# 2010 ANNUAL QUARTZ MINING LICENCE REPORT

**Submitted to Yukon Government, Energy Mines and Resources**

**Yukon Quartz Mining Licence QML-0007**

**March 2011**

Prepared for Carmacks Copper Ltd.

Prepared by:

www.accessconsulting.ca

# 2010 ANNUAL QUARTZ MINING LICENCE REPORT

## Submitted to Yukon Government Energy Mines and Resources

## Yukon Quartz Mining Licence QML-0007

## Carmacks Copper Project, Yukon Territory

**Submitted by:**

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## PROJECT CONTACT LIST

| | |
|---|---|
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# EXECUTIVE SUMMARY

Activities at the mine site during the period 1 January 2010 to 31 December 2010 have been limited. Site activities consisted of five site visits to monitor water quality and flows, the Annual Engineer's Inspection and maintenance work undertaken in response to that inspection. Copies of the associated documents have been attached to this report. A component of the Annual Engineer's Inspection Report is a summary of ongoing geochemical testing. No exploration or development activities were undertaken in 2010.

Security in the amount of $80,300 has been posted with Yukon against the liability incurred to date as a result of exploration activities.

This report has been formatted to respond to the specific requirements in the QML even though there have been no corresponding project undertakings.

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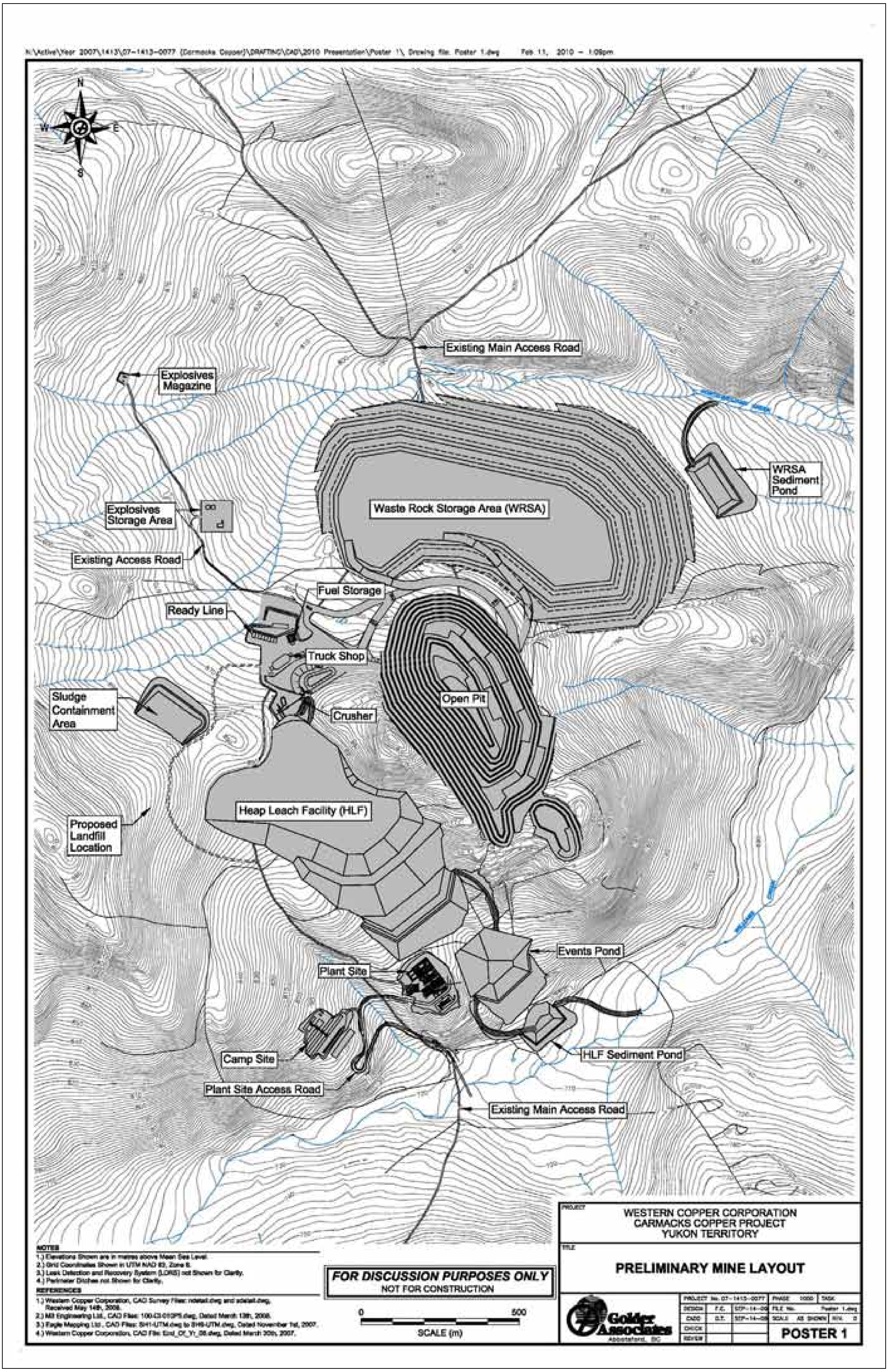
# 1.0 INTRODUCTION

This Annual Report has been prepared for Carmacks Copper Ltd. (CCL) and covers the period from January 1, 2010 to December 31, 2010 as required by Clauses 16.5 and 16.6 of Quartz Mining Licence (QML) QML-0007. This report provides a summary of activities at the Carmacks Copper Property for the reporting year, including: physical stability inspection and minor maintenance activities, and surface and groundwater water quality monitoring.

Few site activities occurred that would normally form a part of this report in future years, once major project permitting is completed. Additional sections and information will be added as necessary to accommodate expanded reporting requirements from future mine development and related plans.

The preliminary mine layout is illustrated in Figure 1.

**Figure 1. Preliminary Mine Layout**



# 2.0 SITE ACTIVITIES

## 2.1 EXPLORATION

No exploration activities occurred during the 2010 reporting period.

## 2.2 CONSTRUCTION AND DEVELOPMENT

### *2.2.1 Overview of Activities by Quarter*

No construction or development activities occurred on the property in 2010.

### *2.2.2 As built drawings*

No “as-built” drawings were produced in 2010.

## 2.3 MINING ACTIVITIES

### *2.3.1 Overview of Activities by Quarter*

No mining activities took place in 2010.

### *2.3.2 Production Schedule – Ore and Waste Removal*

Not applicable for this reporting period; no mining activities took place in 2010.

### *2.3.3 Average Head Grades*

Not applicable for this reporting period; no mining activities took place in 2010.

### 2.3.4 Open Pit Stability

Not applicable for this reporting period; no mining activities took place in 2010.

### 2.3.5 Heap Leach Cells – Status of Leaching (including layout drawing)

Not applicable for this reporting period; no mining activities took place in 2010.

### 2.3.6 Copper Production

Not applicable for this reporting period; no mining activities took place in 2010.

### 2.3.7 Spills

No spills occurred during the reporting period.

### 2.3.8 On-going Reclamation

No reclamation activities occurred during the reporting period.

### 2.3.9 Actions Undertaken in Response to Annual Engineer's Inspection

On August 5$^{th}$, in response to the July 8$^{th}$ annual Engineer's Inspection a small crew was mobilized to site to conduct maintenance on erosion control measures. The work consisted largely of silt fence installation and creation of a series of diversion ditches to reduce movement of sediment towards Williams Creek.

A full report prepared by the engineer in attendance is included in Appendix A. This report has been previously submitted to the Government of Yukon Department of Energy, Mines and Resources, Mineral Resources Branch.

### 2.3.10 Access Road

The access road to the site has not been constructed.

## 2.4 RESOURCES AND RESERVES

The resource and reserve estimates for the property are shown in Tables 1 and 2 respectively. The reserves remain as stated in the "Feasibility Study" prepared in 2007, while the resource was updated later in 2007.

**Table 1. Updated Resource Estimate for Zones 1, 4 and 7 at 0.25% Total Copper Cut-Off**

| | Category | Tonnes (000)'s | Copper (%) Total | Copper (%) Oxide | Gold (g/t) | Silver (g/t) | Contained Metal Copper (000)'s lb. | Contained Metal Gold oz. | Contained Metal Silver oz. |
|---|---|---|---|---|---|---|---|---|---|
| Oxide | Measured | 4,031 | 1.10 | 0.90 | 0.59 | 5.7 | 98,130 | 76,000 | 734,000 |
| | Indicated | 7,949 | 1.04 | 0.84 | 0.39 | 4.0 | 182,448 | 100,000 | 1,032,000 |
| | **M+I** | **11,980** | **1.06** | **0.86** | **0.46** | **4.6** | **280,577** | **176,000** | **1,766,000** |
| | Inferred | 90 | 0.73 | 0.53 | 0.13 | 1.8 | 1,452 | 370 | 5,000 |
| Sulphide | Measured | 695 | 0.80 | 0.02 | 0.26 | 2.5 | 12,192 | 6,000 | 57,000 |
| | Indicated | 3,645 | 0.74 | 0.03 | 0.20 | 2.3 | 59,195 | 24,000 | 269,000 |
| | **M+I** | **4,340** | **0.75** | **0.03** | **0.21** | **2.3** | **71,387** | **30,000** | **326,000** |
| | Inferred | 4,031 | 0.71 | 0.01 | 0.18 | 1.9 | 63,383 | 23,000 | 246,000 |

**Table 2. Mineral Reserve**

| Reserve Class | Ore t (000) | Total Cu (%) | Cu Oxide (%) | Cu Non-Oxide (%) | Au (g/t) | Ag (g/t) |
|---|---|---|---|---|---|---|
| **Proven Mineral Reserve** | 3,190 | 1.227 | 1.028 | 0.199 | 0.659 | 6.20 |
| **Probable Mineral Reserve** | | | | | | |
| Open Pit Ore | 6,462 | 1.099 | 0.938 | 0.162 | 0.466 | 4.49 |
| Estimated Dilution | 960 | 0.065 | 0.043 | 0.021 | 0.018 | 0.20 |
| **Total Probable Mineral Reserve** | 7,422 | 0.965 | 0.822 | 0.144 | 0.408 | 3.93 |
| **Proven and Probable Mineral Reserve** | 10,611 | 1.044 | 0.884 | 0.160 | 0.483 | 4.62 |

## 2.5 CARE AND MAINTENANCE

No activities to report.

## 2.6 PROPOSED DEVELOPMENT AND PRODUCTION FOR UPCOMING YEAR

There are presently no development or production plans for the 2011 year.

# 3.0 MONITORING PROGRAMS AND STUDIES

The QML contains a number of requirements for studies and monitoring programs. The following sections outline work done in respect of these studies and programs. Copies of the actual reports relating to these are appended.

## 3.1 ON-GOING METALLURGICAL STUDIES

### *3.1.1 Field Tests*

No metallurgical field tests were in progress as of 2010.

### *3.1.2 Laboratory Tests*

Metallurgical and geochemical testwork carried out for the Carmacks Copper project includes two sets of long term kinetic tests that concluded in March 2010. Results of this testwork were provided with the 2009 Annual Report, Appendix F. Once these tests were completed, residue from the humidity cells were subjected to a set of static tests to assess impacts of prolonged leaching on the acid rock drainage and metal leaching potential of the neutralized spent ore. Results of this testwork are presented in a Technical Memorandum provided in Appendix C.

The 2009 Annual Report indicated that an extended test on exposure of liner specimens to conditions similar to those in the heap was to conclude in May 2010. The liner testing has been extended and a report will be issued upon completion.

## 3.2 HEAP LEACH PAD LINER PERFORMANCE MONITORING

No liner has been placed and no performance monitoring is in progress.

## 3.3 WATER QUALITY SURVEILLANCE PROGRAM

During 2010, five separate site visits were made for the purpose of collecting water quality data. These visits took place on the following dates:

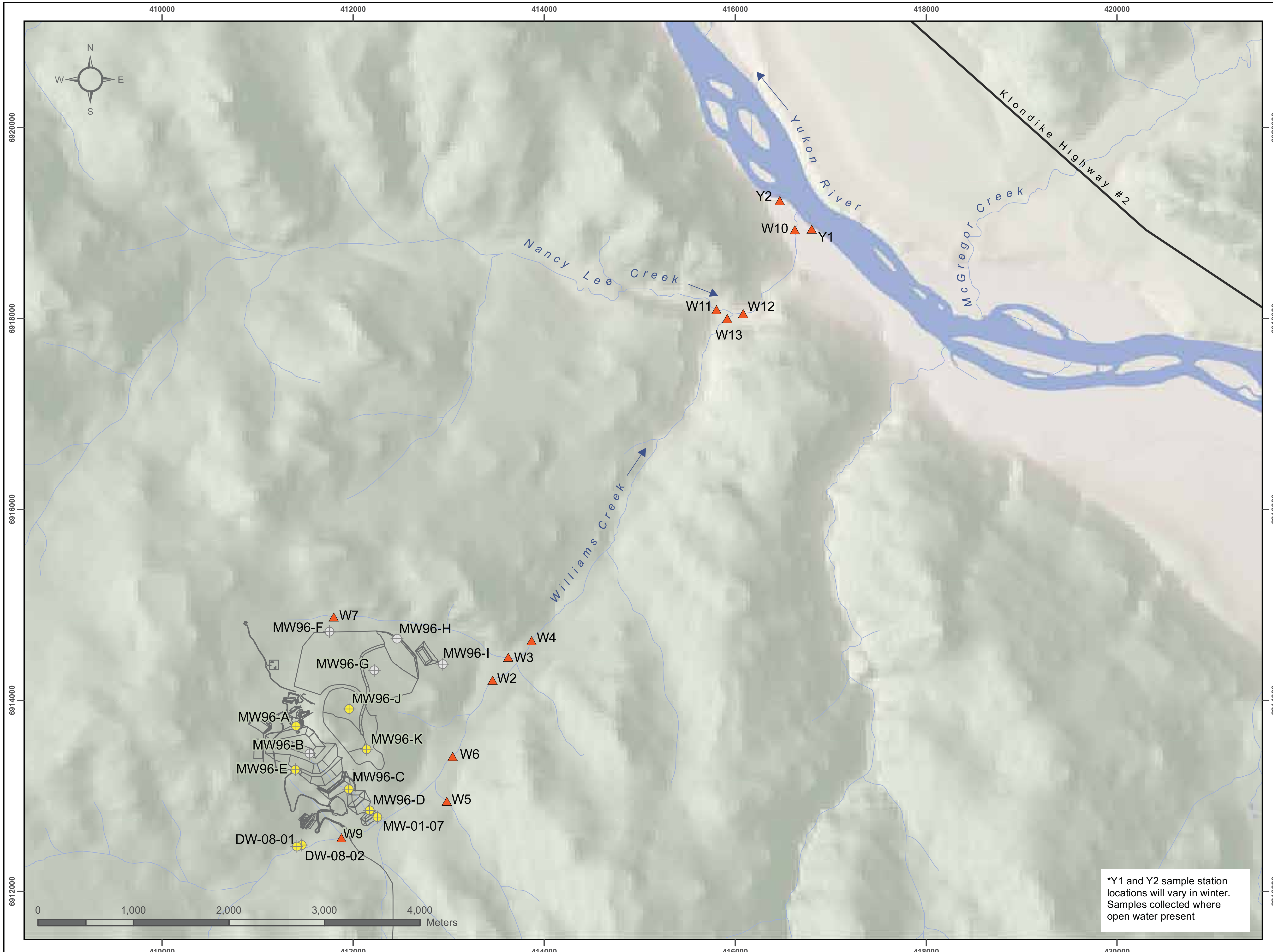
April 22nd
May 11th – 13th
June 10th – 11th
August 17th – 18th
October 20th

The following table lists the locations (shown on Figure 2) that have been established for the routine monitoring of surface water quality to date. Further locations will be added as the mine is brought into production.

**Table 3. Water Quality Surveillance Program Site Descriptions and Locations**

| Station | Description | Northing | Easting |
|---|---|---|---|
| W2 | Williams Creek Upstream of North Williams Creek Confluence | 6914145 | 413499 |
| W3 | Lower North Williams Creek Upstream of Confluence with Williams Creek | 6914379 | 413640 |
| W4 | Williams Creek Downstream of Confluence with North Williams Creek | 6914653 | 413888 |
| W5 | South East Tributary to Williams Creek | 6912947 | 412978 |
| W6 | Williams Creek Downstream of South East Tributary | 6913373 | 413042 |
| W7 | Upper North Williams Creek Tributary Upstream of Road Crossing | 6914810 | 411778 |
| W9 | Williams Creek Upstream of Access Road Crossing | 6912511 | 411907 |
| W10 | Williams Creek Upstream of Yukon River | 6919033 | 416606 |
| W11 | Nancy Lee Creek (Tributary of Williams Creek) | 6918096 | 415803 |
| W12 | Williams Creek Downstream of Confluence with Nancy Lee Creek | 6918000 | 416102 |
| W13 | Williams Creek Upstream of Confluence with Nancy Lee Creek | 6917984 | 415912 |
| Y1* | Yukon River Upstream of Williams Creek | 6918974 | 416752 |
| Y2* | Yukon River Downstream of Williams Creek | 6919308 | 416249 |

Notes: Coordinates are UTM Zone 8 NAD83
* Yukon River open water sample station locations; during freezing conditions samples collected where open water available.




# CARMACKS COPPER PROJECT

## 2010 ANNUAL QUARTZ MINING LICENSE REPORT

Western Copper Corporation

- Actively Monitored Well
- Inactive Well
- Surface Water Monitoring Station
- Contour
- Watercourse
- Waterbody

Datum: NAD83; Projection: UTM Zone 8N

National Topographic Data Base (NTDB) compiled by Natural Resources Canada at a scale of 1:50,000. Cadastral data compiled by Natural Resources Canada. Reproduced under license from © Her Majesty the Queen in Right of Canada, Department of Natural Resources Canada. All rights reserved.

**FIGURE 2**

**MONITORING STATION LOCATIONS**

ACCESS

Drawn by MD | MARCH 2010 | Checked by NS

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### *3.3.1 Surface Water Quality*

Surface water quality sampling was conducted during the four site visits in 2010 between May and October. The reader is referred to the 2010 Environmental Monitoring Update and Data Summary, included in Appendix B for details of the 2010 sampling and results.

### *3.3.2 Groundwater Quality*

Groundwater monitoring was also conducted during each of the year's site visits. The reader is referred to Appendix B for details of the sampling and results.

## 3.4 HYDROGEOLOGY STUDIES

No hydrogeologic studies were required or conducted in 2010.

## 3.5 WATER TREATMENT AND MANAGEMENT

No water treatment studies or water management studies were required or conducted in 2010.

## 3.6 CLIMATE DATA AND SNOW SURVEY MONITORING PROGRAM

Climate data from the meteorological station maintained by Yukon Government close to the property was logged from the end of May continuously throughout 2010. Carmacks Copper plans to install and maintain its own climate monitoring station at the site once a decision to proceed with construction has been made. Refer to Appendix B for a summary of 2010 temperature and precipitation data as well as the latest Yukon Government survey results at the Williams Creek snow course station.

## 3.7 GEOCHEMICAL STUDIES AND ACID-BASE ACCOUNTING

As mentioned in Section 3.1.2, metallurgical and geochemical testwork carried out for the Carmacks Copper project includes two sets of long term kinetic tests that concluded in March 2010. Residue from the humidity cells were subjected to a set of static tests to assess impacts of prolonged leaching on the acid rock drainage and metal leaching potential of the neutralized spent ore. Results of this testwork are presented in a Technical Memorandum provided in Appendix C.

## 3.8 PHYSICAL MONITORING PROGRAM

Aside from the Annual Engineer's Inspection (Appendix A), no physical monitoring of structures and facilities took place at the site in 2010.

## 3.9 ENGINEER'S ANNUAL PHYSICAL INSPECTION REPORTS

As required under Section 16.1 and 16.2 of the QML, Carmacks Copper Ltd. engaged Golder Associates Ltd. to perform an Annual Physical Inspection of the site. The inspection was carried out on July 8, 2010 (QML Section 16.1). The complete report is contained in Appendix A. This report has been previously submitted to Government of Yukon, Department of Energy, Mines and Resources, Mineral Resources Branch.

Since no development has taken place on site, the report focused on existing site conditions and limited infrastructure. All areas observed on July 8 to require maintenance were adequately repaired on August 5.

## 3.10 RECLAMATION AND REVEGETATION STUDIES

In 2007 a test patch of seeding was completed on an approximately 500 m x 12 m area adjacent (west) of the access road south of the Williams Creek crossing and the helicopter pad area. The seeding and resulting vegetation was intended to help stabilize sediments in this area and has been observed in the past three years to be performing well.

## 3.11 SUBMISSION AND APPROVAL OF PLANS

No plans were submitted during 2010.

# 4.0 OUTSTANDING FINANCIAL LIABILITY

## 4.1 HEAP LEACH

At present there has been no update to the assessment of the liability associated with the Heap Leach Facility which was presented in the May 2009 revision of the Preliminary Detailed Closure and Reclamation Plan.

## 4.2 WASTE ROCK STORAGE

There has also been no update to the assessment of the liability associated with the Waste Rock Storage Facility which was presented in the May 2009 revision of the Preliminary Detailed Closure and Reclamation Plan.

## 4.3 OVERALL LIABILITY

The estimated maximum overall liability associated with the development and operation of the mine remains as set out in the May 2009 revision of the Preliminary Detailed Closure and Reclamation Plan

| **Facility or Area Description** | **Cost** | |
|---|---|---|
| OPEN PIT | $ | 23,000 |
| HEAP LEACH FACILITY | $ | 17,295,000 |
| HLF EVENTS AND SEDIMENT PONDS | $ | 296,000 |
| WASTE ROCK STORAGE AREA | $ | 740,000 |
| PLANT AND ANCILLARY FACILITIES | $ | 467,000 |
| CAMP | $ | 103,000 |
| TRUCK SHOP SERVICE COMPLEX | $ | 70,000 |
| MISCELLANEOUS FACILITIES | $ | 95,000 |
| ACCESS AND HAUL ROADS | $ | 248,000 |
| SITE MANAGEMENT | $ | 1,103,000 |
| TOTAL | $ | 20,440,000 |

An additional $2.675 million is estimated to cover costs associated with rinsing and neutralization of the heap leach facility, should it extend to a 9 year period as opposed to the initially estimated 4.5 year period.

To date security in the amount of $80,300 has been posted with Yukon Government. This represents the liability incurred to date due to exploration activities on the site.

## 4.4 ENGINEERING CONTINGENCIES

In accordance with Section 11.0 of the QML, Carmacks Copper Ltd. prepared a Contingency Plan on the basis of a workshop held in October 2009. The plan was submitted to the Chief of Mining Land Use in January 2010. The main purpose of the Contingency Plan was to identify possible alternative approaches to decommissioning the Heap Leach Facility however other facilities were also examined. The plan identified a number of possible failure modes and contingency measures for each of the facilities and recommended further work that should be undertaken. The report was issued in draft format pending comments from government. No comment from government has been received to date. No further work has been undertaken at this time to develop any of the contingency plans identified.

# 5.0 CLOSING STATEMENTS

Access Consulting Group of Whitehorse, Yukon, has prepared this Annual Report on behalf of Carmacks Copper Ltd. We trust this document fulfills your present requirements. If you have any questions or require further details, please contact the undersigned.

**ACCESS CONSULTING GROUP**

**Nichole Speiss, B.Sc., EPI, EPt**
Environmental Scientist

**David Petkovich, B.Sc.**
Senior Environmental Manager

**WESTERN COPPER CORP**
**(On behalf of CARMACKS COPPER LTD.)**

**Paul West-Sells, Ph.D.**
President and Chief Operating Officer

Western Copper Corporation

# 2010 Annual Quartz Mining Licence Report

**Submitted to Yukon Government, Energy Mines and Resources**

**Yukon Quartz Mining Licence QML-0007**

# Appendix A

# Annual Engineer's Inspection Report, September 2010

September 2, 2010

Project No. 07-1413-0077
Doc. No. 150

Mr. Paul West-Sells
President & Chief Operating Officer
Western Copper Corporation
2050 - 1111 West Georgia Street
Vancouver, BC
V6E 4M3

**ANNUAL INSPECTION, JULY 8, 2010**
**CARMACKS COPPER PROJECT, CARMACKS, YUKON**

Dear Mr. West-Sells,

Golder Associates Ltd. (Golder) completed an inspection of the Carmacks Copper project site for Western Copper Corporation on July 8, 2010. The inspection of the proposed future site of Carmacks Copper's mine was completed as part of the requirement of the Quartz Mining License (QML – 0007) for an annual inspection. The inspection was to evaluate the condition and stability of the existing facilities in the area of the heap leach pad facility, the open pit mine area, the waste rock storage area, the processing plant facilities, ore preparation facilities, ore stockpiles, any water diversion structures and/or other related operations or facilities. The inspection was limited in that there are no structures on site at present with the exception of the mine exploration camp. An inspection was however, completed of the entire project area.

## 1.0 INSPECTION

The inspection by Golder was completed by Ms. Fiona Esford along with Scott Casselman – a representative of Western Copper Corporation. The inspection focused on the existing site conditions and the limited site infrastructure. Photographs of the site at the time of the inspection are presented in Appendix A.

The project is in the advanced exploration stage and final permitting for the proposed future mine. As noted the only infrastructure on site, at present, is the exploration camp and a series of access roads to the proposed open pit mine area and other areas of the property. The access roads were developed to provide access for exploration activities.

The inspection of the camp area indicated the camp is well maintained and there is no erosion of sediments from the pad area into the surrounding natural area. The slope behind or west of the camp is stable and is not impacting or causing any safety issues with the camp structures or operations. There is minor slumping of small sections of the slope, but these are not impacting camp safety nor would they represent an issue to workers on the project.

The inspection included the area proposed for the heap leach facility, events pond structure, and the heap leach sediment pond. This portion of the site also includes the area planned for the process plant west of the heap leach embankment. None of these structures have been developed and site preparation in these areas has been limited to the clearing of trees and organic soils (complete in 1997-1998), development of a series of access roads which cross the area, and drilling platforms established as part of the exploration programs. Since the initial clearing, vegetation re-growth has been occurring. Erosion and sediment control measures in this area were initially put into place in September 2008 and further maintained in September 2009. These include a series of ditches and berms to divert water into vegetated areas and to break up flow to reduce the potential for erosion, and silt fences. Additionally, there are several small sediment catch basins. The inspection indicated that there has been some erosion of sediments along the access roads and that the sediment basins are trapping and containing the sediment adequately. Additional capacity remains within these catch basins.

Further down slope, closer to Williams Creek, a series of silt fences have been installed and the area seeded. At the time of the inspection, re-growth in the area seeded in 2009 was observed to be occurring. Minor movement of sediment was observed beyond the lower silt fence. Sediment was observed to have entered a vegetated area beyond this silt fence, but there is no evidence that sediment has entered Williams Creek. On August 5, 2010, additional maintenance of the erosion control measures occurred. An additional silt fence was added to control further sediment movement beyond the existing fence. This work is deemed to be adequate at the current time. As with all temporary erosion control measures, annual inspection and ongoing minor maintenance activities should be anticipated.

The area where the open pit is to be developed was inspected. The excavation slopes of the trenches developed as part of the effort to obtain bulk samples during exploration activities were observed to be in reasonable condition and there was no observed slumping of the excavation slopes or failures of these slopes. There were no visual signs of erosion observed in the area of the proposed open pit. Several of the closed drill pads were inspected and there did not appear to be any erosion noted from these areas that require attention.

The area of the proposed waste rock storage area and the present access road crossing at North Williams Creek were inspected. The waste rock storage area is still tree covered and the drill pads in the area of the proposed waste rock storage area did not have any signs of sediment movement into the surrounding area. The small sediment catch basins at the drill pads still have capacity to manage more sediment, if required. Minor erosion along the ditches of the access road on the north side of North Williams Creek was observed. Small amounts of sediment had eroded and been trapped by the silt fences installed near the access road's crossing of North Williams Creek. The silt fences have reached their capacity to contain more sediment and require minor maintenance. On August 5, maintenance work was conducted in this area. A series of diversion ditches were created along the access road to divert water and sediment from the road area into adjacent vegetated areas. It is anticipated that this work will effectively reduce the movement of sediment towards North Williams Creek. Annual inspection and the requirement for minor maintenance of these sediment control measures should be anticipated.

The process plant and the crusher / truck shop areas were also inspected. The process plant site is partially cleared and the crusher / truck shop site is still tree covered. There was no apparent erosion along any of the access roads in these two areas or at the weather station located just to the west of the crusher / truck shop area.

The new camp site was inspected and it is still tree covered. The site adjacent to the camp where the new water wells were installed was also inspected and there is no apparent movement of sediment beyond the work pads around the wells.

The general site development has not started yet. Therefore, there are no stability concerns associated with the undeveloped facilities and no maintenance required. No permanent water diversion structures are in place. There are however, temporary water management diversion structures (*i.e.*, ditches and sediment catch basins) in place that are appropriate for the exploration stage of the property. It is recommended that they continue to be inspected annually and that ongoing maintenance be conducted, as deemed necessary. All areas observed to require maintenance on July 8, 2010 have subsequently been adequately repaired.

## 2.0 ADDITIONAL HEAP LEACH GEOCHEMISTRY TEST RESULTS

As part of the annual review, we summarize the ongoing geochemical testing of the leached ore obtained from columns using typical ore samples from the site.

The geochemical testing of samples obtained from leached, rinsed, and neutralized ore has been on-going to assess long term geochemical properties of the material and chemical constituents associated with water that would percolate through the material. Testing of samples obtained from two columns were completed in March 2010 and full results have been reported in Golder Doc. No. 105 "*Results of the 2008 Supplemental Geochemical Test Work on Waste Rock and Neutralized Spent Ore*" (March 26, 2010) and further testing conducted on residual material from the long term testing in Golder Doc. No. 145 "*Results of Static Tests on Terminated Humidity Cell Residual Results*" (August 4, 2010).

The leached, rinsed and neutralized column samples underwent testing for major and trace element whole rock analyses, short term leach testing using shake flask extraction (SFE), acid base accounting (ABA) testing, mineralogy and long term leach testing using humidity cells. Following the long term leach testing, residue from the columns was further tested for ABA, and whole rock major and trace element analyses.

The analyses of ABA data from the pre and post leaching (kinetic) test samples suggest that the samples are considered non-acid generating based on both ABA Net Potential Ratio (NPR) and Net Acid Generating) (NAG) test results. Using the more conservative criteria CaCO3 NPR, the samples have more variable acid rock drainage (ARD) characteristics ranging from non-acid generating to potentially acid generating. Changes between the pre and post whole rock analyses test result for major and trace element concentrations are variable, but some variability is likely attributed to sample heterogeneity and sample splits. Depletion calculations on both the pre and post samples indicate that two of the three samples will not go acid due to their low sulphide concentrations in the samples. However, one sample has the potential to go acid.

