



Environmental Protection Department
Permits and Regulatory Affairs Division

UCRL-AR-10191-08-4

Lawrence Livermore National Laboratory
Experimental Test Site 300

Compliance Monitoring Program for
RCRA-Closed Landfill Pits 1 and 7

Fourth Quarter/Annual Report 2008

Authors

Richard G. Blake
Donald H. MacQueen

**This work performed under the auspices of the U.S. Department of Energy by
Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344.**

Contents

	Page
Summary.....	Summ-1
Introduction.....	1
Compliance Monitoring Program Overview	4
Quality Assurance.....	5
Description of Report Contents	6
Summary of Analytical Results.....	6
Inspection and Maintenance Summary.....	12
References	13
Acknowledgments.....	15
Abbreviations and Acronyms	16

Appendices

Appendix A. Tables of Ground Water Measurements.....	A-1
Appendix B. Statistical Methods for Release Detection.....	B-1
Appendix C. Quality Assurance Samples	C-1
Appendix D. Constituents of Concern and Monitoring Frequencies.....	D-1
Appendix E. Graphs of Ground Water Measurements	E-1

Figures

1. Location of LLNL Site 300.....	1
2. Locations of RCRA-closed landfill Pits 1 and 7 at LLNL Site 300.....	2
3. Locations of Pit 1 compliance monitoring wells	2
4. Locations of Pit 7 compliance monitoring wells	3
5. Freon-113 concentrations in water samples collected from ground water monitoring wells around Pit 1	10
6. Perchlorate concentrations in water samples collected from ground water monitoring wells around Pit 7	11
7. Nitrate concentrations in water samples collected from ground water monitoring wells around Pit 7	12

Tables

1. MCLs for radioactivity in drinking water	5
A-1. Pit 1 constituents of concern, monitoring wells, SLs, and quarterly analytical results for 2008	A-1
A-2. Pit 1 additional PCP constituents and quarterly analytical results for 2008.....	A-4
A-3. Pit 7 constituents of concern, monitoring wells, SLs, and quarterly analytical results for 2008	A-6
A-4. Pit 7 additional PCP constituents and quarterly analytical results for 2008.....	A-10
A-5. Pits 1 and 7 groundwater well sampling dates.....	A-11
B-1. Reported WDR 93-100 constituents of concern showing statistical evidence of release.....	B-2
C-1. Pit 1 quality assurance for routine, duplicate, and field blank samples for fourth quarter 2008.....	C-1
C-2. Pit 7 quality assurance for routine, duplicate, and field blank samples for fourth quarter 2008.....	C-2
D-1. Pits 1 and 7 constituents of concern and monitoring frequencies.....	D-1
E-1. Analytical results from 2008 that were omitted from the Appendix E plots due to the use of specially reduced y-axis plot limits.....	E-1

LLNL Experimental Test Site 300 Compliance Monitoring Program for RCRA-Closed Landfill Pits 1 and 7

Fourth Quarter/Annual Report 2008

Summary

This combined fourth quarter and annual 2008 report summarizes compliance activities performed at two Lawrence Livermore National Laboratory (LLNL) Site 300 landfills known as Pits 1 and 7. These pits were closed in 1993 under the Resource Conservation and Recovery Act (RCRA). Compliance activities at the pits consist of ground water sampling and analysis, pit cap inspections, annual subsidence surveys, and reporting of analytical results. Ground water measurements for the fourth quarter of 2008 are contained in **Appendix A, Tables A-1 to A-4**.

No new releases of constituents of concern to ground water from either Pit 1 or Pit 7 are evident in the fourth quarter monitoring data. During this quarter barium, uranium, tritium, and zinc continued to be detected above their statistical limits (SLs) as in the previous quarter in some ground water samples at the pits and are discussed in the "Summary of Analytical Results" section in this report.

All required inspections and annual permanent marker elevation surveys for the Pit 1 and 7 caps were performed and revealed no evidence of significant changes in elevation from last year and were reported in the second and third quarter reports. These inspections and surveys demonstrated the continued functional and structural integrity of the caps, vegetative cover, and drainage structures.

Introduction

This 2008 fourth quarter/annual report summarizes compliance monitoring results for two closed landfills known as Pit 1 and Pit 7 at the LLNL Experimental Test Site (Site 300). Site 300 is a 30.3 square kilometers (km²) (11.8 square miles [mi²]) site, located in the Altamont Hills approximately 10.5 km (6.5 mi) southwest of downtown Tracy, California (**Figure 1**). The landfills are located in the northern portion of the site (**Figure 2**). Closure of these unlined Class I waste management units was completed in December 1992. Site 300 is owned by the United States Department of Energy (DOE) and is operated by the Lawrence Livermore National Security, LLC.



Figure 1. Location of LLNL Site 300.

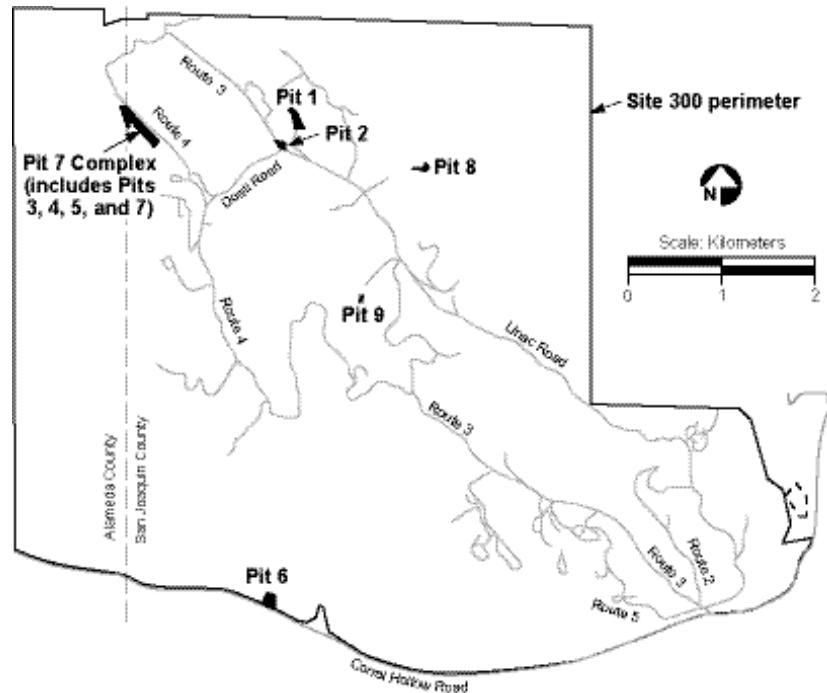


Figure 2. Locations of RCRA-closed landfill Pits 1 and 7 at LLNL Site 300.

Pit 1 is located in the Elk Ravine drainage area, about 300 meters (m) or 984 feet (ft) above mean sea level (MSL). Ground water generally flows in an east-northeast direction beneath Pit 1, following the inclination (dip) of underlying Miocene-age sedimentary rocks (Webster-Scholten, 1994).

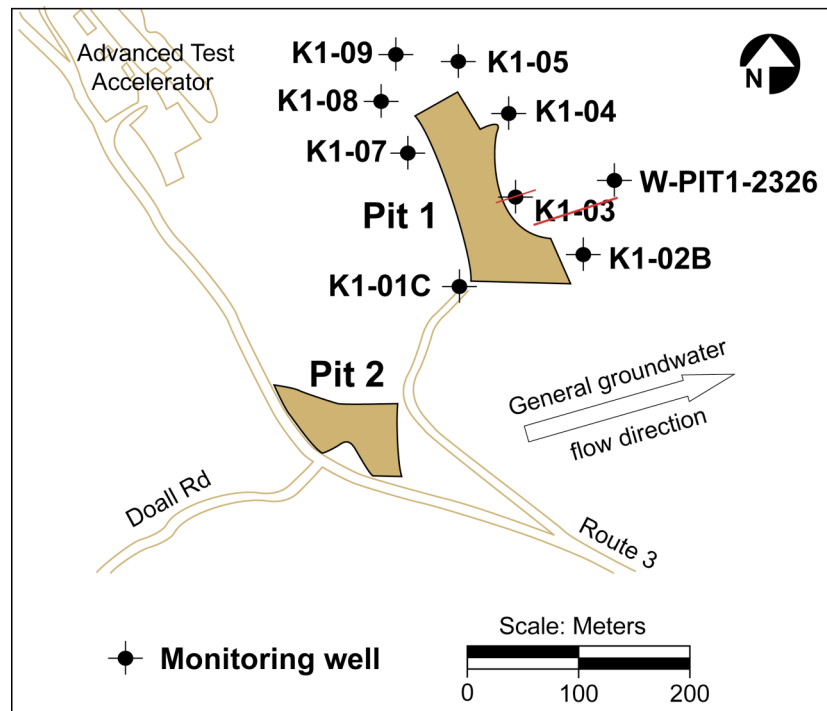


Figure 3. Locations of Pit 1 compliance monitoring wells.

Figure 3 shows the locations of the eight compliance monitoring wells that are used to sample the ground water in the vicinity of Pit 1. Wells K1-01C and K1-07 are hydrologically upgradient from Pit 1. Wells K1-02B, W-PIT1-2326, K1-04, and K1-05 are downgradient. Wells K1-08 and K1-09 are cross-gradient. Well K1-03 has an inoperative pump that is stuck in the casing and cannot be removed. As shown on Figure 3, Well K1-03 has a red line through the well posting indicating that the well is no longer in use. Well W-Pit1-2326 was installed to replace K1-03 (Figure 3). The wells are screened in the uppermost water-bearing zone in the Neroly Formation lower blue sandstone unit (Tnbs₁). The Neroly Formation contains the main aquifer beneath Site 300. Pit 2, which was closed before RCRA was enacted, is hydrologically upgradient from Pit 1. In 1992, a 2.4 m (8 ft) thick RCRA cap, containing an impermeable layer of clay, 0.6 m (2 ft) thick, was constructed over Pit 1. The cap prevents rainwater from percolating through the waste buried in the pit. A water diversion channel was constructed around the pit cap to remove storm water runoff. The diversion channel empties into the adjacent arroyo, a head water of Elk Ravine.

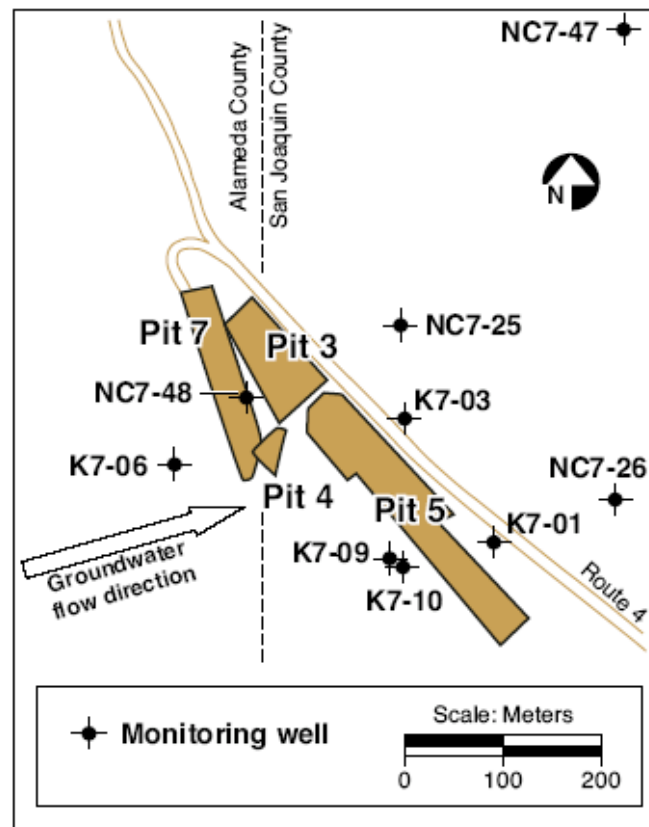


Figure 4. Locations of Pit 7 compliance monitoring wells.

Pit 7 is located in a valley 1.5 km (0.9 miles) west of Pit 1, at an elevation of about 400 m (1,312 ft) above mean sea level (MSL). The Pit 7 Complex comprises Pits 3, 4, 5, and 7. Pits 3, 4, and 5 ceased receiving waste before 1980, when RCRA was enacted. Ground water in bedrock flows 5 to 15 meters per year (m/yr) (16-49 ft/yr) in a

generally east-northeast direction beneath the Pit 7 Complex, following the dip of the underlying Neroly Formation basal sandstone (Tnbs₀) (Webster-Scholten, 1994). With sufficient seasonal rainfall, unconfined ground water can rise from bedrock into the more permeable valley-fill alluvium on the northeast side of the Pit 7 Complex and flow southeastward at velocities of up to 40 m/yr (131 ft/yr). Surface water from the area may also flow southeastward towards Doall Ravine and quickly infiltrate into the sandy soils.

Figure 4 shows the locations of the nine compliance monitoring wells that are used to sample the ground water in the vicinity of Pit 7. Well K7-06 is hydrologically upgradient from Pit 7. Wells K7-01, K7-03, NC7-25, NC7-26, NC7-47, and NC7-48 are downgradient. Wells K7-09 and K7-10 are cross-gradient. Eight of the nine wells are screened in the Qal/weathered bedrock or Tnbs₀ water-bearing zones. Well K7-09 samples a deeper water-bearing zone within the Neroly Formation basal silty claystone unit (Tnsc₀).

In 1992, a RCRA cap, similar to the Pit 1 cap, was constructed over Pit 7. It, too, contains a layer of impermeable clay, 0.6 m (2 ft) thick, to prevent rain water infiltration. The RCRA cap also covers Pit 4 and about 30% of Pit 3. RCRA construction included surface water diversion channels around the cap and a shallow interflow interceptor trench on the west side (upgradient) of Pit 7. During the latter half of 2007 and early 2008, a drainage diversion system was installed in the Pit 7 Complex. The drainage diversion system intercepts and diverts surface and shallow subsurface water flow to prevent ground water rise into the unlined landfills.

Compliance Monitoring Program Overview

This report fulfills quarterly and annual requirements set forth in the following two documents: (1.) *Waste Discharge Requirements Order 93-100* (WDR 93-100), and *Revised Monitoring and Reporting Program No. 93-100*, administered by the California Central Valley Regional Water Quality Control Board (CVRWQCB) (CVRWQCB 1993 and 1998); and (2.) *LLNL Site 300 RCRA Closure and Post-Closure Plans, Landfill Pits 1 and 7* (Rogers/Pacific Corporation 1990). The post-closure plan (PCP) was approved by the California Department of Health Services.

The Compliance Monitoring Program for Pits 1 and 7 combines PCP and WDR 93-100 requirements. The combined requirements include quarterly ground water sampling and analyses to detect potential releases of constituents of concern from landfills, quarterly and annual visual inspections, annual surveys of pit cap marker elevations, repairs as necessary to maintain the integrity of the landfills and their water-diversion systems, and quarterly and annual written reports of work performed.

Quality Assurance

To ensure quality data, we work within the established Quality Assurance (QA) program of the LLNL Environmental Protection Department (EPD). We use protocols and procedures that cover all aspects of ground water sampling, sample tracking, and data management. These written protocols and procedures are contained in the *LLNL Livermore Site and Site 300 Environmental Restoration Project Standard Operating Procedures (SOPs)* (Goodrich and Wimborough, 2006), the *Environmental Monitoring Plan* (Woods, 2005), and the *EPD Quality Assurance Management Plan* (Clark, 2006). SOPs are used to minimize inadvertent sample contamination and maintain sample integrity from the well to the analytical laboratory. Data management SOPs ensure that all laboratory measurements are received, accurately recorded, and properly stored both in a computer database and in hardcopy format.

Each quarter, a duplicate (collocated) set of ground water samples is collected from each monitoring network and a set of blank samples is prepared from a randomly chosen well. Results of quality assurance duplicate analyses are in **Appendix C**. In addition, equipment blanks are prepared and analyzed to ensure that sampling equipment is properly cleaned before use. Each day when samples are collected for volatile organic compound (VOC) analysis, a trip blank (prepared at the analytical laboratory) is carried into the field. It is returned unopened to the analytical laboratory for VOC analysis. If VOCs are detected in a trip blank and in any of the routine samples obtained that day, sample results may be discounted and new sampling may be performed.

As required by DOE Order 241.1, our measurements are reported in *Système Internationale* (SI) units. The SI unit for radioactivity is the becquerel (Bq), equal to 1 nuclear disintegration per second. The more commonly used unit, picocurie (pCi), is equal to 1 nuclear disintegration per 27 seconds. As a convenience, maximum contaminant levels (MCLs) for radioactivity in drinking water are given in both becquerels per liter (Bq/L) and picocuries per liter (pCi/L) in **Table 1** below. Note that MCLs are provided for reference only, because this report does not involve wells used for potable domestic, livestock, or industrial water supply.

Table 1. MCLs for radioactivity in drinking water.

Radiological parameter	MCL (Bq/L)	MCL (pCi/L)
Gross alpha	0.555	15
Gross beta	1.85	50
Tritium	740	20,000
Radium (total)	0.185	5
Uranium (total)	0.74	20

Description of Report Contents

The **Summary of Analytical Results** section reviews any constituents of concern detected in ground water during 2008. Constituents of concern measurements that exceeded SLs or MCLs in drinking water are discussed, as are all detections of organic constituents of concern. Constituents of concern source information is given where it is known from LLNL CERCLA studies.

Appendix A contains the ground water analytical measurements for 2008. Pit 1 data are in **Tables A-1** and **A-2**. Pit 7 data are in **Tables A-3** and **A-4**. **Table A-5** shows the sample dates for both Pits 1 and 7. Note that the **Appendix A** tables may include some small negative values for radioactivity measurements. These are below the method reporting limits (RLs) and are calculated values. They simply indicate that the radioactivity for that ground water sample is close to zero.

Appendix B explains the methods we use to determine the statistical limit of concentration (SL) for a constituent of concern. Requirements for statistical treatment of ground water data are established in the *California Code of Regulations (CCR)*, Title 23, Division 3, Chapter 15, Section 2550.7. The statistical methods we use, prediction intervals (PI) and control charts (CC), are consistent with CCR requirements. If a routine quarterly constituents of concern measurement exceeds its SL and is confirmed by retesting, it is reported to the CVRWQCB as statistically significant evidence of a release. **Table B-1** lists the constituents of concern for metals and radioisotopes that have exceeded SLs since Pits 1 and 7 were officially closed in February 1993. Additional studies covering the Pits 1 and 7 areas have been completed for barium, tritium, uranium, and vanadium (Taffet *et al.* 1996; 2005).

Appendix C contains the results for quality assurance (QA) sample analyses performed during all four quarters of 2008 at Pit 1 (**Table C-1**) and Pit 7 (**Table C-2**).

Appendix D consists of **Table D-1** summarizing constituents of concern and the sampling frequencies in the monitoring networks for both pits. The regulatory drivers for each constituent of concern are also included in **Table D-1**.

Appendix E contains graphs of ground water measurements, and **Table E-1** contains the analytical results from 2008 that were omitted from the **Appendix E** plots due to the use of specially reduced y-axis plot limits.

Summary of Analytical Results

As mentioned in the last quarterly report, there continues to be on-going issues for the Pit 1 and 7 compliance program networks that have and will potentially continue to impact monitoring in the future. The major issue is the remediation activities being conducted by LLNL's Environmental Restoration Department. These activities are

scheduled to begin in the first or second quarters of 2009 and will include pumping, treatment, and re-injection of ground water at the Pit 7 Complex. In 2008, the LLNL Environmental Restoration Department (ERD) conducted verification testing of the treatment facility equipment. As such, the system is not currently operational and testing continues. This activity has the potential, especially during full operation, to significantly alter hydrologic conditions and equilibrium background chemistry in the ground water in the vicinity of the monitoring wells. These potential changes in hydrologic conditions and background ground water chemistry may result in exceedance of the SLs that are not indicative of releases from the pit. Because of this potential impact on the existing compliance-monitoring network, LLNL is working with the CVRWQCB staff and other RPMs to move monitoring at Pit 7 under the CERCLA monitoring program while remediation is taking place. An alternative monitoring program for Pit 7 was approved in the *Interim Remedial Design for the Pit 7 Complex*.

As discussed last quarter, well W-PIT1-2326 was drilled and completed in 2007 as a replacement well for K1-03 at Pit 1. The well continues to be sampled and our goal is to develop SLs for the ground water monitoring from this well as was summarized in a letter to the CVRWQCB (Goodwin, 2007a) and Regional Board responses (CVRWQCB, 2007a; CVRWQCB, 2007b). Well W-PIT1-2326 was sampled during the second through fourth quarters of 2008 and analytical results for the well are summarized in this annual report.

No evidence of a new release of constituents of concern from either Pit 1 or Pit 7 is indicated by fourth quarter measurements. At Pit 1 this quarter, tritium exceeded SLs in ground water samples and is consistent with past quarters (**Table A-1**). Tritium activities exceeded SLs in ground water samples from K1-04 (11.5 Bq/L [310 pCi/L], SL=3.7 Bq/L [100 pCi/L]); K1-05 (5.85 Bq/L [244 pCi/L], SL=3.7 Bq/L [100 pCi/L]), K1-08 (5.62 Bq/L [152 pCi/L], SL=3.7 Bq/L [100 pCi/L]), and K1-09 (5.70 Bq/L [154 pCi/L], SL=3.7 Bq/L [100 pCi/L]). All of these activities are slightly lower than last reported in the third quarter 2008 report. The observed tritium activities likely result from a tritium plume that extends beneath Pit 1 from an upgradient source at the Building 850 firing table (Taffet *et al.*, 1996; Ziagos and Reber-Cox, 1998, and Taffet *et al.*, 2008).

During the fourth quarter, data indicated that the SL for total uranium activities in ground water samples was again exceeded in a sample from well K1-09 (0.118 Bq/L [3.19 pCi/L], SL=0.109 Bq/L [2.95 pCi/L]), as was the case during all quarters of 2008 (**Table A-1**). Evidence of SL exceedance for total uranium in ground water samples from well K1-09 was previously reported to the CVRWQCB (Goodwin, 2007b). In addition, the SL in well K1-08 was exceeded this quarter (0.157 Bq/L [4.24 pCi/L], SL=(0.120 Bq/L [3.24 pCi/L]). Activity levels in this well increased gradually during all three quarters of 2008 but was only above the SL in the fourth quarter. A retest was taken in January 2009 as part of the first quarter sampling requirements and preliminary results indicate a

value of (0.118 Bq/L [3.19 pCi/L]), which is below SL for this well. A second retest has been ordered and will be reported if it confirms the original value indicating the SL was exceeded. Total uranium also increased slightly in the background well, K1-01C (0.158 Bq/L, SL=none), which is located hydrologically up-gradient from Pit 1. Monitoring wells K1-08 and K1-09 are cross-gradient from Pit 1, not downgradient. The increasing uranium concentration in both upgradient wells may be influenced by naturally-occurring uranium in the ground water.

Historical data suggests that there appears to be a slight overall upward trend in total uranium activities in ground water samples from these wells over the last 10 years and that increase is similar in pattern to tritium activities in samples from the same wells. The uranium-235/uranium-238 atomic ratios for samples collected from these wells are indicative of natural uranium (~0.007). In addition, the total uranium activities are within the range of background levels for naturally-occurring uranium in ground water as noted above in well K1-01C. As shown in the 2005 Annual Report (Campbell and MacQueen, 2006) there is a similar slight increase in the total uranium in ground water samples collected from monitoring wells in the vicinity of Pit 1. The total uranium results are most likely explained by an increase in local natural background and are not the result of a release from Pit 1. Given the available information, it does not appear that these exceedances of the statistical limit is indicative of a release of uranium from Pit 1. A historical plot for both tritium and total uranium for well K1-09 is shown in the 2007 Pits 1 and 7 annual monitoring report (Campbell and MacQueen, 2008) and data this quarter indicate that activity levels remain relatively the same.

Also this quarter at Pit 1, barium continued to exceed the SL in K1-09 (48 $\mu\text{g/L}$, SL=46 $\mu\text{g/L}$), which was the same value as reported in the third quarter report. Well K1-09 is cross gradient from Pit 1, and the presence of barium does not represent a new release from the pit. Barium has been reported in the past, and a letter to the CVRWQCB was written on October 25, 2000 notifying the agency of the results. Barium was also reported in the 2006 Pit 1 annual report (Campbell, 2006) indicating that barium background concentrations were increasing slightly in ground water around these wells. The increase is also occurring in monitoring wells up-gradient of Pit 1 and appears to be unrelated to any releases from the pit.

At Pit 7, a ground water sample collected from well K7-09 exceeded the SL for barium (28 $\mu\text{g/L}$, SL=25 $\mu\text{g/L}$) (**Table A-3**). Barium continues to be above SL in this well as reported in the 2007 annual report (Campbell & MacQueen, 2007) but is lower than the value detected in background well K7-06 (84 $\mu\text{g/L}$, SL=none $\mu\text{g/L}$) that is further hydrologically up-gradient. During the second quarter nickel was above SL at well K7-03 (31 $\mu\text{g/L}$, SL=26 $\mu\text{g/L}$) but for the past two quarters the concentration dropped below the SL (22 $\mu\text{g/L}$, and 15 $\mu\text{g/L}$, respectively [SL=26 $\mu\text{g/L}$]). These two results do not

confirm the second quarter indication that the statistical limit was exceeded. Nickel concentrations have historically fluctuated slightly above SLs in samples from this well.

Total uranium activity exceeded its SL in the ground water sample collected from monitoring well K7-01 (0.652 Bq/L [17.2 pCi/L], SL=0.636 Bq/L [17.1 pCi/L]). The last detected measurement of total uranium activity above the SL for monitoring well K7-01 (0.644 Bq/L [17.40 pCi/L]) occurred in samples collected during the third quarter of 2008. LLNL has previously reported elevated total uranium activity in the ground water at Pit 7 to be statistical evidence for a release of depleted uranium from Pit 7 (**Table B-1**). For additional information on the spatial and temporal extent of total uranium and depleted uranium in ground water monitoring wells within the Pit 7 Complex, see Taffet et al. (2005). Depleted uranium has been released in the past from Pits 3, 5, and 7.

Although no SLs for tritium at Pit 7 were exceeded during the fourth quarter 2008, tritium activities continue to exceed the drinking water MCL of 740 Bq/L in the ground water at monitoring wells K7-01 (1650.0 Bq/L [45,594 pCi/L]), and K7-03 (3560.0 Bq/L [96,216 pCi/L]). NC7-25 was above the SL last quarter (9950 Bq/L [268,918 pCi/L]), but was dry this quarter and not sampled. CERCLA investigations have linked the tritium activity in the ground water at monitoring wells K7-01, K7-03, and NC7-25 to releases of tritium from Pits 3 and 5 or underlying sediments during the winter of 1992–93, and continuing during the successive winters of 1994–95, 1995–96, 1996–97, and 1997–98. Generally the highest water levels in the Pit 7 Complex monitoring wells were observed in 1997–98, when these pits were partially inundated from beneath by rising ground water (Taffet *et al.*, 1996 and 2005; Ziagos and Reber-Cox, 1998). CERCLA modeling studies indicate that, given tritium's short half-life of 12.3 years, the relatively slow rate of ground water flow (5-40 m/yr), and the long flow path to the Site 300 boundary, tritium activity in ground water will decrease to below background activities of <3.7 Bq/L (<100 pCi/L) before it can travel off site (Taffet *et al.*, 1996 and 2005).

An Amendment to the CERCLA Interim Site-Wide Record of Decision for the Pit 7 Complex was signed in 2007 that described the selected remedy for the Pit 7 Complex including monitoring, risk and hazard management, monitored natural attenuation, ground water extraction and treatment, and source control. In 2008, a hydraulic drainage diversion system was constructed to control contaminant sources by preventing ground water from rising into the pit waste and underlying contaminated bedrock. In addition a ground water extraction and treatment system was constructed to treat uranium, nitrate, perchlorate, and VOCs in ground water. Tritium in ground water is naturally attenuating to meet cleanup standards.

During the fourth quarter, zinc was detected in ground water samples from wells K7-09 (41 $\mu\text{g/L}$, SL=20 $\mu\text{g/L}$) and K7-10 (46 $\mu\text{g/L}$, SL=20 $\mu\text{g/L}$). A similar value from this quarter was seen in an upgradient non-compliance background well, K7-06 (40 $\mu\text{g/L}$, SL=none), which may indicate an increase in background concentrations.

Similar values were detected in wells K7-09 and K7-10 during the second quarter of 2007, and at that time the wells were retested and came back non-detect and below the SL. The retest samples did not confirm the statistical evidence of a release. Both wells K7-09 and K7-10 are hydrologically up-gradient from Pit 7 and may be influenced by an increased Zn background as indicated by the background well K7-06. Zinc continues to appear at some Pit 7 wells as in the past and a 7-Day letter (Jackson, 2008b) was sent to the CVRWQCB on April 2, 2008 notifying the agency of the results for well NC7-25 that exceed SL (**Table A-3**). We will continue to monitor Zn in the Pit 7 wells.

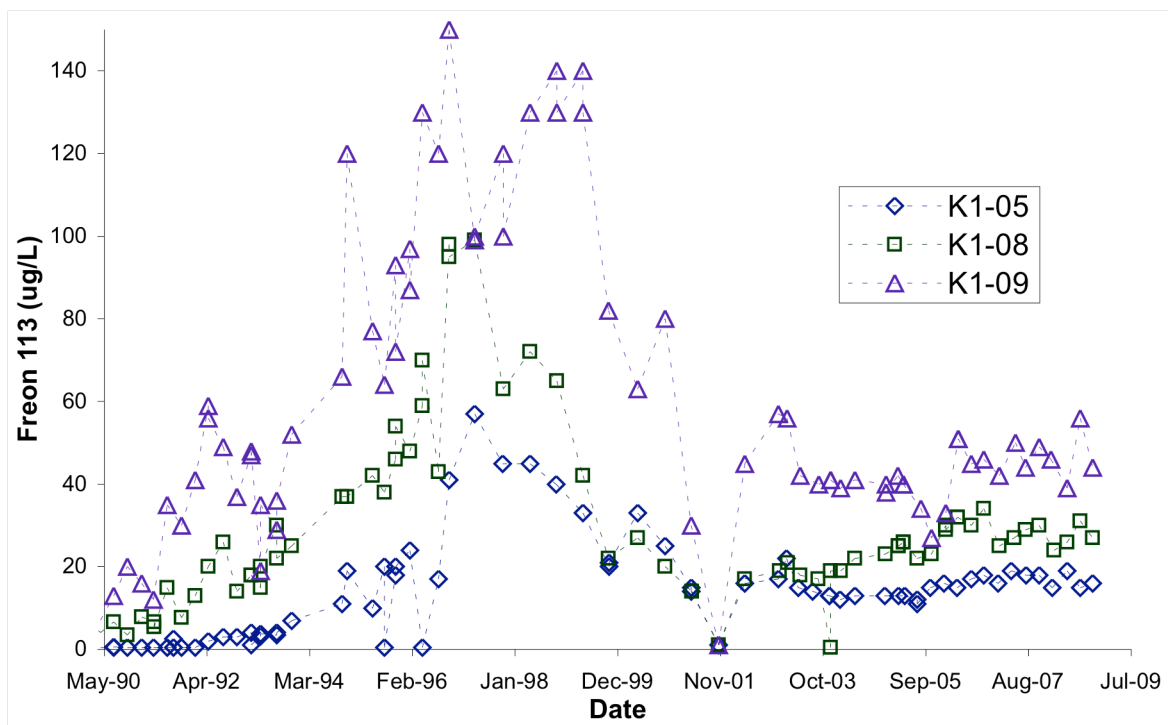


Figure 5. Freon-113 concentrations in water samples collected from ground water monitoring wells around Pit 1.

In addition to reporting on constituents of concern with statistical limits, this report evaluates additional constituents that historically have elevated concentrations and are monitored under the post closure plan or under LLNL's surveillance monitoring program under DOE Order 450.1.

For this annual report, freon-113 results for ground water samples collected from monitoring wells K1-05, K1-08, and K1-09 are plotted (**Figure 5**). The values for the fourth quarter 2008 are shown on **Table A-2**. The freon-113 arises from a source at Building 865, about 300 m (984 ft) west of Pit 1 (Ferry and Holtzaple, 2006). While freon-113 is not a constituent of concern for Pit 1, there have been measurable historic concentrations that have been decreasing. In the past few years, the concentrations appear to be relatively stable.

In addition to reporting on freon, perchlorate was added to the monitoring program in 1998 as part of the EPD surveillance monitoring program required at that time under DOE Order 5400.1 and is reported annually in the Livermore Site Annual Environmental Report (Mathews et. al., 2008). Perchlorate concentrations for this quarter are shown in **Table A-2** and **Table A-4**. For Pit 7, historical trends of perchlorate concentrations in samples collected from ground water monitoring wells K7-01, K7-03, and NC7-25 are shown in **Figure 6**. While perchlorate has been observed above the detection limit ($4 \mu\text{g/L}$) in ground water samples from these wells, concentrations do not appear to be significantly increasing. LLNL will continue to monitor perchlorate to examine any trends in the data.

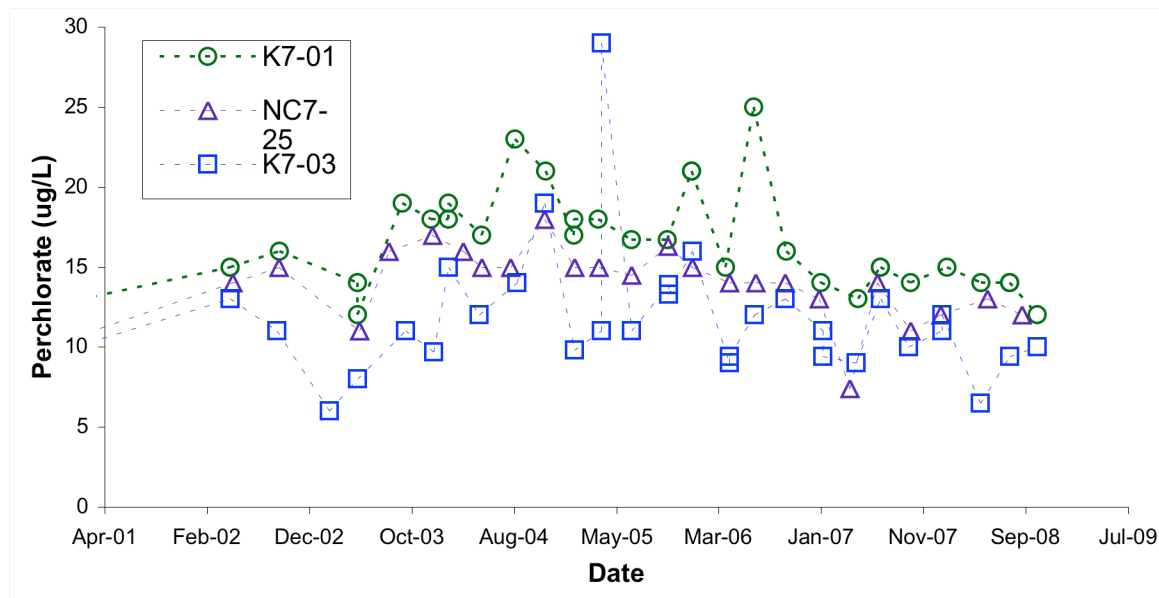


Figure 6. Perchlorate concentrations in water samples collected from ground water monitoring wells around Pit 7.

Nitrate is another constituent that is monitored but is not identified as a constituent of concern for Pit 7. Concentrations in samples collected from ground water monitoring wells K7-01, K7-03, NC7-25, and NC7-47 this quarter (**Table A-4**) and are presented in **Figure 7** as historical concentrations. Other than a few concentrations from samples collected in the early 1990s from well K7-01, nitrate concentrations appear to be stable with no obvious trend.

The concentrations of all VOCs detected in ground water samples from monitoring wells are summed and presented as Total VOCs (TVOCs). As in the past, VOCs were detected in ground water samples from two monitoring wells (**Table A-4**). The TVOC concentrations detected in the ground water at Pit 7 wells K7-01 and K7-03 were $1.5 \mu\text{g/L}$ and $1.4 \mu\text{g/L}$, respectively. The only VOCs in the samples from these wells were Trichloroethylene. The VOCs in these samples are associated with historical releases from Pit 5, not Pit 7 (Webster-Scholten, 1994; Taffet et al., 1996).

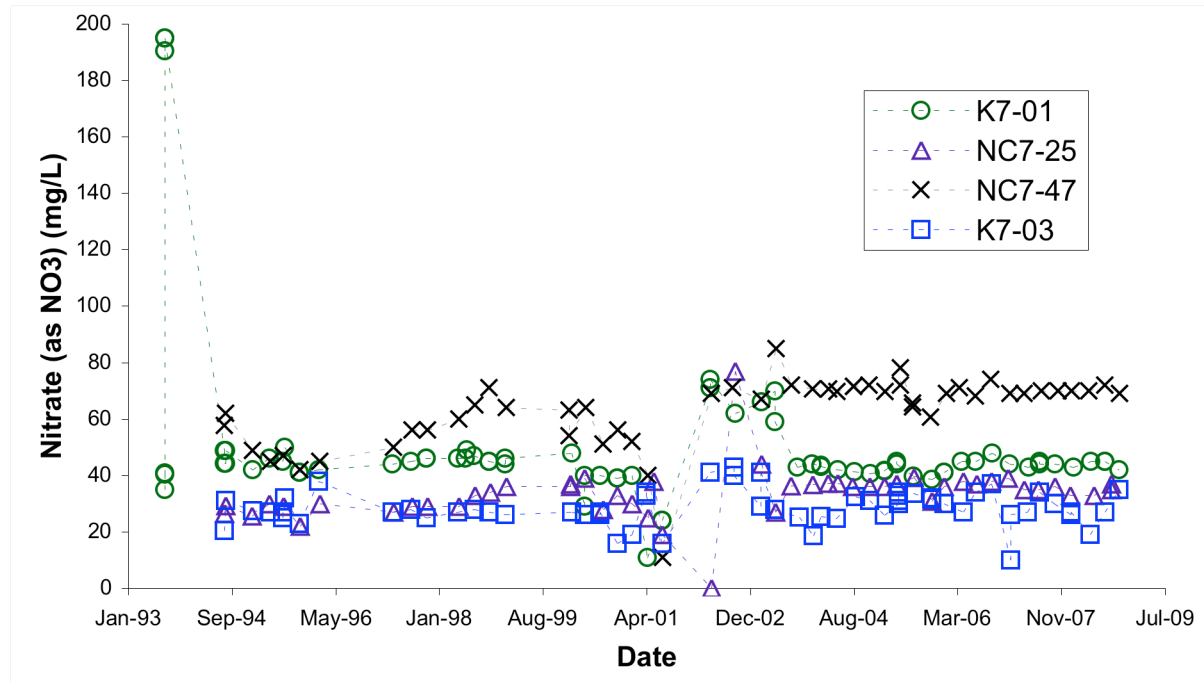


Figure 7. Nitrate concentrations in water samples collected from ground water monitoring wells around Pit 7.

Inspection and Maintenance Summary

Fourth quarter inspections of the caps were performed at Pit 1 and 7 by LLNL staff. These quarterly visual cap inspections include a checklist of issues related to cap integrity, vegetation, and drainage. No deficiencies were noted in the condition of the cap at either pit, although animal burrows were observed on the outer edge of the cap at Pit 1. The annual permanent marker elevation surveys and inspections by a licensed P.E. were performed and reported for the Pit 1 and 7 caps during the second and third quarters of 2008. The survey and inspection did not identify major deficiencies; however, a continuing need to repair larger animal burrows at Pit 7 and removal of weeds from the concrete lining joints in the drainage ditch and in the drainage basin at Pit 1 were noted. All of these repairs were performed by LLNL.

References

- Blake, Richard. G. (2008), *LLNL Experimental Test Site 300 Compliance Monitoring Program for RCRA-Closed Landfill Pits 1 and 7, Second Quarter Report 2008*, Lawrence Livermore National Laboratory, Livermore, CA (UCRL-AR-10191-08-2).
- California Code of Regulations*, Title 23, Division 3, Chapter 15, Section 2550.7.
- Campbell, C. G. (2006), *LLNL Experimental Test Site 300 Compliance Monitoring Program for RCRA-Closed Landfill Pits 1 and 7, Second Quarter Report 2006*, Lawrence Livermore National Laboratory, Livermore, CA (UCRL-AR-10191-06-2).
- Campbell, C. G., and D. H. MacQueen (2006), *LLNL Experimental Test Site 300 Compliance Monitoring Program for RCRA-Closed Landfill Pits 1 and 7, Annual Report for 2005*, Lawrence Livermore National Laboratory, Livermore, CA (UCRL-AR-10191-05-4).
- Campbell, C. G., and D. H. MacQueen (2007), *LLNL Experimental Test Site 300 Compliance Monitoring Program for RCRA-Closed Landfill Pits 1 and 7, Annual Report for 2007*, Lawrence Livermore National Laboratory, Livermore, CA (UCRL-AR-10191-07-4).
- Central Valley Regional Water Quality Control Board (1993), *Order No. 93-100, Waste Discharge Requirements for University of California Lawrence Livermore National Laboratory Site 300 and U.S. Department of Energy, Landfill Pits 1 and 7, San Joaquin County* (June 25, 1993).
- Central Valley Regional Water Quality Control Board (1998), *Revised Monitoring and Reporting Programs No. 93-100 and 96-248, Lawrence Livermore National Laboratory Site 300, San Joaquin County* (September 25, 1998).
- Central Valley Regional Water Quality Control Board (2007a), *Replacement of Monitoring Well K1-03, Lawrence Livermore National Laboratory Site 300, San Joaquin County* (September 18, 2007).
- Central Valley Regional Water Quality Control Board (2007b), *Abandoning Compliance Monitoring Well K1-03, Lawrence Livermore National Laboratory Site 300, San Joaquin County* (March 1, 2007).
- Clark, C. (2001), *Environmental Protection Department Quality Assurance Management Plan-2006*, Lawrence Livermore National Laboratory, Livermore, CA (UCRL-AR-146357 Rev. 6), September 2006.
- Ferry, L. S. and C. S. Holtzapple (2006) *Characterization Summary Report for the Building 865 Study Area at Lawrence Livermore National Laboratory Site 300*. Lawrence Livermore National Laboratory, Livermore, CA, September 30, 2006.
- Goodrich, R., and J.A. Wimburough (Eds.) (2006), *LLNL Livermore Site and Site 300 Environmental Restoration Project Standard Operating Procedures (SOPs)*, Lawrence Livermore National Laboratory, Livermore, CA (UCRL-MA-109115 Rev. 12).
- Goodwin, S. (2007a) Letter: *Abandoning Compliance Monitoring Well K1-03 Monitored Under WDR Order 93-100 for RCRA-Closed Landfill, Pit 1*. Lawrence Livermore National Laboratory submitted to the Central Valley Regional Water Quality Control Board. (February 7, 2007).
- Goodwin, S. (2007b) Letter: *Statistically Significant Evidence for a Release of Total Uranium From Lawrence Livermore National Laboratory Experimental Test Site (Site 300) Pit 1*. Lawrence Livermore National Laboratory submitted to the Central Valley Regional Water Quality Control Board. (April 26, 2007).

- Jackson, C. (2008b) Letter: *Statistically Significant Evidence for a Release of Zinc From Lawrence Livermore National Laboratory Experimental Test Site (Site 300) Pit 7*. Lawrence Livermore National Laboratory submitted to the Central Valley Regional Water Quality Control Board. (April 2, 2008).
- Rogers/Pacific Corporation (1990), *Lawrence Livermore National Laboratory Site 300 Resource Conservation and Recovery Act Closure and Post-Closure Plans, Landfill Pits 1 and 7, Volumes I and II*, Lawrence Livermore National Laboratory, Livermore, CA (Cal EPA No. CA2890090002).
- Taffet, M. J., L. K. Green-Horner, L. C. Hall, T. M. Carlsen, and J. A. Oberdorfer (1996), *Addendum to the Site-Wide Remedial Investigation Report, Lawrence Livermore National Laboratory Site 300: Building 850/Pit 7 Complex Operable Unit*, Lawrence Livermore National Laboratory, Livermore, CA (UCRL-AR-108131 Add. 1).
- Taffet, M., V. Madrid, T. Carlsen, Z. Demir, J. Valett, M. Dresen, W. Daily, S. Coleman, V. Dibley, and L. Ferry (2005), *Final Remedial Investigation/Feasibility Study for the Pit 7 Complex at Lawrence Livermore National Laboratory Site 300*, Livermore National Laboratory, Livermore, CA (UCRL-AR-202492).
- Taffet, M., V. Dibley, L. Ferry, B. Daily, and Z. Demir (2008), *Interim Remedial Design Document for the Pit 7 Complex at Lawrence Livermore National Laboratory Site 300*, Livermore National Laboratory, Livermore, CA (UCRL-AR-234697).
- Taffet, M., *et. al.* (2008), *2007 Compliance Monitoring Report for Site 300, Lawrence Livermore National Laboratory*, Livermore National Laboratory, Livermore, CA (UCRL-AR-206319-07).
- U. S. Department of Energy (1998), *Scientific and Technical Information Management (Order 241.1)*.
- Webster-Scholten, C. P. (Ed.) (1994), *Final Site-Wide Remedial Investigation Report, Lawrence Livermore National Laboratory Site 300*, Lawrence Livermore National Laboratory, Livermore, CA (UCRL-AR-108131).
- Woods, N. J. (Ed.) (2005), *Environmental Monitoring Plan*, Lawrence Livermore National Laboratory, Livermore, CA (UCRL-ID-106132 Rev. 4).
- Ziagos, J. P., and E. Reber-Cox, to M. Piros, K. Setian, and S. Timm (1998), Letter: *Submittal of the Ground Water Tritium Plume Characterization Summary Report for the Building 850/Pits 3 and 5 Operable Unit, Lawrence Livermore National Laboratory Site 300 (10-98ERD/Tritium Plume Char. Summ:rtd, October 30, 1998)*.

Acknowledgments

The compliance monitoring program for Pits 1 and 7 could not be conducted without the dedicated efforts of many people. Rosanne Depue provided essential administrative and editorial assistance. Don MacQueen provided detailed analytical information. Suzie Chamberlain performed quality reviews and data table preparation. Eric Walter coordinated the sampling activities. Mario Silva sampled the monitoring wells and packaged the samples for shipment. Della Burruss and Becky Goodrich provided excellent data management support and ensured data quality. Off-site analytical support was provided by BC Laboratories, Inc. and Eberline Services, Inc. We thank John Scott, Karen Folks, and Dawn Chase at Site 300 for their cooperation in this effort. A draft of this report was reviewed by LLNL peers including Suzie Chamberlain, Mike Taffet, and Karen Folks, whose suggestions for improvements were incorporated.

Abbreviations and Acronyms

1,1-DCE	1,1-dichloroethene
Bq	becquerel (SI unit of radioactivity)
Cal EPA	California Environmental Protection Agency
CC	control chart (statistical method)
CCR	California Code of Regulations
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CVRWQCB	Central Valley Regional Water Quality Control Board
DOE	U.S. Department of Energy
DTSC	Department of Toxic Substances Control (California)
EPA	U.S. Environmental Protection Agency
EPD	Environmental Protection Department (LLNL)
ft	foot
GWE	ground water elevation (in feet above MSL)
km	kilometer
L	liter
LLNL	Lawrence Livermore National Laboratory
m	meter
MCL	maximum contaminant level (for drinking water)
mg	milligram
MSL	mean sea level (datum for elevation measurements)
m/yr	ground water seepage rate in meters per year
μg	microgram
nd	no detections above reporting limits
nd (exc)	no detections, except as listed
pCi	picocurie (unit of radioactivity equal to 0.037 Bq)
PCP	post-closure plan
PE	Professional Engineer
PI	prediction interval (statistical method)
QA	quality assurance
RCRA	Resource Conservation and Recovery Act
RL	reporting limit (contractual concentration near zero)
RPM	Remedial Program Manager
SI	<i>Système Internationale</i> (units of measurement)
Site 300	Experimental Test Site, LLNL
SL	statistically determined concentration limit
SOP	standard operating procedure
TCE	trichloroethene
Tnbs ₀	Neroly Formation basal sandstone
Tnbs ₁	Neroly Formation lower blue sandstone
Tnsc ₀	Neroly Formation basal silty claystone
TVOC	total volatile organic compounds
VOC	volatile organic compound
WDR	Waste Discharge Requirements (permit)

Appendix A

Tables of Ground Water Measurements

Table A-1. Pit 1 constituents of concern, monitoring wells, SLs, and quarterly analytical results for 2008.

Quarter			1	2	3	4
Constituents of Concern (units)	Well	SL	Result	Result	Result	Result
Arsenic ($\mu\text{g/L}$)	K1-01C	-(a)	12	11	10	14
	K1-07	-(a)	14	12	11	12
	K1-02B	20	12	17	11	13
	K1-04	19	11	16	10	12
	K1-05	24	15	19	13	14
	K1-08	21	14	13	14	16
	K1-09	19	12	13	13	15
	W-PIT1-2326	TBD	-	12	12	13
Barium ($\mu\text{g/L}$)	K1-01C	TBD	25	<25	<25	<25
	K1-07	TBD	27	27	28	28
	K1-02B	25	25	<25	<25	<25
	K1-04	32	28	28	27	27
	K1-05	41	40	38	38	38
	K1-08	51	42	40	43	46
	K1-09	46	43	47, 48, 49	48	48
	W-PIT1-2326	TBD	-	38	32	34
Beryllium ($\mu\text{g/L}$)	K1-01C	-	<0.2	<0.5	<2	<0.5
	K1-07	-	<0.5	<2	<2	<0.5
	K1-02B	0.5	<0.5	<0.5	<2	<0.5
	K1-04	0.5	<0.5	<0.5	<2	<0.5
	K1-05	0.5	<0.5	<0.5	<2	<0.5
	K1-08	0.5	<0.5	<2	<2	<0.5
	K1-09	0.5	<0.5	<2	<2	<0.5
	W-PIT1-2326	TBD	-	<0.5	<0.5	<0.5
Cadmium ($\mu\text{g/L}$)	K1-01C	-	<0.5	<0.5	<0.5	<0.5
	K1-07	-	<0.5	<0.5	<0.5	<0.5
	K1-02B	0.5	<0.5	<0.5	<0.5	<0.5
	K1-04	0.5	<0.5	<0.5	<0.5	<0.5
	K1-05	0.5	<0.5	<0.5	<0.5	<0.5
	K1-08	0.5	<0.5	<0.5	<0.5	<0.5
	K1-09	0.5	<0.5	<0.5	<0.5	<0.5
	W-PIT1-2326	-	-	<0.5	<0.5	<0.5
Cobalt ($\mu\text{g/L}$)	K1-01C	-	<25	<25	<25	<25
	K1-07	-	<25	<25	<25	<25
	K1-02B	25	<25	<25	<25	<25
	K1-04	25	<25	<25	<25	<25
	K1-05	25	<25	<25	<25	<25
	K1-08	25	<25	<25	<25	<25
	K1-09	25	<25	<25	<25	<25
	W-PIT1-2326	TBD	-	<25	<25	<25

Table A-1. Pit 1 constituents of concern, monitoring wells, SLs, and quarterly analytical results for 2008.

Quarter			1	2	3	4
Constituents of Concern (units)	Well	SL	Result	Result	Result	Result
Copper ($\mu\text{g/L}$)	K1-01C	-	<10	<10	<10	<10
	K1-07	-	<10	<10	<10	<10
	K1-02B	34	<10	11	19	12
	K1-04	34	<10	<10	<10	<10
	K1-05	34	<10	<10	<10	<10
	K1-08	34	<10	<10	<10	<10
	K1-09	34	<10	<10	<10	<10
	W-PIT1-2326	TBD	-	<10	<10	<10
Lead ($\mu\text{g/L}$)	K1-01C	-	<2	<2	<2	<2
	K1-07	-	<2	<2	<2	<2
	K1-02B	2	<2	<2	<2	<2
	K1-04	2	<2	<2	<2	<2
	K1-05	2	<2	<2	<2	<2
	K1-08	2	<2	<2	<2	<2
	K1-09	2	<2	<2	<2	<2
	W-PIT1-2326	TBD	-	<2	<2	<2
Nickel ($\mu\text{g/L}$)	K1-01C	-	<5	<5	<5	<5
	K1-07	-	<5	<5	<5	<5
	K1-02B	12	<5	<5	<5	<5
	K1-04	12	<5	<5	<5	<5
	K1-05	12	<5	<5	<5	<5
	K1-08	12	<5	<5	<5	<5
	K1-09	12	<5	<5	<5	<5
	W-PIT1-2326	TBD	-	<5	<5	<5
Vanadium ($\mu\text{g/L}$)	K1-01C	-	61	64	69	63
	K1-07	-	67	64	63	67
	K1-02B	78	53	50	49	49
	K1-04	48	36	36	39	30
	K1-05	97	63	68	70	65
	K1-08	100	60	61	63	66
	K1-09	92	55	61	62	59
	W-PIT1-2326	TBD	-	56	46	48
Zinc ($\mu\text{g/L}$)	K1-01C	-	<20	<20	<20	<20
	K1-07	-	<20	<20	<20	<20
	K1-02B	94	<20	<20	29	<20
	K1-04	94	<20	<20	<20	44
	K1-05	94	<20	<20	<20	<20
	K1-08	94	<20	<20	<20	<20
	K1-09	94	<20	<20	<20	<20
	W-PIT1-2326	TBD	-	<20	<20	<20

Table A-1. Pit 1 constituents of concern, monitoring wells, SLs, and quarterly analytical results for 2008.

Quarter			1	2	3	4
Constituents of Concern (units)	Well	SL	Result	Result	Result	Result
Radium 226 (Bq/L)	K1-01C	-	0.004	0.008	0.006	0.005
	K1-07	-	0.002	0.003	0.007	0.004
	K1-02B	0.044	0.005	0.001	-0.002	0.004
	K1-04	0.044	0.002	0	0.002	0.002
	K1-05	0.044	0.005	0.005	0.009	0.002
	K1-08	0.044	0.003	-0.001	0.001	0.003
	K1-09	0.044	0.001	0.003	-0.001	0.007
	W-PIT1-2326	TBD	-	0.006	0	0.003
Tritium (Bq/L)	K1-01C	-	33.3	29.5	30	31.4
	K1-07	-	2.08	1.39	0.307	1.57
	K1-02B	- ^(b)	149	145	140	131
	K1-04	3.7	12.8	11.1	13.5	11.5
	K1-05	3.7	7.36	7.18	9.03	5.85
	K1-08	3.7	7.95	5.96	8.47	5.62
	K1-09	4.44	6.44	5.88	6.66	5.7
	W-PIT1-2326	TBD	-	115	115	112
Uranium (calculated total)	K1-01C	-	0.097	0.138	0.143	0.158
	K1-07	-	0.107	0.101	0.103	0.101
	K1-02B	0.192	0.117	0.126	0.126	0.127
	K1-04	0.124	0.073	0.07	0.074	0.065
	K1-05	0.109	0.11	0.109	0.099	0.101
	K1-08	0.12	0.087	0.109	0.118	0.157
	K1-09	0.109	0.119	0.11	0.114	0.118
	W-PIT1-2326	TBD	-	0.094	0.104	0.094
Thorium 228 (Bq/L)	K1-01C	-	0.002	0.004	0	0
	K1-07	-	0	0.001	0.001	0.001
	K1-02B	0.023	-0.001	-0.001	0.001	0
	K1-04	0.023	-0.001	-0.001	0.002	0
	K1-05	0.023	-0.001	0	0.001	0.001
	K1-08	0.023	-0.001	-0.001	0.002	0.002
	K1-09	0.023	0	0	0.002	0.002
	W-PIT1-2326	TBD	-	-0.001	0.002	0.001
Thorium 232 (Bq/L)	K1-01C	-	0	0	0	0
	K1-07	-	0	0	0	0
	K1-02B	0.009	0	0	0	0
	K1-04	0.009	-0.001	0	0	0
	K1-05	0.009	0	0	0	0
	K1-08	0.009	0	0	0	0
	K1-09	0.009	0	0	0	0
	W-PIT1-2326	TBD	-	0	0	0
Thorium 230 (Bq/L)	K1-01C	-	0.001	0.001	0	0.002
	K1-07	-	-0.001	-0.002	-0.001	0.003
	K1-02B	-	0.001	0	0.001	0.006
	K1-04	-	-0.002	0.001	0	0.002
	K1-05	-	0	0	0.001	0
	K1-08	-	-0.001	-0.001	0.001	0.003
	K1-09	-	0	-0.001	0.004	0.001
	W-PIT1-2326	TBD	-	0.003	0.001	0.003

Table A-1. Pit 1 constituents of concern, monitoring wells, SLs, and quarterly analytical results for 2008.

Quarter			1	2	3	4
Constituents of Concern (units)	Well	SL	Result	Result	Result	Result
HMX ($\mu\text{g/L}$)	K1-01C	-	<1	<1	<1	<1
	K1-07	-	<1	<1	<1	<1
	K1-02B	5	<1	<1	<1	<1
	K1-04	5	<1	<1	<1	<1
	K1-05	5	<1	<1	<1	<1
	K1-08	5	<1	<1	<1	<1
	K1-09	5	<1	<1	<1	<1
	W-PIT1-2326	TBD	-	<1	<1	<1
RDX ($\mu\text{g/L}$)	K1-01C	-	<1	<1	<1	<1
	K1-07	-	<1	<1	<1	<1
	K1-02B	5	<1	<1	<1	<1
	K1-04	5	<1	<1	<1	<1
	K1-05	5	<1	<1	<1	<1
	K1-08	5	<1	<1	<1	<1
	K1-09	5	<1	<1	<1	<1
	W-PIT1-2326	TBD	-	<1	<1	<1

(a) Wells K1-01C and K1-07 have no release detection SLs for constituents of concern because they are upgradient of Pit 1.

(b) K1-02B is an exempt well (deemed to be insensitive to the detection of a tritium release from Pit 1).

(c) Radioactivity measurements are corrected for the background radioactivity inside the measurement chamber.

A negative result for radioactivity indicates that the sample measured lower than the background by the amount shown. Radioactivity values shown as 0.000 measured less than 0.0005 Bq/L.

Note: Statistical limits (SLs) to be determined (TBD). SLs will be developed in the future after sufficient data has been collected.

Table A-2. Pit 1 additional PCP constituents and fourth quarter 2008 analytical results.

Constituent (units)	Monitoring Well									
	K1-01C ^(a) 27-Oct-08	K1-07 ^(a) 16-Oct-08	K1-02B 27-Oct-08	K1-04 20-Oct-08	K1-05 16-Oct-08	K1-08 14-Oct-08	K1-09 14-Oct-08	W-PIT1-2326 27-Oct-08		
Depth to water (ft)	106.45	140.78	135	156.03	170.83	154.93	161.33	178.57		
Ground water elevation (ft above MSL)	975.49	968.85	972.23	966.64	960.03	967.81	965.35	969.22		
Field pH (Units)	7.77	7.54	7.78	7.96	7.91	7.68	7.79	7.86		
Field Specific Conductance (umhos/cm)	680	604	711	601	629	645	653	691		
Field Temperature (°C)	21.2	21.5	20.6	21.3	22.1	21.1	21.6	21.1		
Gross alpha (Bq/L)	0.149	0.087	0.088	0.044	0.055	0.087	0.06	-0.046		
Gross beta (Bq/L)	0.143	0.12	0.112	0.098	0.132	0.121	0.137	0.136		
Nitrate (as NO ₃) (mg/L)	35	33	36	31	37	35	35	31		
Perchlorate (µg/L)	<4	<4	6.5	<4	<4	<4	<4	5.6		
Total VOCs (µg/L)	<1000	<1000	<1000	<1000	16	27	44	<1000		
Freon 113 (µg/L)	<0.5	<0.5	<0.5	<0.5	16	27	44	<0.5		

^(a) Upgradient well.

Table A-3. Pit 7 constituents of concern, monitoring wells, SLs, and quarterly analytical results for 2008.

Quarter			1	2	3	4
Constituents of Concern (units)	Well	SL	Result	Result	Result	Result
Arsenic ($\mu\text{g/L}$)	K7-06	— ^(a)	19	19	20	18
	K7-01	14.0	9.6	8.6	9.1	11
	K7-03	3.2	<2	<2	<2	3.6
	K7-09	2.0	<2	<2	<2	<2
	K7-10	4.2	4.5, <2, <2 ^(b)	2.5	2.5	4.4
	NC7-25	8.6	5.6	5.7	6.9	DRY
	NC7-26	3.6	<2	2.2	2.2	4.3
	NC7-47	17.0	11	2.2	12	14
	NC7-48	19.0	6.2	6.5	6.3	6.7
Barium ($\mu\text{g/L}$)	K7-06	—	82	85	82	84
	K7-01	230	180	200	210	200
	K7-03	85	76	79	68	85
	K7-09	25	<25	<25	29	28
	K7-10	120	100	44	77	41
	NC7-25	140	74	79	80	DRY
	NC7-26	39	25	26	25	26
	NC7-47	63	59	<25	62	62
	NC7-48	400	120	140	130	140
Beryllium ($\mu\text{g/L}$)	K7-06	—	<0.5	<5	<0.5	<2
	K7-01	0.5	<0.5	<5	<0.5	<0.5
	K7-03	0.5	<0.5	<5	<0.5	<0.5
	K7-09	0.5	<0.5	<5	<0.5	<2
	K7-10	0.5	<0.5	<5	<0.5	<2
	NC7-25	0.5	<0.5	<0.5	<0.5	DRY
	NC7-26	0.5	<0.5	<5	<0.5	<0.5
	NC7-47	0.5	<0.5	<0.5	<0.5	<0.5
	NC7-48	0.5	<0.5	<5	<0.5	<2
Cadmium ($\mu\text{g/L}$)	K7-06	—	1.6	2.2	1.2	<0.5
	K7-01	0.5	<0.5	<0.5	<0.5	<0.5
	K7-03	0.5	<0.5	<0.5	<0.5	<0.5
	K7-09	0.5	<0.5	<0.5	<0.5	<0.5
	K7-10	1.6	<0.5	<0.5	<0.5	<0.5
	NC7-25	0.6	<0.5	<0.5	<0.5	DRY
	NC7-26	0.5	<0.5	<0.5	<0.5	<0.5
	NC7-47	0.5	<0.5	<0.5	<0.5	<0.5
	NC7-48	1.2	<25	<0.5	<0.5	<0.5
Cobalt ($\mu\text{g/L}$)	K7-06	—	<25	<25	<25	<25
	K7-01	25	<25	<25	<25	<25
	K7-03	25	<25	<25	<25	<25
	K7-09	25	<25	<25	<25	<25
	K7-10	25	<25	<25	<25	<25
	NC7-25	25	<25	<25	<25	DRY
	NC7-26	25	<25	<25	<25	<25
	NC7-47	25	<25	<25	<25	<25
	NC7-48	25	<0.5	<25	<25	<25

Table A-3. Pit 7 constituents of concern, monitoring wells, SLs, and quarterly analytical results for 2008.

Quarter			1	2	3	4
Constituents of Concern						
(units)	Well	SL	Result	Result	Result	Result
Copper ($\mu\text{g/L}$)	K7-06	—	<10	<10	<10	<10
	K7-01	40	<10	<10	<10	<10
	K7-03	140	19	14	16	17
	K7-09	10	<10	<10	<10	<10
	K7-10	10	<10	<10	<10	<10
	NC7-25	10	<10	<10	<10	DRY
	NC7-26	10	<10	<10	<10	<10
	NC7-47	10	<10	<10	<10	<10
	NC7-48	10	<10	<10	<10	<10
Lead ($\mu\text{g/L}$)	K7-06	—	<2	<2	<2	<2
	K7-01	6	<2	<2	<2	<2
	K7-03	6.1	<2	<2	<2	<2
	K7-09	5.9	<2	<2	<2	<2
	K7-10	2	<2	<2	<2	<2
	NC7-25	2	<2	<2	<2	DRY
	NC7-26	5.1	<2	<2	<2	<2
	NC7-47	7.6	<2	<2	<2	<2
	NC7-48	2	5.0, <1, <1 ^(b)	<2	<2	<2
Nickel ($\mu\text{g/L}$)	K7-06	—	<5	<5	<5	<5
	K7-01	25	<5	<5	<5	5.0
	K7-03	26	5.1	31, 16, 35	22	15
	K7-09	29	7	<5	11	<5
	K7-10	13	<5	<5	<5	<5
	NC7-25	13	<5	<5	<5	DRY
	NC7-26	5	<5	<5	<5	<5
	NC7-47	14	<5	<5	<5	<5
	NC7-48	48	<5	<5	<5	<5
Vanadium ($\mu\text{g/L}$)	K7-06	—	40	40	36	40
	K7-01	25	<25	<25	<25	<25
	K7-03	25	<25	<25	<25	<25
	K7-09	25	<25	<25	<25	<25
	K7-10	25	<25	<25	<25	<25
	NC7-25	25	<25	<25	<25	DRY
	NC7-26	25	<25	<25	<25	<25
	NC7-47	79	60	<25	64	61
	NC7-48	110	<25	<25	<25	<25
Zinc ($\mu\text{g/L}$)	K7-06	—	<20	<20	<20	40
	K7-01	52	<20	<20	<20	<20
	K7-03	72	<20	<20	<20	<20
	K7-09	20	<20	<20	<20	41
	K7-10	20	<20	<20	<20	46
	NC7-25	36	200, 30, 480 ^(b)	95	<20	DRY
	NC7-26	20	<20	<20	<20	<20
	NC7-47	50	<20	<20	<20	<20
	NC7-48	44	<20	<20	<20	44

Table A-3. Pit 7 constituents of concern, monitoring wells, SLs, and quarterly analytical results for 2008.

Quarter			1	2	3	4
Constituents of Concern						
(units)	Well	SL	Result	Result	Result	Result
Radium 226 (Bq/L) ^(c)	K7-06	—	0.01	0.02	0.01	0.006
	K7-01	0.08	0.04	0.038	0.037	0.042
	K7-03	0.03	0.007	0.005	0.004	0.004
	K7-09	0.023	0.005	0.003	0.014	0.005
	K7-10	0.032	0.112, 0.009, 0.000 ^(b)	0.017	0.008	0.007
	NC7-25	0.054	0.027	0.017	0.027	DRY
	NC7-26	0.034	0.012	0.014	0.008	0.013
	NC7-47	0.022	0.004	0.003	0.002	0.002
	NC7-48	0.04	0.015	0.013	0.014	0.016
Tritium (Bq/L)	K7-06	—	-0.231	0.462	-0.944	0.622
	K7-01	— ^(d)	1770	1750	1720	1650
	K7-03	— ^(d)	3850	3700	3310	3560
	K7-09	4.8	-0.232	1.86	-2.01	0.155
	K7-10	4.8	-0.707	-0.385	-1.31	0.388
	NC7-25	— ^(d)	10800	10200	9950	DRY
	NC7-26	— ^(d)	105	105	98	96.9
	NC7-47	4.8	-0.186	1.1	-2.3	-1.49
	NC7-48	16.4	-1.4	1.01	-0.0873	2.02
Uranium (total, Bq/L)	K7-06	—	0.038	0.031	0.034	0.032
	K7-01	0.636	0.598	0.603	0.644	0.652
	K7-03	0.224	0.244	0.175	0.207	0.222
	K7-09	0.035	0.001	0.038	0.001	0.003
	K7-10	0.083	0.016	0.01	0.017	0.017
	NC7-25	1.262	1.258	1.225	1.239	DRY
	NC7-26	0.034	0.012	0.009	0.012	0.010
	NC7-47	0.178	0.07	0.074	0.078	0.071
	NC7-48	2.327	0.243	0.389	0.34	0.298
Thorium 228 (Bq/L)	K7-06	—	0.001	0.005	0.005	0.001
	K7-01	0.024	0.001	0.002	0.001	0
	K7-03	0.024	0.001	0.008	0.005	0
	K7-09	0.024	0.003	0.007	0.001	0
	K7-10	0.024	0	0.007	0.001	0.001
	NC7-25	0.024	0.001	0.013	0.001	DRY
	NC7-26	0.024	0.001	0.008	0.001	0
	NC7-47	0.024	0	0	0.001	0.001
	NC7-48	0.024	0	0.012	0.001	0
Thorium 230 (Bq/L)	K7-06	-	0	-0.001	0.005	0.006
	K7-01	-	0.001	0.001	0.003	0.003
	K7-03	-	0	0.001	0.005	0.003
	K7-09	-	0	0.004	0.006	0.011
	K7-10	-	0	0.003	0	0.015
	NC7-25	-	0	0.008	0.001	DRY
	NC7-26	-	-0.001	0	0.017	0.003
	NC7-47	-	-0.001	0	0	-0.001
	NC7-48	-	-0.002	0.009	0	0.015

Table A-3. Pit 7 constituents of concern, monitoring wells, SLs, and quarterly analytical results for 2008.

