ice cover blocks contact with air and reduces the potential for re-aeration (CCME 1999). Reduced oxygen levels have been shown to cause lethal and sublethal (physiological and behavioural) effects in various organisms, especially fish (CCME 1999). Little is known about water quality requirements during winter for adult grayling (Ford *et al.* 1995). Ford *et al.* (1995) list the lower lethal oxygen concentration for grayling at 1.4 mg/L to 2.0 mg/L for juveniles and adults, respectively. The Northern River Basins Study (NRBS) (2002) lists the acute[1] DO requirement for adult salmonids in northern rivers at 2 mg/L, while chronic[2] DO requirements are generally accepted to be around 6 mg/L for adult salmonids.

The mid-winter survey was completed from February 21 to 23, 2012. The late-winter survey was completed from April 5 to 6, 2012 to document conditions when flow was most constricted and DO levels the lowest over the winter. An underwater Aqua-Vu video camera was also deployed at each station to monitor and record fish presence for approximately five to 20 minutes, depending on whether fish were present or not and how soon they were detected. Photographs of each site were also collected and are shown on Figure 7 and 8 in the results.

**Photo 2. Measuring winter DO levels on Victoria Creek (April 5, 2012).**

[1] The acute DO requirement for salmonids is the minimal amount of oxygen necessary to avoid short-term mortality, usually under two days (NRBS 2002).
[2] The chronic DO requirement for salmonids is the amount of oxygen required for long-term health and survival (NRBS 2002).

# 3 RESULTS

## 3.1 FALL RECONNAISSANCE

During the fall investigation a total of ten monitoring stations, Stations DL 1 to DL 10 (Table 1), were established from the downstream to upstream extent. Pool depth at these locations ranged from 0.80 m to 1.20 m. Victoria Creek was moderately turbid at all sites downstream of Back Creek due to suspected placer activity. Site descriptions and fall photographs of each station are provided in Appendix A.

During station establishment and temperature logger installation, Arctic grayling were documented at two locations. Grayling were observed feeding in the pool at station DL 6 and DL 10 (grayling size 10 to 20 cm at both sites). During another site visit for water sampling and hydrometric monitoring work (October 11, 2011), a group of three juvenile grayling (10 to 15 cm) were observed downstream from DL 10 with another five similarly sized grayling in the pool at DL 10. On October 13, 2011, visual observations of grayling were also documented in the large pool at the Back Creek confluence (DL 9) and moving downstream towards DL 8, (size 20 to 30 cm).

**Table 1. Fish overwintering monitoring station descriptions and locations.**

| Station Name | Location | UTM Coordinates (Zone 8) | | Fall Pool Depth (m) |
|---|---|---|---|---|
| | | Easting | Northing | |
| DL 1 | Most downstream site | 0392308 | 6878649 | 1.10 |
| DL 2 | Downstream of road crossing | 0392301 | 6878716 | <1.00 |
| DL 3 | Upstream of road crossing | 0392400 | 6878884 | <1.00 |
| DL 4 | 145 m upstream of DL3 | 0392441 | 6879020 | >1.00 |
| DL 5 | Mid-creek | 0392251 | 6879733 | 0.90 |
| DL 6 | 286 m downstream of Dome Creek | 0392037 | 6880155 | >1.10 |
| DL 7 | Dome Creek confluence | 0391813 | 6880333 | 0.80 |
| DL 8 | 468 m upstream of DL7 | 0391650 | 6880776 | 0.90 |
| DL 9 | Back Creek confluence | 0391609 | 6880863 | >1.20 |
| DL 10 | Most upstream site | 0391747 | 6880902 | 1.25 |

## 3.2 TEMPERATURE LOGGER DATA

Temperature loggers recorded data every 30 minutes from September 13-14, 2011 to May 29-30, 2012 (Table 2). The average water temperature at DL 2 was the warmest on record through the logging period, followed by DL 8 (0.38 °C and 0.36 °C, respectively; Table 2). Water temperatures at both of these stations stayed above zero degrees throughout the winter. Conversely, the DL 3 and DL 4 stations had the lowest average water temperatures over the logging period (both 0.21 °C; Table 2) and dropped to a minimum temperature of - 0.12 °C.

In general, at most stations water temperatures dropped to near zero degrees at the end of September or mid-October (Figure 2 to Figure 6). Some sites stayed around zero degrees for the winter (DL 3, 4, 5), with many others fluctuating just above zero (DL 1, 2, 6, 7, 8, 9, 10). In the spring, water temperatures generally started increasing around May 10, 2012 for most sites (Figure 2 to Figure 6). The exceptions were DL 5 and DL 6 which started warming earlier around May 1, 2012 (Figure 4) and DL 8 and DL 9 which had an early warming period around April 14, 2012 (Figure 5 and Figure 6). Note in the fall of 2011, these sites also had a more gradual temperature decline towards zero degrees as winter approached.

**Table 2. Temperature data record for temperature loggers DL 1 to DL 10 as well as mean, minimum and maximum temperatures recorded over the logging period.**

| Data logger | Install Date (Time) | Retrieval Date (Time) | Mean Water Temperature Recorded (°C) | Min to Max Temperature Recorded (°C) |
|---|---|---|---|---|
| DL 1 | Sept 13, 2011 (10:15 am) | May 29, 2012 (5:00 pm) | 0.32 | -0.03 to 6.36 |
| DL 2 | Sept 13, 2011 (10:53 am) | May 29, 2012 (5:10 pm) | 0.38 | 0.05 to 6.36 |
| DL 3 | Sept 13, 2011 (11:50 pm) | May 30, 2012 (11:35 am) | 0.21 | -0.12 to 6.13 |
| DL 4 | Sept 13, 2011 (12:25 pm) | May 30, 2012 (11:35 am) | 0.21 | -0.12 to 6.20 |
| DL 5 | Sept 13, 2011 (1:55 pm) | May 31, 2012 (1:08 pm) | 0.26 | -0.09 to 6.31 |
| DL 6 | Sept 13, 2011 (4:30 pm) | May 31, 2012 (3:30 pm) | 0.29 | -0.06 to 6.23 |
| DL 7 | Sept 13, 2012 (5:10 pm) | May 31, 2012 (3:30 pm) | 0.31 | 0.00 to 6.18 |
| DL 8 | Sept 13, 2012 (5:30 pm) | May 30, 2012 (3:23 pm) | 0.36 | 0.02 to 6.18 |
| DL 9 | Sept13, 2012 (5:45 pm) | May 30, 2012 (2:48 pm) | 0.32 | -0.03 to 6.54 |
| DL 10 | Sept 14, 2012 (12:40 pm) | May 30, 2012 (2:40 pm) | 0.31 | 0.00 to 6.03 |