The SFE leachates for the neutralized ore samples were slightly alkaline for two samples and acidic for one sample. Leachates from the SFE comply with MMER guidelines with the exception of the pH from one of the samples (acidic pH of 5.96 compared to the guidelines of 6.0).

Humidity cell (also referred to as kinetic) testing was conducted over a period of 100 weeks for two column samples and 55 weeks for the third column sample. These results show that the leachate derived from the neutralized ore is neutral to alkaline and within MMER guideline limits, with the exception of one of the samples which is slightly acidic and less than or equal to the minimum MMER guideline (pH of 6.0). MMER metals concentrations of the humidity cell leachate are all below MMER – Maximum Monthly Mean concentrations and appear to have been declining over time.

Overall, the test results indicate that the leached, rinsed, neutralized, ore has a low potential for acid rock drainage or metal leaching. Over the short term, the residual alkali amendment from the neutralizing step will maintain circum-neutral to alkaline pH values in leachate from the heap leach pad. At the beginning of the test program the concentrations of Metal Mining Effluent Regulation (MMER) metals were below the guidelines and continued to decline over time indicating that metal leaching should not be an issue over the short or long term. Metals mobile under alkaline pH conditions likewise generally declined with time or reached a steady state concentration. Weathering rates observed in humidity cell tests are generally considered an order of magnitude higher than in the field (ASTM D5744-96, 2001) such that the observed neutral pH of the samples after 100 and 55 weeks of testing may translate to almost 20 years of leaching at the site with no apparent signs of a decline in pH. In addition, the proposed cover design for the heap leach pad will reduce the rate of infiltration of precipitation into and through the heap, thereby reducing the rate at which residual alkali amendment is dissolved and prolonging the residence time of the amendment in the field to maintain a circum-neutral pH condition. It is possible the pH may eventually decline with time. However, the low concentrations and generally rapid depletion rate of sulphide sulphur suggest that sulphides should not be a long term source of mineral acidity.

A large 8 m high column of leached, rinsed, and neutralized ore has just been dismantled and a new series of testing, as was conducted on the other column samples (*i.e.,* ABA, SFE, whole rock analysis, humidity cell testing, and residue testing following completion of the humidity cell testing), will begin approximately in mid-August.

## 3.0 RECOMMENDED ACTIONS

The inspection of the proposed mine site for the Carmacks Copper was completed on July 8, 2010 and indicated that as the site development has not been started yet, there is limited infrastructure and limited requirements for maintenance or further investigations. The required maintenance to manage some minor erosion items in the area of the events pond, the future heap leach sediment pond, and access road area near North Williams Creek was completed successfully in early August 2010. There is no further maintenance work related to this inspection required at this time.

We trust that this letter satisfies your requirements. If you require additional information, please do not hesitate to contact us.

Yours very truly,

**GOLDER ASSOCIATES LTD.**

Fiona Esford, P.Eng.
Senior Geotechnical Engineer

John Hull, P.Eng. (BC, NWT, NU, YK)
Principal

FE/JAH/fe/aw/rs

Attachments: Appendix A – Photographs

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## REFERENCES

Golder Doc. No. 105 "*Results of the 2008 Supplemental Geochemical Test Work on Waste Rock and Neutralized Spent Ore"* (March 26, 2010).

Golder Doc. No. 145 *"Results of Static Tests on Terminated Humidity Cell Residual Results"* (August 4, 2010).

# APPENDIX A
## Photographs

*Photographs 1 - 4:* *Carmacks Exploration Camp Infrastructure, which includes an office, core shack, equipment shed, temporary trailers for accommodations and kitchen facilities, and drill core storage area.*

*Date Taken:* *July 8, 2010*

*Photographs 5 - 6:* *Drill pad access road located north of Williams Creek and downstream of the area of the proposed heap leach facility sediment pond. Photographs show vegetation re-growth which has occurred and is assisting in stabilizing previously transported sediments.*

*Date Taken:* *July 8, 2010*

*Photograph 7: Silt fences located between the area of the proposed heap leach facility sediment pond and Williams Creek were generally in good condition, however, some sediment was observed to have travelled beyond (bypassed) the silt fence in the foreground. However, no evidence of sediment entering Williams Creek was observed at the time of the inspection.*

*Date Taken: July 8, 2010*


*Photograph 8:* *An additional row of silt fencing was added beyond the green silt fence on August 5 to control further sediment movement towards Williams Creek.*

*Date Taken:* *August 5, 2010*

*Photograph 9: View of proposed heap leach facility and plant site area, taken from area of proposed open pit, looking southwest.*

*Date Taken: July 8, 2010*

*Photographs 10 - 11:* *Access roads within the proposed waste rock storage area.*

*Date Taken:* *July 8, 2010*

*Photograph 12: Access road east of North Williams Creek.*

*Date Taken: July 8, 2010*

*Photograph 13:* *Yellow areas show where diversion ditches were excavated to redirect surface water runoff from the road side into the vegetated areas on either side of the access road.*

*Date Taken:* *August 5, 2010*

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Western Copper Corporation

# 2010 ANNUAL QUARTZ MINING LICENCE REPORT

SUBMITTED TO YUKON GOVERNMENT, ENERGY MINES AND RESOURCES

YUKON QUARTZ MINING LICENCE QML-0007

# Appendix B

# 2010 Environmental Monitoring Program Update and Data Summary, March 2011

Western Copper Corporation

# 2010 ENVIRONMENTAL MONITORING PROGRAM UPDATE AND DATA SUMMARY

## CARMACKS COPPER PROJECT
## YUKON TERRITORY

Prepared by:

ACCESS
CONSULTING GROUP

March 2011

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## APPENDICES

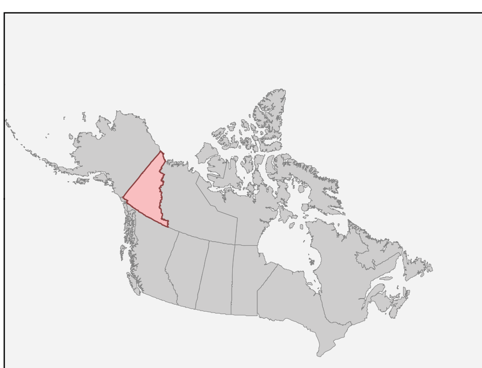
## 1.0 BACKGROUND & INTRODUCTION

The Carmacks Copper project is a proposed open pit copper mine and solvent extraction and electrowinning processing facility being developed by Carmacks Copper Ltd., a wholly owned subsidiary of Western Copper Corporation (Western Copper) of Vancouver, British Columbia. The ore body is located in Yukon (Figure 1), about 38 km northwest of the Village of Carmacks, or 192 km northwest of Whitehorse (Figure 2). The project site is located in the upper reaches of Williams Creek, approximately 9 km upstream of the confluence with the Yukon River. Williams Creek is a small erosional creek originating in the Dawson Range and draining northeast into the Yukon River downstream of Carmacks.

An initial assessment of baseline environmental conditions at the project site was undertaken between 1992 and 1994, with periodic data collection occurring in 1997 and 1999. In August 2005 the environmental monitoring program (EMP) was re-activated to update baseline data for the project area and has continued on a regular basis during ice free months, roughly between April and October. The EMP focuses primarily on collecting groundwater and surface water quality data, conducting fisheries, wildlife, vegetation, benthic and sediment studies (as required or permissible), and noting general site conditions throughout the years.

During 2010 no construction or development activities occurred at Carmacks Copper. Access Consulting Group conducted five site visits, which focused on the collection of baseline surface water and groundwater quality data, and noting site conditions. This report provides a summary of EMP activities completed and data collected to incorporate 2010 results and analysis. The five site visits in 2010 took place in April, May, June, August and October.

Table 1 summarizes environmental monitoring activities that have occurred at the Carmacks Copper site between 2005 and 2010.

Western Copper Corporation

ACCESS

## 2010 ENVIRONMENTAL MONITORING PROGRAM UPDATE AND DATA SUMMARY

FIGURE 1

PROJECT LOCATION


**CARMACKS COPPER PROJECT**

**2010 ENVIRONMENTAL MONITORING PROGRAM UPDATE AND DATA SUMMARY**

Western Copper Corporation

- Project Location
- Access Road
- Road
- Exploration Road
- Contour
- Watercourse
- Waterbody

Datum: NAD83; Projection: UTM Zone 8N

National Topographic Data Base (NTDB) compiled by Natural Resources Canada at a scale of 1:50,000. Cadastral data compiled by Natural Resources Canada. Reproduced under license from © Her Majesty the Queen in Right of Canada, Department of Natural Resources Canada. All rights reserved.

**FIGURE 2**

**PROJECT OVERVIEW**

ACCESS

| Drawn by MD | MARCH 2010 | Checked by NS |
|---|---|---|

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**Table 1 Summary of Environmental Monitoring Conducted Between 2005 and 2010**

| Date | Surface Water | Groundwater | Sediment | Benthos | Fisheries | Wildlife | Vegetation |
|---|---|---|---|---|---|---|---|
| Aug-05 | √ | | √ | | | | |
| Oct-05 | √ | | √ | | √ | | |
| Dec-05 | | | | | | √ | |
| Mar-06 | √ | | | | | | |
| Jun-06 | √ | √ | √ | | √ | | |
| Jul-06 | √ | √ | √ | | √ | √ | √ |
| Aug-06 | √ | √ | √ | | | | |
| Sep-06 | √ | √ | √ | √ | √ | | |
| Oct-06 | √ | √ | √ | | | | |
| Apr-07 | √ | √ | | | | | |
| May-07 | √ | √ | | | | | |
| Jun-07 | √ | √ | | | | | |
| Jul-07 | √ | √ | | | | | |
| Aug-07 | √ | √ | | | | | |
| Sep-07 | √ | √ | √ | √ | | | |
| Oct-07 | √ | √ | | | | | |
| Mar-08 | √ | | | | | | |
| Apr-08 | √ | | | | | | |
| May-08 | √ | √ | | | | | |
| June-08 | √ | √ | | | | | |
| July-08 | √ | √ | | | | | |
| Aug-08 | √ | √ | | | | | |
| Sept-08 | √ | √ | √ | | | | √ |
| Oct-08 | √ | √ | √ | | | | |
| Nov-08 | √ | | | | | | |
| May-09 | √ | √ | | | | | |
| July-09 | √ | √ | | | √ | | |
| Sept-09 | √ | | | | √ | | |
| Oct-09 | √ | √ | | | | | |
| Apr-10 | √* | | | | | | |
| May-10 | √ | √ | | | | | |
| June-10 | √ | √ | | | | | |
| Aug-10 | √ | √ | | | | | |
| Oct-10 | √ | | | | | | |

*Hydrology at W4 and W12 only

# 2.0 SURFACE WATER QUALITY MONITORING

Surface water quality samples have been routinely collected from Williams Creek, Nancy Lee Creek, and the Yukon River for analysis of physical parameters (pH, conductivity, total suspended solids, total dissolved solids, turbidity, hardness); inorganic nonmetallic parameters (ammonium, nitrogen, phosphorous, orthophosphate, dissolved organic carbon, total inorganic carbon, total organic carbon); weak acid dissociable cyanide; and total and dissolved metals. In-situ measurements (temperature, pH, conductivity, total dissolved solids, and dissolved oxygen) are also collected during sample collection.

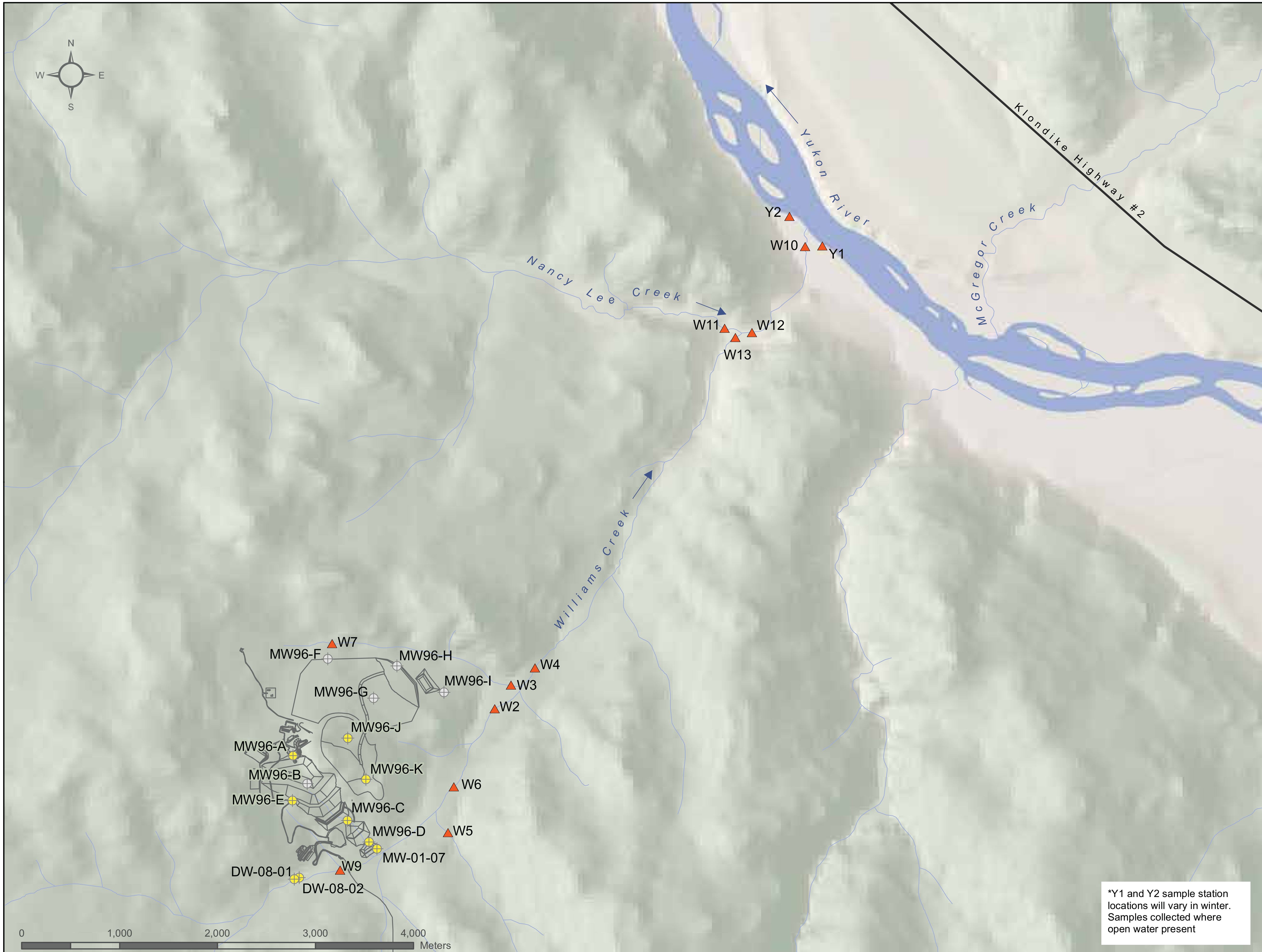
## 2.1 SURFACE WATER QUALITY SAMPLE STATION LOCATIONS & SAMPLING FREQUENCY

The thirteen surface water quality monitoring stations located on mainstem Williams Creek (seven), tributaries to Williams Creek (four), and on the Yukon River (two) are described in Table 2 and illustrated on Figure 3.

**Table 2 Surface Water Quality Monitoring Station Locations in Williams Creek Watershed**

| Station | Description / Location |
|---|---|
| W2 | Williams Creek Upstream of North Williams Creek Confluence |
| W3 | Lower North Williams Creek Upstream of Confluence with Williams Creek |
| W4 | Williams Creek Downstream of Confluence with North Williams Creek |
| W5 | South East Tributary to Williams Creek |
| W6 | Williams Creek Downstream of South East Tributary |
| W7 | Upper North Williams Creek Tributary Upstream of Road Crossing |
| W9 | Williams Creek Upstream of Access Road Crossing |
| W10 | Williams Creek Upstream of Yukon River |
| W11 | Nancy Lee Creek (Tributary of Williams Creek) |
| W12 | Williams Creek Downstream of Confluence with Nancy Lee Creek |
| W13 | Williams Creek Upstream of Confluence with Nancy Lee Creek |
| Y1 | Yukon River Upstream of Williams Creek |
| Y2 | Yukon River Downstream of Williams Creek |

Surface water quality monitoring activities took place at ten of the thirteen stations in 2010 (see Table 3). Williams Creek near the confluence with Yukon River (station W10) as well as the Yukon River (stations Y1 and Y2) were not monitored in 2010 due to the logistical challenge of accessing these locations. The data collected from these locations in previous years is considered relatively robust at this stage prior to project advancement.




**CARMACKS COPPER PROJECT**

**2010 ENVIRONMENTAL MONITORING PROGRAM UPDATE AND DATA SUMMARY**

Western Copper Corporation

Actively Monitored Well
Inactive Well
Surface Water Monitoring Station
Contour
Watercourse
Waterbody

Datum: NAD83; Projection: UTM Zone 8N

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**FIGURE 3**

**MONITORING STATION LOCATIONS**

ACCESS

Drawn by MD | MARCH 2010 | Checked by NS

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## Table 3 Water Quality Monitoring between 1989 and 2010

| Sample Event | Sample Stations | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | W2 | W3 | W4 | W5 | W6 | W7 | W9 | W10 | W11 | W12 | W13 | Y1* | Y2* |
| Oct-89 | Y | Y | Y | Y | Y | Y | Y | N | N | N | N | - | - |
| Aug-91 | N | Y | Y | Y | N | Y | Y | Y | N | N | N | - | - |
| Dec-91 | N | N | Y | Y | N | Y | Y | Y | Y | N | N | - | - |
| May-92 | N | Y | Y | Y | N | Y | Y | Y | Y | N | N | - | - |
| Jul-92 | N | Y | Y | Y | N | Y | Y | Y | N | N | N | - | - |
| Oct-92 | N | Y | Y | Y | N | Y | Y | Y | Y | N | N | - | - |
| May-94 | N | Y | Y | Y | N | Y | Y | N | N | N | N | - | - |
| Sep-97 | N | Y | Y | N | N | N | Y | N | N | N | N | - | - |
| Oct-99 | N | N | N | N | N | N | Y | Y | N | N | N | - | - |
| Aug-05 | Y | Y | Y | N | N | Y | Y | N | N | N | N | - | - |
| Oct-05 | Y | Y | Y | N | Y | Y | Y | Y | Y | Y | Y | - | - |
| Mar-06 | N | Y | Y | N | N | N | Y | Y | N | Y | Y | Y | Y |
| Jun-06 | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Jul-06 | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Aug-06 | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Sep-06 | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Oct-06 | Y | Y | Y | Y | Y | N | Y | Y | Y | Y | Y | Y | Y |
| Apr-07 | Y | Y | Y | Y | Y | N | Y | Y | Y | Y | Y | Y | Y |
| May-07 | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | N | Y |
| Jun-07 | Y | Y | Y | Y | Y | Y | Y | N | N | N | N | N | N |
| Jul-07 | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Aug-07 | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Sep-07 | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Oct-07 | Y | Y | Y | Y | Y | Y | Y | N | N | N | N | N | N |
| Mar-08 | Y | N | Y | N | N | N | Y | N | Y | Y | Y | Y | Y |
| Apr-08 | Y | Y | Y | N | Y | N | Y | N | Y | Y | Y | Y | Y |
| May-08 | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Jun-08 | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Jul-08 | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Aug-08 | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Sep-08 | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Oct-08 | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Nov-08 | Y | Y | Y | N | N | N | N | Y | Y | Y | Y | Y | Y |
| May-09 | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| July-09 | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Sep-09 | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Oct-09 | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Apr-10 | N | N | Y** | N | N | N | N | N | N | Y** | N | N | N |
| May-10 | Y | Y | Y | Y | Y | Y | Y | N | Y | Y | Y | N | N |
| Jun-10 | Y | Y | Y | Y | Y | Y | Y | N | Y | Y | Y | N | N |
| Aug-10 | Y | Y | Y | Y | Y | Y | Y | N | Y | Y | Y | N | N |
| Oct-10 | Y | Y | Y | Y | Y | Y | Y | N | Y | Y | Y | N | N |

* Yukon River sample stations established in 2006

**Hydrology only

### 2.2 PROTOCOL

Surface water quality sampling was undertaken using Industry recognized Best Management Practices and Standard Operating Procedures for the collection of surface water samples.

### 2.3 RESULTS AND DISCUSSION

Water quality data collected since 2005 are stored in an EQWin database that is customized to manage environmental sampling data. Historic data has not been entered into the database due to formatting challenges as original laboratory data is not available. Further, evaluation of the older data revealed that the laboratory's method detection limit (MDL) for many parameters was greater than applicable Canadian Water Quality Guidelines (CWQG; CCME 1999).

A summary of water quality data for each station sampled between 2005 and 2010 is provided for a number of parameters of interest, most of which have an associated CWQG for freshwater aquatic life including: pH, total suspended solids, total aluminum, total arsenic, total cadmium, total copper, total chromium, total iron, total lead, total mercury, total molybdenum, total selenium, total nickel, total zinc, ammonia nitrogen, nitrate nitrogen and nitrite nitrogen. Summary statistics are provided at each station for:

- average;
- sample size (count);
- minimum;
- maximum;
- count of samples less than laboratory MDL (< DL);
- standard deviation;
- 1st quartile;
- median;
- 3rd quartile; and
- Count of samples above the standard (in this case, 'standard' refers to the CCME CWQG, if applicable).

Where concentrations were below the laboratory MDL, one half the MDL value was used in for statistical calculation. Associated water quality summary graphs for the above listed parameters are provided within Appendix A.

## pH

For the most part pH falls within the CWQG range of 6.5 – 9.0. However, an occasional measurement of pH below 6.5 has been noted, with values as low as 4.64 (W5 on May 9, 2007). The few occasions where pH was measured below 6.5 tend to occur during spring freshet when high water levels were flowing over moss and organics present along creek banks. As water seeps through layers of decaying organic matter it can dissolve carbonic dioxide produced by decay which can result in lower pH levels. Measurements have also been observed to be near pH 9.0, with one measurement above at 9.97 at W2 on September 9, 2009. On average (as shown in Table 4) pH ranges between 7.34 and 7.97 for all sites.

**Table 4 Field pH – Water Quality Summary Statistics for 2005 – 2010**

| Statistic | W2 | W3 | W4 | W5 | W6 | W7 | W9 | W10 | W11 | W12 | W13 | Y1 | Y2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Average | 7.9 | 7.34 | 7.76 | 7.36 | 7.74 | 7.34 | 7.57 | 7.78 | 7.82 | 7.91 | 7.9 | 7.96 | 7.97 |
| Count | 29 | 29 | 29 | 24 | 27 | 24 | 28 | 23 | 26 | 28 | 27 | 20 | 19 |
| Minimum | 7.01 | 6.36 | 6.98 | 4.64 | 7.03 | 6.23 | 6.53 | 6.6 | 5.13 | 6.57 | 5.63 | 6.92 | 6.93 |
| Maximum | 9.97 | 8.5 | 9.03 | 8.1 | 8.31 | 8.4 | 8.84 | 8.65 | 8.8 | 8.9 | 8.71 | 8.7 | 8.63 |
| Standard Deviation | 0.58 | 0.42 | 0.52 | 0.67 | 0.36 | 0.49 | 0.44 | 0.6 | 0.66 | 0.55 | 0.63 | 0.46 | 0.5 |
| 1st Quartile | 7.54 | 7.12 | 7.27 | 7.2 | 7.49 | 7.05 | 7.36 | 7.32 | 7.67 | 7.74 | 7.8 | 7.8 | 7.82 |
| Median | 7.9 | 7.3 | 7.73 | 7.42 | 7.8 | 7.3 | 7.56 | 7.96 | 7.96 | 7.9 | 7.95 | 8.05 | 8.1 |
| 3rd Quartile | 8.16 | 7.64 | 8.15 | 7.78 | 7.96 | 7.6 | 7.86 | 8.26 | 8.17 | 8.17 | 8.23 | 8.22 | 8.25 |
| Count Over Standard | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 |

## Total Suspended Solids

Total suspended solids (TSS) values were generally low during sampling events, with average values ranging between 4 mg/L and 14 mg/L for all sites (Table 5). Elevations in TSS or spikes tend to occur during freshet as well as following rain events.

**Table 5 Total Suspended Solids – Water Quality Summary Statistics for 2005 – 2010**

| Statistic | W2 | W3 | W4 | W5 | W6 | W7 | W9 | W10 | W11 | W12 | W13 | Y1 | Y2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Average | 6 | 5 | 6 | 6 | 14 | 4 | 4 | 6 | 5 | 6 | 11 | 14 | 13 |
| Count | 29 | 29 | 30 | 24 | 26 | 24 | 31 | 22 | 27 | 28 | 28 | 23 | 24 |
| Minimum | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| Maximum | 100 | 26 | 76 | 35 | 123 | 29 | 24 | 42 | 34 | 40 | 120 | 98 | 90 |
| Count <DL | 17 | 13 | 17 | 11 | 8 | 18 | 16 | 14 | 13 | 12 | 13 | 7 | 5 |
| Standard Deviation | 19 | 7 | 15 | 10 | 27 | 7 | 6 | 12 | 8 | 8 | 25 | 23 | 21 |
| 1st Quartile | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 |
| Median | 1 | 2 | 1 | 1 | 2 | 1 | 2 | 1 | 2 | 2 | 1 | 6 | 5 |
| 3rd Quartile | 3 | 6 | 4 | 6 | 12 | 1 | 4 | 4 | 6 | 6 | 7 | 14 | 14 |

## Total Aluminum

As shown in Table 6, total aluminum concentrations regularly exceed the CWQG of 0.1 mg/L (at pH ≥ 6.5, or 0.005 mg/L at pH < 6.5). A site specific water quality objective of 0.66 mg/L has been derived using CCME protocols by Minnow Environmental Inc. (assessing water quality data collected between 2005 and 2008). Average concentrations for all sites range between 0.0769 mg/L (W7) and 0.3937 mg/L (Y2). Downstream stations where fish have been observed (W10, W11, and W13) periodically exceed the site specific objective as do most other stations including the Yukon River.

**Table 6 Total Aluminum – Water Quality Summary Statistics for 2005 – 2010**

| Statistic | W2 | W3 | W4 | W5 | W6 | W7 | W9 | W10 | W11 | W12 | W13 | Y1 | Y2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Average | 0.1075 | 0.1527 | 0.125 | 0.1574 | 0.2048 | 0.0769 | 0.0774 | 0.1778 | 0.1194 | 0.112 | 0.1435 | 0.3135 | 0.3937 |
| Count | 31 | 31 | 32 | 24 | 28 | 28 | 33 | 23 | 28 | 29 | 30 | 23 | 24 |
| Minimum | 0.01 | 0.006 | 0.01 | 0.01 | 0.01 | 0.025 | 0.0055 | 0.005 | 0.0088 | 0.01 | 0.0025 | 0.019 | 0.01 |
| Maximum | 1.44 | 1.76 | 1.48 | 1.68 | 2.09 | 0.405 | 0.623 | 1.08 | 0.746 | 0.634 | 1.12 | 2.1 | 2.04 |
| Count <DL | 1 | 1 | 1 | 0 | 1 | 0 | 2 | 1 | 1 | 1 | 3 | 0 | 1 |
| Standard Deviation | 0.2541 | 0.3569 | 0.2703 | 0.3402 | 0.4059 | 0.0908 | 0.123 | 0.2767 | 0.1825 | 0.1373 | 0.2372 | 0.4964 | 0.5281 |
| 1st Quartile | 0.0195 | 0.0116 | 0.0198 | 0.0268 | 0.033 | 0.0365 | 0.017 | 0.0191 | 0.026 | 0.0273 | 0.0152 | 0.0279 | 0.07 |
| Median | 0.035 | 0.03 | 0.0358 | 0.0439 | 0.084 | 0.0458 | 0.03 | 0.078 | 0.045 | 0.05 | 0.0393 | 0.0894 | 0.229 |
| 3rd Quartile | 0.092 | 0.0877 | 0.079 | 0.1465 | 0.1725 | 0.0663 | 0.058 | 0.1585 | 0.1087 | 0.156 | 0.1555 | 0.4155 | 0.4632 |
| Count Over Standard | 6 | 8 | 7 | 8 | 13 | 7 | 6 | 9 | 8 | 10 | 11 | 12 | 15 |
| % Over Standard | 19.4 | 25.8 | 21.9 | 33.3 | 46.4 | 25 | 18.2 | 39.1 | 28.6 | 34.5 | 36.7 | 52.2 | 62.5 |

## Total Arsenic

Table 7 shows that site arsenic concentrations are well below the CWQG of 0.005 mg/L. Average arsenic values for the sites are estimated to range between 0.00041 and 0.00059 mg/L.

**Table 7 Total Arsenic – Water Quality Summary Statistics for 2005 – 2010**

| Statistic | W2 | W3 | W4 | W5 | W6 | W7 | W9 | W10 | W11 | W12 | W13 | Y1 | Y2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Average | 0.00055 | 0.00052 | 0.00055 | 0.0005 | 0.00055 | 0.0005 | 0.00051 | 0.00048 | 0.0005 | 0.00041 | 0.00043 | 0.00059 | 0.00058 |
| Count | 31 | 31 | 32 | 24 | 28 | 28 | 33 | 23 | 28 | 29 | 30 | 23 | 24 |
| Minimum | 0.0001 | 0.0001 | 0.0001 | 0.0002 | 0.0001 | 0.0001 | 0.0001 | 0.0002 | 0.0002 | 0.0001 | 0.0001 | 0.0001 | 0.0002 |
| Maximum | 0.0016 | 0.0022 | 0.0014 | 0.0023 | 0.0013 | 0.0026 | 0.0014 | 0.0018 | 0.0016 | 0.0008 | 0.0008 | 0.0026 | 0.0016 |
| Count <DL | 2 | 2 | 3 | 1 | 2 | 4 | 4 | 1 | 0 | 4 | 3 | 3 | 1 |
| Standard Deviation | 0.00029 | 0.00037 | 0.00027 | 0.00041 | 0.00025 | 0.00044 | 0.00029 | 0.00031 | 0.00026 | 0.00016 | 0.00017 | 0.0005 | 0.00027 |
| 1st Quartile | 0.0004 | 0.0004 | 0.0004 | 0.0003 | 0.0004 | 0.00036 | 0.00038 | 0.00038 | 0.0004 | 0.0003 | 0.00031 | 0.0004 | 0.00044 |
| Median | 0.0005 | 0.00044 | 0.0005 | 0.00045 | 0.0005 | 0.0004 | 0.0005 | 0.0004 | 0.00043 | 0.0004 | 0.0004 | 0.0005 | 0.0005 |
| 3rd Quartile | 0.00063 | 0.0005 | 0.0006 | 0.00052 | 0.0007 | 0.0005 | 0.0006 | 0.0005 | 0.0005 | 0.0005 | 0.0005 | 0.00055 | 0.0006 |
| Count Over Standard | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

## Total Cadmium

The CWQG for total cadmium is dependent on hardness, and Minnow Environmental Inc. calculated the guideline to range between 0.00003 and 0.00006 mg/L (depending on the station) in their *Evaluation of Water Quality and Development of Background-Based Site-Specific Water Quality Objectives for Williams Creek* (May 2008), which evaluated data collected between 2005 and 2007. Prior to 2009 most results were below the MDL; improved laboratory MDLs were implemented in 2009 and 2010 and since then (~8 sample events) the data shows that exceedances of the hardness dependent guideline have occurred at all but four stations (W2, W3, W9 and W10) once, and three times for W7 and W12.