Quarter			1	2	3	4
Constituents of Concern (units)	Well	SL	Result	Result	Result	Result
Thorium 232 (Bq/L)	K7-06	-	0	0.001	0.001	0
	K7-01	0.014	0	0	0	0
	K7-03	0.014	0	0	0.002	0
	K7-09	0.014	-0.001	0	0	0
	K7-10	0.014	0	0	0	0.001
	NC7-25	0.014	0	0.011	0	DRY
	NC7-26	0.014	0	0	0	0
	NC7-47	0.014	0	0	0	0
	NC7-48	0.014	0	0.001	0.001	0
HMX ($\mu\text{g/L}$)	K7-06	—	<1	<1	<1	<1
	K7-01	5	<1	<1	-	<1
	K7-03	5	<1	<1	<1	<1
	K7-09	5	<1	<1	<1	<1
	K7-10	5	<1	<1	<1	<1
	NC7-25	5	<1	<1	<0.77	DRY
	NC7-26	5	<1	<1	<0.83	<0.71
	NC7-47	5	<1	<1	<1	<1
	NC7-48	5	<1	<1	<1	<1
RDX ($\mu\text{g/L}$)	K7-06	—	<1	<1	<1	<1
	K7-01	5	<1	<1	-	<1
	K7-03	5	<1	<1	<1	<1
	K7-09	5	<1	<1	<1	<1
	K7-10	5	<1	<1	<1	<1
	NC7-25	5	<1	<1	<0.77	DRY
	NC7-26	5	<1	<1	<0.83	<0.71
	NC7-47	5	<1	<1	<1	<1
	NC7-48	5	<1	<1	<1	<1

^(a) Well K7-06 has no SLs for constituents of concern because it is upgradient from Pit 7.

^(b) Multiple data separated by commas indicate resample, reanalysis, or duplicate results.

^(c) Radioactivity measurements are corrected for the background radioactivity inside the measurement chamber.

A negative result for radioactivity indicates that the sample measured lower than the background by the amount shown.

Radioactivity values shown as 0.000 are less than 0.0005 Bq/L.

^(d) Exempt well (insensitive to further detection of tritium releases).

Table A-4. Pit 7 additional PCP constituents and fourth quarter 2008 analytical results.

Constituent (units)	K7-06 ^(a)	K7-01	K7-03	K7-09	K7-10	NC7-26	NC7-47	NC7-48
Dates Sampled	6-Oct-08	13-Oct-08	13-Oct-08	6-Oct-08	6-Oct-08	13-Oct-08	14-Oct-08	6-Oct-08
Depth to water (ft)	27.17	20.73	28.71	49.72	36.61	71.94	63.04	47.92
Ground water elevation (ft above MSL)	1386.78	1298.29	1310.38	1295.58	1306.7	1256.73	1205.47	1344.9
Field pH (Units)	7.88	7.23	7.68	7.55	7.96	7.86	7.84	7.44
Field Specific Conductance (μ mhos/cm)	445	732	714	744	968	651	645	713
Field Temperature (Degrees C)	20.1	20.1	20.6	21.8	20.7	21.9	17.9	20.6
Gross alpha (Bq/L)	0.005	0.566	0.234	0.012	-0.06	-0.034	0.03	0.241
Gross beta (Bq/L)	0.081	0.36	0.131	0.577	0.185	0.102	0.155	0.162
Nitrate (as NO ₃) (mg/L)	15	42	35	<0.5	1.7	<0.5	69	19
Perchlorate (μ g/L)	<4	12	10	<4	<4	<4	<4	<4
VOCs (E8260) (μ g/L)	<1000	1.5	1.4	<1000	<1000	<1000	<1000	<1000
Trichloroethene	<0.5	1.5	1.4	<0.5	<0.5	<0.5	<0.5	<0.5

^(a) Upgradient well.

Table A-5. Pits 1 and 7 groundwater well sampling dates.

Pit	Quarter	Location	Sample Date
1	1	K1-01C	28-Jan-2008
1	2	K1-01C	6-May-2008
1	3	K1-01C	21-Jul-2008
1	4	K1-01C	27-Oct-2008
1	1	K1-02B	31-Jan-2008
1	2	K1-02B	23-Apr-2008
1	3	K1-02B	22-Jul-2008
1	4	K1-02B	27-Oct-2008
1	1	K1-04	10-Jan-2008
1	2	K1-04	23-Apr-2008
1	3	K1-04	21-Jul-2008
1	4	K1-04	20-Oct-2008
1	1	K1-05	14-Jan-2008
1	2	K1-05	23-Apr-2008
1	3	K1-05	21-Jul-2008
1	4	K1-05	16-Oct-2008
1	1	K1-07	24-Jan-2008
1	2	K1-07	24-Apr-2008
1	3	K1-07	22-Jul-2008
1	4	K1-07	16-Oct-2008
1	1	K1-08	29-Jan-2008
1	2	K1-08	24-Apr-2008
1	3	K1-08	22-Jul-2008
1	4	K1-08	14-Oct-2008
1	1	K1-09	7-Jan-2008
1	2	K1-09	24-Apr-2008
1	2	K1-09	11-Jun-2008
1	2	K1-09	18-Jun-2008
1	3	K1-09	22-Jul-2008
1	4	K1-09	14-Oct-2008
1	2	W-PIT1-2326	5-May-2008
1	3	W-PIT1-2326	29-Jul-2008
1	4	W-PIT1-2326	27-Oct-2008
7	1	K7-01	22-Jan-2008
7	2	K7-01	30-Apr-2008
7	3	K7-01	24-Jul-2008
7	4	K7-01	13-Oct-2008
7	1	K7-03	7-Jan-2008
7	2	K7-03	28-Apr-2008
7	2	K7-03	11-Jun-2008
7	2	K7-03	18-Jun-2008
7	3	K7-03	24-Jul-2008
7	4	K7-03	13-Oct-2008
7	1	K7-06	3-Jan-2008
7	2	K7-06	30-Apr-2008
7	3	K7-06	28-Jul-2008

Table A-5. Pits 1 and 7 groundwater well sampling dates.

Pit	Quarter	Location	Sample Date
7	4	K7-06	6-Oct-2008
7	1	K7-09	15-Jan-2008
7	2	K7-09	30-Apr-2008
7	3	K7-09	23-Jul-2008
7	4	K7-09	6-Oct-2008
7	1	K7-10	15-Jan-2008
7	1	K7-10	14-Feb-2008
7	1	K7-10	21-Feb-2008
7	1	K7-10	3-Mar-2008
7	1	K7-10	10-Mar-2008
7	2	K7-10	28-Apr-2008
7	3	K7-10	23-Jul-2008
7	4	K7-10	6-Oct-2008
7	1	NC7-25	3-Jan-2008
7	1	NC7-25	5-Feb-2008
7	1	NC7-25	12-Feb-2008
7	1	NC7-25	19-Feb-2008
7	2	NC7-25	20-May-2008
7	3	NC7-25	28-Aug-2008
7	1	NC7-26	15-Jan-2008
7	2	NC7-26	28-Apr-2008
7	3	NC7-26	24-Jul-2008
7	4	NC7-26	13-Oct-2008
7	1	NC7-47	10-Jan-2008
7	2	NC7-47	22-Apr-2008
7	3	NC7-47	23-Jul-2008
7	4	NC7-47	14-Oct-2008
7	1	NC7-48	3-Jan-2008
7	1	NC7-48	5-Feb-2008
7	1	NC7-48	12-Feb-2008
7	1	NC7-48	19-Feb-2008
7	2	NC7-48	28-Apr-2008
7	3	NC7-48	28-Jul-2008
7	4	NC7-48	6-Oct-2008

Appendix B

Statistical Methods for Release Detection

Appendix B

Statistical Methods for Release Detection

Monitoring and reporting provisions of the RCRA closure and post-closure plan (PCP) for landfill Pits 1 and 7 require the use of U.S. EPA-approved statistical methods to evaluate the monitoring data. Waste Discharge Requirements (WDR) Order 93-100 requires statistical methods from the California Code of Regulations (CCR), Title 23. LLNL applies statistical methods from CCR, Title 23, Division 3, Chapter 15, Section 2550.7, as they are also consistent with U.S. EPA guidance.

We use statistically determined concentration limits (SLs) to detect potential releases of constituents of concern to ground water from solid wastes contained in closed landfills. We employ two statistical methods, prediction intervals (PIs) and control charts (CCs), to generate SLs. Both methods are sensitive to constituents of concern concentration increases. Both methods are cost-effective, requiring only one measurement of a constituent of concern per quarter per monitoring well.

We prefer the PI method when constituents of concern concentrations in ground water are similar upgradient and downgradient from the monitored unit. We use parametric PI methods when the upgradient constituents of concern concentration data are all above the detection limit and the data are approximately normally distributed. Analysts also use parametric methods on log-transformed data, if the transformed data follow a normal distribution. Nonparametric PI methods are more effective when the data cannot be transformed to a normal distribution, or when they contain nondetections.

When the concentration of a constituent of concern is spatially variable in the vicinity of a monitored unit, we develop a control chart for each downgradient monitoring well. The control chart compares each new quarterly COC measurement with its concentration history for that well.

Wherever sufficient historical detections of a constituent of concern exist, we calculate an SL such that a single future measurement has approximately a 1-in-100 chance of exceeding the SL, when no change in concentration has actually occurred. This yields a statistical test with a significance level of approximately 0.01. Where historical detections exist, but nondetections constitute part of the data, we set the SL equal to the highest concentration measured. If historical analyses show all nondetections of a constituent of concern, then we select the analytical laboratory reporting limit (RL) as the SL. To test false-positive results, we employ a verification procedure containing two discrete retests, in accordance with CCR Title 23, Chapter 15, Section 2550.7.

Table B-1 lists all constituents of concern that have indicated statistically significant evidence of release to ground water from Pit 1 or Pit 7, the date when the CVRWQCB was notified by letter, and the status of any further investigation.

Table B-1. Reported WDR 93-100 constituents of concern showing statistical evidence of release.

Constituents of Concern	Pit	Reported to CVRWQCB	Status of Release Investigation
Metals			
Arsenic	1	06/03/94	Transferred to CERCLA
Arsenic	7	10/17/95	Transferred to CERCLA
Barium	1	10/17/95	Transferred to CERCLA
Barium	1	06/14/96	Transferred to CERCLA
Barium	1	10/25/00	Transferred to CERCLA
Barium	7	11/09/93	Completed ^(a)
Barium	7	07/10/97	Transferred to CERCLA
Barium	7	08/03/00	Transferred to CERCLA
Barium	7	10/25/00	
Barium	7	02/08/01	Transferred to CERCLA
Cadmium	7	10/17/95	Transferred to CERCLA
Copper	1	02/08/01	Transferred to CERCLA
Copper	7	10/17/95	Transferred to CERCLA
Lead	1	04/01/99	Transferred to CERCLA
Nickel	7	10/17/95	Transferred to CERCLA
Nickel	7	05/03/96	Transferred to CERCLA
Nickel	7	07/10/01	Transferred to CERCLA
Vanadium	7	06/03/94	Completed ^(a)
Zinc	7	10/17/95	Transferred to CERCLA
Zinc	7	04/19/99	Transferred to CERCLA
Zinc	7	04/02/08	Transferred to CERCLA
Radioisotopes			
Radium-226	7	10/17/95	Transferred to CERCLA
Tritium	1	10/21/96	Transferred to CERCLA
Tritium	1	01/14/99	Transferred to CERCLA
Tritium	7	01/19/93	Completed ^(a)
Uranium	1	02/17/94	Completed ^(a)
Uranium	1	10/21/96	Transferred to CERCLA
Uranium	7	09/10/93	Completed ^(a)
Uranium	7	11/10/98	Transferred to CERCLA
Uranium	1	04/26/07	Transferred to CERCLA

^(a) Taffet *et al.* 1996.

Appendix C

Quality Assurance Samples

Table C-1. Pit 1 quality assurance for routine, duplicate, and field blank samples for fourth quarter 2008.

Fourth Quarter 2008				
Constituent	K1-01C routine 27-Oct	K1-01C duplicate 27-Oct	PIT 1 field blank 27-Oct	units
Arsenic	14	13	<2	$\mu\text{g/L}$
Barium	<25	<25	<25	$\mu\text{g/L}$
Beryllium	<0.5	<0.5	<0.5	$\mu\text{g/L}$
Cadmium	<0.5	<0.5	<0.5	$\mu\text{g/L}$
Cobalt	<25	<25	<25	$\mu\text{g/L}$
Copper	<10	<10	<10	$\mu\text{g/L}$
Lead	<2	<2	<2	$\mu\text{g/L}$
Nickel	<5	<5	<5	$\mu\text{g/L}$
Vanadium	63	64	<25	$\mu\text{g/L}$
Zinc	<20	<20	<20	$\mu\text{g/L}$
Nitrate (as NO ₃)	35	34	<0.5	mg/L
Perchlorate	<4	<4	<4	$\mu\text{g/L}$
He compounds				
HMX	<1	<1	<1	$\mu\text{g/L}$
RDX	<1	<1	<1	$\mu\text{g/L}$
Radioactivity				
Radium 226 ^(a)	0.005 ± 0.004	0.004 ± 0.004	-0.002 ± 0.004	Bq/L
Tritium	31.4 ± 4.07	30.7 ± 4.07	0.155 ± 1.92	Bq/L
Uranium (total)	0.158 ± 0.013	0.161 ± 0.013	0.001 ± 0.001	Bq/L
Thorium 228	0.000 ± 0.001	0.000 ± 0.002	0.002 ± 0.001	Bq/L
Thorium 232	0.000 ± 0.000	0.000 ± 0.000	0.000 ± 0.000	Bq/L
Thorium 230	0.002 ± 0.001	0.006 ± 0.002	0.005 ± 0.002	Bq/L
Gross alpha	0.149 ± 0.081	0.155 ± 0.130	-0.023 ± 0.011	Bq/L
Gross beta	0.143 ± 0.034	0.131 ± 0.034	-0.005 ± 0.023	Bq/L

^(a) Radioactivity is corrected for the background radioactivity inside the measurement apparatus. Negative activity indicates that the sample contained less than the background activity by the amount shown. Radioactivity equal to or less than the 2-sigma uncertainty shown is considered to be a nondetection.

Table C-2. Pit 7 quality assurance for routine, duplicate, and field blank samples for fourth quarter 2008.

Constituent	Fourth Quarter 2008			units
	K7-01 routine	K7-01 duplicate	PIT 7 field blank	
	6-Oct-08	6-Oct-08	13-Oct-08	
Arsenic	4.4	3.6	2.1	µg/L
Barium	41	52	<25	µg/L
Beryllium	<2	<2	<0.5	µg/L
Cadmium	<0.5	<0.5	<0.5	µg/L
Cobalt	<25	<25	<25	µg/L
Copper	<10	<10	<10	µg/L
Lead	<2	<2	<2	µg/L
Nickel	<5	<5	<5	µg/L
Vanadium	<25	<25	<25	µg/L
Zinc	46	38	<20	µg/L
Radium 226 ^(a)	0.007 ± 0.006	0.011 ± 0.006	0.001 ± 0.005	Bq/L
Tritium	0.388 ± 1.89	0.0777 ± 1.89	0.155 ± 1.96	Bq/L
Uranium (calculated total)	0.017 ± 0.003	0.017 ± 0.004	0.001 ± 0.002	Bq/L
Thorium 228	0.001 ± 0.003	0.000 ± 0.002	0.001 ± 0.002	Bq/L
Thorium 232	0.001 ± 0.001	0.000 ± 0.001	0.000 ± 0.001	Bq/L
Thorium 230	0.015 ± 0.004	0.008 ± 0.002	0.007 ± 0.003	Bq/L
HMX	<1	<1	<1	µg/L
RDX	<1	<1	<1	µg/L
Gross alpha	-0.060 ± 0.152	0.000 ± 0.048	0.018 ± 0.021	Bq/L
Gross beta	0.185 ± 0.041	0.166 ± 0.037	0.007 ± 0.024	Bq/L
Nitrate (as NO ₃)	1.7	1.6	<0.5	mg/L
Perchlorate	<4	<4	<4	µg/L
1,1,1-Trichloroethane	<0.5	<0.5	<0.5	µg/L
1,1,2,2-Tetrachloroethane	<0.5	<0.5	<0.5	µg/L
1,1,2-Trichloroethane	<0.5	<0.5	<0.5	µg/L
1,1-Dichloroethane	<0.5	<0.5	<0.5	µg/L
1,1-Dichloroethene	<0.5	<0.5	<0.5	µg/L
1,2-Dichloroethane	<0.5	<0.5	<0.5	µg/L
1,2-Dichloroethene (total)	<2	<2	<2	µg/L
1,2-Dichloropropane	<0.5	<0.5	<0.5	µg/L
2-Chloroethylvinylether	<10	<10	<10	µg/L
Bromodichloromethane	<0.5	<0.5	<0.5	µg/L
Bromoform	<0.5	<0.5	<0.5	µg/L
Bromomethane	<0.5	<0.5	<0.5	µg/L
Carbon tetrachloride	<0.5	<0.5	<0.5	µg/L
Chlorobenzene	<0.5	<0.5	<0.5	µg/L
Chloroethane	<0.5	<0.5	<0.5	µg/L
Chloroform	<0.5	<0.5	0.98	µg/L
Chloromethane	<0.5	<0.5	<0.5	µg/L
cis-1,3-Dichloropropene	<0.5	<0.5	<0.5	µg/L
Dibromochloromethane	<0.5	<0.5	<0.5	µg/L
Dichlorodifluoromethane	<0.5	<0.5	<0.5	µg/L
Freon 113	<0.5	<0.5	<0.5	µg/L
Methylene chloride	<1	<1	<1	µg/L
Tetrachloroethene	<0.5	<0.5	<0.5	µg/L
trans-1,3-Dichloropropene	<0.5	<0.5	<0.5	µg/L
Trichloroethene	<0.5	<0.5	<0.5	µg/L
Trichlorofluoromethane	<0.5	<0.5	<0.5	µg/L
Vinyl chloride	<0.5	<0.5	<0.5	µg/L

^(a) Radioactivity is corrected for the background radioactivity inside the measurement apparatus.

Negative activity indicates that the sample contained less than the background activity by the amount shown.

Radioactivity equal to or less than the 2-sigma uncertainty shown is considered to be a nondetection.

Appendix D

Constituents of Concern (COCs) and Monitoring Frequencies

Table D-1. Pits 1 and 7 constituents of concern and monitoring frequencies.^(a)

Constituent	WDR ^(b)	PCP ^(c)	Pit 1	Pit 7
Arsenic	X		Q	Q
Barium	X		Q	Q
Beryllium	X		Q	Q
Cadmium	X		Q	Q
Chloride		X	A	
Chromium		X	SA	
Cobalt	X		Q	Q
Copper	X		Q	Q
Iron		X	SA	
Lead	X		Q	Q
Manganese		X	SA	
Mercury		X	SA	
Nickel	X		Q	Q
Nitrate		X	SA	
Selenium		X	SA	
Silver		X	SA	
Sodium		X	SA	
Sulfate		X	A	
Vanadium	X		Q	Q
Zinc	X		Q	Q
Total organic carbon (TOC)		X	A	
Total organic halides (TOX)		X	A	
EPA Method 601		X		Q
EPA Method 624		X	A	
EPA Method 625		X	A	
EPA Method 608		X	A	
Gross alpha and gross beta		X	SA	Q
Radium 226	X		Q	Q
Thorium 228	X		Q	Q
Thorium 232	X		Q	Q
Tritium	X		Q	Q
Uranium (total)	X		Q	Q
HMX	X		Q	Q
RDX	X		Q	Q
Ground water elevation		X	SA	Q
Ground water temperature		X	SA	
pH		X	SA	
Specific conductance		X	SA	

^(a) Monitoring frequencies are: Q (quarterly); SA (semiannually); A (annually).

^(b) Constituents of concern required to be monitored by WDR 93-100 Rev. 2 (CVRWQCB, 1998).

^(c) Additional constituents of concern required to be monitored by the post-closure plan (Rogers/Pacific Corporation, 1990).

Appendix E

Graphs of Ground Water Measurements

Table E-1. Analytical results from 2008 that were omitted from the Appendix E plots due to the use of specially reduced y-axis plot limits.

Pit Area	Constituent	Monitoring Well	Date Sampled	RL (<) or		Units
				Hit (h) ^(a)	Concentration	
Pit 7	Arsenic	K7-10	9/29/03	<	1000	ug/L
Pit 7	Arsenic	NC7-26	1/17/06	<	50	ug/L
Pit 7	Arsenic	NC7-26	1/10/06	<	50	ug/L
Pit 7	Arsenic	NC7-26	1/19/06	<	50	ug/L
Pit 7	Copper	K7-01	10/24/05	h	193	ug/L
Pit 7	Copper	K7-09	2/7/03	h	20	ug/L
Pit 7	Copper	K7-09	4/4/05	<	50	ug/L
Pit 7	Copper	K7-10	4/4/05	<	50	ug/L
Pit 7	Copper	NC7-25	4/6/05	<	50	ug/L
Pit 7	Copper	NC7-25	8/28/08	<	50	ug/L
Pit 7	Copper	NC7-26	4/6/05	<	50	ug/L
Pit 7	Copper	NC7-26	1/24/07	h	41	ug/L
Pit 7	Copper	NC7-48	4/26/01	<	50	ug/L
Pit 7	Copper	NC7-48	4/30/02	<	50	ug/L
Pit 7	Copper	NC7-48	4/6/05	<	50	ug/L
Pit 7	Copper	NC7-48	5/6/03	<	50	ug/L
Pit 7	Nickel	K7-01	4/5/05	<	100	ug/L
Pit 7	Nickel	K7-03	11/27/02	h	60	ug/L
Pit 7	Nickel	K7-03	4/14/05	<	100	ug/L
Pit 7	Nickel	K7-03	4/14/05	<	100	ug/L
Pit 7	Nickel	K7-03	1/21/04	h	79	ug/L
Pit 7	Nickel	K7-03	4/20/04	h	70	ug/L
Pit 7	Nickel	K7-06	4/5/05	<	100	ug/L
Pit 7	Nickel	K7-09	4/4/05	<	100	ug/L
Pit 7	Nickel	K7-10	4/4/05	<	100	ug/L
Pit 7	Nickel	NC7-25	8/28/08	<	100	ug/L
Pit 7	Nickel	NC7-25	4/6/05	<	100	ug/L
Pit 7	Nickel	NC7-26	4/6/05	<	100	ug/L
Pit 7	Nickel	NC7-47	4/26/05	<	100	ug/L
Pit 7	Zinc	K7-01	8/4/04	h	110	ug/L

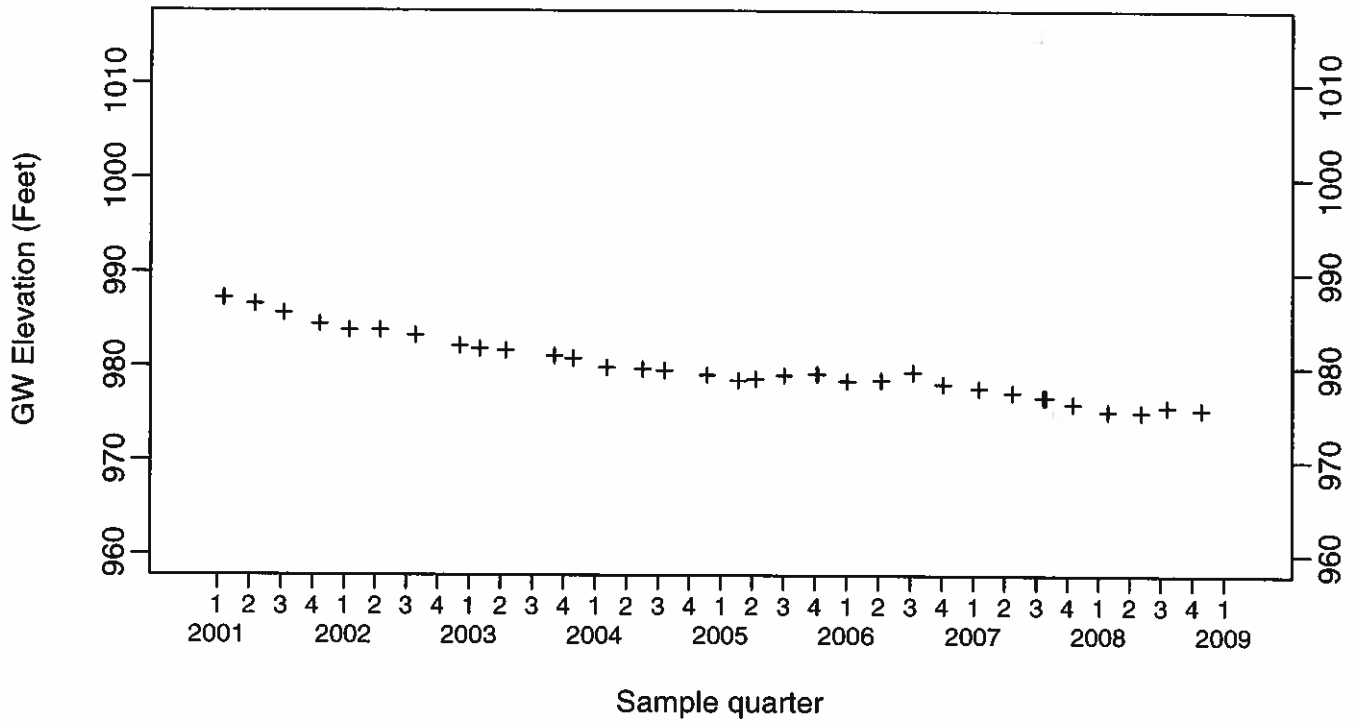
Table E-1. Analytical results from 2008 that were omitted from the Appendix E plots due to the use of specially reduced y-axis plot limits.

Pit Area	Constituent	Monitoring Well	Date Sampled	RL (<) or Hit (h) ^(a)	Concentration	Units
Pit 7	Zinc	K7-03	4/17/01	h	180	ug/L
Pit 7	Zinc	K7-03	6/10/01	h	110	ug/L
Pit 7	Zinc	K7-03	4/14/05	h	110	ug/L
Pit 7	Zinc	K7-03	6/30/05	h	162	ug/L

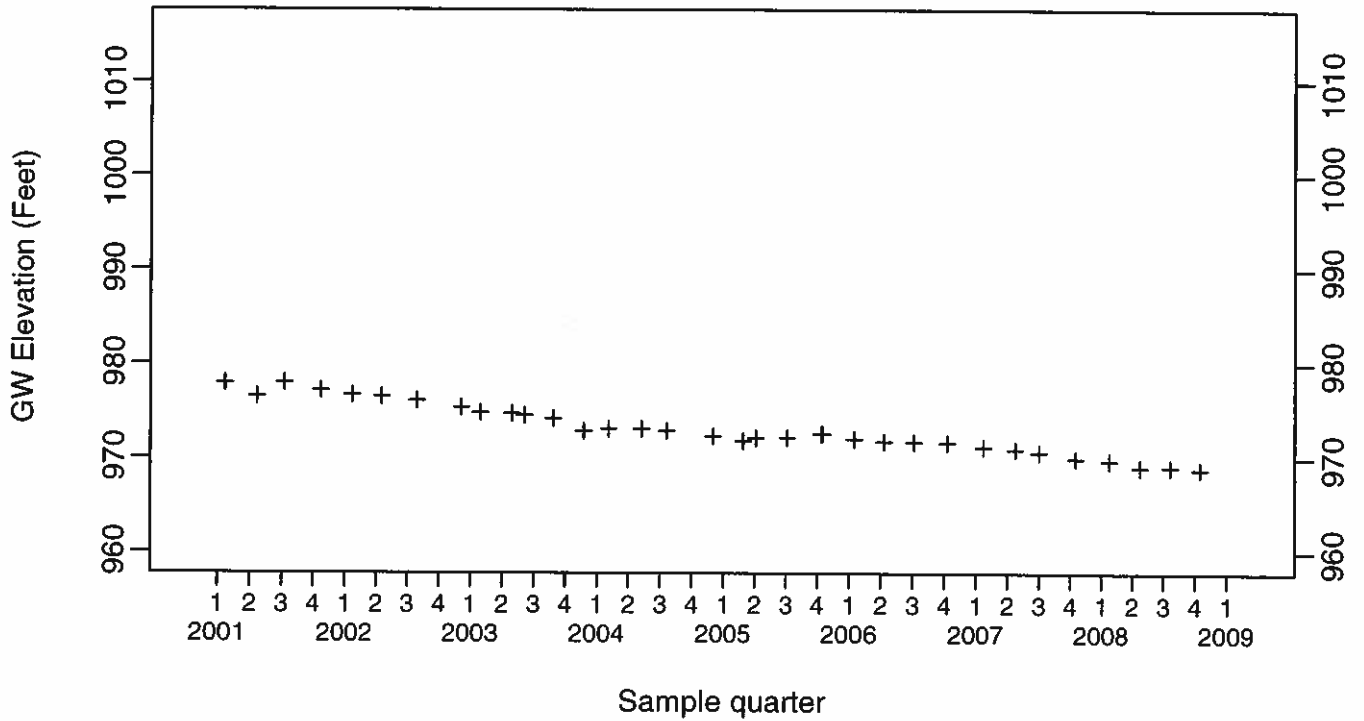
^(a) Values labeled as "<" had high reporting limits (RLs) for that particular analytical result. These values were not included in the plots. The "h" indicate values that, if plotted, would have significantly altered the y-axis scale. These values have been addressed in past reports and are not an indication of a problem at a well.

Pit 1 Area GW Elevation (Feet)

Background Monitoring Point K1-01C

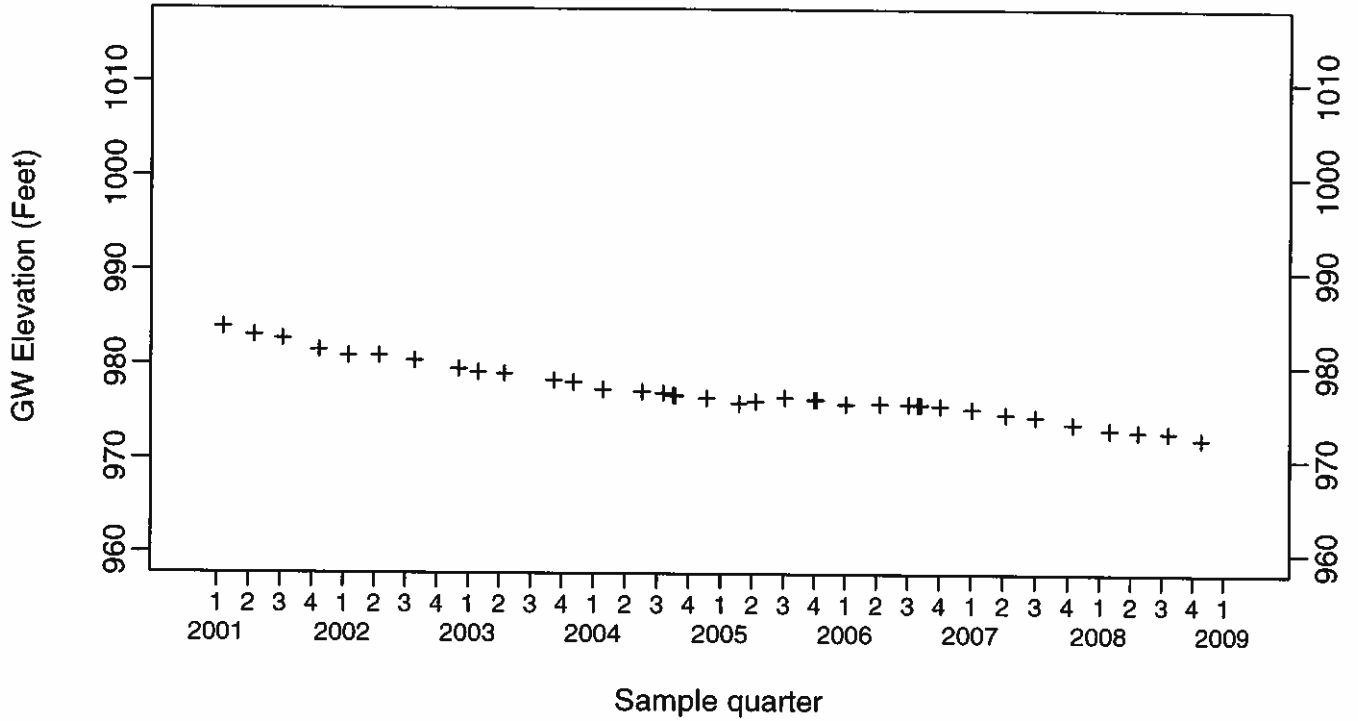


Background Monitoring Point K1-07

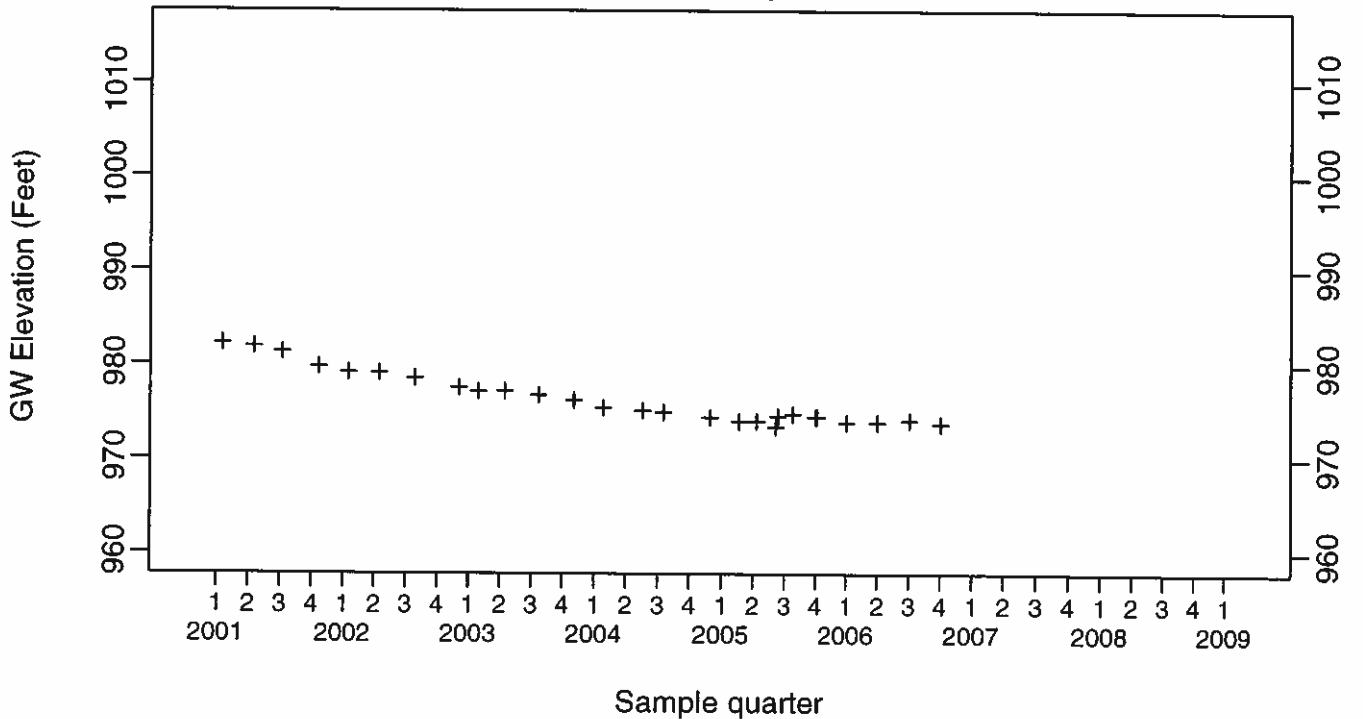


Pit 1 Area GW Elevation (Feet)

Compliance Monitoring Point K1-02B

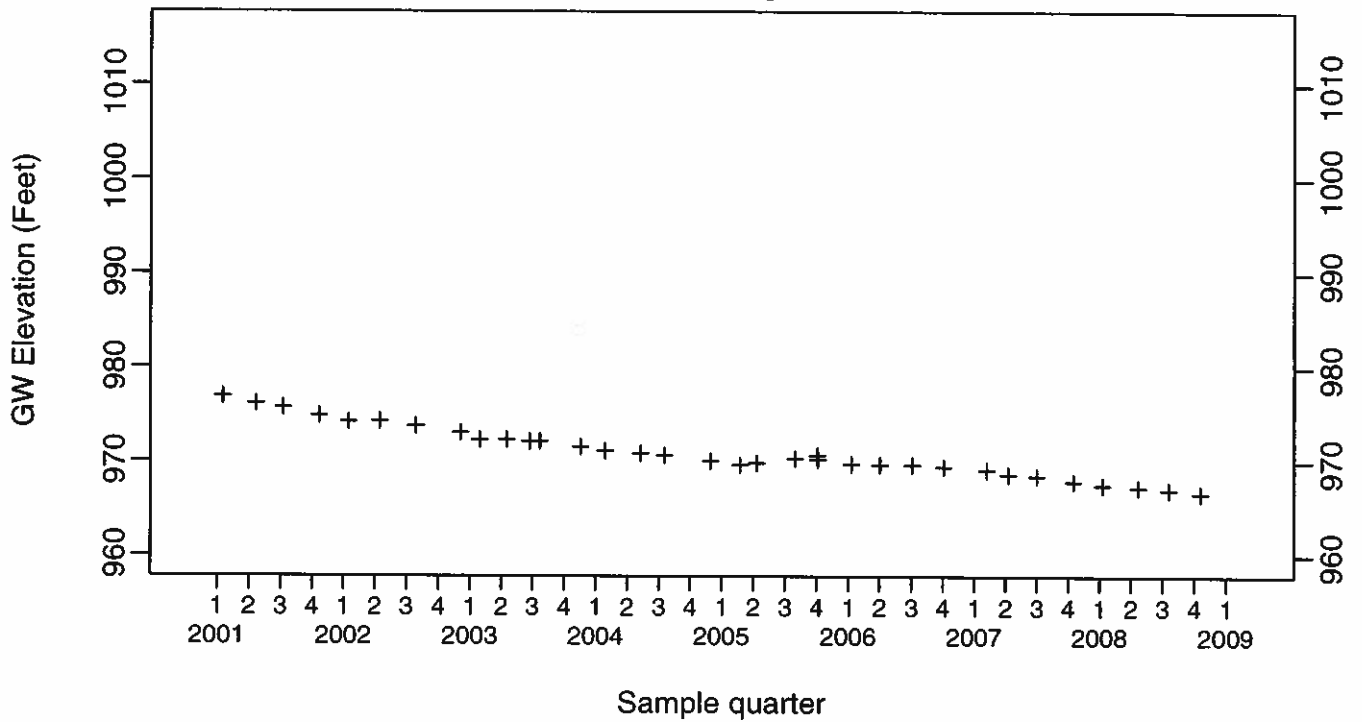


Compliance Monitoring Point K1-03

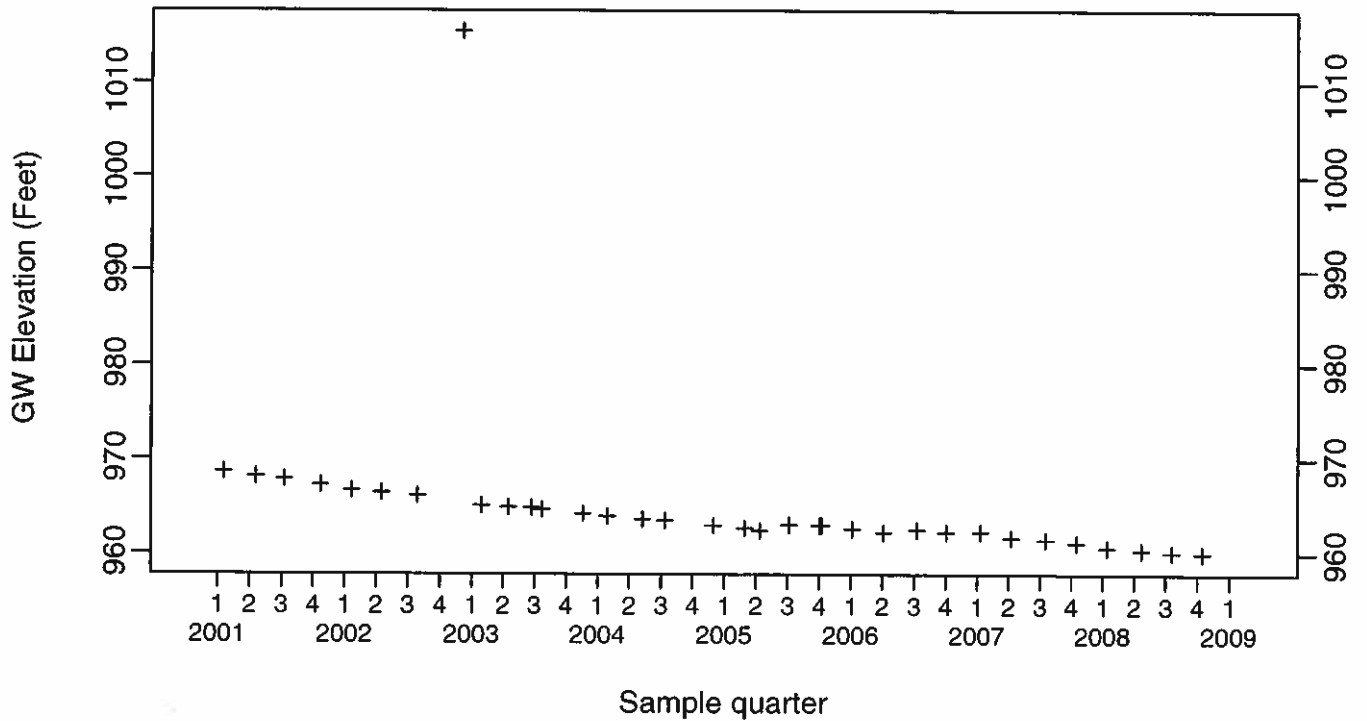


Pit 1 Area GW Elevation (Feet)

Compliance Monitoring Point K1-04

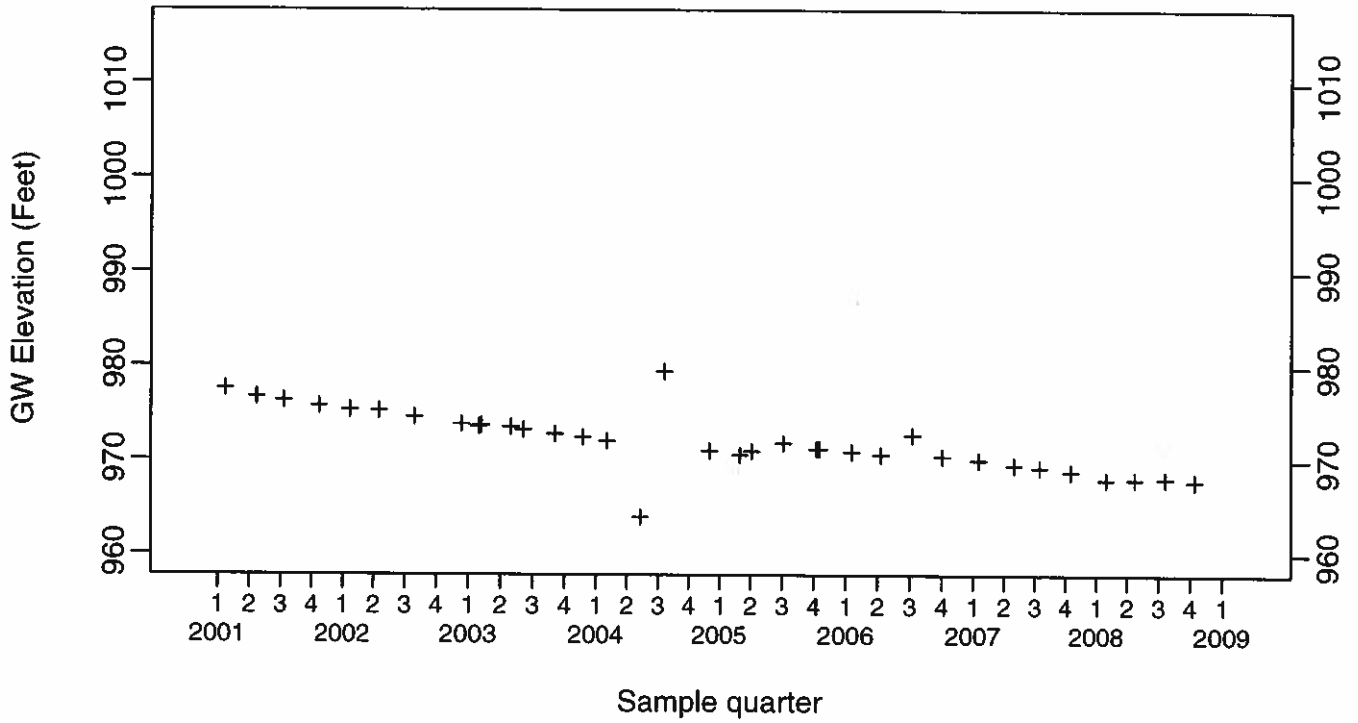


Compliance Monitoring Point K1-05

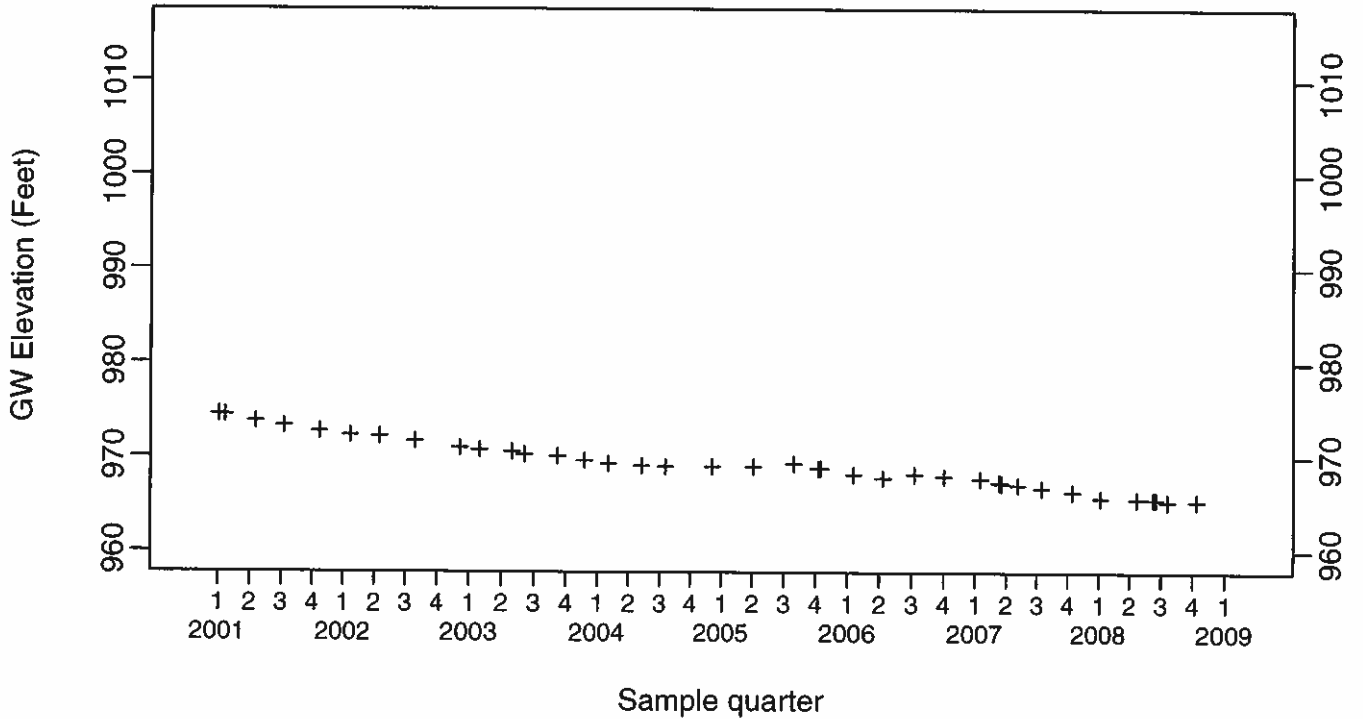


Pit 1 Area GW Elevation (Feet)

Compliance Monitoring Point K1-08

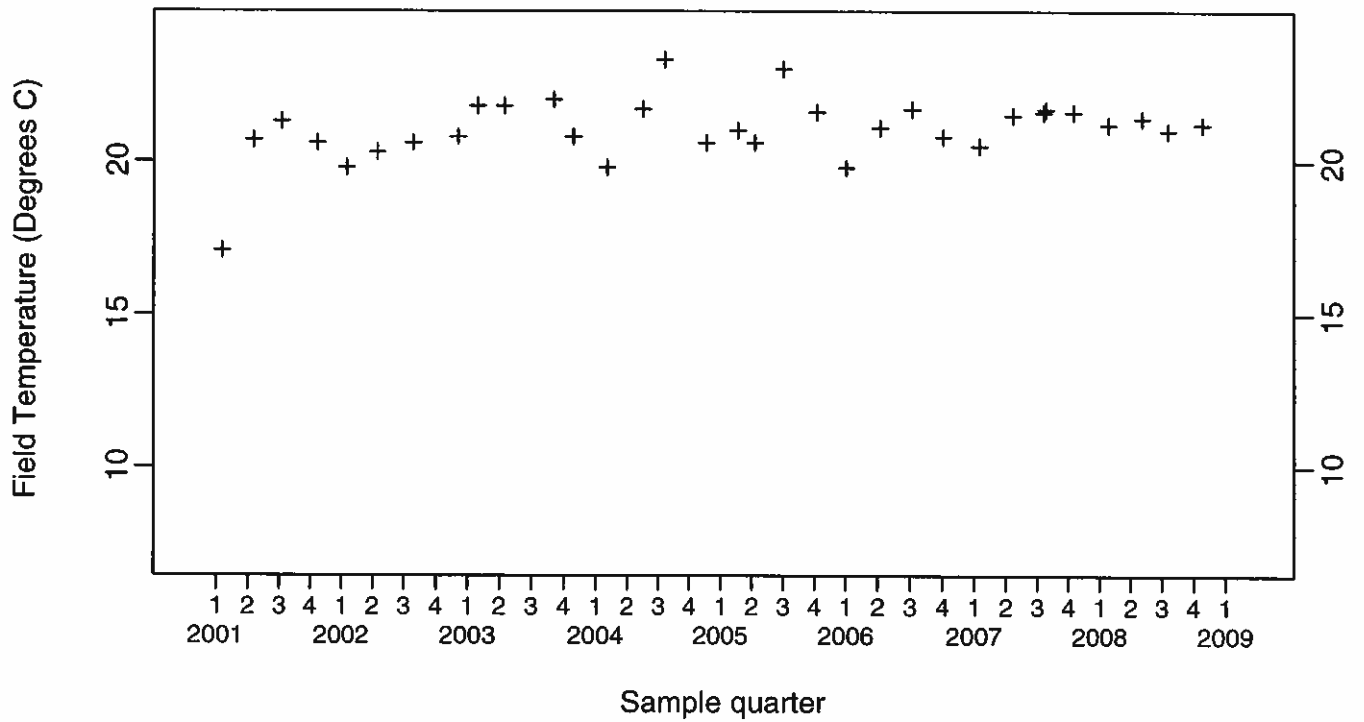


Compliance Monitoring Point K1-09

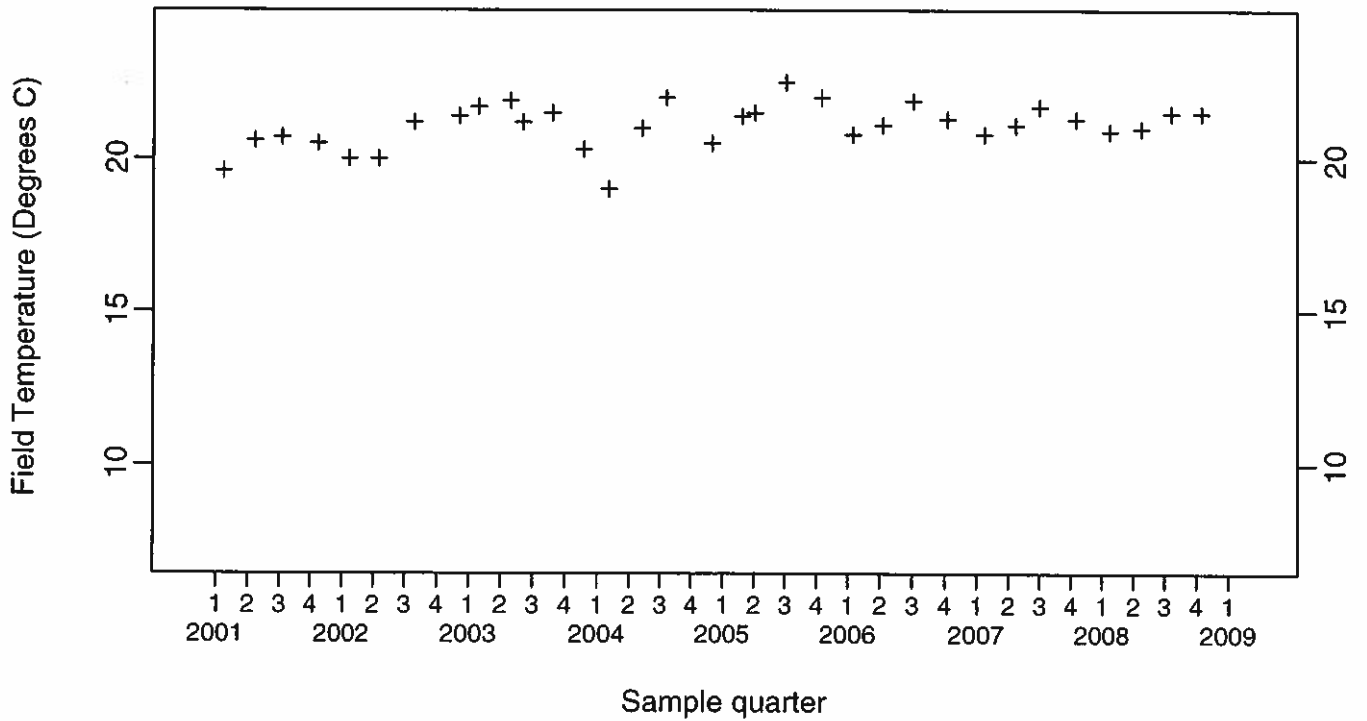


Pit 1 Area Field Temperature (Degrees C)

Background Monitoring Point K1-01C

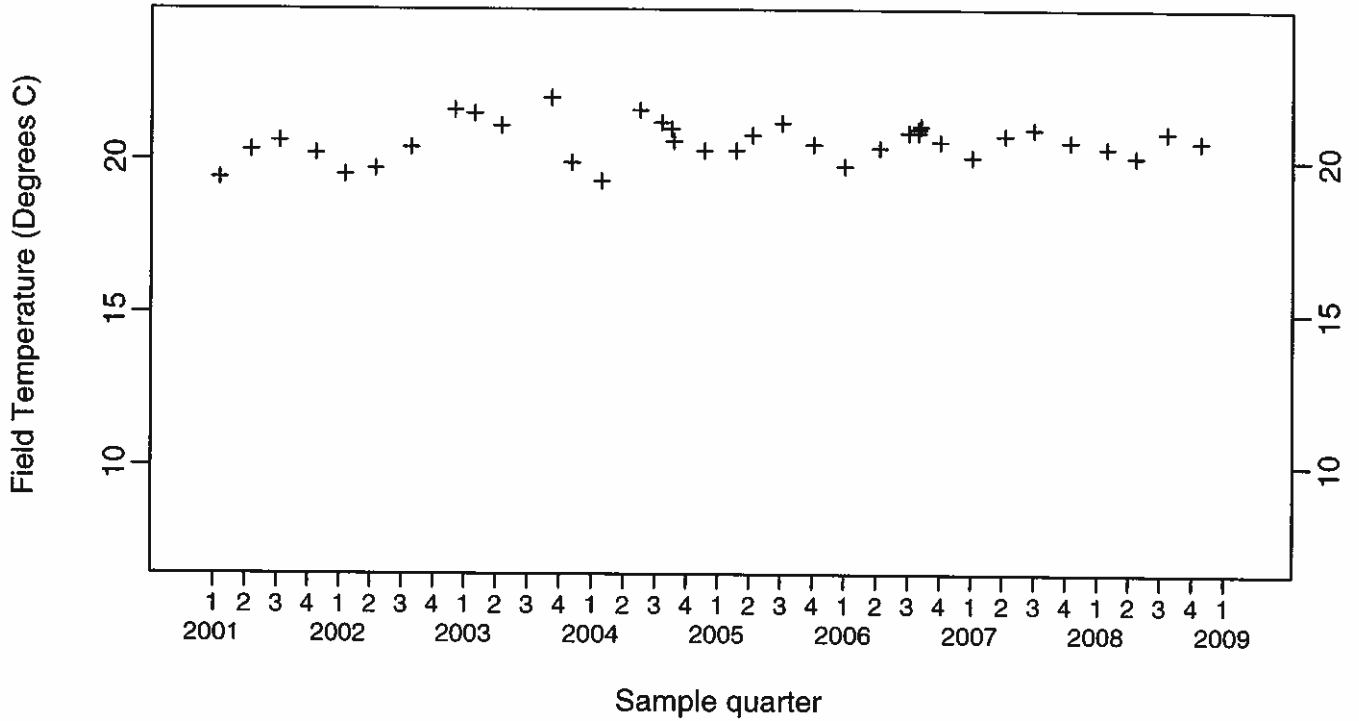


Background Monitoring Point K1-07

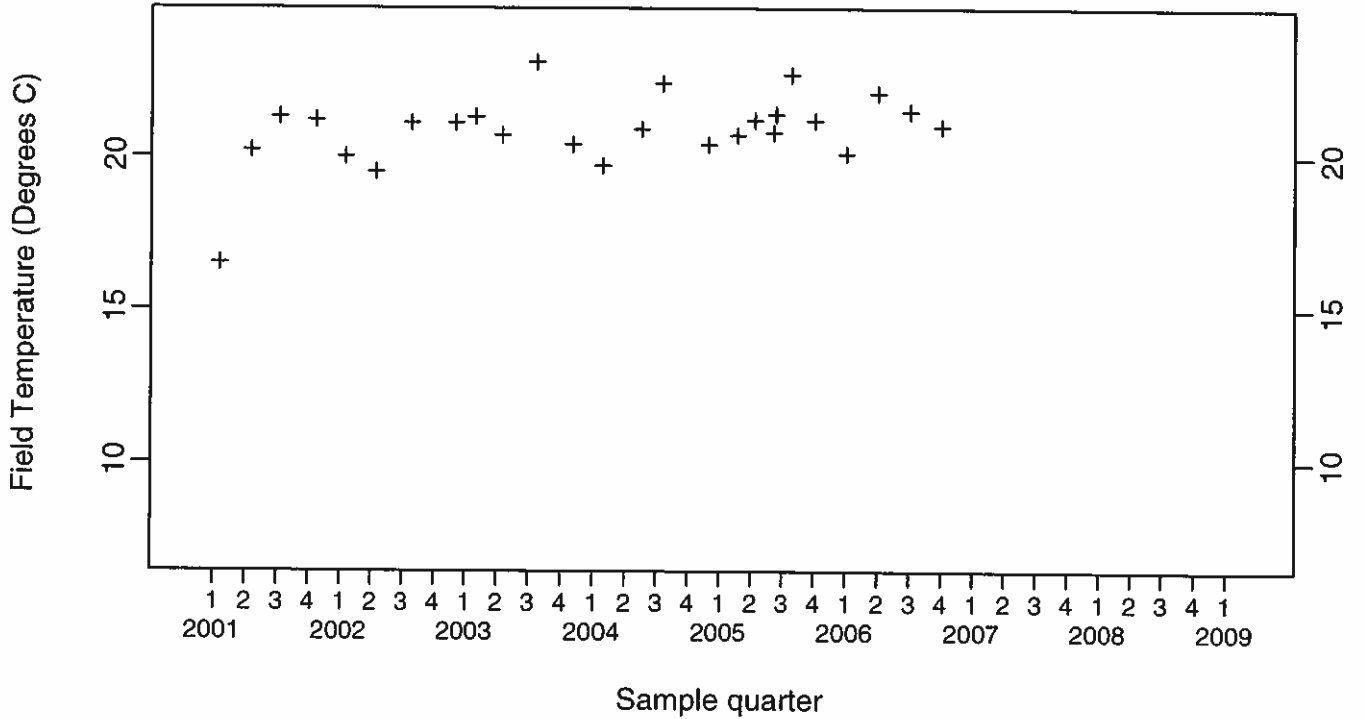


Pit 1 Area Field Temperature (Degrees C)

Compliance Monitoring Point K1-02B

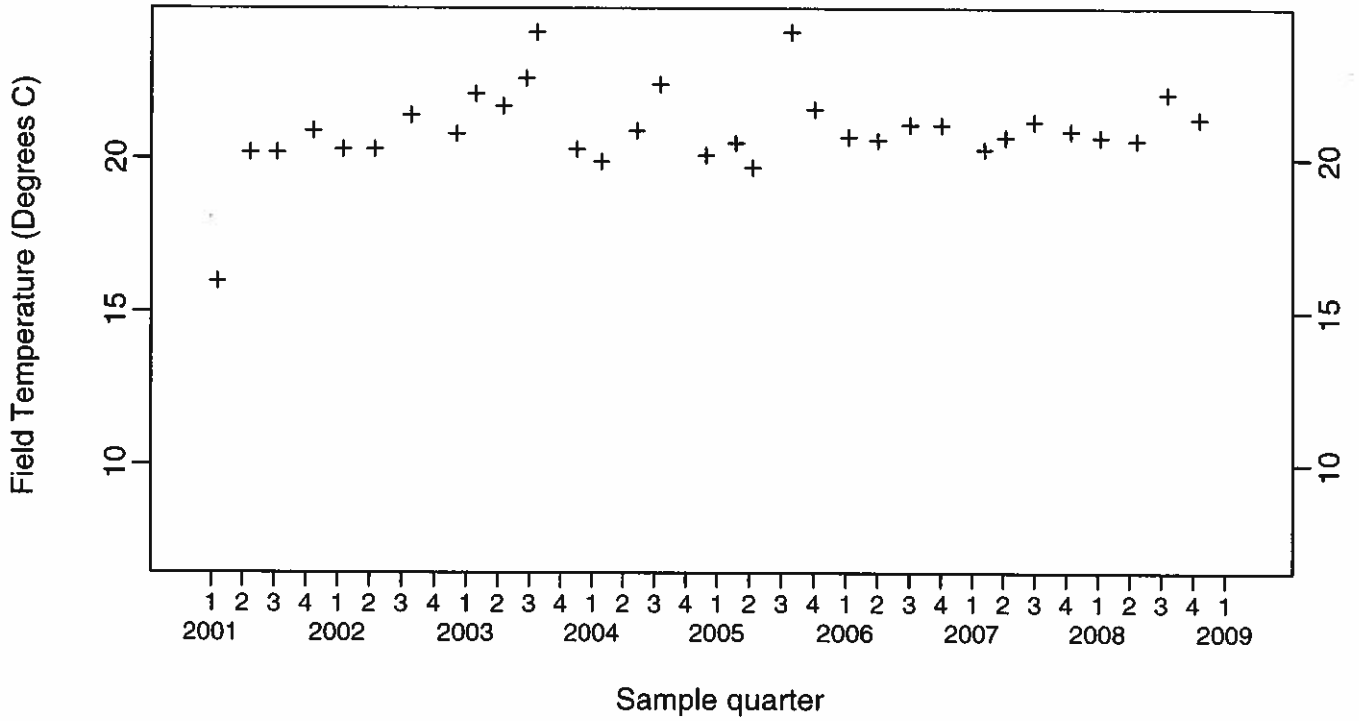


Compliance Monitoring Point K1-03

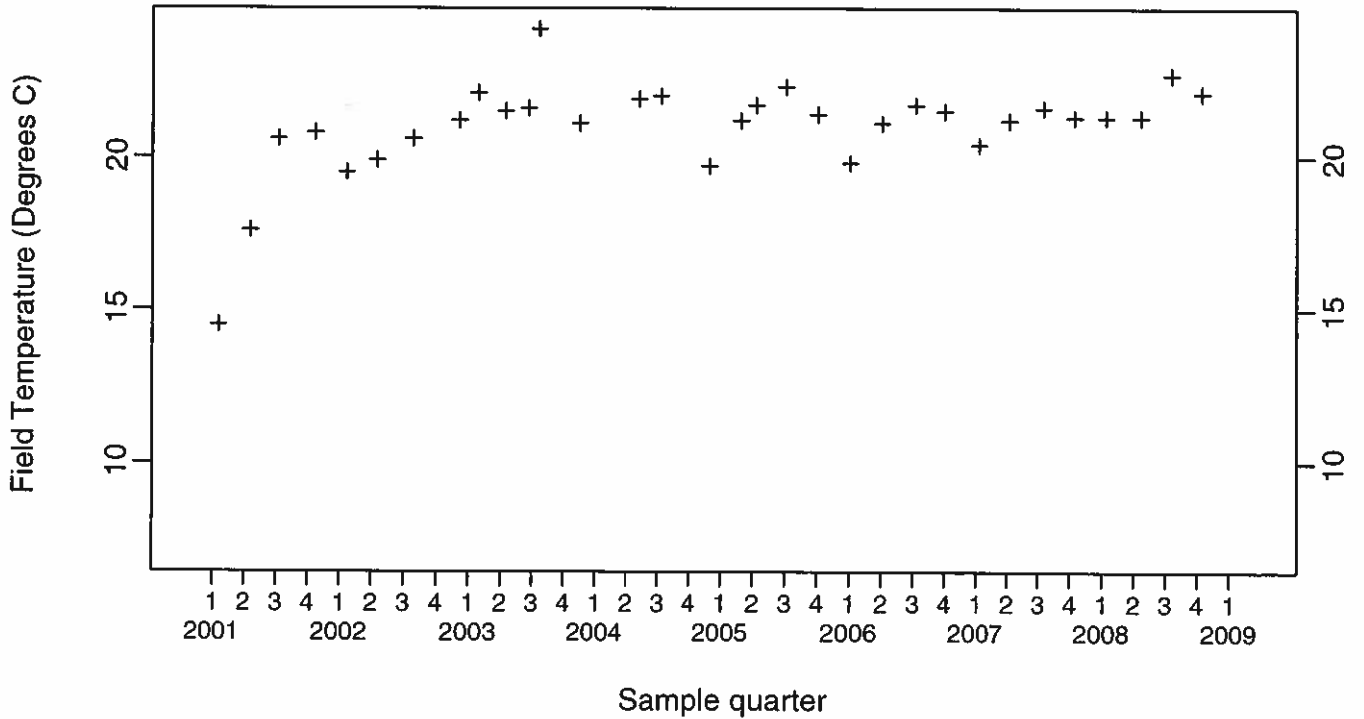


Pit 1 Area Field Temperature (Degrees C)