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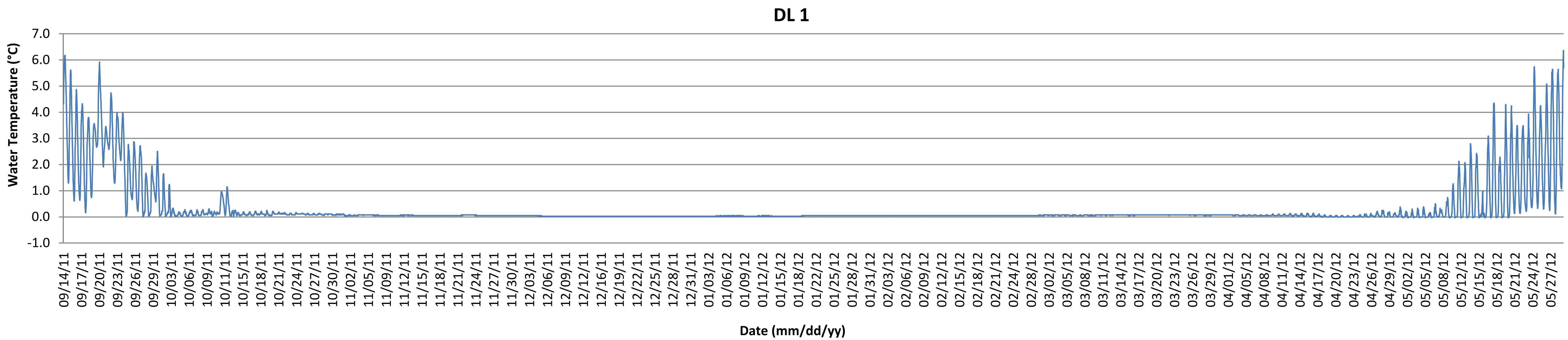


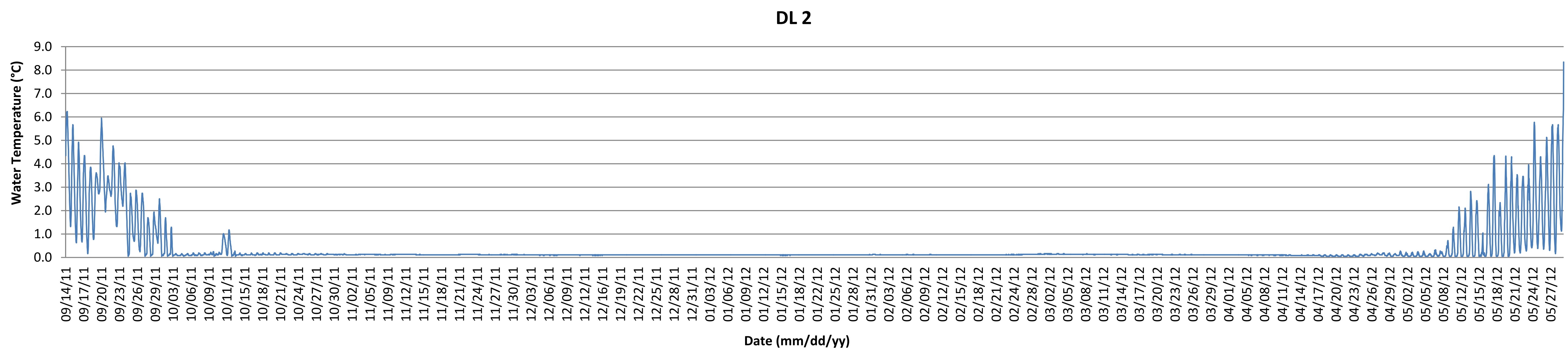
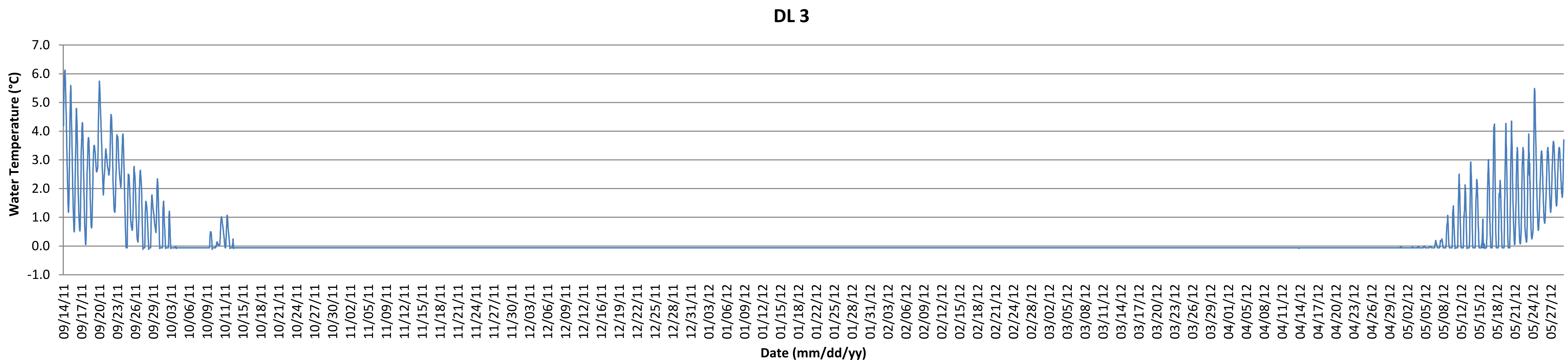