**Table 8 Total Cadmium – Water Quality Summary Statistics for 2005 – 2010**

| Statistic | W2 | W3 | W4 | W5 | W6 | W7 | W9 | W10 | W11 | W12 | W13 | Y1 | Y2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Average | 0.000016 | 0.000014 | 0.000021 | 0.000014 | 0.000017 | 0.00003 | 0.000018 | 0.00002 | 0.000033 | 0.000465 | 0.000017 | 0.000018 | 0.000019 |
| Count | 31 | 31 | 32 | 24 | 28 | 28 | 33 | 23 | 28 | 29 | 30 | 23 | 24 |
| Minimum | 0.000003 | 0.000003 | 0.000003 | 0.000005 | 0.000003 | 0.000005 | 0.000003 | 0.000005 | 0.000003 | 0.000003 | 0.000003 | 0.000005 | 0.000005 |
| Maximum | 0.00005 | 0.00004 | 0.00012 | 0.000041 | 0.000089 | 0.00024 | 0.00008 | 0.00006 | 0.00034 | 0.0127 | 0.00004 | 0.000054 | 0.00005 |
| Count <DL | 19 | 20 | 19 | 16 | 18 | 14 | 20 | 12 | 12 | 13 | 16 | 14 | 12 |
| Standard Deviation | 0.000014 | 0.000012 | 0.000025 | 0.000012 | 0.000019 | 0.000049 | 0.000018 | 0.000016 | 0.000064 | 0.002354 | 0.000013 | 0.000016 | 0.000013 |
| 1st Quartile | 0.000005 | 0.000005 | 0.000005 | 0.000005 | 0.000005 | 0.000005 | 0.000005 | 0.000005 | 0.000009 | 0.000009 | 0.000005 | 0.000005 | 0.00001 |
| Median | 0.00001 | 0.00001 | 0.00001 | 0.000009 | 0.00001 | 0.00001 | 0.00001 | 0.000013 | 0.000012 | 0.000018 | 0.00001 | 0.00001 | 0.000016 |
| 3rd Quartile | 0.000023 | 0.000024 | 0.000035 | 0.000016 | 0.000024 | 0.000035 | 0.000035 | 0.000031 | 0.000035 | 0.000035 | 0.000029 | 0.000027 | 0.000024 |

## Total Chromium

The CWQG for hexavalent chromium is 0.001 mg/L, which has been exceeded by total chromium measured at each station. Laboratory speciation is not readily available for the valence states of chromium identified in the CWQG; therefore, the lower value of 0.001 mg/L for hexavalent chromium is used to compare with total chromium. This is a conservative approach since the hexavalent form of chromium comprises only a fraction of the total. In Minnow's evaluation of water quality (Minnow, 2008) the guideline for chromium was observed to be exceeded at 5 percent or less of the time. Average total chromium (Table 9) ranges between 0.0005 mg/L (W12) and 0.0011 mg/L (Y2).

**Table 9 Total Chromium – Water Quality Summary Statistics for 2005 – 2010**

| Statistic | W2 | W3 | W4 | W5 | W6 | W7 | W9 | W10 | W11 | W12 | W13 | Y1 | Y2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Average | 0.0006 | 0.0008 | 0.0007 | 0.0008 | 0.0008 | 0.0008 | 0.0006 | 0.0006 | 0.0007 | 0.0005 | 0.0006 | 0.001 | 0.0011 |
| Count | 31 | 31 | 32 | 24 | 28 | 28 | 33 | 23 | 28 | 29 | 30 | 23 | 24 |
| Minimum | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0002 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 |
| Maximum | 0.0027 | 0.0039 | 0.0027 | 0.0034 | 0.0038 | 0.0026 | 0.0017 | 0.002 | 0.002 | 0.0014 | 0.0025 | 0.004 | 0.0037 |
| Count <DL | 13 | 15 | 13 | 7 | 6 | 6 | 12 | 11 | 7 | 12 | 12 | 6 | 5 |
| Standard Deviation | 0.0005 | 0.001 | 0.0006 | 0.0007 | 0.0008 | 0.0006 | 0.0005 | 0.0005 | 0.0005 | 0.0004 | 0.0006 | 0.001 | 0.001 |
| 1st Quartile | 0.0003 | 0.0003 | 0.0003 | 0.0003 | 0.0004 | 0.0003 | 0.0003 | 0.0003 | 0.0003 | 0.0003 | 0.0003 | 0.0003 | 0.0004 |
| Median | 0.0005 | 0.0003 | 0.0005 | 0.0005 | 0.0006 | 0.0006 | 0.0005 | 0.0005 | 0.0006 | 0.0005 | 0.0004 | 0.0006 | 0.001 |
| 3rd Quartile | 0.0009 | 0.0011 | 0.0011 | 0.0009 | 0.0011 | 0.001 | 0.0009 | 0.0008 | 0.0009 | 0.0007 | 0.0009 | 0.0012 | 0.0014 |
| Count Over Standard | 6 | 8 | 10 | 4 | 9 | 6 | 6 | 3 | 4 | 3 | 5 | 9 | 11 |

## Total Copper

The CWQG for total copper is hardness dependent and regularly exceeded as shown in Table 10:

- 0.002 mg/L at hardness less than 120 mg/L;
- 0.003 mg/L at hardness from 120 – 180 mg/L; and
- 0.004 mg/L at hardness greater than 180 mg/L.

Minnow Environmental calculated the following hardness dependent, CCME derived site specific water quality objective for total copper:

- 0.021 mg/L at hardness less than 120 mg/L;
- 0.032 mg/L at hardness from 120 – 180 mg/L; and
- 0.042 mg/L at hardness greater than 180 mg/L.

Table 10 shows average concentrations for all sites ranging between 0.00137 mg/L (Y1) and 0.00497 mg/L (W7). However, at W7 the maximum total copper concentration of 0.066 mg/L is thought to be erroneous. At W7 North Williams Creek is narrow and shallow and mobilization of sediment or soil may have incidentally contaminated the sample.

**Table 10 Total Copper – Water Quality Summary Statistics for 2005 – 2010**

| Statistic | W2 | W3 | W4 | W5 | W6 | W7 | W9 | W10 | W11 | W12 | W13 | Y1 | Y2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Average | 0.00163 | 0.00193 | 0.00219 | 0.00205 | 0.00163 | 0.00497 | 0.00147 | 0.00248 | 0.00254 | 0.00238 | 0.00211 | 0.00137 | 0.00182 |
| Count | 31 | 31 | 32 | 24 | 28 | 28 | 33 | 23 | 28 | 29 | 30 | 23 | 24 |
| Minimum | 0.00048 | 0.0005 | 0.0005 | 0.0005 | 0.0005 | 0.001 | 0.00047 | 0.001 | 0.0007 | 0.0005 | 0.0005 | 0.0005 | 0.0005 |
| Maximum | 0.008 | 0.005 | 0.014 | 0.007 | 0.005 | 0.066 | 0.004 | 0.004 | 0.005 | 0.00401 | 0.007 | 0.004 | 0.008 |
| Count <DL | 6 | 3 | 6 | 2 | 5 | 1 | 7 | 1 | 1 | 2 | 4 | 7 | 8 |
| Standard Deviation | 0.00142 | 0.0011 | 0.00247 | 0.00135 | 0.00104 | 0.01201 | 0.00086 | 0.0009 | 0.00098 | 0.0009 | 0.00136 | 0.00101 | 0.00177 |
| 1st Quartile | 0.001 | 0.001 | 0.001 | 0.001 | 0.00099 | 0.002 | 0.00088 | 0.002 | 0.002 | 0.002 | 0.0012 | 0.00059 | 0.00064 |
| Median | 0.001 | 0.00181 | 0.00159 | 0.002 | 0.00132 | 0.00261 | 0.001 | 0.002 | 0.00243 | 0.002 | 0.002 | 0.001 | 0.001 |
| 3rd Quartile | 0.002 | 0.00203 | 0.0026 | 0.003 | 0.002 | 0.003 | 0.002 | 0.003 | 0.003 | 0.003 | 0.00214 | 0.002 | 0.002 |
| Count Over Standard | 4 | 8 | 9 | 8 | 5 | 16 | 4 | 9 | 13 | 10 | 6 | 2 | 5 |
| % Over Standard | 12.9 | 25.8 | 28.1 | 33.3 | 17.9 | 57.1 | 12.1 | 39.1 | 46.4 | 34.5 | 20 | 8.7 | 20.8 |

## Total Iron

In addition to total aluminum and copper, total iron concentrations also regularly exceed the CWQG of 0.3 mg/L (Table 11). Therefore, a CCME derived site specific water quality objective of 1.1 mg/L has been calculated by Minnow Environmental (assessing water quality data collected between 2005 and 2008). Average concentrations shown in Table 11 for all sites range between 0.198 mg/L (W12) and 0.665 mg/L (W5). Downstream stations where fish have been observed (W10, W11, and W13) periodically exceed the site specific objective as do most other stations including the Yukon River.

**Table 11 Total Iron – Water Quality Summary Statistics for 2005 – 2010**

| Statistic | W2 | W3 | W4 | W5 | W6 | W7 | W9 | W10 | W11 | W12 | W13 | Y1 | Y2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Average | 0.392 | 0.469 | 0.385 | 0.665 | 0.527 | 0.295 | 0.234 | 0.285 | 0.252 | 0.198 | 0.227 | 0.421 | 0.578 |
| Count | 31 | 31 | 32 | 24 | 28 | 28 | 33 | 23 | 28 | 29 | 30 | 23 | 24 |
| Minimum | 0.01 | 0.01 | 0.01 | 0.05 | 0.01 | 0.05 | 0.04 | 0.029 | 0.02 | 0.03 | 0.02 | 0.04 | 0.04 |
| Maximum | 2.2 | 4.66 | 2.2 | 6.09 | 2.8 | 2.2 | 0.84 | 1.2 | 1.2 | 0.7 | 1.48 | 2.4 | 3.44 |
| Count <DL | 3 | 4 | 2 | 1 | 2 | 3 | 2 | 3 | 8 | 7 | 9 | 5 | 3 |
| Standard Deviation | 0.378 | 0.893 | 0.389 | 1.181 | 0.54 | 0.435 | 0.212 | 0.337 | 0.301 | 0.199 | 0.322 | 0.63 | 0.829 |
| 1st Quartile | 0.265 | 0.1 | 0.254 | 0.3 | 0.296 | 0.1 | 0.1 | 0.067 | 0.05 | 0.05 | 0.05 | 0.079 | 0.129 |
| Median | 0.3 | 0.2 | 0.3 | 0.363 | 0.365 | 0.13 | 0.17 | 0.11 | 0.157 | 0.1 | 0.081 | 0.16 | 0.26 |
| 3rd Quartile | 0.4 | 0.418 | 0.355 | 0.525 | 0.522 | 0.228 | 0.3 | 0.381 | 0.265 | 0.3 | 0.296 | 0.405 | 0.625 |
| Count Over Standard | 15 | 9 | 10 | 16 | 17 | 7 | 5 | 7 | 7 | 7 | 6 | 7 | 10 |

## Total Lead

The CWQG for total lead is dependent on hardness (typically ranging between 0.002 mg/L and 0.007 mg/L). Table 12 shows occasional exceedances of the guideline, while average concentrations range between 0.00014 mg/L and 0.00061 mg/L.

**Table 12  Total Lead – Water Quality Summary Statistics for 2005 – 2010**

| Statistic | W2 | W3 | W4 | W5 | W6 | W7 | W9 | W10 | W11 | W12 | W13 | Y1 | Y2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Average | 0.00022 | 0.00030 | 0.00019 | 0.00014 | 0.00016 | 0.00061 | 0.00036 | 0.00019 | 0.00043 | 0.00024 | 0.00038 | 0.00021 | 0.00037 |
| Count | 31 | 31 | 32 | 24 | 28 | 28 | 33 | 23 | 28 | 29 | 30 | 23 | 24 |
| Minimum | 0.00001 | 0.00001 | 0.00001 | 0.00001 | 0.00001 | 0.00001 | 0.00002 | 0.00004 | 0.00000 | 0.00002 | 0.00002 | 0.00002 | 0.00005 |
| Maximum | 0.0033 | 0.0038 | 0.0014 | 0.001 | 0.0006 | 0.0111 | 0.0037 | 0.0005 | 0.0071 | 0.0016 | 0.0037 | 0.0008 | 0.0019 |
| Count <DL | 16 | 7 | 12 | 8 | 9 | 10 | 11 | 7 | 12 | 5 | 9 | 8 | 4 |
| Standard Deviation | 0.00059 | 0.00069 | 0.00029 | 0.00019 | 0.00014 | 0.00208 | 0.00076 | 0.00013 | 0.00134 | 0.00030 | 0.00072 | 0.00021 | 0.00043 |
| 1st Quartile | 0.00005 | 0.00006 | 0.00005 | 0.00005 | 0.00005 | 0.00005 | 0.00005 | 0.00008 | 0.00005 | 0.00010 | 0.00005 | 0.00005 | 0.00010 |
| Median | 0.00005 | 0.00010 | 0.00010 | 0.00010 | 0.00010 | 0.00010 | 0.00010 | 0.00015 | 0.00010 | 0.00020 | 0.00010 | 0.00013 | 0.00022 |
| 3rd Quartile | 0.00012 | 0.00020 | 0.00020 | 0.00020 | 0.00020 | 0.00023 | 0.00023 | 0.00030 | 0.00020 | 0.00030 | 0.00029 | 0.00030 | 0.00033 |
| Count Over Standard | 1 | 2 | 1 | 0 | 0 | 2 | 3 | 0 | 2 | 1 | 3 | 0 | 1 |
| % Over Standard | 3.2 | 6.5 | 3.1 | 0 | 0 | 7.1 | 9.1 | 0 | 7.1 | 3.4 | 10 | 0 | 4.2 |

## Total Mercury

Total mercury concentrations infrequently register above laboratory detection levels (MDL = 0.00001 mg/L).  The CWQG for inorganic mercury is 0.000026 mg/L and average total mercury has been estimated to range between 0.000006 mg/L and 0.000012 mg/L using ½ the MDL to calculate (Table 13).

**Table 13  Total Mercury – Water Quality Summary Statistics for 2005 – 2010**

| Statistic | W2 | W3 | W4 | W5 | W6 | W7 | W9 | W10 | W11 | W12 | W13 | Y1 | Y2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Average | 0.00001 | 0.00001 | 0.00001 | 0.00001 | 0.00001 | 0.00001 | 0.00001 | 0.00001 | 0.00001 | 0.00001 | 0.00001 | 0.00001 | 0.00001 |
| Count | 22 | 21 | 22 | 17 | 20 | 20 | 23 | 15 | 20 | 20 | 21 | 16 | 17 |
| Minimum | 0.00001 | 0.00001 | 0.00001 | 0.00001 | 0.00001 | 0.00001 | 0.00001 | 0.00001 | 0.00001 | 0.00001 | 0.00001 | 0.00001 | 0.00001 |
| Maximum | 0.00005 | 0.00005 | 0.00005 | 0.00005 | 0.00005 | 0.00005 | 0.00006 | 0.00005 | 0.00005 | 0.00005 | 0.00005 | 0.00001 | 0.00005 |
| Count <DL | 21 | 17 | 19 | 14 | 16 | 14 | 21 | 14 | 18 | 18 | 19 | 16 | 16 |
| Standard Deviation | 0.00001 | 0.00001 | 0.00001 | 0.00001 | 0.00001 | 0.00001 | 0.00001 | 0.00001 | 0.00001 | 0.00001 | 0.00001 | 0 | 0.00001 |
| 1st Quartile | 0.00001 | 0.00001 | 0.00001 | 0.00001 | 0.00001 | 0.00001 | 0.00001 | 0.00001 | 0.00001 | 0.00001 | 0.00001 | 0.00001 | 0.00001 |
| Median | 0.00001 | 0.00001 | 0.00001 | 0.00001 | 0.00001 | 0.00001 | 0.00001 | 0.00001 | 0.00001 | 0.00001 | 0.00001 | 0.00001 | 0.00001 |
| 3rd Quartile | 0.00001 | 0.00001 | 0.00001 | 0.00001 | 0.00001 | 0.00001 | 0.00001 | 0.00001 | 0.00001 | 0.00001 | 0.00001 | 0.00001 | 0.00001 |
| Count Over Standard | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 0 | 1 |

## Total Molybdenum

The CWQG for total molybdenum is 0.073 mg/L and has not been exceeded at any of the stations.  Average total molybdenum ranges between 0.00039 mg/L and 0.00424 mg/L.

**Table 14 Total Molybdenum – Water Quality Summary Statistics for 2005 – 2010**

| Statistic | W2 | W3 | W4 | W5 | W6 | W7 | W9 | W10 | W11 | W12 | W13 | Y1 | Y2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Average | 0.0042 | 0.00072 | 0.00424 | 0.00059 | 0.00335 | 0.00039 | 0.0009 | 0.00133 | 0.00066 | 0.00143 | 0.00244 | 0.00097 | 0.00095 |
| Count | 31 | 31 | 32 | 24 | 28 | 28 | 33 | 23 | 28 | 29 | 30 | 23 | 24 |
| Minimum | 0.0005 | 0.00028 | 0.00066 | 0.00026 | 0.00062 | 0.00001 | 0.00015 | 0.00034 | 0.00019 | 0.00037 | 0.0007 | 0.0005 | 0.00033 |
| Maximum | 0.009 | 0.00115 | 0.026 | 0.001 | 0.007 | 0.001 | 0.004 | 0.003 | 0.002 | 0.003 | 0.005 | 0.00131 | 0.00138 |
| Count <DL | 2 | 16 | 2 | 13 | 1 | 16 | 11 | 4 | 11 | 5 | 1 | 3 | 5 |
| Standard Deviation | 0.00212 | 0.00027 | 0.00434 | 0.00021 | 0.00181 | 0.00029 | 0.00087 | 0.00057 | 0.00036 | 0.00068 | 0.0009 | 0.00017 | 0.00022 |
| 1st Quartile | 0.003 | 0.0005 | 0.002 | 0.0005 | 0.002 | 0.00015 | 0.0005 | 0.001 | 0.0005 | 0.00095 | 0.002 | 0.00098 | 0.00091 |
| Median | 0.00489 | 0.00056 | 0.00385 | 0.0005 | 0.00346 | 0.0005 | 0.00058 | 0.00118 | 0.00051 | 0.00138 | 0.00262 | 0.001 | 0.001 |
| 3rd Quartile | 0.00528 | 0.001 | 0.005 | 0.00069 | 0.00441 | 0.0005 | 0.001 | 0.00166 | 0.00078 | 0.002 | 0.003 | 0.00101 | 0.001 |
| Count Over Standard | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

## Total Nickel

The CWQG for total nickel is dependent on hardness, and typically ranges between 0.065 mg/L and 0.15 mg/L (depending on the station) (Minnow, 2008). Average concentrations (Table 15) range between 0.00102 mg/L and 0.00244 mg/L.

**Table 15 Total Nickel – Water Quality Summary Statistics for 2005 – 2010**

| Statistic | W2 | W3 | W4 | W5 | W6 | W7 | W9 | W10 | W11 | W12 | W13 | Y1 | Y2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Average | 0.00105 | 0.00139 | 0.00106 | 0.00202 | 0.00135 | 0.00155 | 0.0011 | 0.0011 | 0.00128 | 0.00102 | 0.00102 | 0.00141 | 0.00244 |
| Count | 31 | 31 | 32 | 24 | 28 | 28 | 33 | 23 | 28 | 29 | 30 | 23 | 24 |
| Minimum | 0.0005 | 0.00025 | 0.00025 | 0.00025 | 0.00025 | 0.00025 | 0.00025 | 0.00025 | 0.00025 | 0.00025 | 0.00025 | 0.00025 | 0.00025 |
| Maximum | 0.005 | 0.01 | 0.006 | 0.017 | 0.009 | 0.004 | 0.007 | 0.008 | 0.01 | 0.006 | 0.005 | 0.009 | 0.03 |
| Count <DL | 5 | 7 | 7 | 3 | 4 | 2 | 9 | 7 | 5 | 10 | 9 | 7 | 6 |
| Standard Deviation | 0.00084 | 0.00202 | 0.00102 | 0.00353 | 0.00157 | 0.00069 | 0.00147 | 0.00159 | 0.00176 | 0.00107 | 0.00095 | 0.00197 | 0.00597 |
| 1st Quartile | 0.00068 | 0.00055 | 0.0006 | 0.00076 | 0.00075 | 0.00117 | 0.0005 | 0.0005 | 0.0007 | 0.0005 | 0.0005 | 0.0005 | 0.00059 |
| Median | 0.0008 | 0.0007 | 0.00076 | 0.00101 | 0.001 | 0.00145 | 0.00078 | 0.00065 | 0.001 | 0.0007 | 0.00072 | 0.00063 | 0.00095 |
| 3rd Quartile | 0.001 | 0.00119 | 0.00101 | 0.00128 | 0.00133 | 0.002 | 0.001 | 0.0009 | 0.00108 | 0.0011 | 0.00112 | 0.0011 | 0.00145 |
| Count Over Standard | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |

## Total Selenium

Total selenium concentrations (shown in Table 16) are below the CWQG of 0.001 mg/L.

**Table 16 Total Selenium – Water Quality Summary Statistics for 2005 – 2010**

| Statistic | W2 | W3 | W4 | W5 | W6 | W7 | W9 | W10 | W11 | W12 | W13 | Y1 | Y2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Average | 0.0002 | 0.00016 | 0.0002 | 0.00014 | 0.00016 | 0.00016 | 0.0002 | 0.00017 | 0.00018 | 0.0002 | 0.00021 | 0.00023 | 0.0002 |
| Count | 31 | 31 | 32 | 24 | 28 | 28 | 33 | 23 | 28 | 29 | 30 | 23 | 24 |
| Minimum | 0.00007 | 0.00002 | 0.00007 | 0.00002 | 0.00006 | 0.00005 | 0.00006 | 0.00008 | 0.00005 | 0.00005 | 0.00008 | 0.0001 | 0.0001 |
| Maximum | 0.0005 | 0.0008 | 0.0009 | 0.0003 | 0.0003 | 0.0003 | 0.0009 | 0.0003 | 0.001 | 0.0006 | 0.0007 | 0.0009 | 0.0003 |
| Count <DL | 18 | 22 | 19 | 21 | 19 | 17 | 22 | 19 | 19 | 18 | 17 | 16 | 17 |
| Standard Deviation | 0.00013 | 0.00015 | 0.00019 | 0.0001 | 0.00009 | 0.0001 | 0.00017 | 0.00009 | 0.00018 | 0.00013 | 0.00015 | 0.00018 | 0.00008 |
| 1st Quartile | 0.0001 | 0.00009 | 0.0001 | 0.00009 | 0.0001 | 0.00008 | 0.0001 | 0.0001 | 0.00009 | 0.0001 | 0.0001 | 0.0001 | 0.00012 |
| Median | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.00013 | 0.0001 | 0.00015 | 0.00014 | 0.00019 | 0.0002 |
| 3rd Quartile | 0.0003 | 0.0002 | 0.0003 | 0.0002 | 0.00022 | 0.0003 | 0.0003 | 0.00025 | 0.00022 | 0.0003 | 0.0003 | 0.0003 | 0.0003 |
| Count Over Standard | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

## Total Zinc

Total zinc has not exceeded the CCME Guideline (0.03 mg/L) during 2005 to 2010 sampling. Average total zinc concentrations (Table 17) range between 0.0041 mg/L and 0.0061 mg/L.

**Table 17 Total Zinc – Water Quality Summary Statistics for 2005 – 2010**

| Statistic | W2 | W3 | W4 | W5 | W6 | W7 | W9 | W10 | W11 | W12 | W13 | Y1 | Y2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Average | 0.0052 | 0.0041 | 0.0061 | 0.0045 | 0.0047 | 0.0058 | 0.0046 | 0.0048 | 0.0055 | 0.0052 | 0.0043 | 0.0047 | 0.0054 |
| Count | 31 | 31 | 32 | 24 | 28 | 28 | 33 | 23 | 28 | 29 | 30 | 23 | 24 |
| Minimum | 0.0005 | 0.0005 | 0.0002 | 0.0005 | 0.0003 | 0.0005 | 0.0004 | 0.0007 | 0.001 | 0.0004 | 0.0003 | 0.0005 | 0.001 |
| Maximum | 0.022 | 0.012 | 0.027 | 0.016 | 0.023 | 0.027 | 0.02 | 0.02 | 0.022 | 0.0168 | 0.013 | 0.014 | 0.019 |
| Count <DL | 1 | 3 | 2 | 1 | 0 | 3 | 2 | 0 | 0 | 1 | 1 | 2 | 0 |
| Standard Deviation | 0.0046 | 0.0032 | 0.0069 | 0.004 | 0.0047 | 0.006 | 0.004 | 0.0043 | 0.0043 | 0.0039 | 0.0034 | 0.0034 | 0.0044 |
| 1st Quartile | 0.0018 | 0.0019 | 0.002 | 0.002 | 0.002 | 0.0023 | 0.002 | 0.002 | 0.0027 | 0.002 | 0.002 | 0.002 | 0.0027 |
| Median | 0.004 | 0.003 | 0.004 | 0.0036 | 0.0035 | 0.004 | 0.004 | 0.004 | 0.005 | 0.005 | 0.0033 | 0.005 | 0.0046 |
| 3rd Quartile | 0.0071 | 0.006 | 0.0065 | 0.006 | 0.005 | 0.0063 | 0.006 | 0.0055 | 0.0072 | 0.008 | 0.006 | 0.007 | 0.0063 |
| Count Over Standard | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

## Total Ammonia

The CWQG for total ammonia is pH and water temperature dependent. The lowest applicable guideline determined by Minnow Environmental (May 2008) was 0.12 mg/L. Average total ammonia concentrations range between 0.021 mg/L and 0.035 mg/L (Table 18).

**Table 18 Ammonia Nitrogen – Water Quality Summary Statistics for 2005 – 2010**

| Statistic | W2 | W3 | W4 | W5 | W6 | W7 | W9 | W10 | W11 | W12 | W13 | Y1 | Y2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Average | 0.028 | 0.027 | 0.026 | 0.025 | 0.031 | 0.035 | 0.026 | 0.021 | 0.026 | 0.028 | 0.026 | 0.021 | 0.022 |
| Count | 31 | 31 | 32 | 24 | 28 | 26 | 33 | 23 | 28 | 28 | 28 | 23 | 24 |
| Minimum | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 |
| Maximum | 0.15 | 0.11 | 0.18 | 0.07 | 0.17 | 0.19 | 0.17 | 0.025 | 0.16 | 0.18 | 0.19 | 0.025 | 0.025 |
| Count <DL | 25 | 25 | 30 | 20 | 22 | 17 | 30 | 23 | 25 | 24 | 26 | 23 | 22 |
| Standard Deviation | 0.025 | 0.02 | 0.029 | 0.015 | 0.032 | 0.037 | 0.027 | 0.009 | 0.028 | 0.031 | 0.033 | 0.009 | 0.008 |
| 1st Quartile | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 |
| Median | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 |
| 3rd Quartile | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 |
| Count Over Standard | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

## Nitrate Nitrogen

The CWQG for nitrate nitrogen is 2.9 mg/L, which has not been exceeded at any station. Average nitrate nitrogen concentrations range between 0.03 mg/L and 0.15 mg/L (Table 19).

**Table 19 Nitrate Nitrogen – Water Quality Summary Statistics for 2005 – 2010**

| Statistic | W2 | W3 | W4 | W5 | W6 | W7 | W9 | W10 | W11 | W12 | W13 | Y1 | Y2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Average | 0.09 | 0.11 | 0.06 | 0.03 | 0.04 | 0.03 | 0.03 | 0.06 | 0.15 | 0.04 | 0.05 | 0.03 | 0.05 |
| Count | 26 | 25 | 26 | 20 | 23 | 22 | 28 | 17 | 23 | 22 | 22 | 17 | 18 |
| Minimum | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| Maximum | 1.2 | 2 | 0.2 | 0.1 | 0.2 | 0.15 | 0.2 | 0.3 | 2.55 | 0.2 | 0.22 | 0.2 | 0.2 |
| Count <DL | 13 | 18 | 13 | 15 | 12 | 18 | 20 | 6 | 15 | 10 | 11 | 8 | 7 |
| Standard Deviation | 0.23 | 0.4 | 0.07 | 0.03 | 0.06 | 0.03 | 0.04 | 0.09 | 0.53 | 0.04 | 0.06 | 0.05 | 0.06 |
| 1st Quartile | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| Median | 0.03 | 0.01 | 0.02 | 0.01 | 0.02 | 0.01 | 0.01 | 0.04 | 0.01 | 0.02 | 0.04 | 0.02 | 0.03 |
| 3rd Quartile | 0.07 | 0.03 | 0.06 | 0.05 | 0.05 | 0.03 | 0.03 | 0.06 | 0.05 | 0.05 | 0.07 | 0.04 | 0.05 |
| Count Over Standard | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

## Nitrite Nitrogen

The CWQG for nitrite nitrogen is 0.06 mg/L and has not been exceeded (Table 20). Average nitrite nitrogen concentrations range between 0.011 mg/L and 0.018 mg/L.