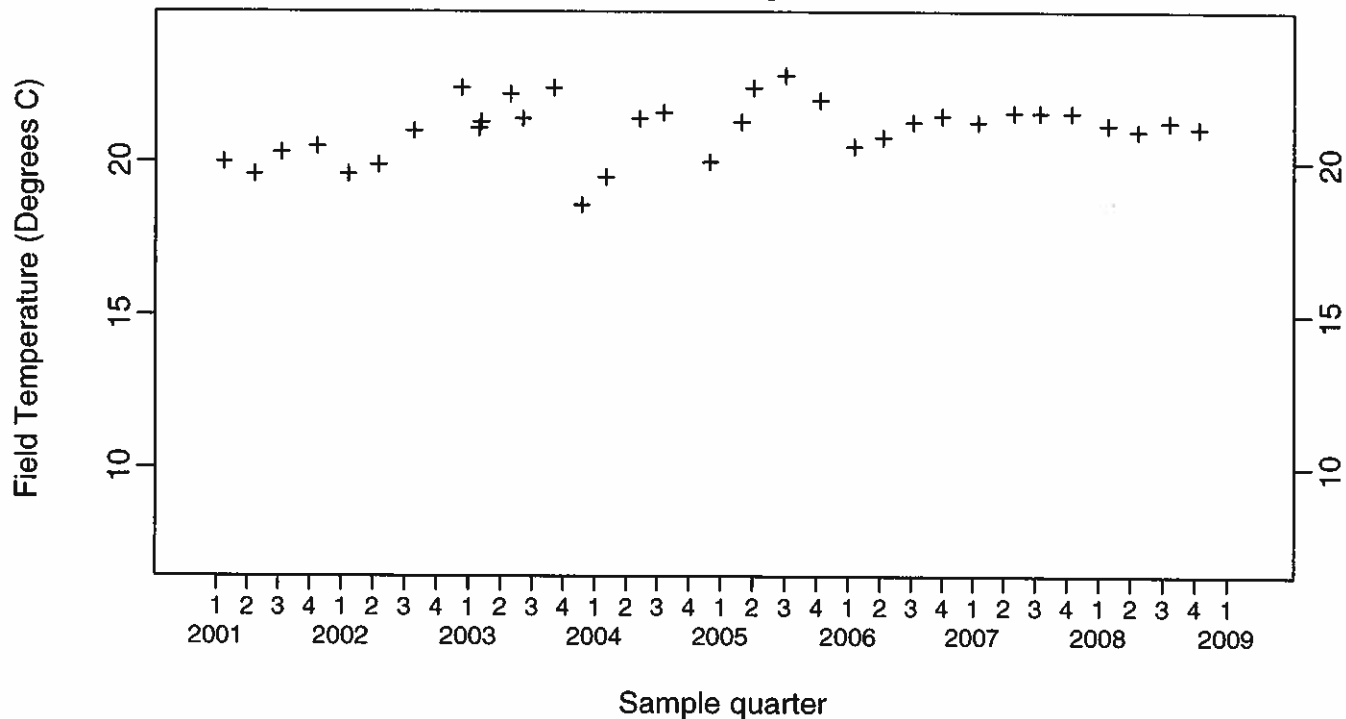
Compliance Monitoring Point K1-04



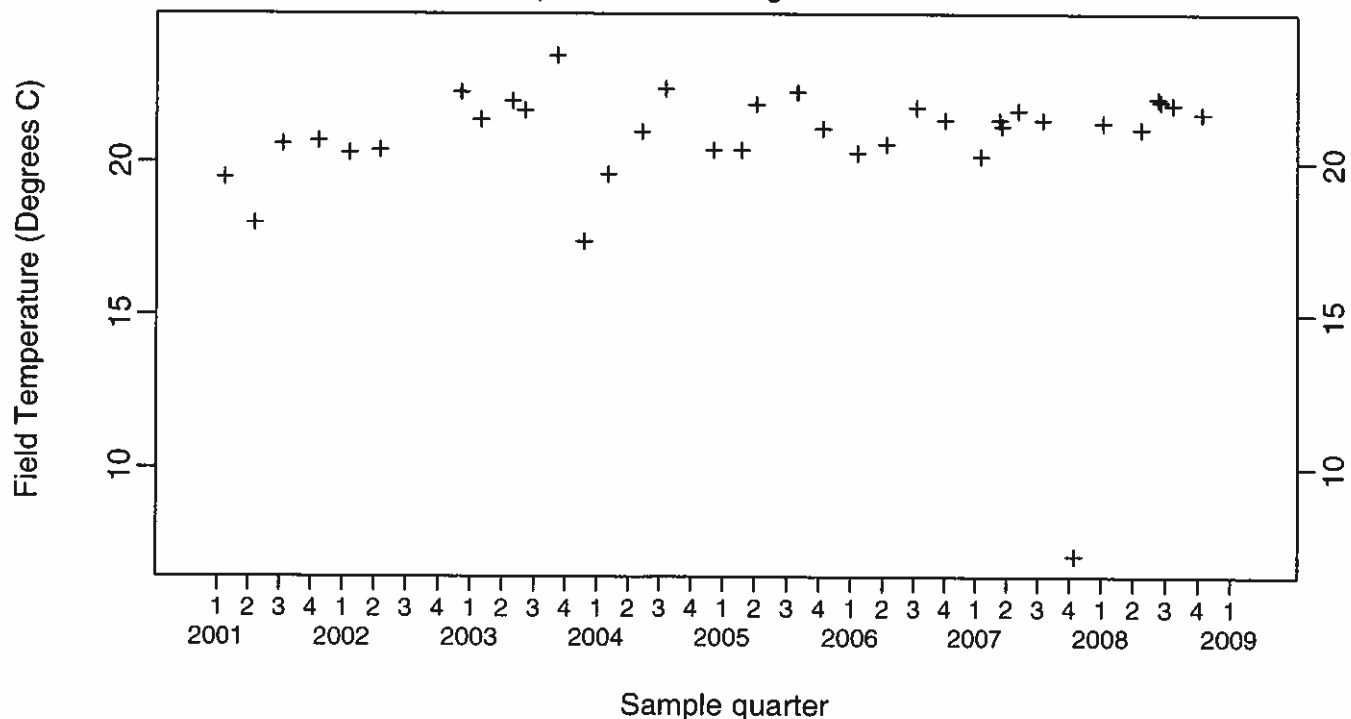
Compliance Monitoring Point K1-05

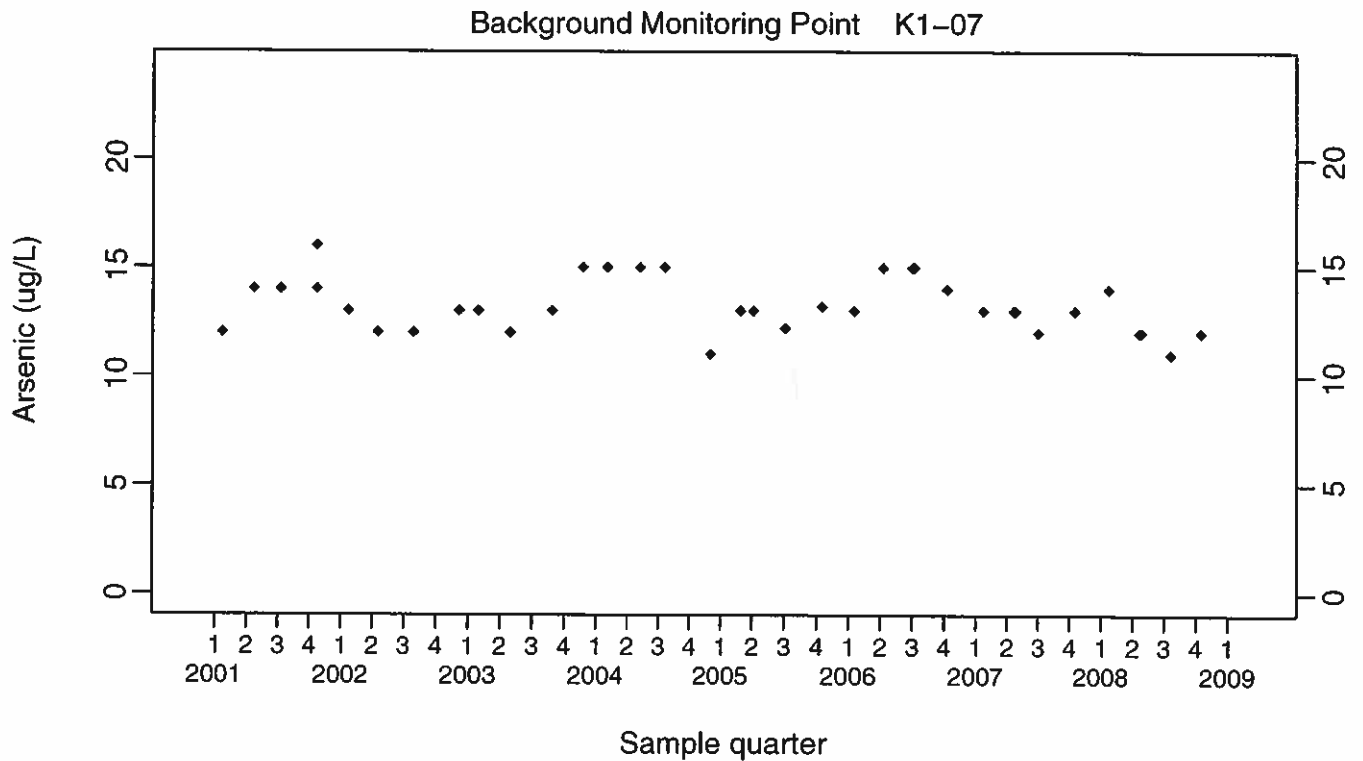
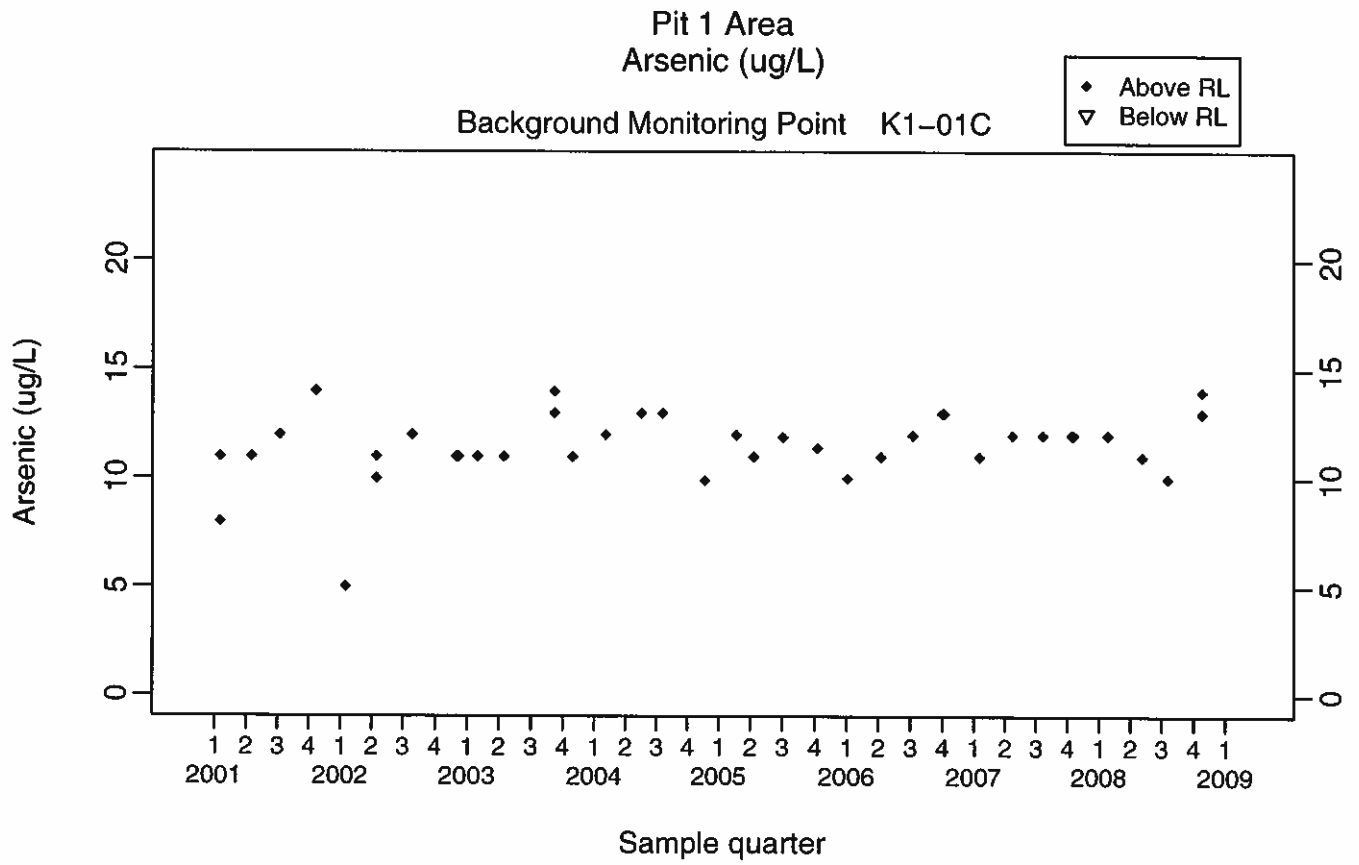


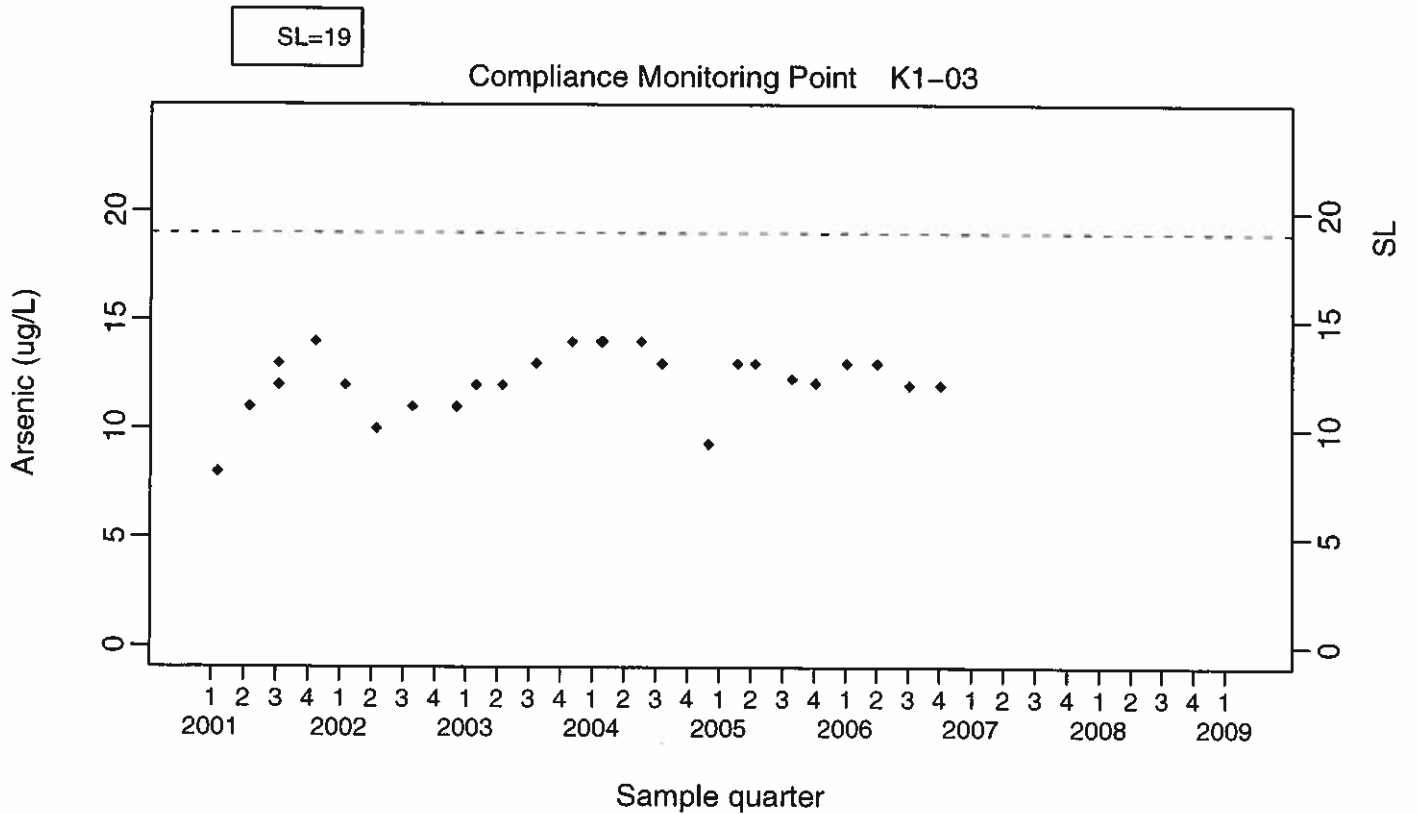
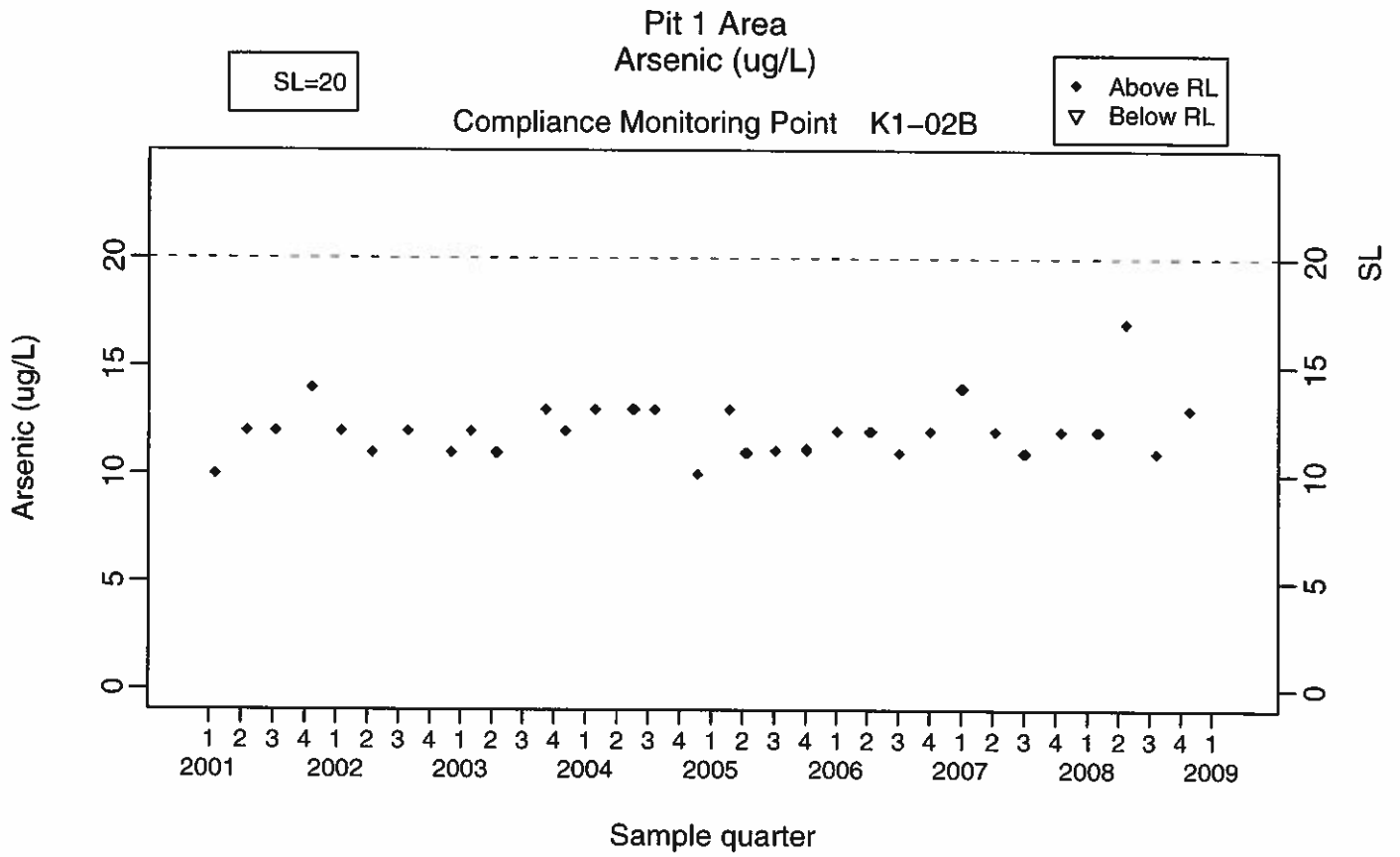
Pit 1 Area Field Temperature (Degrees C) Compliance Monitoring Point K1-08

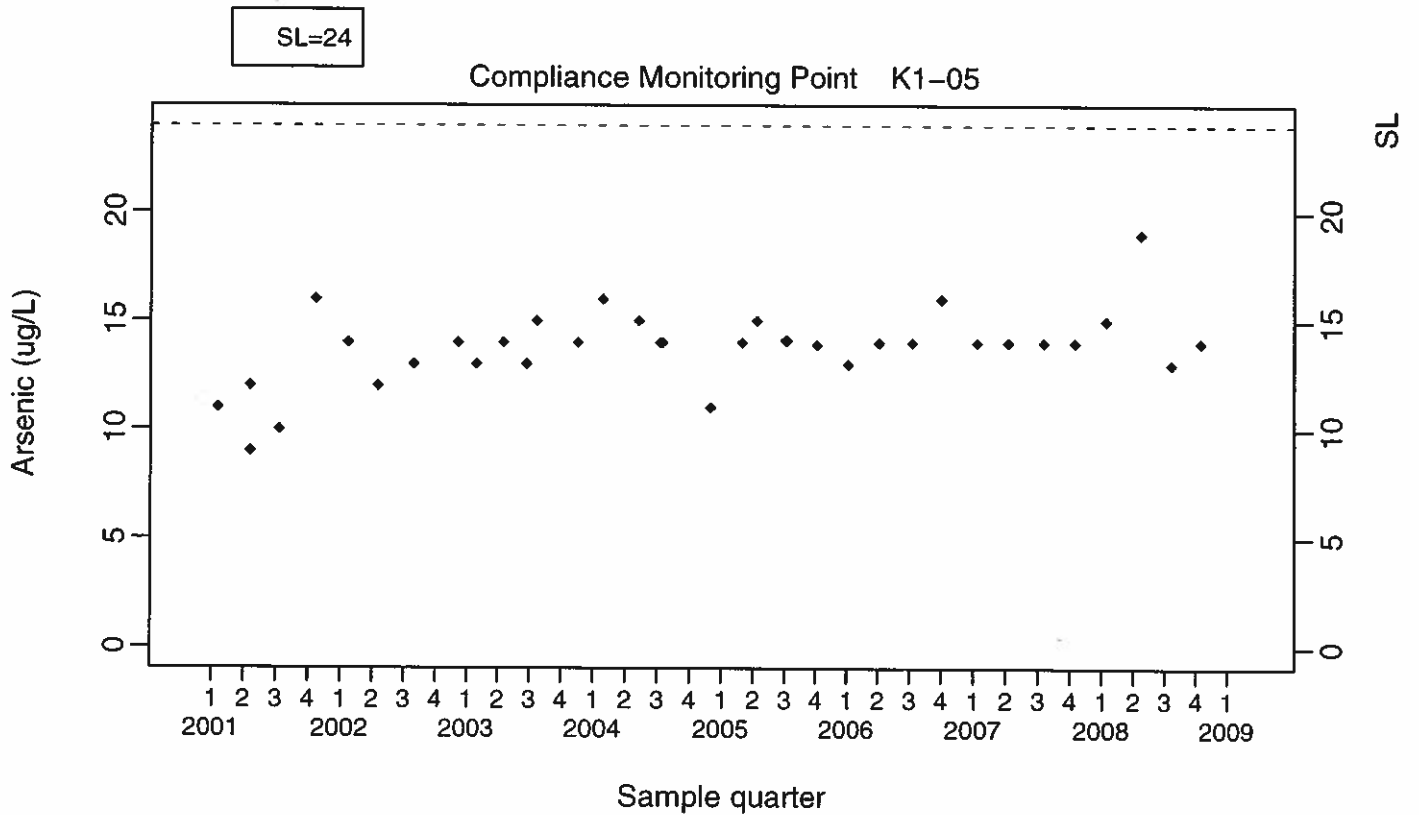
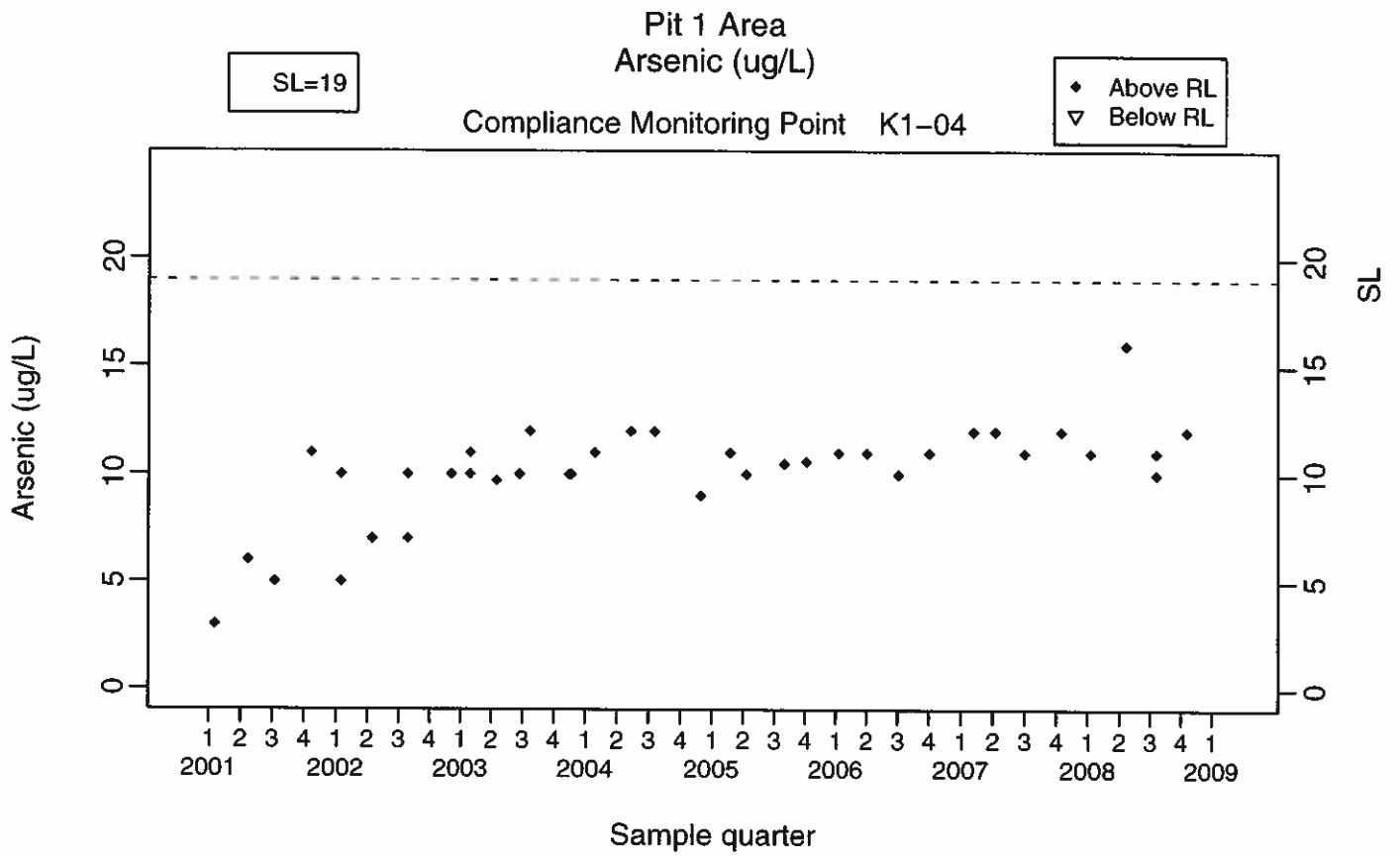


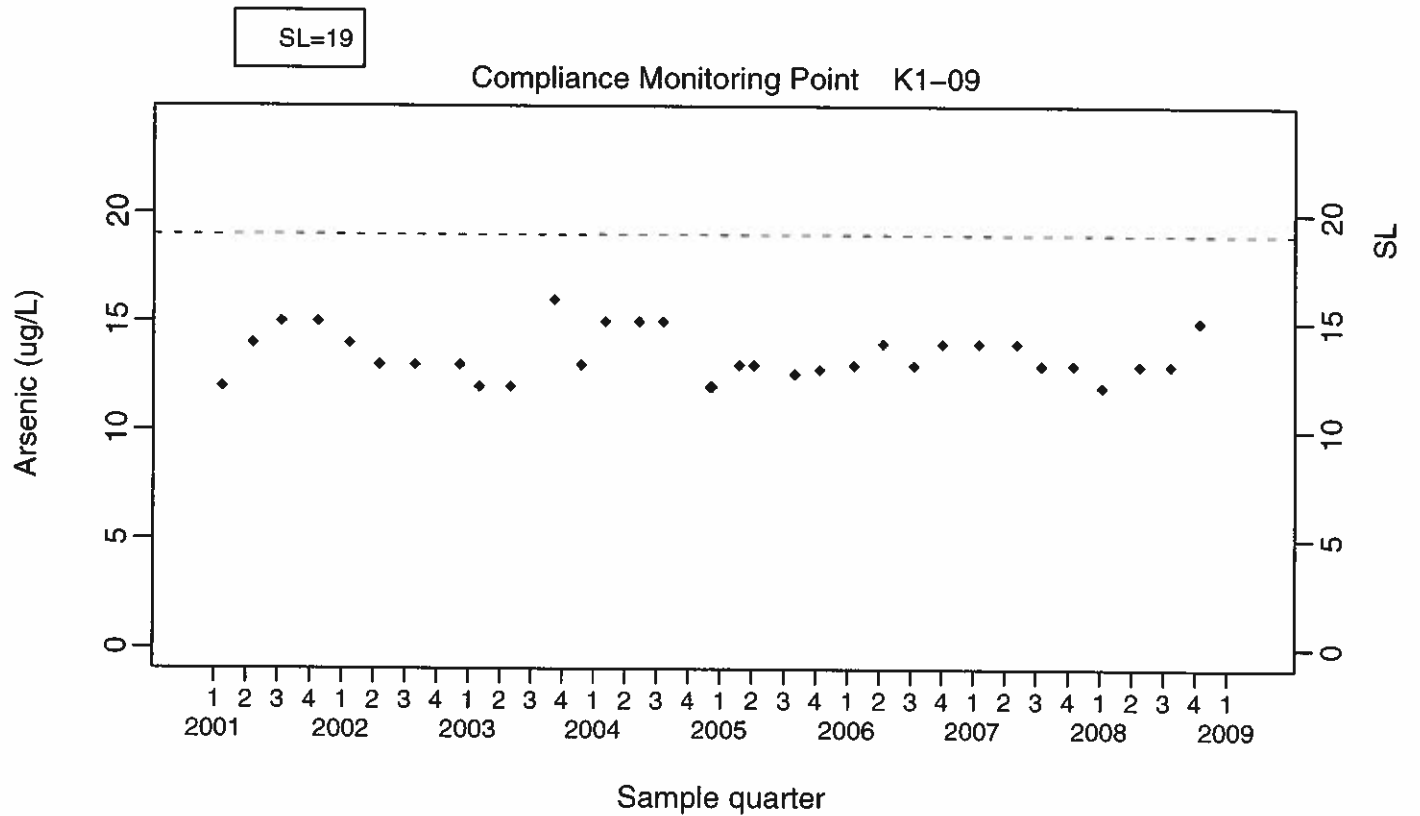
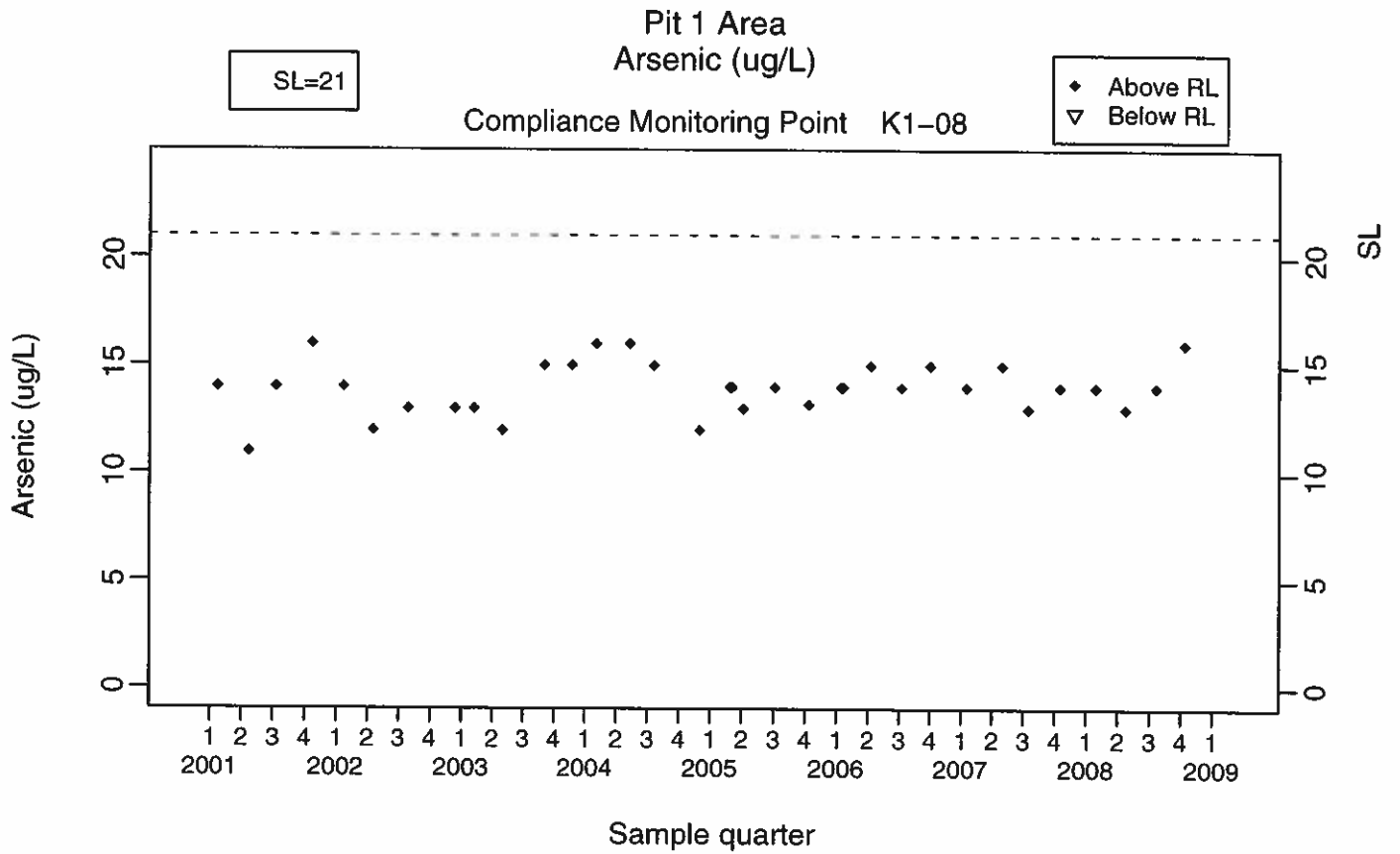
Compliance Monitoring Point K1-09

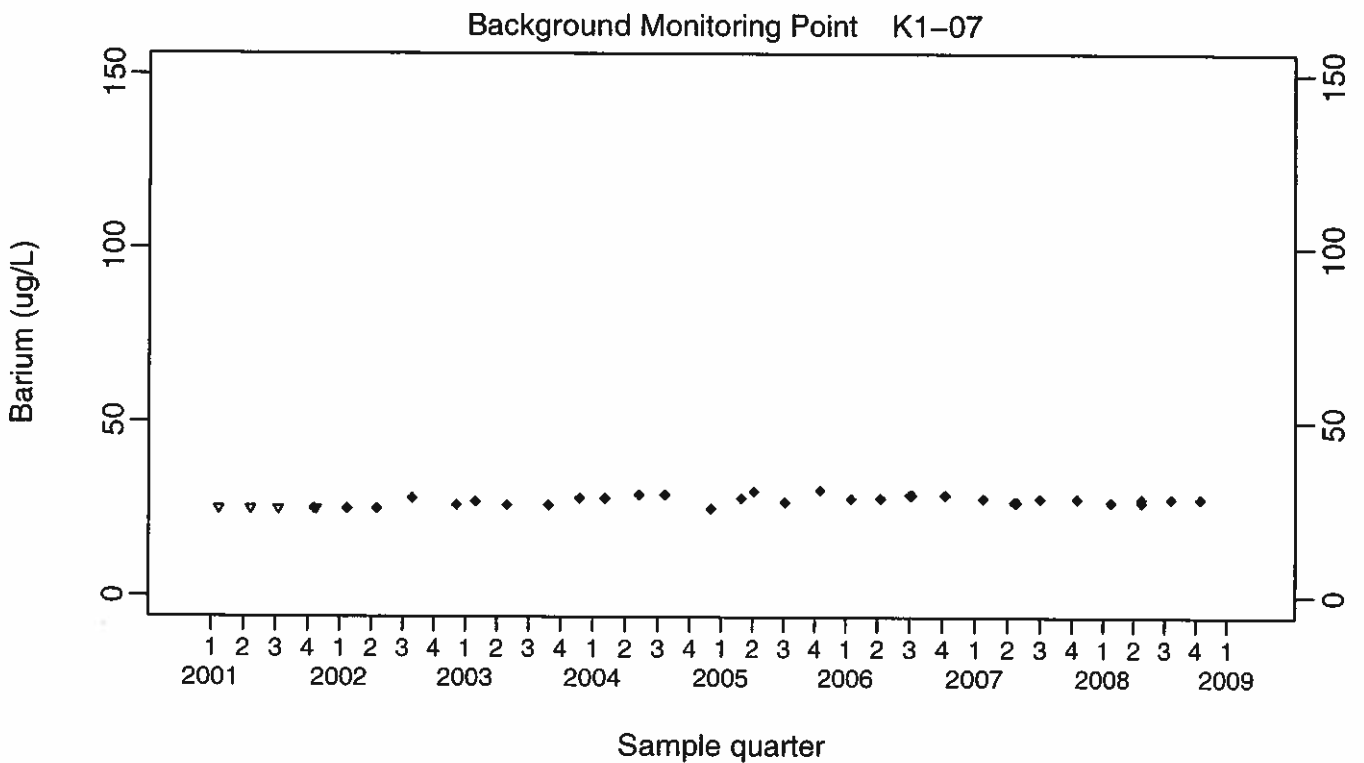
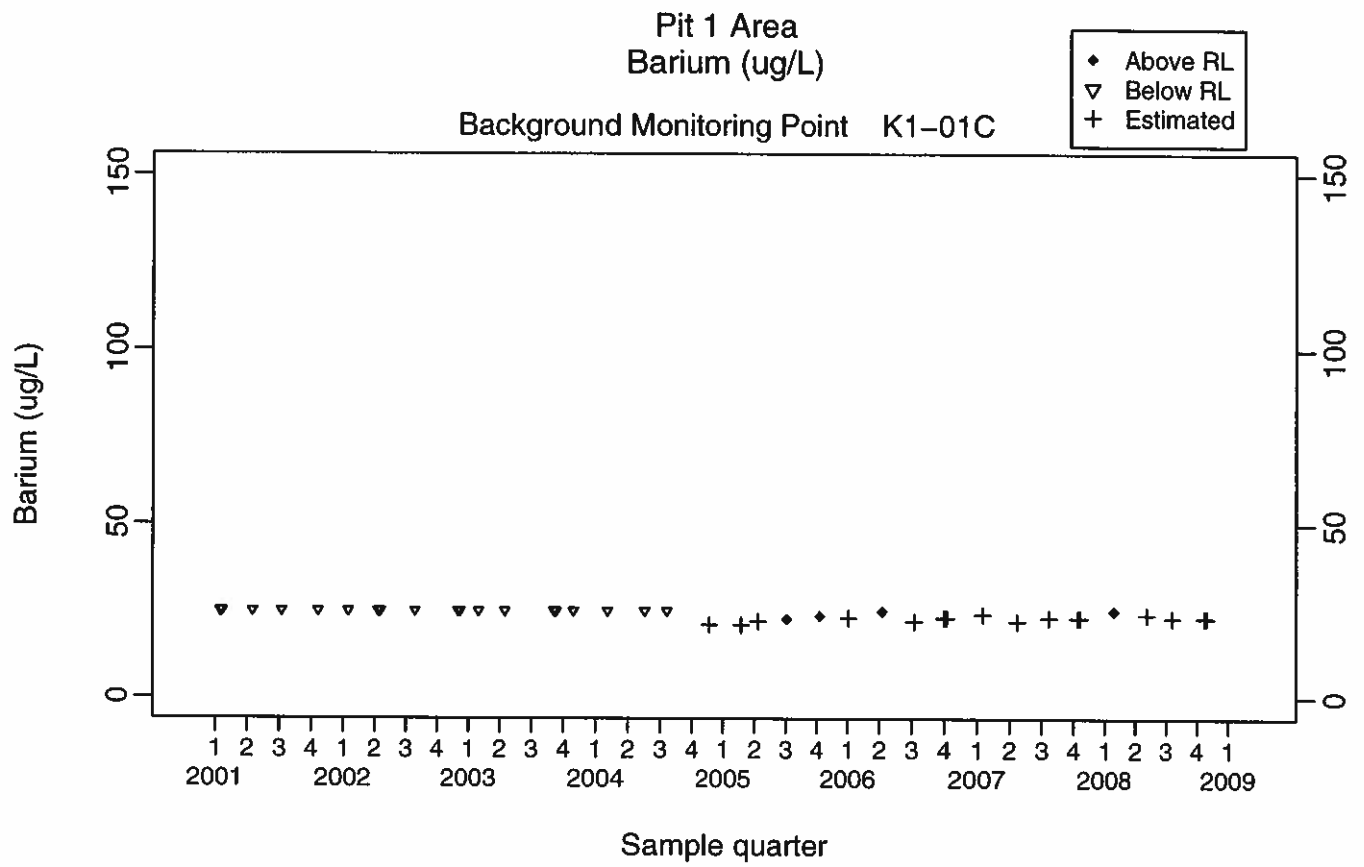


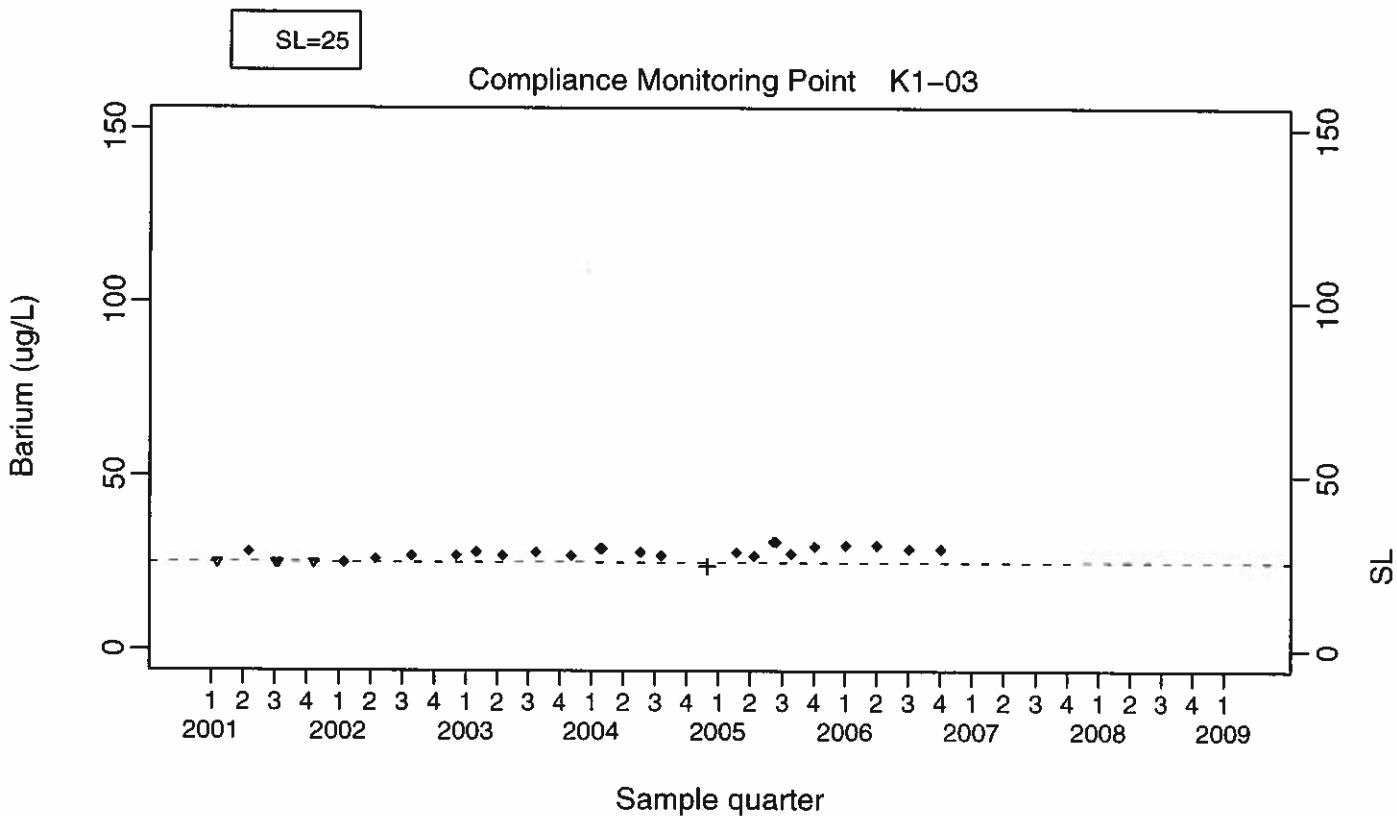
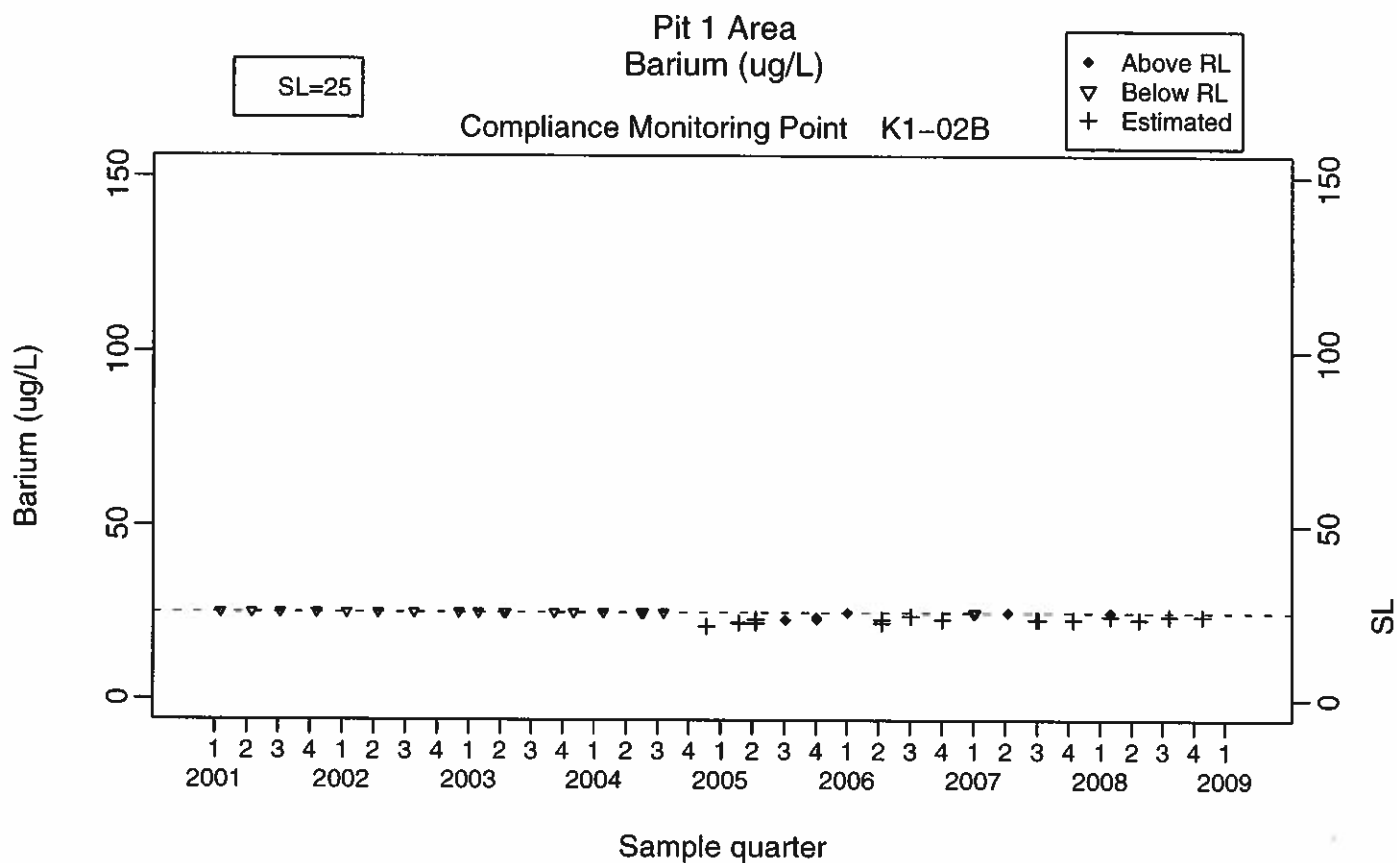


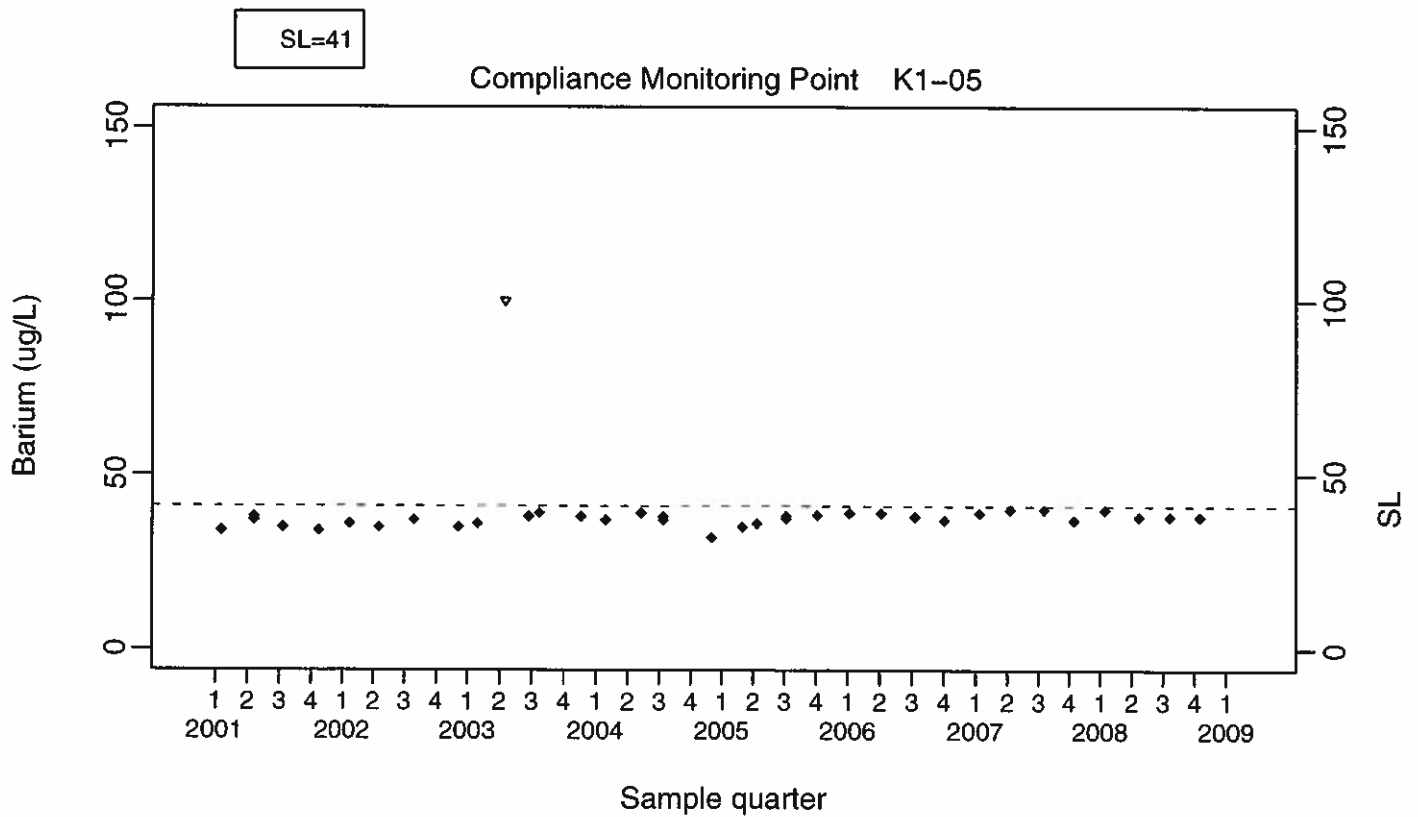
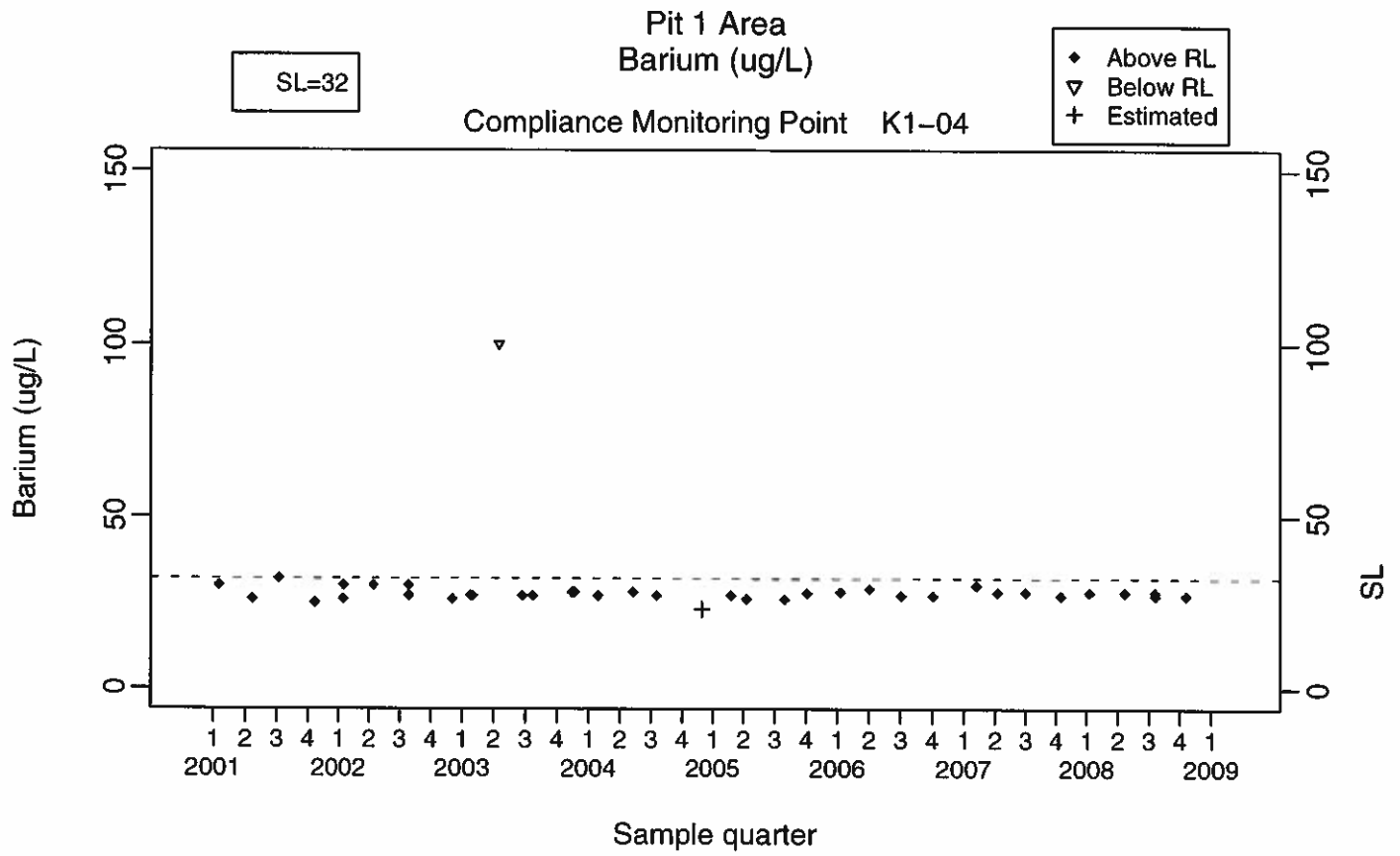


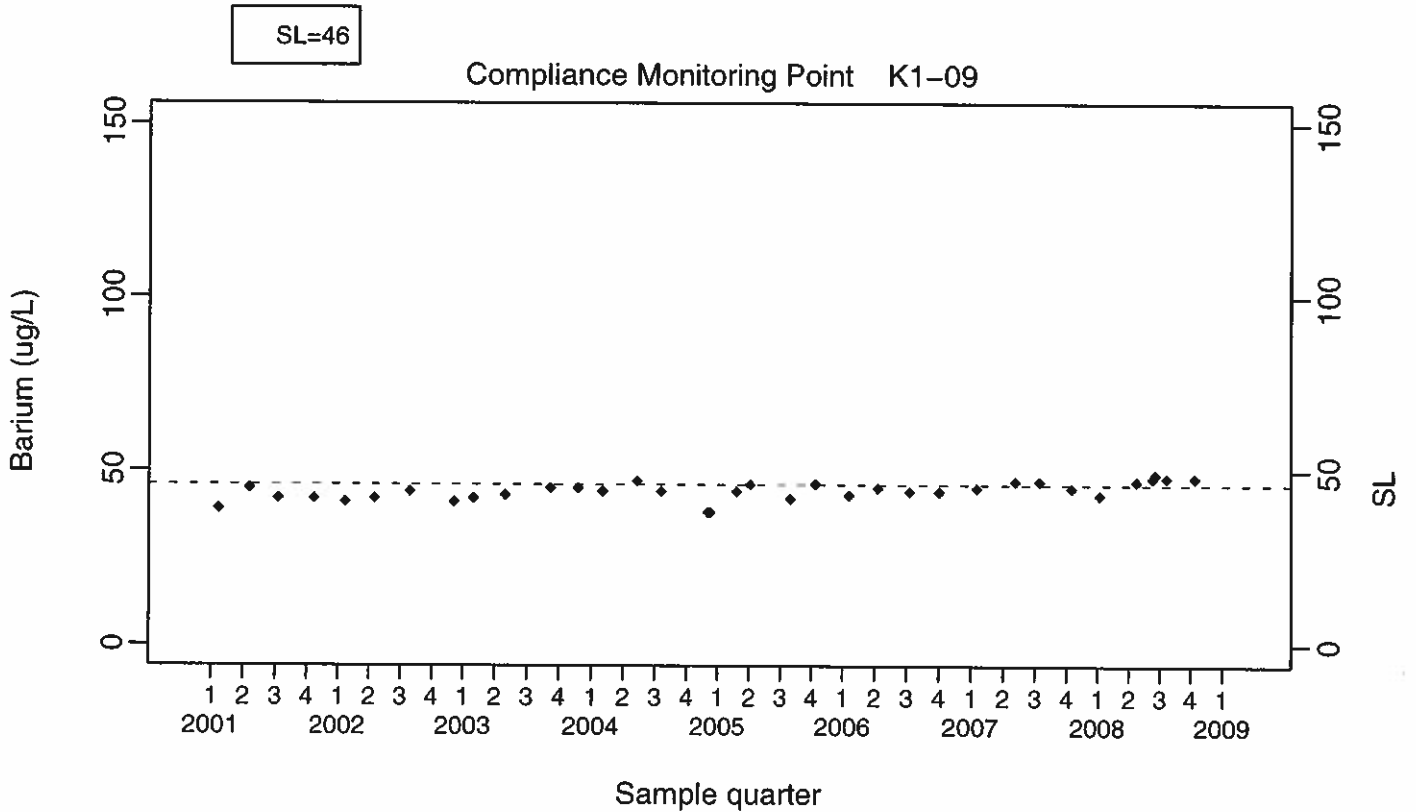
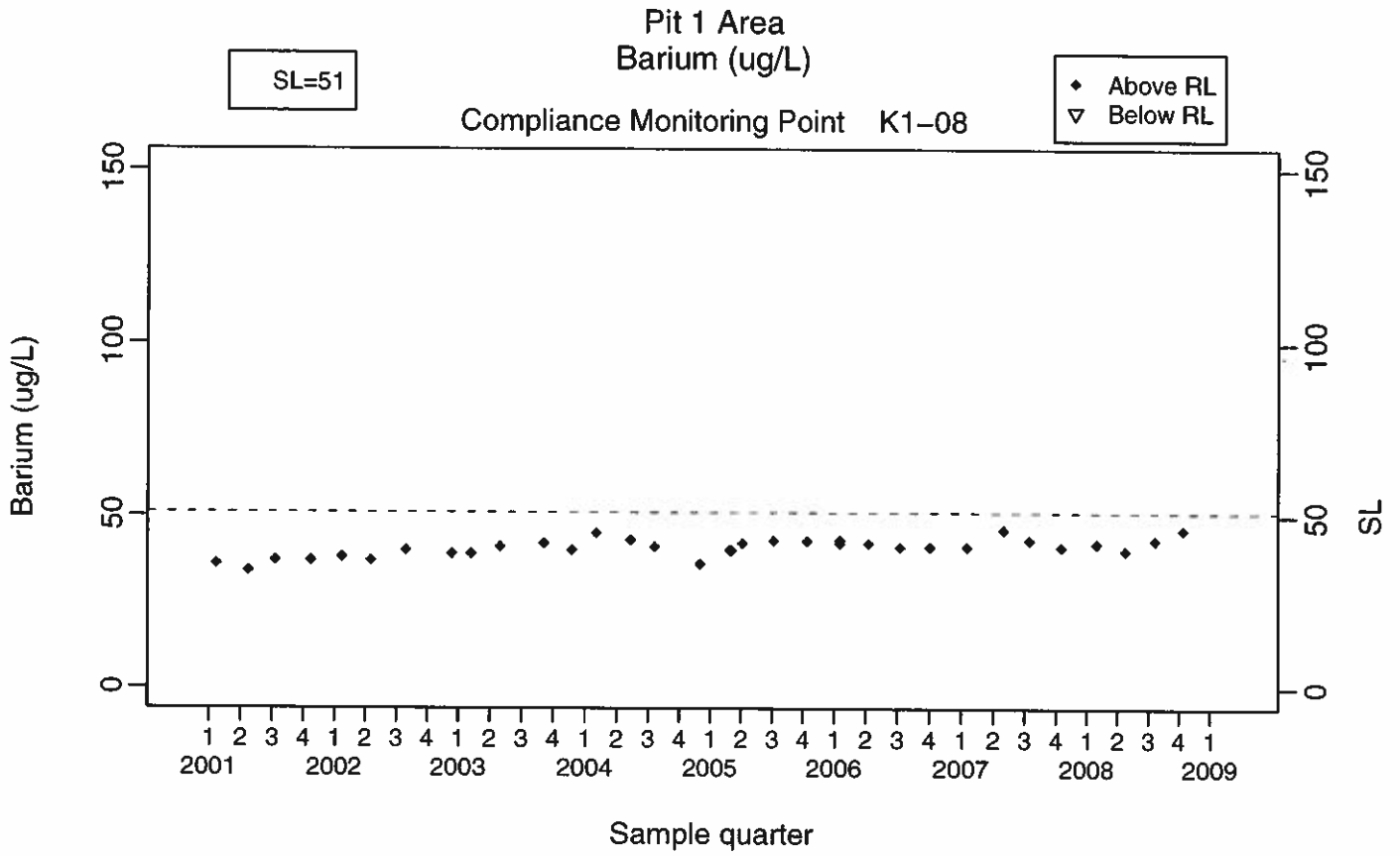