**Figure 2.** Water temperature record from September 2011 to May 2012 for Stations DL 1 and DL 2.



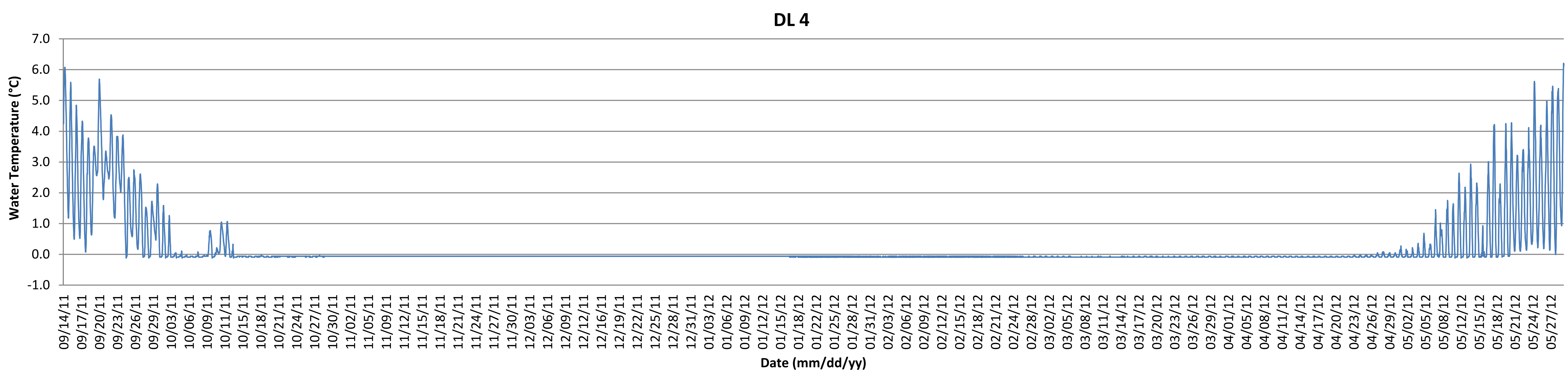
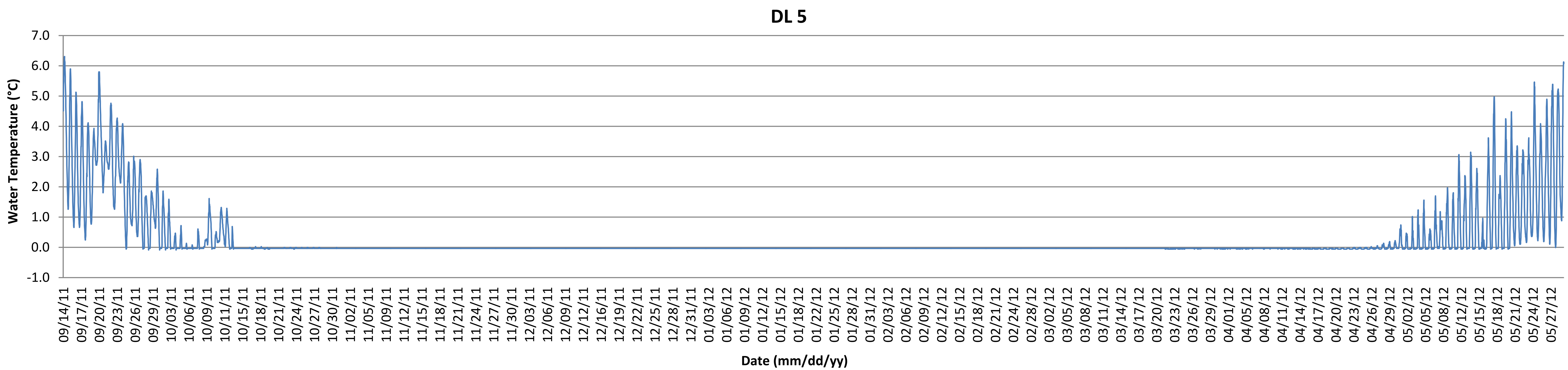