**Table 20 Nitrite Nitrogen – Water Quality Summary Statistics for 2005 – 2010**

| Statistic | W2 | W3 | W4 | W5 | W6 | W7 | W9 | W10 | W11 | W12 | W13 | Y1 | Y2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Average | 0.011 | 0.013 | 0.012 | 0.013 | 0.012 | 0.018 | 0.013 | 0.014 | 0.012 | 0.012 | 0.014 | 0.014 | 0.016 |
| Count | 26 | 25 | 26 | 20 | 23 | 22 | 28 | 17 | 23 | 22 | 22 | 17 | 18 |
| Minimum | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 |
| Maximum | 0.04 | 0.05 | 0.04 | 0.04 | 0.04 | 0.07 | 0.06 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.05 |
| Count <DL | 24 | 22 | 23 | 17 | 21 | 15 | 23 | 13 | 19 | 19 | 18 | 13 | 11 |
| Standard Deviation | 0.011 | 0.013 | 0.012 | 0.012 | 0.012 | 0.019 | 0.014 | 0.012 | 0.011 | 0.012 | 0.013 | 0.013 | 0.013 |
| 1st Quartile | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.004 |
| Median | 0.005 | 0.005 | 0.007 | 0.008 | 0.005 | 0.01 | 0.008 | 0.01 | 0.005 | 0.005 | 0.007 | 0.01 | 0.01 |
| 3rd Quartile | 0.021 | 0.025 | 0.021 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.022 | 0.024 | 0.025 | 0.025 | 0.025 |
| Count Over Standard | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

## 3.0 SURFACE WATER HYDROLOGY

Surface water hydrology, or discharge, relates the dynamics of flow in surface water systems with correlations drawn between precipitation and surface runoff. Discharge quantities are generally determined by topography, season, drainage, land-use, and soil conditions. Instantaneous flow measurements are collected when conditions permit (ice free/sufficient flow, typically May through October) during water sampling events. Data logging hydrometric instrumentation at stations W4, W10 and W12 has also been used to record stage and discharge records on a more continuous basis since 2006.

During 2009 spring freshet, the hydrology station at W10 became dislodged from the creek while the one at W4 was moderately affected. In July 2009 new hydrology stations were constructed at W4 and W12. The W10 hydrology station was not re-established as W12 was determined to be the proposed point of compliance for mine receiving water quality standards. In April 2010, hydrology stations W4 and W12 were visited to install data logging instruments. Barometric and water level data was logged until October 2010 when the loggers were retrieved.

## 3.1 PROTOCOL

Manual water flow measurements are taken using a Price 1210 Mini meter, Price 1205 AA meter (S00790), or Global Flow Probe FP101 (Serial #56269). This manual metering may not always be possible as it is ice and flow condition dependent. Bucket flows or estimates may be used as a substitute. Flow measurements are obtained by following the appropriate protocol as described in ASTM International *Standard D 4409-95: Standard Test Method for Velocity Measurements of Water in Open Channels with Rotating Element Current Meters* and *Standard D 3858-95 Standard Test Method for Open-Channel Flow Measurement of Water by Velocity Area Method* as applicable.

## 3.2 RESULTS

Manual flow measurements collected from Williams Creek during 2006 to 2010 and subsequent calculations of discharge are shown on Figure 4. Figure 5 shows level logger data processed for discharge at station W4 as well as manually metered measurements collected between 2006 and 2010. Figure 6 shows level logger data processed for discharge at station W10 between 2006 and 2008, and at W12 for 2009 and 2010 as well as manual measurements.

**Figure 4 Williams Creek Watershed Manual Measurements of Discharge 2006 to 2010**

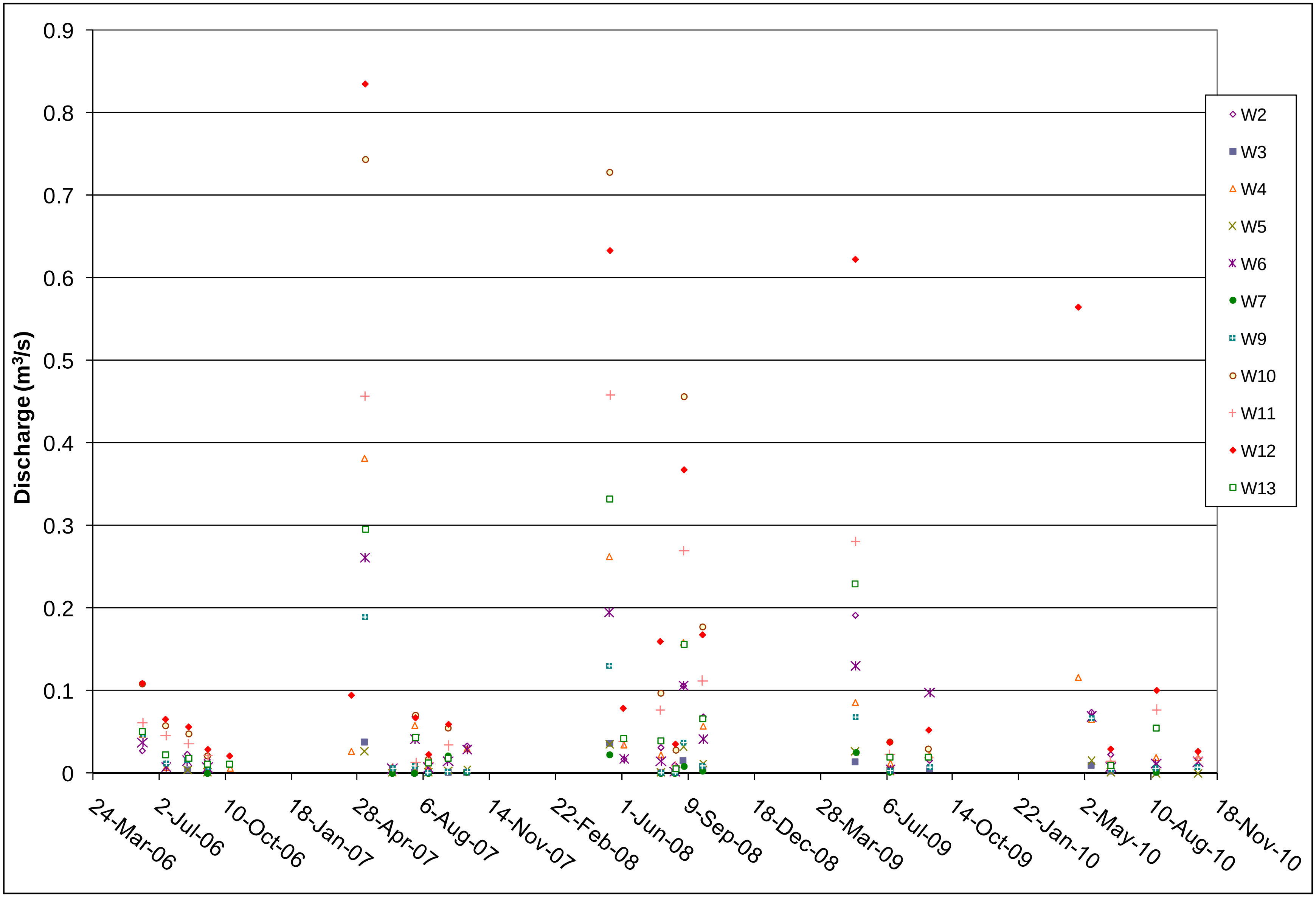


**Figure 5 Williams Creek Station W4 Discharge for 2006 to 2010 Using Logger Instrumentation & Manual Methods**

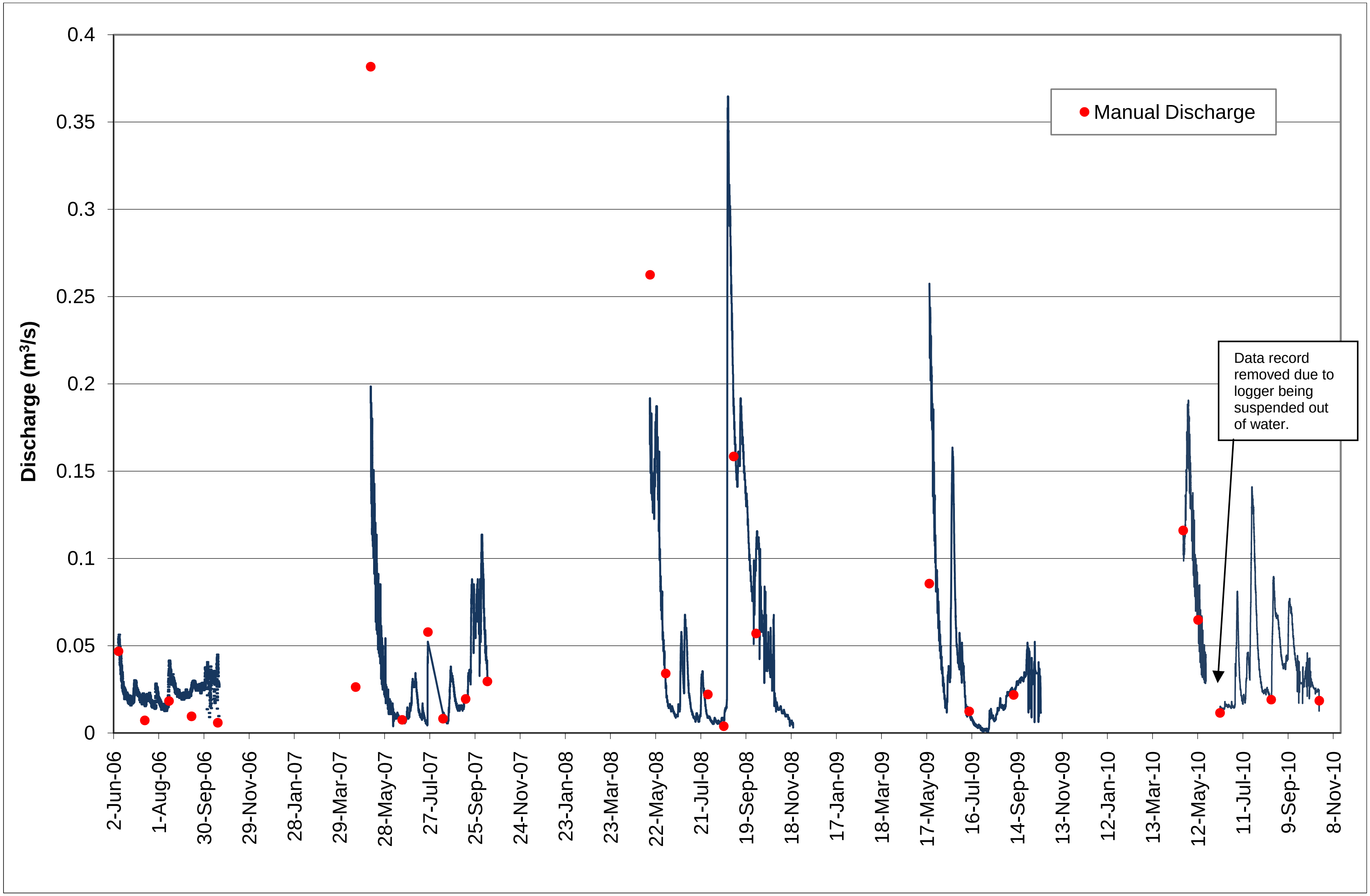
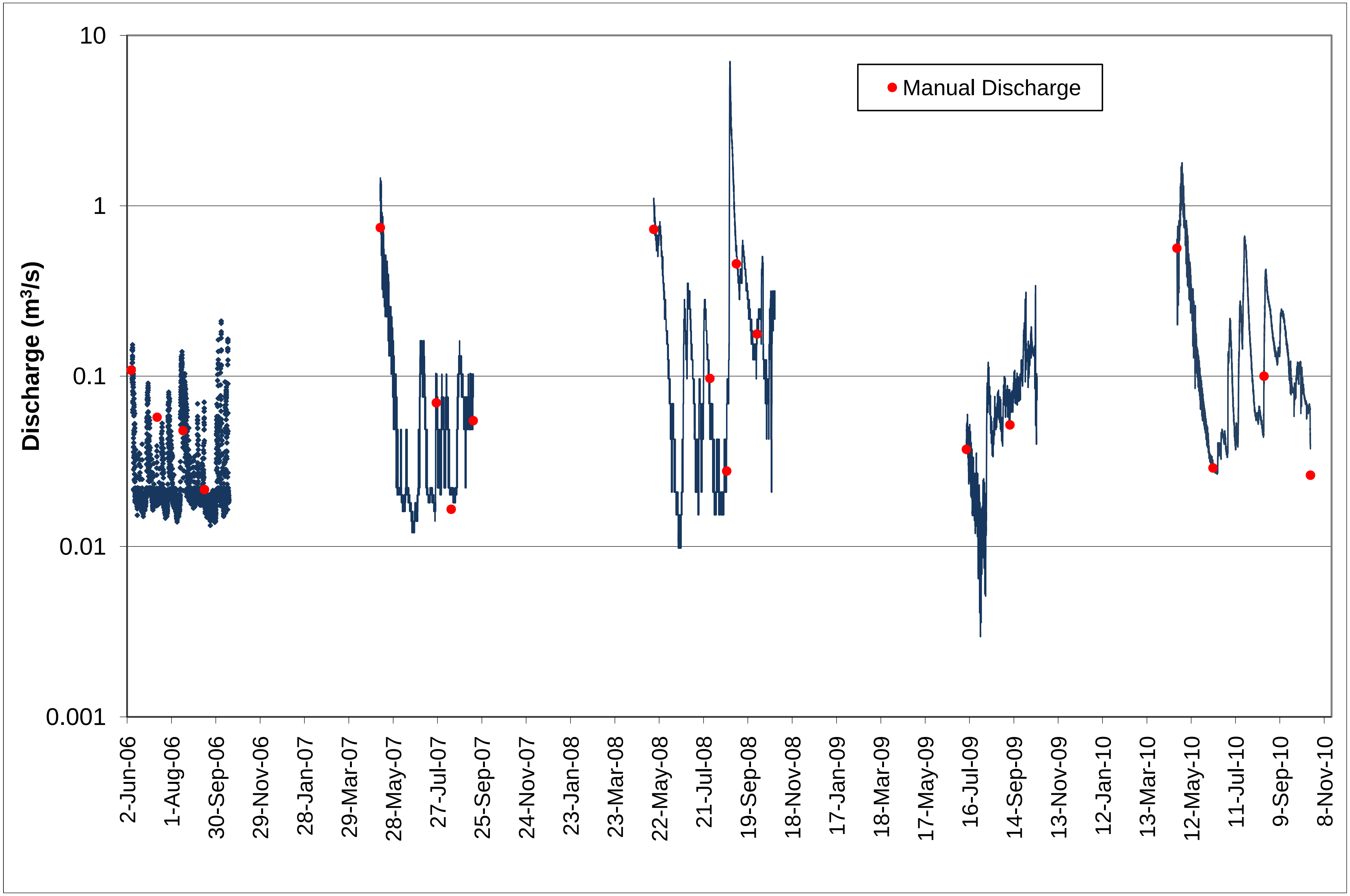


**Figure 6 Williams Creek Station W10 Discharge for 2006 to 2008, and Station W12 for 2009 and 2010, Using Logger Instrumentation & Manual Methods**



### 3.3 DISCUSSION

Figures 4 to 6 show peak flows occur during spring freshet with less dramatic increases in flow during the summer following rainfall events. A substantial increase in flow on August 25, 2008 was observed after a heavy rainfall event which resulted in 62.3 mm falling in little more than 24 hours. By October ice usually starts to form on the stream banks and beds and discharge can become elevated when ice that has formed melts during the day and break up occurs.

In 2006 and 2009 the data loggers were installed after freshet in lower Williams Creek, however, in 2007 and 2008 freshet was partially captured at W10. In 2007, the loggers were launched on May 10 at station W10; the following statistics are provided for the period of May 10 to June 10 2007:

- Minimum discharge = 0.016 $m^3/s$;
- Maximum discharge = 1.456 $m^3/s$; and
- Average discharge = 0.233 $m^3/s$.

In 2008, the loggers were launched on May 14 at station W10; the following summary statistics are provided for the period of May 14 to June 14, 2008:

- Minimum discharge = 0.015 $m^3/s$;
- Maximum discharge = 1.107 $m^3/s$; and
- Average discharge = 0.345 $m^3/s$.

In 2010 loggers were launched on April 22 at W4 and W10 to capture spring freshet. Because the loggers were installed over creek-bed ice, confidence in the data before mid-May is lowered and could be +/- 25%. The W4 level logger became suspended out of water in May and resulted in part of the data record being removed until the logger was dropped to the creek bed in June.

## 4.0 CLIMATE

In 1994, Water Resources Division of DIAND established an automatic meteorological station at the site. The station monitors air and soil temperature, solar radiation, wind speed, and precipitation. The station is operated by Yukon Government, Water

Resources Branch and continuous records are available from September 1994 to September 2008, except where gaps occur due to equipment malfunctions. Unfortunately due to logger malfunction no data is available between September 2008 and May 2010. Available temperature and precipitation between 2007 and 2010 are summarized in Table 21, while Figures 7 and 8 graphically show 2010 temperature and precipitation data.

**Table 21 Williams Creek Temperature and Rainfall 2007 – 2010**

| Month | Average Temperature ˚C | | | Total Rainfall mm | | |
|---|---|---|---|---|---|---|
| | 2007 | 2008 | 2010 | 2007 | 2008 | 2010 |
| January | -13.72 | -20.29 | | 0 | 0 | |
| February | -19.56 | -16.71 | | 0 | 4.6 | |
| March | -15.20 | -6.41 | | 0.4 | 3.4 | |
| April | 1.18 | 0.40 | | 4.3 | 7.6 | |
| May | 7.79 | 7.42 | | 13.4 | 15.1 | |
| June | 14.11 | 11.24 | 12.67 | 36.7 | 44.2 | 51 |
| July | 15.03 | 12.13 | 14.51 | 63 | 49 | 83.3 |
| August | 13.95 | 10.10 | 14.03 | 45.6 | 111 | 40.6 |
| September | 5.68 | 8.16* | 6.41 | 36.9 | 15.9* | 21 |
| October | -3.19 | | -0.92 | 20.1 | | 12.8 |
| November | -7.37 | | -8.11 | 0.4 | | 0.9 |
| December | -18.25 | | -21.30 | 0 | | 0 |

* 2008 Data available to September 12, 2008 only.

**Figure 7 Williams Creek Air Temperatures for May 2010 – January 2011**

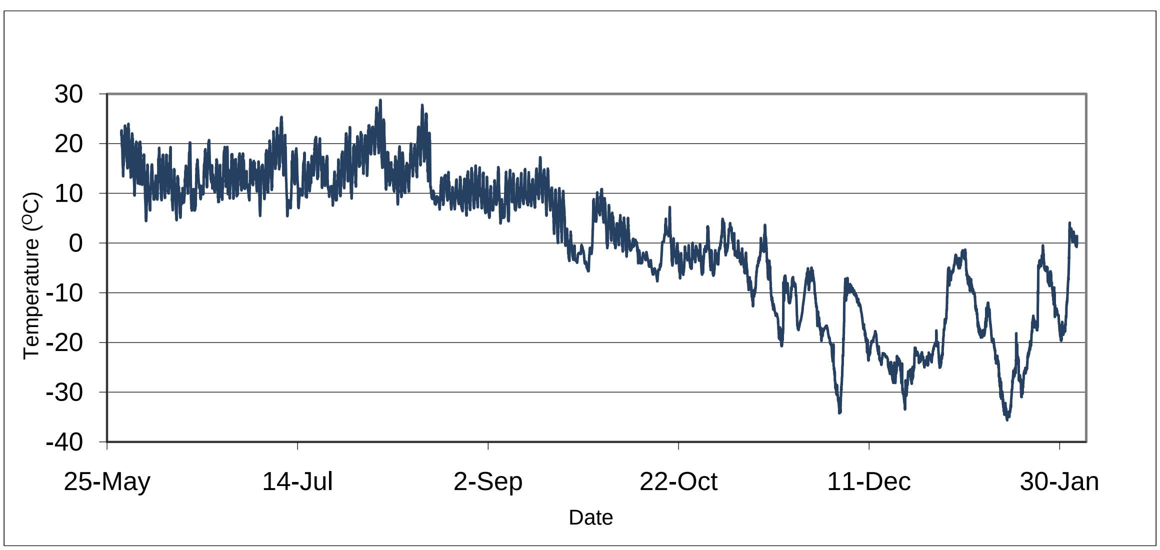
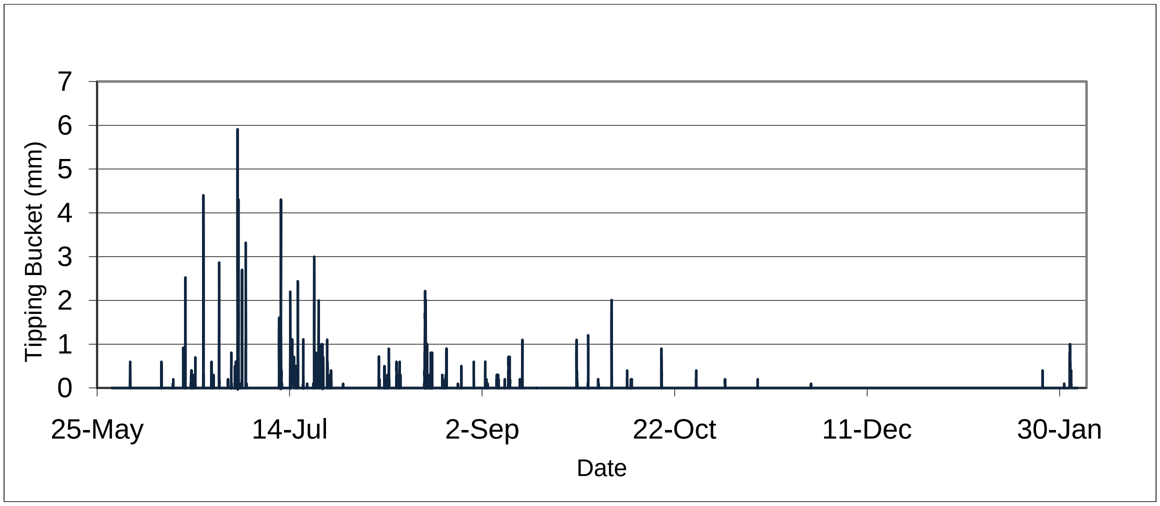


**Figure 8 Williams Creek Rainfall for May 2010 – January 2011**




A snow course station also exists at the site and is monitored by Yukon Government in February, March and April. The Williams Creek snow course station data for February between 2008 and 2011 follows:

- On February 23, 2011 snow depth was measured at 72 cm with a water content of 153 mm.
- On February 23, 2010 snow depth was measured at 53 cm with a water content of 96 mm.
- On February 24, 2009 snow depth was measured at 66 cm with a water content of 134 mm.
- On February 27, 2008 of 62 cm with an estimated water content of 103 mm.

Average February water content over 16 years of monitoring at Williams Creek is 83 mm. As described in Yukon Government's Yukon Snow Survey Bulletin and Water Supply Forecast (March, 2011), the March 1 Yukon snowpack is variable, however, a large pocket of significantly above normal snowpack exists around Carmacks.

## 5.0 GROUNDWATER MONITORING

Groundwater monitoring wells are typically inspected during site visits and groundwater quality samples are collected when possible. Samples collected are sent to an accredited laboratory for analysis of the same parameters as surface water samples including physical parameters (pH, conductivity, total suspended solids, total dissolved solids, turbidity, hardness); inorganic nonmetallic parameters (ammonium, nitrogen, phosphorous, orthophosphate, dissolved organic carbon, total inorganic carbon, total organic carbon); weak acid dissociable cyanide; and total and dissolved metals. In-situ measurements (temperature, pH, conductivity, total dissolved solids, and dissolved oxygen) are also collected during sample collection.

### 5.1 MONITORING WELL SAMPLE STATION LOCATIONS & SAMPLING FREQUENCY

A total of 11 monitoring wells were established on site in 1996 in the heap leach pad area, waste rock storage area, and open pit area (see Figure 3):

- Leach pad — MW96-A to E
- Waste rock storage area — MW96-F, G, H & I
- Open pit — MW96-J and K

During initial inspections and monitoring of these wells, a few were removed from the monitoring program; one from the leach pad area and all in the waste rock storage area:

- MW96-B: bailer lodged in well September 2007;
- MW96-F: ice plugged;
- MW96-G: no PVC pipe (only casing);
- MW96-H: ice plugged;
- MW96-I: ice plugged.

Remaining monitoring wells within the leach pad and open pit areas were monitored in May, June and August 2010.

- MW96-A: samples obtained May and June 2010;
- MW96-C: samples obtained May 2010;
- MW96-D: no water observed;
- MW96-E: samples obtained May, June and August 2010;
- MW96-J: no samples obtained, bailer does not fit down well;
- MW96-K: no samples obtained, bailer does not fit down well.

In addition, new wells have been installed and are also being checked.

- HYD-WELL-1 or MW-01-07: installed late 2007 below heap leach pad sediment pond area, appears ice plugged at each visit, no samples able to be collected so far;
- DW08-01: shallow well installed summer of 2008 in proposed camp location – dry when checked in 2010;
- DW08-02: shallow well installed summer of 2008 in proposed camp location – sampled in May, June and August 2010.

No water sample was collected from the camp potable water well in 2010 as the camp was not used by Western Copper.

Most of the existing monitoring wells will be decommissioned once project components are constructed. For the purposes of monitoring groundwater quality during operations of the Carmacks Copper mine, additional wells (or other complementary approaches) will be established on site, particularly downgradient of specific project components (i.e. heap leach area and waste rock storage area).

### 5.2 PROTOCOL

Sampling of groundwater was undertaken using Standard Operating Procedures for the collection of groundwater samples and follow ASTM guides including the *D 4448-01: Standard Guide for Sampling Ground-Water Monitoring Wells*.

### 5.3 RESULTS

Table 22 shows the monitoring well locations (also in Figure 3), well depths, depth to water measured between 2006 and 2010, and includes whether or not the site was visited or if water was present.

As with surface water quality data, groundwater quality data collected since 2005 are stored in an EQWin database that is customized to manage environmental sampling data. Historic data is unavailable in its original format to be entered into the database.

Groundwater quality summary graphs for certain parameters (arsenic, cadmium, copper, iron, lead, nickel, zinc) have been prepared for actively monitored wells and are presented in Figures 9 through 15.

## Table 22 Groundwater Monitoring Well Sample Locations, Events and Depth (m) to Water Measurements 2006 - 2010

| Monitoring Well # | MW96-A | MW96-B | MW96-C | MW96-D | MW96-E | MW96-F | MW96-H | MW96-I | MW96-J | MW96-K** | HYD-WELL-1 or MW-01-07 | DW08-01 | DW08-02 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Easting | 411395 | 411535 | 411946 | 412165 | 411385 | 411745 | 412453 | 412931 | 411950 | 412086 | 412219 | 411455 | 411404 |
| Northing | 6913718 | 6913433 | 6913059 | 6912838 | 6913271 | 6914708 | 6914635 | 6914367 | 6913899 | 6913459 | 6912688 | 6912473 | 6912458 |
| Drilled Depth (m) | 91.4 | 91.4 | 50.0 | 41.1 | 91.4 | 62.5 | 55.2 | 54.9 | 90.5 | 93.0 | | | |
| Measured Depth (m) | 89.67 | 91.97 | 50.0 | 10.38 | 93.25 | 6.59* | 7.72* | 2.81* | 91.52 | 93.9 | | | |
| **Date** | | | | | | | | | | | | | |
| Jun-06 | 62.09 | 42.22 | 40.38 | No water | Not located | 4.96 | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| Jul-06 | 62.14 | 42.53 | No water | No water | Not located | No water | N/A | N/A | No water | N/A | N/A | N/A | N/A |
| Aug-06 | 62.43 | 42.34 | 42.06 | No water | 54.5 | 4.96 | 2.9 | 2.1 | No water | N/A | N/A | N/A | N/A |
| Sep-06 | 64.53 | 42.14 | 40.45 | No water | 44.5 | 6.04 | 6.23 | No water | 91.58 | N/A | N/A | N/A | N/A |
| Oct-06 | 62.65 | 43.01 | 42.64 | No water | 42.38 | 3.95* | No water | 1.84 | 91.08 | N/A | N/A | N/A | N/A |
| Apr-07 | frozen | frozen | frozen | frozen | frozen | Little water | Not visited | Not visited | frozen | No water | N/A | N/A | N/A |
| May-07 | no water | 42.93 | 41.08 | | 50.62 | 6.35 | frozen | No water | 91.57 | No water | N/A | N/A | N/A |
| Jun-07 | 55.6 | 43.55 | 41.3 | No water | 52.8 | 6.44 | 1.84 | No water | No water | No water | N/A | N/A | N/A |
| Jul-07 | 50.5 | 42.7 | no water | No water | 53.12 | 6.29 | No water | 2.11 | No water | No water | N/A | N/A | N/A |
| Aug-07 | 48.2 | 43.52 | 41.4 | No water | 53.34 | Little water | No water | No water | No water | No water | N/A | N/A | N/A |
| Sep-07 | 48.3 | 43.5 | 41.4 | No water | 53.55 | Ice plug | No water | Ice plug | No water | No water | N/A | N/A | N/A |
| Oct-07 | 59.2 | N/A*** | 19.5 | No water | 61.6 | Ice plug | Ice plug | Ice plug | No water | No water | new well installed | N/A | N/A |
| May-08 | 7.18* | N/A*** | 41.17 | Not visited | 54.56 | Not visited | Not visited | Not visited | Not visited | Not visited | Not visited | N/A | N/A |
| Jun-08 | 50.65 | N/A*** | 40.96 | No water | 55.28* | Not visited | Not visited | Not visited | 91.48 | 91.45 | Not visited | N/A | N/A |
| Jul-08 | 47.87 | N/A*** | 40.98 | Not visited | 54.8 | Not visited | Ice plug | Not visited | Not visited | Not visited | plugged | N/A | N/A |
| Aug-08 | 61.35 | N/A*** | not recorded | No water | 54.8 | Not visited | Not visited | Not visited | No water | No water | plugged | 5.18 | 6.68 |
| Sep-08 | 64.35 | N/A*** | 41.14 | Not visited | 55.43 | Not visited | Not visited | Not visited | 91.2 | 88.55 | plugged | 5.23 | 6.73 |
| Oct-08 | 58 | N/A*** | 51.08 | No water | 82 | Not visited | Not visited | Not visited | 75 | 83 | frozen | 6.5 | 6.8 |
| Nov-08 | No water | N/A*** | waterra frozen | Not visited | Not visited | Not visited | Not visited | Not visited | Not visited | Not visited | Not visited | Not visited | Not visited |
| May-09 | 44.47* | N/A*** | 39.48 | No water | 51.3 | Not visited | Not visited | Not visited | ice build-up | ice build-up | frozen | Not visited | Not visited |
| Jul-09 | ice build-up | N/A*** | 38.57 | No water | No water | Not visited | Not visited | Not visited | ice build-up | ice build-up | frozen | Not visited | Not visited |
| Oct-09 | 55.87 | N/A*** | 47.53 | No water | 46 | Not visited | Not visited | Not visited | 90.61 | 91.6 | Not visited | Not visited | Not visited |
| May-10 | 56.9 | N/A*** | 38.27 | No water | 43.65 | Not visited | Not visited | Not visited | 91.62 | 91.84 | Not visited | No water | 4.97 |
| Jun-10 | 57.8 | N/A*** | 10.83 to ice | No water | 43.835 | Not visited | Not visited | Not visited | 91.605 | 91.88 | frozen | No water | 5.55 |