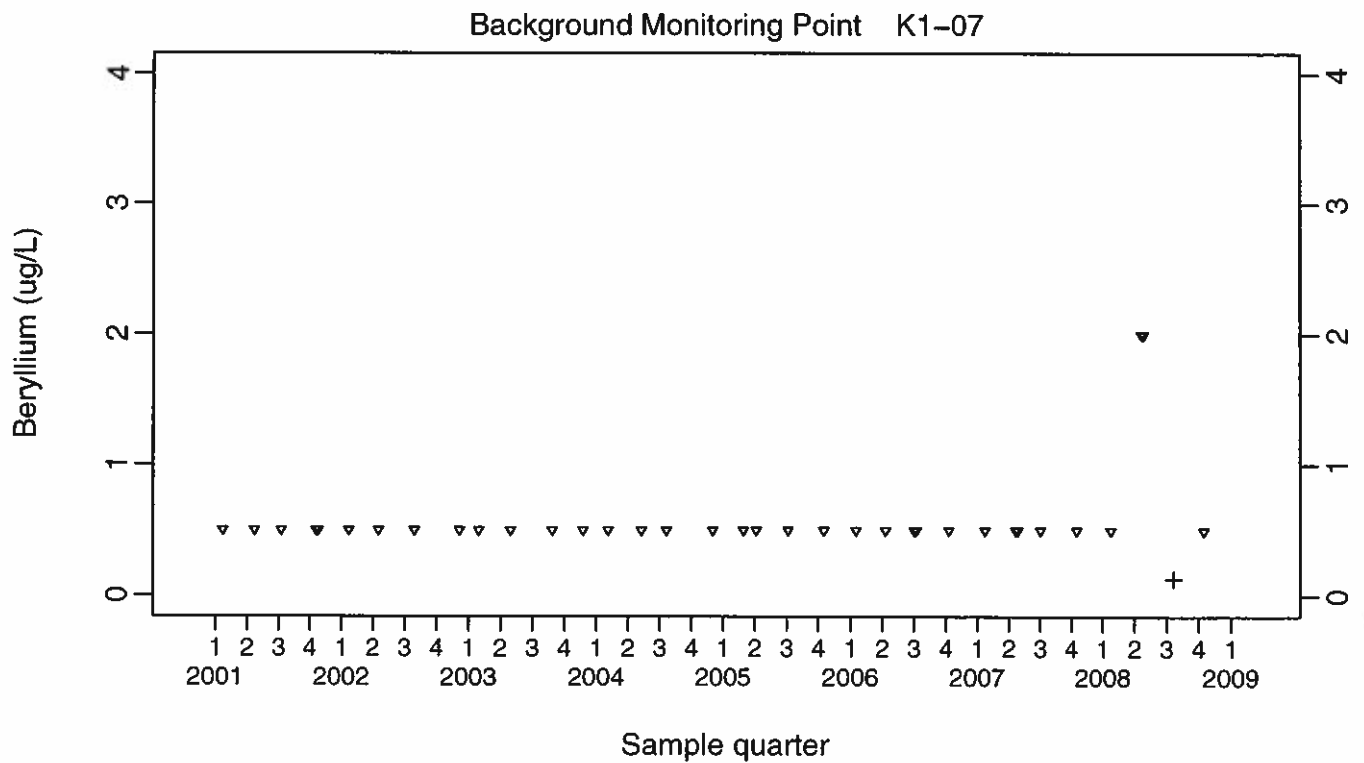
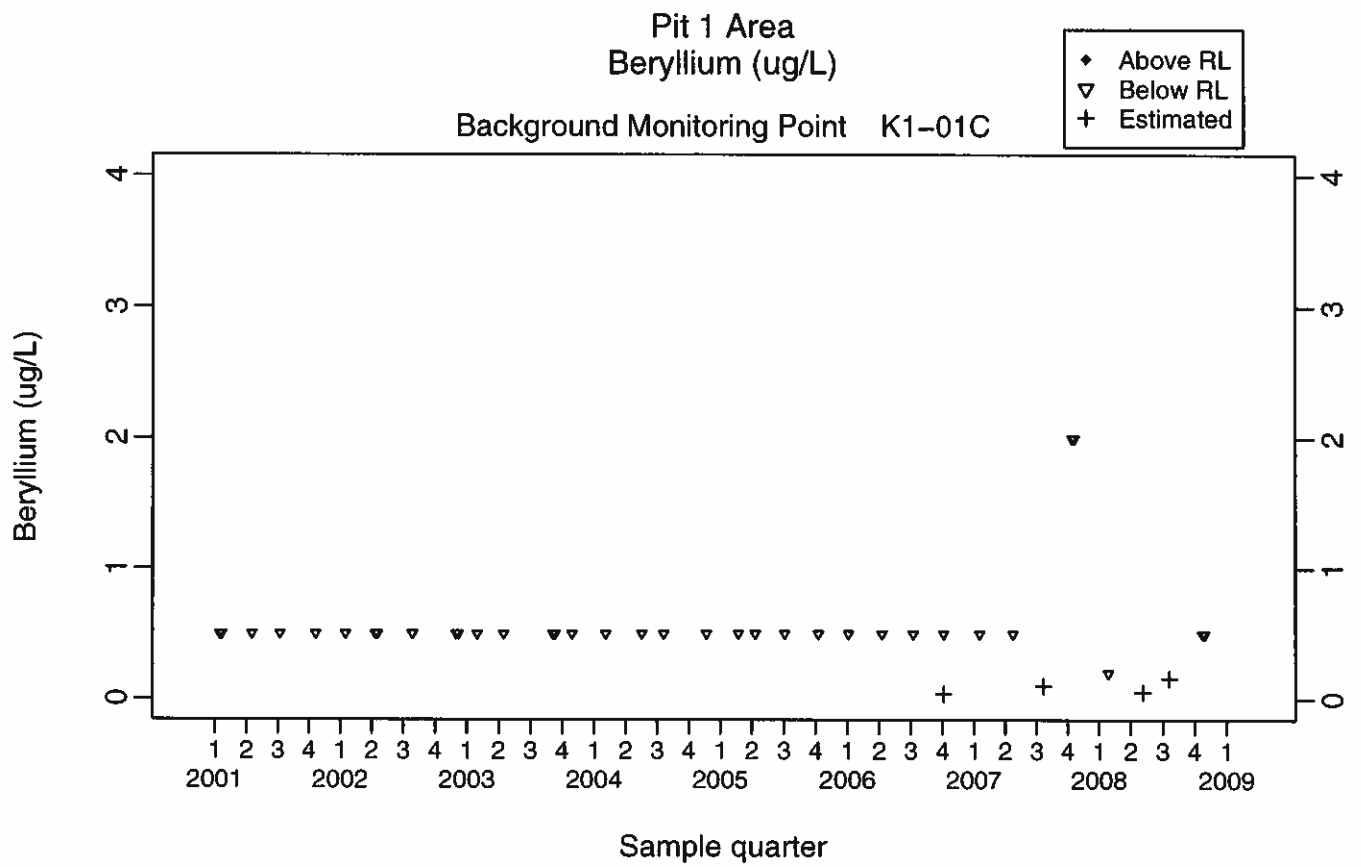


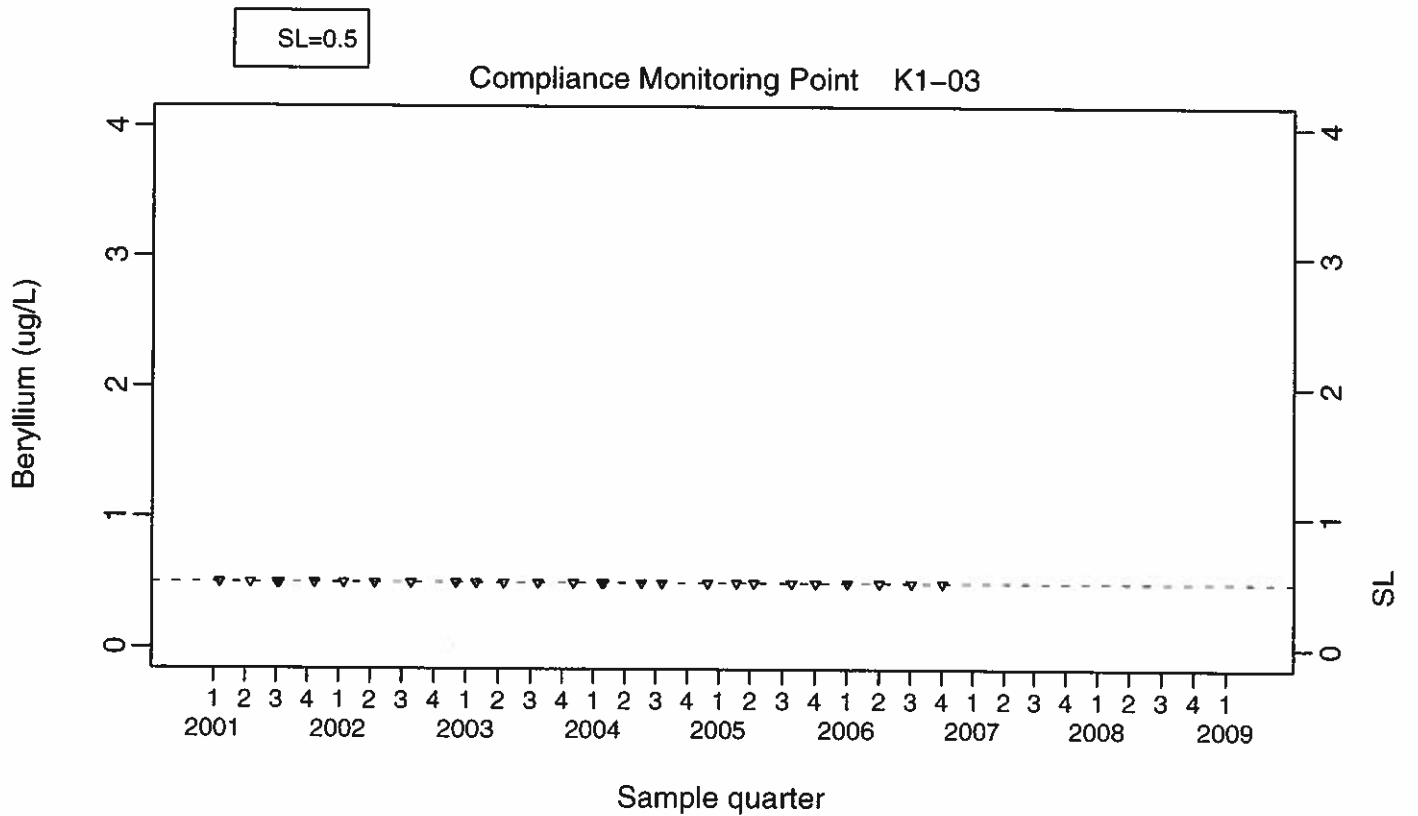
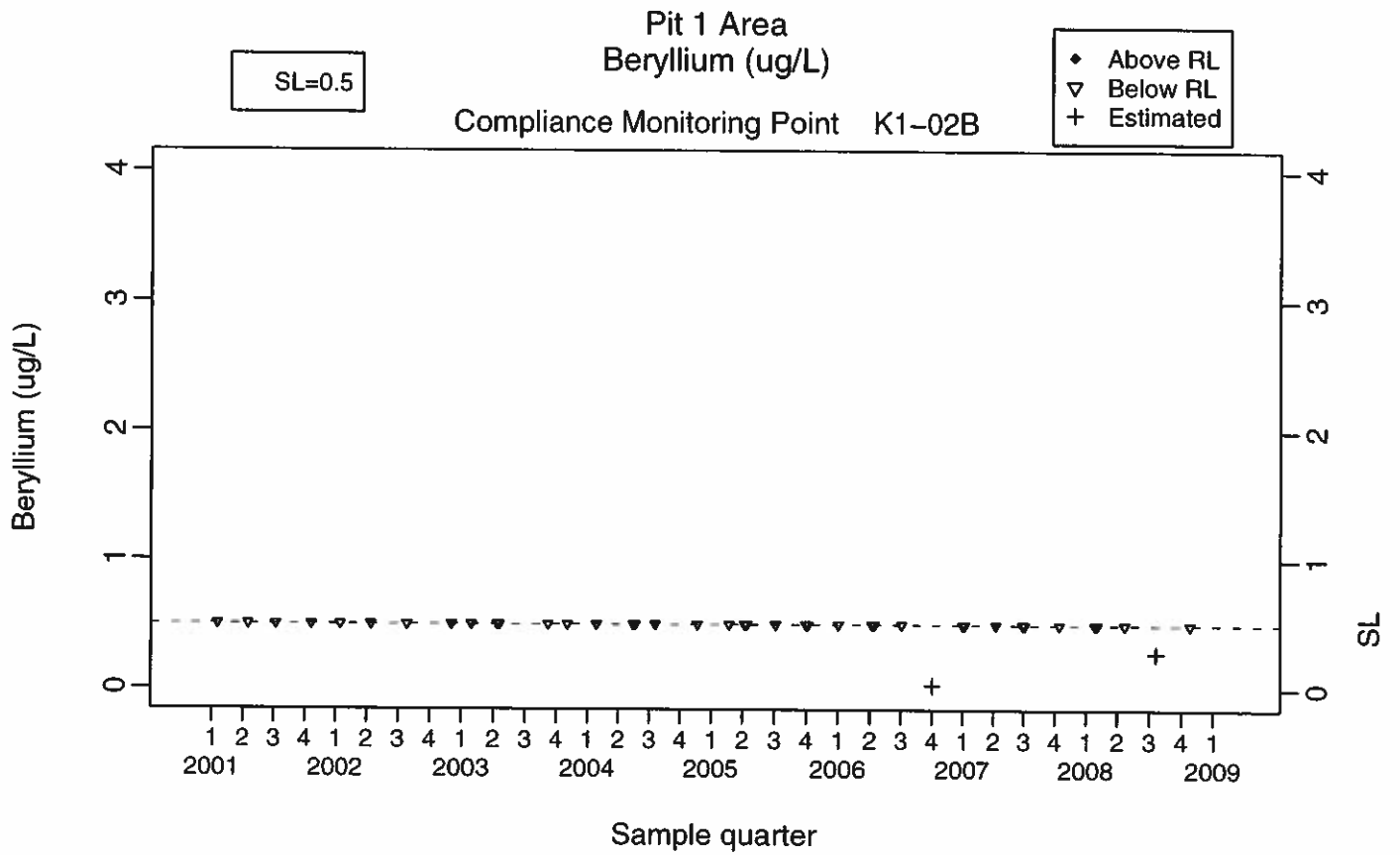


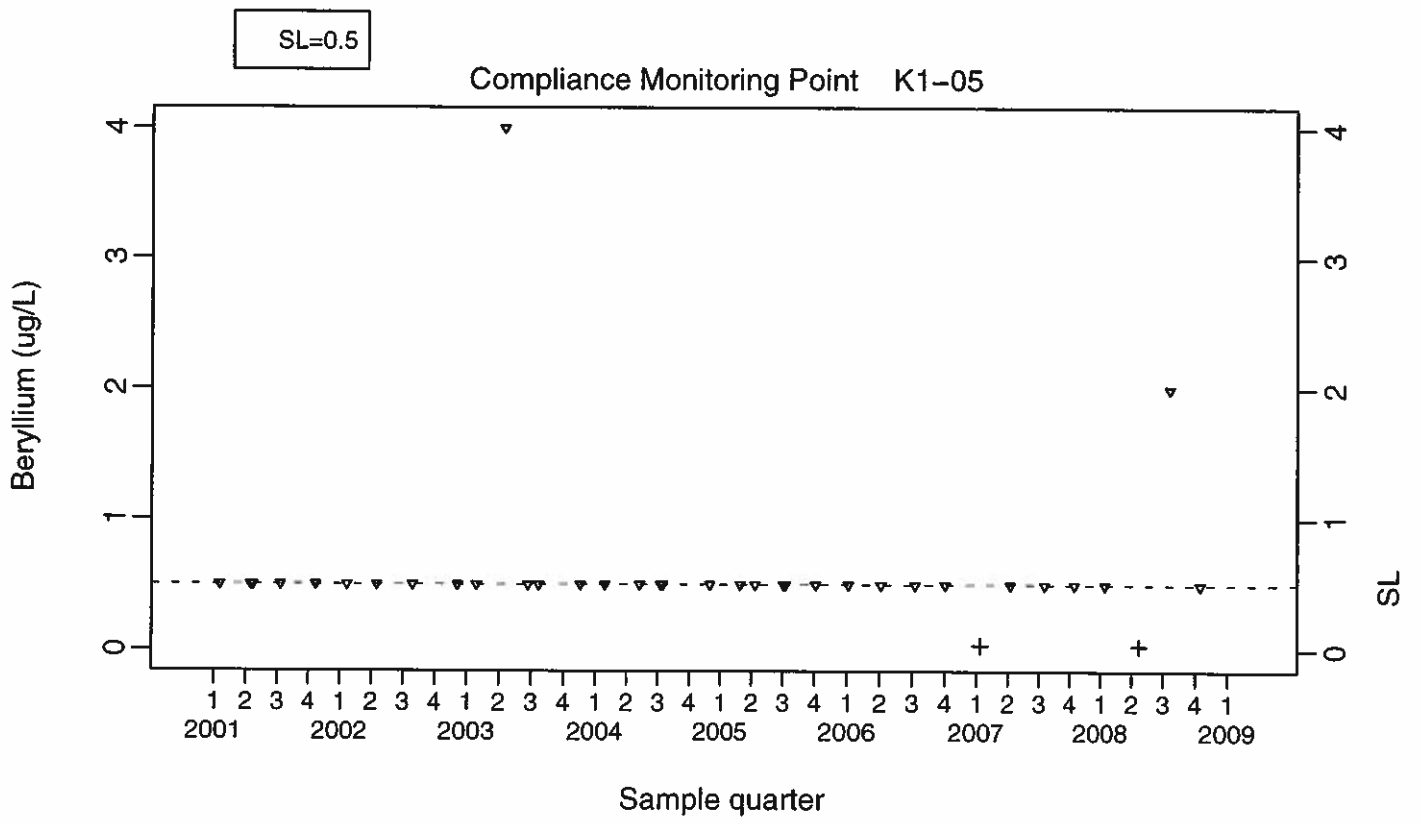
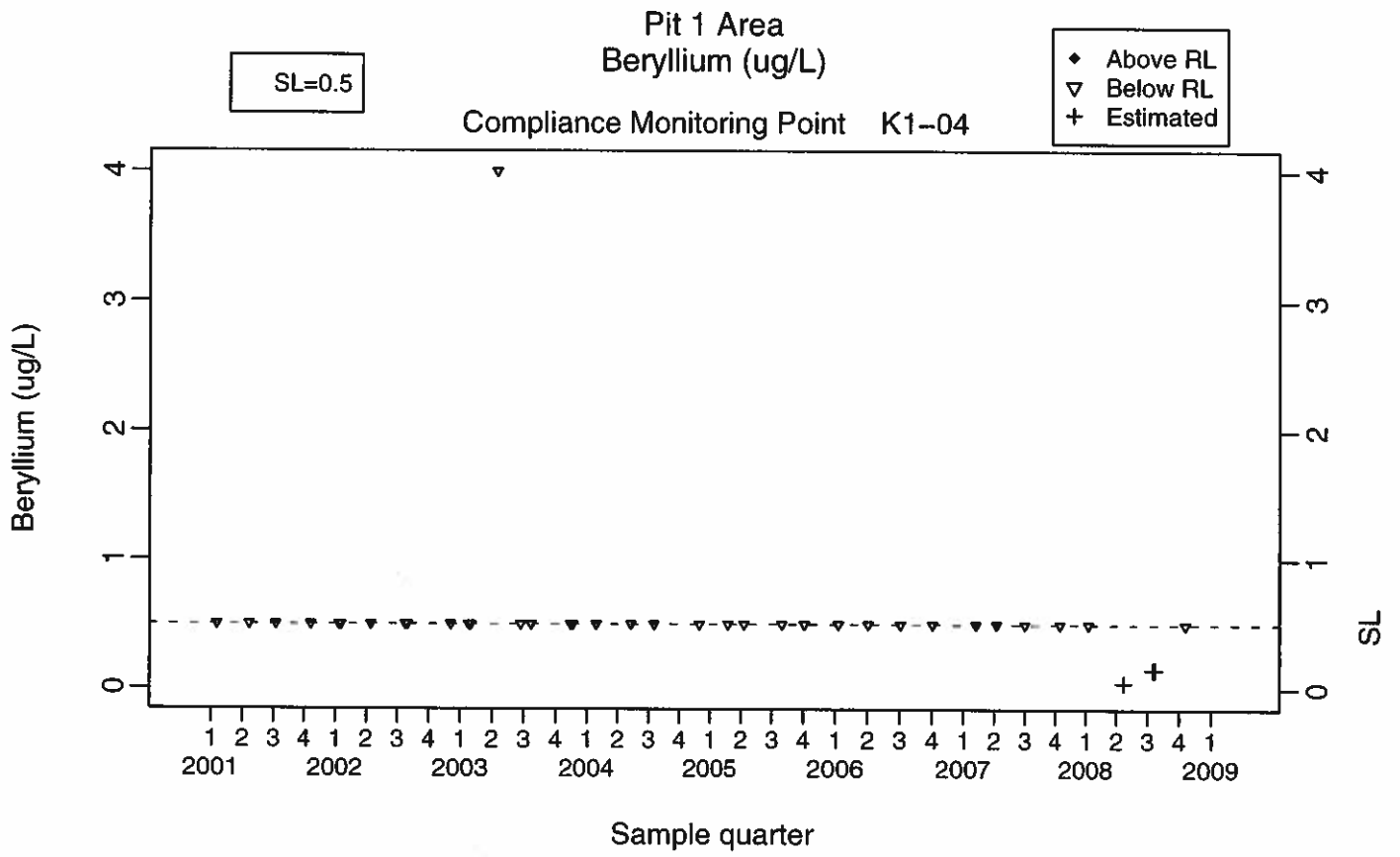


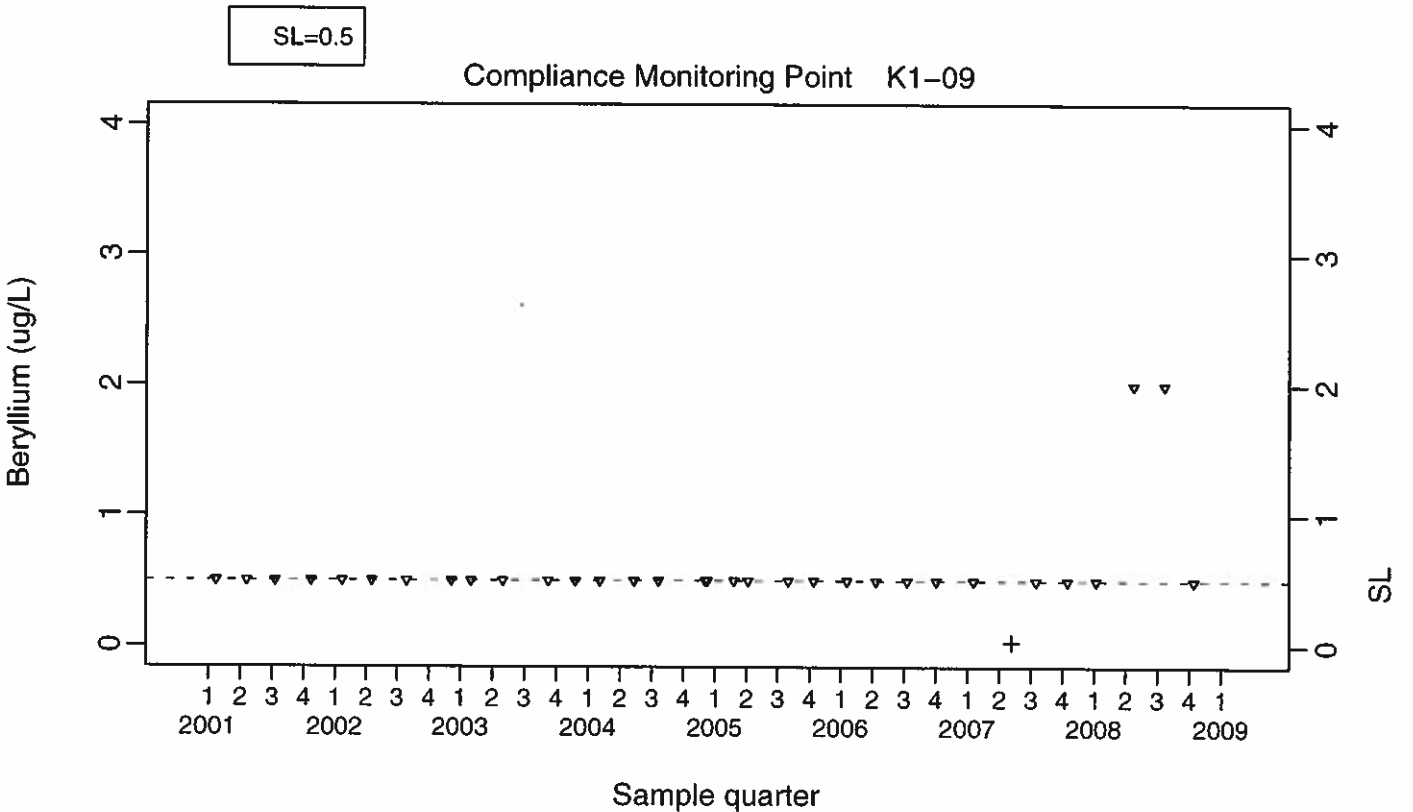
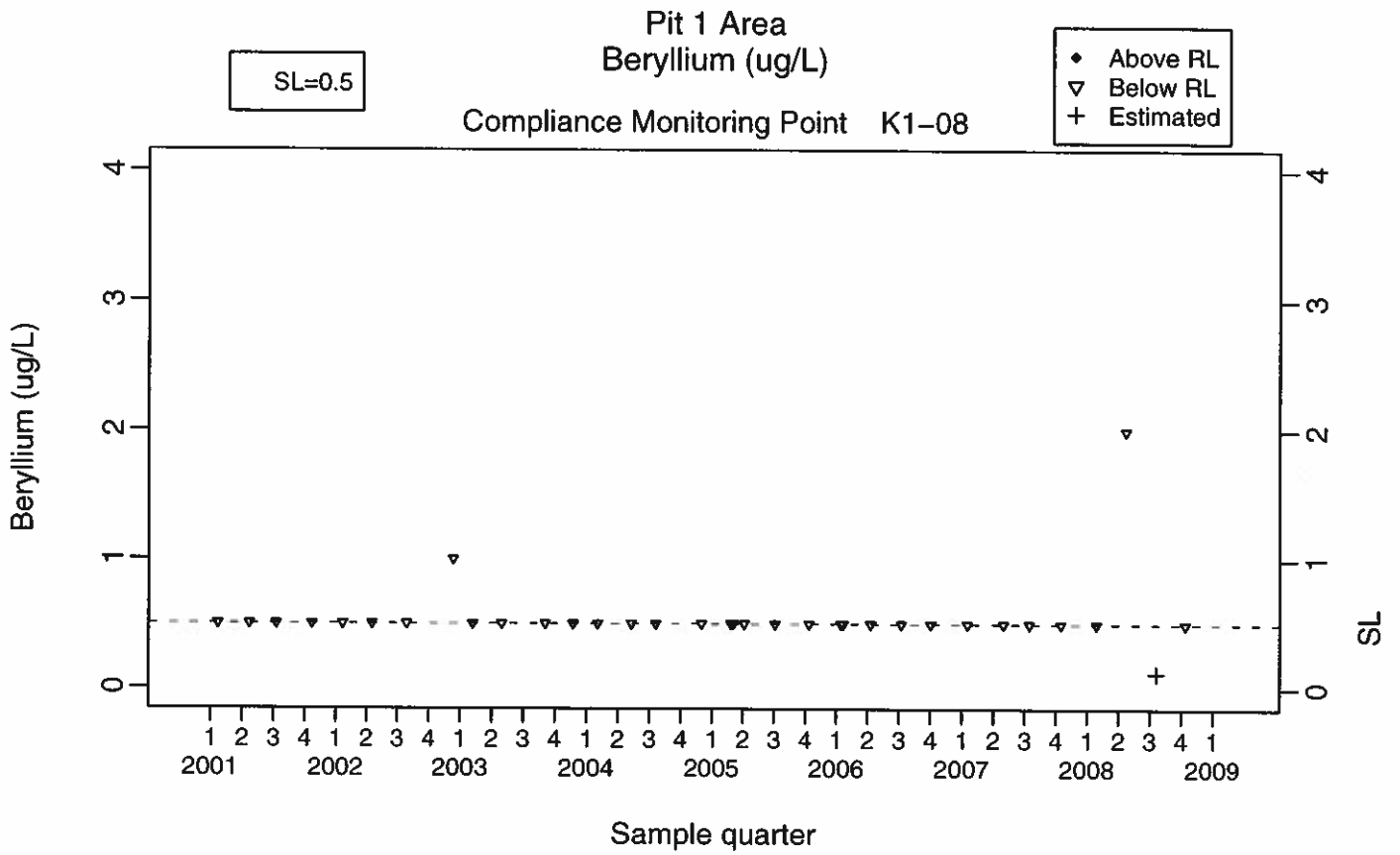


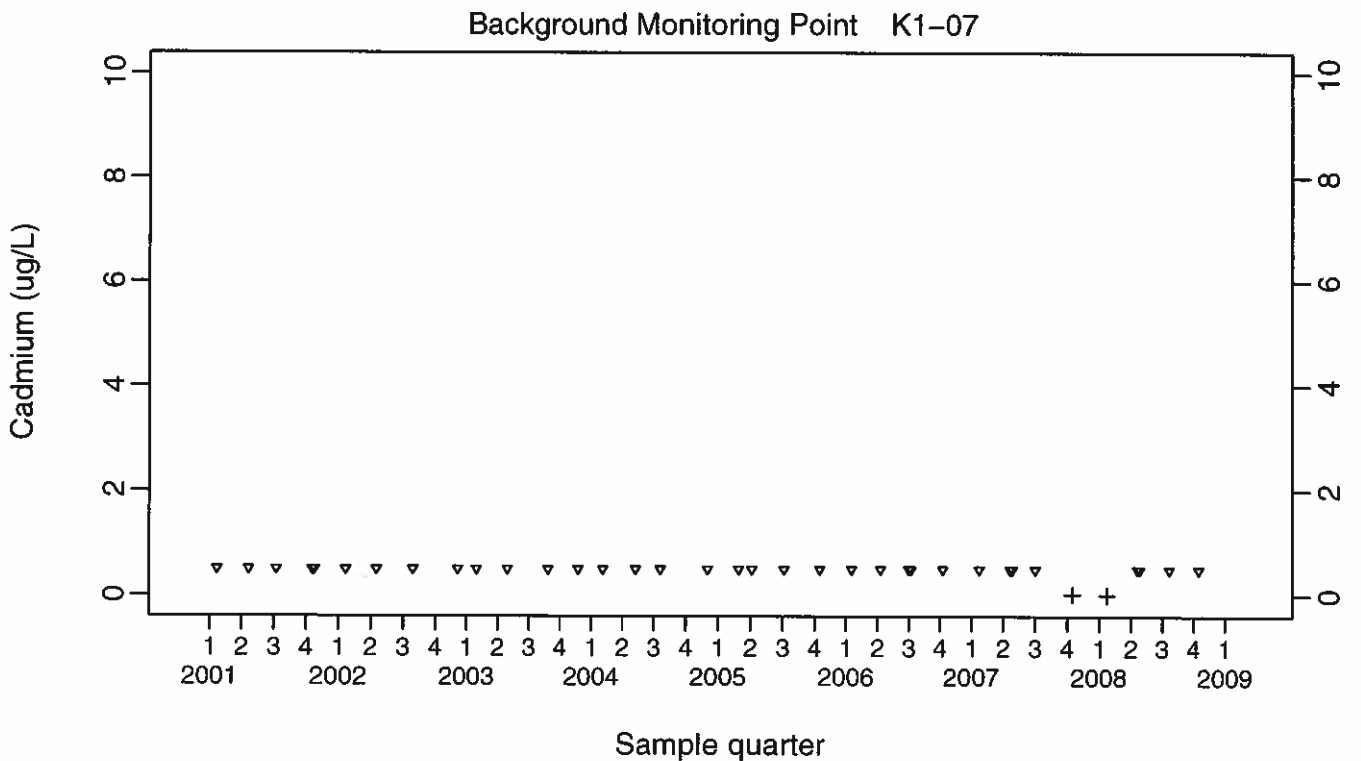
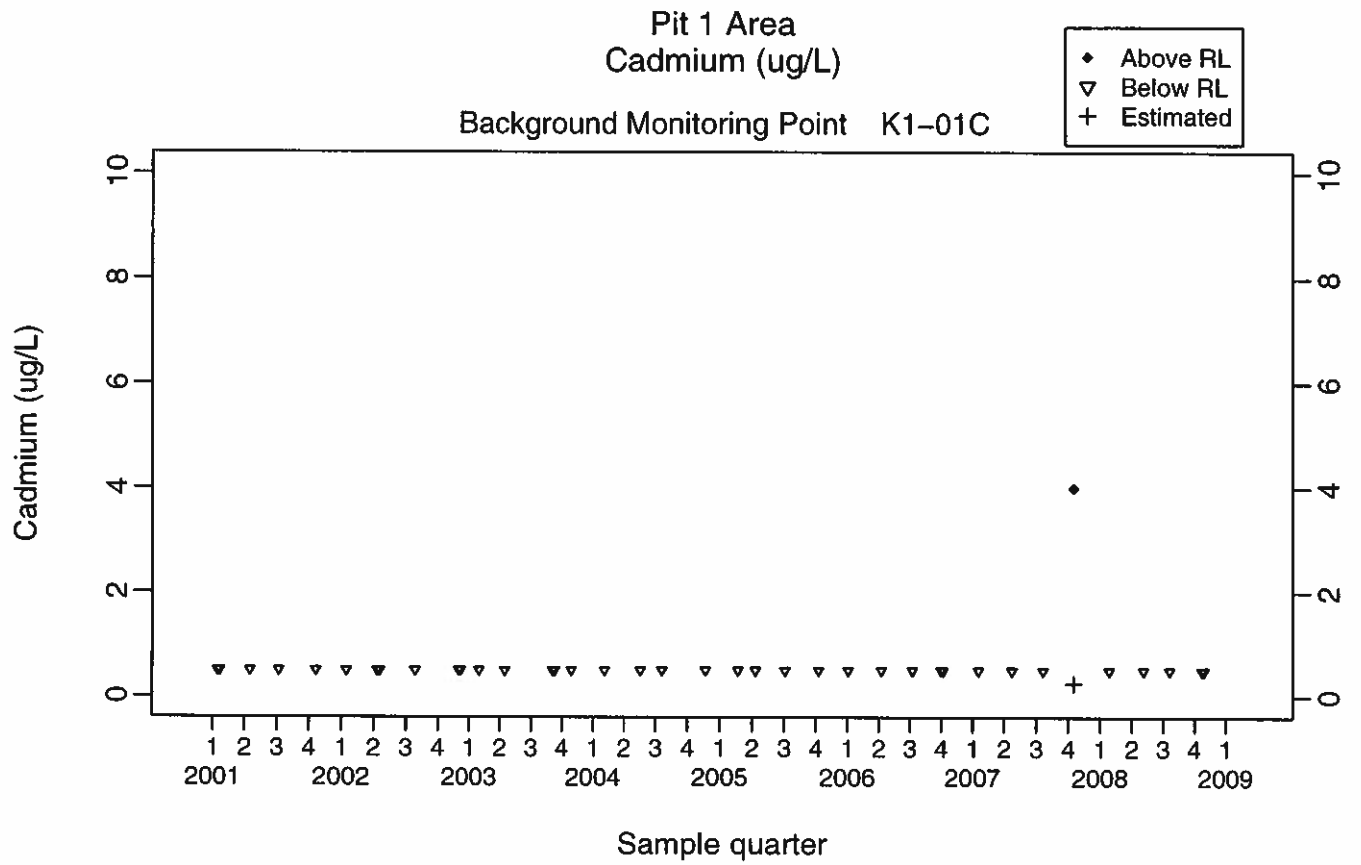


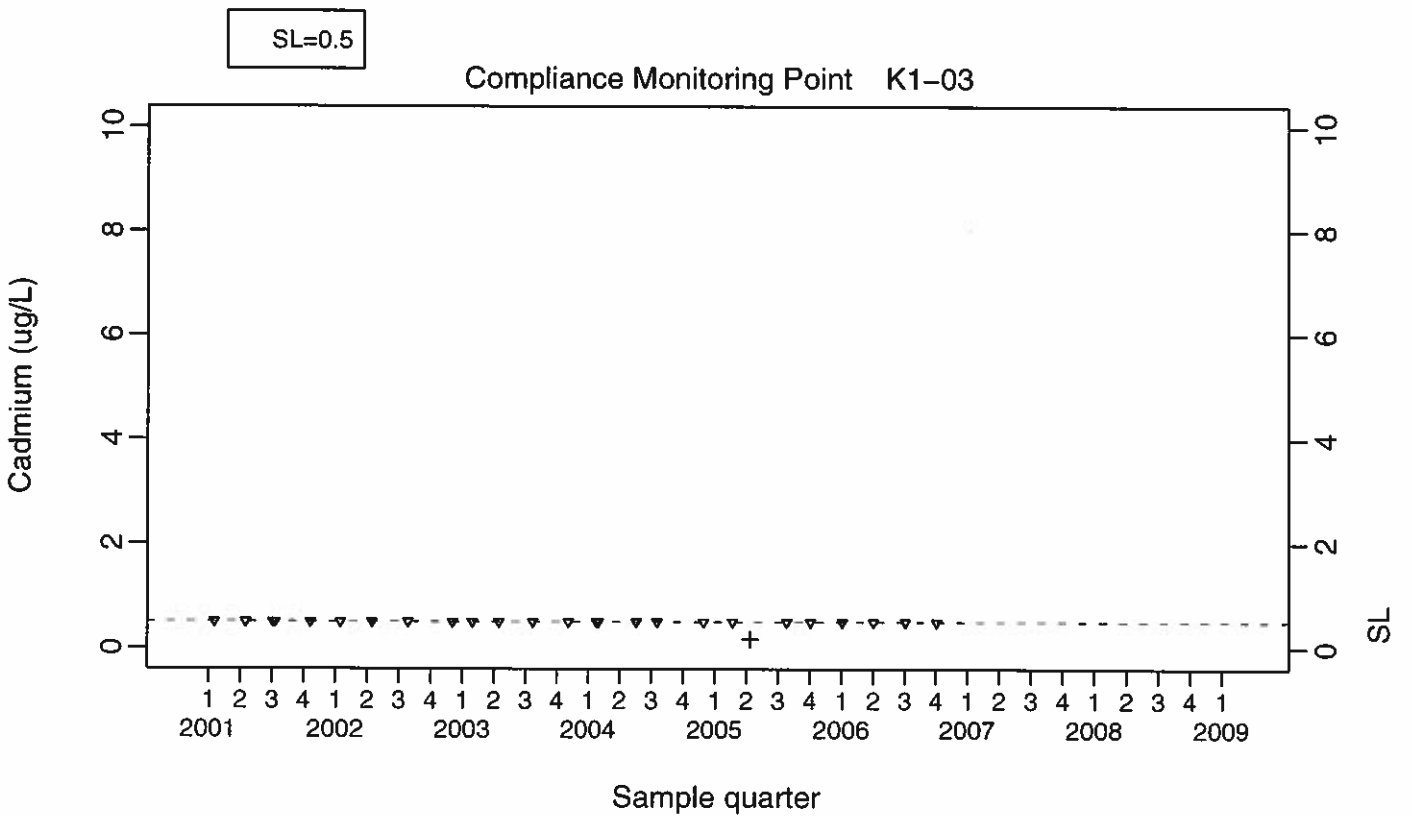
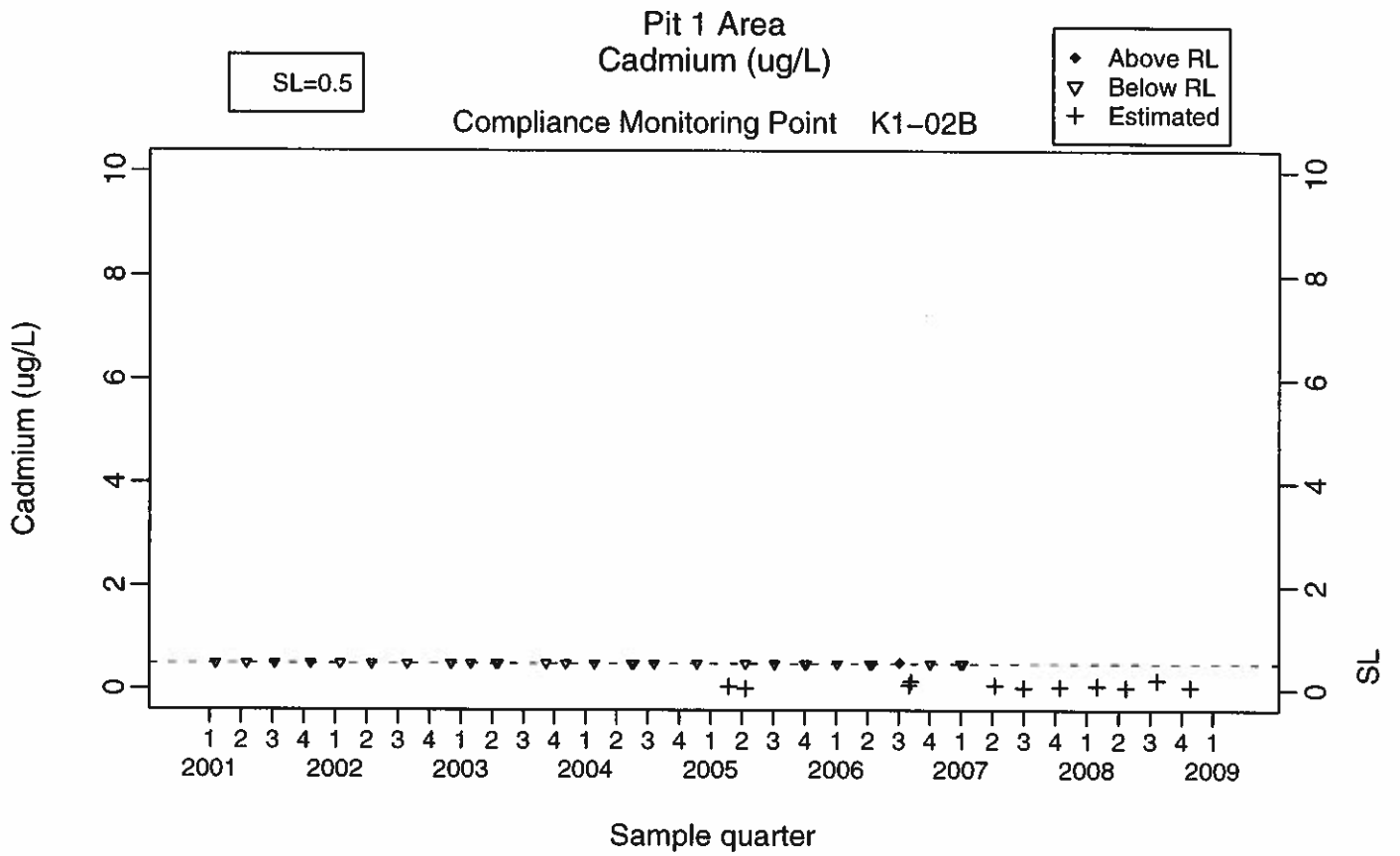


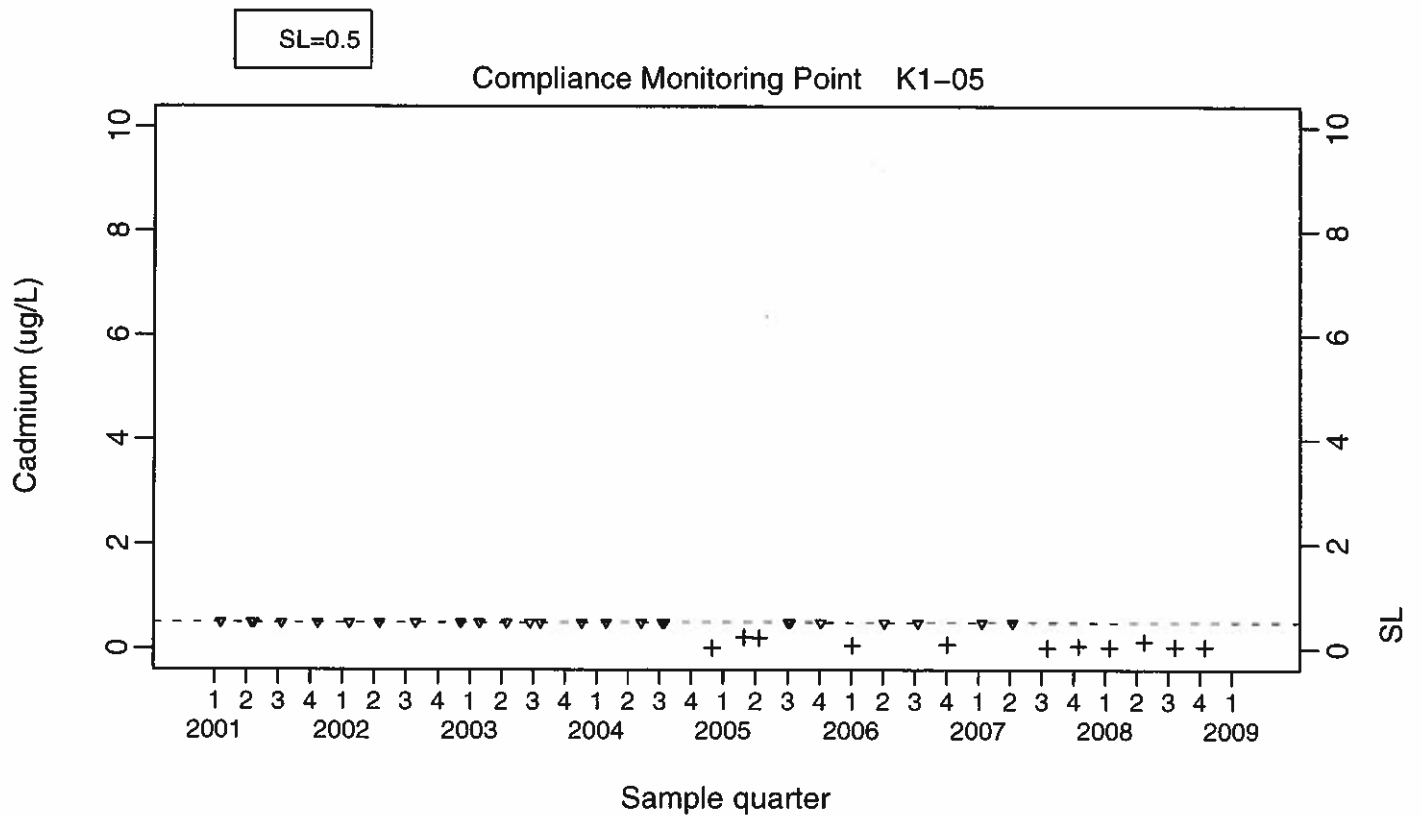
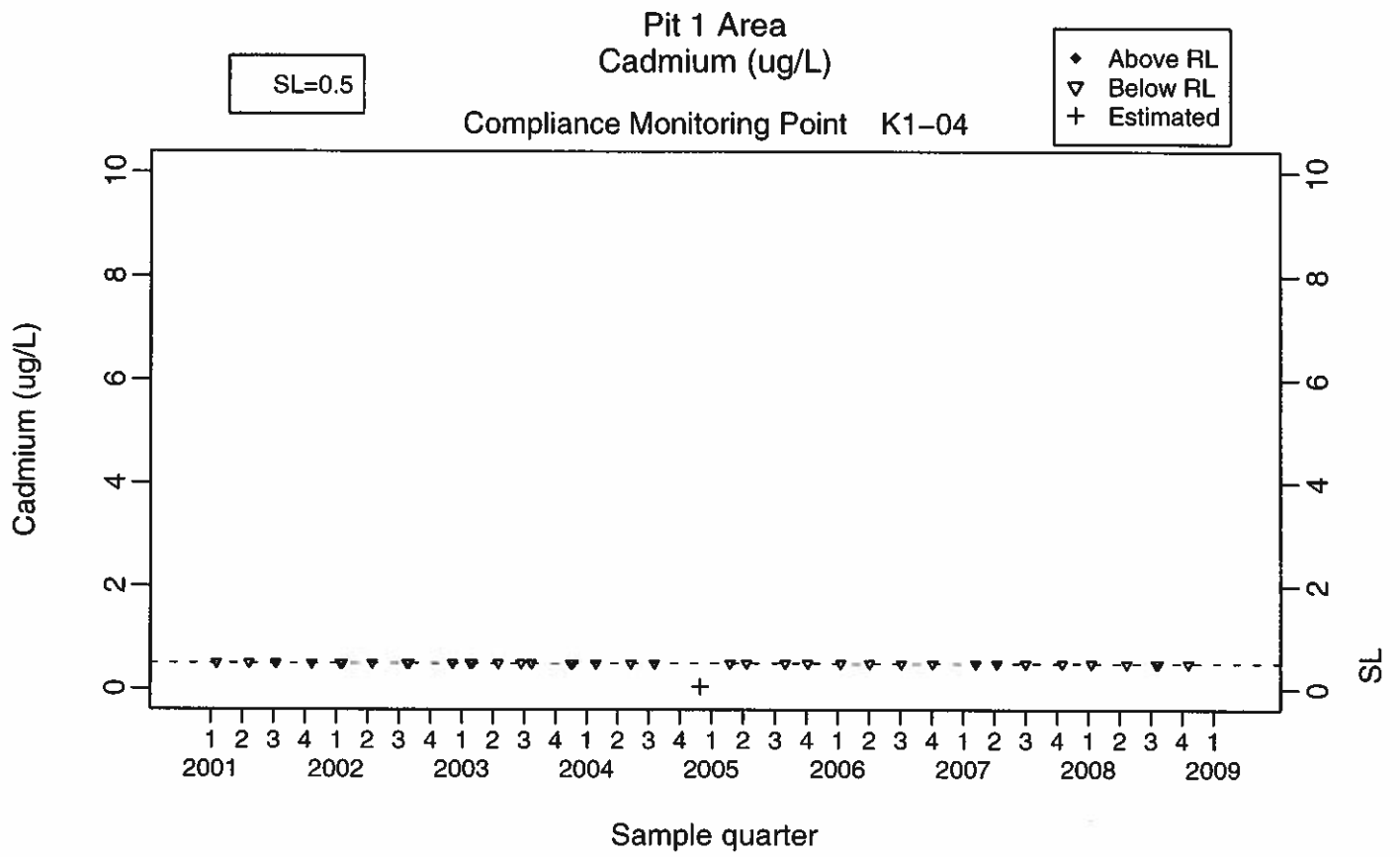


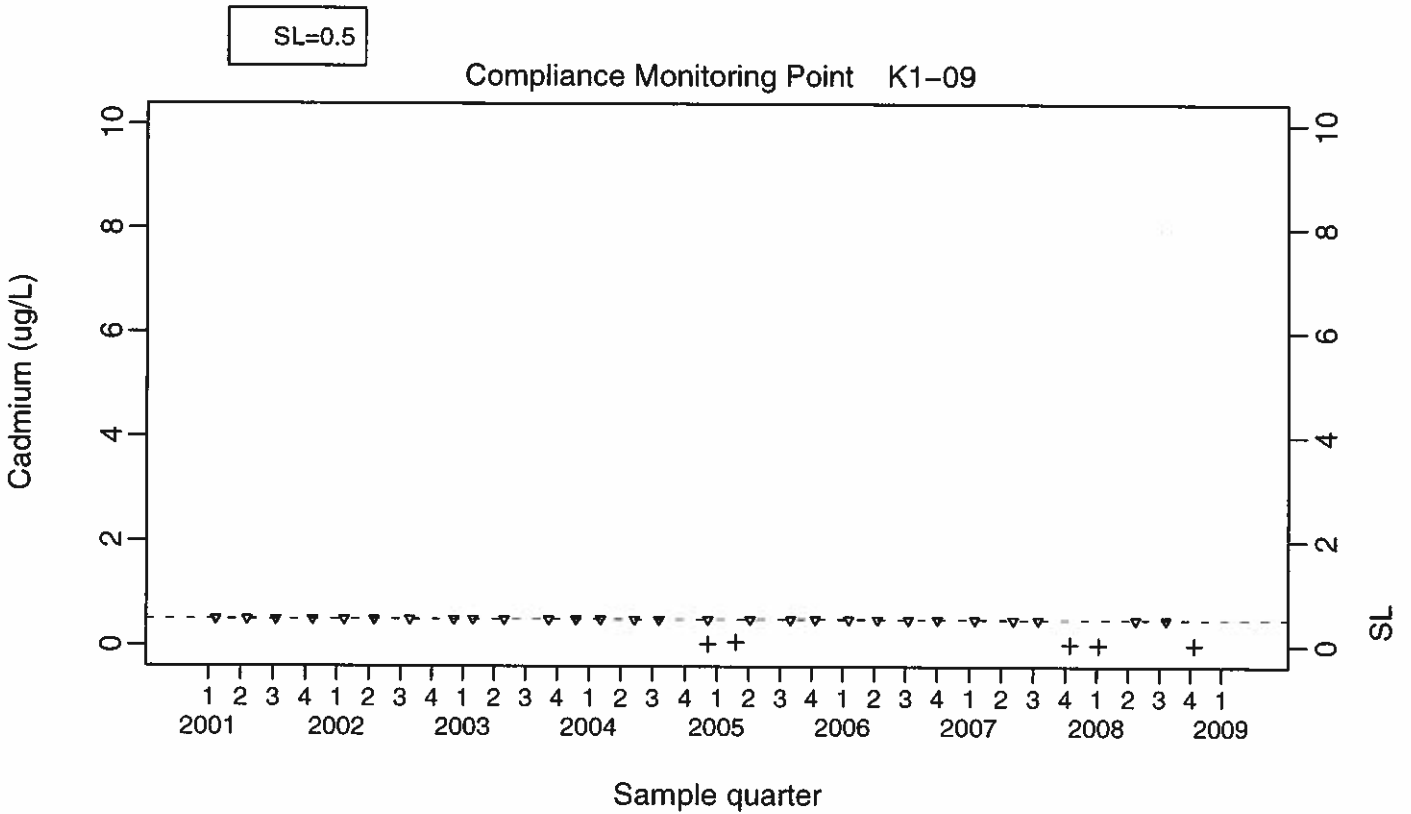
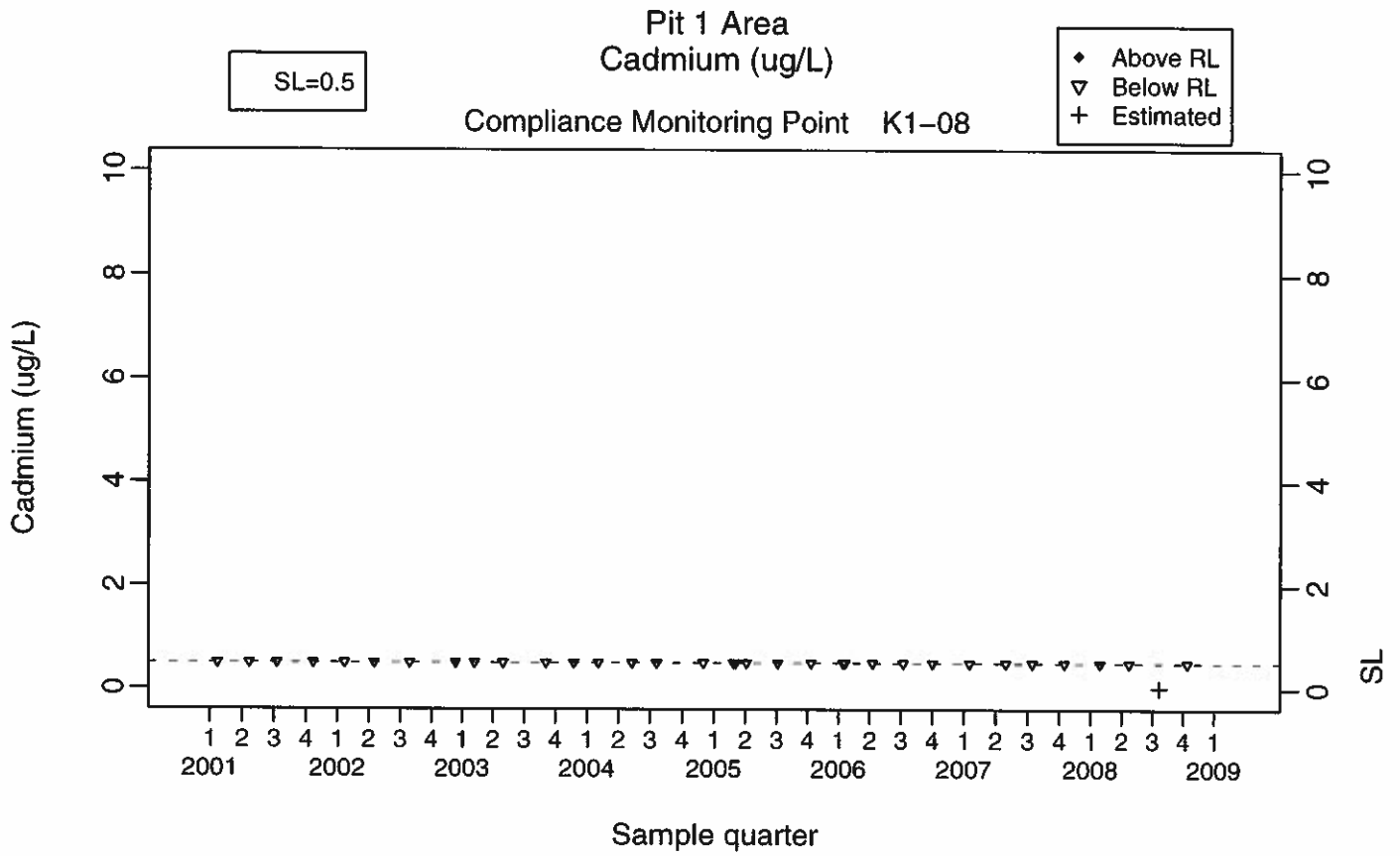


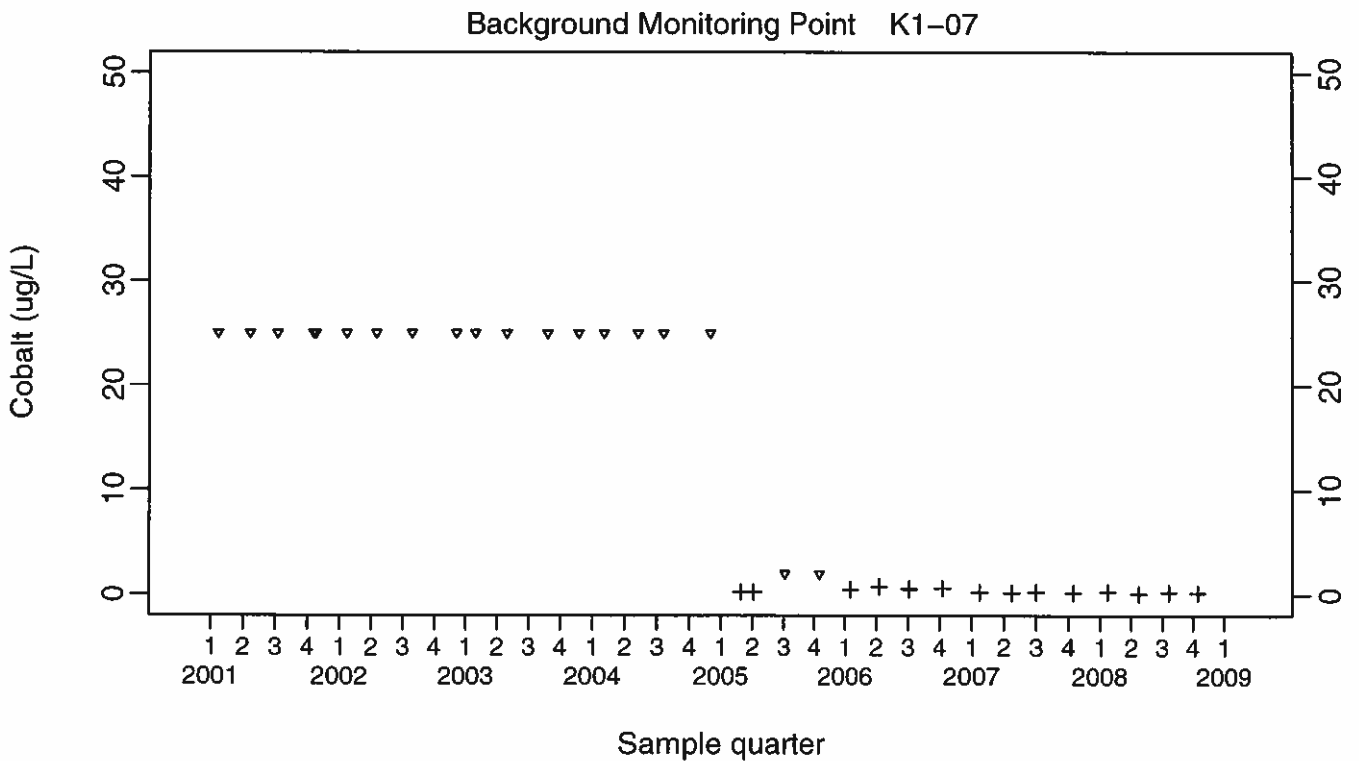
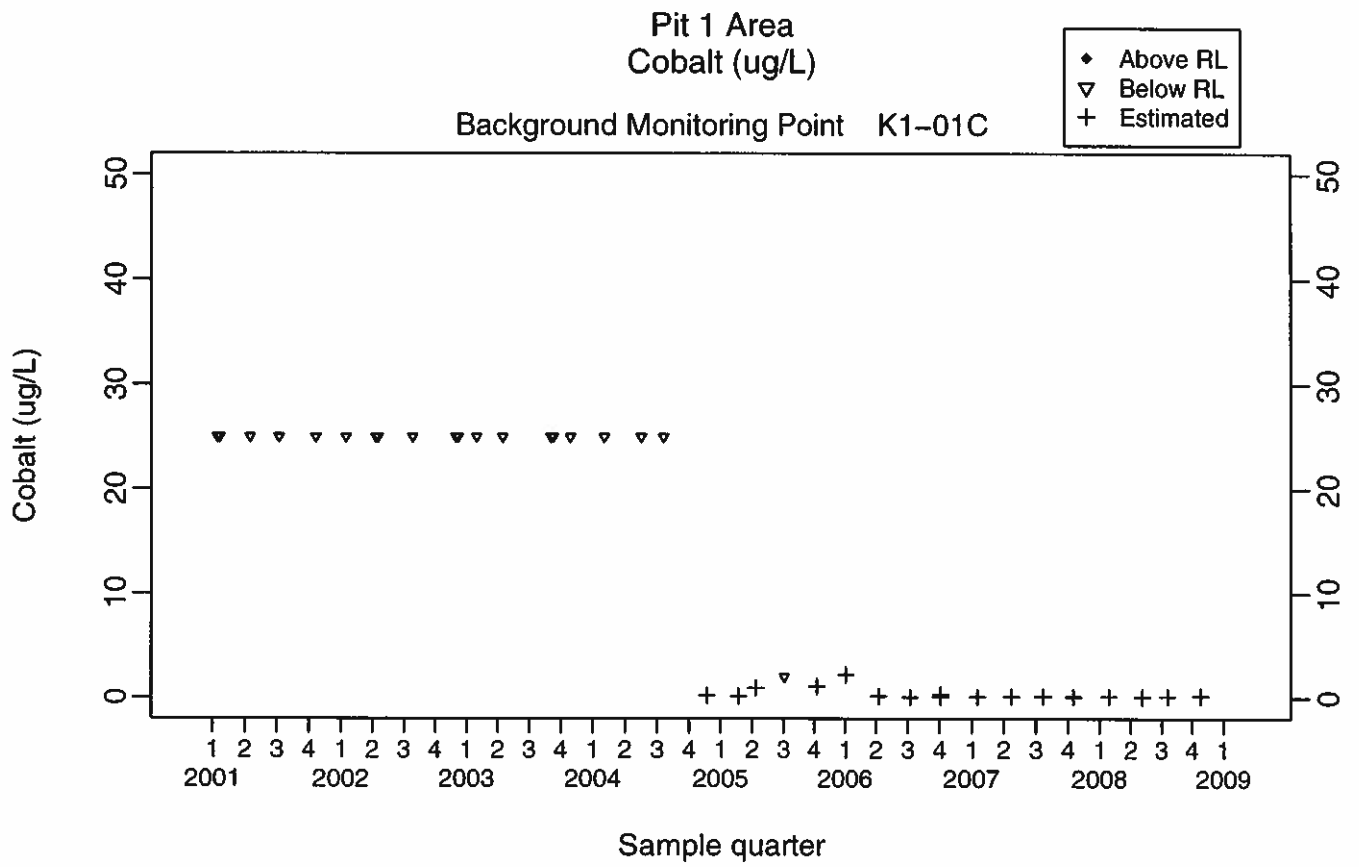


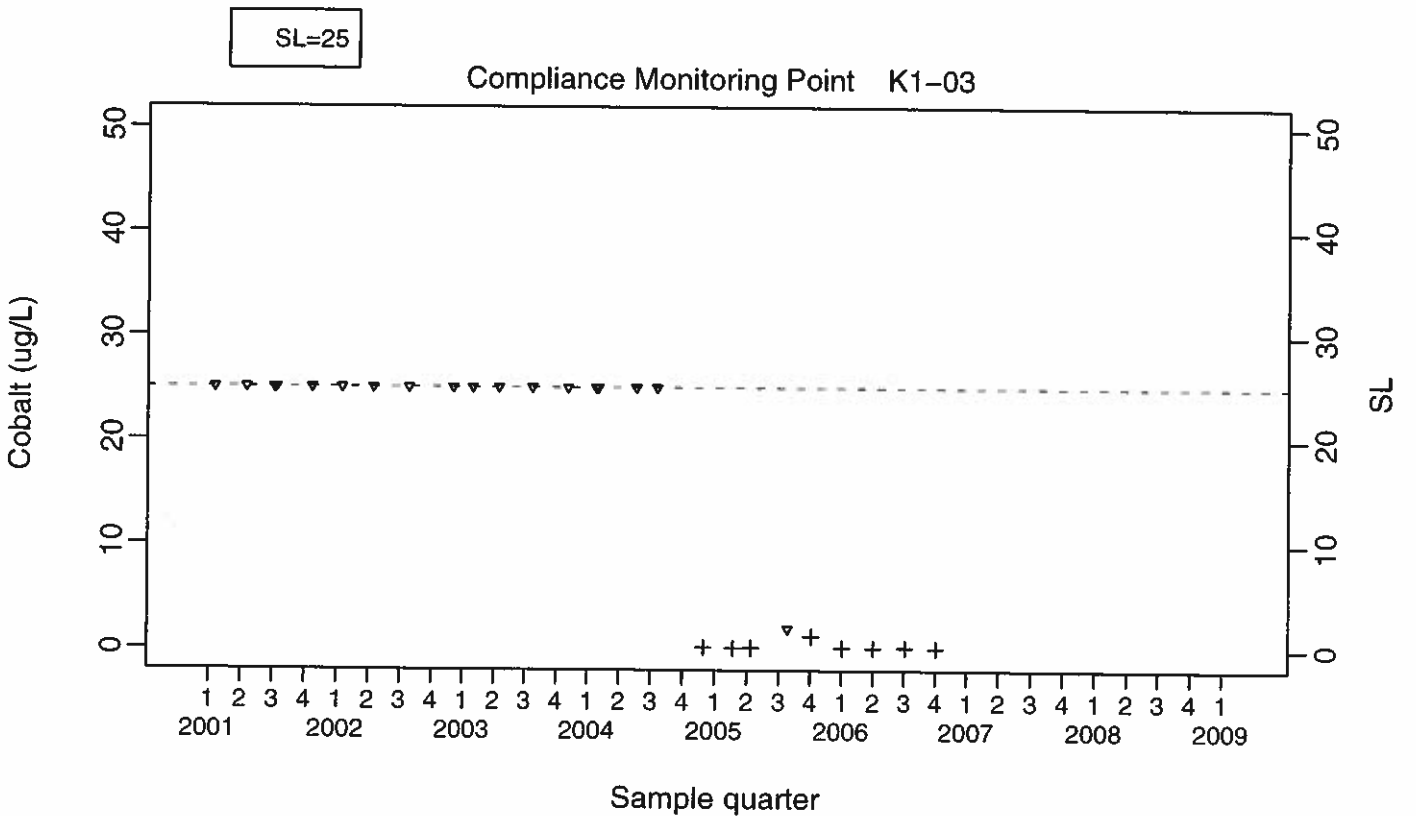
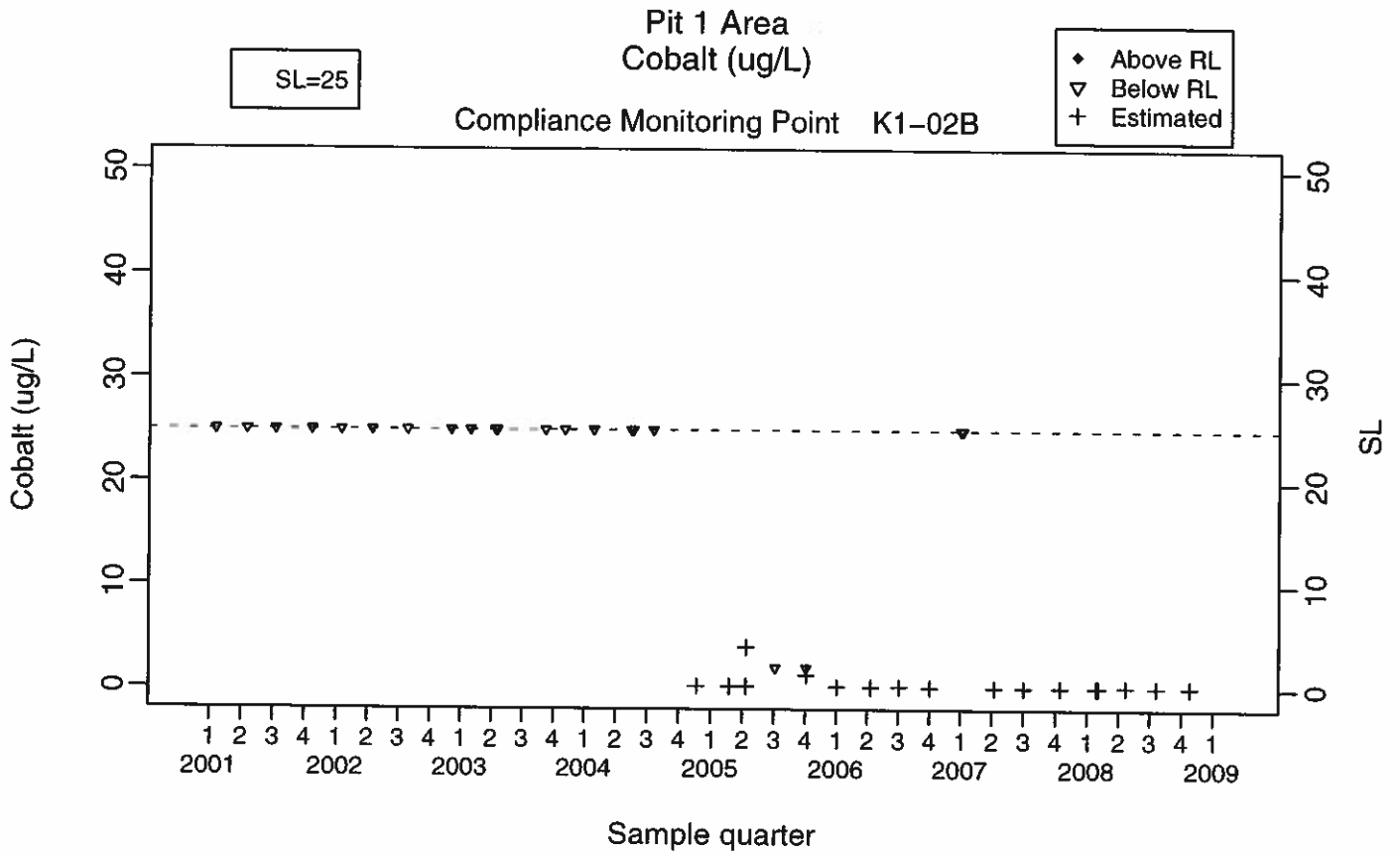