**Figure 3.** Water temperature record from September 2011 to May 2012 for Stations DL 3 and DL 4.



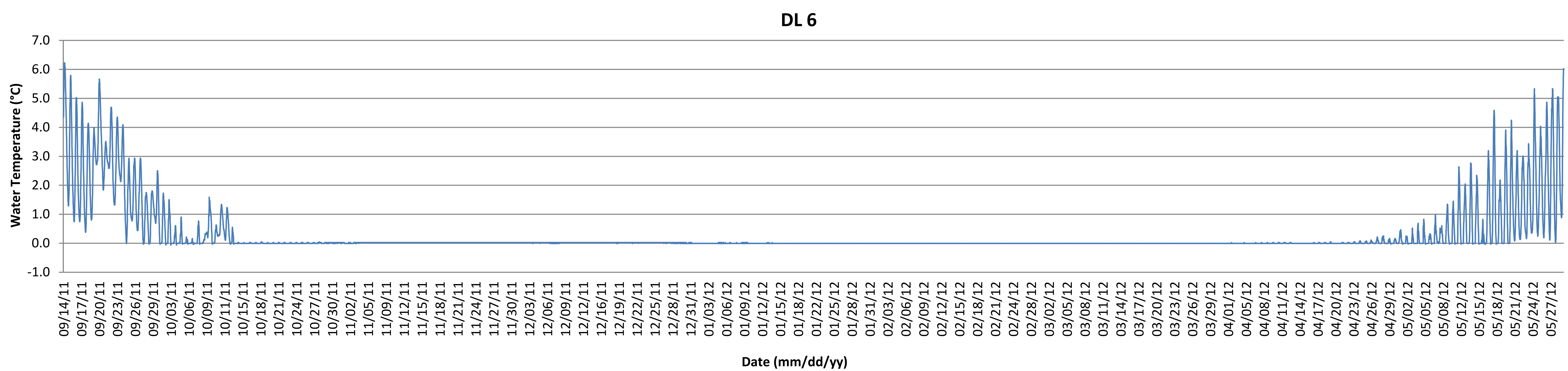
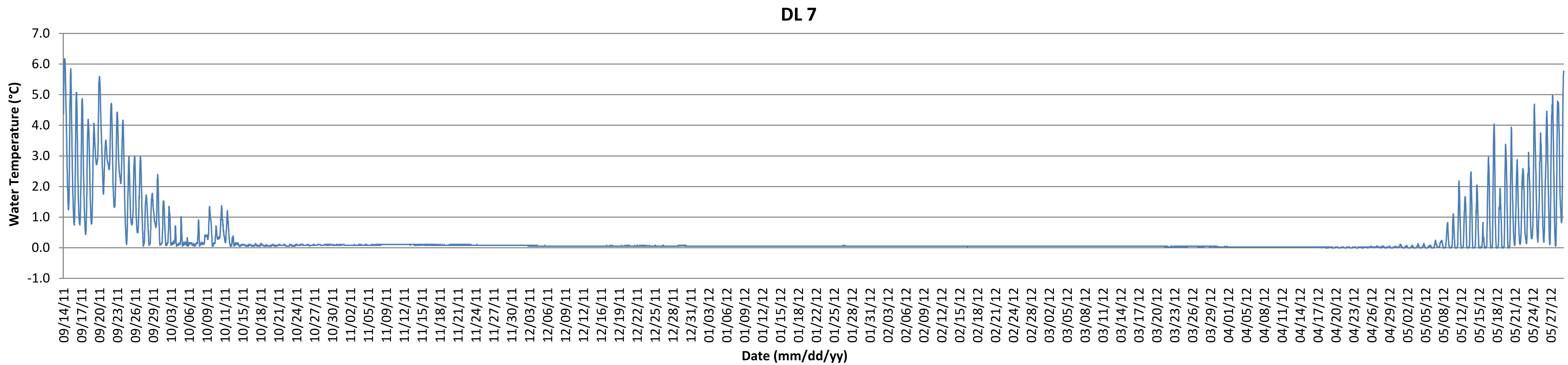




**Figure 4.** Water temperature record from September 2011 to May 2012 for Stations DL 5 and DL 6.



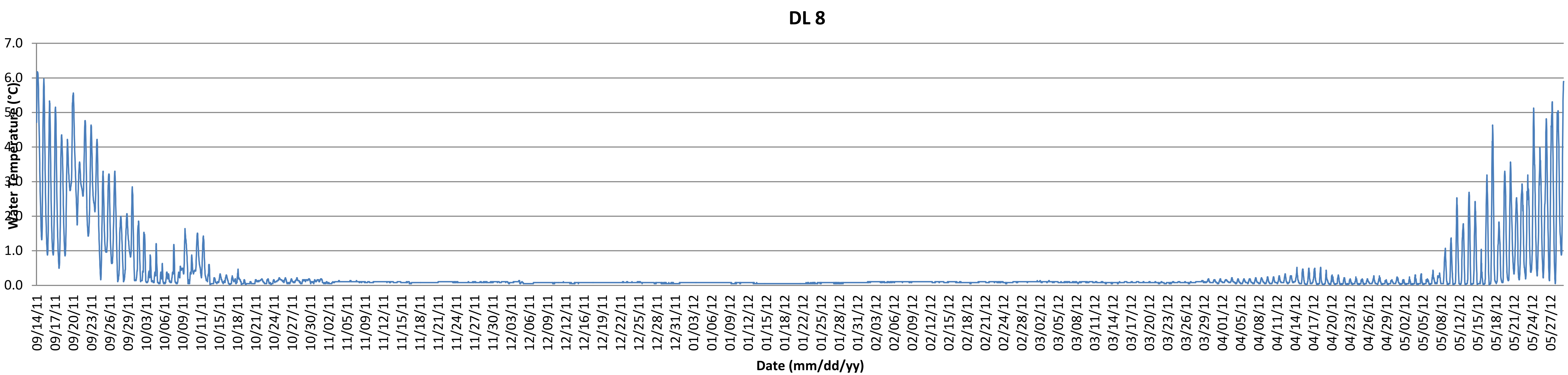
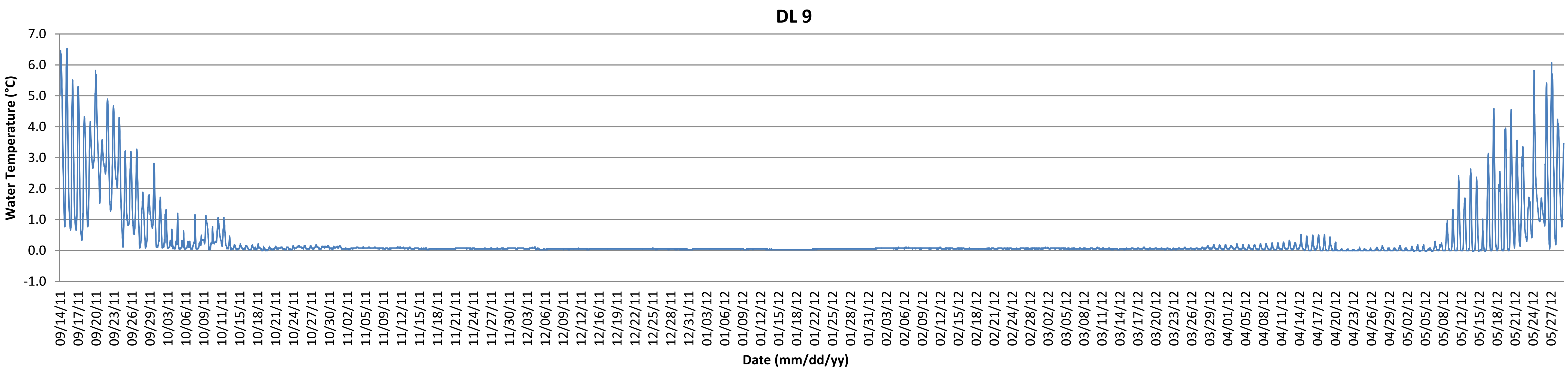