* Depth to ice

**Assumed buried by trenching until located in April 2007

*** Bailer jammed at ~29 m Sept07

**Figure 9 Carmacks Copper Monitoring Wells, Total Arsenic**

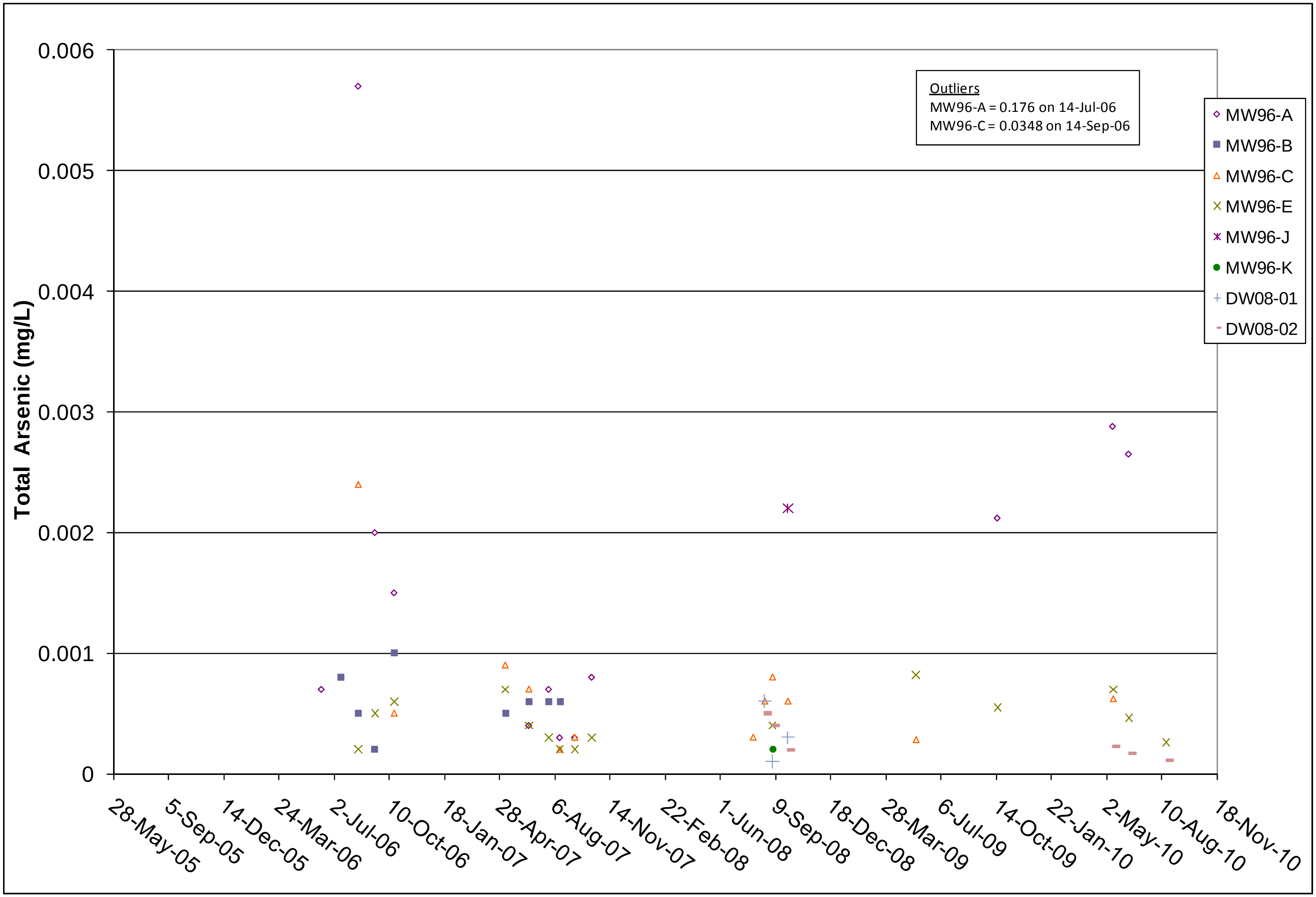


**Figure 10 Carmacks Copper Monitoring Wells, Total Cadmium**

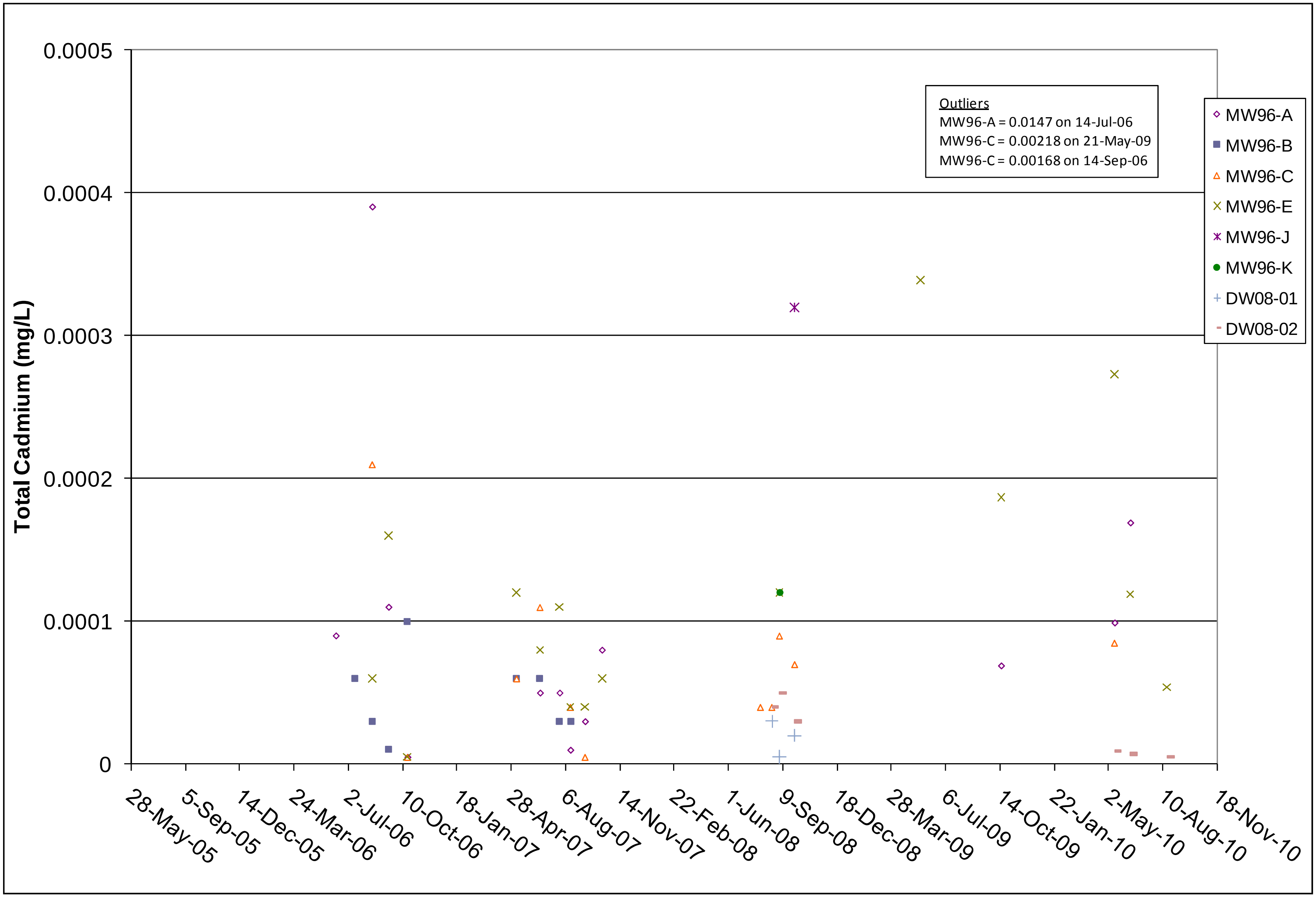


**Figure 11 Carmacks Copper Monitoring Wells, Total Copper**

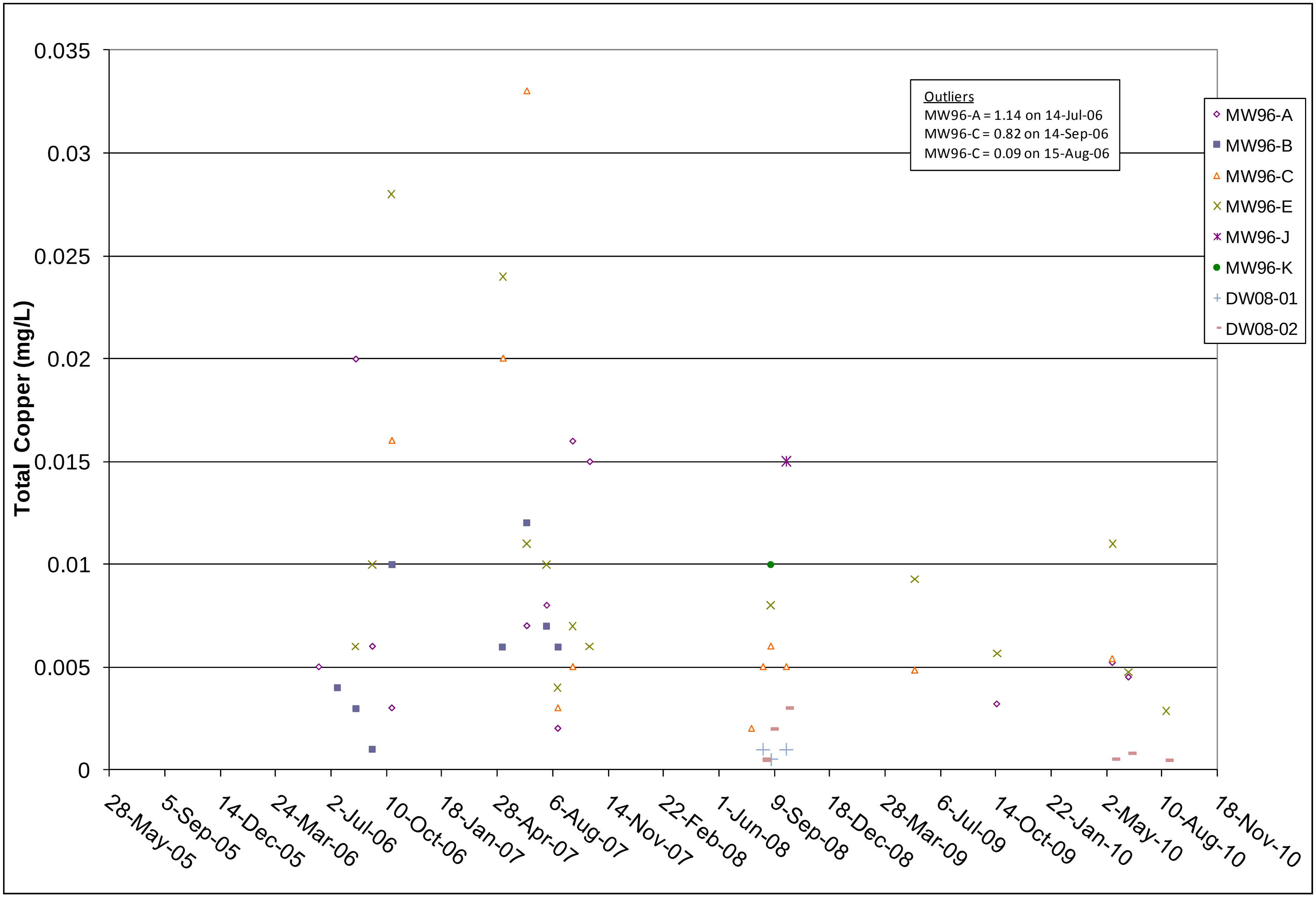


**Figure 12 Carmacks Copper Monitoring Wells, Total Iron**

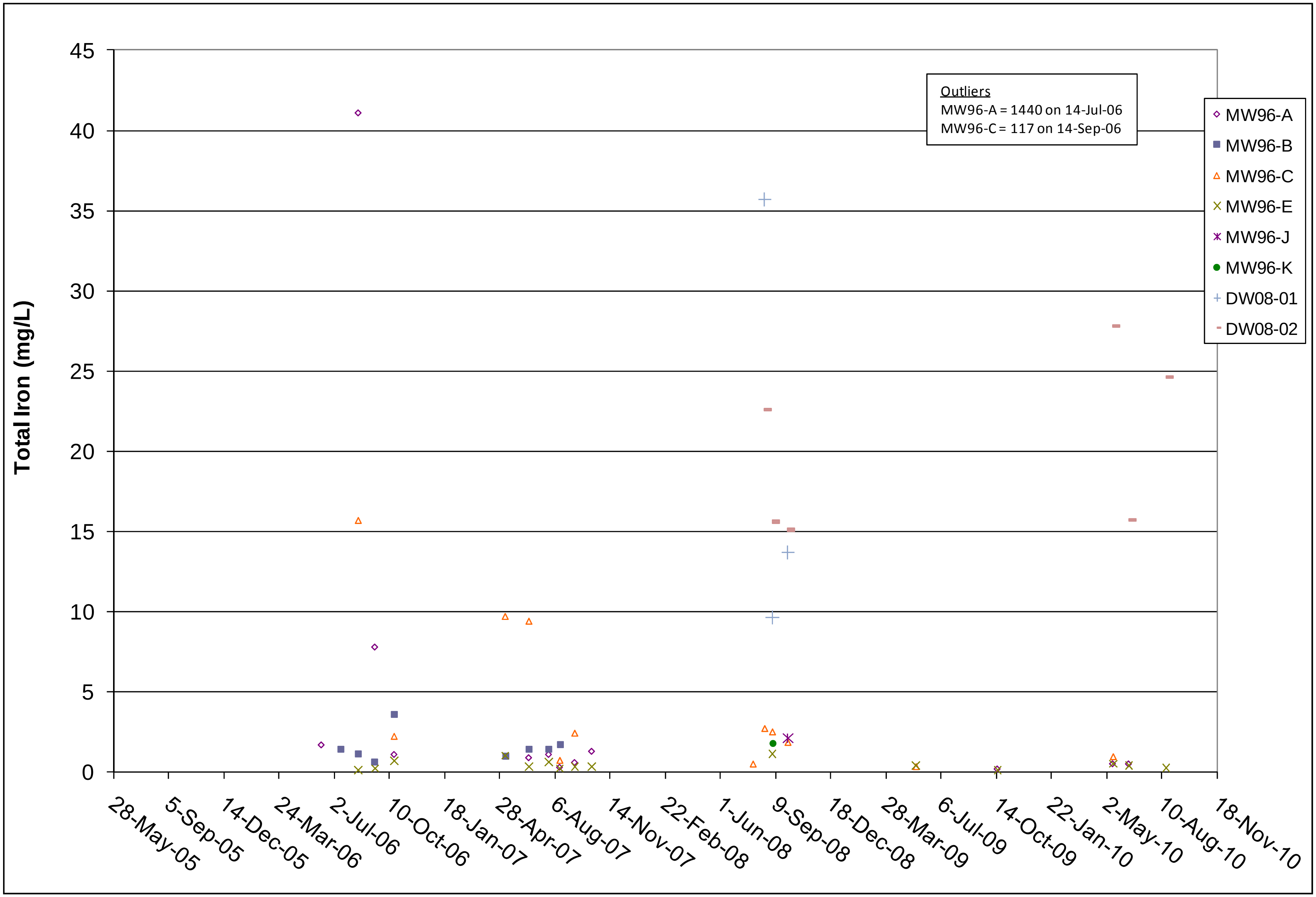


**Figure 13 Carmacks Copper Monitoring Wells, Total Lead**

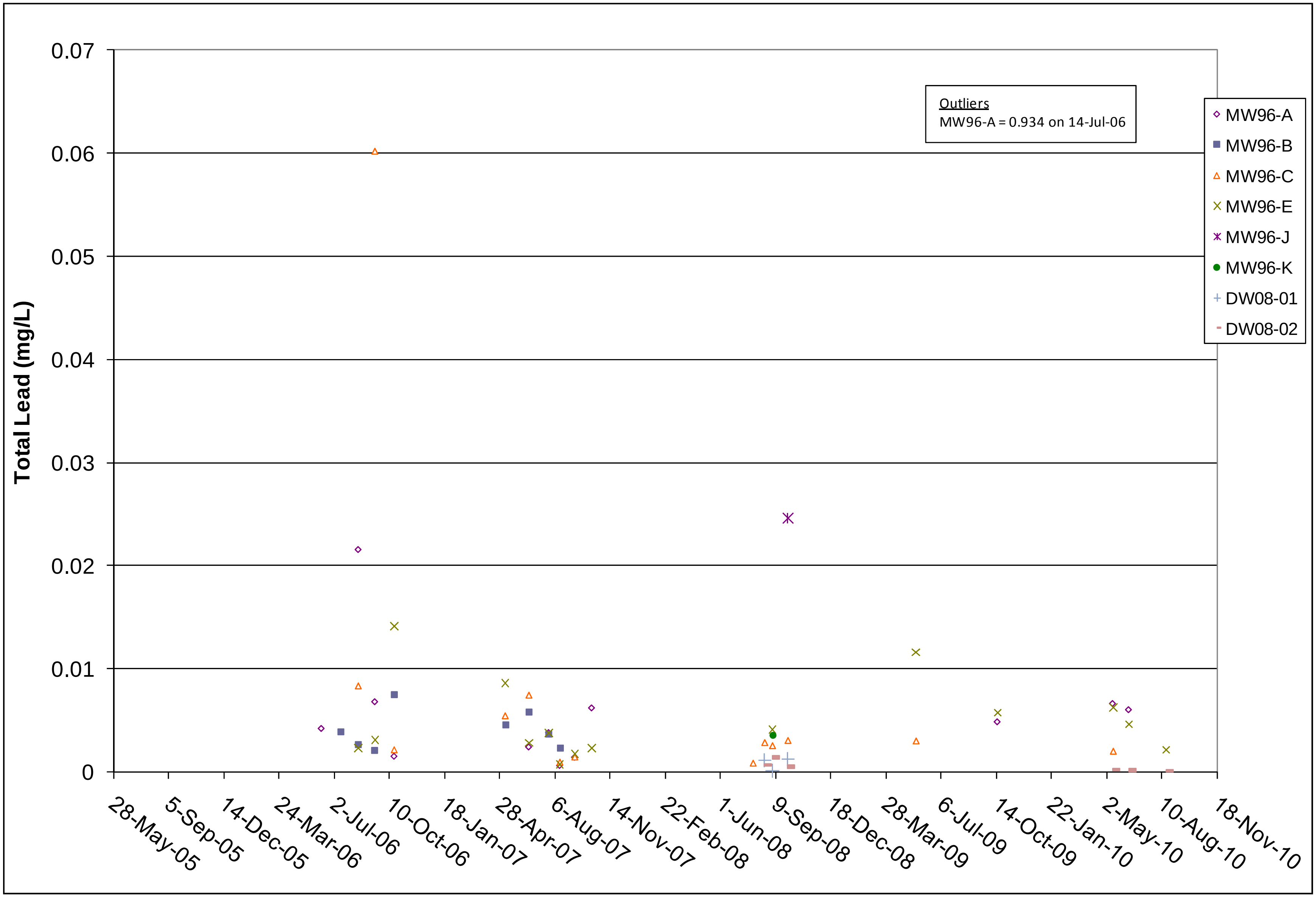


**Figure 14 Carmacks Copper Monitoring Wells, Total Nickel**

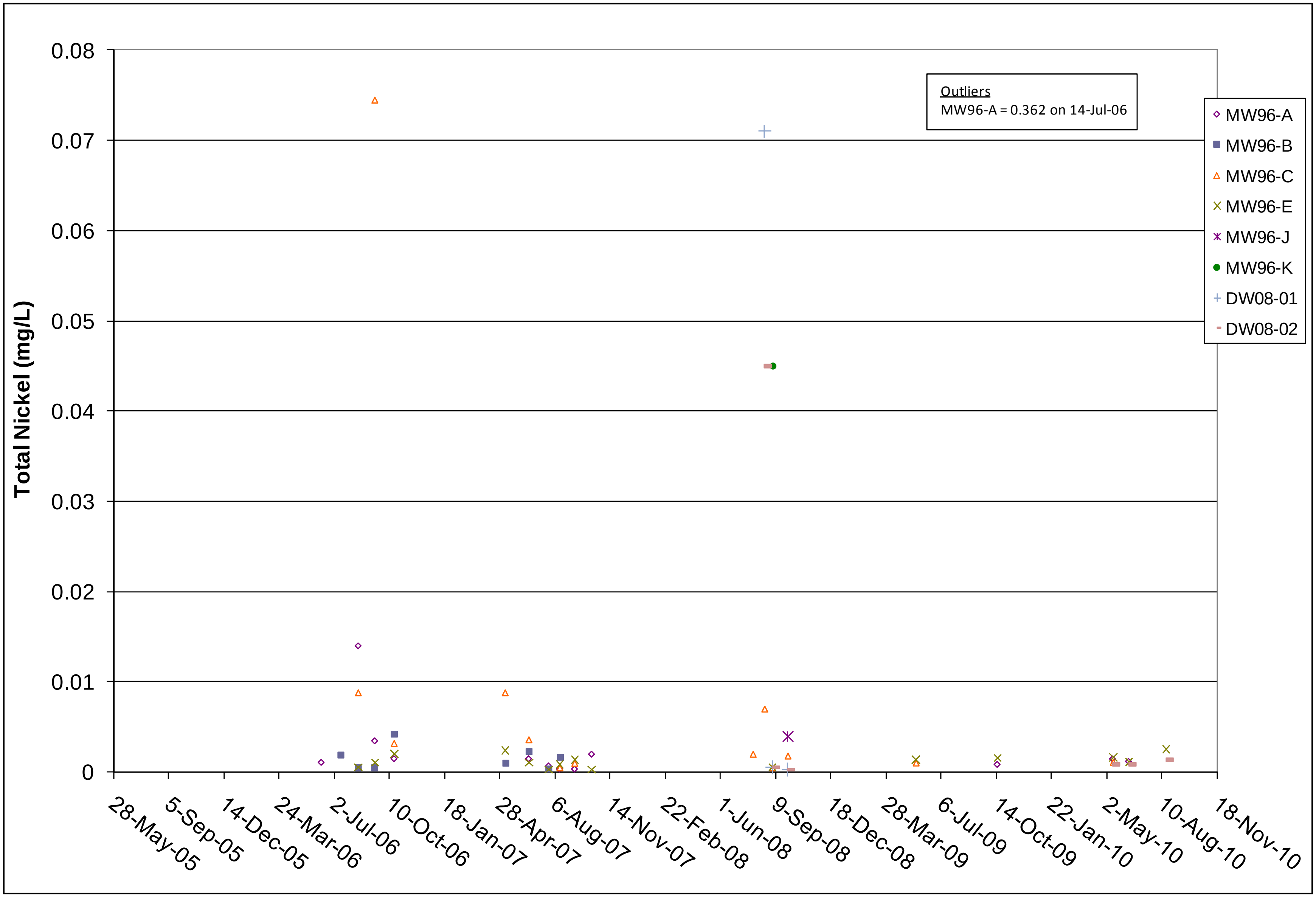
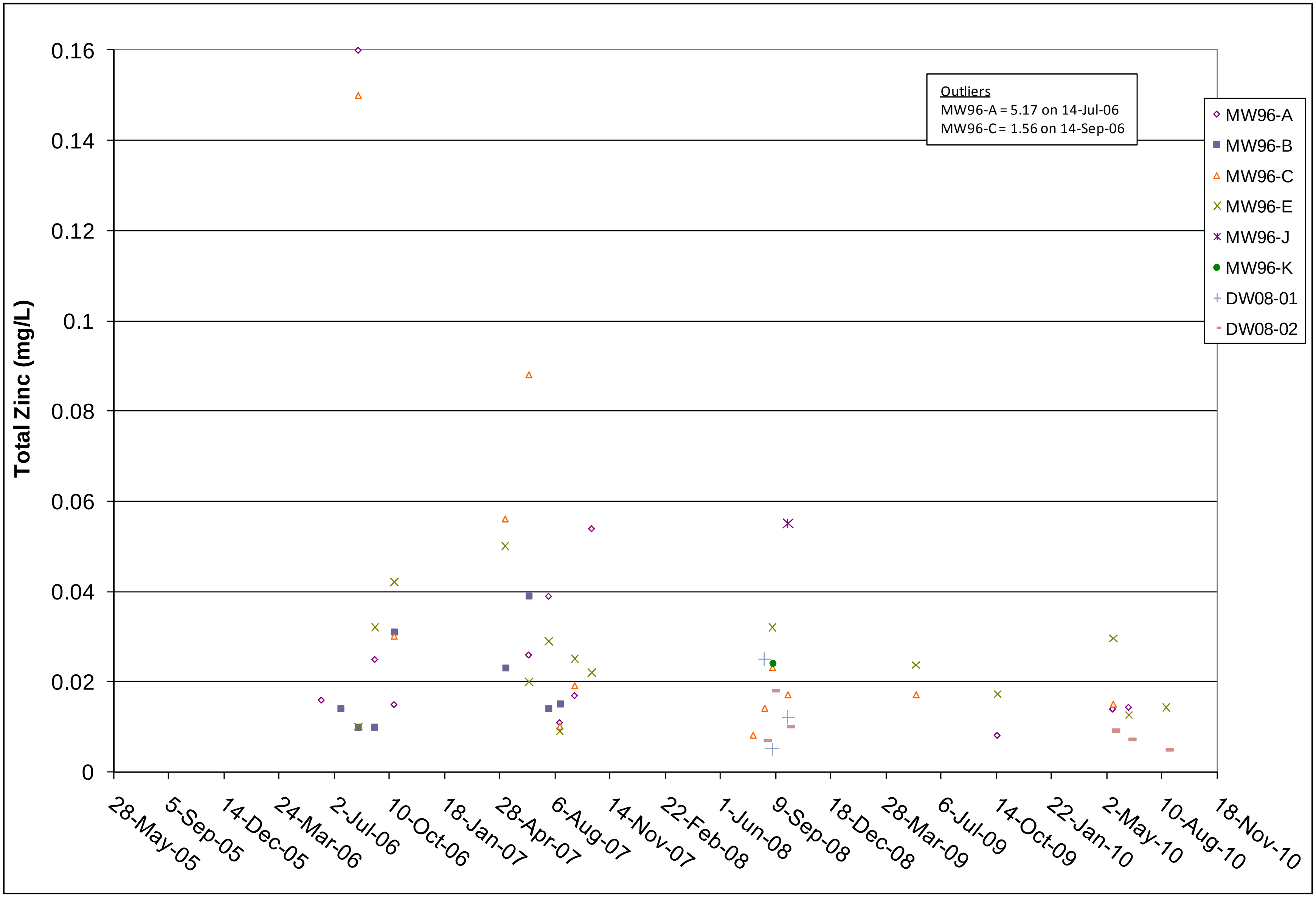


**Figure 15 Carmacks Copper Monitoring Wells, Total Zinc**



## 6.0 CLOSING STATEMENT

Access Consulting Group of Whitehorse, Yukon, has prepared this *2010 Environmental Monitoring Program Update and Data Summary* for the Carmacks Copper Project for the exclusive use of Western Copper Corp. and is based on data and information collected during site investigations. Access Consulting Group has followed standard professional procedures in conducting the investigations and in preparing the contents of this report. The material in this report reflects Access Consulting Group's best judgment in light of the information available at the time of the preparation of this report. Any use that a third party makes of this report, or any reliance on decisions to be made based on it, is the responsibility of the third parties. Access Consulting Group accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report. Access Consulting Group believes that the contents of this report are substantively correct.

The information and data contained in this report, including without limitation, the results of any sampling and analyses conducted by Access Consulting Group, are based solely on the conditions observed at the time of the field assessment and have been developed or obtained through the exercise of Access Consulting Group's professional judgment and are set to the best of Access Consulting Group's knowledge, information, and belief. Although every effort has been made to confirm that all such information and data is factual, complete and accurate, Access Consulting Group offers no guarantees or warranties, either expressed or implied, with respect to such information or data.

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If you have any questions or require further details, please contact the undersigned.