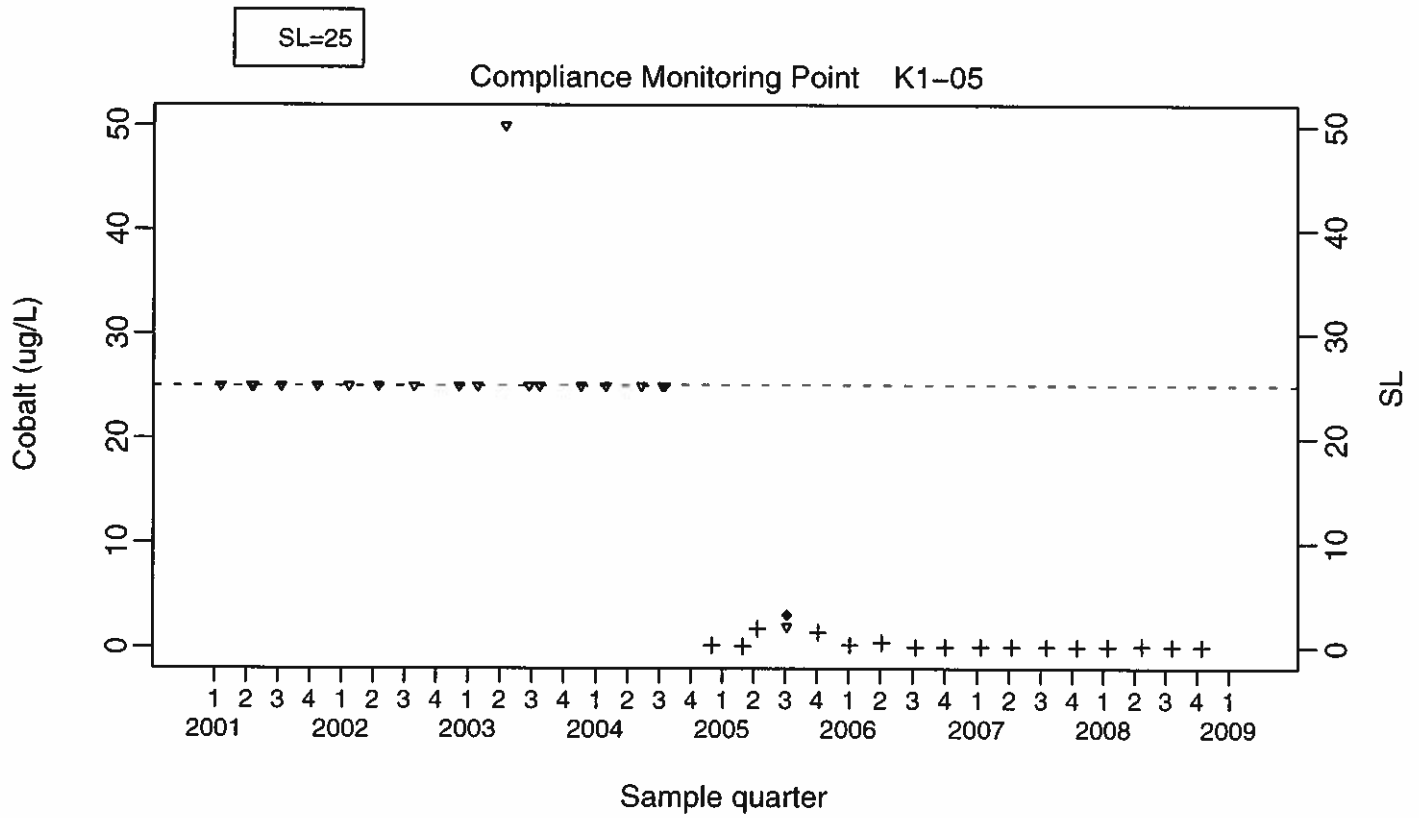
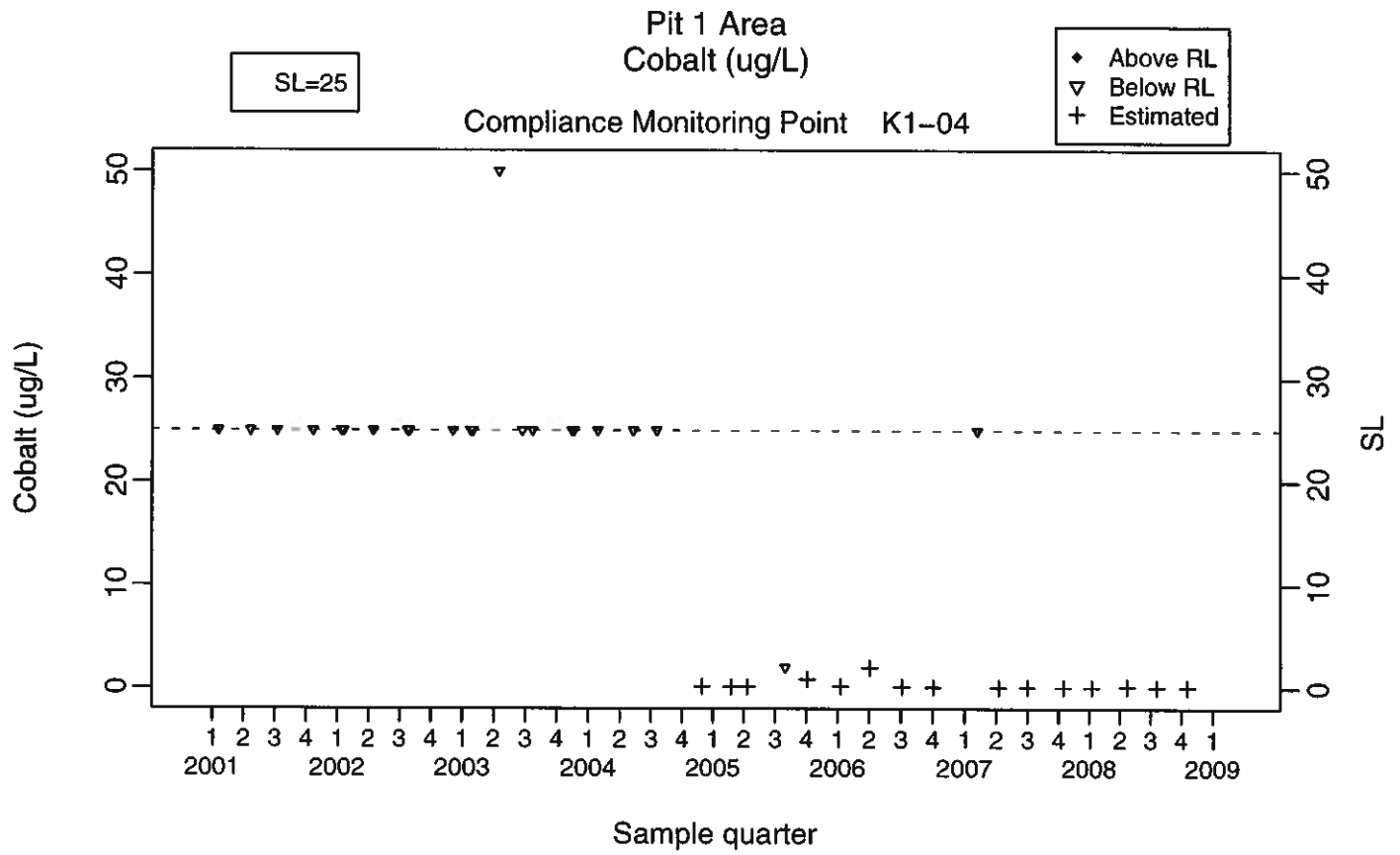


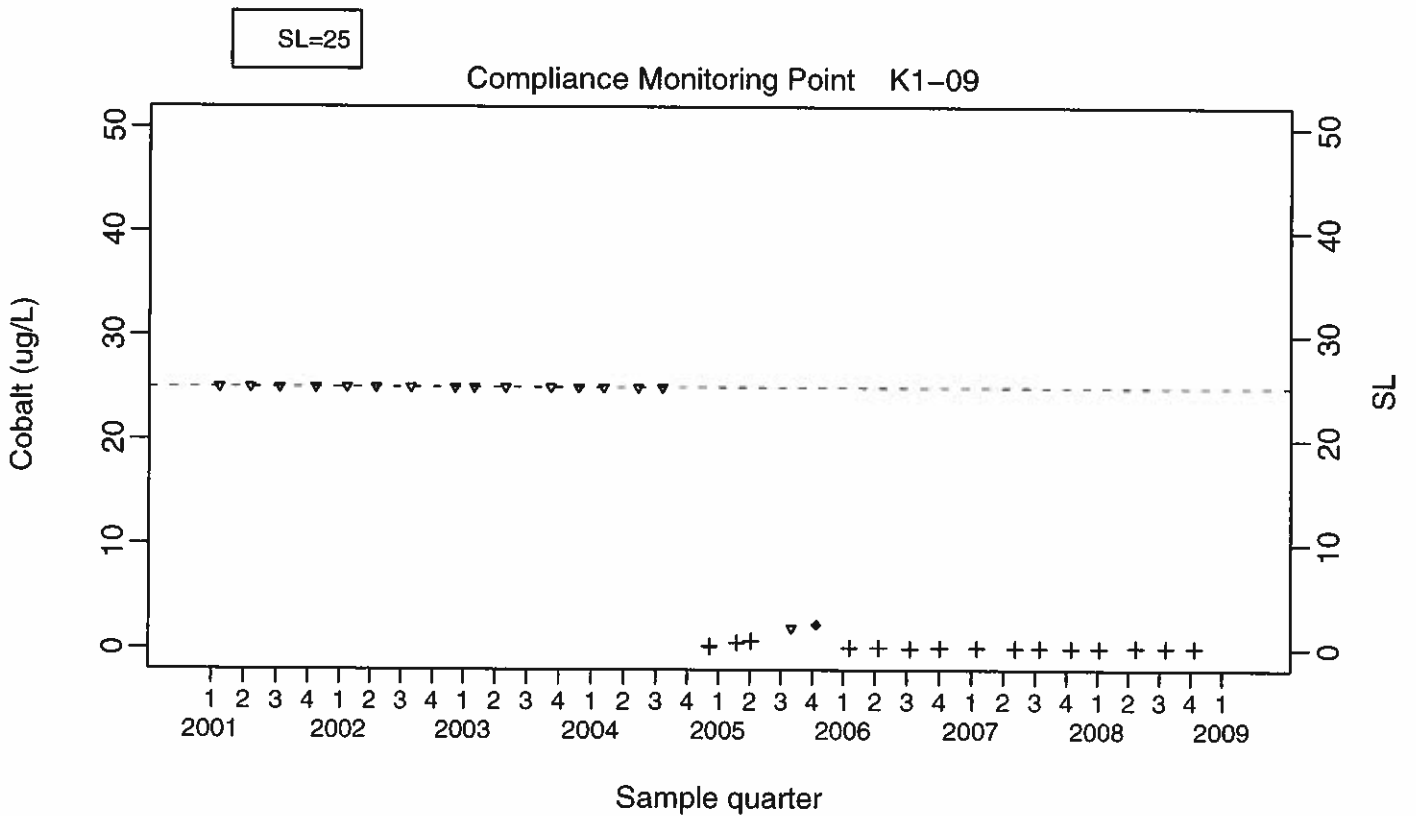
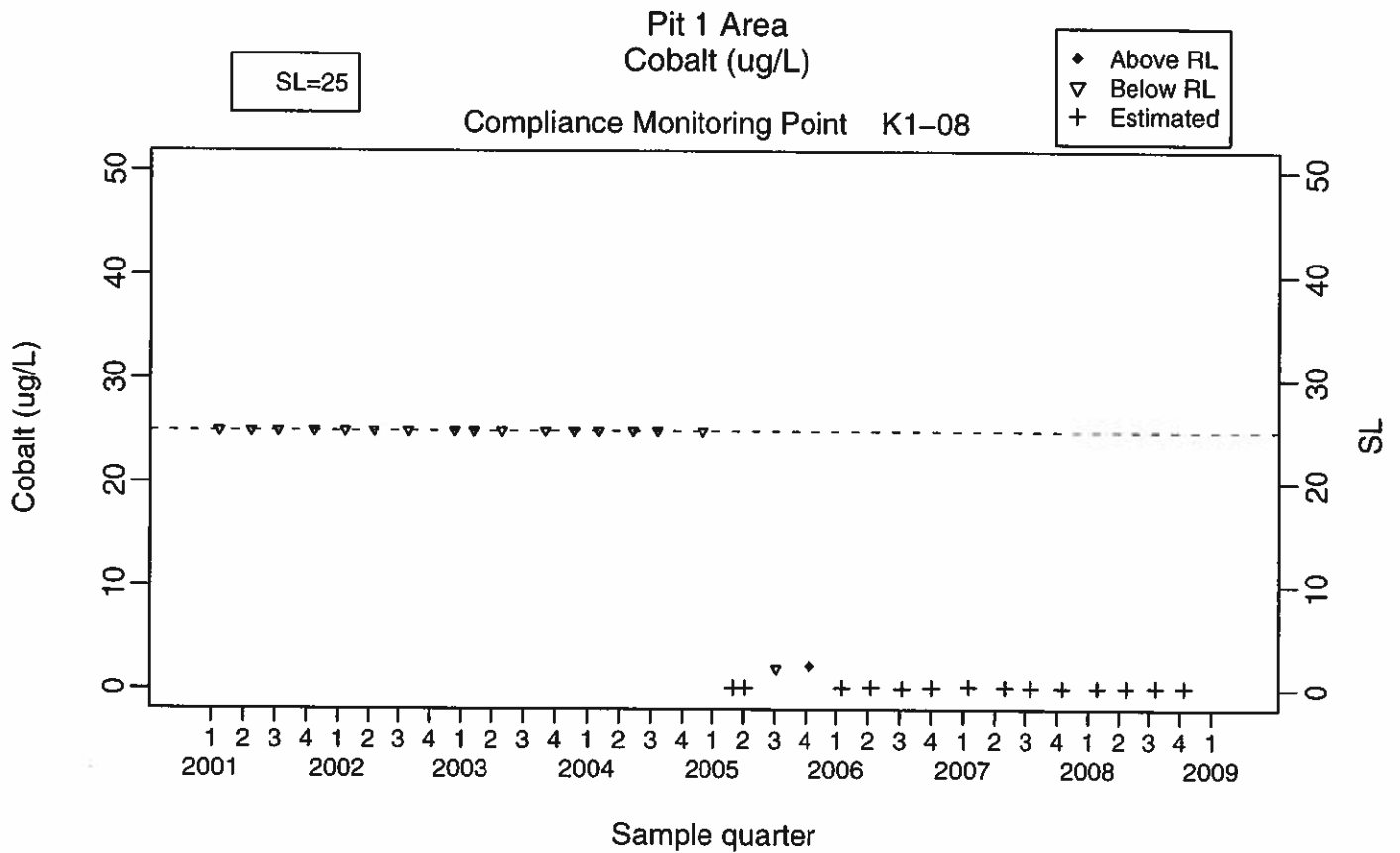


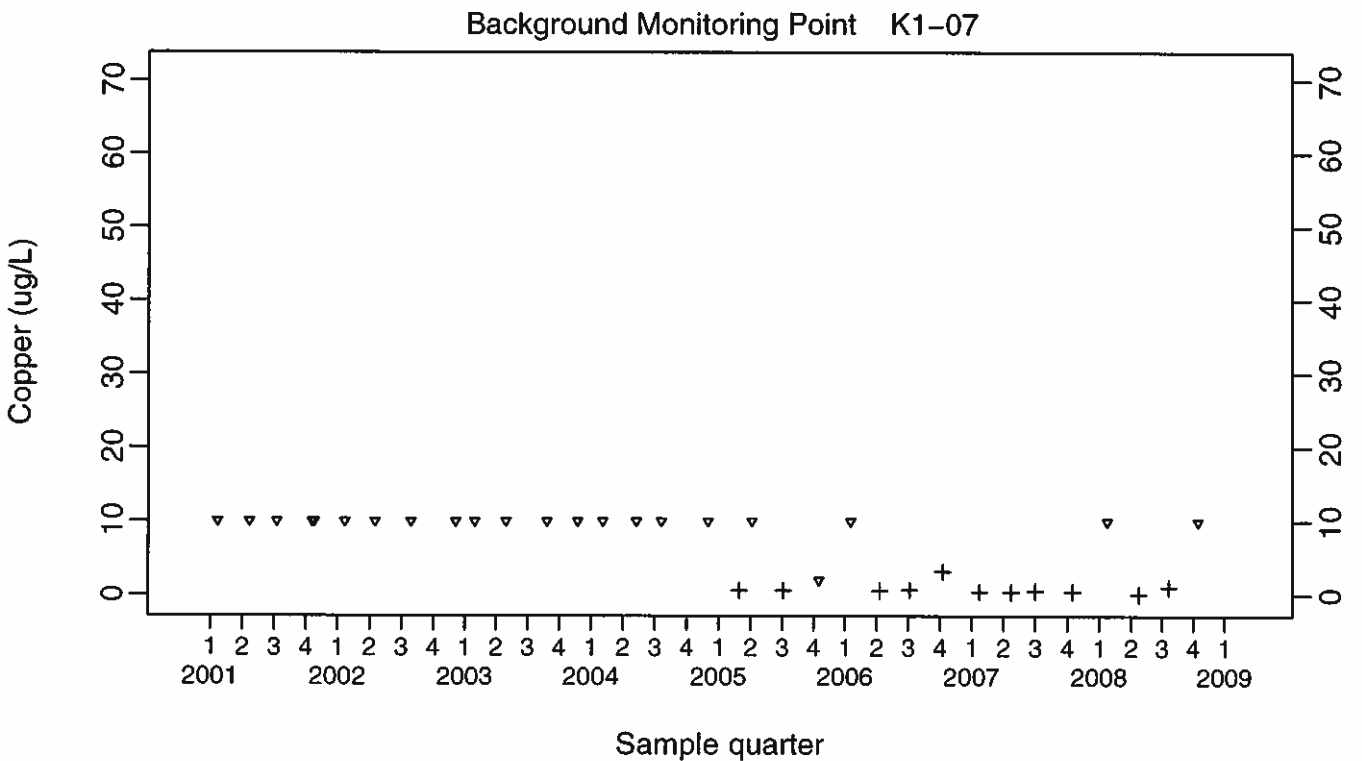
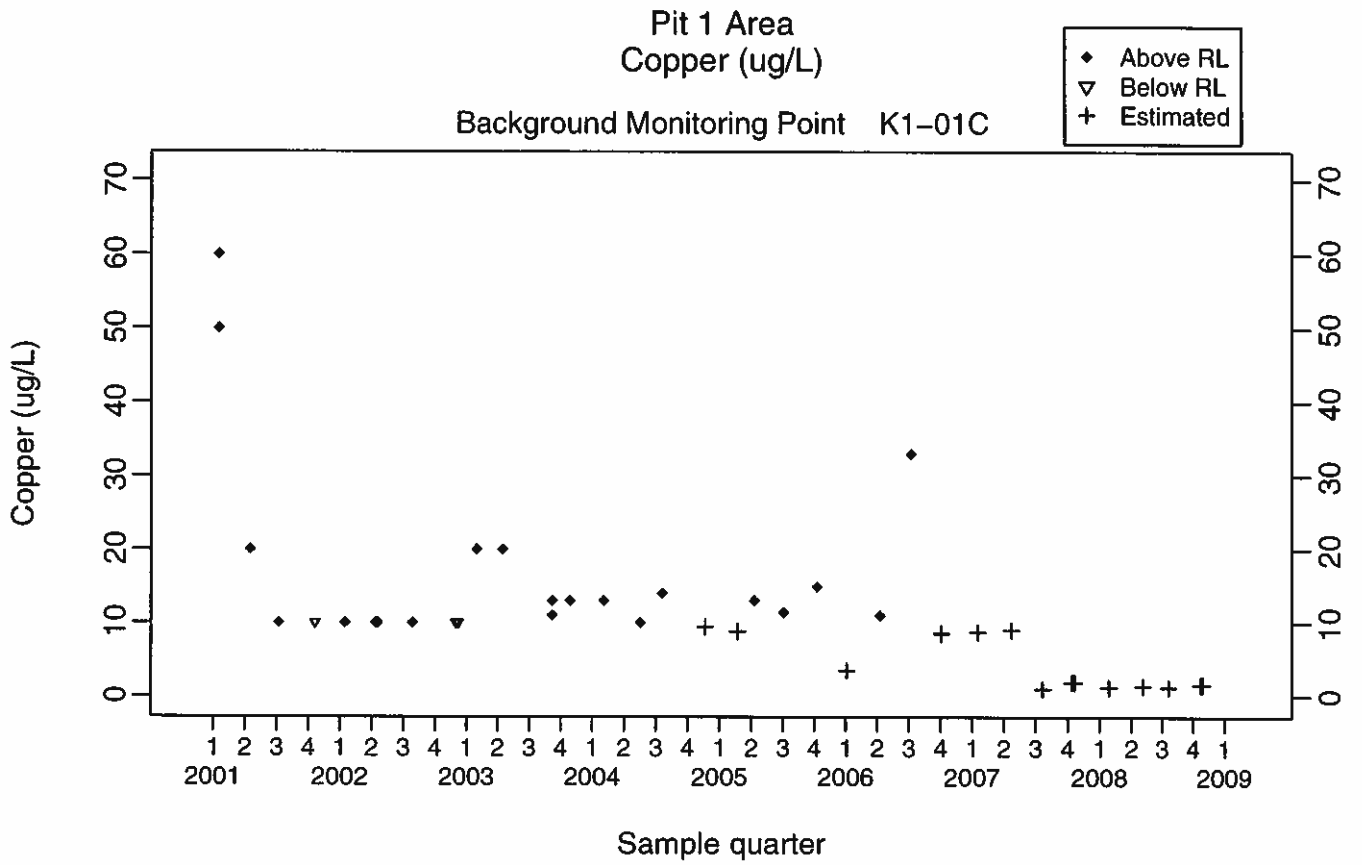


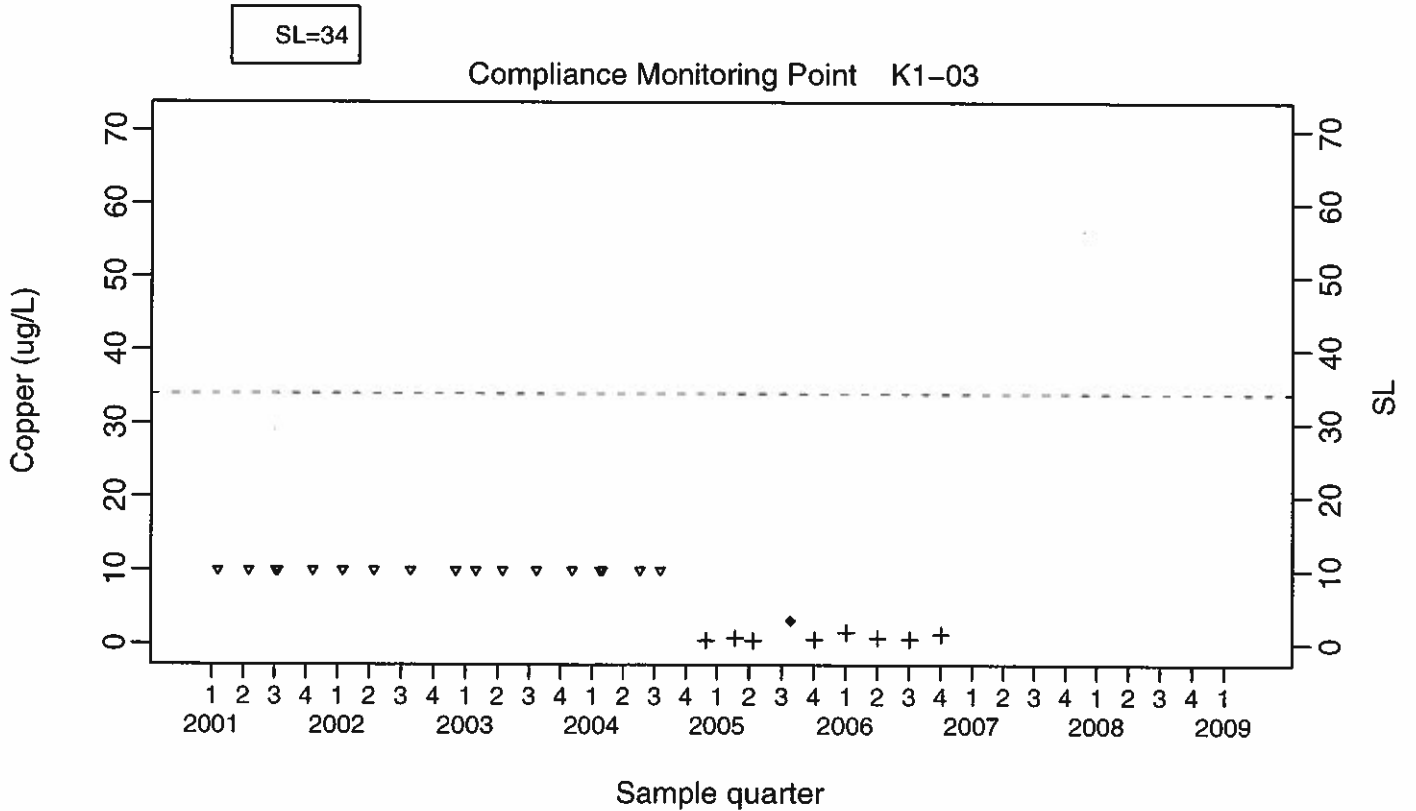
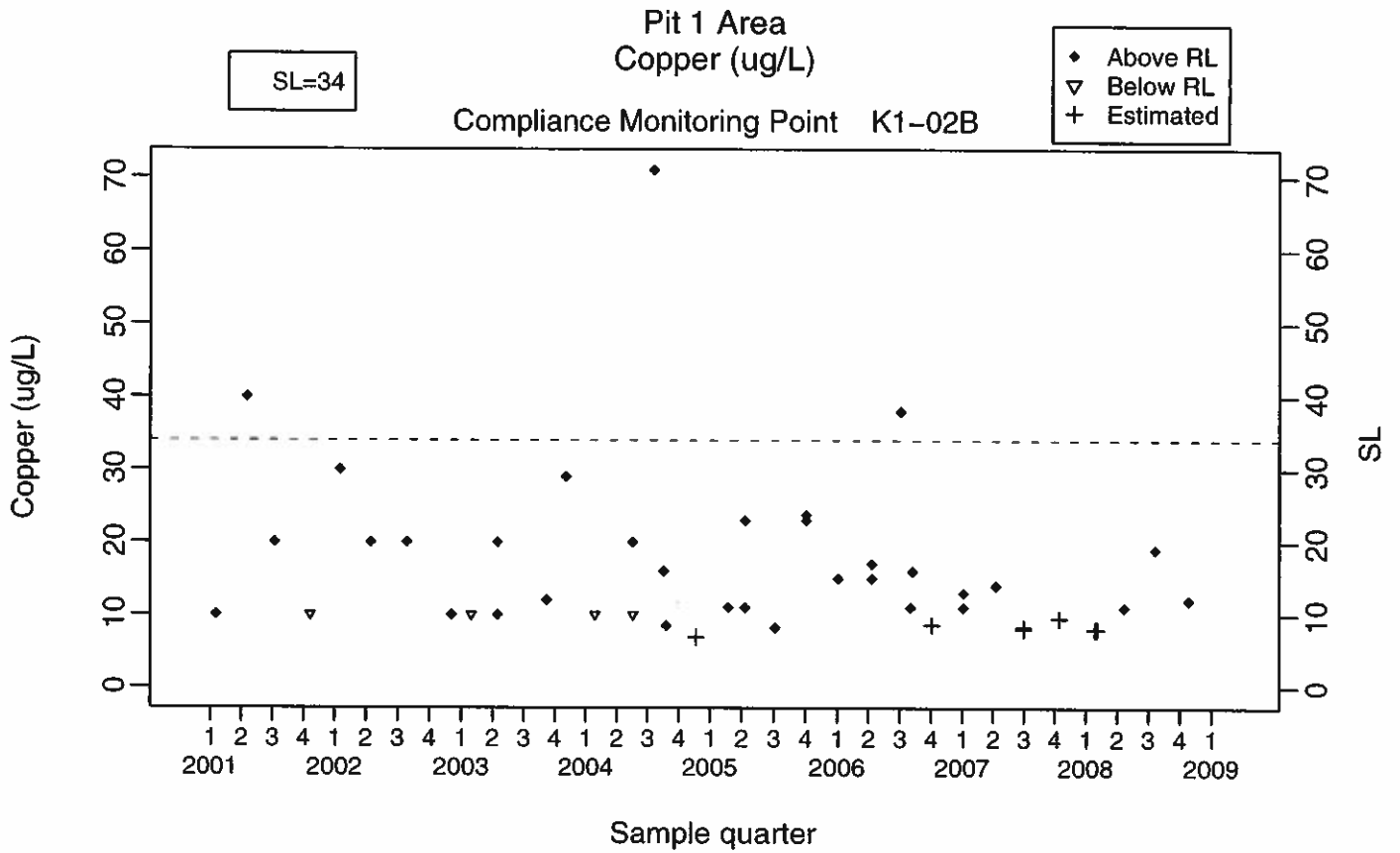


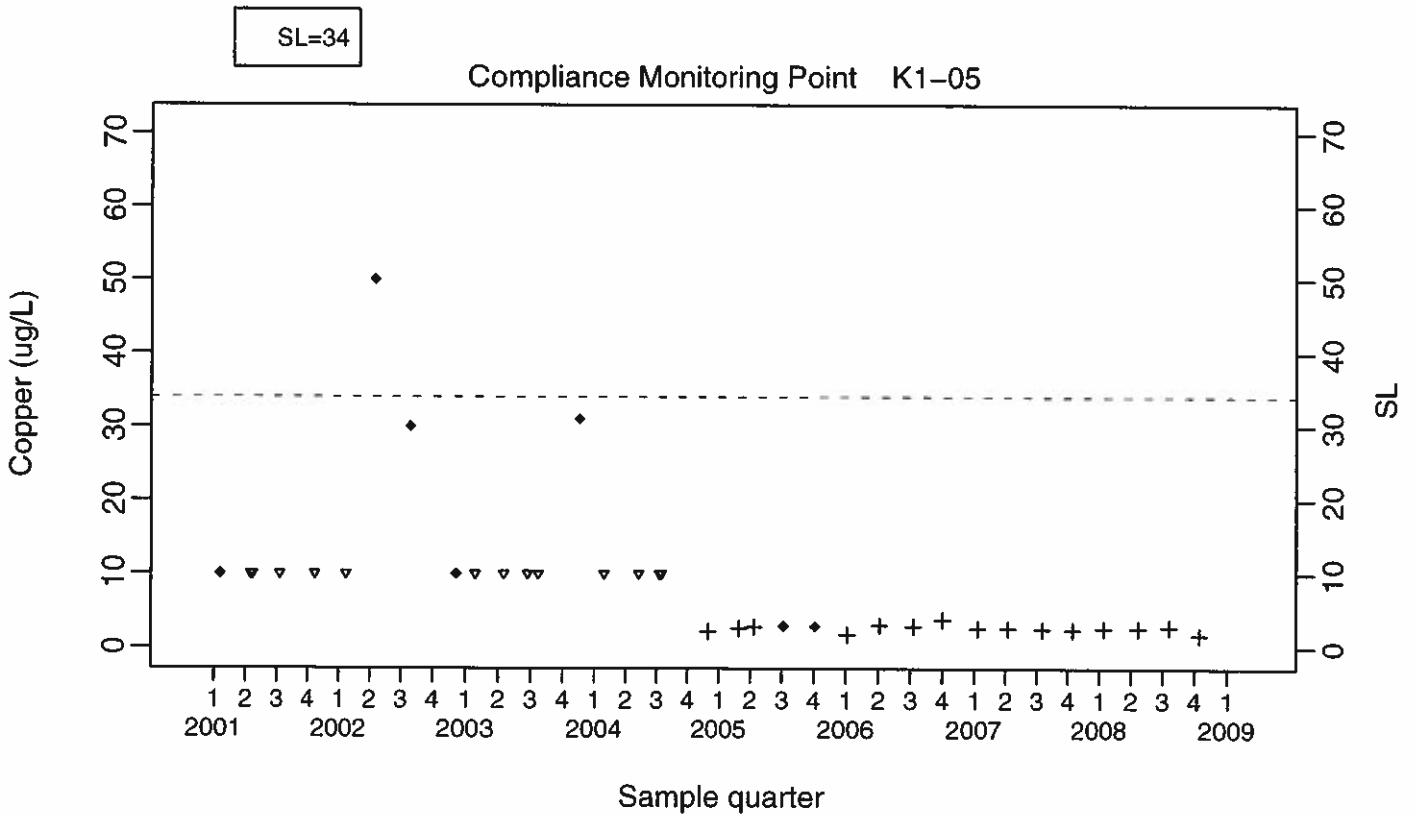
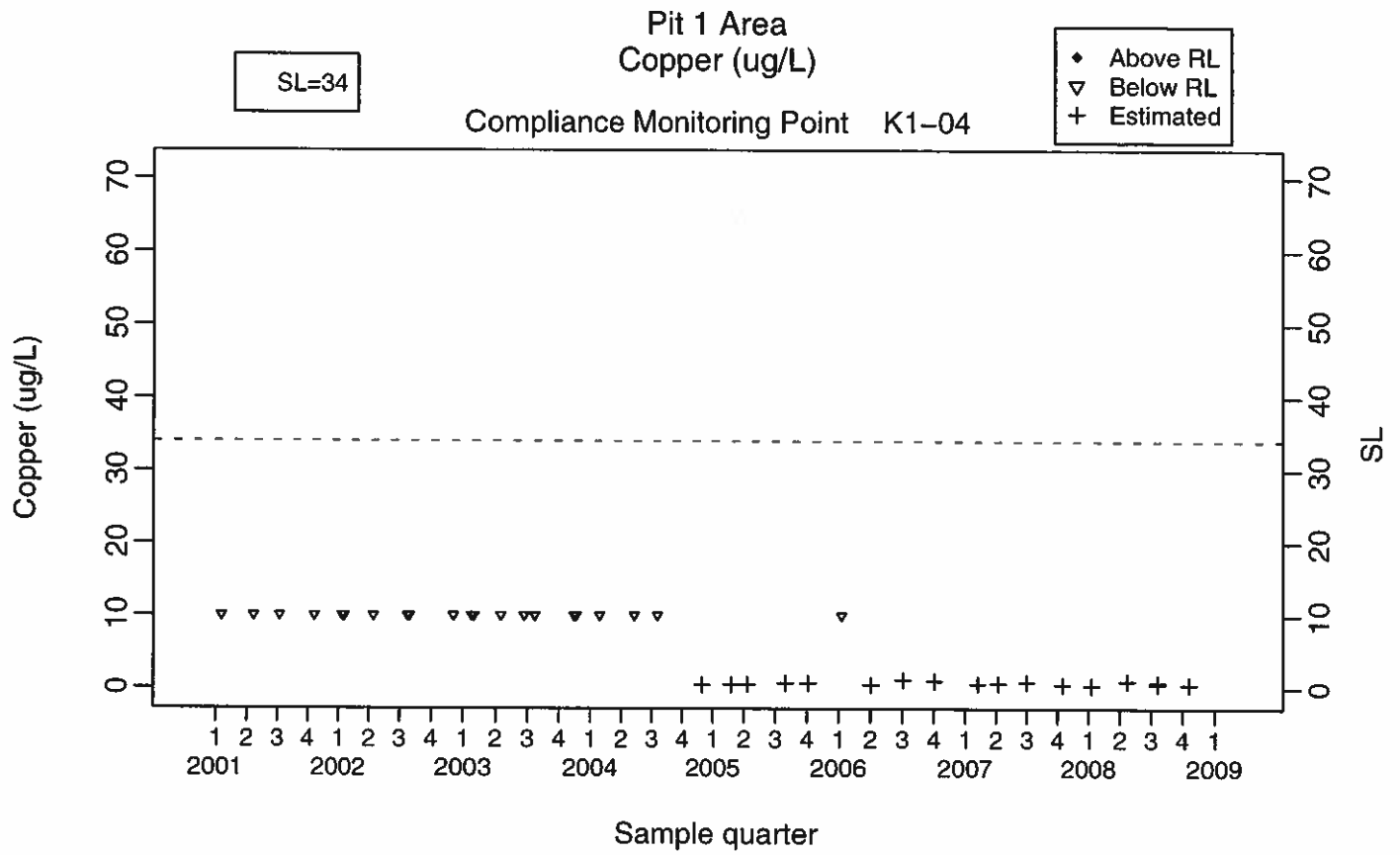


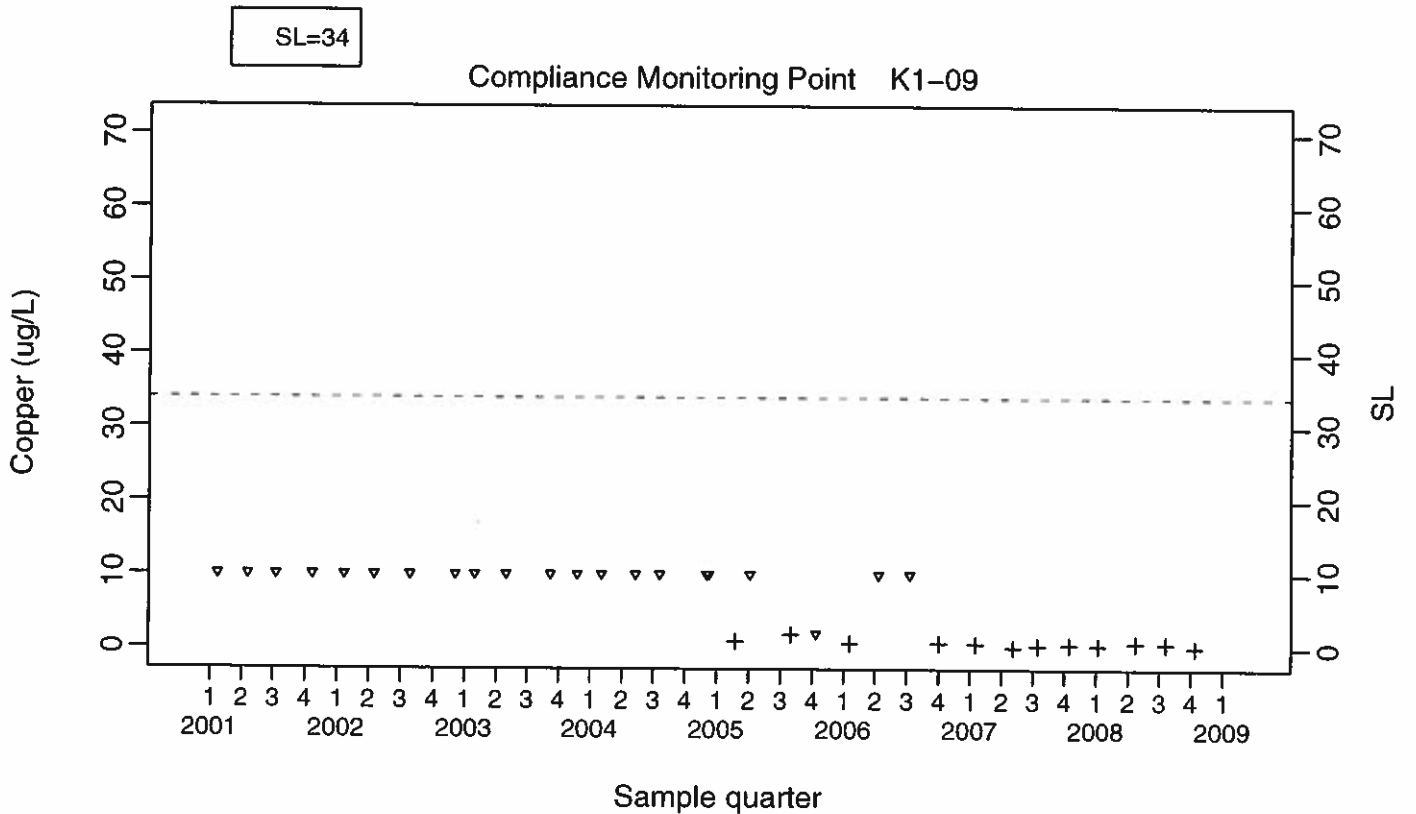
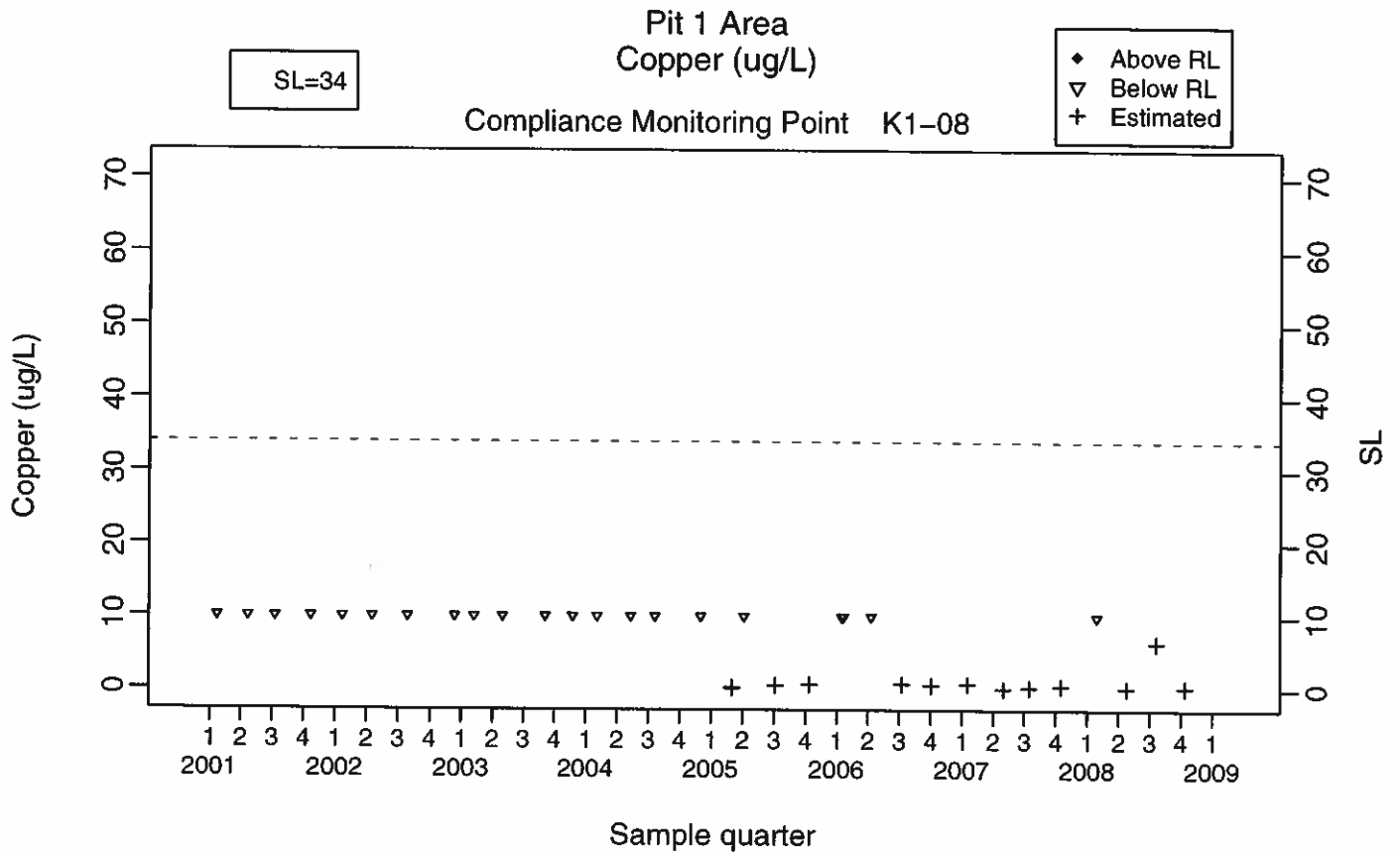


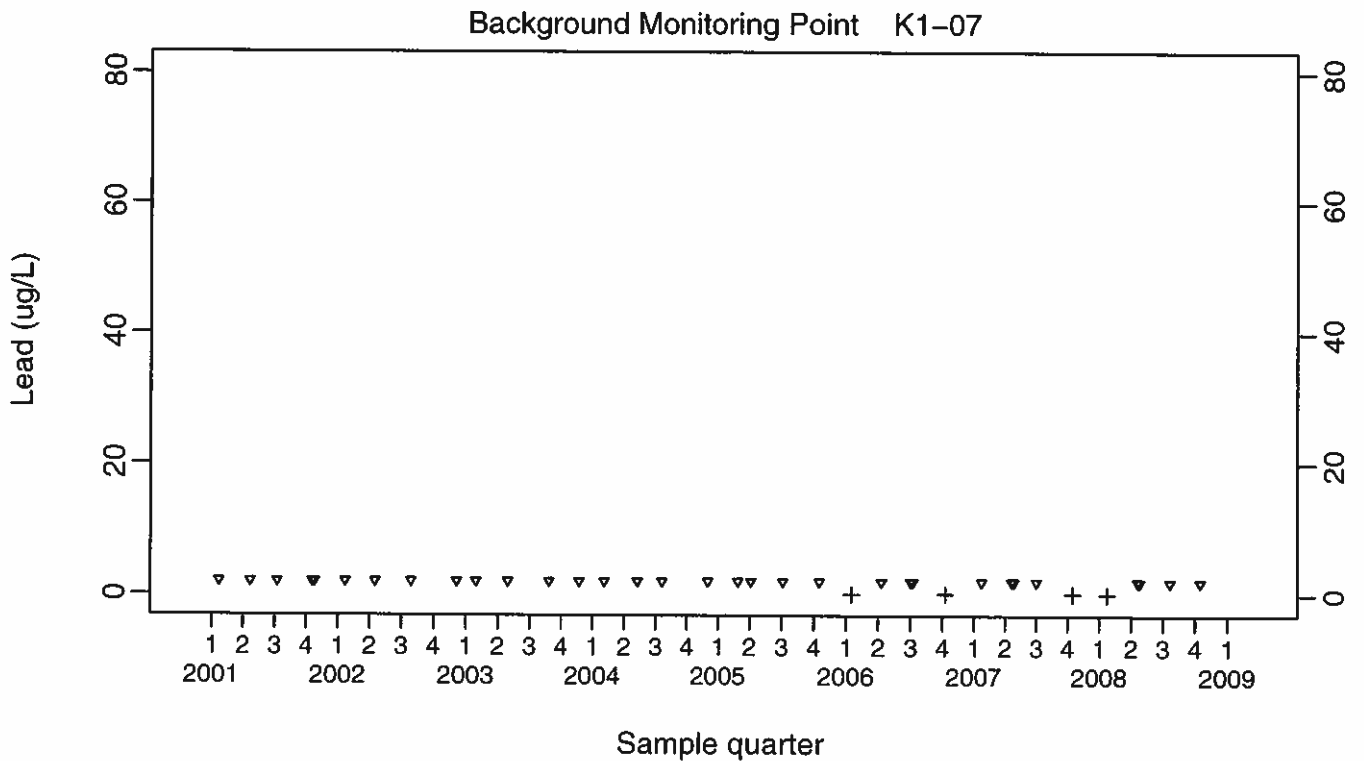
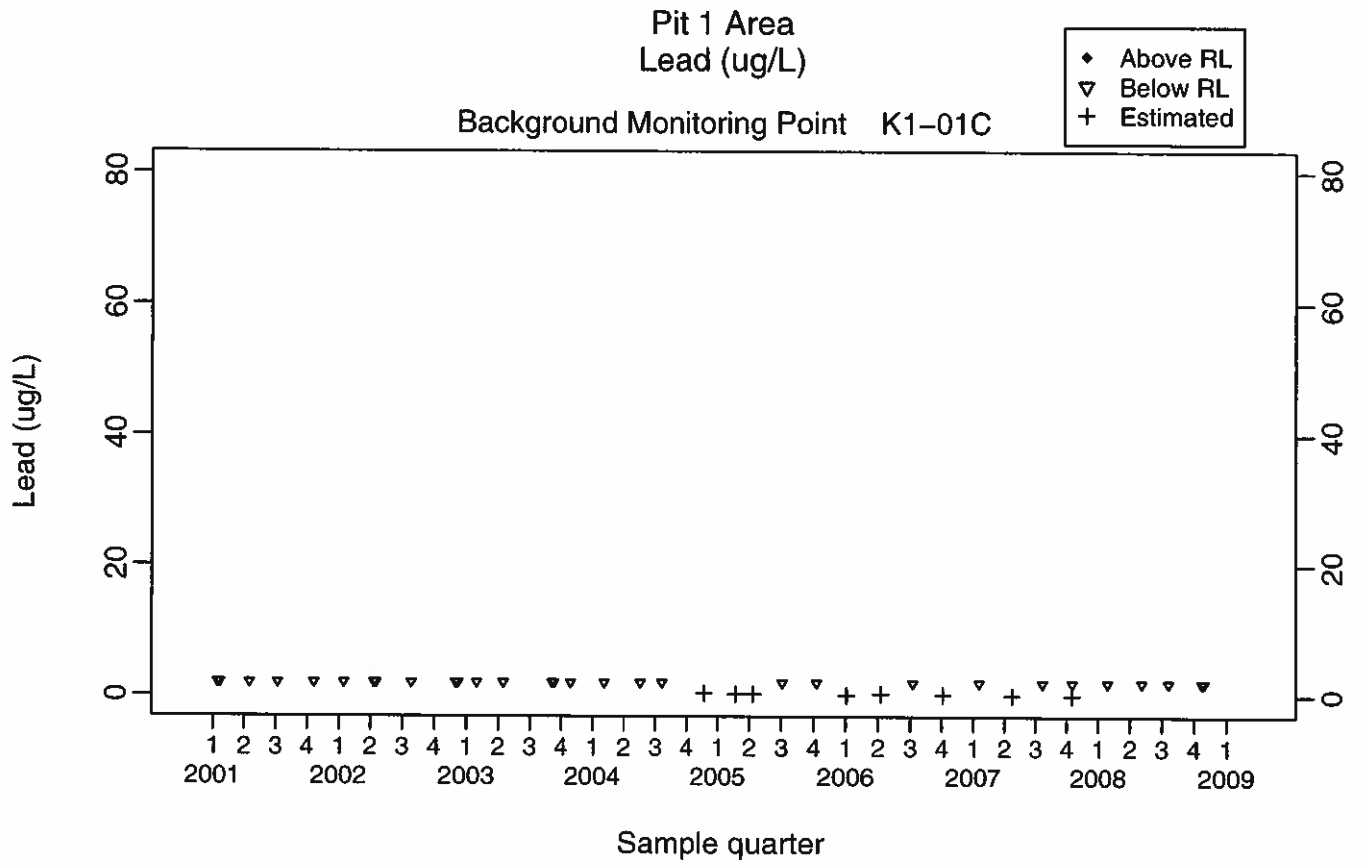


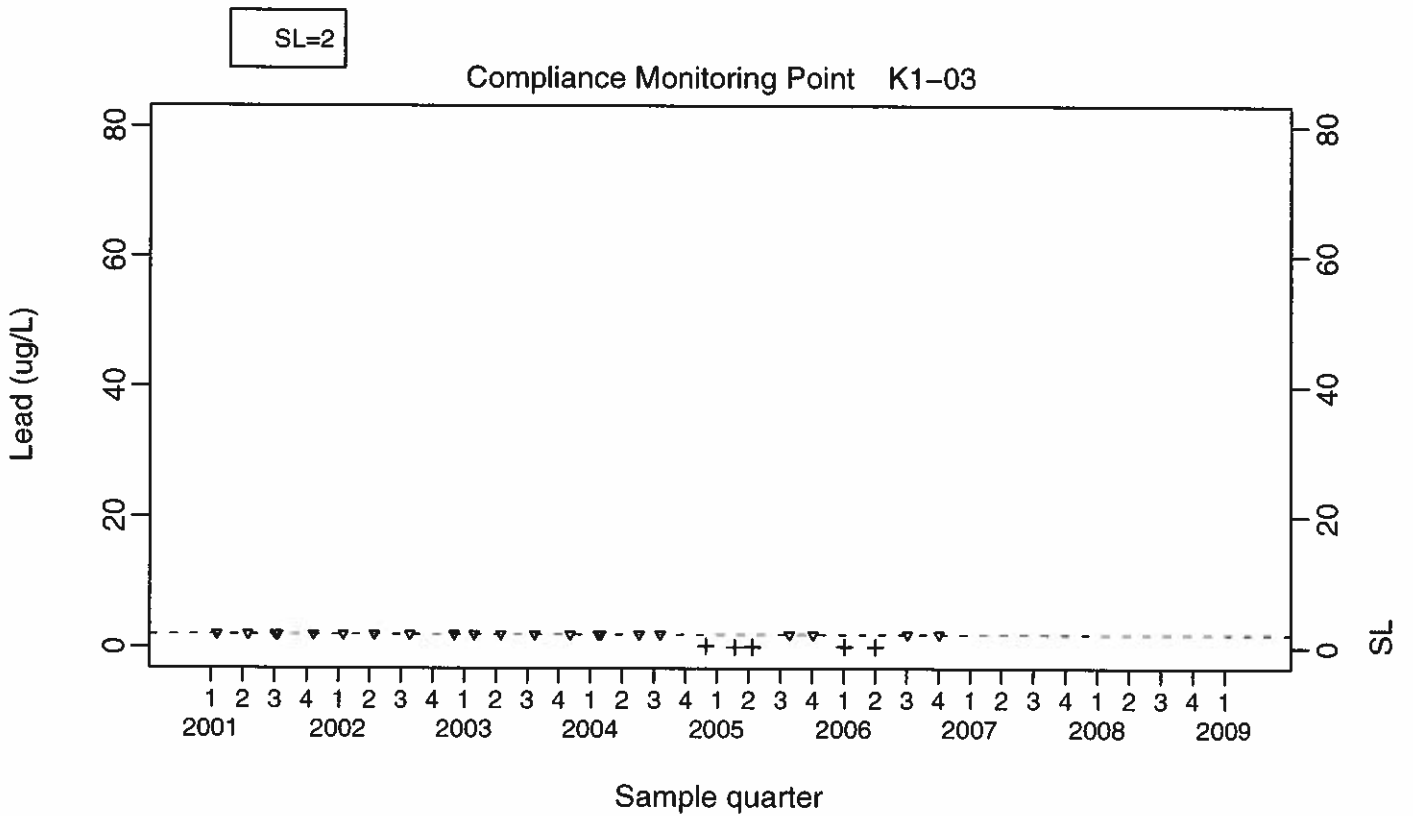
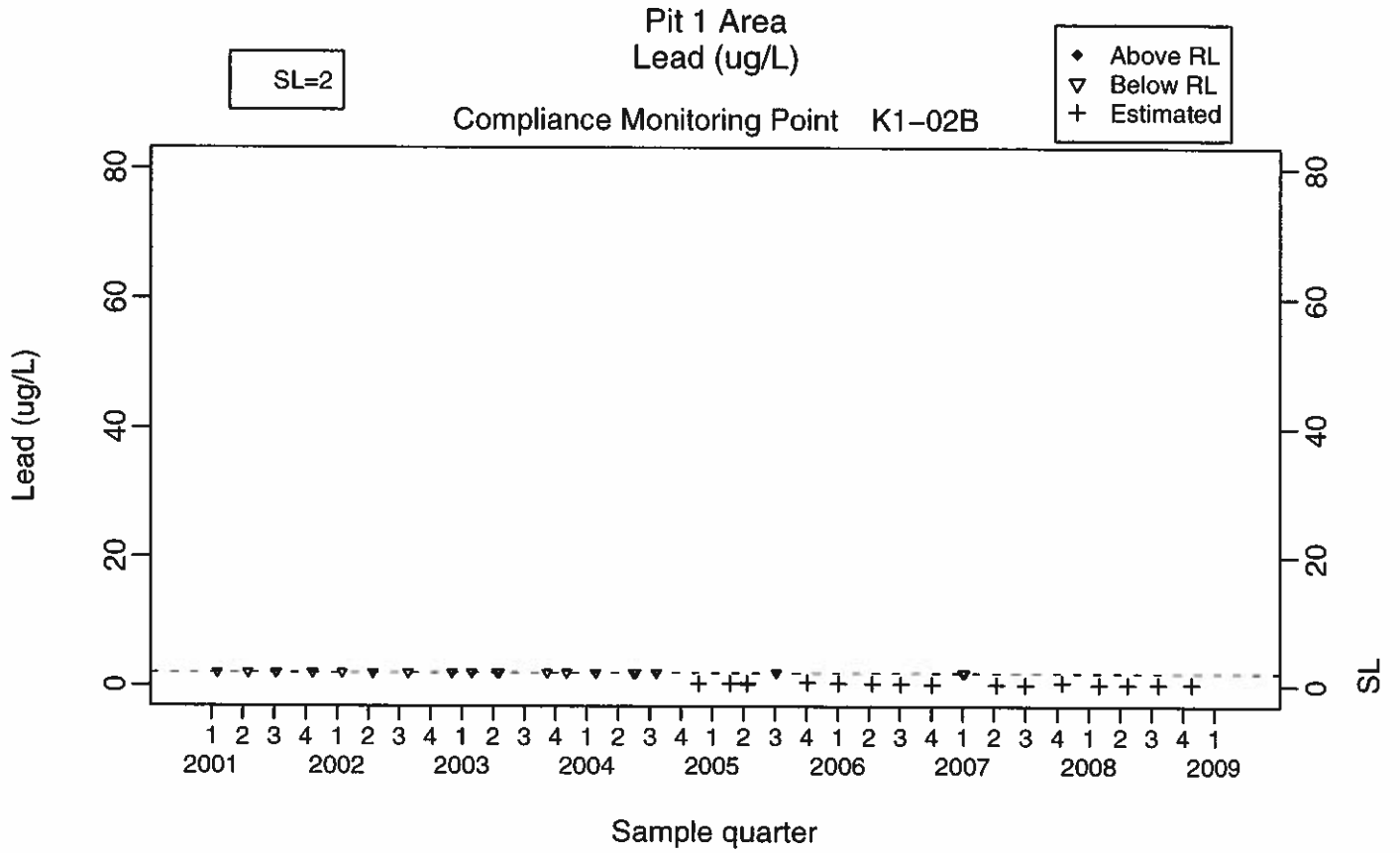


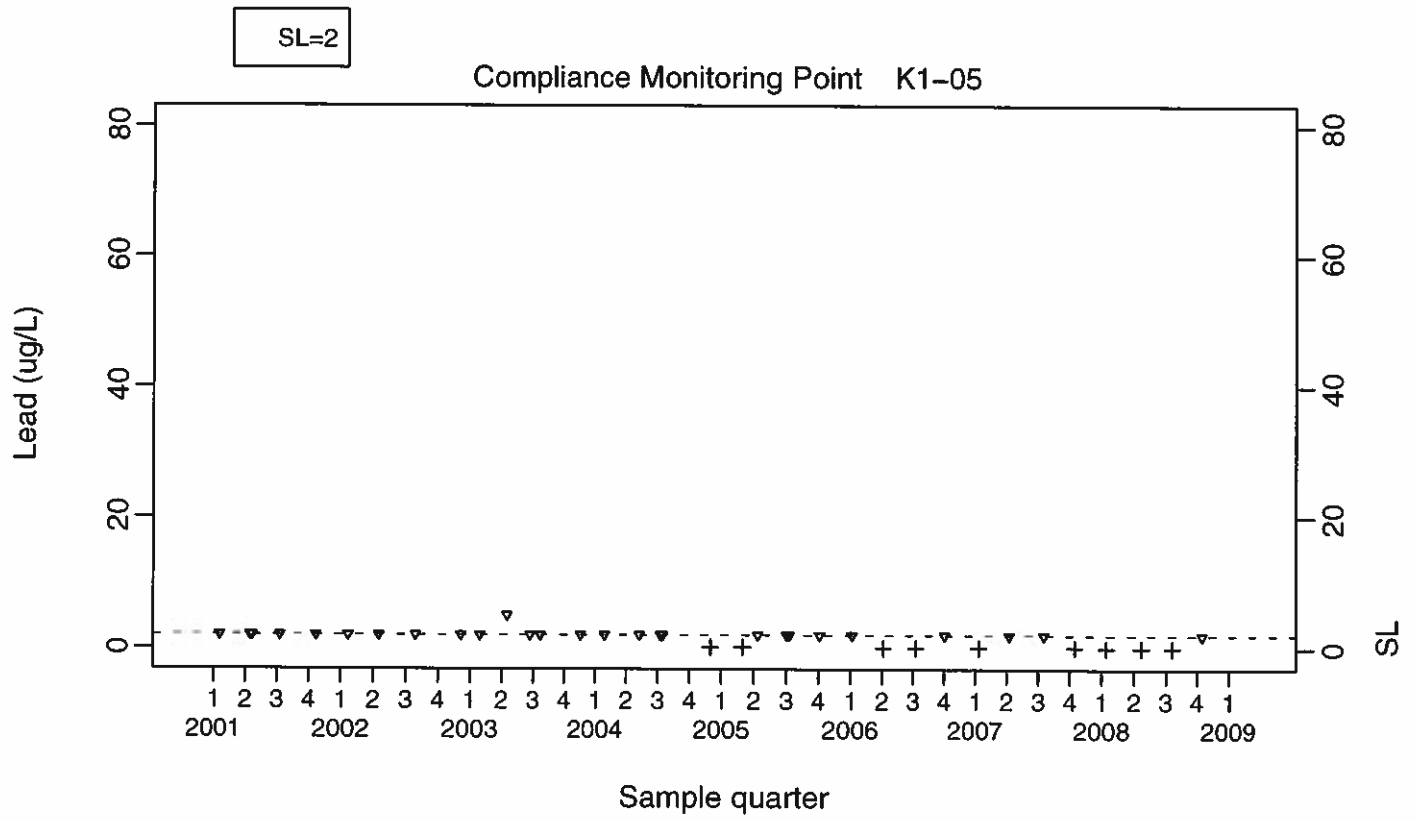
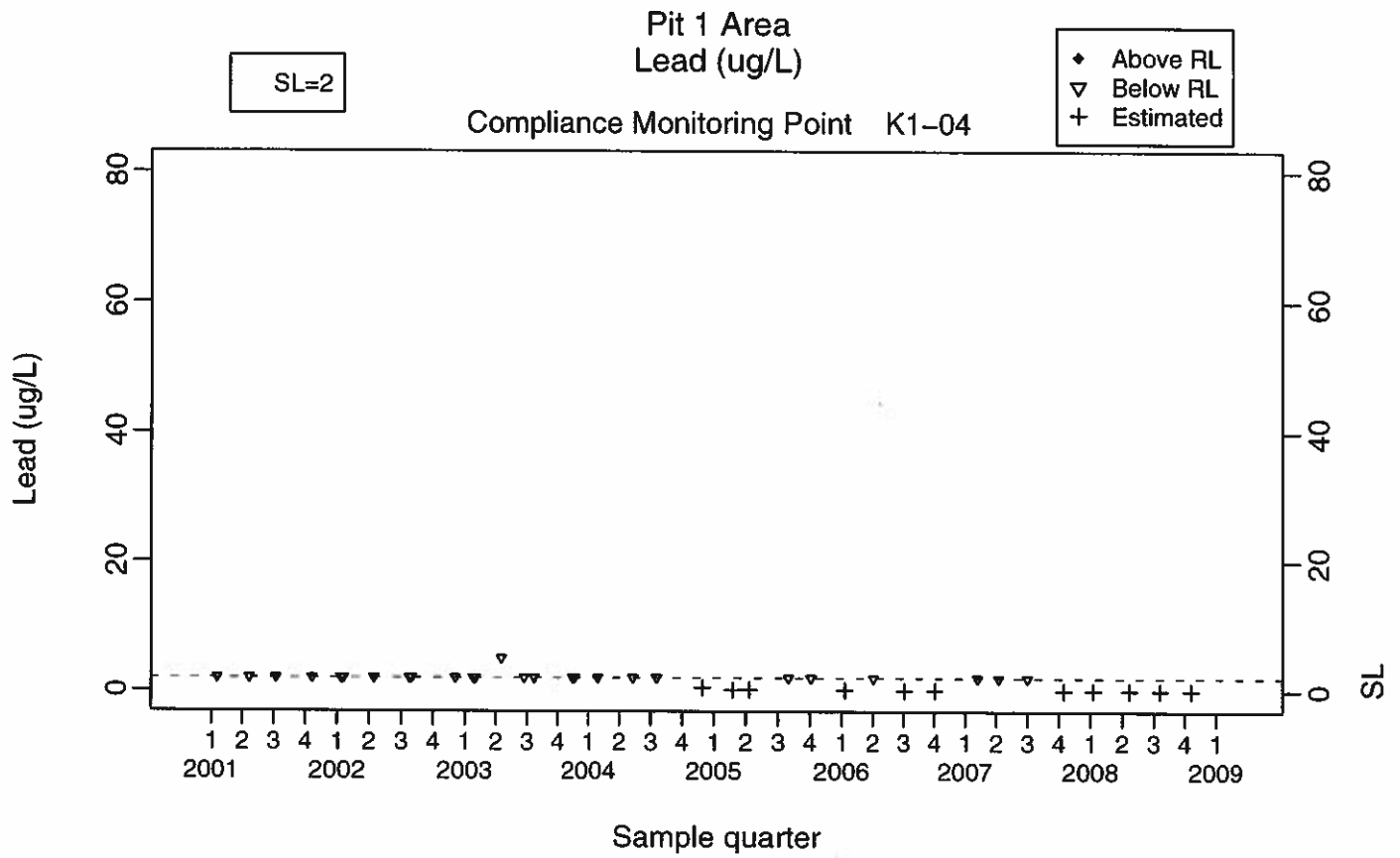