**Figure 5.** Water temperature record from September 2011 to May 2012 for Stations DL 7 and DL 8.



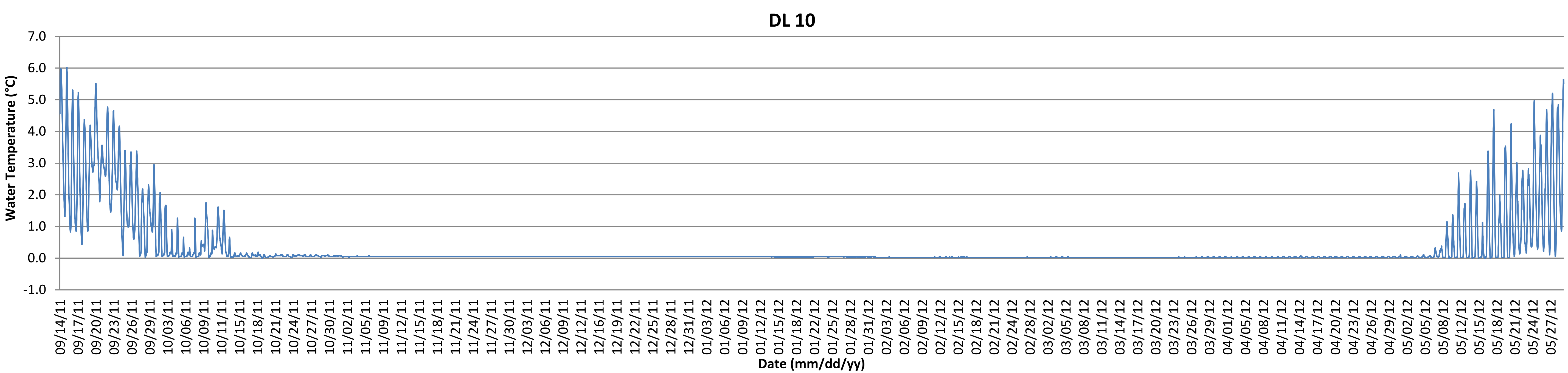




**Figure 6.** Water temperature record from September 2011 to May 2012 for Stations DL 9 and DL 10.

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## 3.3 WINTER SURVEYS

### 3.3.1 Open Water Areas

During the mid-winter visit in February 2012, the study area was walked to assess open water areas on Victoria Creek, except for the section between DL 8 and DL 7. During the late-winter survey in April 2012, the entire study area was assessed.

Open water areas were identified between DL 1 and DL 2 during both winter surveys (see Section 3.3.2). Upstream towards the road culvert, ice thicknesses increased with considerable overflow ice conditions upstream of the culvert. Overflow ice extended into the forest area surrounding the DL 3 location. Overflow ice was also present up to station DL 4 during the late-winter survey.

Between DL 4 and DL 5 there were sections of thin ice evident through depressions in the snow (Photo 3). These were concentrated just upstream of the confluence with Minnesota Creek. Between DL 5 and DL 6 there were no open water areas, except for some depressions in the snow where ice was thinner. This pattern continued upstream towards DL 7 and DL 8. There were open water areas just downstream from DL 8, as well as between DL 9 and DL 10 during both surveys (Photo 4). Results are displayed spatially on Figure 7 and Figure 8. More details on open water conditions during the surveys are found in Appendix B.

**Photo 3. Thin ice depressions along Victoria Creek (February 2012).**

**Photo 4. Areas on Victoria Creek with thin ice and open water (February 2012).**

### 3.3.2 Water Quality & Ice Measurements

Water quality and ice measurements were collected at each station during the mid- and late-winter surveys. DO levels had declined slightly from February to April 2012, while ice thickness had increased during that period (Table 3, Table 4). DO ranged from 11.83 to 14.72 mg/L in February and from 7.95 to 9.48 mg/L in April. While oxygen levels did appear to decline from mid to late winter, levels remained sufficient to support fish and water depths beneath the ice were adequate to allow for continued flow. No measurements could be taken at the DL 3 station because overflow ice was too thick to determine if there was flow below the ice.

Table 3. Mid-winter water quality, ice thickness and water depths at the monitoring stations (February 2012).

| Station | DO (mg/L) | Temp (°C) | pH | SPC (µs/cm) | Ice Thickness (m) | Water Depth (m) |
|---|---|---|---|---|---|---|
| DL 1 | 11.84 | 0.09 | 6.54 | 264 | 0.26 | 0.58 |
| DL 2 | 12.74 | 0.06 | 7.06 | 269 | 0.10 | 0.67 |
| DL 3 | - | - | - | - | - | - |
| DL 4 | 14.00 | 0.02 | 6.58 | 262 | 0.67 | 0.70 |
| DL 5 | 14.57 | 0.02 | 6.81 | 258 | 0.23 | 0.50 |
| DL 6 | 13.97 | 0.02 | 6.77 | 234 | 0.38 | 0.59 |
| DL 7 | 14.72 | 0.06 | 6.71 | 203 | 0.11 | 0.62 |
| DL 8 | 14.27 | 0.06 | 6.95 | 225 | 0.07 | 0.50 |
| DL 9 | 13.19 | 0.70 | 6.91 | 227 | 0.14 | 0.50 |
| DL 10 | 14.58 | 0.01 | 6.67 | 227 | 0.69 | 0.50 |

Table 4. Late-winter water quality, ice thickness and water depths at the monitoring stations (April 2012).

| Station | DO (mg/L) | Temp (°C) | pH | SPC | Ice Thickness (m) | Water Depth (m) |
|---|---|---|---|---|---|---|
| DL 1 | 7.95 | 0.40 | 7.10 | 353 | 0.35 | 0.48 |
| DL 2 | 9.47 | 0.00 | 7.18 | 391 | 0.14 | 0.18 |
| DL 3 | - | - | - | - | >1.30 | - |
| DL 4 | 9.00 | 0.00 | 7.33 | 423 | 0.78 | 0.36 |
| DL 5 | 9.48 | 0.00 | 7.33 | 438 | 0.62 | 0.41 |
| DL 6 | 9.32 | 0.00 | 7.33 | 442 | 0.52 | 0.54 |
| DL 7 | 9.33 | 0.00 | 7.33 | 439 | 0.26 | 0.73 |
| DL 8 | 8.32 | 0.10 | 7.22 | 233 | 0.11 | 0.40 |
| DL 9 | 8.40 | 0.00 | 7.14 | 228 | 0.19 | 0.62 |
| DL 10 | 9.08 | 0.00 | 7.38 | 234 | 0.90 | 0.36 |