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## 7.0 REFERENCES

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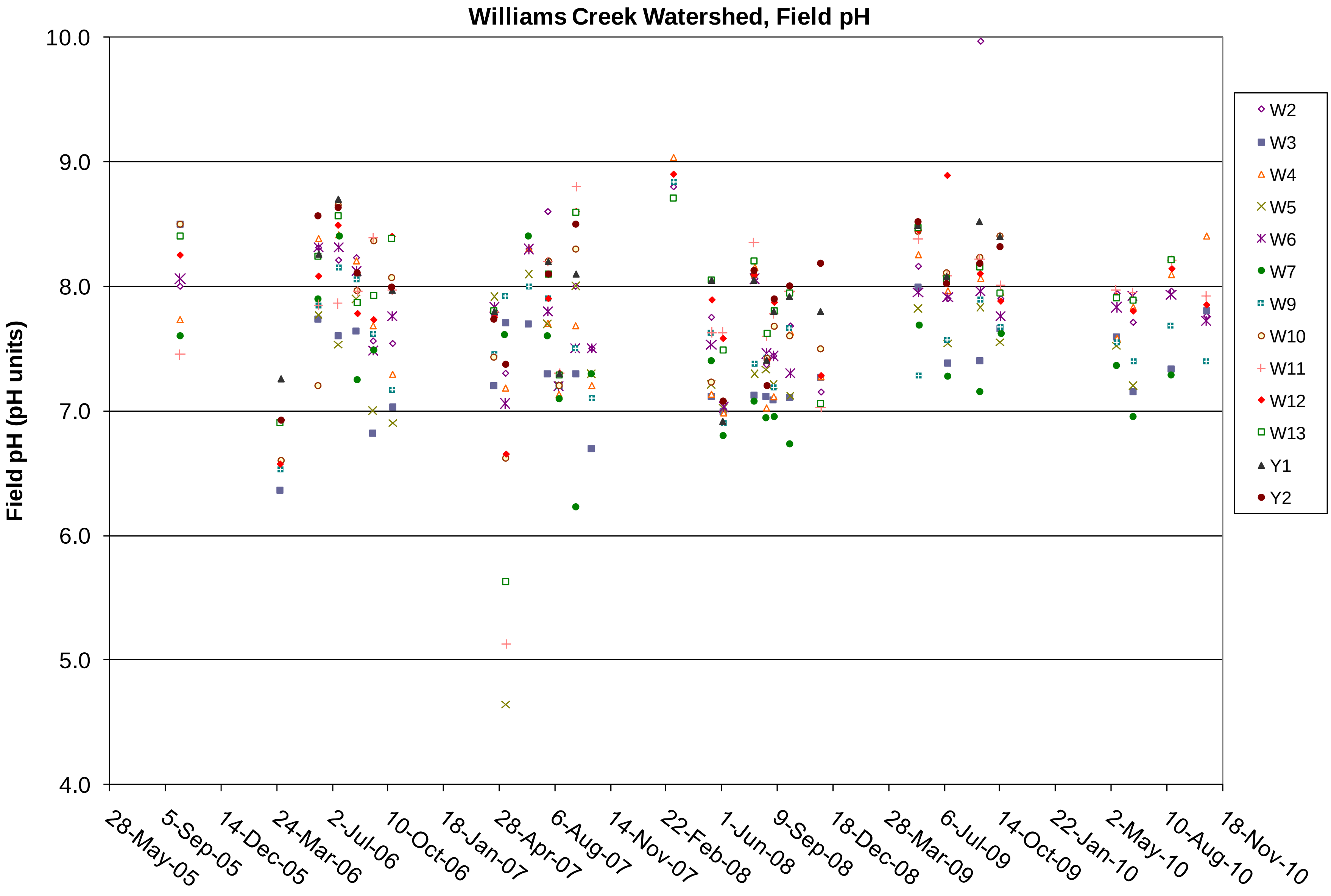
Western Copper Corporation

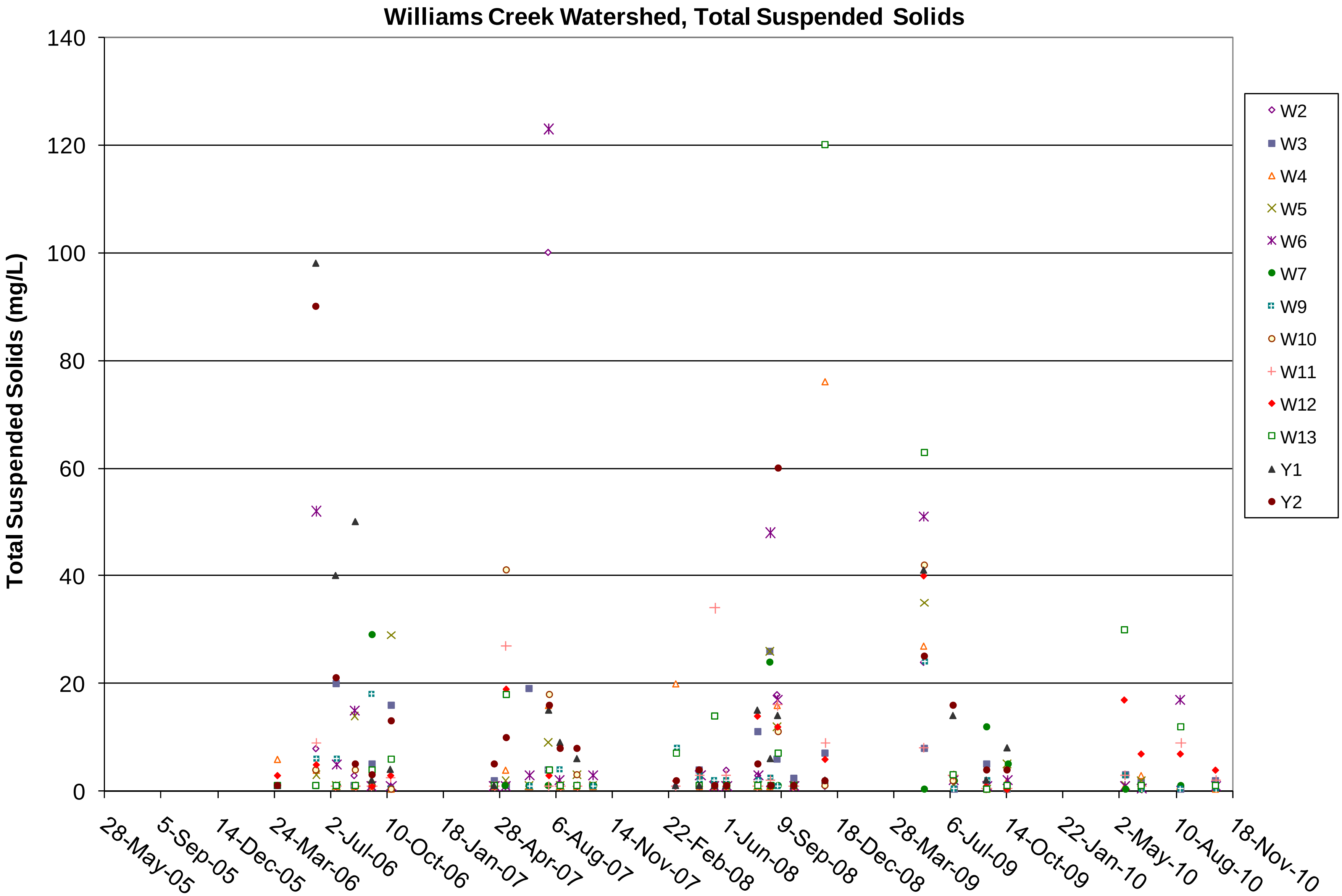
# 2010 ENVIRONMENTAL MONITORING PROGRAM UPDATE AND DATA SUMMARY

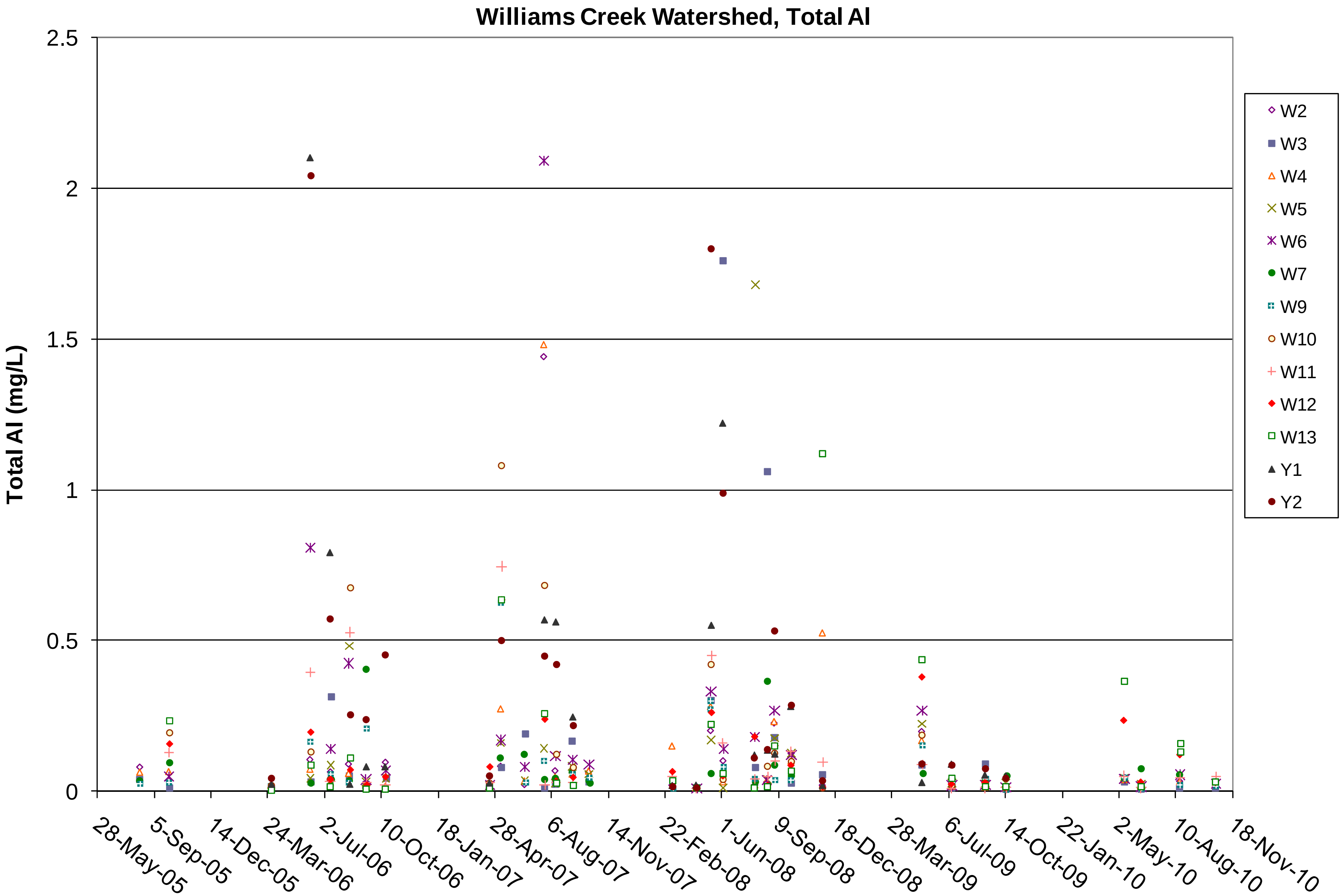
## CARMACKS COPPER PROJECT
## YUKON TERRITORY

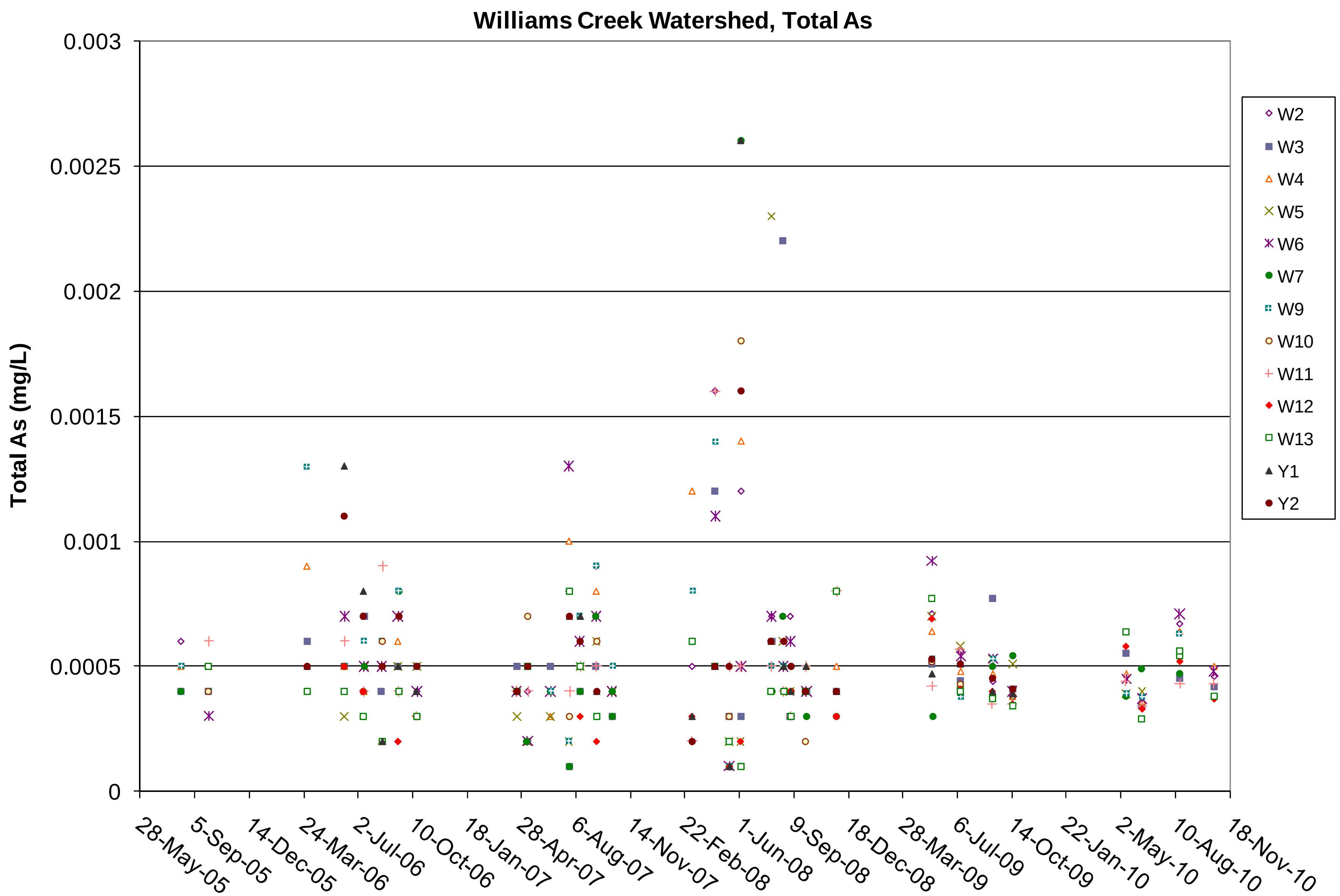
# Appendix A

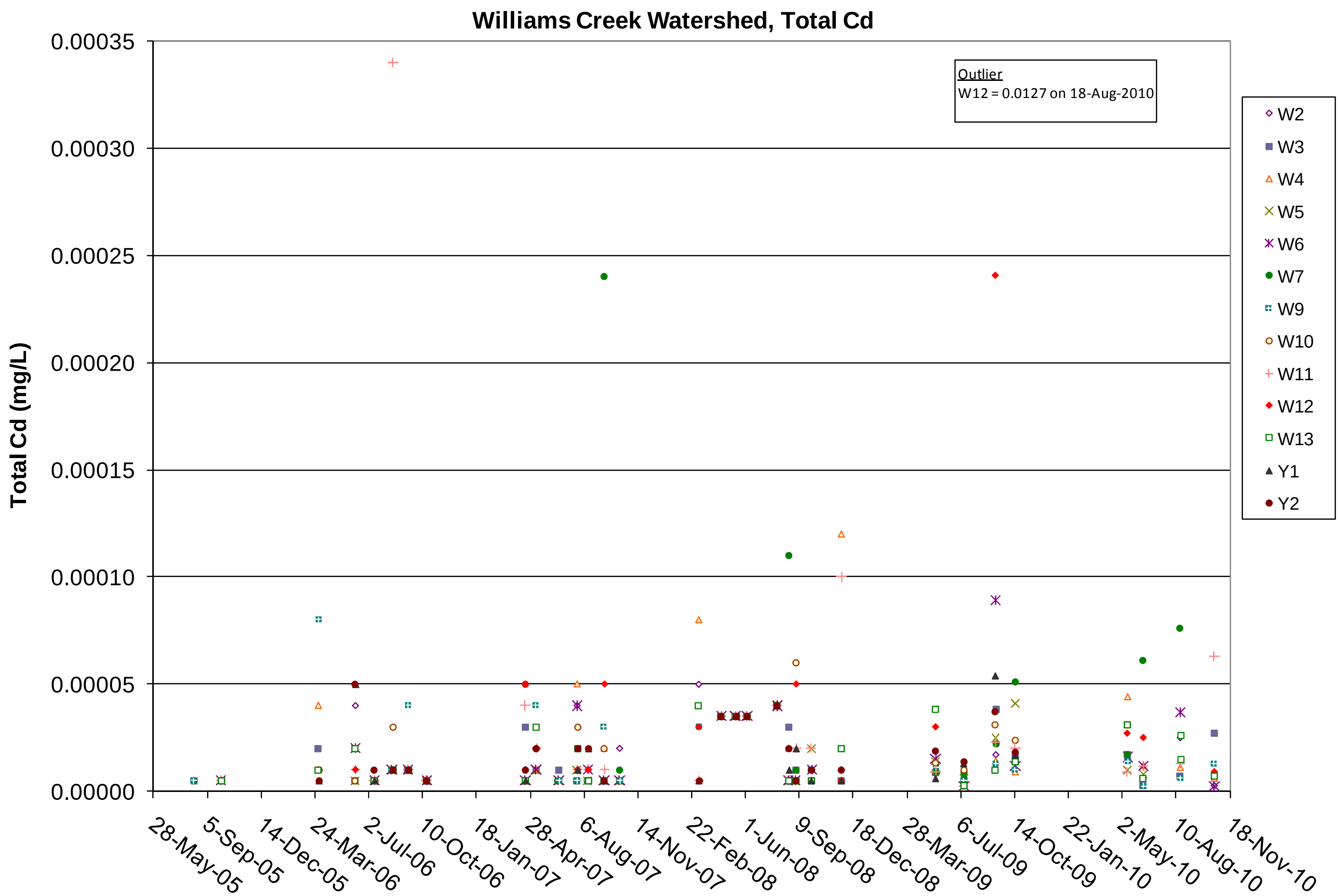
# Surface Water Quality Graphs for Williams Creek Watershed, 2005 to 2010

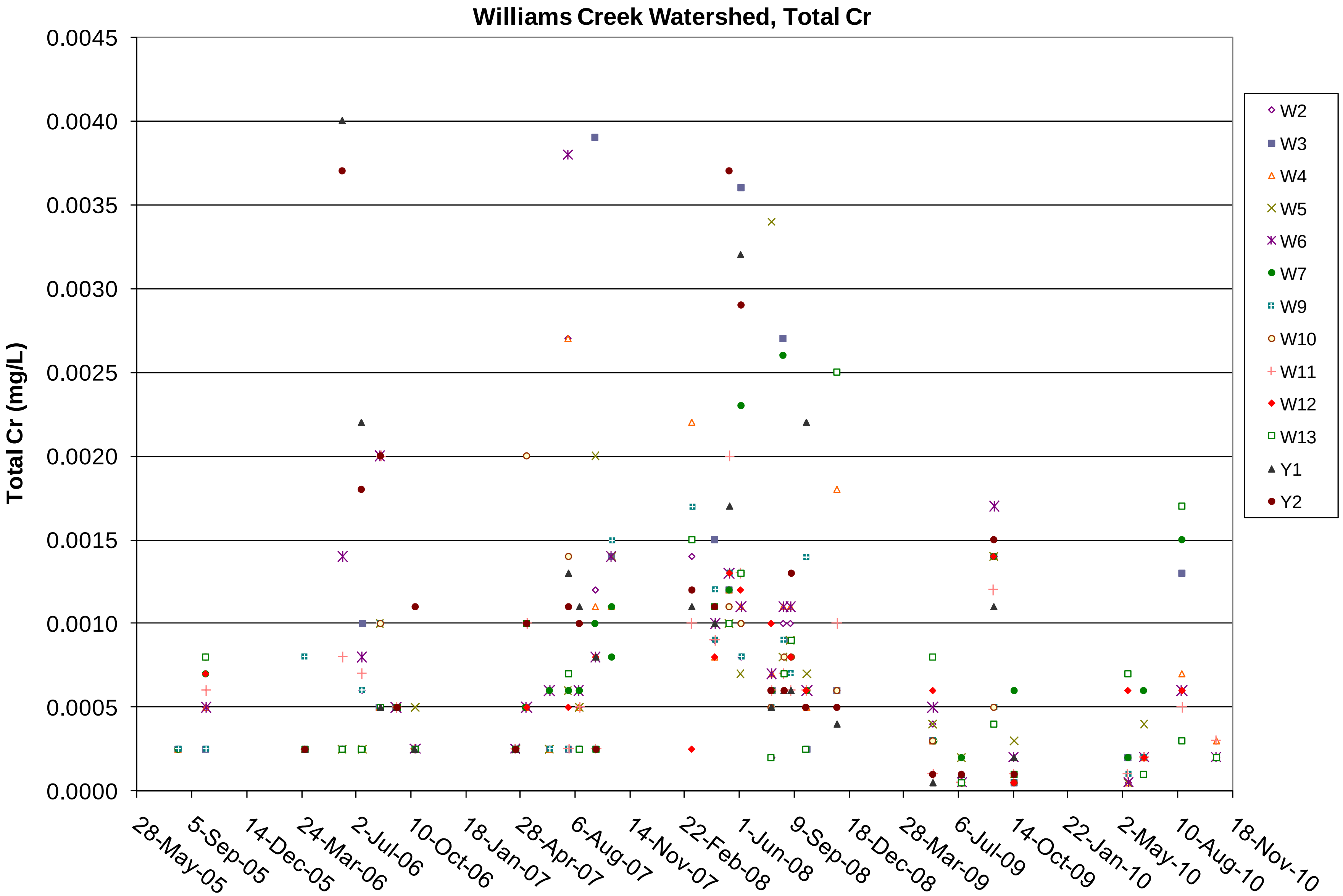

Williams Creek Watershed, Field pH
Field pH (pH units)
10.0
9.0
8.0
7.0
6.0
5.0
4.0
28-May-05
5-Sep-05
14-Dec-05
24-Mar-06
2-Jul-06
10-Oct-06
18-Jan-07
28-Apr-07
6-Aug-07
14-Nov-07
22-Feb-08
1-Jun-08
9-Sep-08
18-Dec-08
28-Mar-09
6-Jul-09
14-Oct-09
22-Jan-10
2-May-10
10-Aug-10
18-Nov-10
W2
W3
W4
W5
W6
W7
W9
W10
W11
W12
W13
Y1
Y2

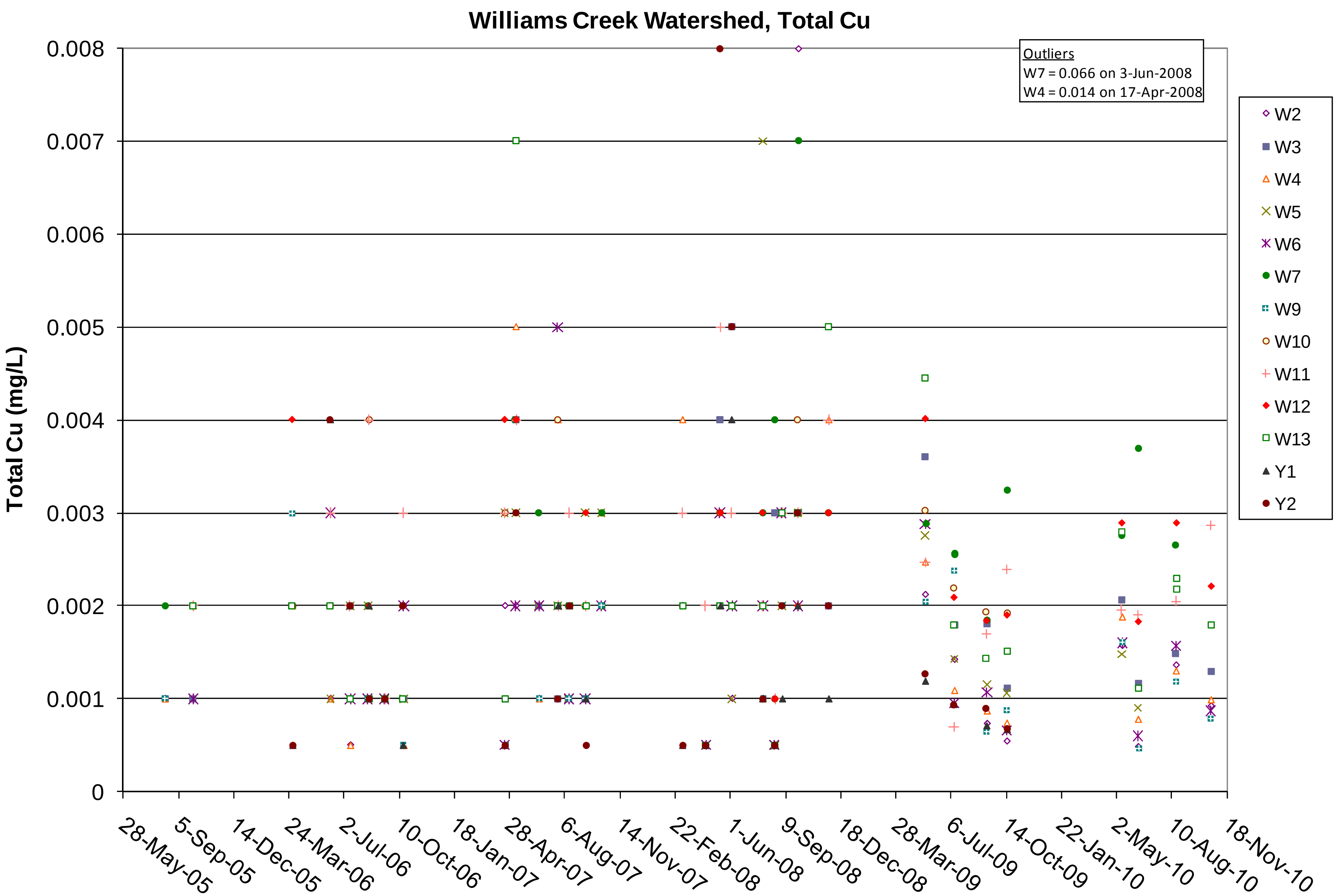

Williams Creek Watershed, Total Suspended Solids
Total Suspended Solids (mg/L)
140
120
100
80
60
40
20
0
28-May-05
5-Sep-05
14-Dec-05
24-Mar-06
2-Jul-06
10-Oct-06
18-Jan-07
28-Apr-07
6-Aug-07
14-Nov-07
22-Feb-08
1-Jun-08
9-Sep-08
18-Dec-08
28-Mar-09
6-Jul-09
14-Oct-09
22-Jan-10
2-May-10
10-Aug-10
18-Nov-10
W2
W3
W4
W5
W6
W7
W9
W10
W11
W12
W13
Y1
Y2

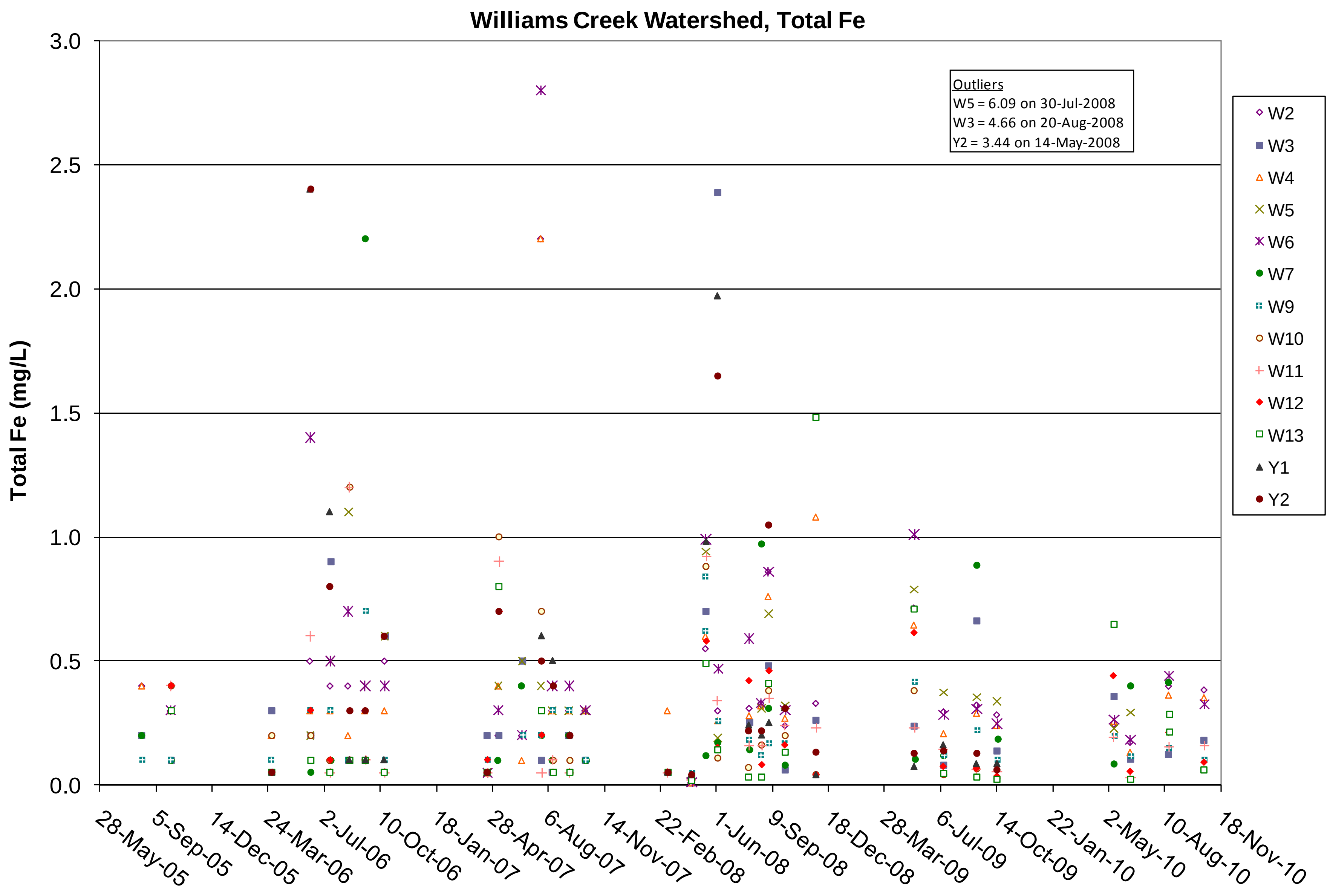

Williams Creek Watershed, Total Al
Total Al (mg/L)
2.5
2
1.5
1
0.5
0
28-May-05
5-Sep-05
14-Dec-05
24-Mar-06
2-Jul-06
10-Oct-06
18-Jan-07
28-Apr-07
6-Aug-07
14-Nov-07
22-Feb-08
1-Jun-08
9-Sep-08
18-Dec-08
28-Mar-09
6-Jul-09
14-Oct-09
22-Jan-10
2-May-10
10-Aug-10
18-Nov-10
W2
W3
W4
W5
W6
W7
W9
W10
W11
W12
W13
Y1
Y2