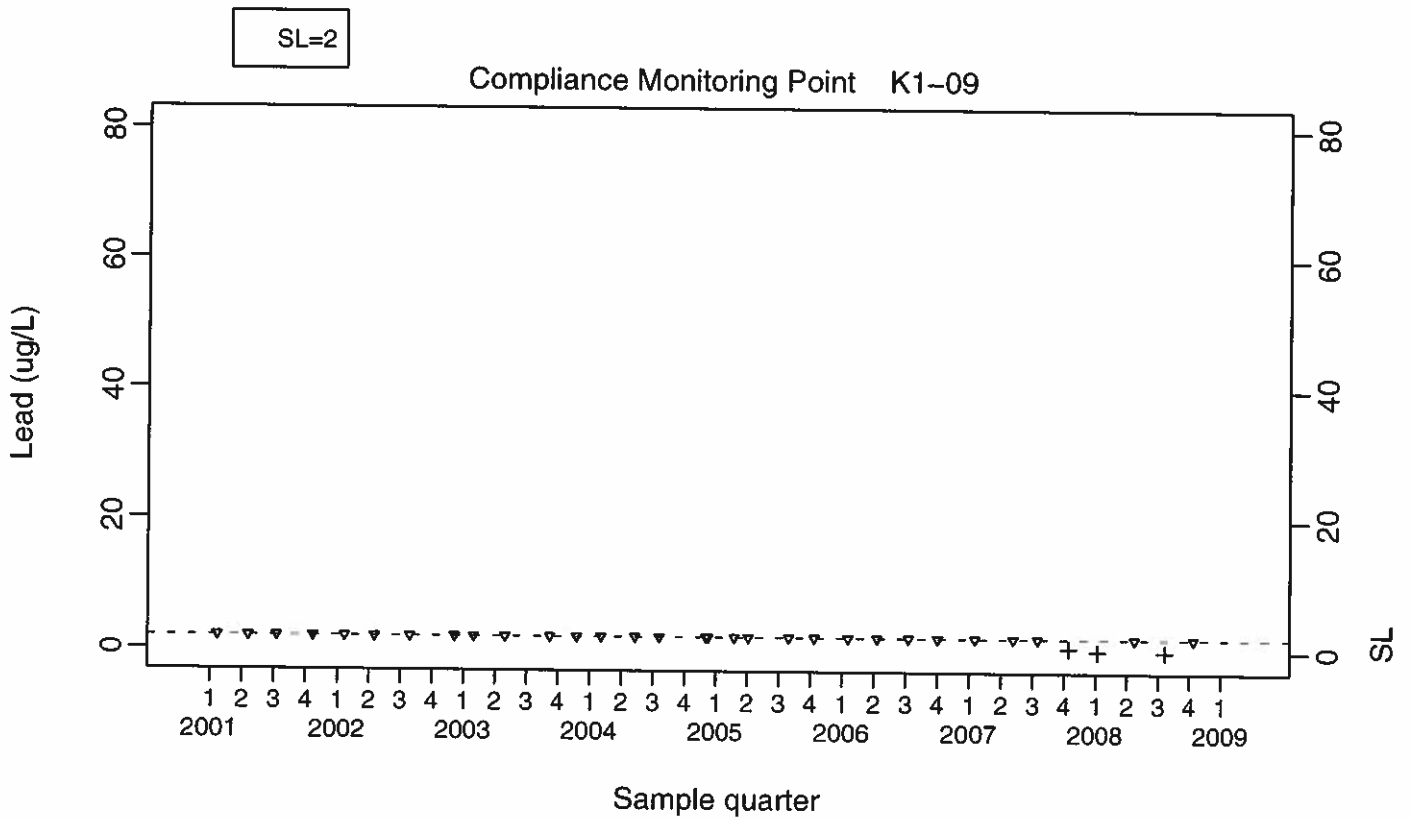
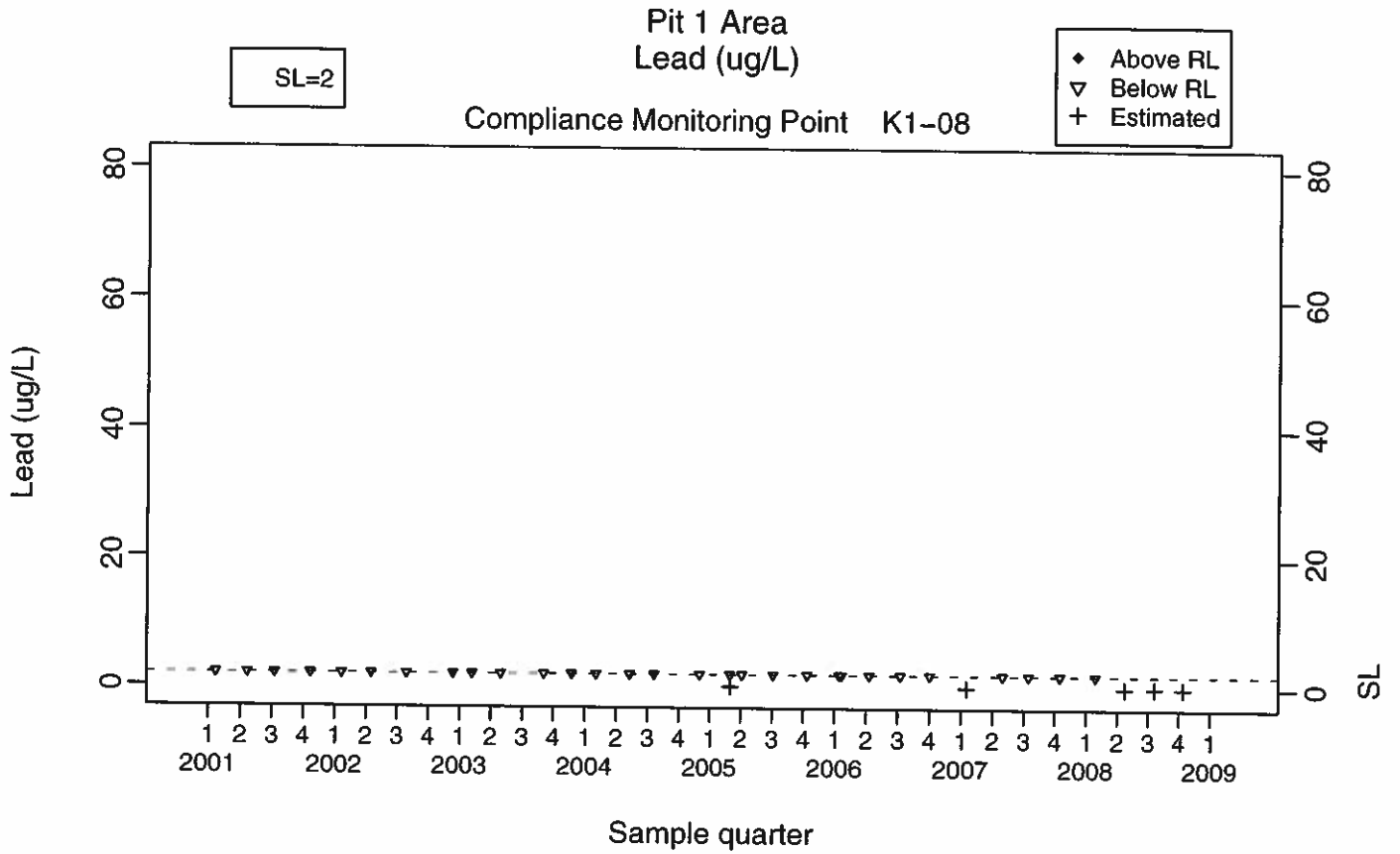


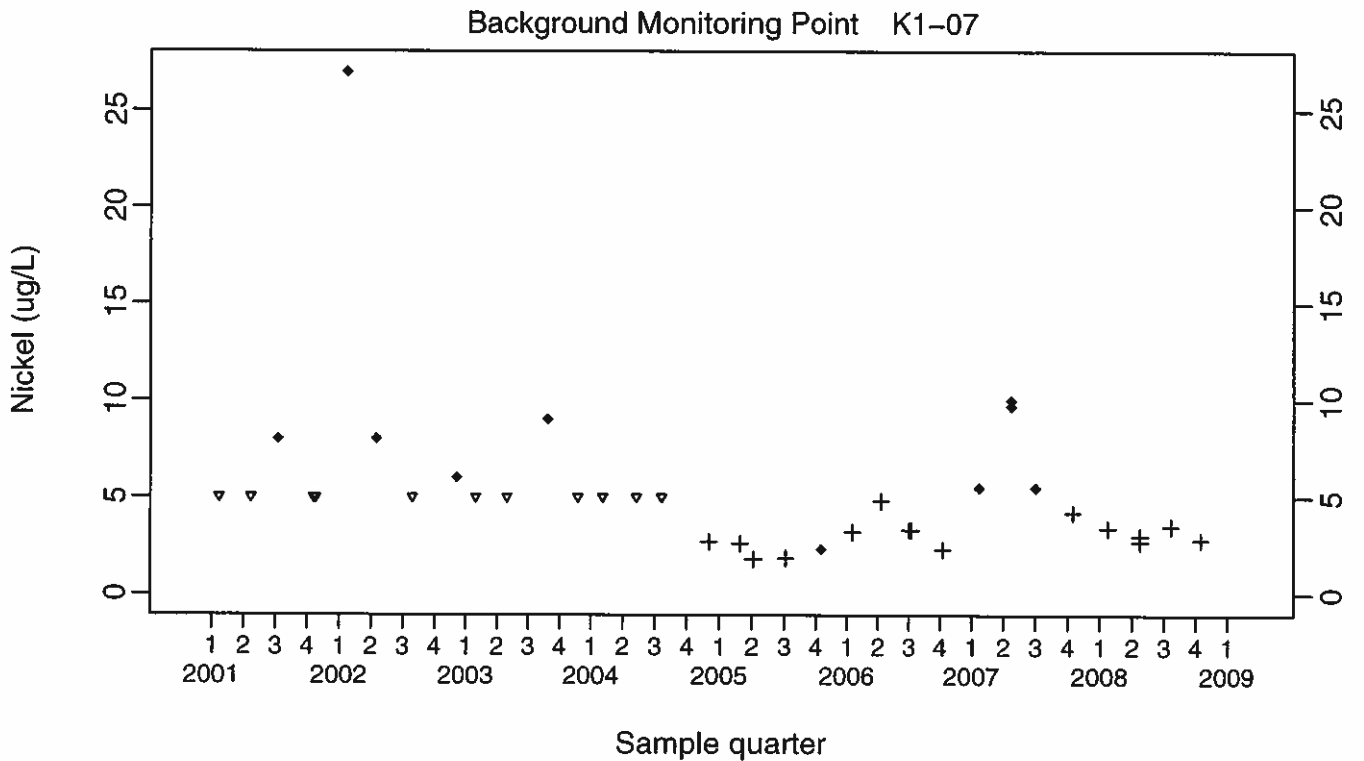
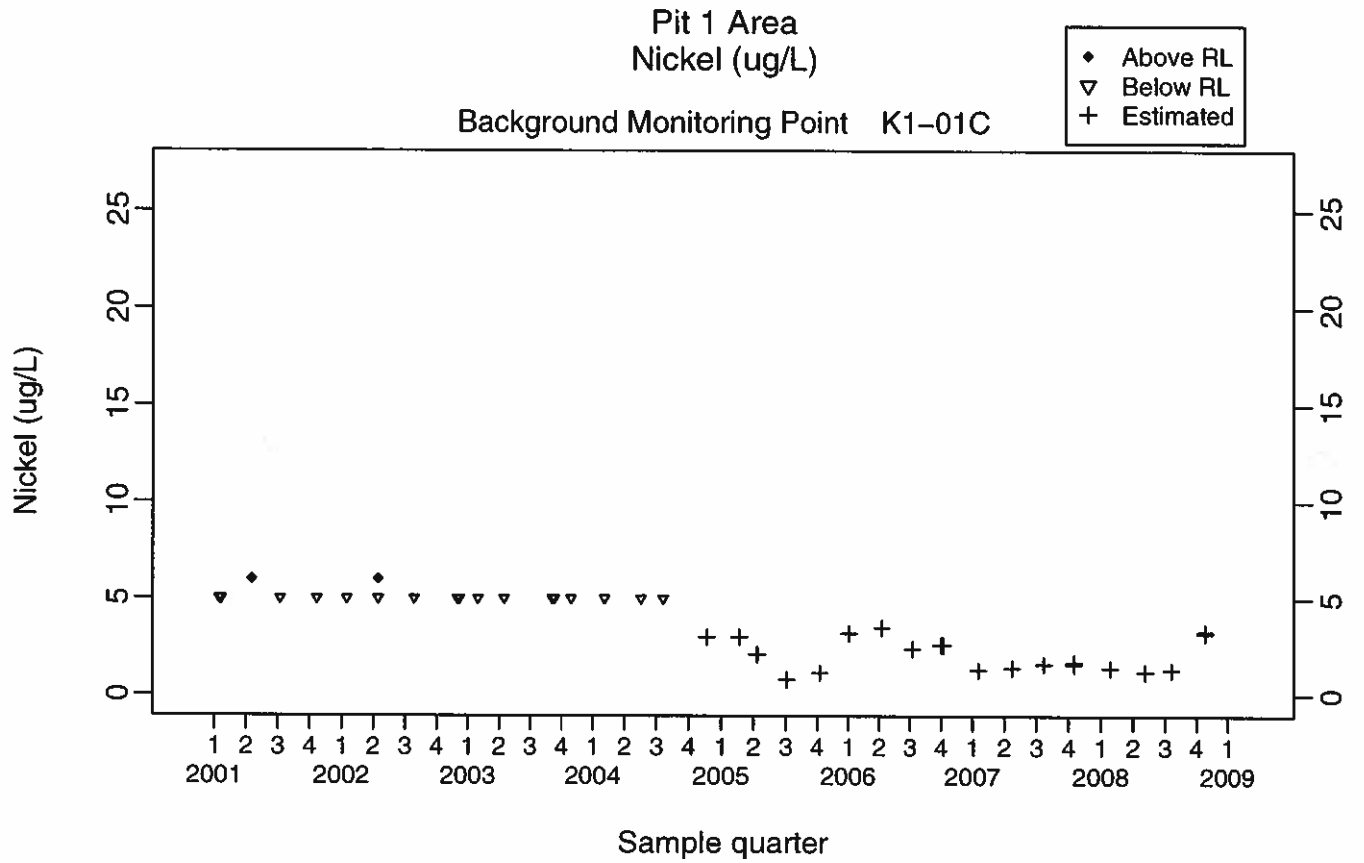


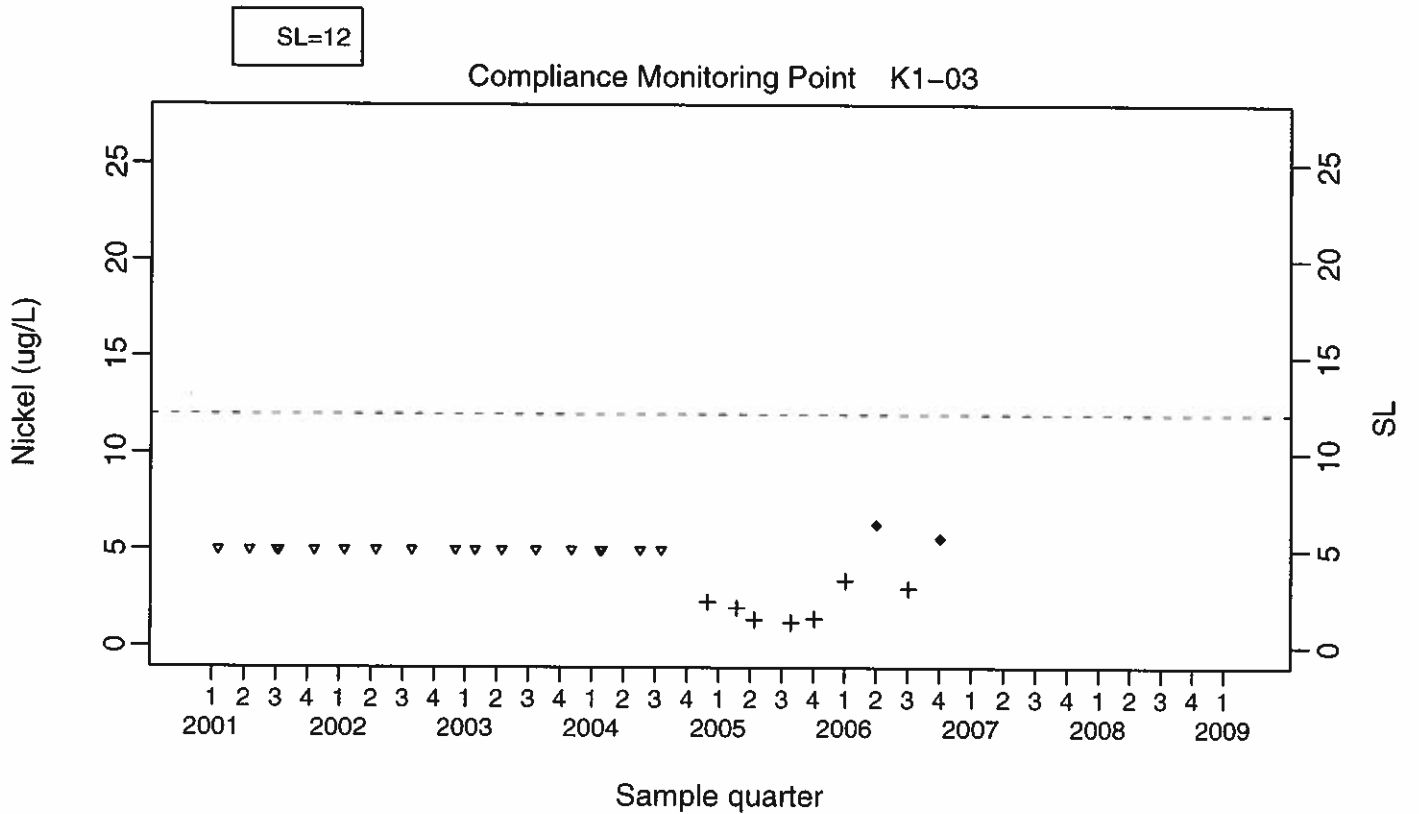
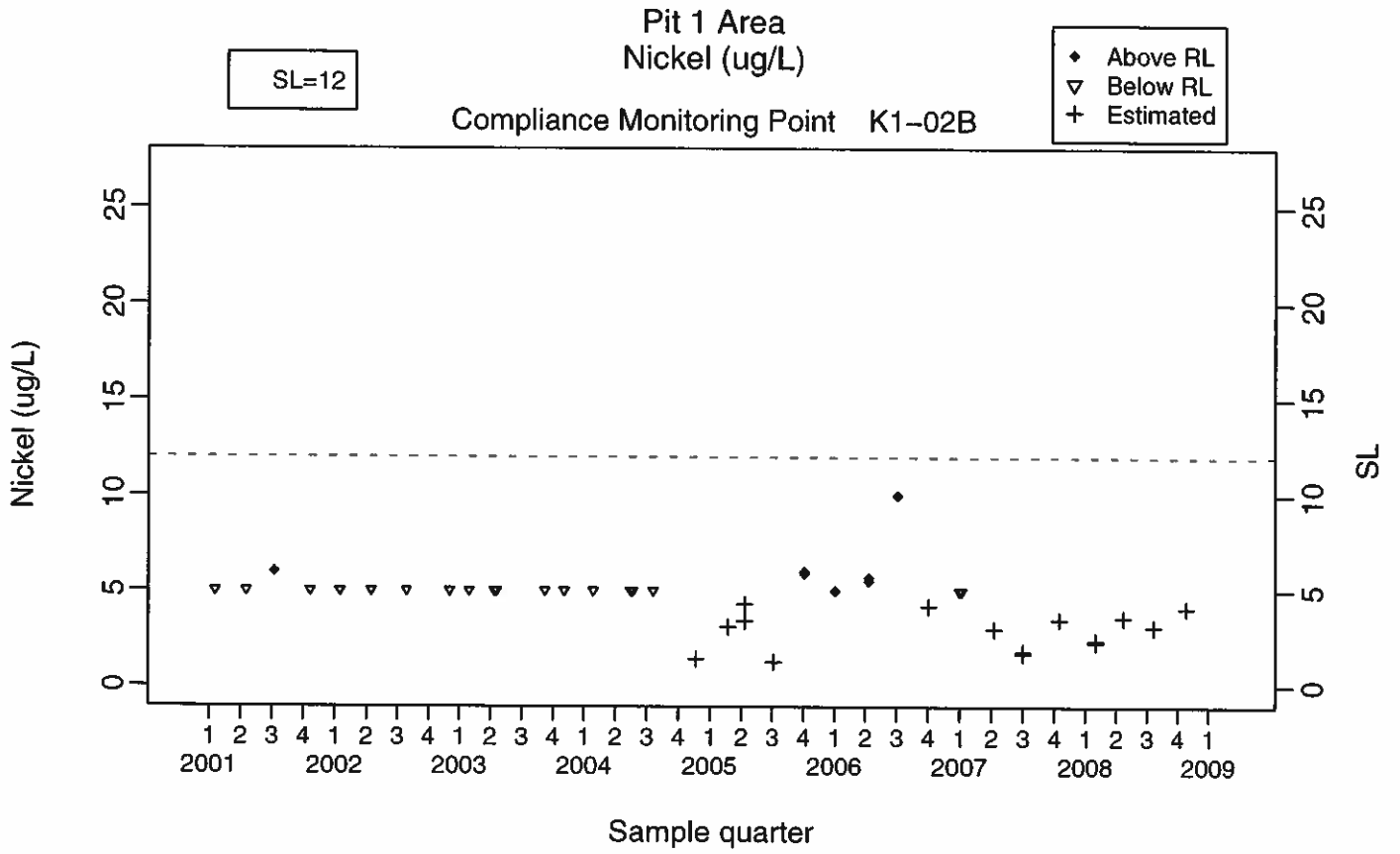


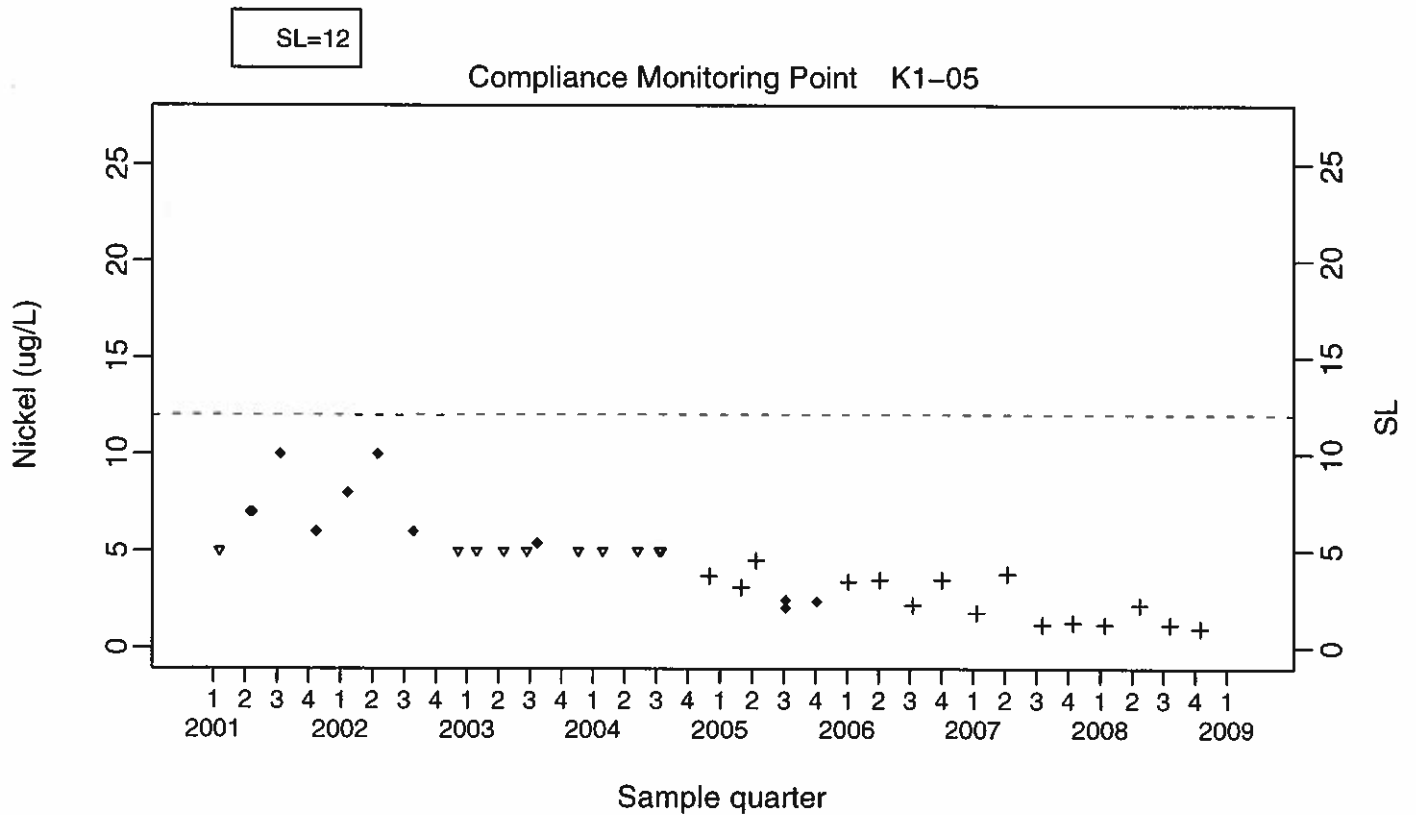
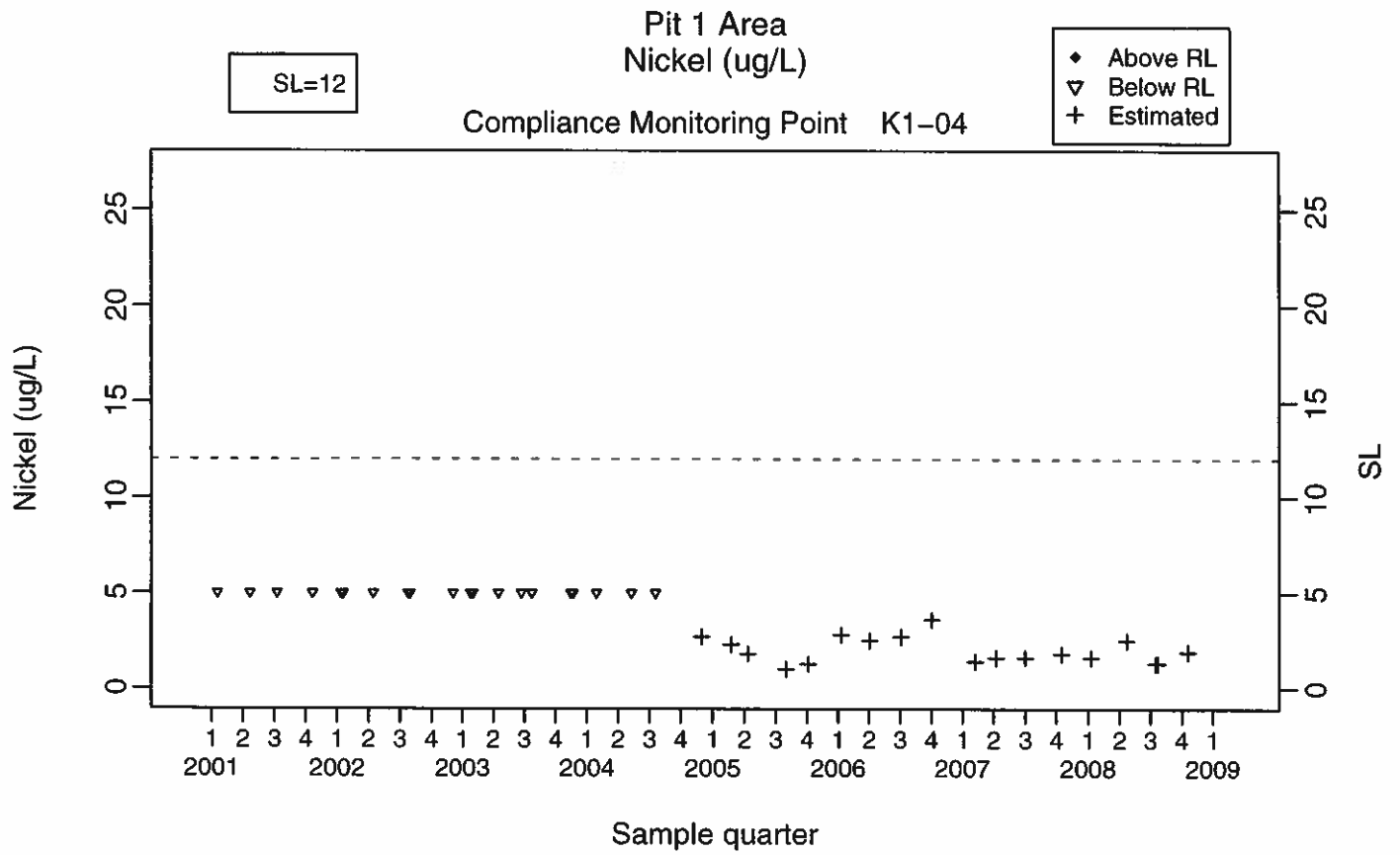


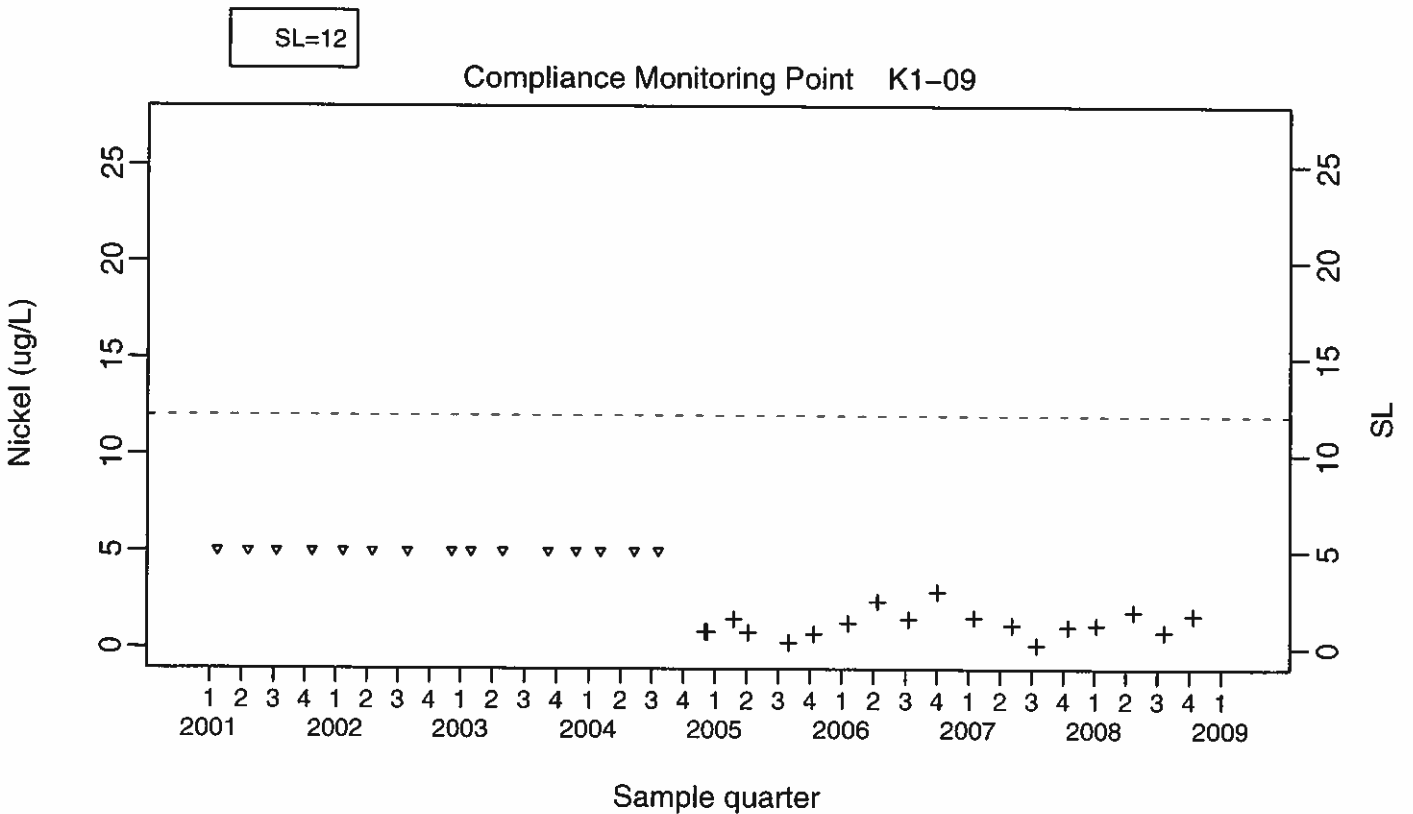
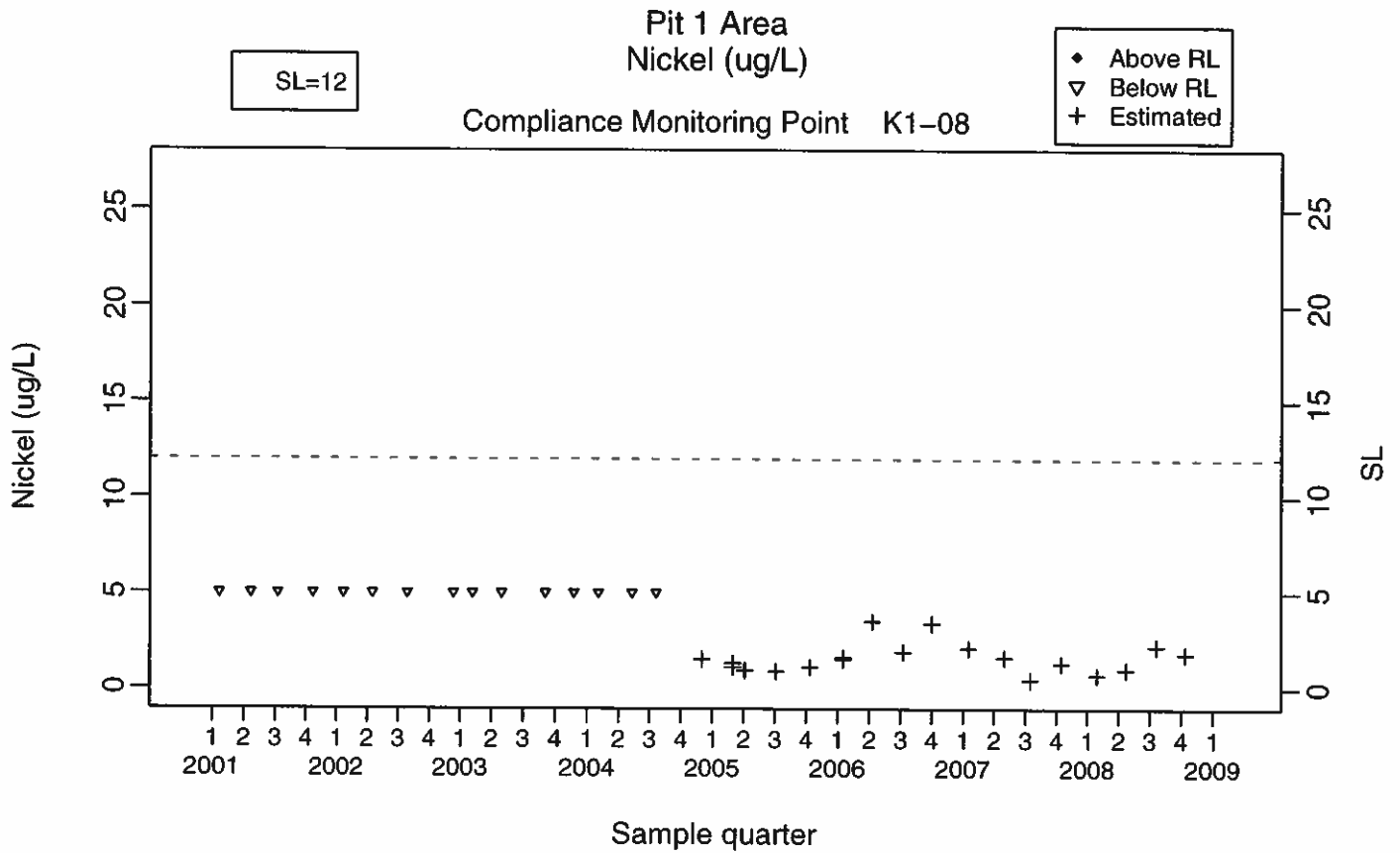


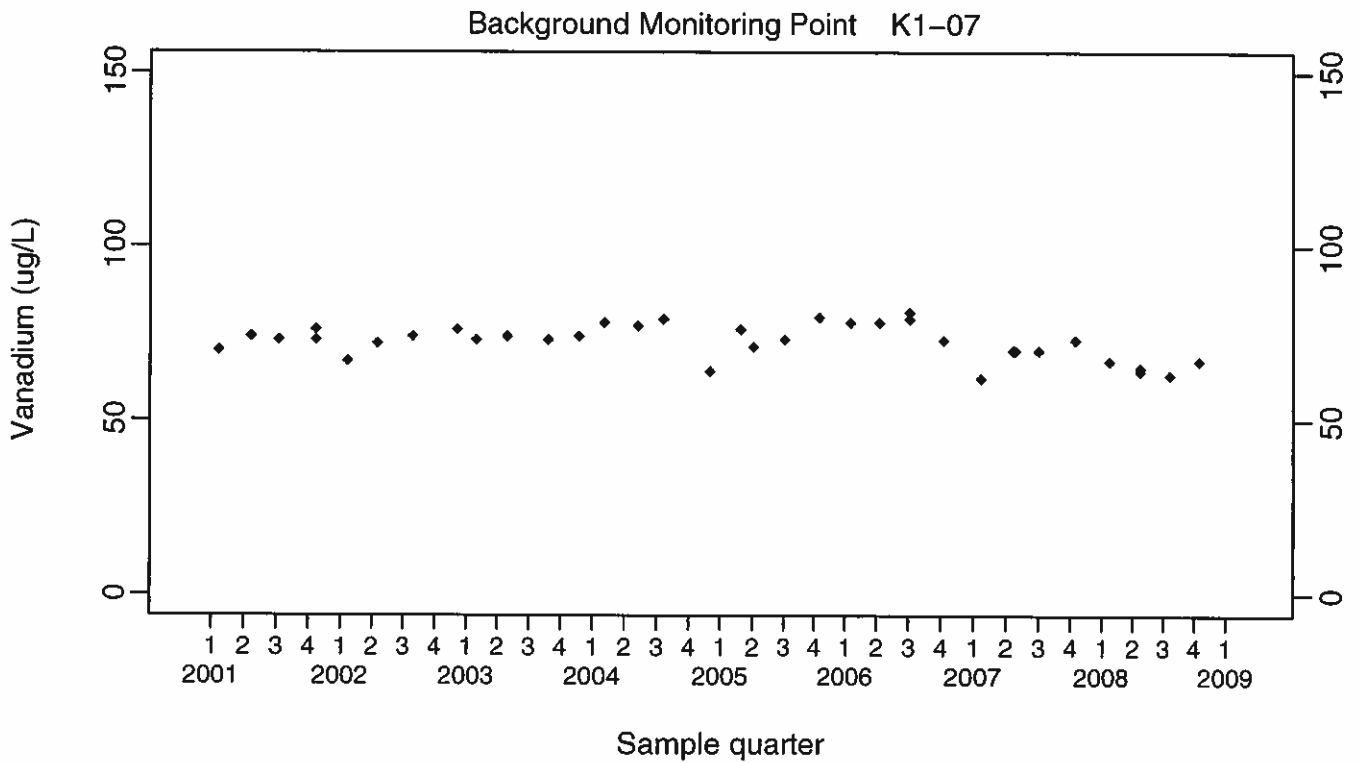
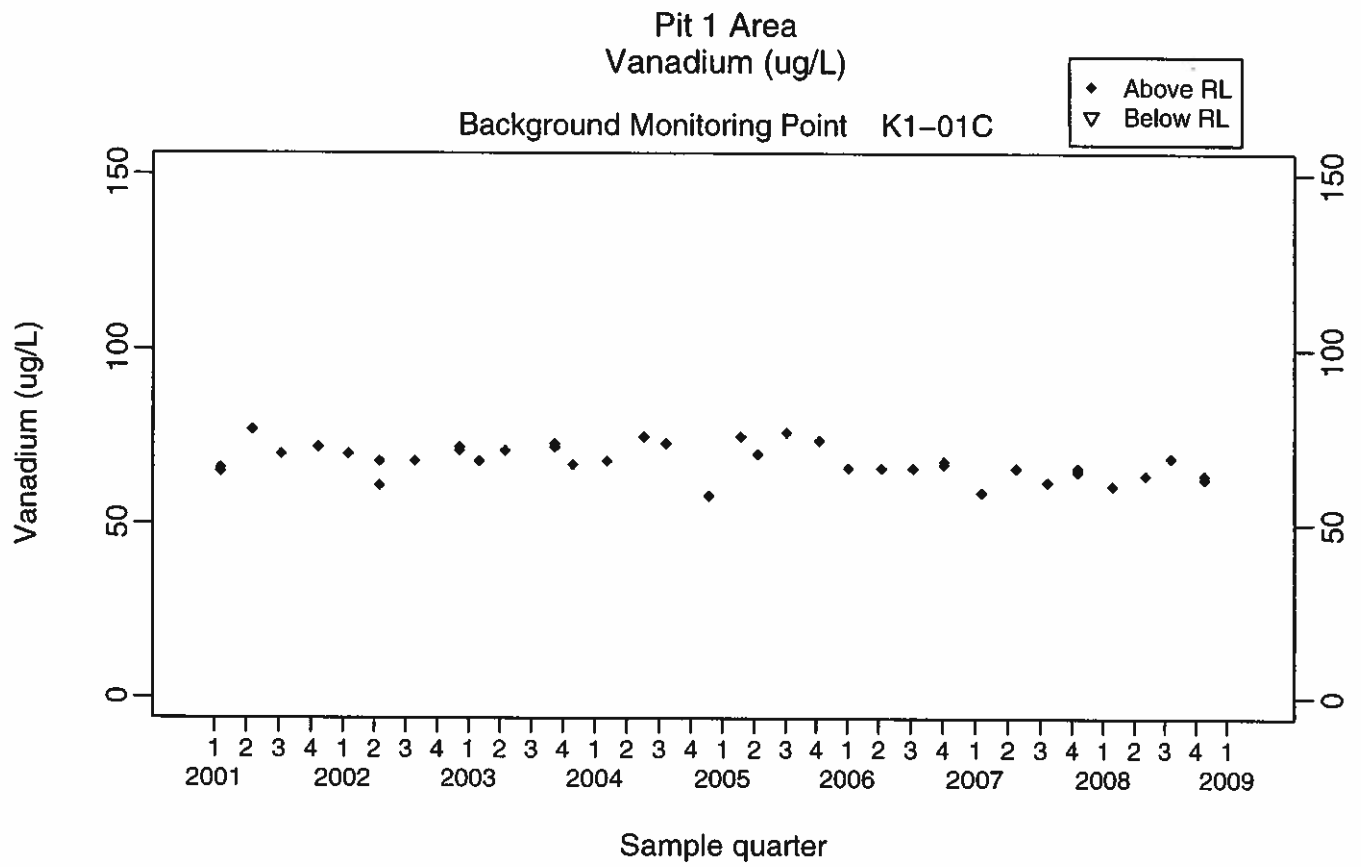


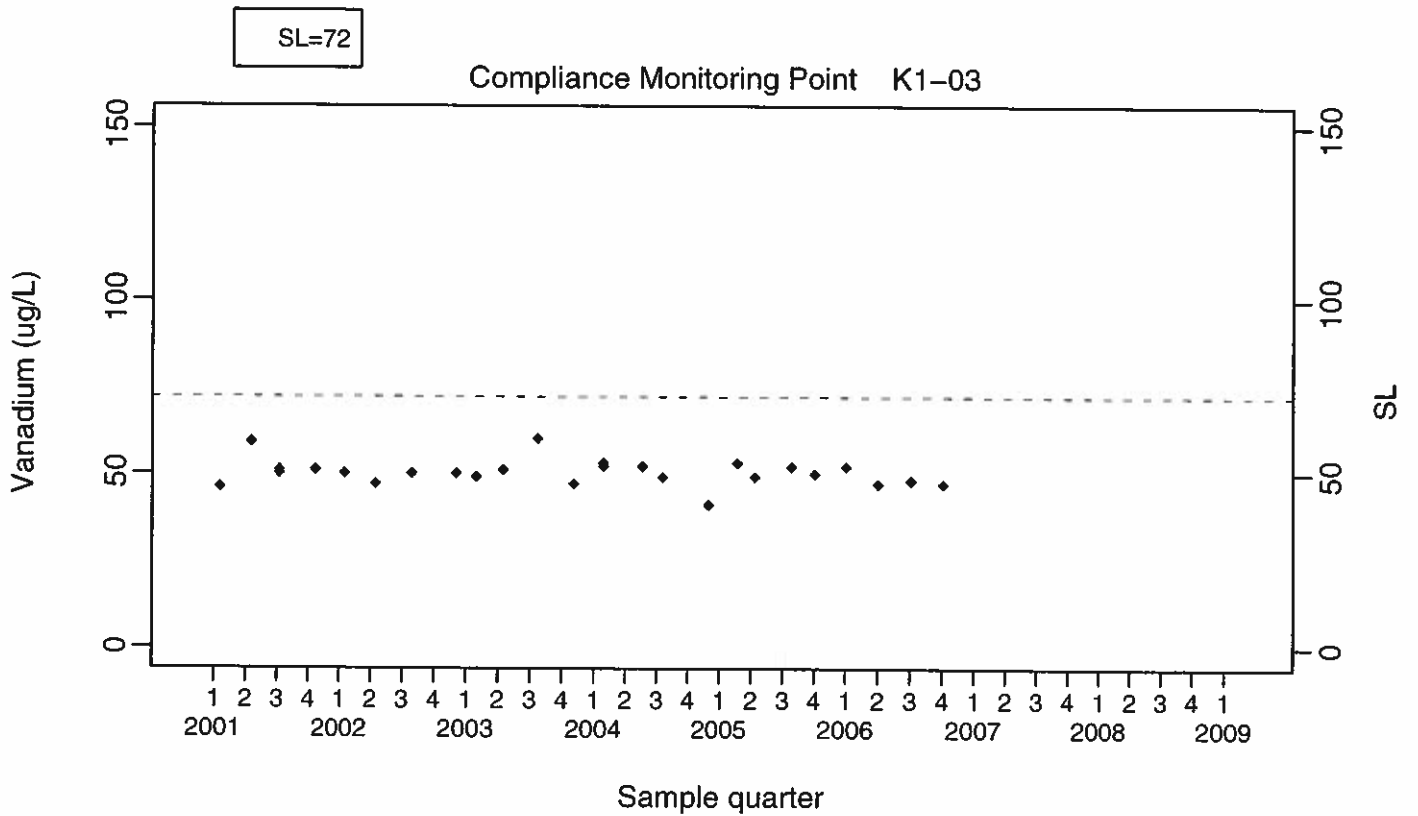
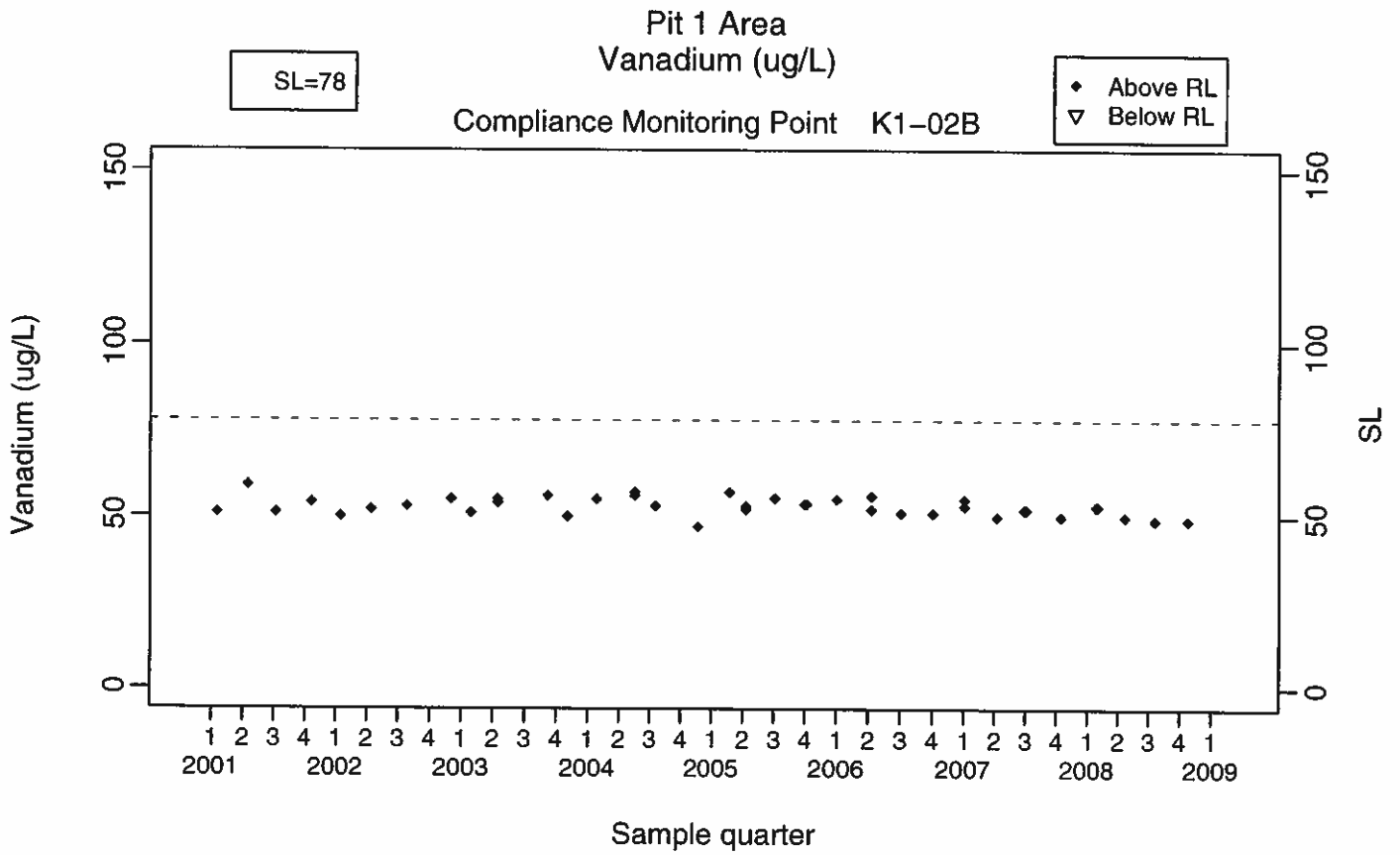


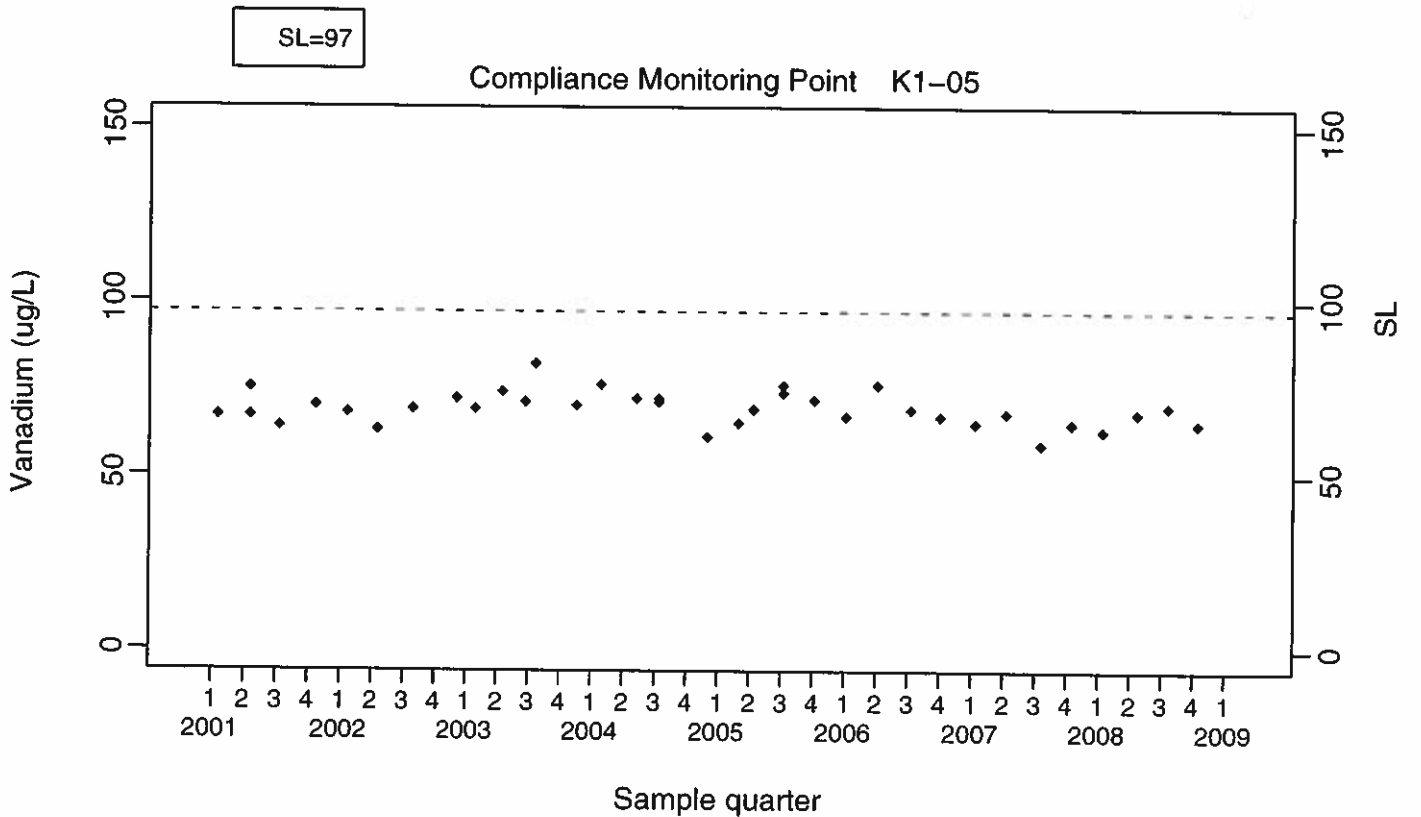
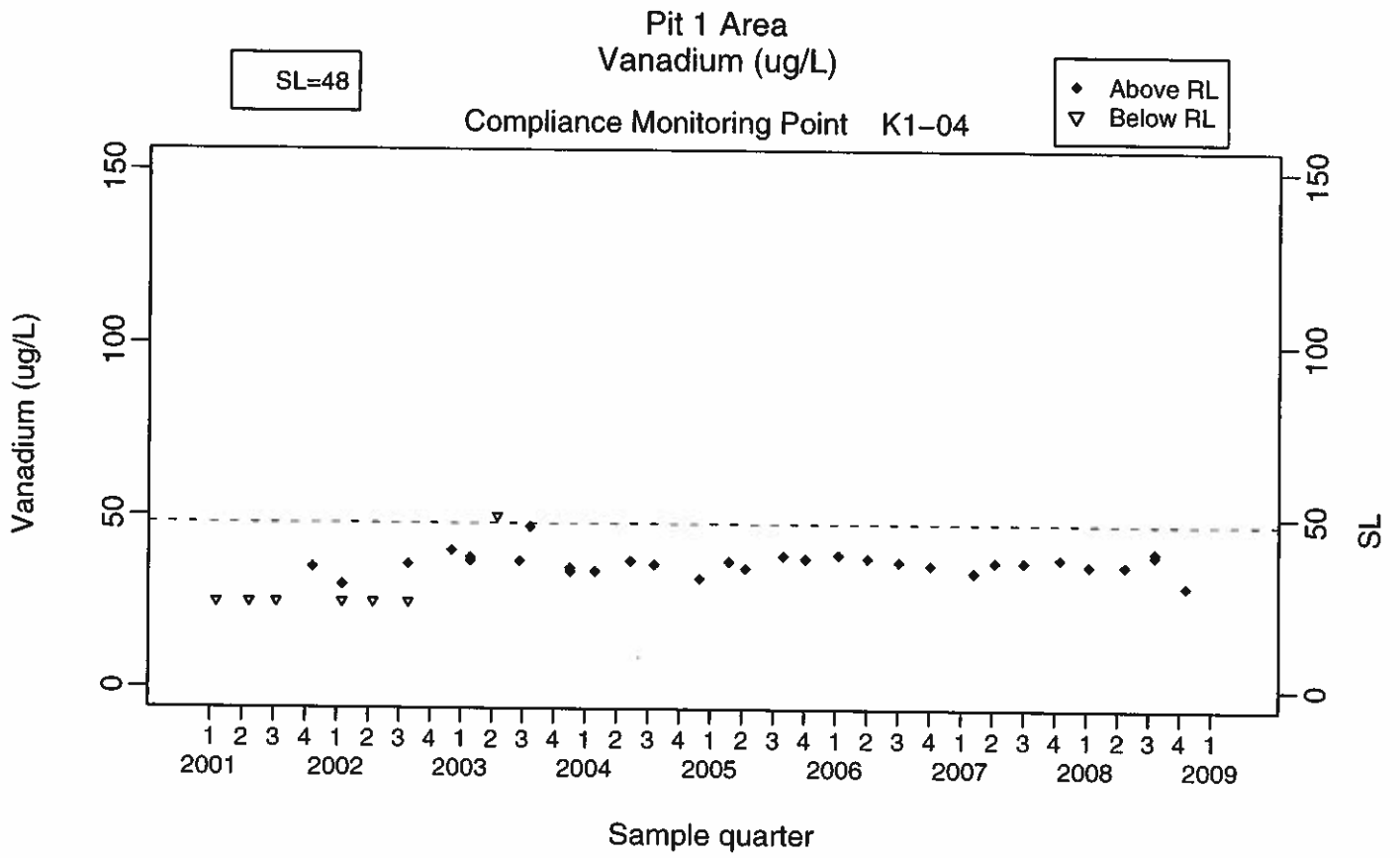


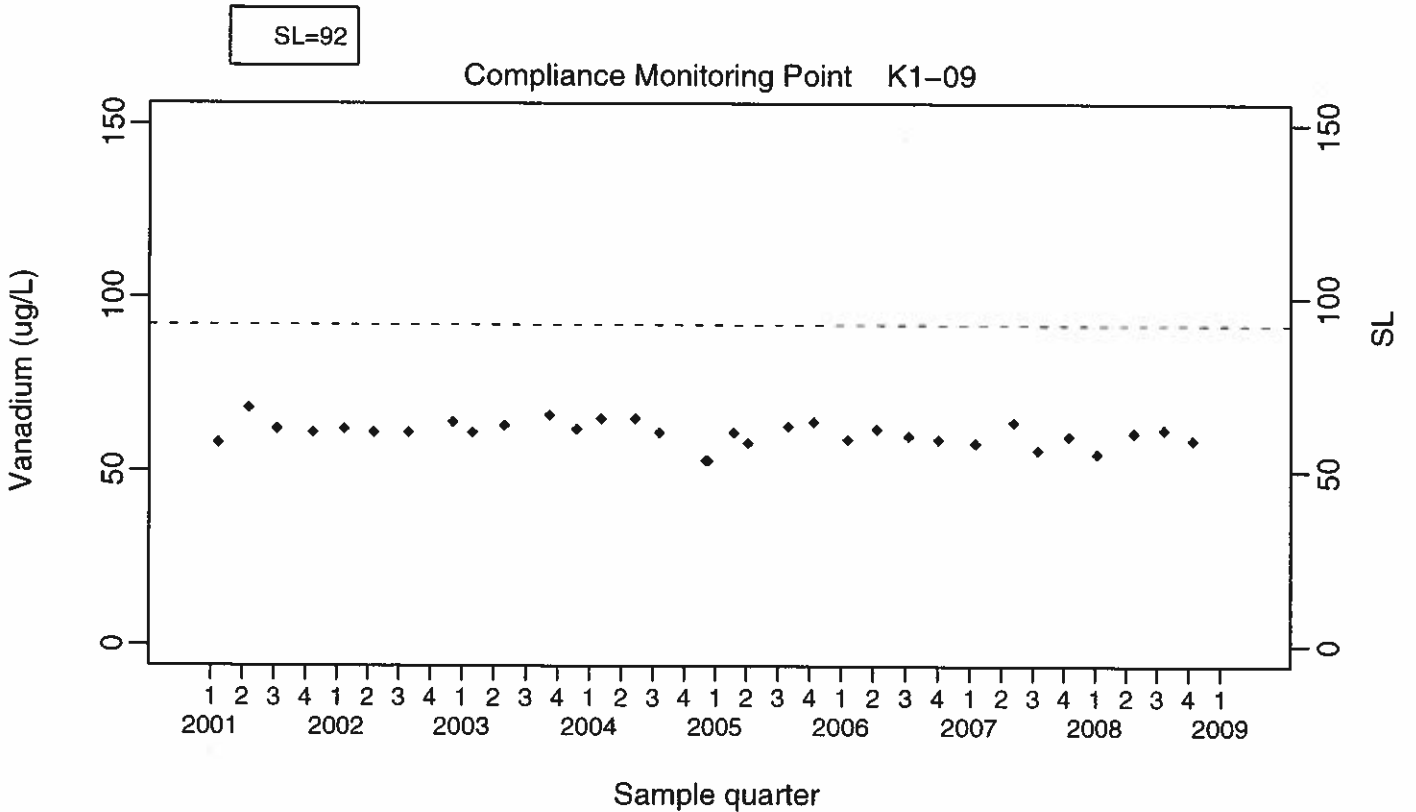
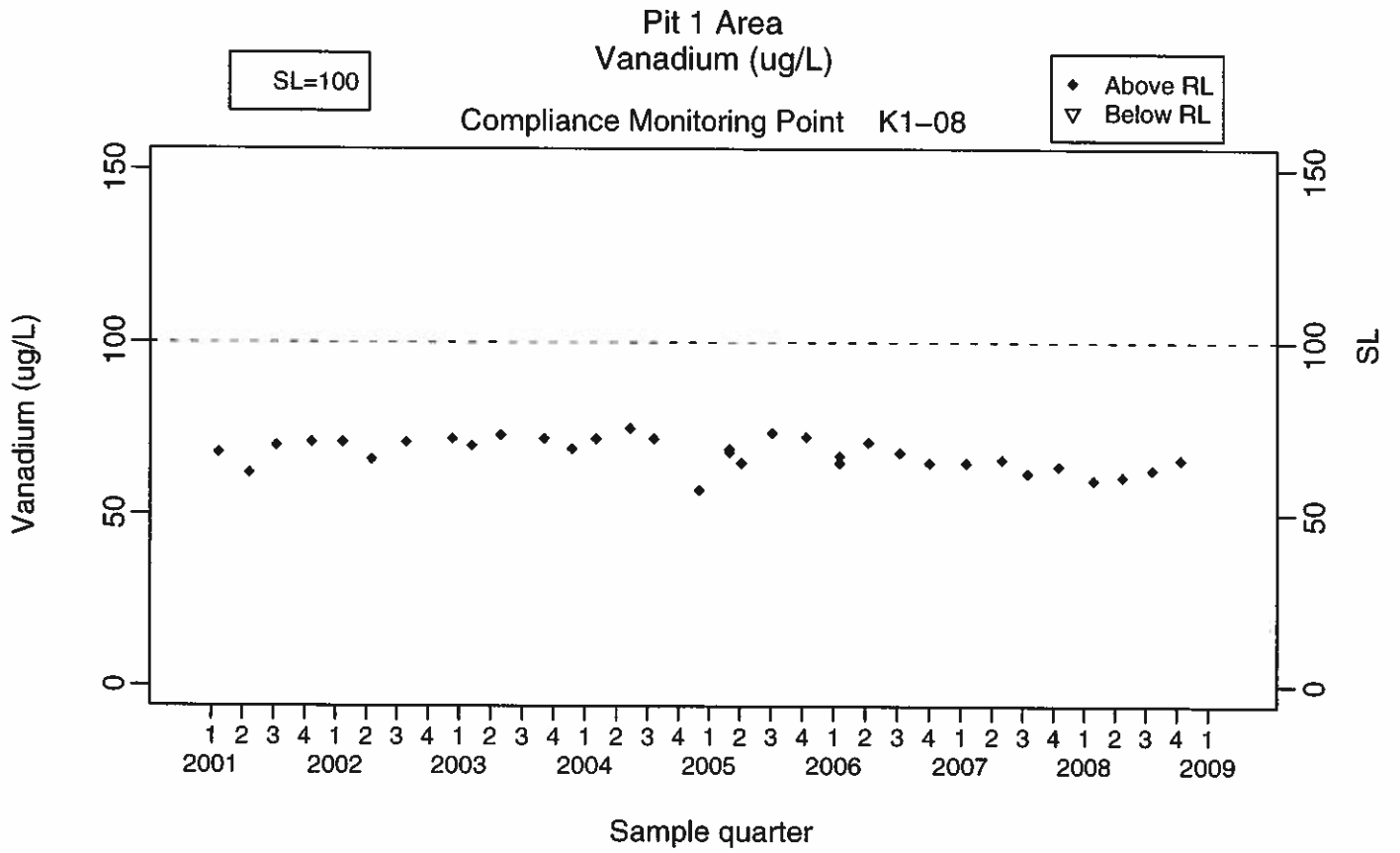