### 3.3.3 Underwater Video Monitoring

Fish presence was successfully documented using underwater video monitoring and recording during both winter surveys. During the mid-winter survey, fish were identified at four out of ten stations, from the mid to upper sections of the study area (Table 5; Figure 7; Figure 8). During the late-winter survey, fish were identified at seven out of ten stations, including some of the more downstream stations (Table 5; Figure 7; Figure 8).

All fish species were identified as Arctic grayling, except for one individual at DL 1, which remains unidentifiable due to video resolution. The largest number of fish observed was found at the DL 5 and DL 6 stations during both visits. The number of fish observed was based on the maximum number of fish observed at one time during video monitoring, so that individuals were not counted multiple times. The time spent on video monitoring depended on viewing conditions and how soon fish were observed. Sampling effort was prolonged until fish were observed or up to 27 minutes; when fish were observed, sampling effort would generally continue until observers had a good sense of how many individual fish were present. No video monitoring could be undertaken at Station DL 3 as thick overflow ice had buried the station. Photos 5 to 7 provide an example of the video footage acquired.

**Table 5. Number of fish observed during the mid- and late-winter surveys as well as observation effort in terms of underwater video monitoring and recording time.**

| Station | Mid-Winter (February 2012) | | Late-Winter (April 2012) | |
|---|---|---|---|---|
| | # Fish Observed | Effort (min:sec) | # Fish Observed | Effort (min:sec) |
| DL1 | 0 | 21:19 | 1 | 11:00 |
| DL2 | 0 | 27:27 | 1 | 10:00 |
| DL3 | - | n/a | - | n/a |
| DL4 | 0 | 21:04 | 1 | 06:20 |
| DL5 | 11 | 18:06 | 7 | 11:00 |
| DL6 | 10 | 17:94 | 7 | 05:02 |
| DL7 | 2 | 16:37 | 4 | 09:00 |
| DL8 | 0 | 11:49 | 0 | 20:40 |
| DL9 | 3 | 16:41 | 4 | 02:43 |
| DL10 | 0 | 11:41 | 0 | 09:45 |
| **TOTAL** | **26** | **163 min 18 sec** | **25** | **85 min 30 sec** |

**Photo 5. Underwater video recording snapshot of Arctic grayling at DL 6 (April 2012).**

Photo 6. Underwater video recording snapshot of one Arctic grayling at DL 4 (upper centre of photo; April 2012).

Photo 7. Underwater video recording snapshot of one Arctic grayling at DL 9 – Back Creek confluence (April 2012).

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**DL5: Upstream view from the monitoring station.**


**DL4: Upstream view from the monitoring station.**


**DL3: Upstream view of overflow conditions.**


**DL1: View looking downstream of the monitoring station.**

### Monitoring Stations

Site / Month of obs. — Fish observed

Site — No fish observed

* asterix indicates site not sampled due to extensive overflow conditions during the February and April sampling events.

### Project Features

Open water (22 February 2012)

Road

Watercourse

# Winter Fish Observations and Open Water Areas on Victoria Creek (Lower Section).

Data Sources

1:50,000 Topographic Spatial Data provided by Geomatics Yukon - Yukon Government via online source (Corporate Spatial Warehouse) www.geomaticsyukon.ca.

Project data displayed is site specific. Data collected by EDI Environmental Dynamics Inc. (2011/2012) was obtained using Garmin GPS technology.

Mount Nansen Road layer digitized / modified by EDI (2011) using orthophotos provided by Yukon Government, Energy, Mines and Resources (2011).

Disclaimer
This document is not an official land survey and the spatial data presented is subject to change.

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Map Scale = 1:4,000 (printed on 11 x 17)
Map Projection: North American Datum 1983 UTM Zone 8N

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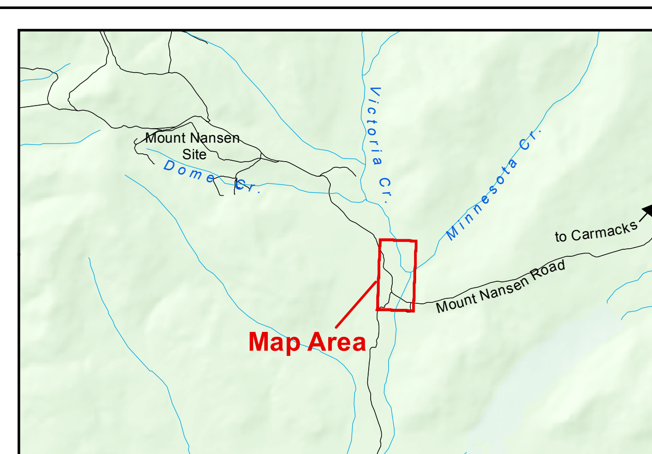