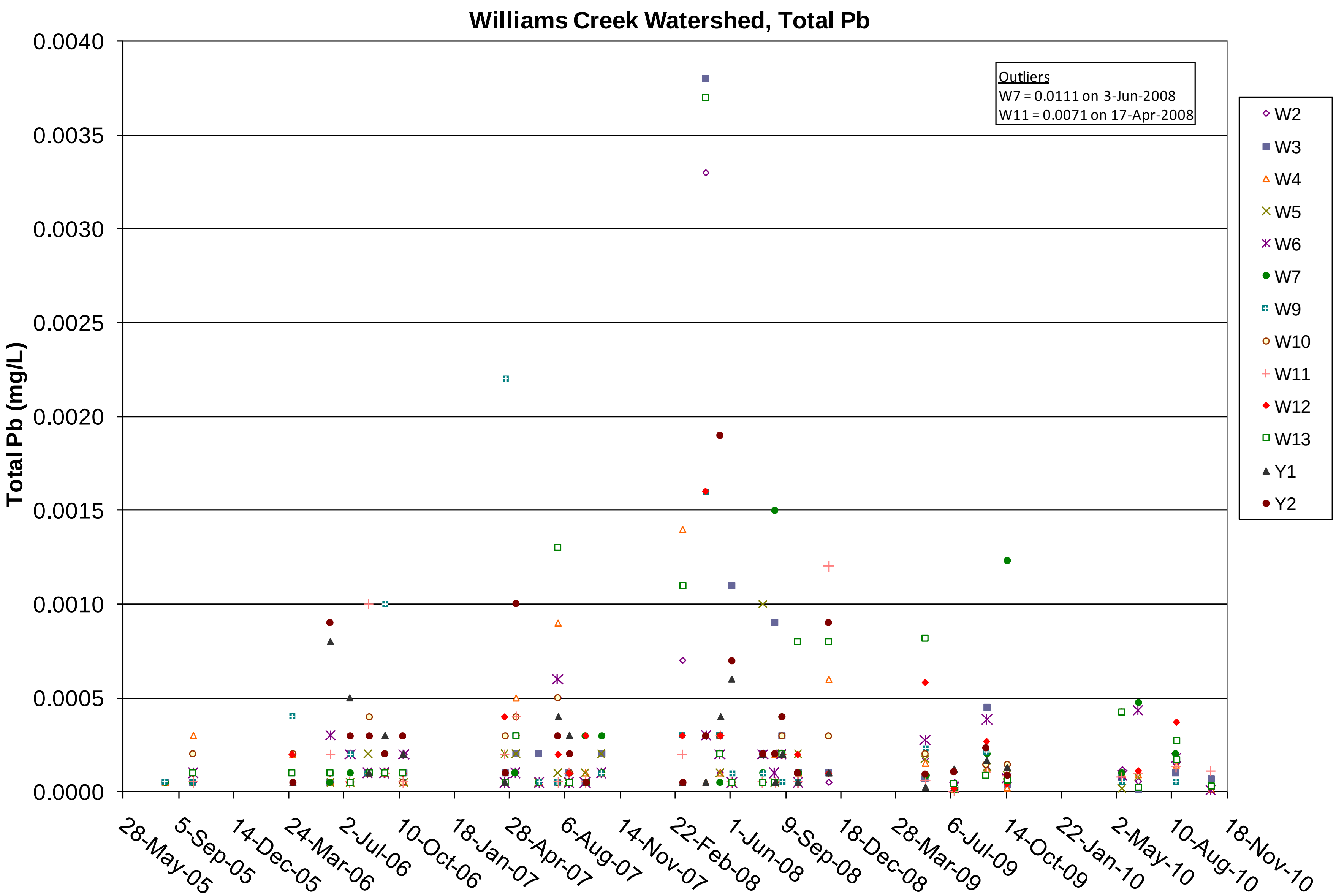

Williams Creek Watershed, Total As
Total As (mg/L)
0.003
0.0025
0.002
0.0015
0.001
0.0005
0
28-May-05
5-Sep-05
14-Dec-05
24-Mar-06
2-Jul-06
10-Oct-06
18-Jan-07
28-Apr-07
6-Aug-07
14-Nov-07
22-Feb-08
1-Jun-08
9-Sep-08
18-Dec-08
28-Mar-09
6-Jul-09
14-Oct-09
22-Jan-10
2-May-10
10-Aug-10
18-Nov-10
W2
W3
W4
W5
W6
W7
W9
W10
W11
W12
W13
Y1
Y2

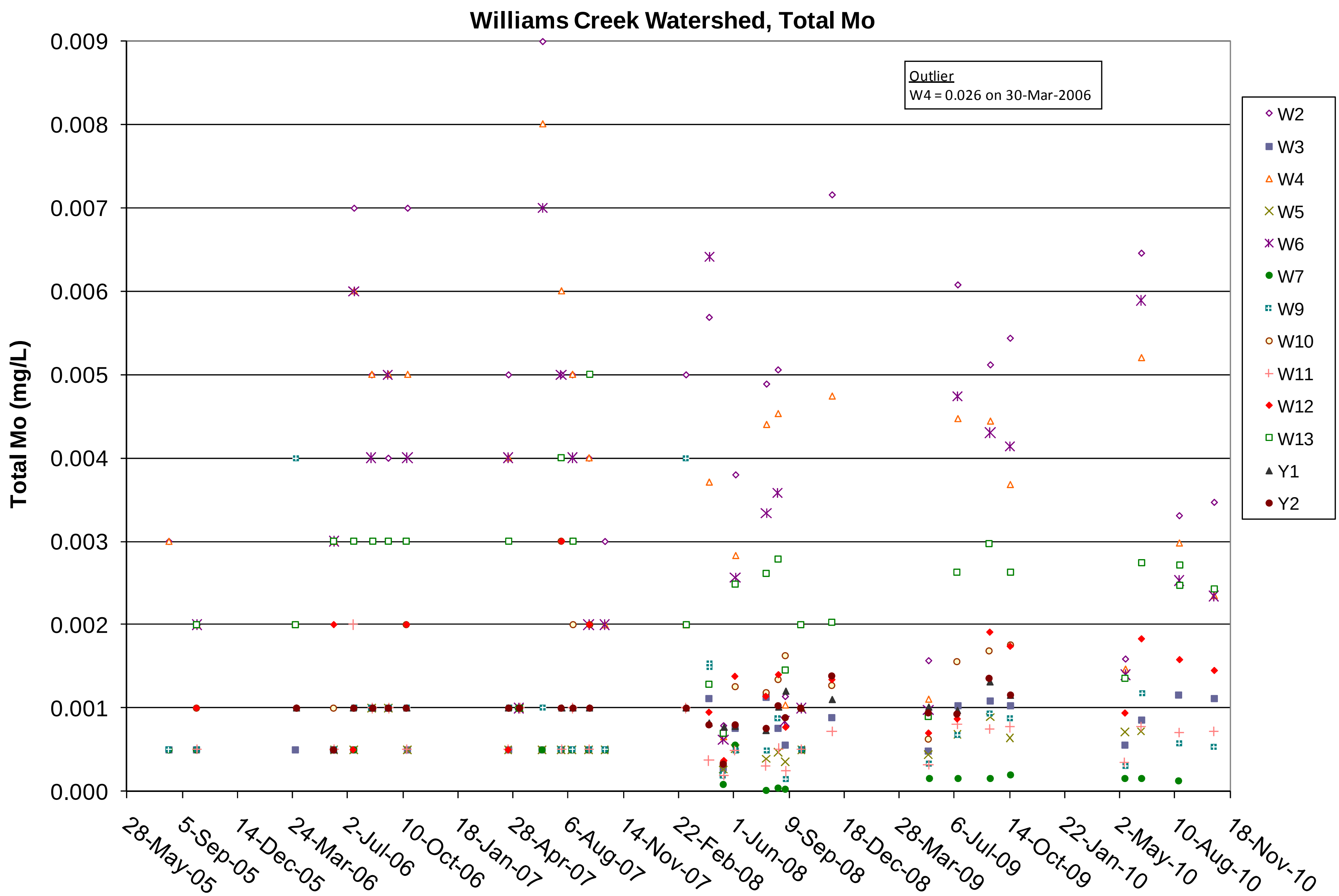

Williams Creek Watershed, Total Cd
Total Cd (mg/L)
0.00035
0.00030
0.00025
0.00020
0.00015
0.00010
0.00005
0.00000
Outlier
W12 = 0.0127 on 18-Aug-2010
W2
W3
W4
W5
W6
W7
W9
W10
W11
W12
W13
Y1
Y2
28-May-05
5-Sep-05
14-Dec-05
24-Mar-06
2-Jul-06
10-Oct-06
18-Jan-07
28-Apr-07
6-Aug-07
14-Nov-07
22-Feb-08
1-Jun-08
9-Sep-08
18-Dec-08
28-Mar-09
6-Jul-09
14-Oct-09
22-Jan-10
2-May-10
10-Aug-10
18-Nov-10

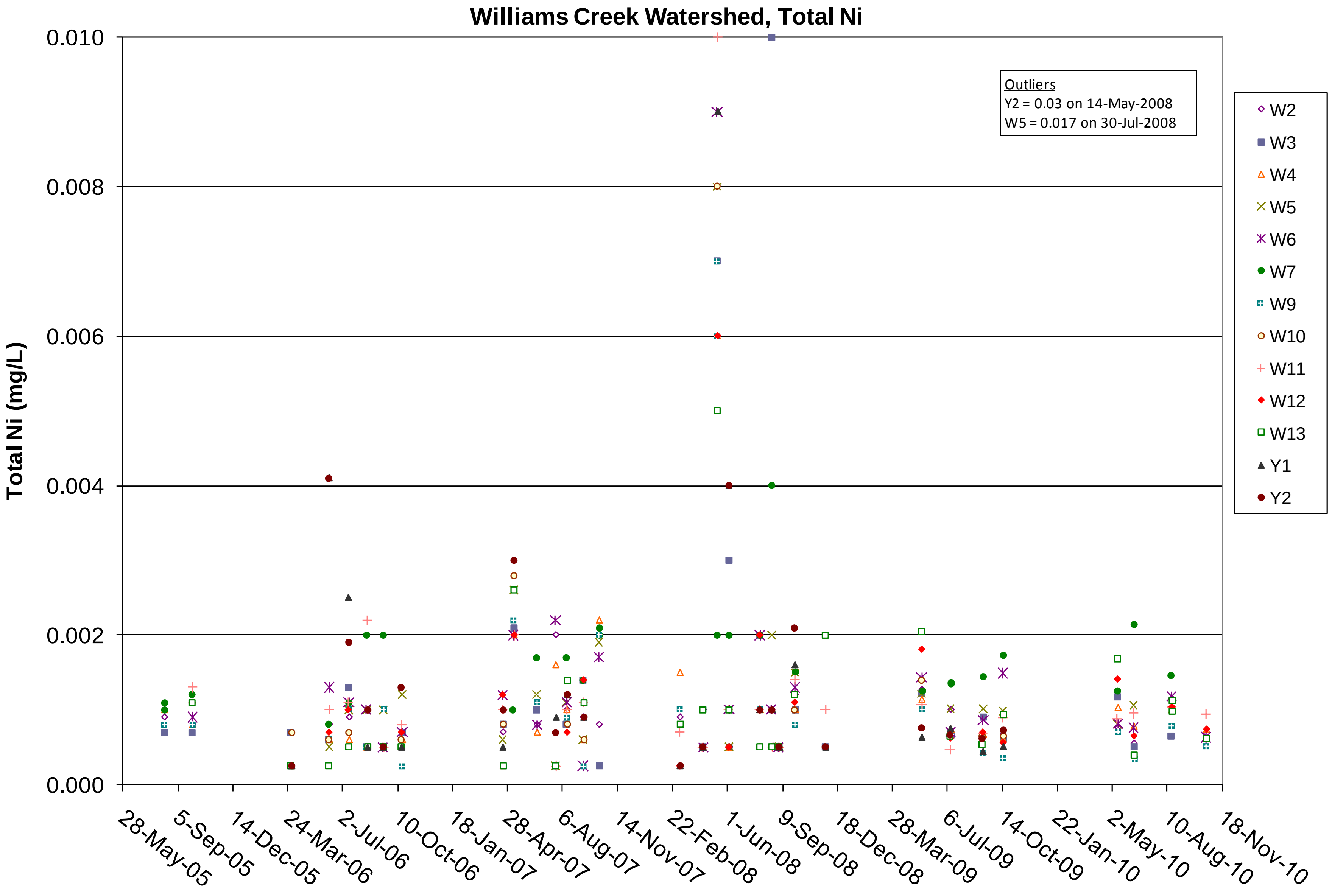

Williams Creek Watershed, Total Cr
Total Cr (mg/L)
0.0045
0.0040
0.0035
0.0030
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
28-May-05
5-Sep-05
14-Dec-05
24-Mar-06
2-Jul-06
10-Oct-06
18-Jan-07
28-Apr-07
6-Aug-07
14-Nov-07
22-Feb-08
1-Jun-08
9-Sep-08
18-Dec-08
28-Mar-09
6-Jul-09
14-Oct-09
22-Jan-10
2-May-10
10-Aug-10
18-Nov-10
W2
W3
W4
W5
W6
W7
W9
W10
W11
W12
W13
Y1
Y2

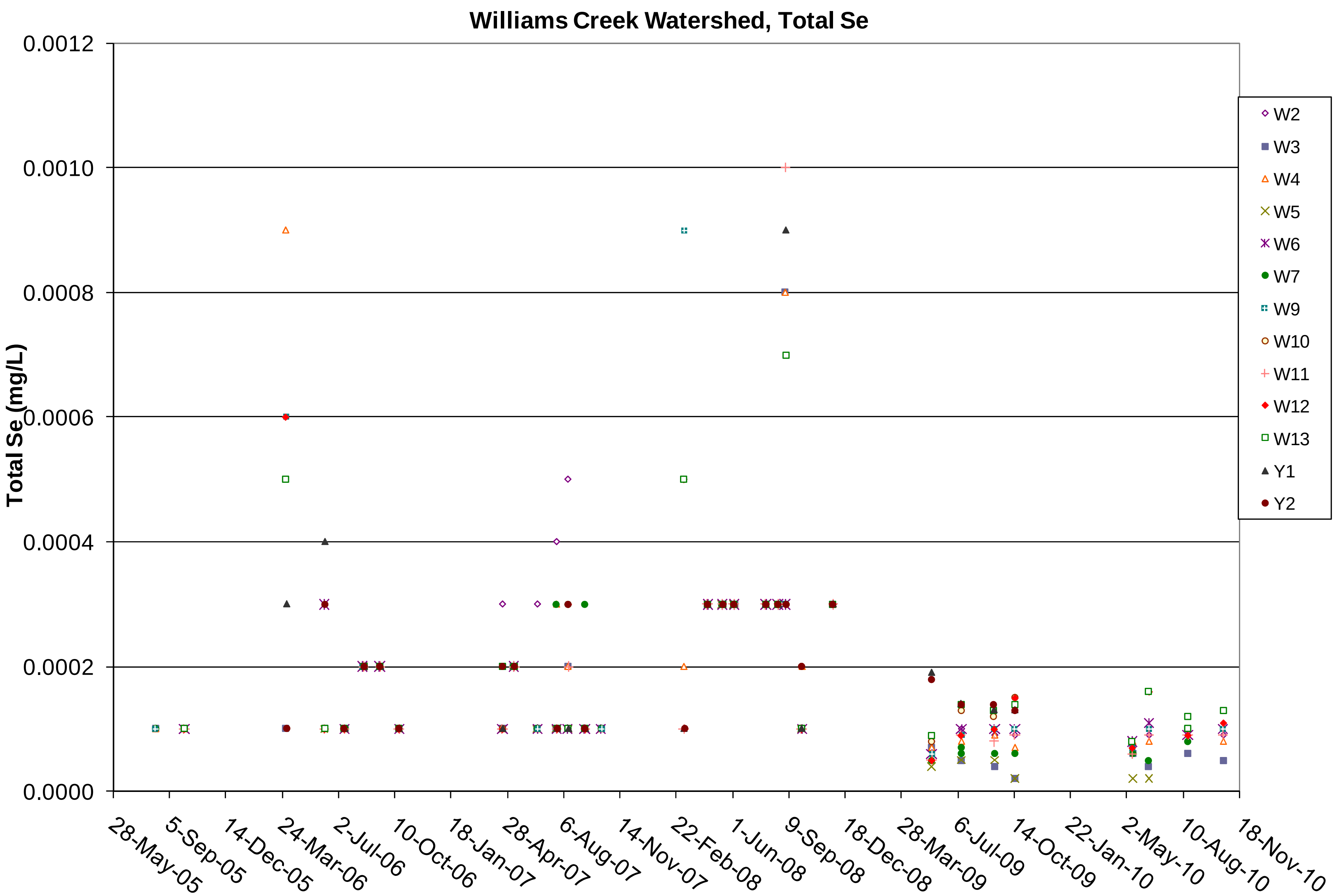

Williams Creek Watershed, Total Cu
Total Cu (mg/L)
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0
Outliers
W7 = 0.066 on 3-Jun-2008
W4 = 0.014 on 17-Apr-2008
W2
W3
W4
W5
W6
W7
W9
W10
W11
W12
W13
Y1
Y2
28-May-05
5-Sep-05
14-Dec-05
24-Mar-06
2-Jul-06
10-Oct-06
18-Jan-07
28-Apr-07
6-Aug-07
14-Nov-07
22-Feb-08
1-Jun-08
9-Sep-08
18-Dec-08
28-Mar-09
6-Jul-09
14-Oct-09
22-Jan-10
2-May-10
10-Aug-10
18-Nov-10

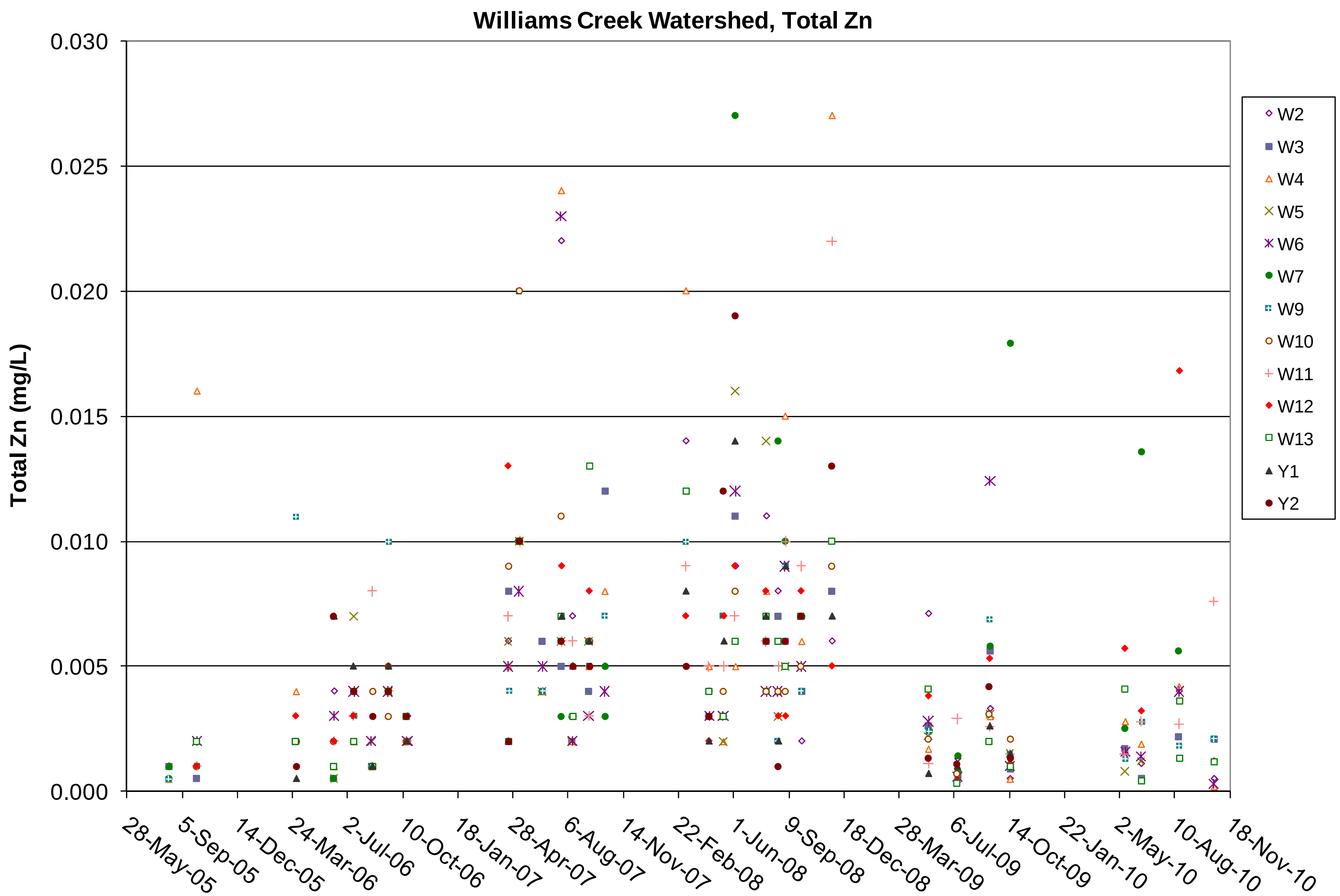

Williams Creek Watershed, Total Fe
Total Fe (mg/L)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Outliers
W5 = 6.09 on 30-Jul-2008
W3 = 4.66 on 20-Aug-2008
Y2 = 3.44 on 14-May-2008
W2
W3
W4
W5
W6
W7
W9
W10
W11
W12
W13
Y1
Y2
28-May-05
5-Sep-05
14-Dec-05
24-Mar-06
2-Jul-06
10-Oct-06
18-Jan-07
28-Apr-07
6-Aug-07
14-Nov-07
22-Feb-08
1-Jun-08
9-Sep-08
18-Dec-08
28-Mar-09
6-Jul-09
14-Oct-09
22-Jan-10
2-May-10
10-Aug-10
18-Nov-10

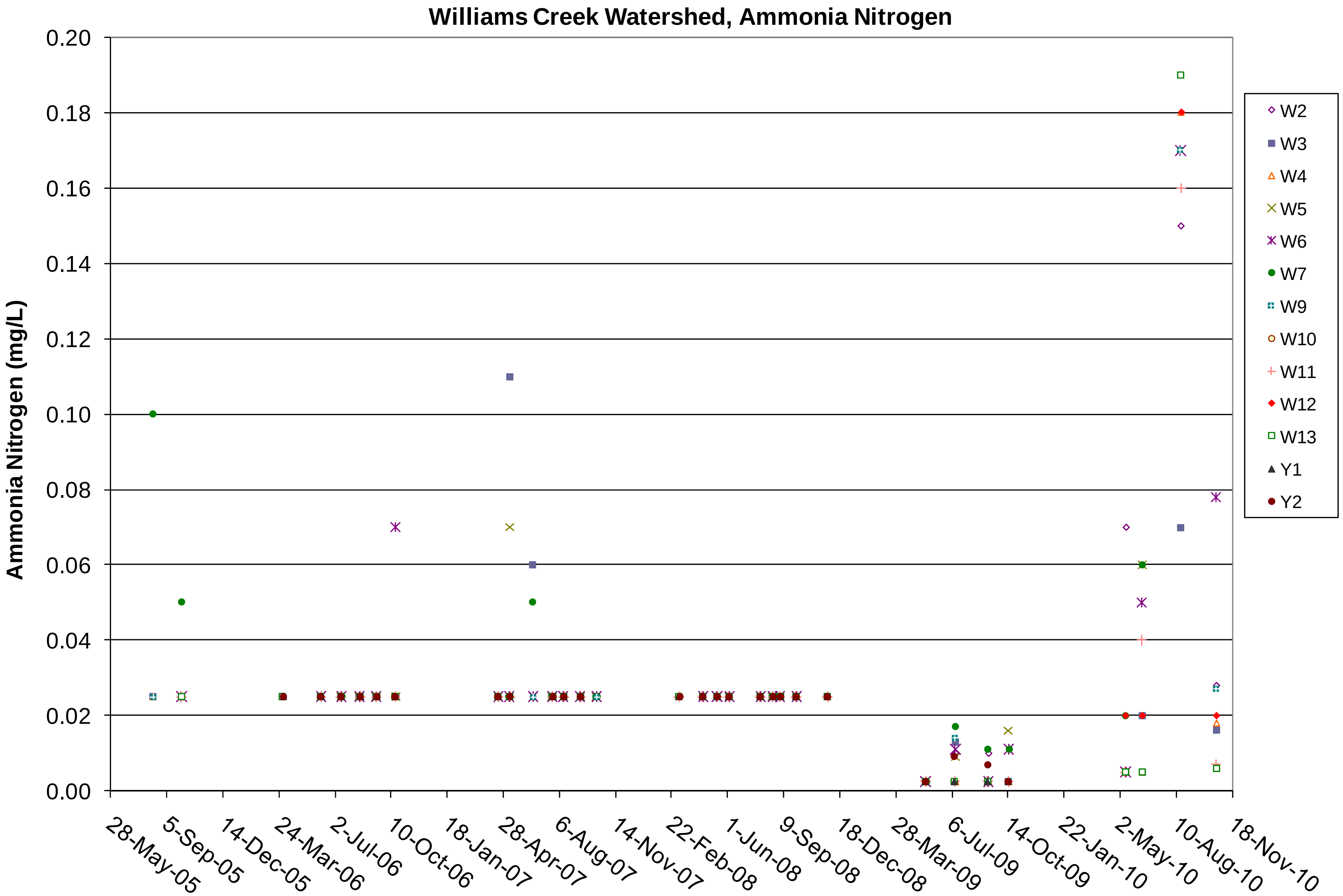

Williams Creek Watershed, Total Pb
Total Pb (mg/L)
0.0040
0.0035
0.0030
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
Outliers
W7 = 0.0111 on 3-Jun-2008
W11 = 0.0071 on 17-Apr-2008
W2
W3
W4
W5
W6
W7
W9
W10
W11
W12
W13
Y1
Y2
28-May-05
5-Sep-05
14-Dec-05
24-Mar-06
2-Jul-06
10-Oct-06
18-Jan-07
28-Apr-07
6-Aug-07
14-Nov-07
22-Feb-08
1-Jun-08
9-Sep-08
18-Dec-08
28-Mar-09
6-Jul-09
14-Oct-09
22-Jan-10
2-May-10
10-Aug-10
18-Nov-10

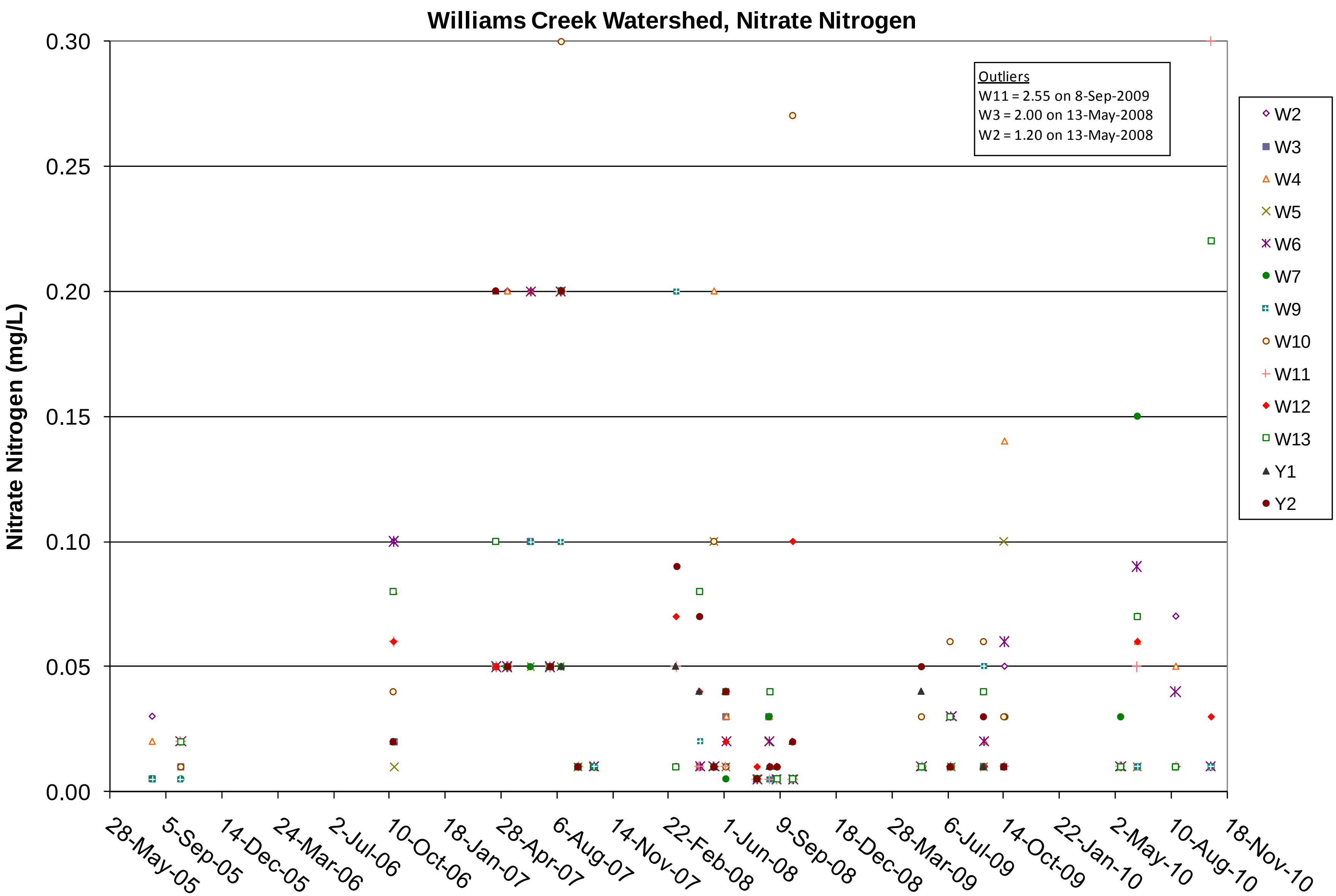

Williams Creek Watershed, Total Mo
Total Mo (mg/L)
0.009
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0.000
Outlier
W4 = 0.026 on 30-Mar-2006
W2
W3
W4
W5
W6
W7
W9
W10
W11
W12
W13
Y1
Y2
28-May-05
5-Sep-05
14-Dec-05
24-Mar-06
2-Jul-06
10-Oct-06
18-Jan-07
28-Apr-07
6-Aug-07
14-Nov-07
22-Feb-08
1-Jun-08
9-Sep-08
18-Dec-08
28-Mar-09
6-Jul-09
14-Oct-09
22-Jan-10
2-May-10
10-Aug-10
18-Nov-10