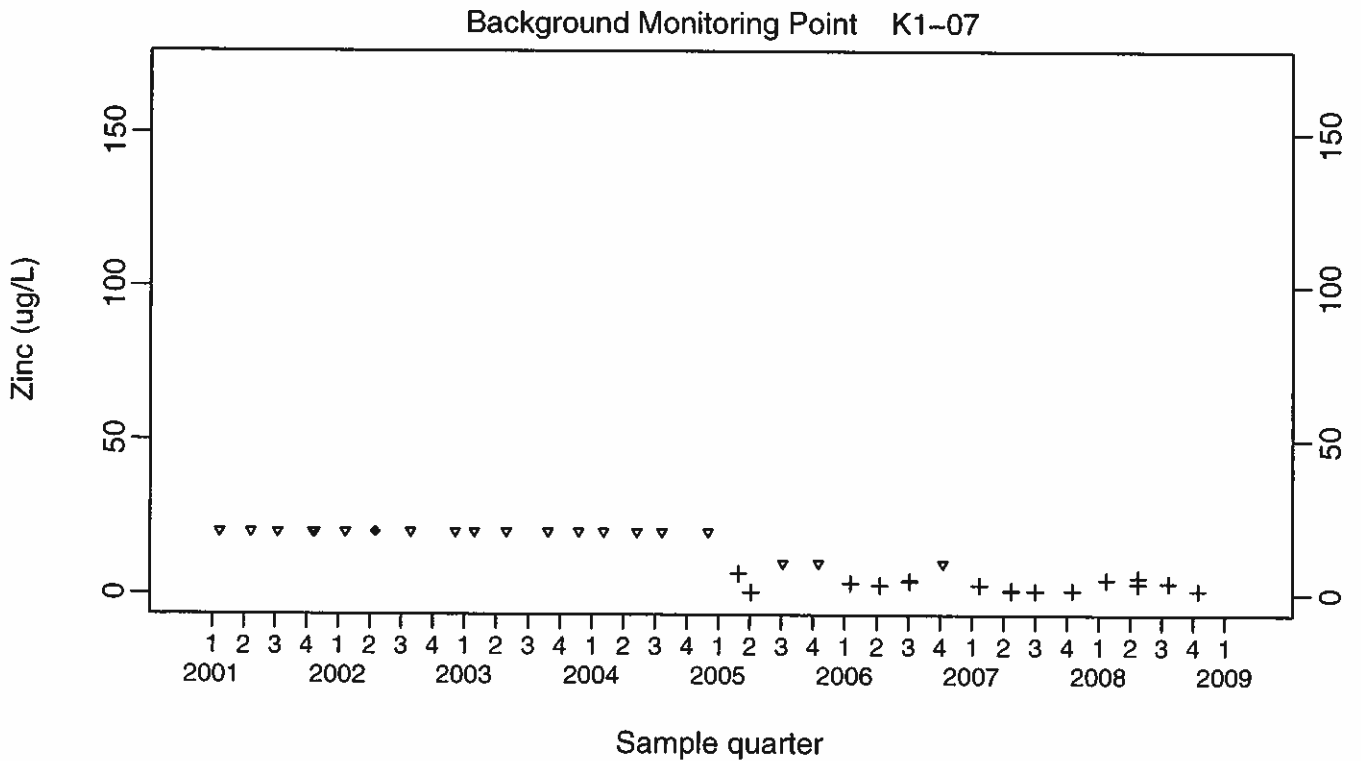
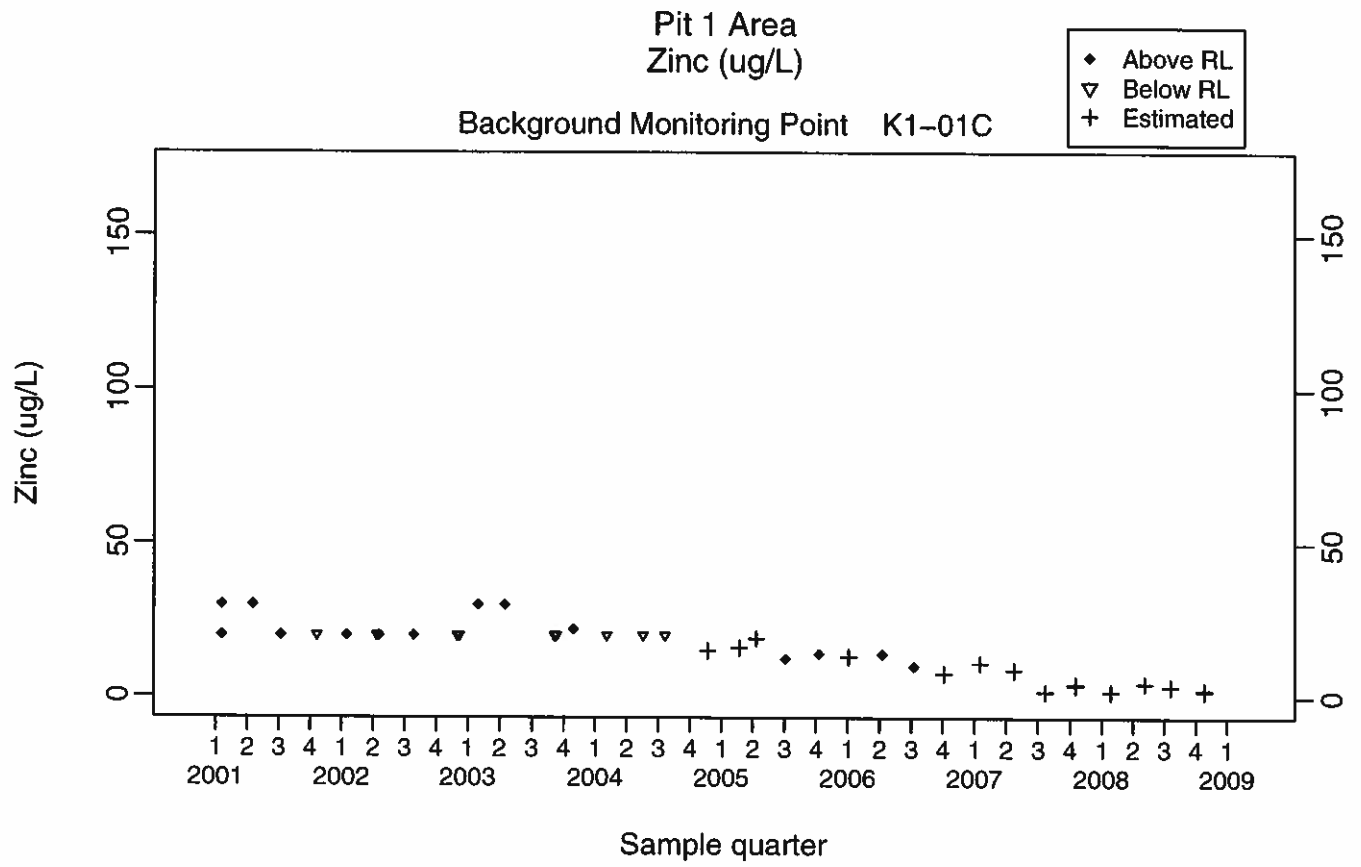


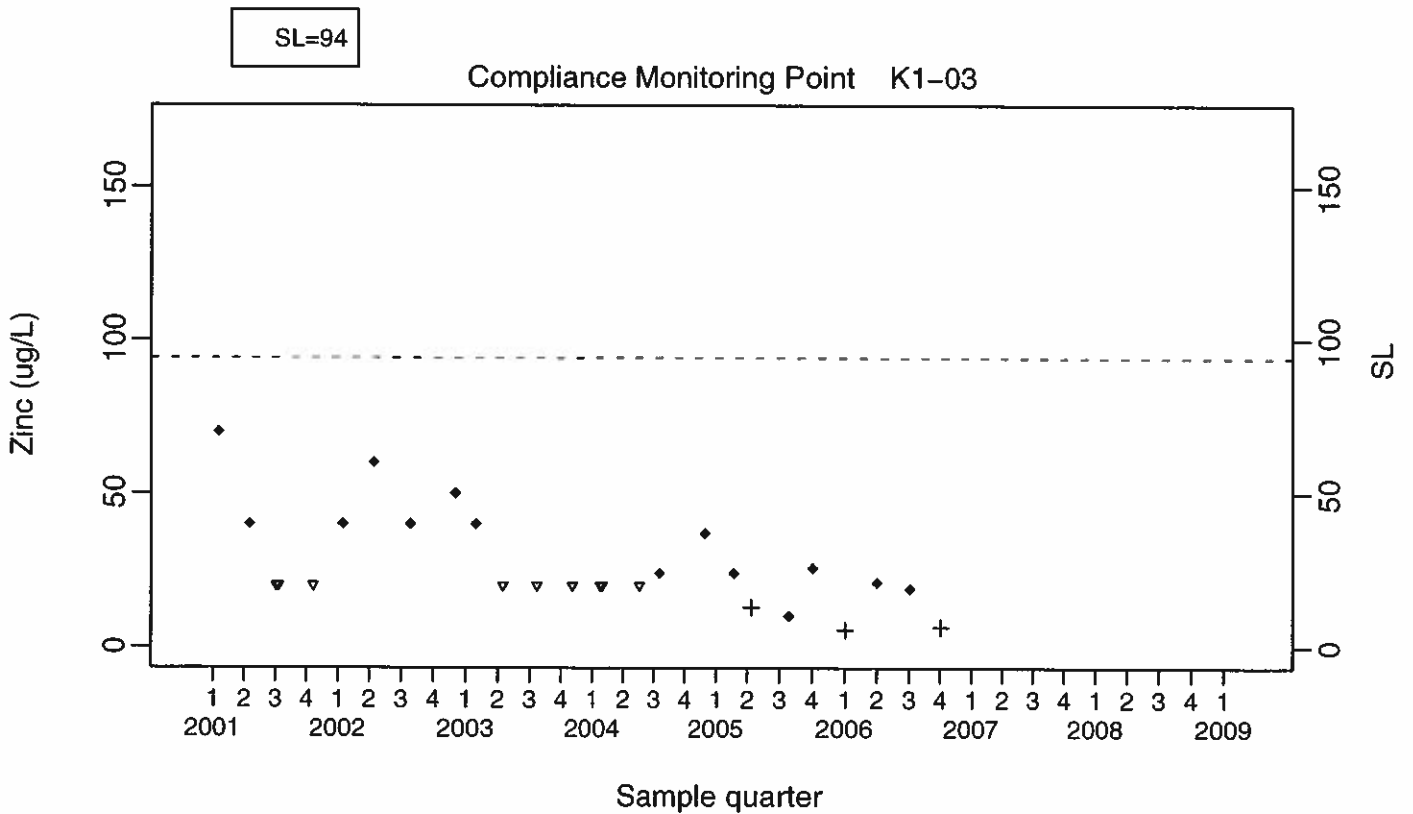
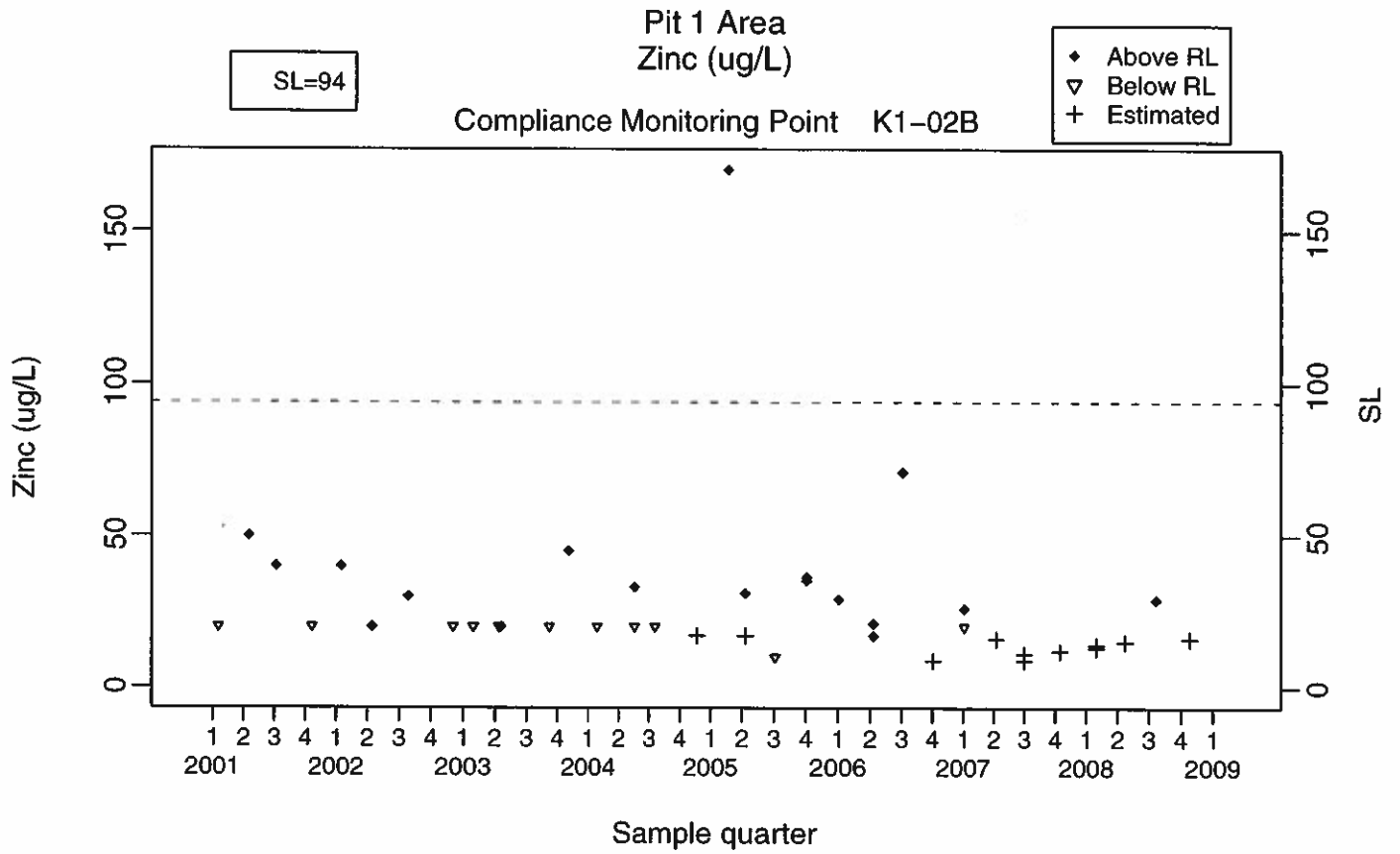


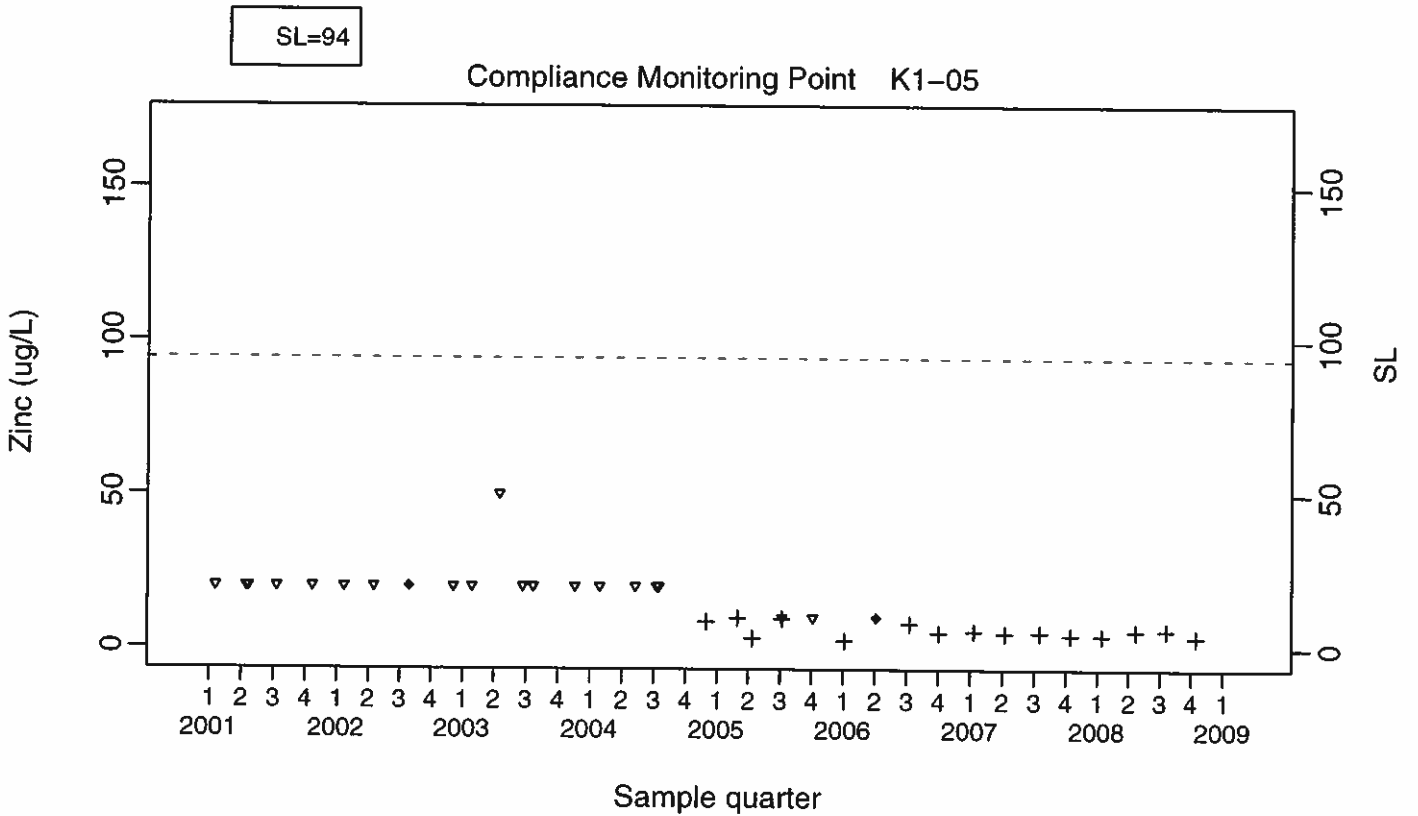
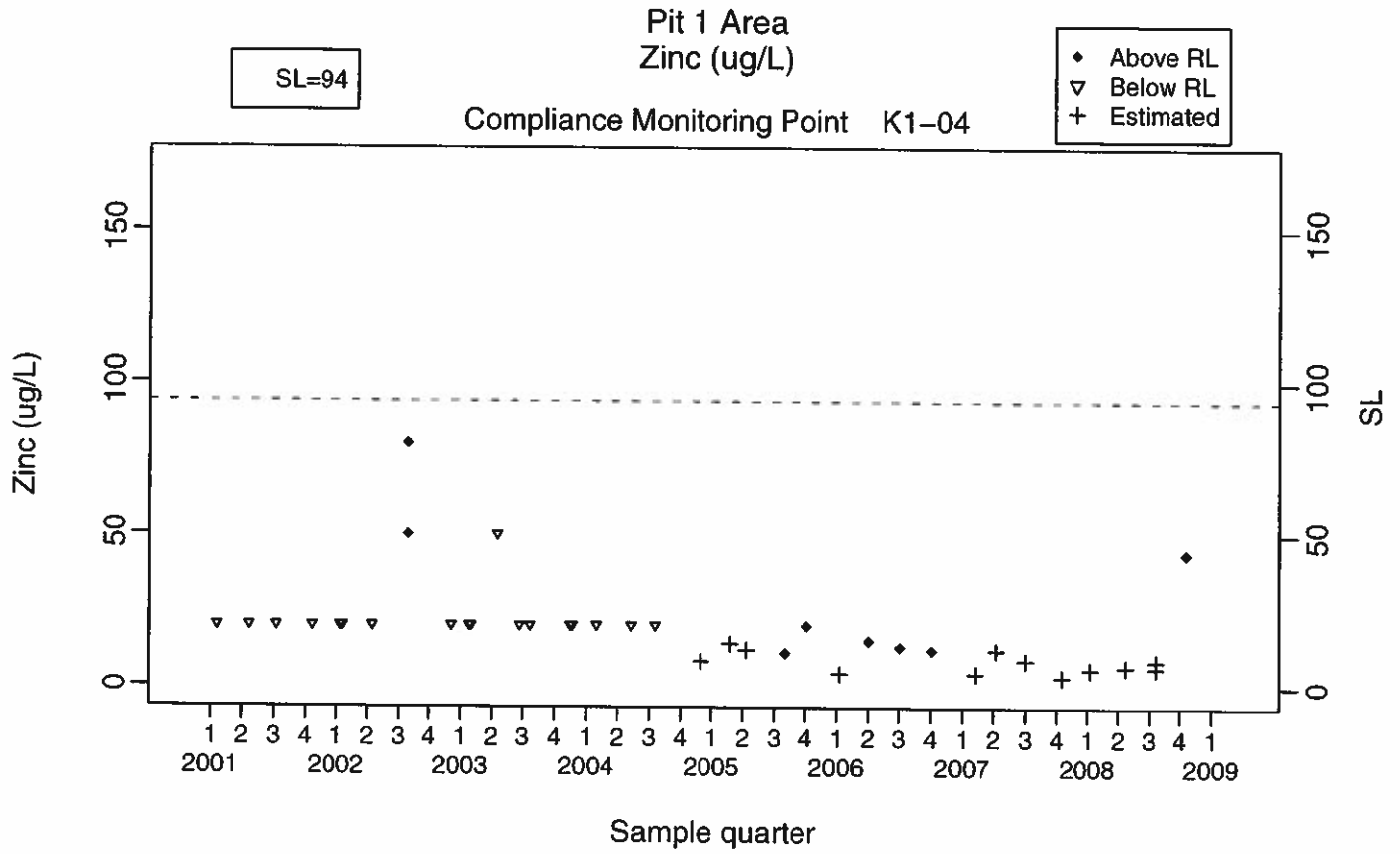


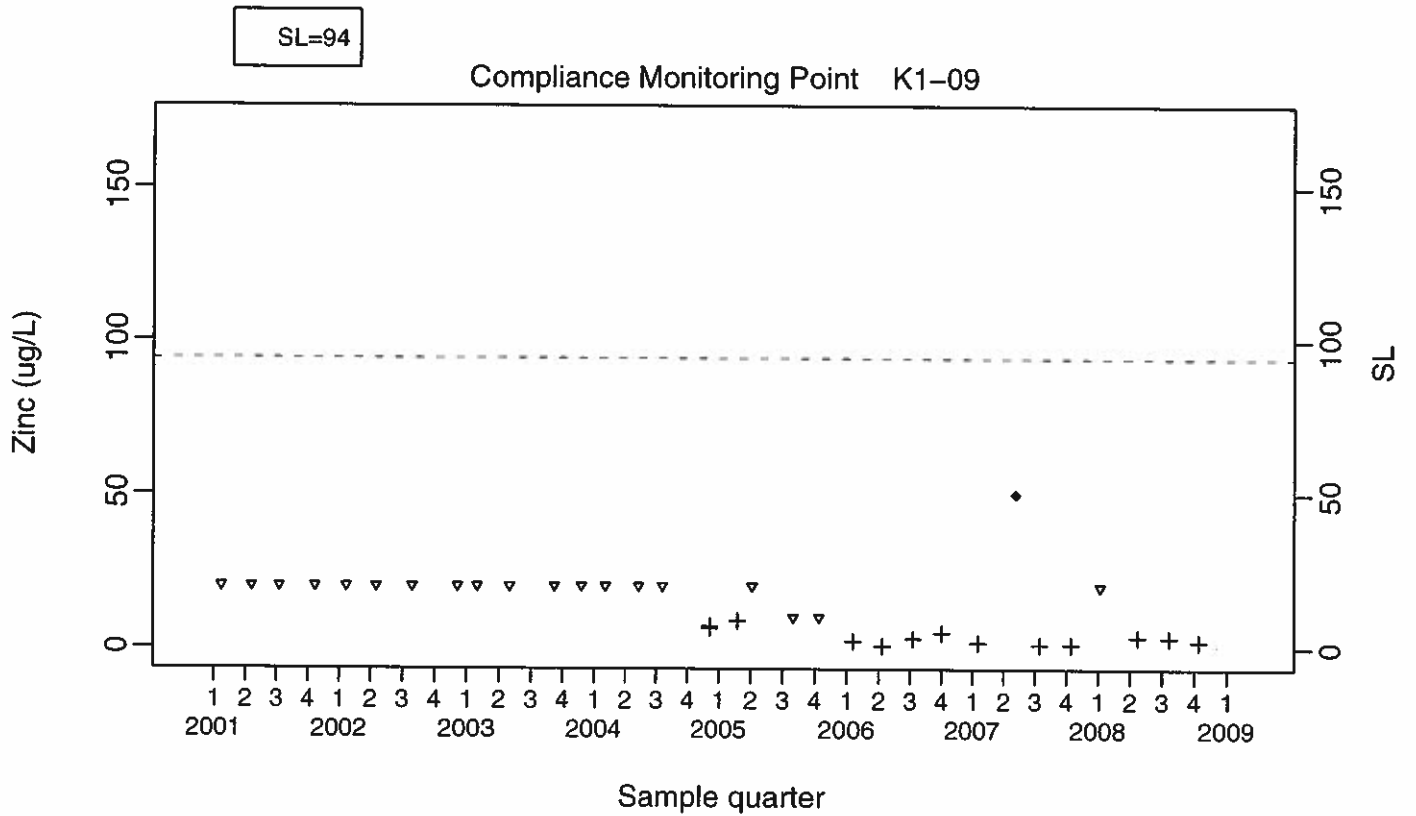
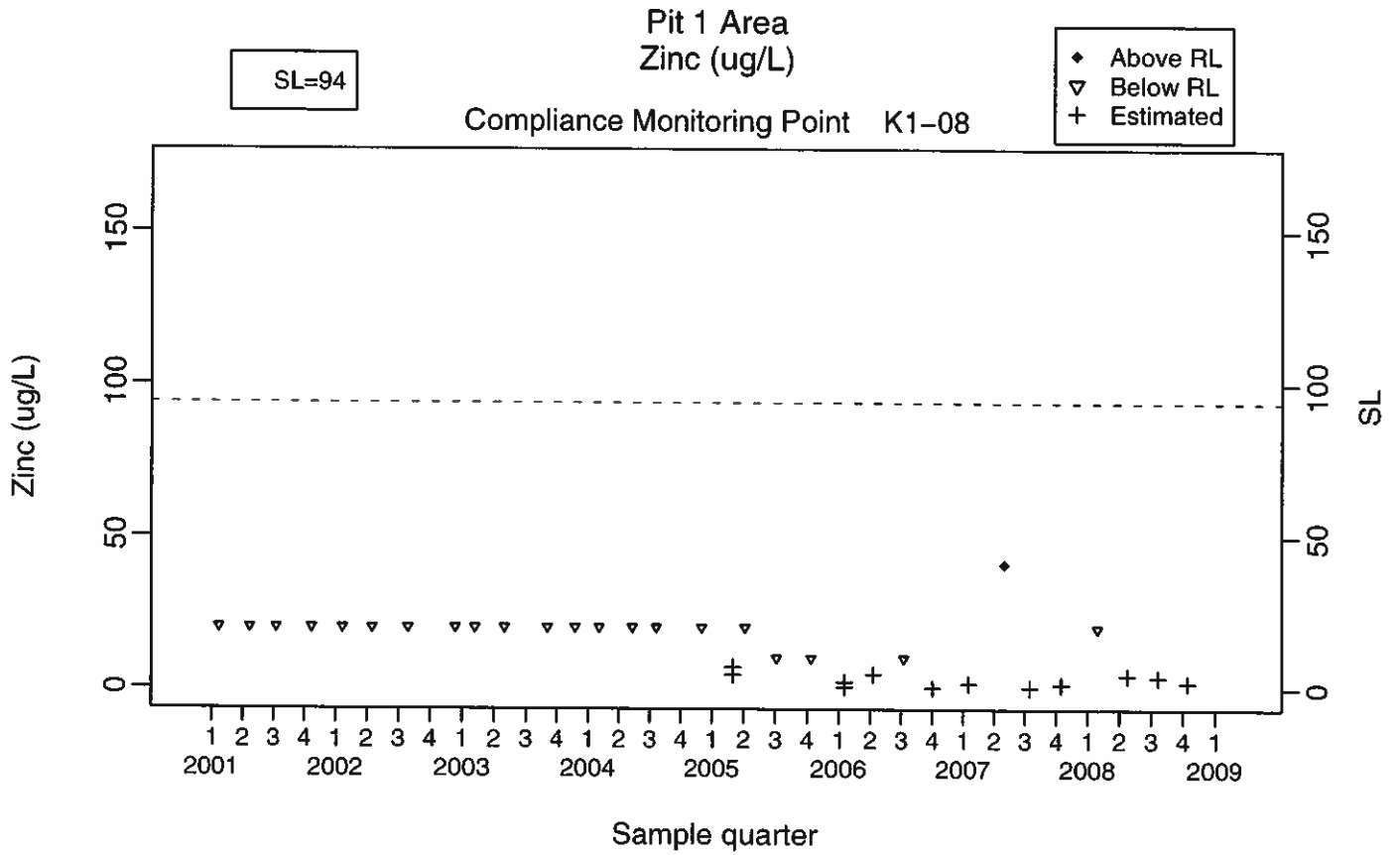


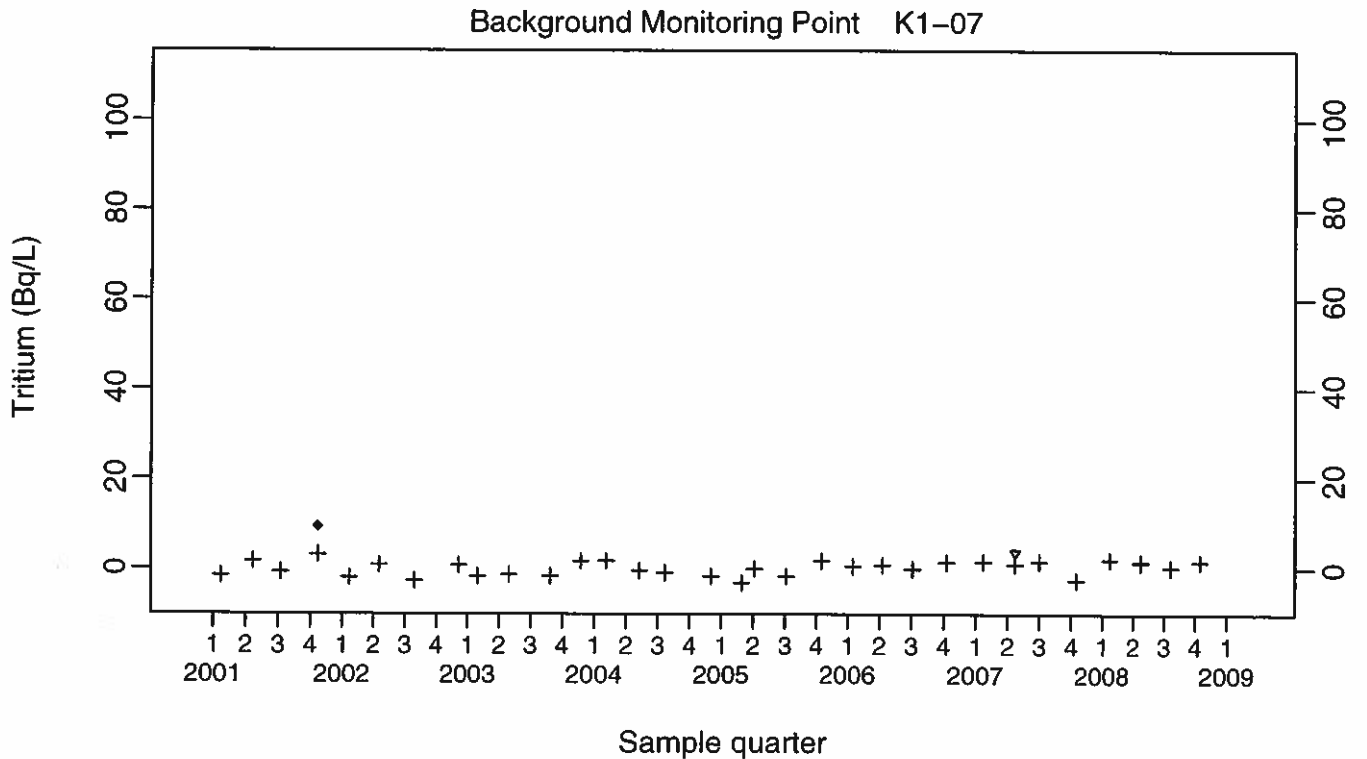
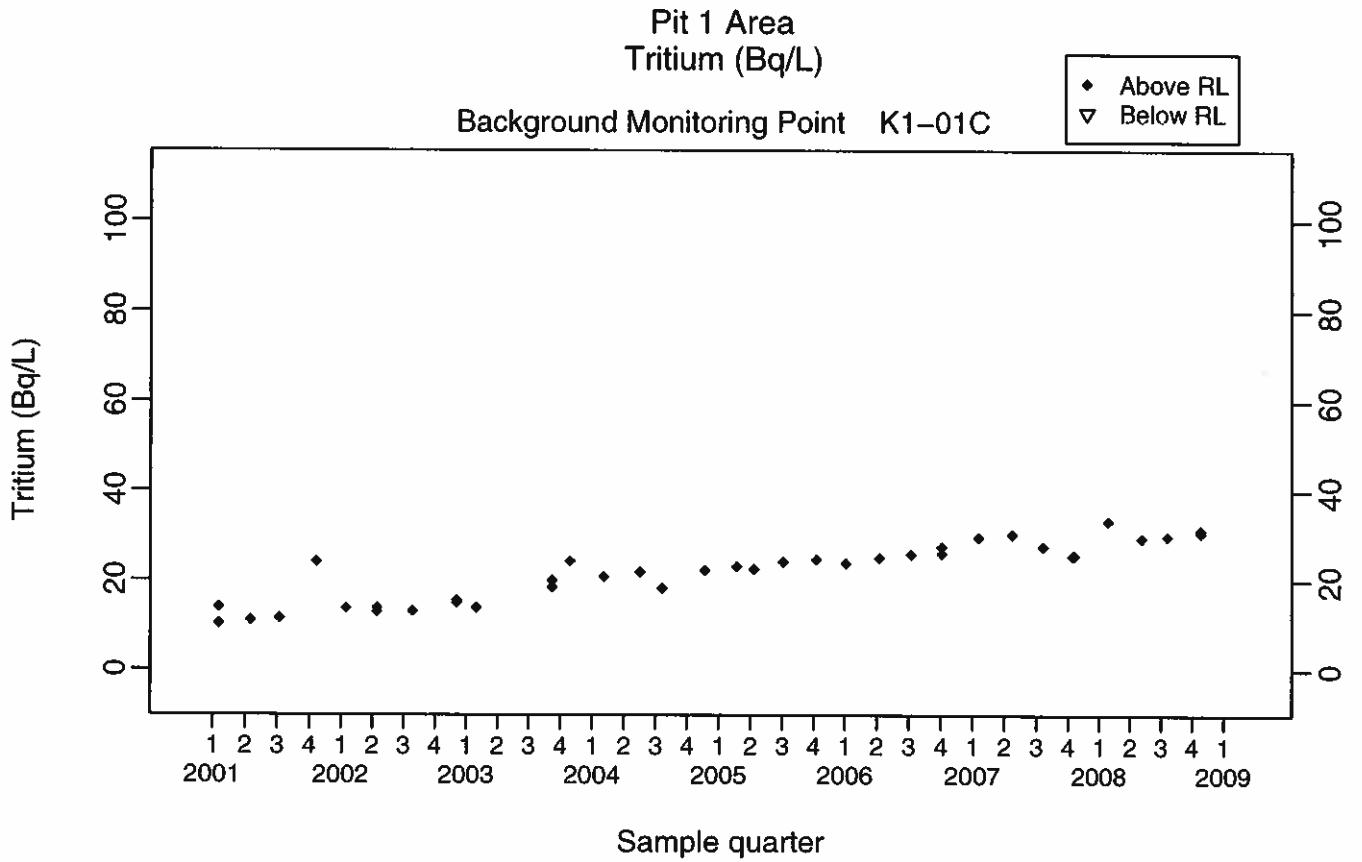


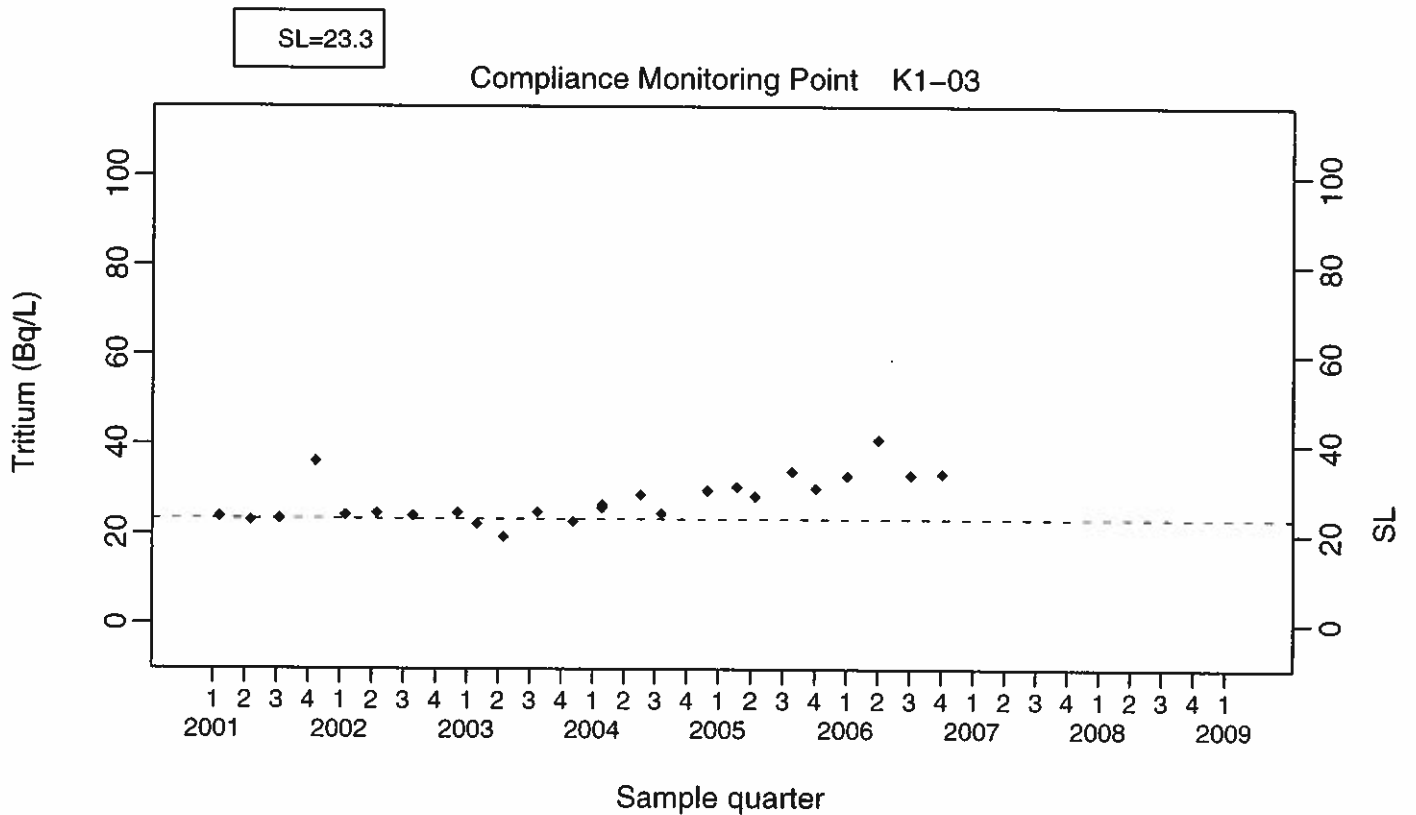
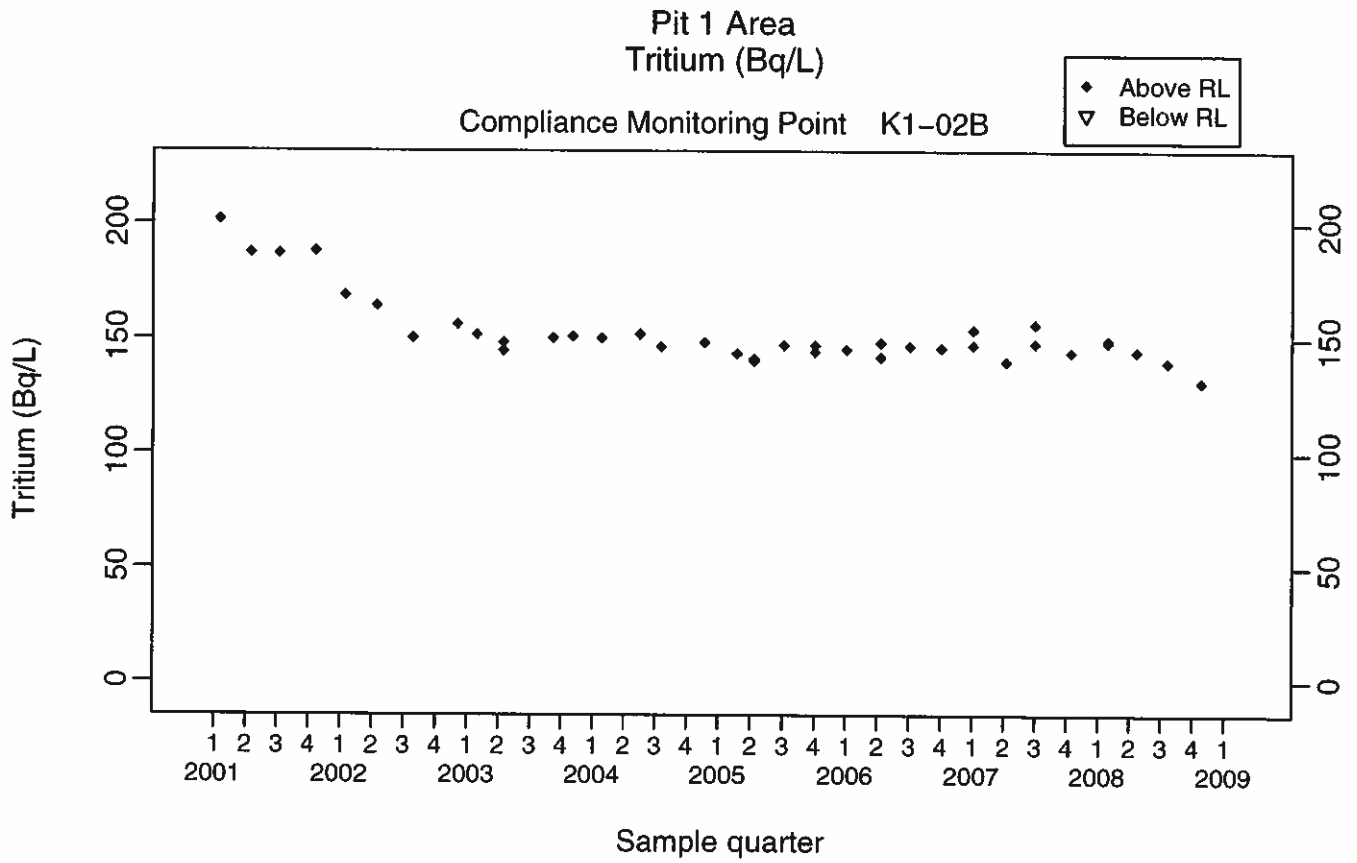


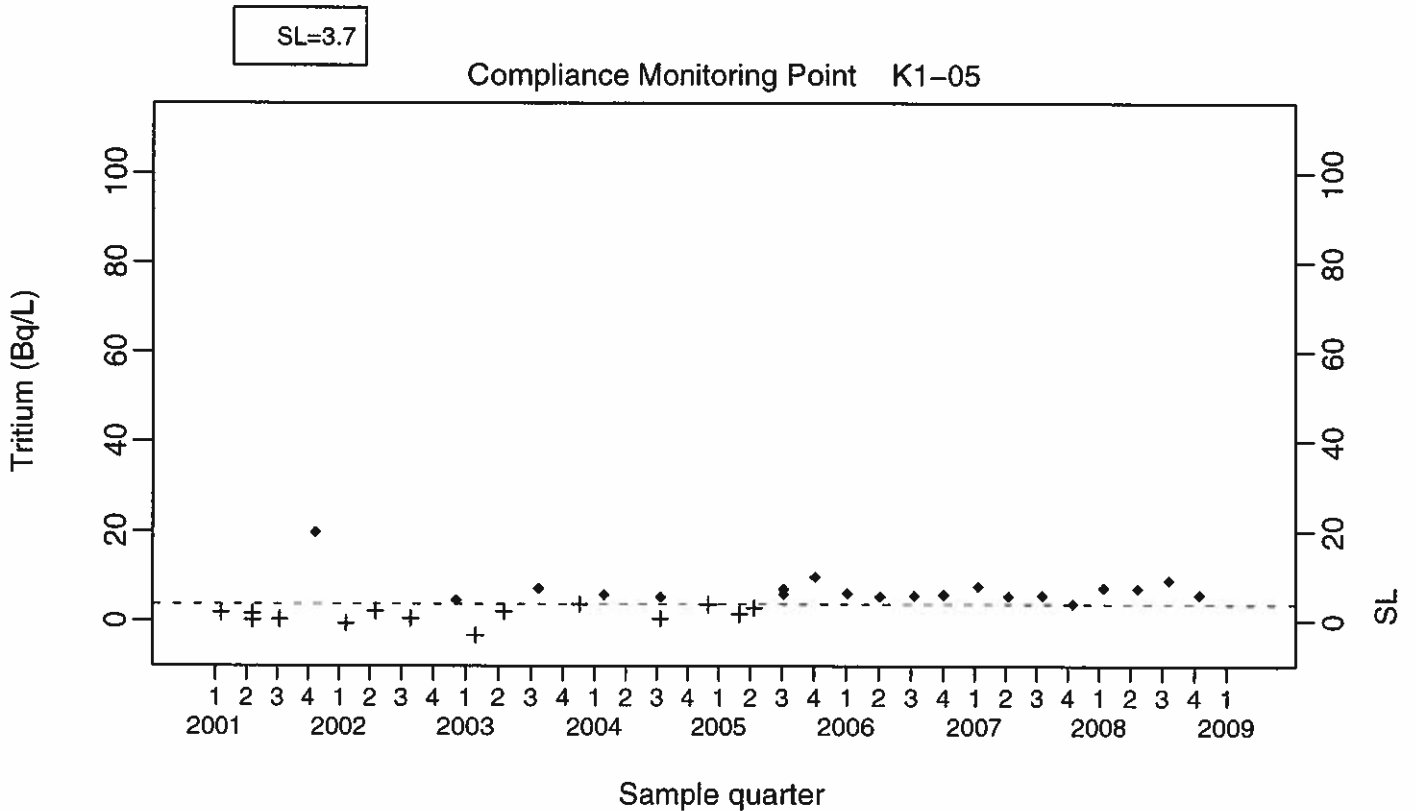
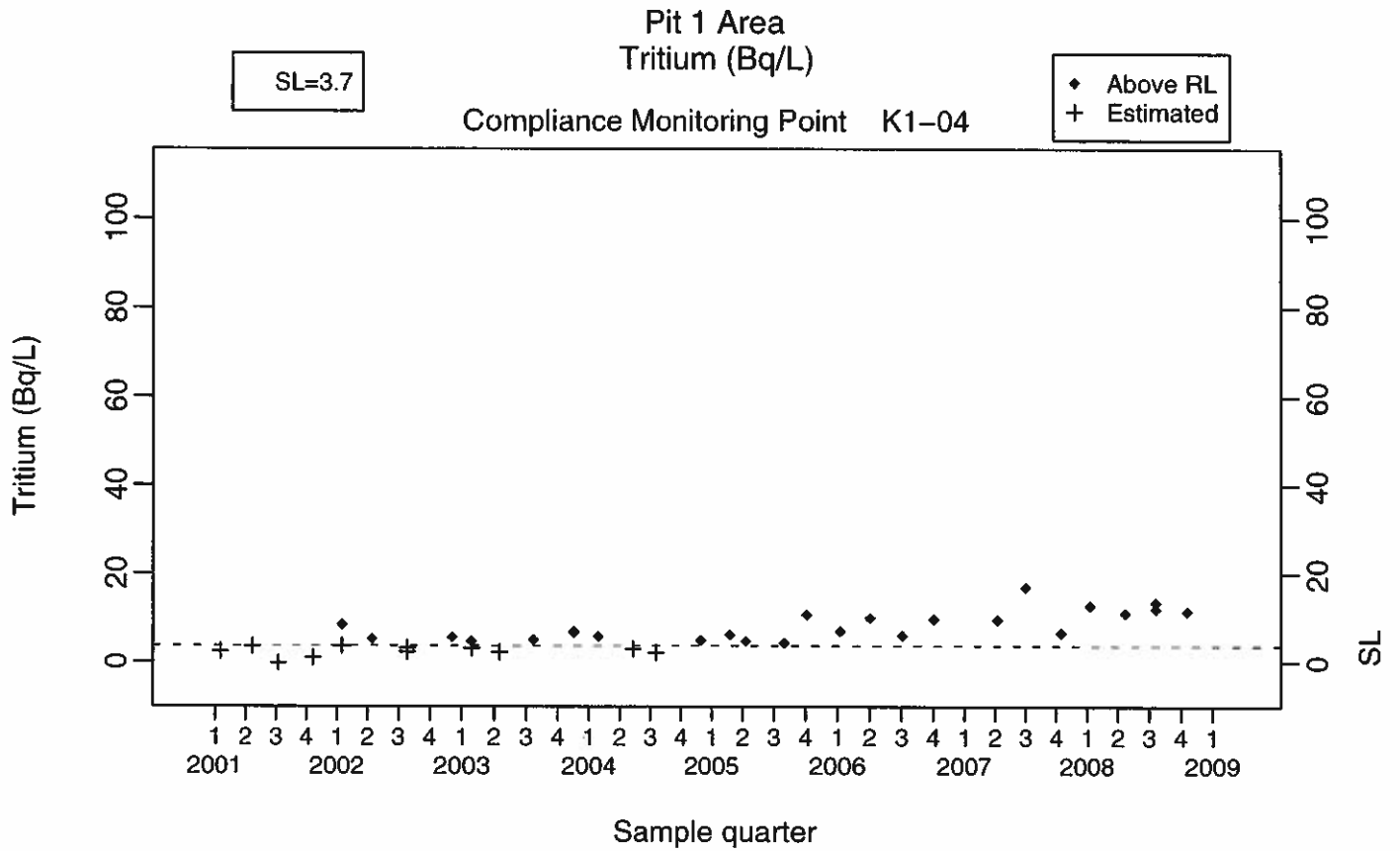


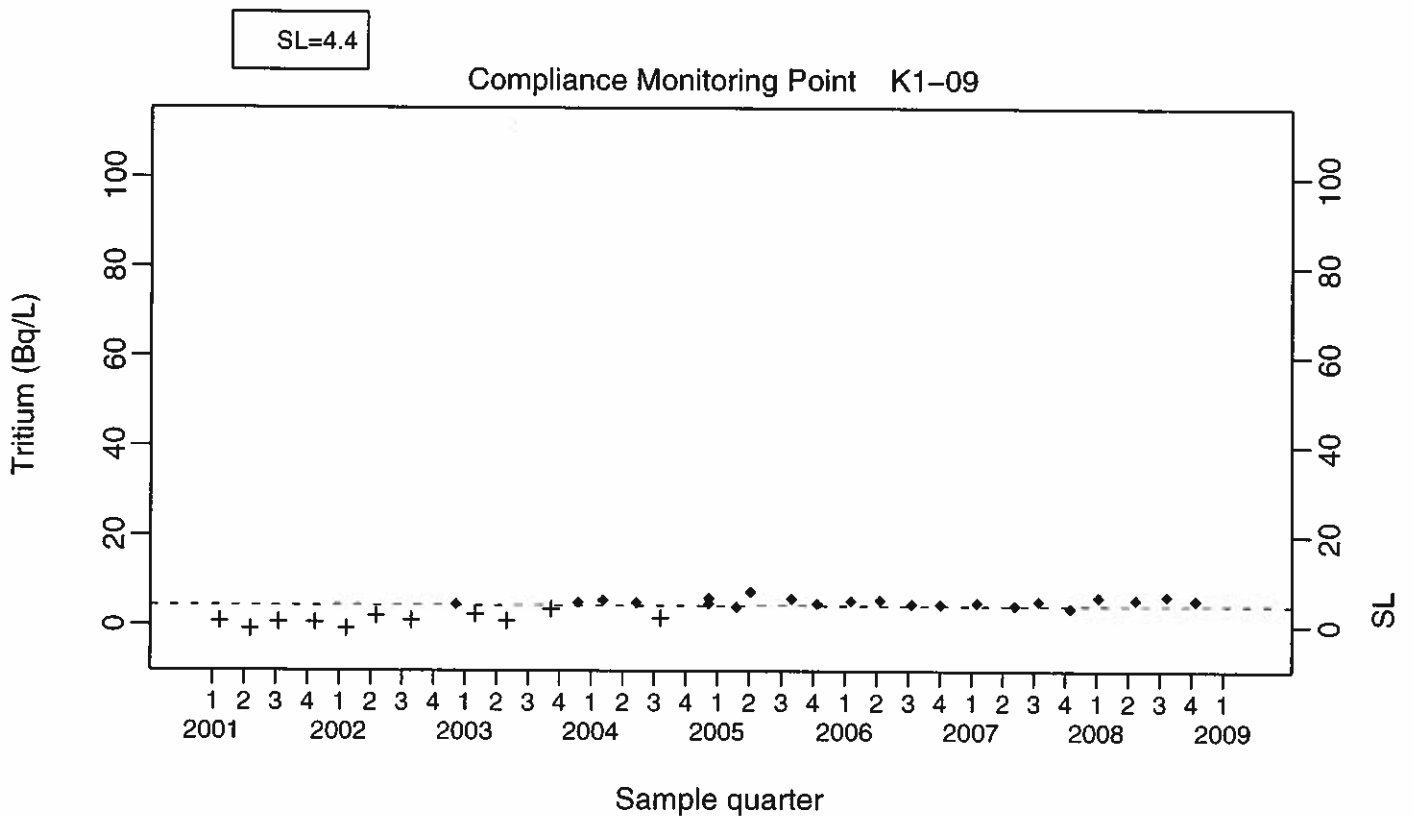
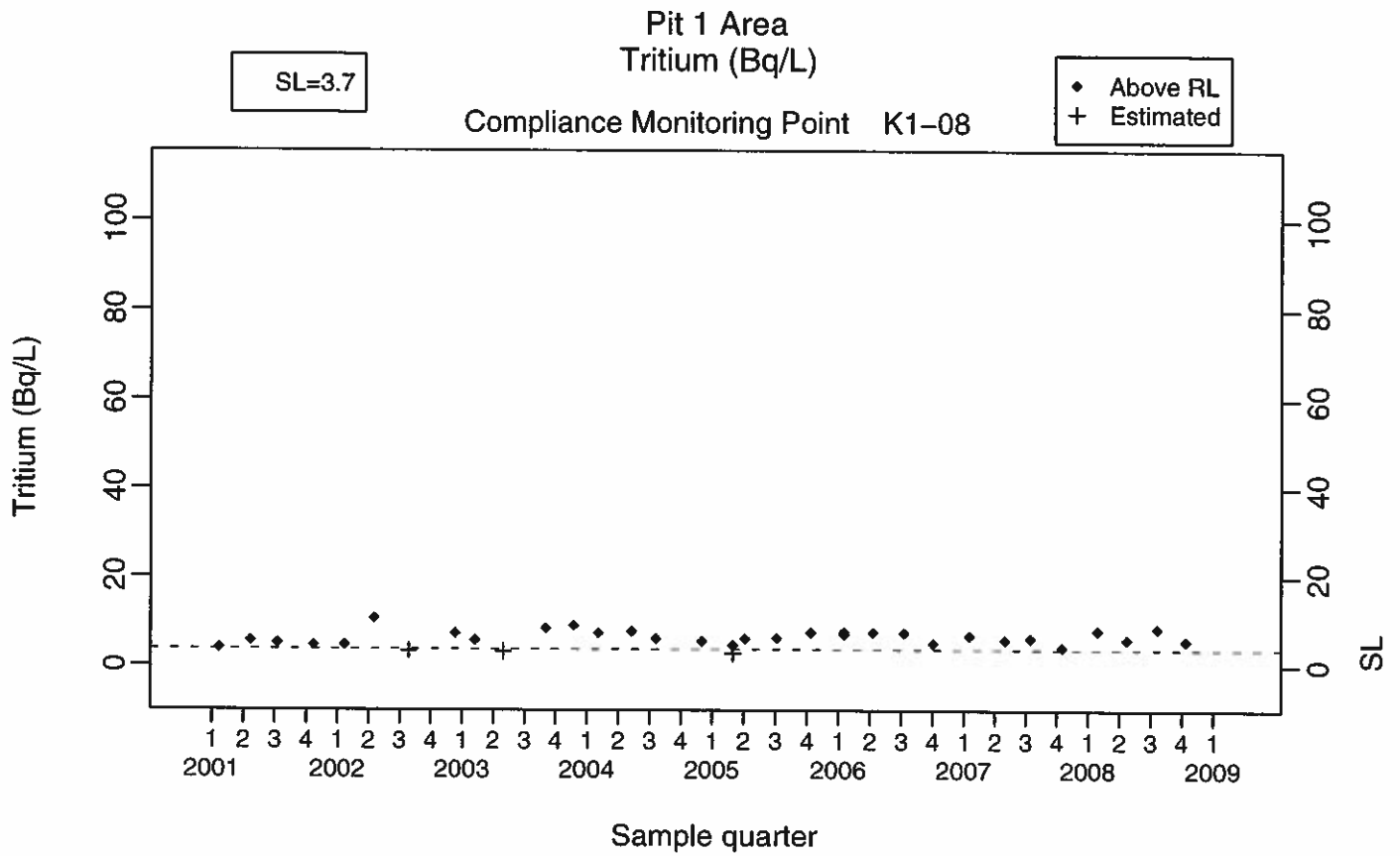


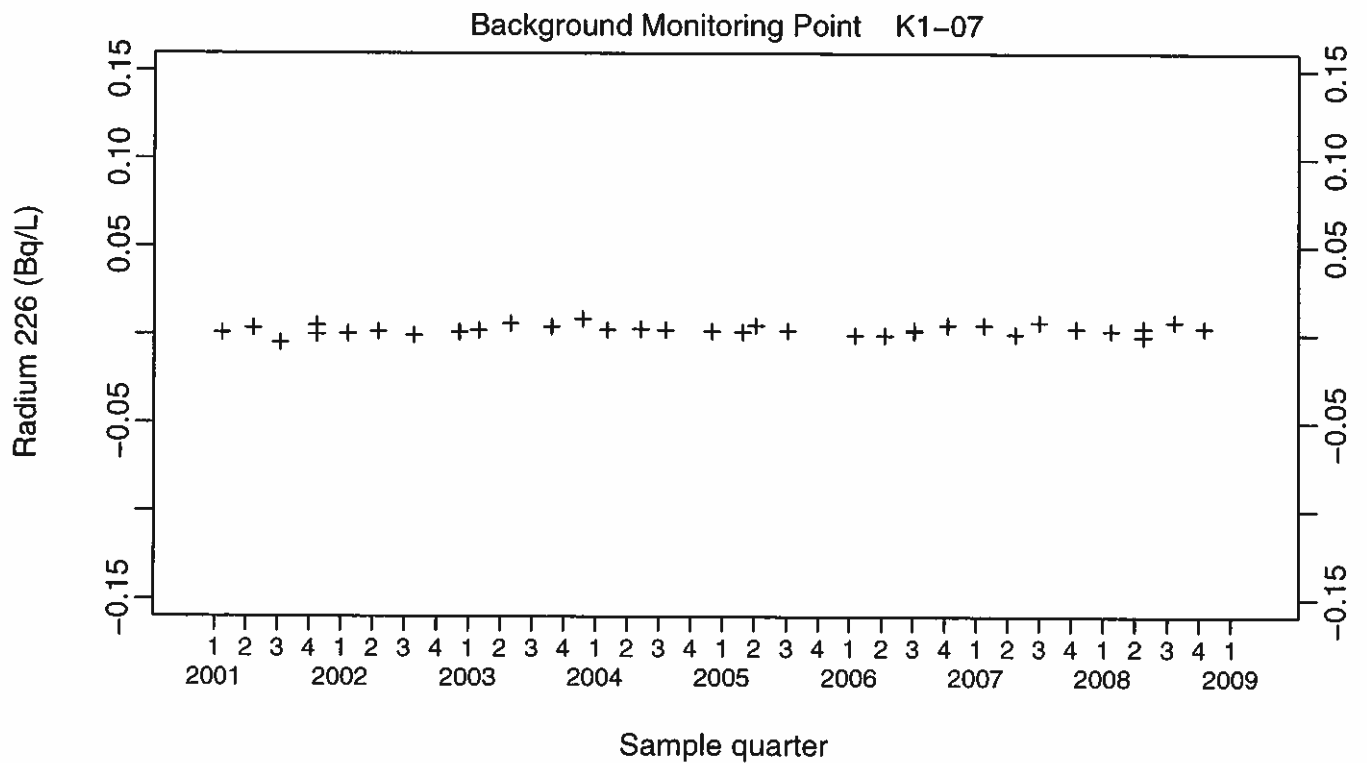
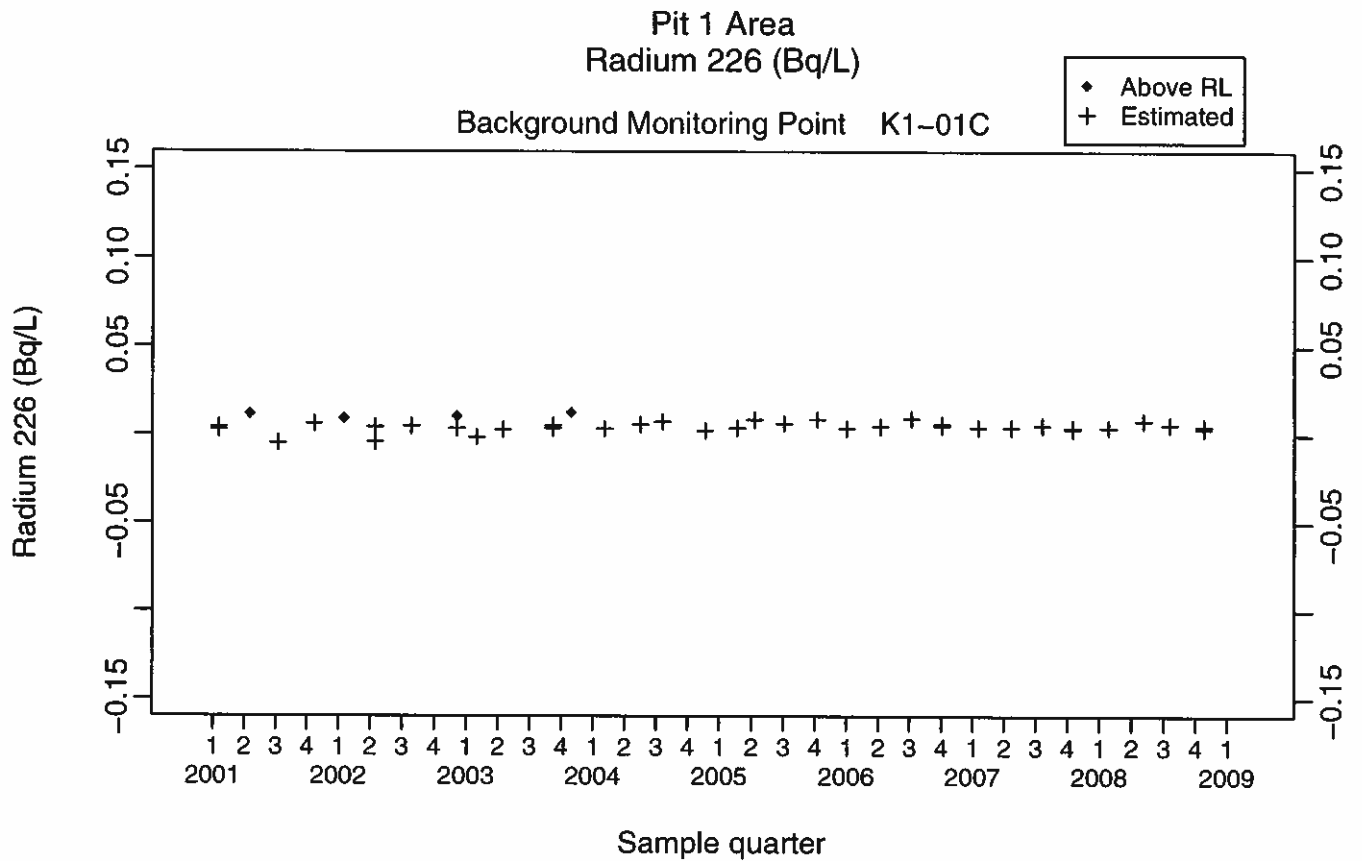