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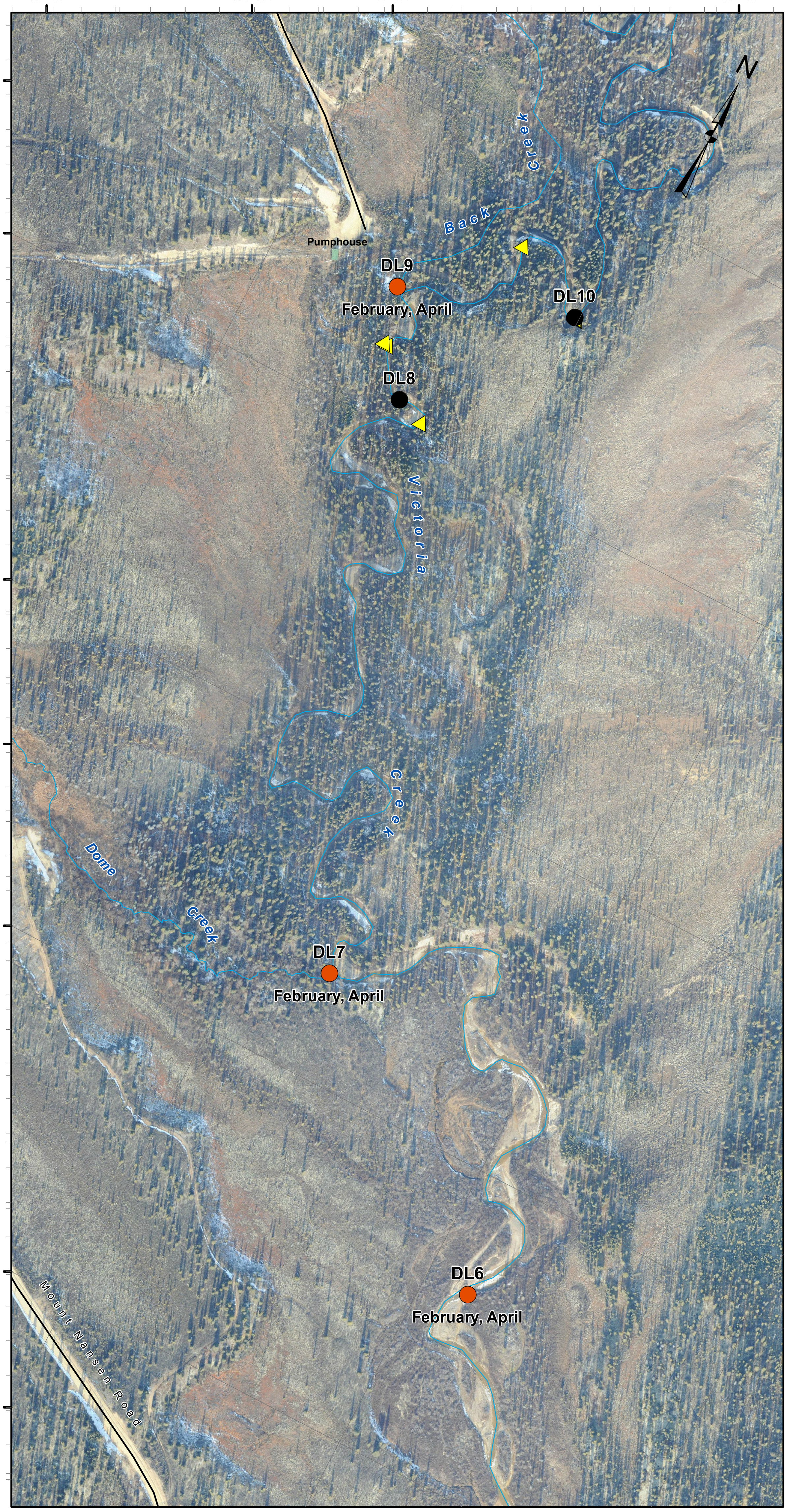



**DL10: Upstream view from the monitoring station.**


**DL9: Thin ice upstream from the monitoring station.**


**DL8: Downstream view of open water conditions.**


**DL6: View looking downstream of the monitoring station.**

### Monitoring Stations

Site — Month of obs. — Fish observed

Site — No fish observed

### Project Features

Open water (22 February 2012)

Road

Watercourse

## Winter Fish Observations and Open Water Areas on Victoria Creek (Upper Section).

Data Sources

1:50,000 Topographic Spatial Data provided by Geomatics Yukon - Yukon Government via online source (Corporate Spatial Warehouse) www.geomaticsyukon.ca.

Project data displayed is site specific. Data collected by EDI Environmental Dynamics Inc. (2011/2012) was obtained using Garmin GPS technology.

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Map Projection: North American Datum 1983 UTM Zone 8N

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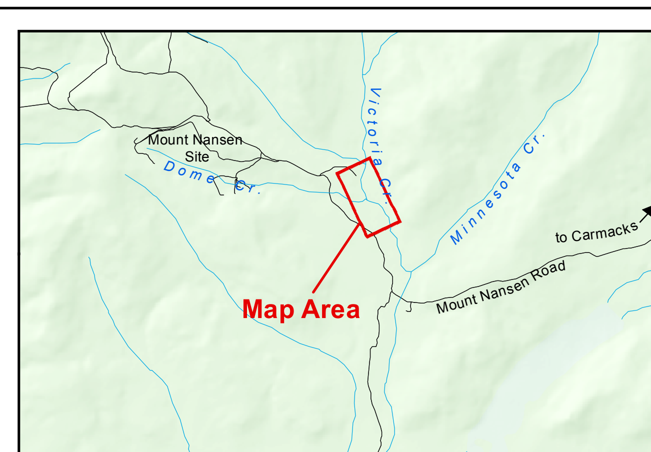
|---|---|---|---|
| LG | MP / MM | Date: 7/17/2012 | FIGURE 8 |

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# 4 CONCLUSIONS

This study determined that Victoria Creek does support fish through the winter. Sufficient winter DO levels and adequate flow beneath the ice appeared to be sustained at all stations except for DL 3, where conditions could not be confirmed due to thick overflow ice.

Suitable fish overwintering conditions exist in many areas of Victoria Creek, but there appeared to be a general selection towards the deeper, larger pools that warm earlier in the spring, such as stations DL 5, 6, 7 and 9. These stations had the highest number of fish observed during both winter surveys, and stations DL 5 and DL 6 started warming one week before other sites, while station DL 9 started warming as early as one month before other sites.

Pool depths at these stations were no less than 0.80 m during the fall reconnaissance trip and ice thickness through the winter ranged from 0.19 to 0.62 m. Open water over the winter did not appear to correlate with fish presence or absence. Stations DL 5, 6, and 7 had no adjacent open water areas over the winter; while station DL 9 had open water up and downstream.