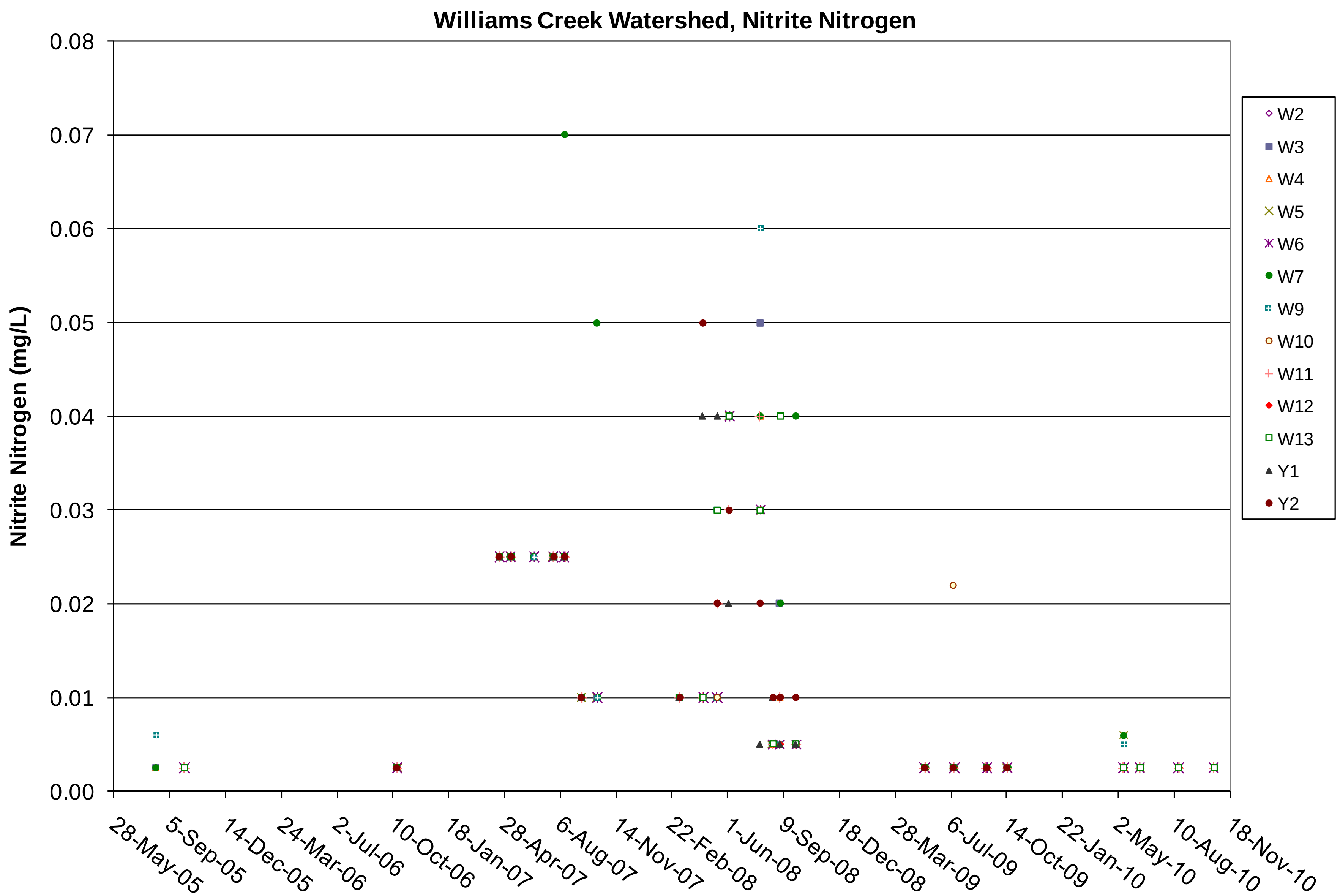

Williams Creek Watershed, Total Ni
Total Ni (mg/L)
0.010
0.008
0.006
0.004
0.002
0.000
Outliers
Y2 = 0.03 on 14-May-2008
W5 = 0.017 on 30-Jul-2008
W2
W3
W4
W5
W6
W7
W9
W10
W11
W12
W13
Y1
Y2
28-May-05
5-Sep-05
14-Dec-05
24-Mar-06
2-Jul-06
10-Oct-06
18-Jan-07
28-Apr-07
6-Aug-07
14-Nov-07
22-Feb-08
1-Jun-08
9-Sep-08
18-Dec-08
28-Mar-09
6-Jul-09
14-Oct-09
22-Jan-10
2-May-10
10-Aug-10
18-Nov-10


Williams Creek Watershed, Total Se
Total Se (mg/L)
0.0012
0.0010
0.0008
0.0006
0.0004
0.0002
0.0000
28-May-05
5-Sep-05
14-Dec-05
24-Mar-06
2-Jul-06
10-Oct-06
18-Jan-07
28-Apr-07
6-Aug-07
14-Nov-07
22-Feb-08
1-Jun-08
9-Sep-08
18-Dec-08
28-Mar-09
6-Jul-09
14-Oct-09
22-Jan-10
2-May-10
10-Aug-10
18-Nov-10
W2
W3
W4
W5
W6
W7
W9
W10
W11
W12
W13
Y1
Y2


Williams Creek Watershed, Total Zn
Total Zn (mg/L)
0.030
0.025
0.020
0.015
0.010
0.005
0.000
28-May-05
5-Sep-05
14-Dec-05
24-Mar-06
2-Jul-06
10-Oct-06
18-Jan-07
28-Apr-07
6-Aug-07
14-Nov-07
22-Feb-08
1-Jun-08
9-Sep-08
18-Dec-08
28-Mar-09
6-Jul-09
14-Oct-09
22-Jan-10
2-May-10
10-Aug-10
18-Nov-10
W2
W3
W4
W5
W6
W7
W9
W10
W11
W12
W13
Y1
Y2


Williams Creek Watershed, Ammonia Nitrogen
Ammonia Nitrogen (mg/L)
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
28-May-05
5-Sep-05
14-Dec-05
24-Mar-06
2-Jul-06
10-Oct-06
18-Jan-07
28-Apr-07
6-Aug-07
14-Nov-07
22-Feb-08
1-Jun-08
9-Sep-08
18-Dec-08
28-Mar-09
6-Jul-09
14-Oct-09
22-Jan-10
2-May-10
10-Aug-10
18-Nov-10
W2
W3
W4
W5
W6
W7
W9
W10
W11
W12
W13
Y1
Y2


Williams Creek Watershed, Nitrate Nitrogen
Nitrate Nitrogen (mg/L)
0.30
0.25
0.20
0.15
0.10
0.05
0.00
28-May-05
5-Sep-05
14-Dec-05
24-Mar-06
2-Jul-06
10-Oct-06
18-Jan-07
28-Apr-07
6-Aug-07
14-Nov-07
22-Feb-08
1-Jun-08
9-Sep-08
18-Dec-08
28-Mar-09
6-Jul-09
14-Oct-09
22-Jan-10
2-May-10
10-Aug-10
18-Nov-10
Outliers
W11 = 2.55 on 8-Sep-2009
W3 = 2.00 on 13-May-2008
W2 = 1.20 on 13-May-2008
W2
W3
W4
W5
W6
W7
W9
W10
W11
W12
W13
Y1
Y2


Williams Creek Watershed, Nitrite Nitrogen
Nitrite Nitrogen (mg/L)
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
28-May-05
5-Sep-05
14-Dec-05
24-Mar-06
2-Jul-06
10-Oct-06
18-Jan-07
28-Apr-07
6-Aug-07
14-Nov-07
22-Feb-08
1-Jun-08
9-Sep-08
18-Dec-08
28-Mar-09
6-Jul-09
14-Oct-09
22-Jan-10
2-May-10
10-Aug-10
18-Nov-10
W2
W3
W4
W5
W6
W7
W9
W10
W11
W12
W13
Y1
Y2

Western Copper Corporation

# 2010 Annual Quartz Mining Licence Report

**Submitted to Yukon Government, Energy Mines and Resources**

**Yukon Quartz Mining Licence QML-0007**

## Appendix C

## Results of Static Tests on Terminated Humidity Cell Residual Material

**TECHNICAL MEMORANDUM**

**DATE** August 4, 2010 **PROJECT No.** 07-1413-0077

**TO** Paul West-Sells
Western Copper Corporation **DOC. No.** 145

**FROM** Steven A. Atkin **EMAIL** Satkin@golder.com

**RESULTS OF STATIC TESTS ON TERMINATED HUMIDITY CELL RESIDUAL MATERIAL**

## 1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has conducted geochemical testing to characterize the acid rock drainage (ARD) and metal leaching (ML) properties of neutralized spent ore samples that were derived from residue of metallurgical leached, rinsed and neutralized column tests of ore from the Western Copper Corporation (WCC), Carmacks Copper Project (Carmacks). The metallurgical and geochemical testing was conducted as part of the feasibility study for the project. Amongst the tests conducted were two sets of long term kinetic tests the first began in March 2008 and terminated in March 2010 after 100 weeks of humidity cell testing and the second began in February 2009 and terminated in March 2010 after 55 weeks of testing. Upon completion of the tests, the residue from the humidity cells were subjected to a set of static tests in order to assess the impacts of prolonged leaching on the ARD and ML potential of the neutralized spent ore.

This technical memorandum presents the results of the static tests conducted on samples of the residual material collected from the three terminated humidity cell tests and provides a comparison of the static test results of the residual material (post-kinetic test material) to static test results conducted on the material prior to the kinetic testing (pre-kinetic test material) (Golder, 2010). Golder 2010 also presents the results of the kinetic test results.

## 2.0 BACKGROUND

WCC conducted bench-scale column leaching tests in 2008 on ore samples collected from the Carmacks site. The original ore samples for the metallurgical tests consisted of material that was representative of crushed ore collected by Access Consulting Group (ACG) (ACG, 2007). The metallurgical tests were conducted at PRA Metallurgical Division, Inspectorate America Corporation for metallurgical testing (PRA, 2009a and PRA, 2009b). Upon completion of the metallurgical testing, the samples were treated to neutralize any lingering acidity.

Samples of neutralized spent ore were provided to Golder for geochemical testing and were intended to represent ore in the heap at closure after: the ore had been leached with acid to recover copper from the ore; rinsed to flush the acid out the spent ore; and then neutralized with alkalis to return the spent ore to a neutral pH. Three samples of neutralized spent ore were collected from two leach columns, two samples were taken from the top and bottom of Column 3 (T1 and B1, respectively) and one sample was collected from the full length of Column 6 (Col-6). All of the geochemical testing was conducted at SGS in Burnaby, British Columbia.

The entire ARD/ML geochemical testing program for the neutralized spent ore samples consisted of static and kinetic tests (humidity cells); the results of which are reported in Golder, 2010. Upon completion of the kinetic tests, Golder recommended that the residual material in each humidity cell (T1 from HC-7, B1 from HC-8 and Col-6 from HC-9) undergo a suite of post-kinetic testing following the guidelines of Price (1997) using a suite of static tests similar to the static tests conducted on the material prior to the kinetic testing. The static testing conducted on the residual material consisted of whole rock major and trace element analyses and Acid Base Accounting (ABA); these test methods are described in detail in Golder, 2010. The Net Acid Generation (NAG) test was recommended as an additional static test, as a compliment to the ABA test, to check on the residual sulphides; this test method is described in further detail in Section 3.3.

## 3.0 RESULTS

The section that follows reviews the results of the pre- and post-kinetic static geochemical testing of the neutralized spent ore samples. Each of the tests is designed to address either the ARD or ML properties of the rock. In some cases, the tests overlap and provide alternative methods of determining the ARD/ML potential of the test material (*e.g.,* the ARD is assessed using three different methods, the bulk and carbonate acid neutralizing capacity as well as using the NAG tests). The true ARD/ML potential of the neutralized spent ore samples is best assessed using all of the data together rather than viewing individual tests alone.

### 3.1 Acid Base Accounting (ABA)

All of the pre- and post-kinetic test samples underwent a standard suite of ABA analysis, including paste pH, sulphur speciation (total sulphur – S(T), sulphide sulphur - S(-2) and sulphate sulphur – S(SO4)), total inorganic carbon (TIC), carbonate neutralizing potential (CaCO3 NP) and bulk neutralizing potential (NP). From these parameters, derived functions were calculated to determine the ARD potential of the samples: acid generating potential (AP), net-neutralizing potential (NNP) and the net-potential ratio (or NPR = NP/AP and CaCO3 NPR = CaCO3 NP/AP). Results of ABA analyses of the pre- and post-kinetic test samples are presented in Table 1. Table 2 summarizes the results of paste pH and sulphur speciation analyses and the NP, NPR and CaCO3 NPR calculations.

In general, the paste pH of the pre- and post-kinetic test samples remains nearly unchanged. The sulphur species concentrations are all low and the dominant sulphur species is primarily sulphate sulphur for both the pre- and post-kinetic test samples. The sulphide sulphur concentration is near the method detection limit (0.01 wt %) for all samples and although the concentration generally decreases between the pre- and post-kinetic test samples, the change is within the analytical error between multiple samples.

All of the samples have measureable NP and show little change after 100 weeks of leaching for the Column 3 T1 and B1 samples or 55 weeks for Column 6 sample during the humidity cell tests. The post-kinetic test samples are considered non-potentially acid generating based upon the Price (2009) criteria (NPR>2). However, based upon the more conservative CaCO3 NP, the post-kinetic test samples have variable ARD potentials: sample T1 is uncertain acid generating potential (1 < NPR < 2), sample B1 is potentially acid generating (NPR < 1), and sample Col-6 is non-potentially acid generating.

**Table 2: Summary of ABA Results for Pre- and Post-kinetic Test Samples**

| Sample ID | Paste pH | S(T) % | S(SO4) % | S(S-2) % | NP | NPR | CaCO3 NPR |
|---|---|---|---|---|---|---|---|
| **Pre-Kinetic Test Samples** | | | | | | | |
| T 1 | 7.85 | 0.12 | 0.07 | 0.05 | 10.8 | 6.9 | 4.27 |
| B 1 | 5.91 | 0.55 | 0.42 | 0.13 | 6.3 | 1.6 | 0.21 |
| Col-6 | 7.89 | 0.38 | 0.3 | 0.08 | 8.8 | 3.5 | 1.33 |
| **Post-kinetic Test Samples** | | | | | | | |
| T1 (HC 7) | 7.97 | 0.12 | 0.05 | 0.07 | 7.9 | 3.6 | 1.9 |
| B1 (HC 8) | 6.17 | 0.27 | 0.24 | 0.03 | 5.5 | 5.9 | 0.85 |
| Col-6 (HC 9) | 8.04 | 0.2 | 0.18 | 0.02 | 9.7 | 15.5 | 6.67 |

## 3.2 Net Acid Generation NAG Test

The NAG test procedure is an accelerated oxidation tests in which a strong oxidant (hydrogen peroxide) is applied to a crushed sample to rapidly oxidize sulphide minerals. The reaction is allowed to progress until all of the sulphide minerals within the sample are exhausted. The pH (NAG pH) of the solution is measured after the reaction is complete. A sample with excess available NP to neutralize the acidity created by sulphide mineral oxidation will have a NAG pH that is expected to be circum-neutral; a sample lacking sufficient NP will have a solution NAG pH that is more acidic. The cut-off between potentially acid generating and non-potentially acid generating rock is a NAG pH of 4.5 (NAG pH > 4.5 = non-acid forming) (AMIRA, 2002).

Results of NAG testing for the post-kinetic test samples are presented in Table 3. NAG testing was not conducted on the pre-kinetic test samples. All of the post-kinetic samples are classified as non-acid forming based upon the AMIRA (2002) criteria.

**Table 3: NAG Testing Results for Post-kinetic Test Samples**

| Sample ID | NAG pH After Reaction |
|---|---|
| T1 (HC 7) | 6.48 |
| B1 (HC 8) | 6.32 |
| Col-6 (HC 9) | 6.39 |

## 3.3 Whole Rock Major and Trace Element Analysis

Results of whole rock major and trace element analysis of the post-kinetic test samples are presented in Tables 4 and Table 5, respectively, along with the results of the pre-kinetic test results.

Changes in major element chemistry vary depending upon the analyte. Exchangeable elements such as potassium and sodium show a consistent decline between the pre- and post-kinetic test samples. Calcium and sulphur concentrations also decline between the pre- and post-kinetic test samples which may reflect dissolution of gypsum which was reported in sample B1 (Golder, 2010).

Trace elemental compositions between the pre- and post-kinetic samples are varied and may reflect differences resulting in sample heterogeneity and multiple analyses as much as changes resulting from the long term leaching. Table 6 lists pre- and post kinetic test trace elemental analyses for the CCME regulated parameters. The concentrations are generally low and equivalent to those of unmineralized rock. The concentrations of silver, copper and molybdenum from the pre-kinetic test samples exceeded the concentrations in an average high calcium granite (a reference material) by an order of magnitude or more (Golder, 2010) and the concentrations remain elevated in the post-kinetic test samples as well. Only aluminum and iron show a consistent decrease in concentration between the pre- and post-kinetic test analyses.

**Table 6: Trace Element Summary for Pre and Post-kinetic Test Samples**

| Sample ID | Al | Ag | As | Cd | Cr | Cu | Fe | Hg | Mo | Ni | Pb | Se | Tl | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ppm | ppm | ppm | ppm | ppm | ppm | ppm | ppm | ppm | ppm | ppm | ppm | ppm | ppm |
| Average High Ca granite | 82000 | 0.051 | 1.9 | 0.13 | 22 | 30 | 29600 | 0.08 | 1 | 15 | 15 | 0.05 | 0.72 | 60 |
| **Pre-Kinetic Test Samples** | | | | | | | | | | | | | | |
| T 1 | 10400 | 3.4 | 2.7 | 0.2 | 57 | 647.2 | 26200 | 0.2 | 90.1 | 5.4 | 4.5 | <0.5 | 0.3 | 38 |
| B 1 | 16100 | 3.9 | 3.5 | 0.4 | 61 | 866.9 | 41000 | 0.2 | 175.5 | 6.8 | 4.3 | 1.1 | 0.3 | 58 |
| Col-6 | 19300 | 5.5 | 3.2 | 1.1 | 58 | 721 | 42800 | 0.8 | 390.4 | 7.5 | 6.3 | 2.7 | 0.4 | 70 |
| **Post-Kinetic Test Samples** | | | | | | | | | | | | | | |
| T1 (HC 7) | 10100 | 3.5 | 3.3 | 0.2 | 52 | 882.6 | 25400 | 0.176 | 71.3 | 5.3 | 4.1 | <0.5 | 0.3 | 42 |
| B1 (HC 8) | 13000 | 3.8 | 2.7 | 0.4 | 49 | 730.5 | 35900 | 0.261 | 182.3 | 6.4 | 3.3 | 1.1 | 0.3 | 57 |
| Col-6 (HC 9) | 12000 | 4.3 | 3.4 | 0.4 | 54 | 626.8 | 33300 | 0.177 | 169.6 | 6.1 | 5.6 | 1.5 | 0.3 | 51 |

## 3.4 Review of Depletion Calculations

Calculations for the time to completely consume sulphide sulphur and NP (depletion calculations) have been prepared for the neutralized spent ore pre- and post-kinetic test samples.

Sulphur depletion was calculated using either total sulphur or sulphide sulphur concentrations from the ABA tests and sulphate leaching rates from the humidity cell tests. Depletion calculations based upon total sulphur analysis are conservative because they assume that all of the sulphate released is derived entirely from pyrite oxidation. In reality, the sulphate concentration measured in the leachate is derived from both non-acid generating sources such as gypsum dissolution and potentially acid generating sources such as pyrite oxidation and jarosite dissolution. Sulphide sulphur depletion calculations are based upon pyrite oxidation alone as the source of acidity. Table 7 summarizes the results of depletion calculations. The results of the calculations suggest:

- The T1 sample calculations indicate that the total and sulphide sulphur will outlast the NP for both the pre- and post-kinetic test samples.
- The B1 sample calculations indicate that the NP will outlast both the total and sulphide sulphur for both the pre- and post kinetic test samples.
- The Col-6 sample calculations indicate that the NP will outlast the sulphide sulphur the primary source of acidity but not the total sulphur for both the pre- and post-kinetic test samples.

**Table 7: Results of Depletion Calculations**

| Sample ID | S (based on Total Sulphur) | S (based on Sulphide Sulphur) | NP (alkalinity) |
|---|---|---|---|
| **Pre-Kinetic Test Material** | | | |
| T 1 | 91.0 | 31.4 | 8.6 |
| B 1 | 157.3 | -41.4 | 225.7 |
| Col-6 | 47.9 | -11.4 | 9.0 |
| **Post-kinetic Test Material** | | | |
| T1 (HC 7) | 89.8 | 47.7 | 5.8 |
| B1 (HC 8) | 21.2 | -89.1 | 191.0 |
| Col-6 (HC 9) | 12.3 | -23.3 | 10.0 |

## 4.0 CONCLUSION

Static tests were conducted on test residue from the humidity cells of three neutralized spent ore samples (Col-3 T1, Col-3 B1, and Col-6) from the Carmacks Copper Project upon termination of the humidity cell tests. Detailed results of the static testing of the pre-kinetic test samples are provided in Golder, 2010. Results of the post-kinetic test analyses suggest that the samples (T1, B1, and Col-6) are considered non-acid generating based on both ABA (NPR) and NAG test results. Using the more conservative criteria, the CaCO3 NPR, the samples have more variable ARD characteristics ranging from non-acid generating to potentially acid generating. Changes between the pre- and post-kinetic test sample solid-phase major and trace element concentrations are variable. The concentrations of potassium, sodium, calcium and sulphur appear to decrease in the major element analyses and aluminum and iron in the trace element analyses. The decrease in solid phase metal concentration could be due to metal leaching during the kinetic test procedure. The inconsistencies in the changes in concentrations (*e.g.*, iron remains variable between the pre- and post-kinetic test whole rock analyses but decrease between the two sets of samples in the trace elemental analyses) suggest that some of the variability may also be due to sample heterogeneity and using different sample splits for the different tests. Depletion calculations on both the pre- and post-kinetic test samples indicate that two of the three materials (B1 and Col-6) will not go acid due to low sulphide concentrations in the samples; however one sample (T1) has the potential to go acid.

Given the test results for this effort, the neutralized spent ore from the Carmacks Project has a low potential for ARD or ML. Over the short term, the residual alkali amendment from the neutralizing step will maintain circum-neutral to alkaline pH values in leachate from the heap leach pad. At the beginning of the test program the concentrations of MMER metals were below the guidelines and continued to decline over time indicting that metal leaching should not be an issue over the short or long term. Metals mobile under alkaline pH conditions likewise generally declined with time or reached a steady state concentration. Weathering rates observed in humidity cell tests are generally considered an order of magnitude higher than in the field (ASTM D5744-96, 2001) such that the observed neutral pH of the samples after 94 weeks of testing may translate to almost 20 years of leaching at the site with no apparent signs of a decline in pH. In addition, the proposed cover design for the heap leach pad will reduce the rate of infiltration of precipitation into and through the heap, reducing the rate at which residual alkali amendment is dissolved and prolonging the residence time of the amendment in the heap to maintain circum-neutral pH condition within the neutralized spent ore. It is possible the pH may eventually decline with time, however the low concentrations and the generally rapid depletion rates of sulphide sulphur suggest that sulphides should not be a long term source of mineral acidity.

We trust this information is sufficient for you needs at this time. Please do not hesitate to contact the undersigned if you have any further questions.

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Attachments: Attachment 1: Table 1 - Acid Base Accounting Results, Carmacks Copper Project
Attachment 2: Table 4 - Table 4Whole Rock Major Element Analysis Results, Carmacks Copper Project
Attachment 3: Table 5 - Trace Element Analysis Results, Carmacks Copper Project

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**Table 1**
**Acid Base Accounting Results**
**Carmacks Copper Project**

**Pre-Kinetic Test Material**

| Sample ID | Rock type | Paste pH | S(T) % | S(SO4) % | S(S-2) % | AP | NP | TIC % | CaCO3 NP | Net NP | NPR | CaNPR | ARD Potential (NPR) | ARD Potential (CaNPR) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| T 1 | Neutralized Spent Ore | 7.85 | 0.12 | 0.07 | 0.05 | 1.6 | 10.8 | 0.08 | 6.7 | 9.2 | 6.9 | 4.27 | non-PAG | non-PAG |
| B 1 | Neutralized Spent Ore | 5.91 | 0.55 | 0.42 | 0.13 | 4.1 | 6.3 | 0.01 | 0.8 | 2.2 | 1.6 | 0.21 | uncertain | PAG |
| Col-6 | Neutralized Spent Ore | 7.89 | 0.38 | 0.3 | 0.08 | 2.5 | 8.8 | 0.04 | 3.3 | 6.3 | 3.5 | 1.33 | non-PAG | uncertain |

**Post-Kinetic Test Material**

| Sample ID | Rock type | Paste pH | S(T) % | S(SO4) % | S(S-2) % | AP | NP | TIC % | CaCO3 NP | Net NP | NPR | CaNPR | ARD Potential (NPR) | ARD Potential (CaNPR) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| T1 (HC 7) | Neutralized Spent Ore Residue | 7.97 | 0.12 | 0.05 | 0.07 | 2.2 | 7.9 | 0.05 | 4.2 | 5.7 | 3.6 | 1.90 | non-PAG | uncertain |
| B1 (HC 8) | Neutralized Spent Ore Residue | 6.17 | 0.27 | 0.24 | 0.03 | 0.9 | 5.5 | <0.01 | <0.8 | 4.6 | 5.9 | 0.85 | non-PAG | PAG |
| Col-6 (HC 9) | Neutralized Spent Ore Residue | 8.04 | 0.2 | 0.18 | 0.02 | 0.6 | 9.7 | 0.05 | 4.2 | 9.1 | 15.5 | 6.67 | non-PAG | non-PAG |

**Table 4**
**Whole Rock Major Element Analysis Results**
**Carmacks Copper Project**

**Pre-Kinetic Test Material**

| Sample ID | Rock type | SiO2 % | Al2O3 % | Fe2O3 % | CaO % | MgO % | Na2O % | K2O % | TiO2 % | MnO % | P2O5 % | BaO % | Cr2O3 % | LOI % | Total % | C % | S % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| T 1 | Neutralized Spent Ore | 58.36 | 18.08 | 5.19 | 4.5 | 2.07 | 4.95 | 2.01 | 0.87 | 0.05 | 0.12 | 0.17 | 0.02 | 3.07 | 99.46 | 0.12 | 0.12 |
| B 1 | Neutralized Spent Ore | 54.56 | 17.73 | 7.47 | 4.46 | 2.52 | 4.68 | 2.2 | 0.85 | 0.07 | 0.33 | 0.15 | 0.02 | 4.79 | 99.81 | 0.01 | 0.55 |
| Col-6 | Neutralized Spent Ore | 59.93 | 15.78 | 6.5 | 4.05 | 1.95 | 3.89 | 2.26 | 0.76 | 0.05 | 0.3 | 0.15 | 0.01 | 4.16 | 99.8 | 0.07 | 0.37 |

**Post-Kinetic Test Material**

| Sample ID | Rock type | SiO2 % | Al2O3 % | Fe2O3 % | CaO % | MgO % | Na2O % | K2O % | TiO2 % | MnO % | P2O5 % | BaO % | Cr2O3 % | LOI % | Total % | C % | S % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| T1 (HC 7) | Neutralized Spent Ore Residue | 61.2 | 16.67 | 5.38 | 3.85 | 1.78 | 4.7 | 1.62 | 0.71 | 0.06 | 0.21 | 0.14 | 0.01 | 3.5 | 99.83 | 0.08 | 0.12 |
| B1 (HC 8) | Neutralized Spent Ore Residue | 60.44 | 15.49 | 6.26 | 3.4 | 2.06 | 4.21 | 1.88 | 0.66 | 0.07 | 0.61 | 0.14 | 0.01 | 4.24 | 99.47 | 0.02 | 0.27 |
| Col-6 (HC 9) | Neutralized Spent Ore Residue | 57.4 | 16.26 | 6.55 | 3.95 | 2.06 | 4.44 | 1.74 | 0.73 | 0.07 | 0.43 | 0.12 | 0.01 | 4.58 | 98.34 | 0.08 | 0.2 |

**Table 5**
**Trace Element Analysis Results**
**Carmacks Copper Project**

**Pre-Kinetic Test Material**

| Sample ID | Rock type | Al ppm | Ag ppm | As ppm | Ba ppm | Be ppm | Bi ppm | Ca % | Cd ppm | Co ppm | Cr ppm | Cu ppm | Fe ppm | Hg ppm | K % | La ppm | Mg % | Mn ppm | Mo ppm | Na % | Ni ppm | P % | Pb ppm | S % | Sb ppm | Sc ppm | Sr ppm | Th ppm | Ti % | Tl ppm | U ppm | V ppm | W ppm | Zn ppm | Zr ppm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| T 1 | Neutralized Spent Ore | 10400 | 3.4 | 2.7 | 571 | <1 | 1.9 | 0.59 | 0.2 | 7.1 | 57 | 647.2 | 26200 | 0.2 | 0.59 | 6 | 0.71 | 234 | 90.1 | 0.07 | 5.4 | 0.037 | 4.5 | 0.1 | <0.1 | 5.3 | 42 | 1 | 0.175 | 0.3 | 0.5 | 90 | 5.4 | 38 | 2 |
| B 1 | Neutralized Spent Ore | 16100 | 3.9 | 3.5 | 470 | <1 | 3.4 | 0.71 | 0.4 | 10 | 61 | 866.9 | 41000 | 0.2 | 0.9 | 8 | 1.03 | 306 | 175.5 | 0.07 | 6.8 | 0.136 | 4.3 | 0.57 | 0.1 | 6.9 | 47 | 2 | 0.191 | 0.3 | 0.5 | 122 | 6.8 | 58 | 2.2 |
| Col-6 | Neutralized Spent Ore | 19300 | 5.5 | 3.2 | 660 | <1 | 5.3 | 0.72 | 1.1 | 11.9 | 58 | 721 | 42800 | 0.8 | 1.05 | 10 | 1.04 | 337 | 390.4 | 0.13 | 7.5 | 0.115 | 6.3 | 0.42 | 0.1 | 7.5 | 43 | 2.4 | 0.229 | 0.4 | 0.7 | 133 | 17.7 | 70 | 2.6 |

**Post-Kinetic Test Material**

| Sample ID | Rock type | Al ppm | Ag ppm | As ppm | Ba ppm | Be ppm | Bi ppm | Ca % | Cd ppm | Co ppm | Cr ppm | Cu ppm | Fe % | Hg ppm | K % | La ppm | Mg % | Mn ppm | Mo ppm | Na % | Ni ppm | P % | Pb ppm | S % | Sb ppm | Sc ppm | Sr ppm | Th ppm | Ti % | Tl ppm | U ppm | V ppm | W ppm | Zn ppm | Zr ppm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| T1 (HC 7) | Neutralized Spent Ore Residue | 10100 | 3.5 | 3.3 | 570 | <1 | 2 | 0.51 | 0.2 | 7.8 | 52 | 882.6 | 25400 | 0.176 | 0.5 | 6 | 0.64 | 228 | 71.3 | 0.04 | 5.3 | 0.037 | 4.1 | 0.11 | 0.1 | 6 | 34 | 1 | 0.168 | 0.3 | 0.6 | 87 | 4.6 | 42 | 2.2 |
| B1 (HC 8) | Neutralized Spent Ore Residue | 13000 | 3.8 | 2.7 | 546 | <1 | 3.5 | 0.44 | 0.4 | 9.8 | 49 | 730.5 | 35900 | 0.261 | 0.8 | 8 | 0.89 | 293 | 182.3 | 0.04 | 6.4 | 0.112 | 3.3 | 0.25 | 0.1 | 7.3 | 38 | 1.9 | 0.176 | 0.3 | 0.5 | 116 | 8.6 | 57 | 2.3 |
| Col-6 (HC 9) | Neutralized Spent Ore Residue | 12000 | 4.3 | 3.4 | 585 | <1 | 4.4 | 0.6 | 0.4 | 8.3 | 54 | 626.8 | 33300 | 0.177 | 0.66 | 7 | 0.75 | 267 | 169.6 | 0.04 | 6.1 | 0.085 | 5.6 | 0.18 | 0.1 | 6.1 | 41 | 1.6 | 0.167 | 0.3 | 0.5 | 101 | 5 | 51 | 2.3 |

**Notes:**
**na indicates that no analysis was performed**