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# APPENDIX A MONITORING STATION PHOTOS & DESCRIPTIONS

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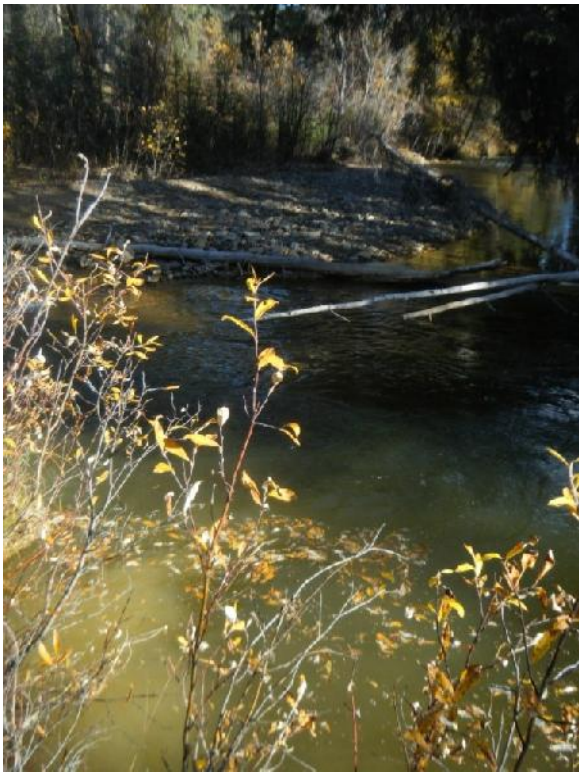
| Station DL1 | Description |
| --- | --- |
|  | - Deep pool (110 cm) in a side channel<br>- Overhanging vegetation (willow)<br>- Small woody debris<br>- Cobble  substrate |
| **Station DL2** | **Description** |
|  | - Upstream from Station 1, but downstream from the Victoria at Road hydrology site<br>- Back eddy pool (<100 cm) with good cover (large woody debris, submerged willow)<br>- Located in bend in creek with riffle section upstream<br>- Cobble, gravel and fines substrate |

| Station DL3 | Description |
| --- | --- |
|  | - Back eddy pool upstream from road culvert<br>- Depth <100 cm<br>- Overhanging willow cover<br>- Substrate is large gravel and fines |
| **Station DL4** | **Description** |
|  | - Large back eddy pool, very deep >100 cm<br>- In a bend in creek, below a riffle section<br>- 145 m upstream from DL3<br>- Mostly cobble substrate |

| Station DL5 | Description |
| --- | --- |
|  | - 700 m upstream from DL4<br>- Road is about 100 m away<br>- Deep pool (90 cm) at bend in creek, with riffle section upstream<br>- Overhanging willow cover and small woody debris<br>- Cobble mixed with fines, some small boulders |
| **Station DL6** | **Description** |
|  | - Deep pool, >110 cm depth<br>- Riffle section upstream<br>- Some overhanging willow cover<br>- Large and small cobble mixed with fines and gravel |

| Station DL7 | Description |
|---|---|
|  | - At Dome Creek confluence, upstream from falls<br>- 468 m d/s from DL8<br>- Deep pool (80 cm) at bend in creek<br>- Overhanging willow cover<br>- Large woody debris near pool – good cover for fish<br>- Substrate mostly cobble and large gravel |
| **Station DL8** | **Description** |
|  | - Downstream of Back Creek confluence (90 m)<br>- Pool is 0.90 cm depth<br>- Lots of shade spruce and willow<br>- Large woody debris near pool – good cover for fish<br>- Small and large cobble with fines |

| Station DL9 | Description |
| --- | --- |
|  | - 90 m u/s from DL8, at confluence of Back Creek<br>- Very deep pool (>120 cm)<br>- Riffle section upstream near Upper Victoria water quality site<br>- Small cobble and gravel with sand |
| **Station DL10** | **Description** |
|  | - Very deep pool, 125 cm depth<br>- Large woody debris in stream<br>- Gravel and small cobble substrate with sand |

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# APPENDIX B WINTER STREAM WALK NOTES (OPEN WATER CONDITIONS)

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Table B-1. Open water and ice conditions during the mid- and late-winter surveys (February and April 2012).

| Area | Conditions - Feb 2012 | Conditions – April 2012 |
|---|---|---|
| **DL1** | Open areas directly upstream and thin ice | Open water in main channel 4 m from station |
| **DL1-DL2** | Open areas | Open water sections |
| **DL2** | Thin ice | Thinner ice in spots |
| **DL2-DL3** | Overflow conditions upstream of culvert | Overflow conditions upstream of culvert |
| **DL3** | Considerable overflow, ice very thick | Considerable overflow, ice very thick (>126 cm) |
| **DL3-DL4** | Overflow in places, no open water | Overflow in places, no open water |
| **DL4** | Thick ice | Thick ice, no open water |
| **DL4-DL5** | Near Minnesota Creek thin ice. See waypoints 10, 8, 7, 6 | Some open water depressions seen. |
| **DL5** | Thin ice, heard flow upstream | No open water, thick ice. |
| **DL5-DL6** | No open water, some areas have thin ice (snow depressions) | No open water |
| **DL6** | No open water | No open water |
| **DL6-DL7** | No open water, some areas have thin ice (snow depressions) | No open water, some areas have thin ice (snow depressions) |
| **DL7** | No open water, some thin ice depressions | Thin ice depressions in snow d/s |
| **DL7-DL8** | Not investigated | No open water, aside from a little ways below DL8 |
| **DL8** | Thin ice, open water just downstream (waypoint 5) | Hole remained open, open areas up and downstream |
| **DL8-DL9** | Open water sections (H/WQ-VC-DBC) | Open water near H/WQ-VC-DBC at intermittent riffle sections |
| **DL9** | Open water upstream of site | Open water sections above and below site |
| **DL9-DL10** | Open water 20 m section downstream waypoint 001 | VC-U site open water section, open water at large bend towards DL10 |
| **DL10** | Ice covered, open water a ways downstream (see above) | No open water immediately up or downstream of DL10 |