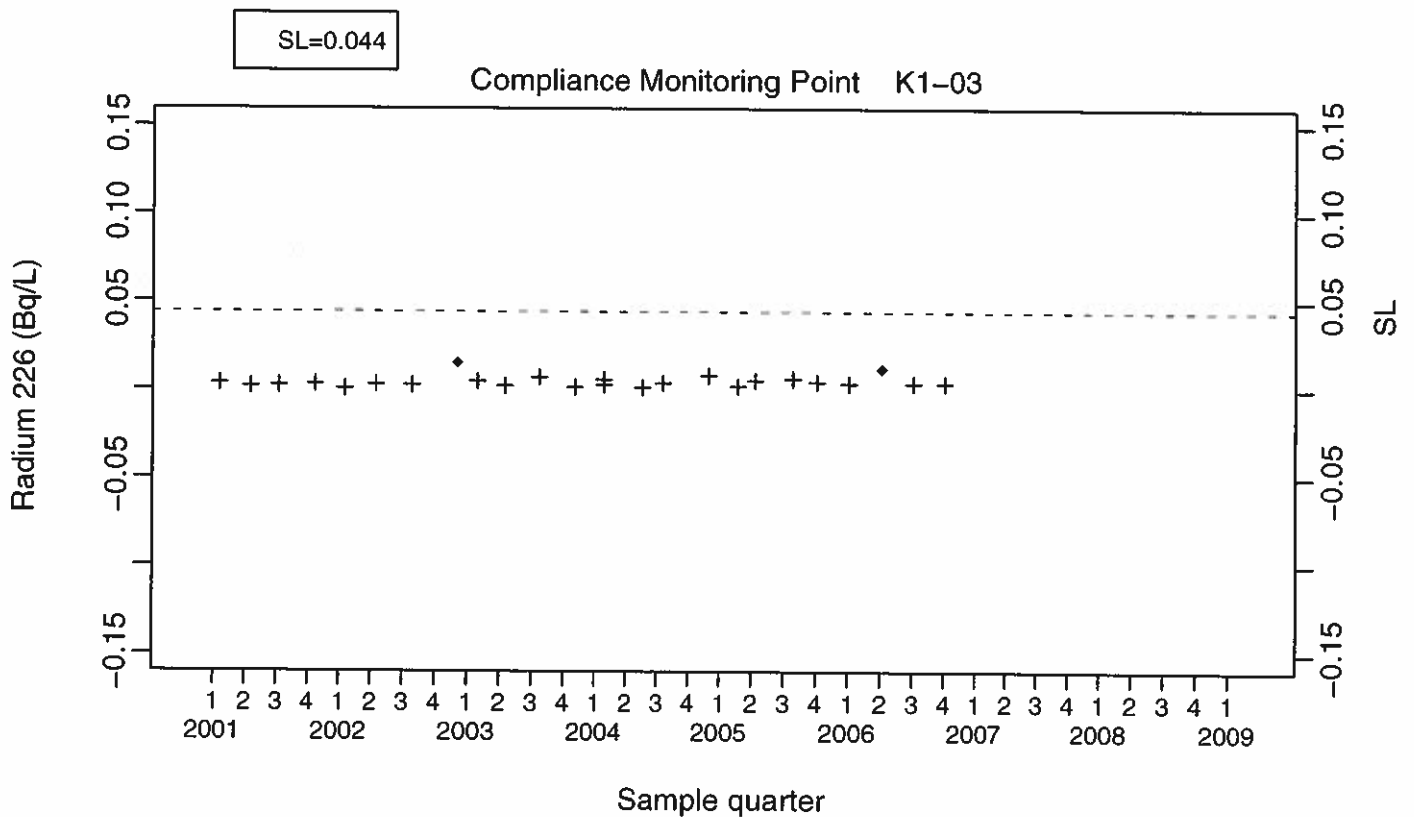
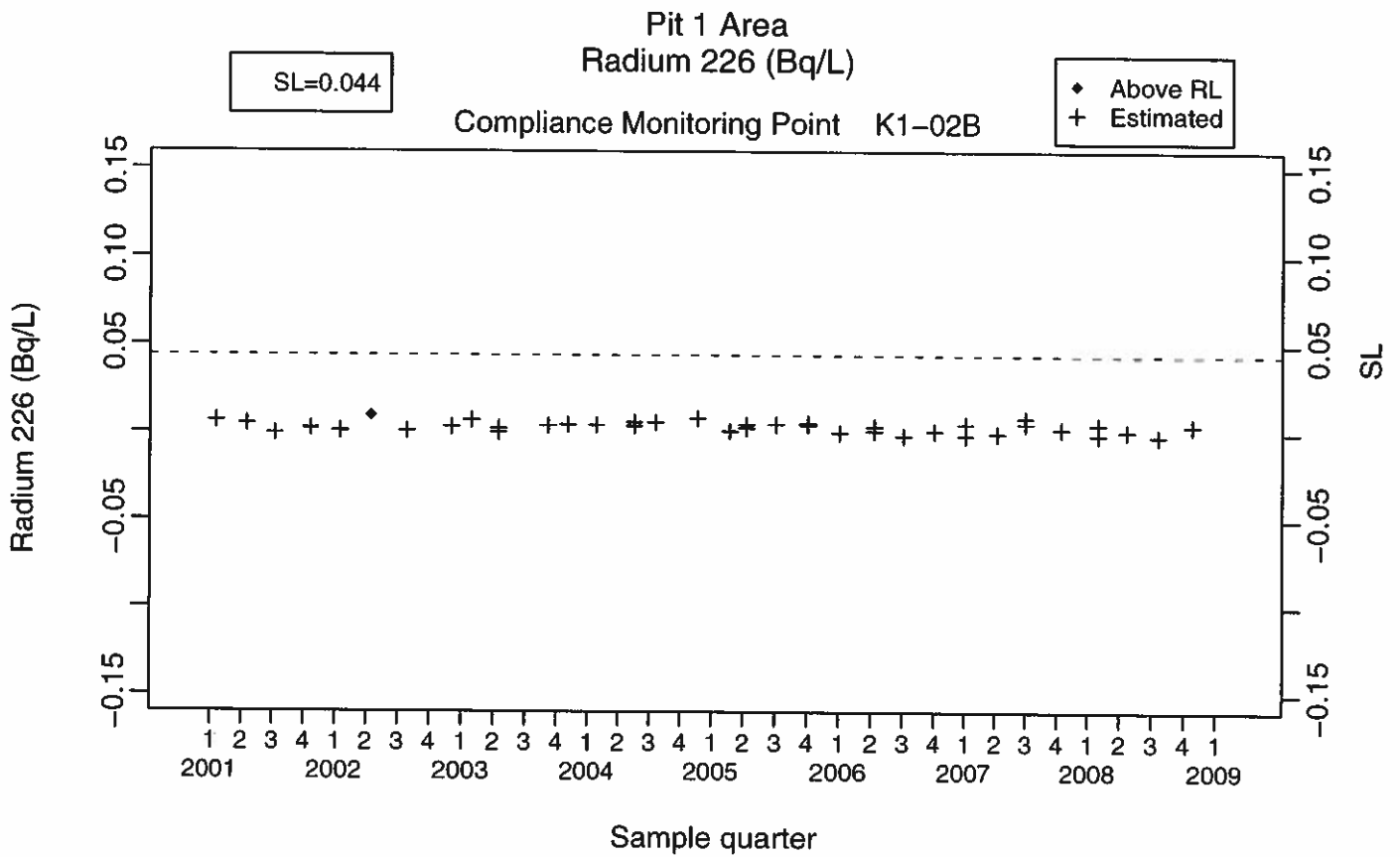


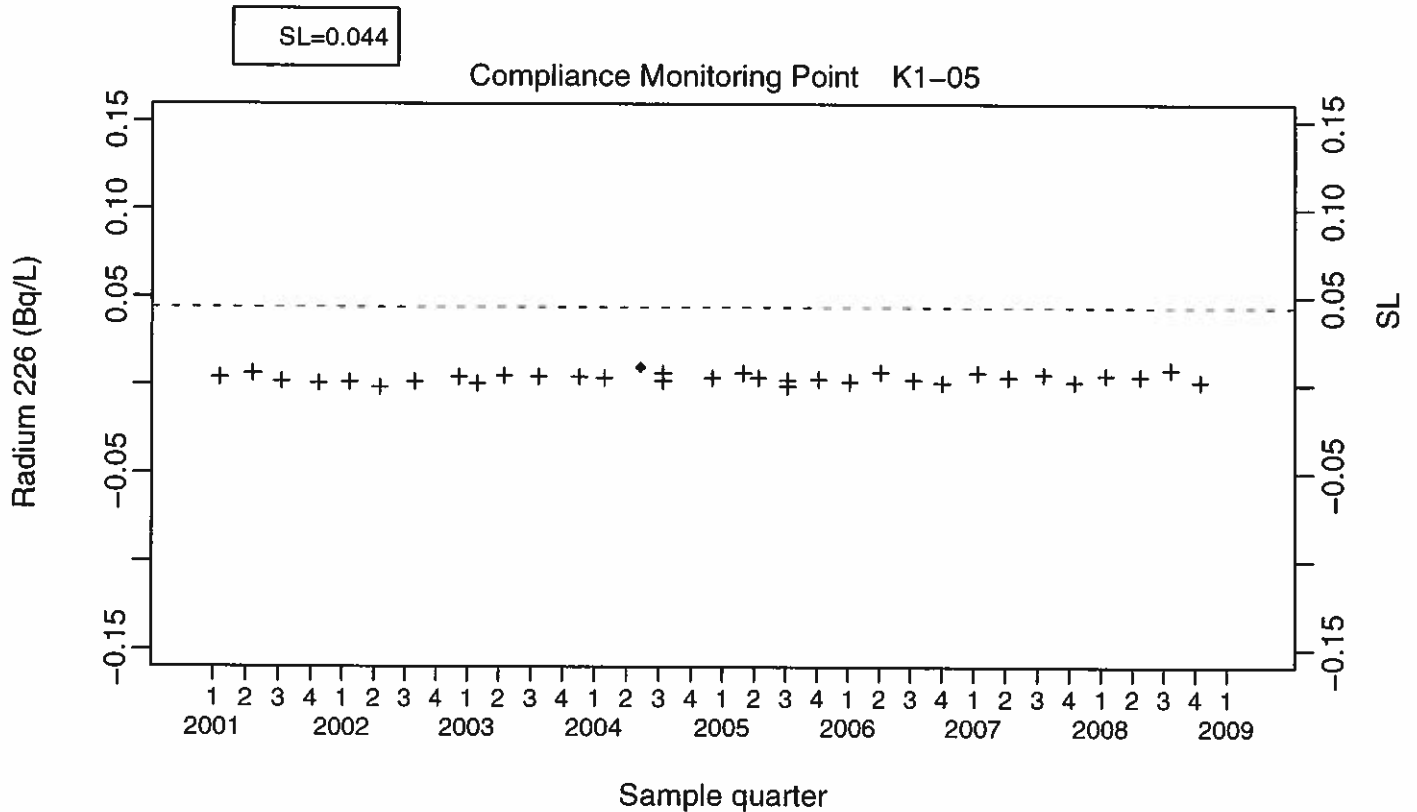
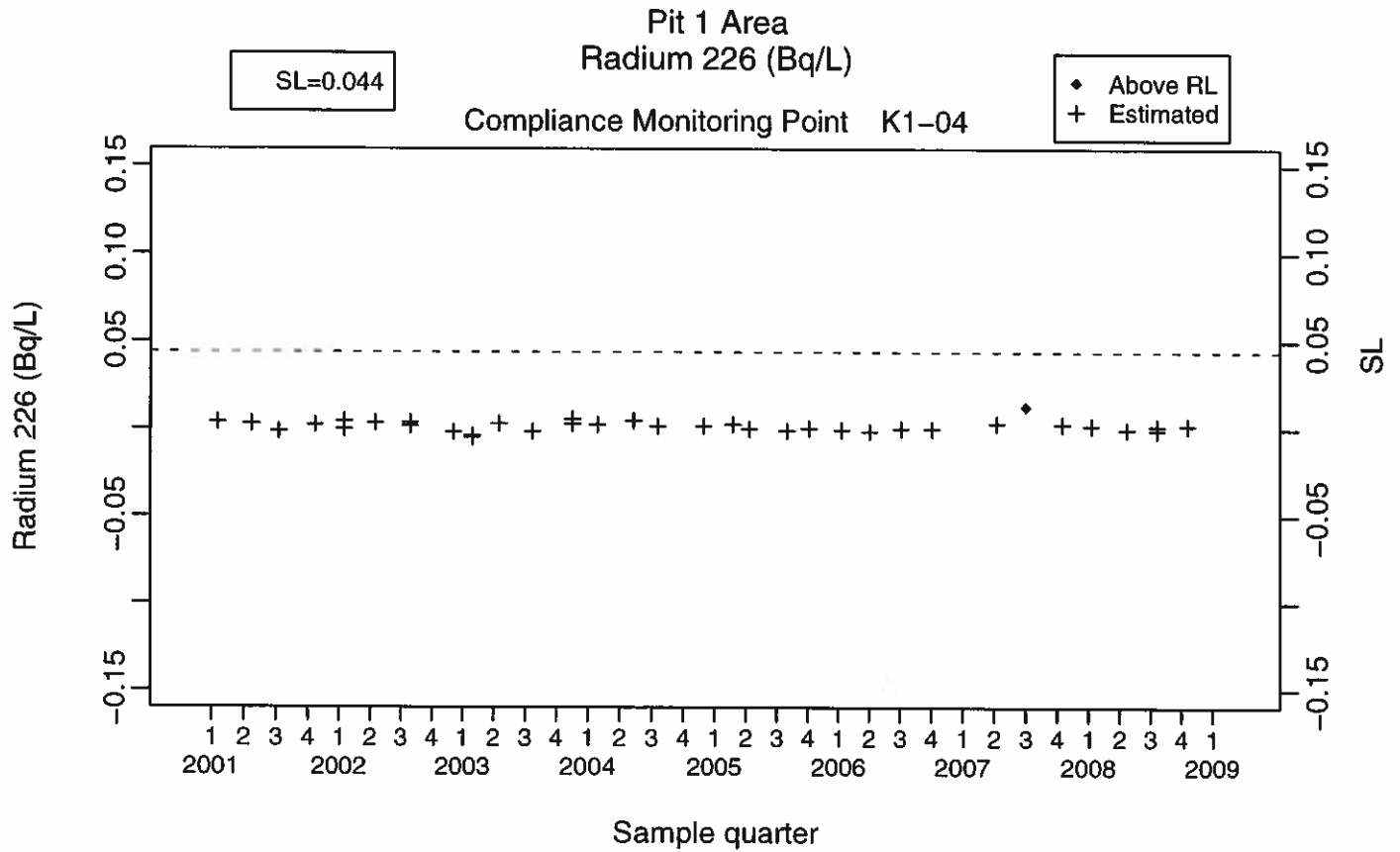


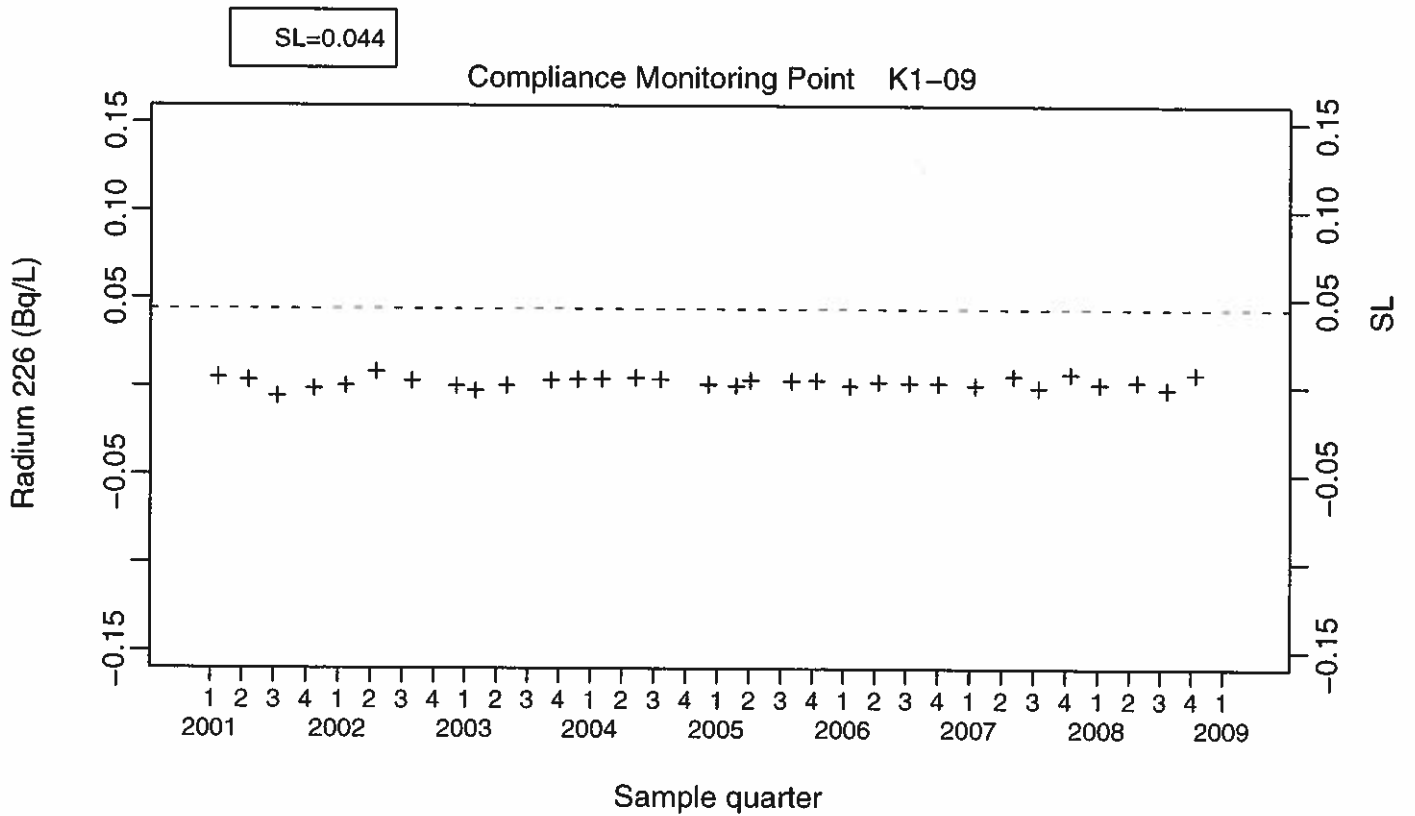
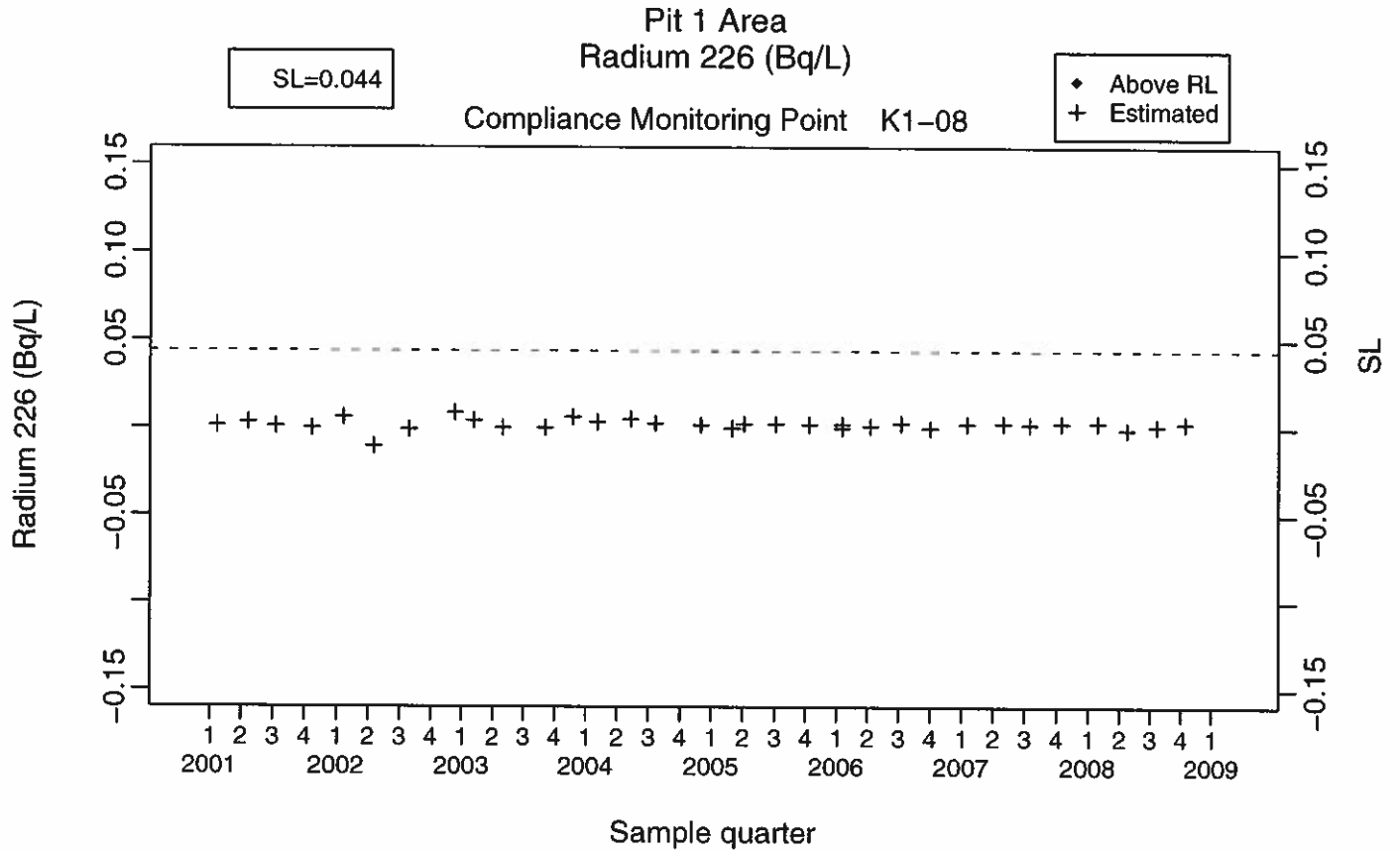


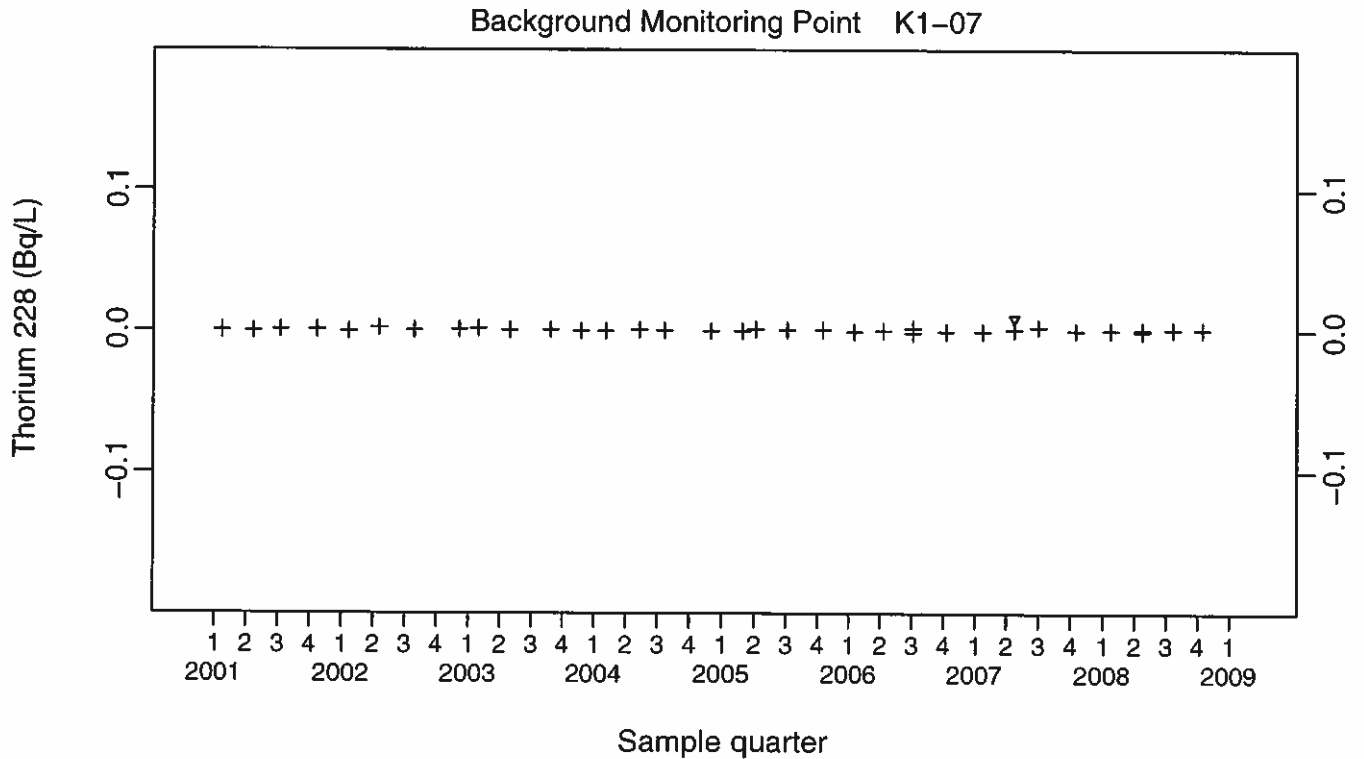
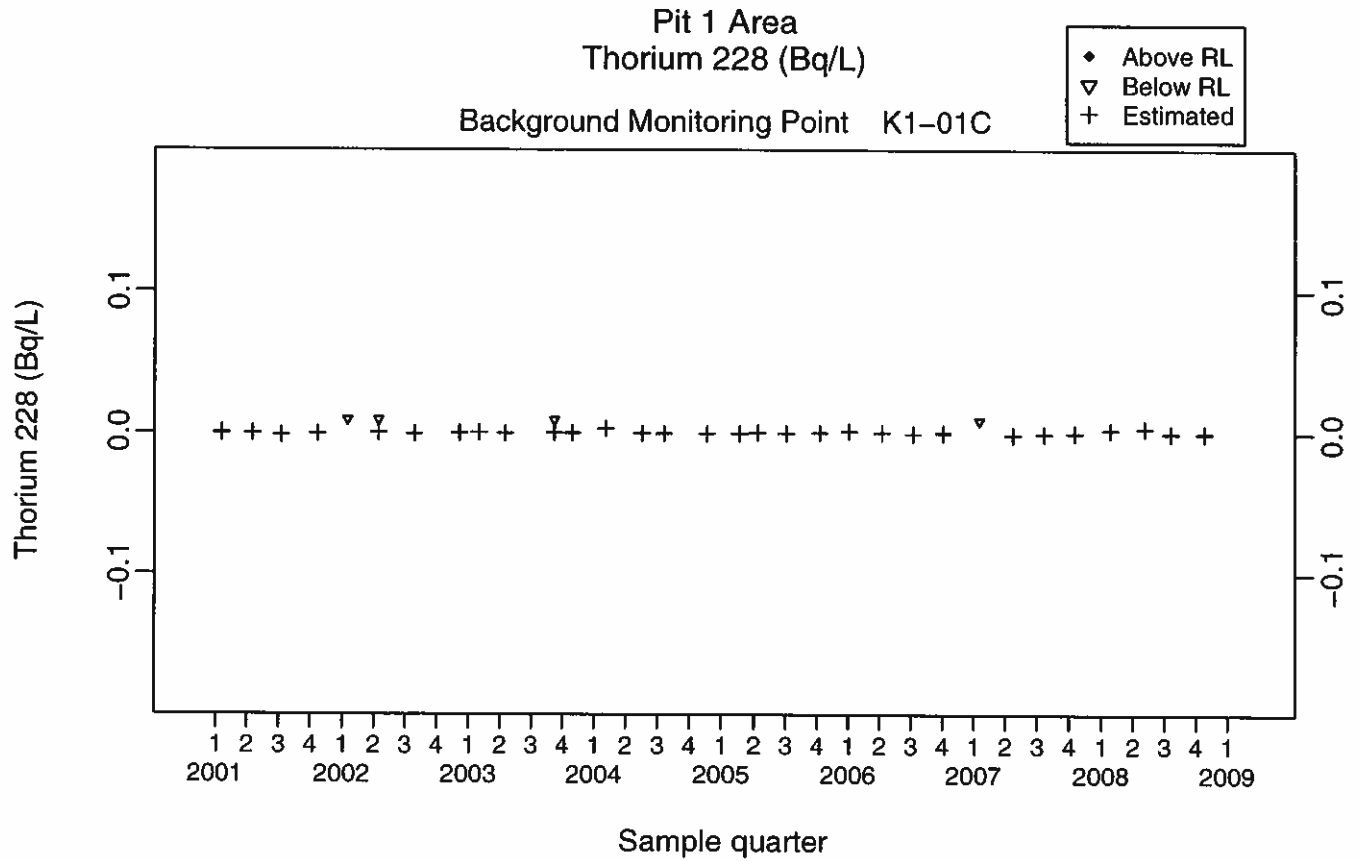


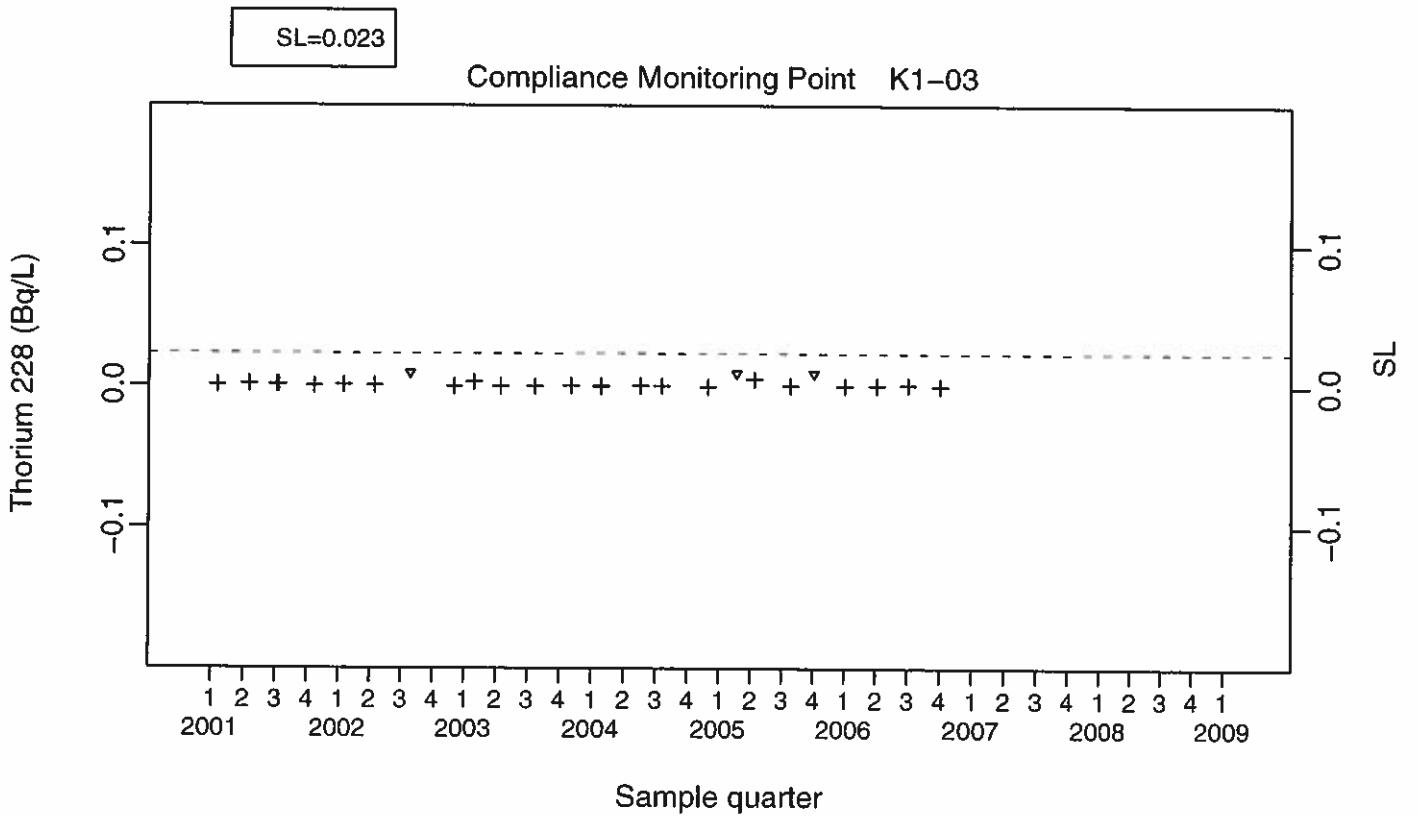
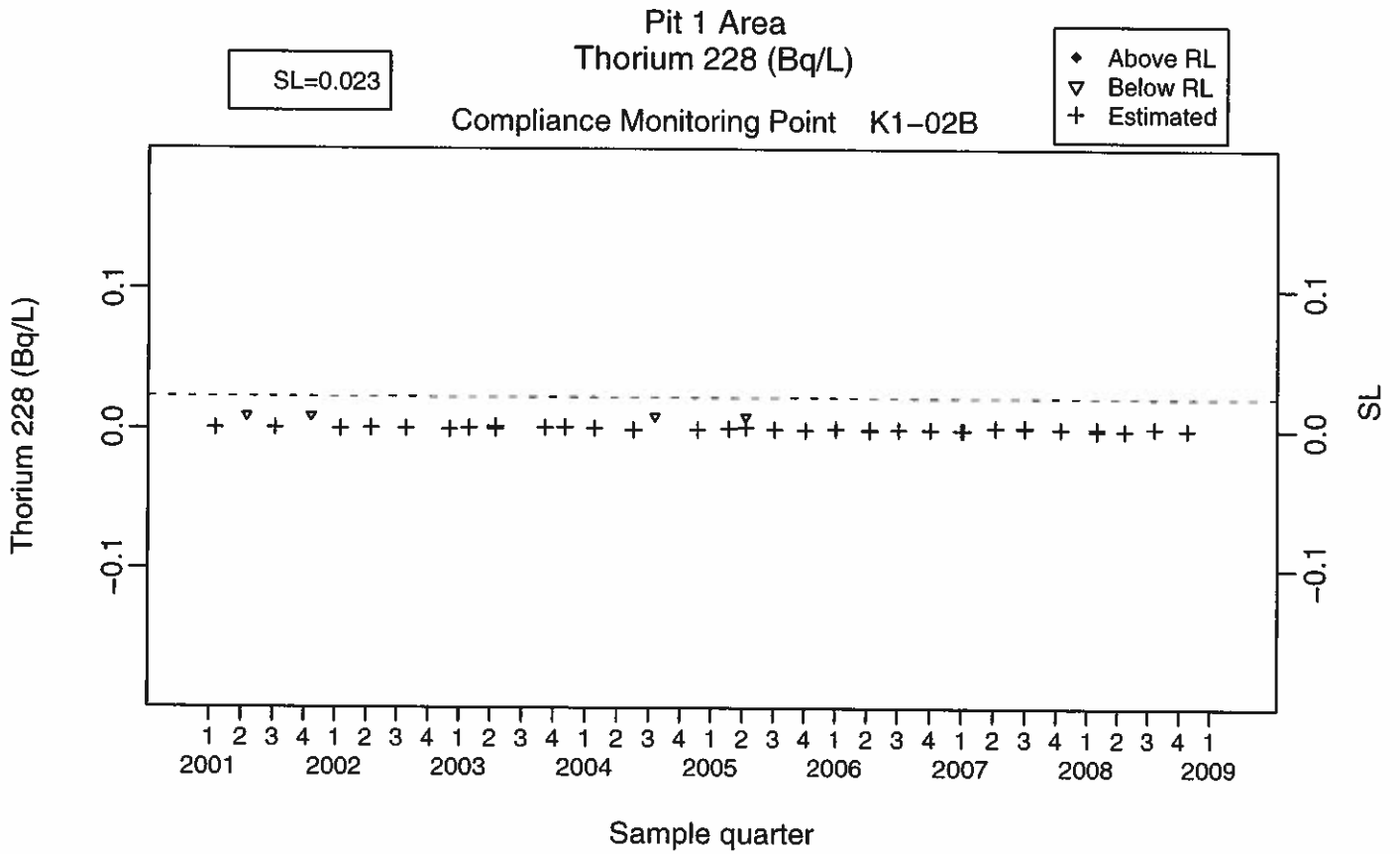


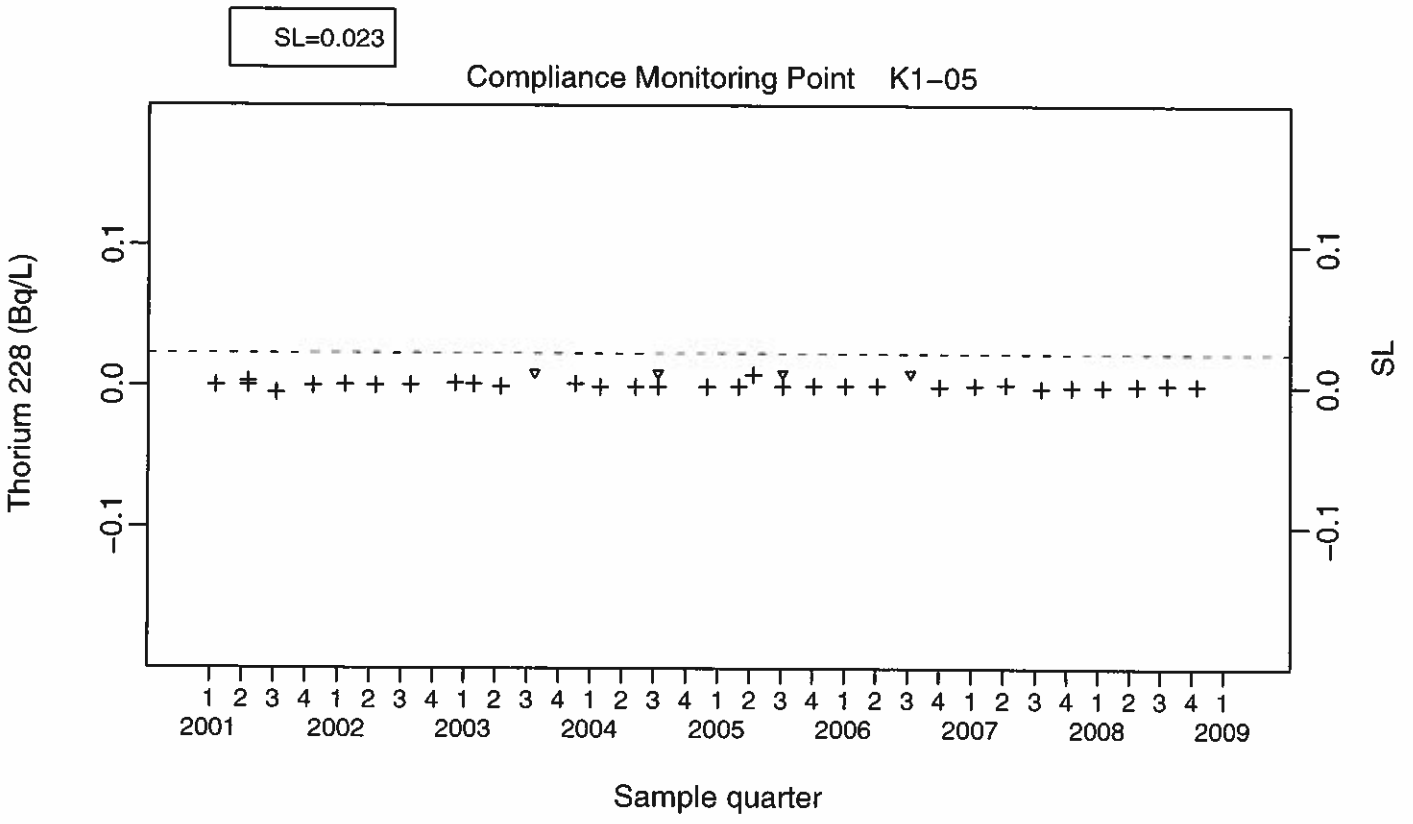
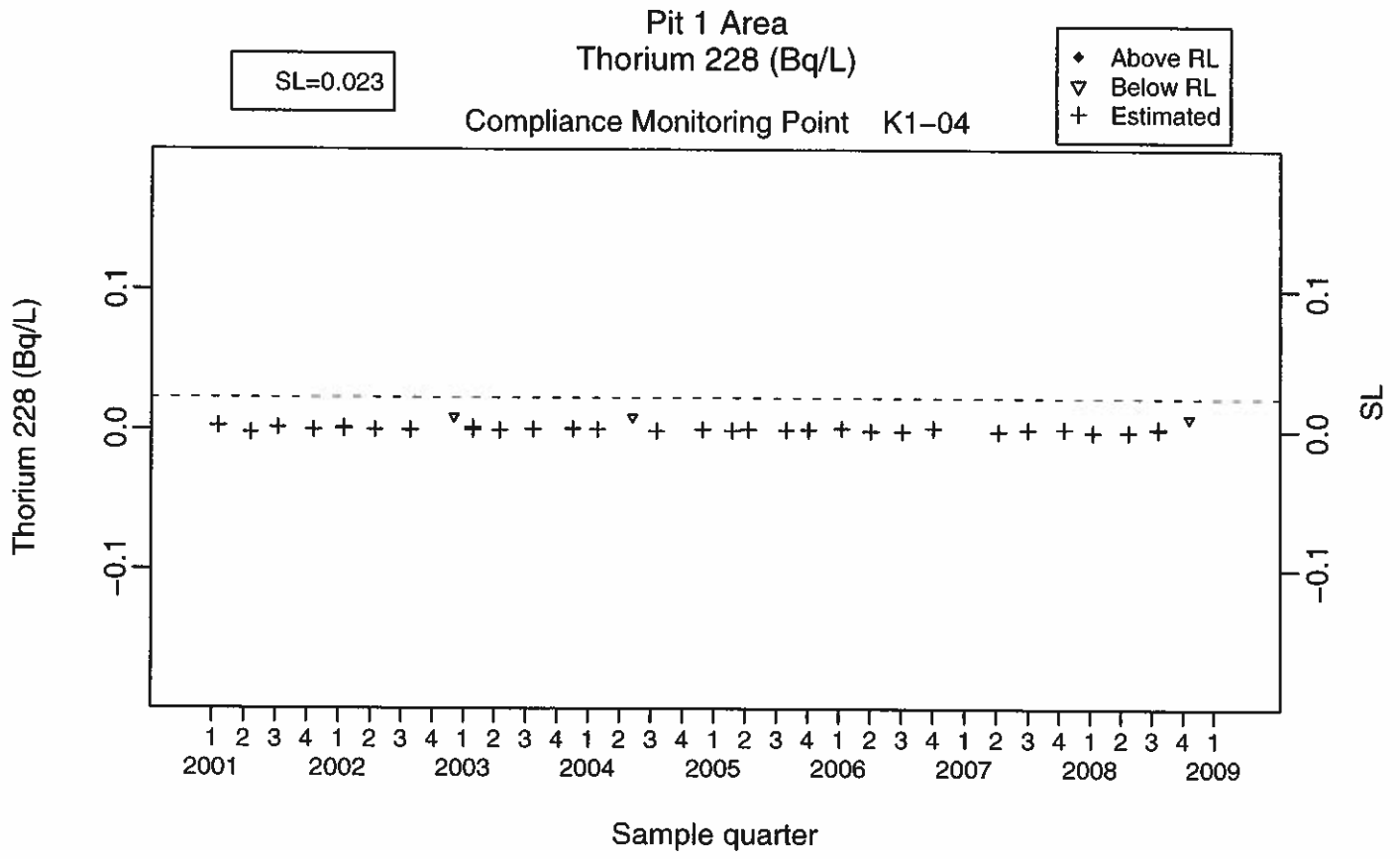


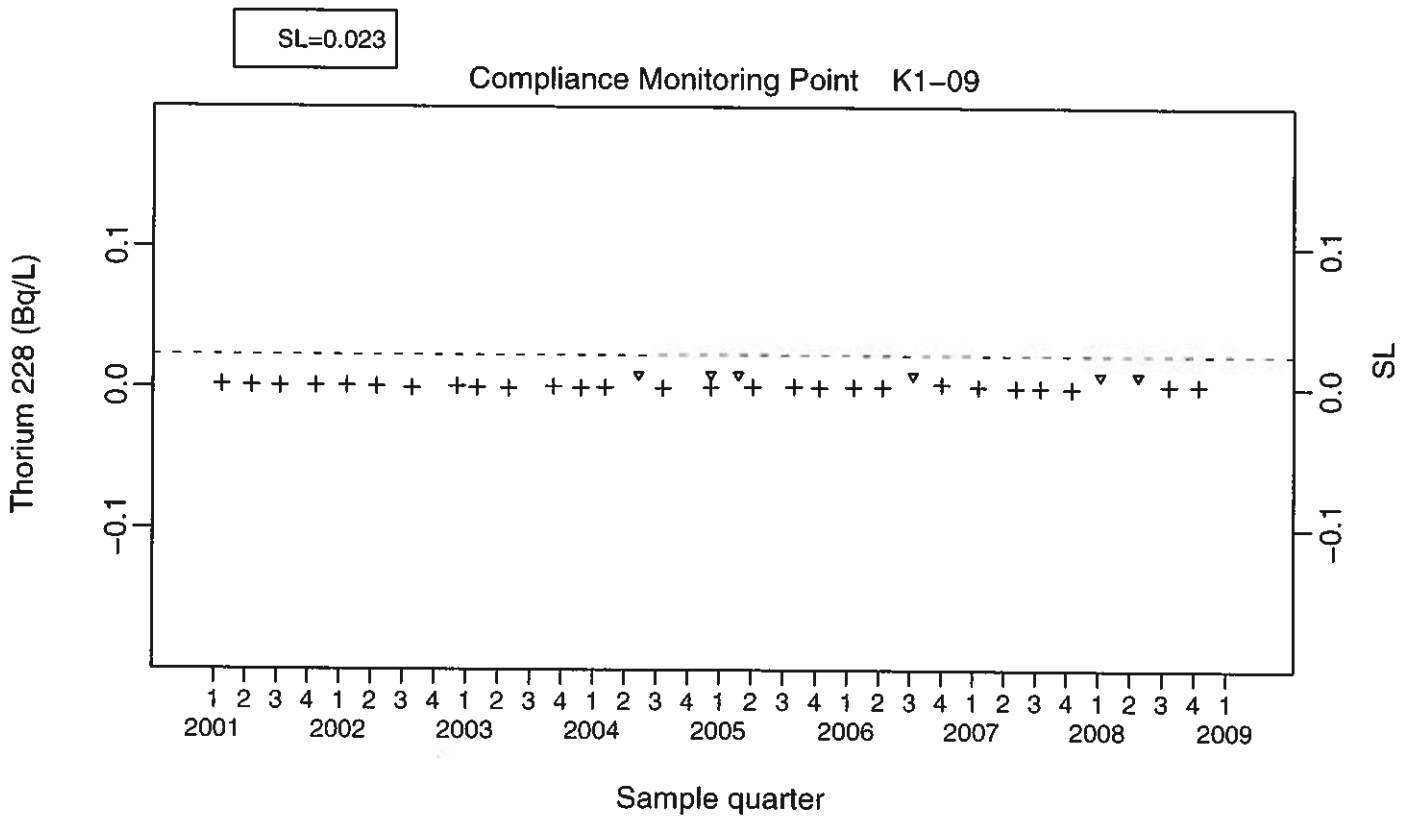
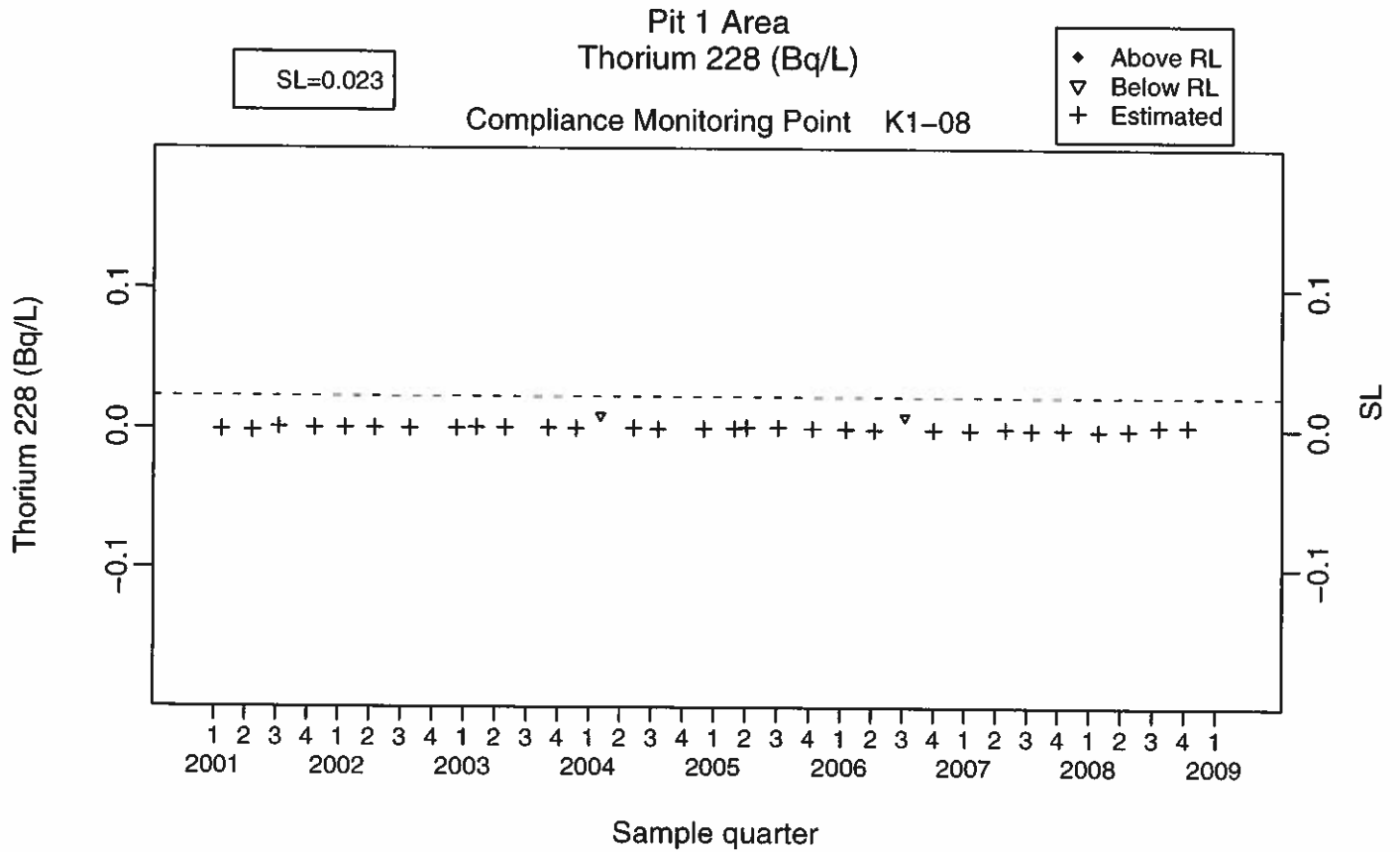


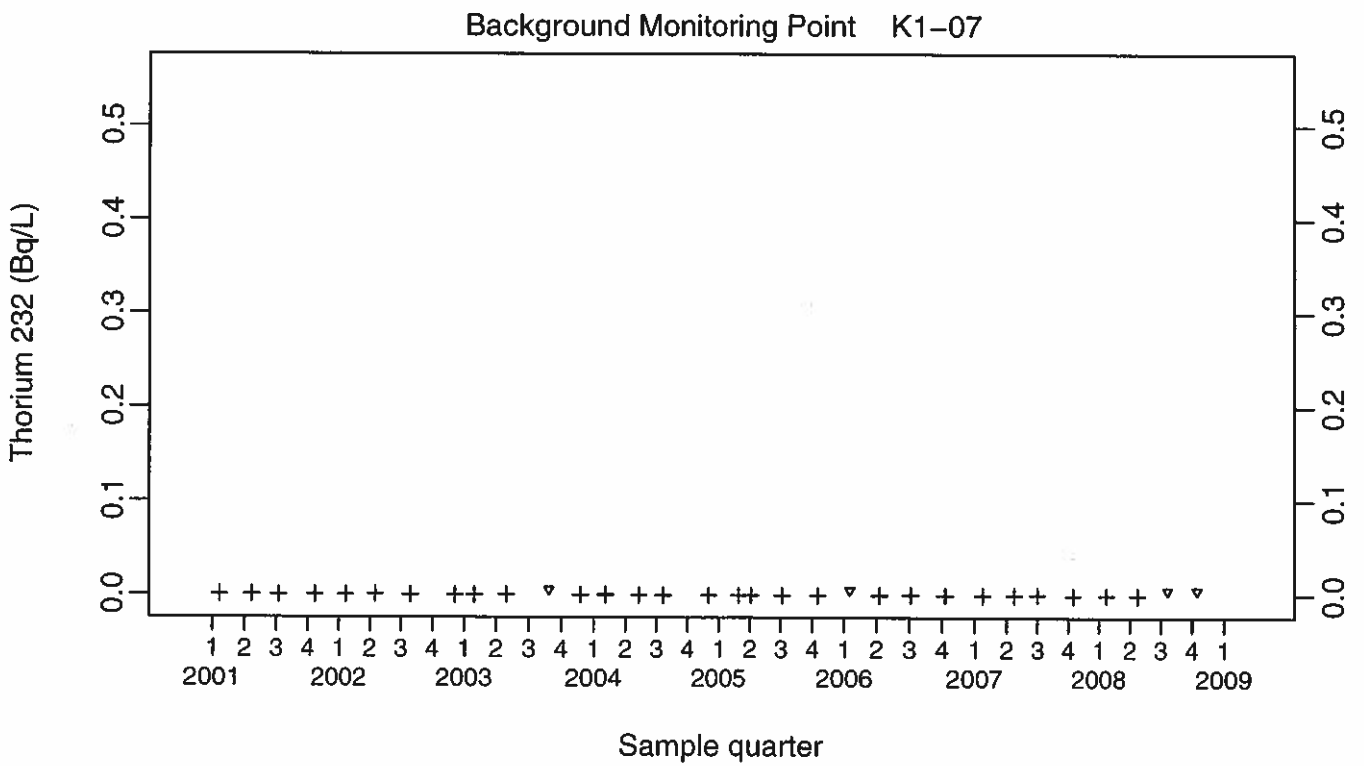
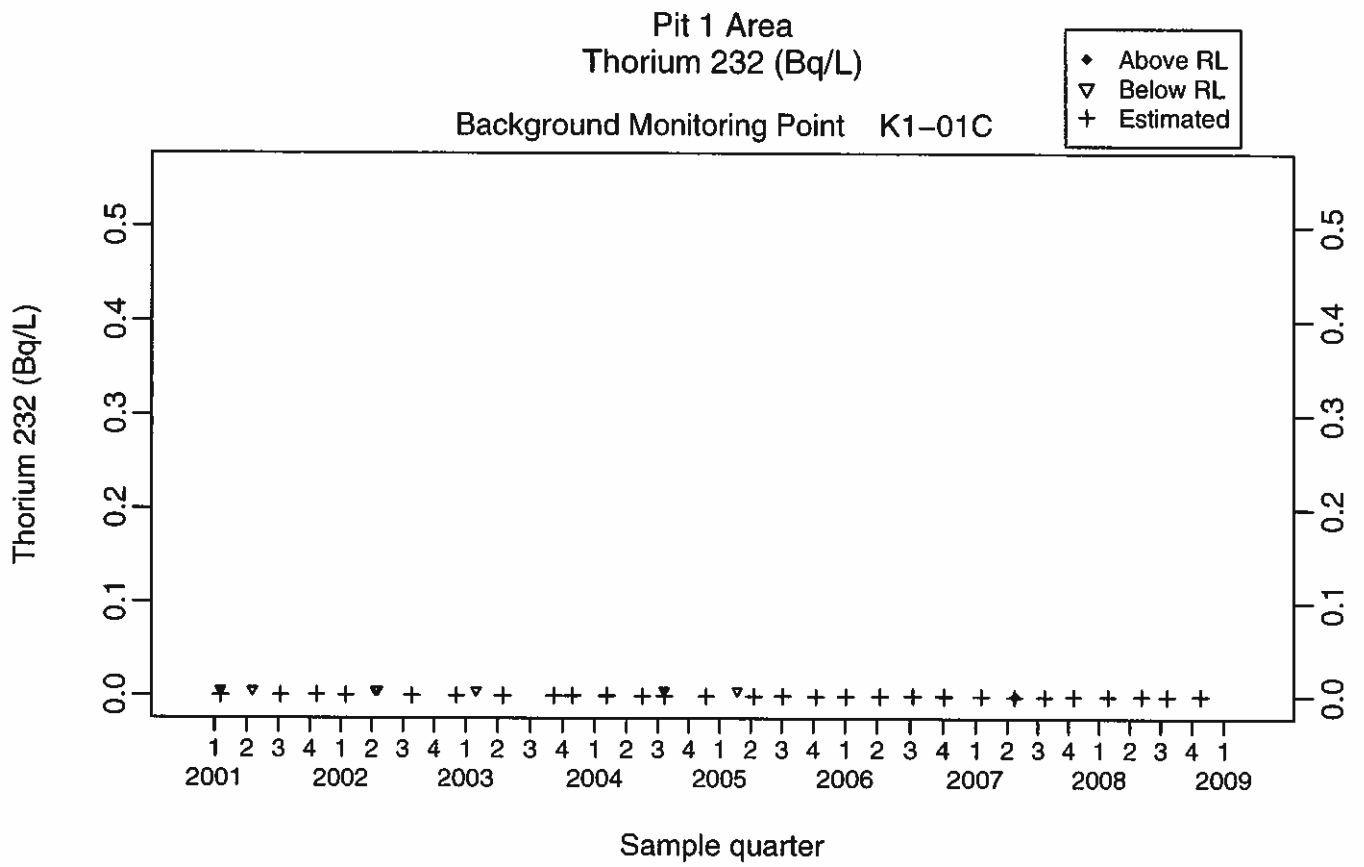


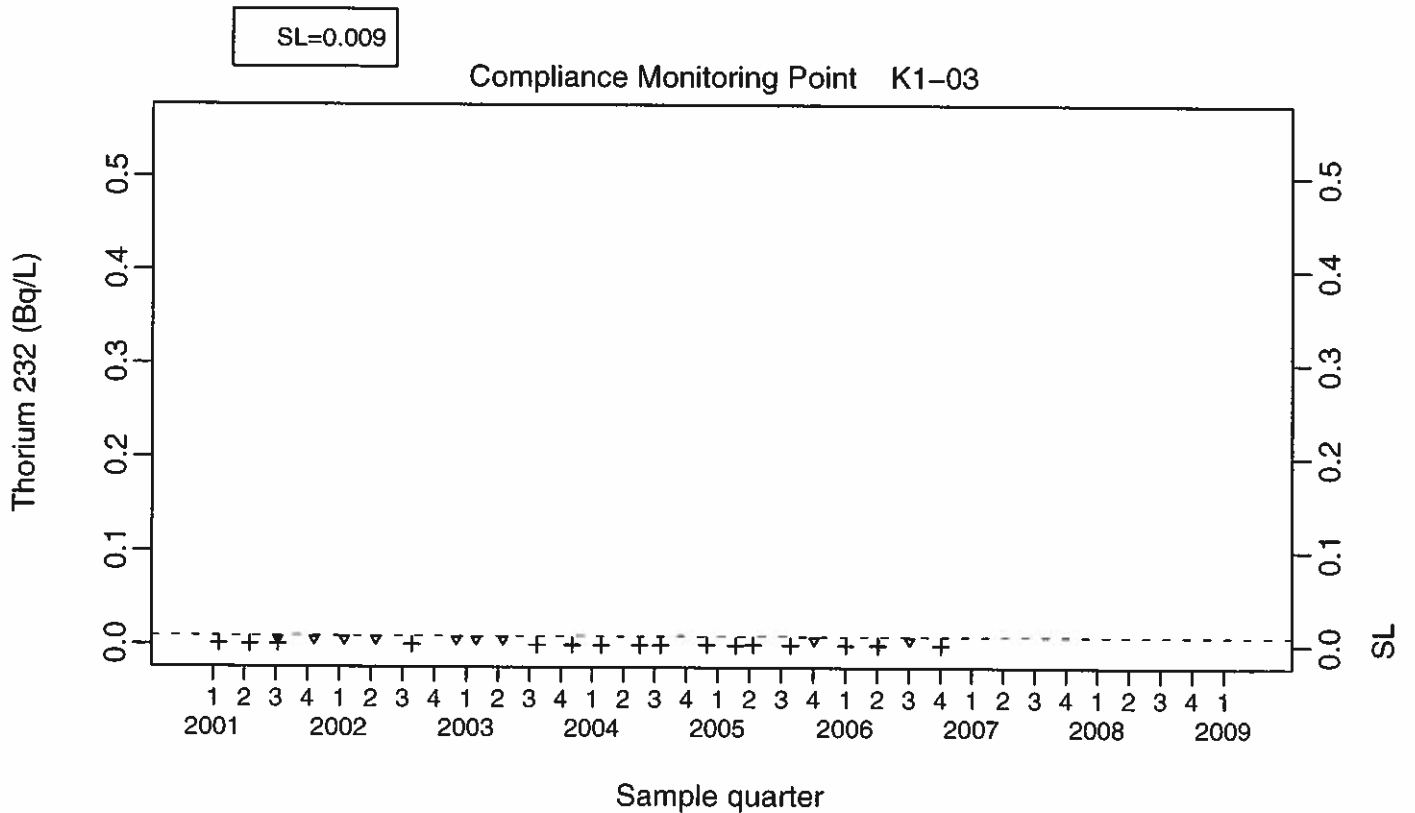
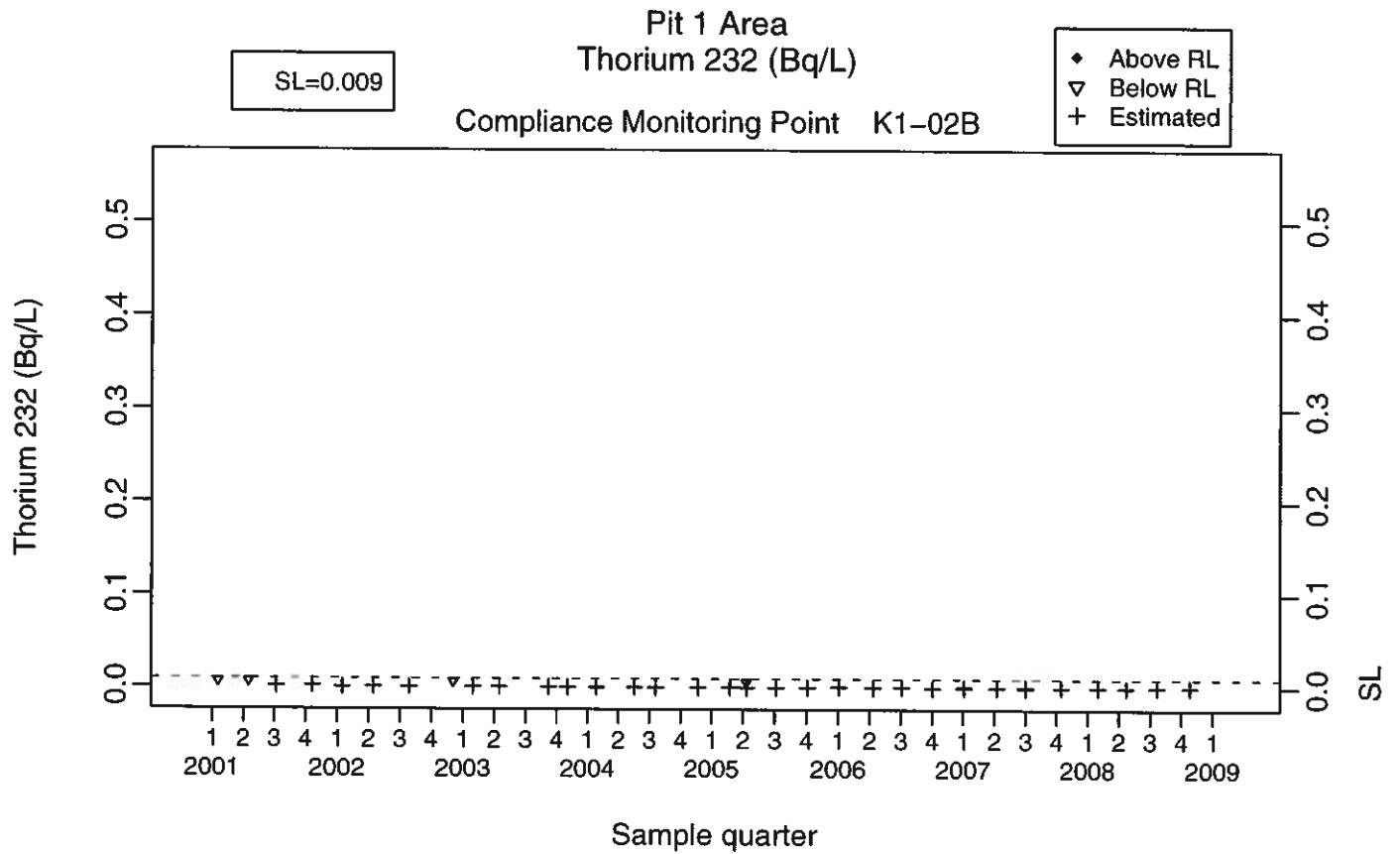


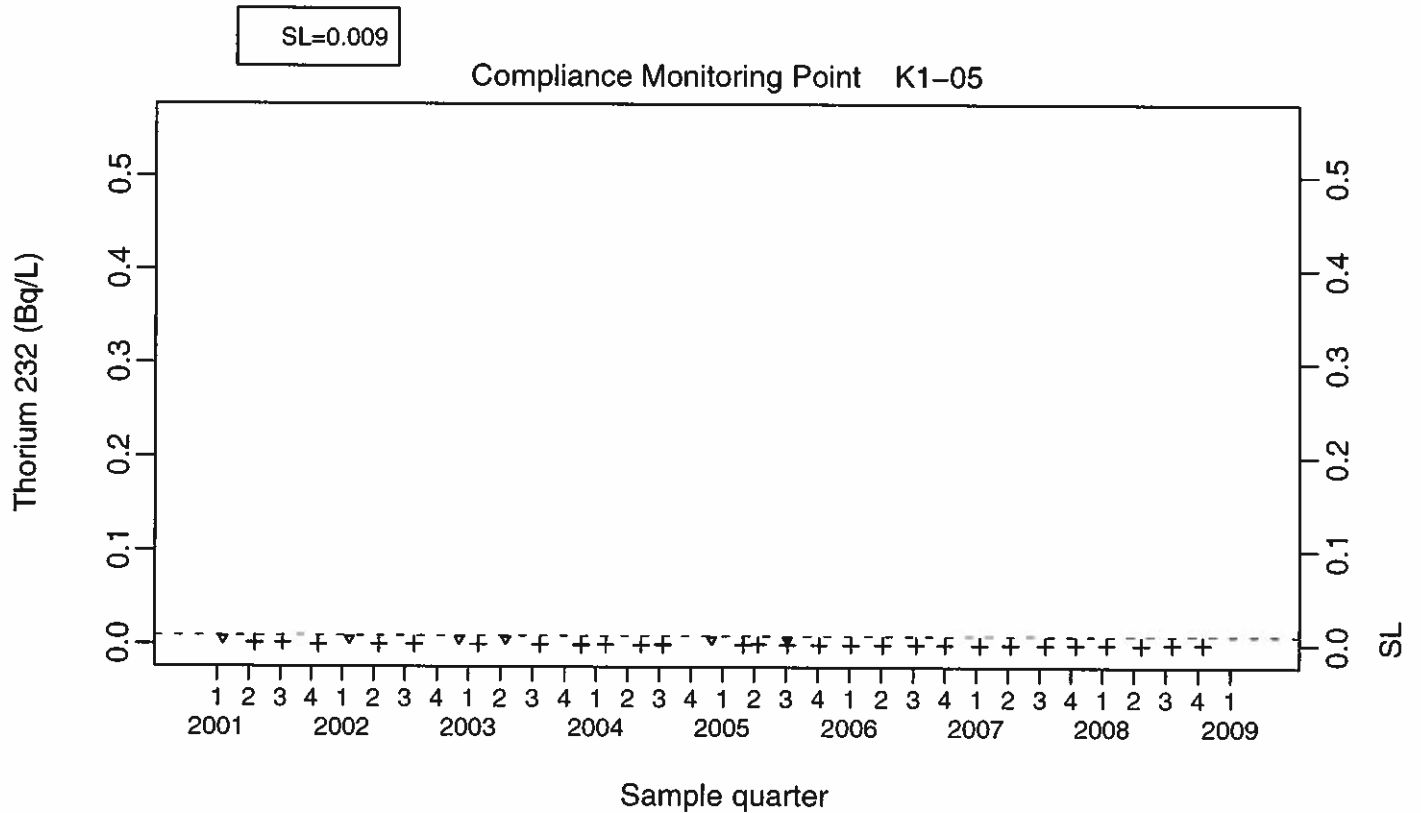
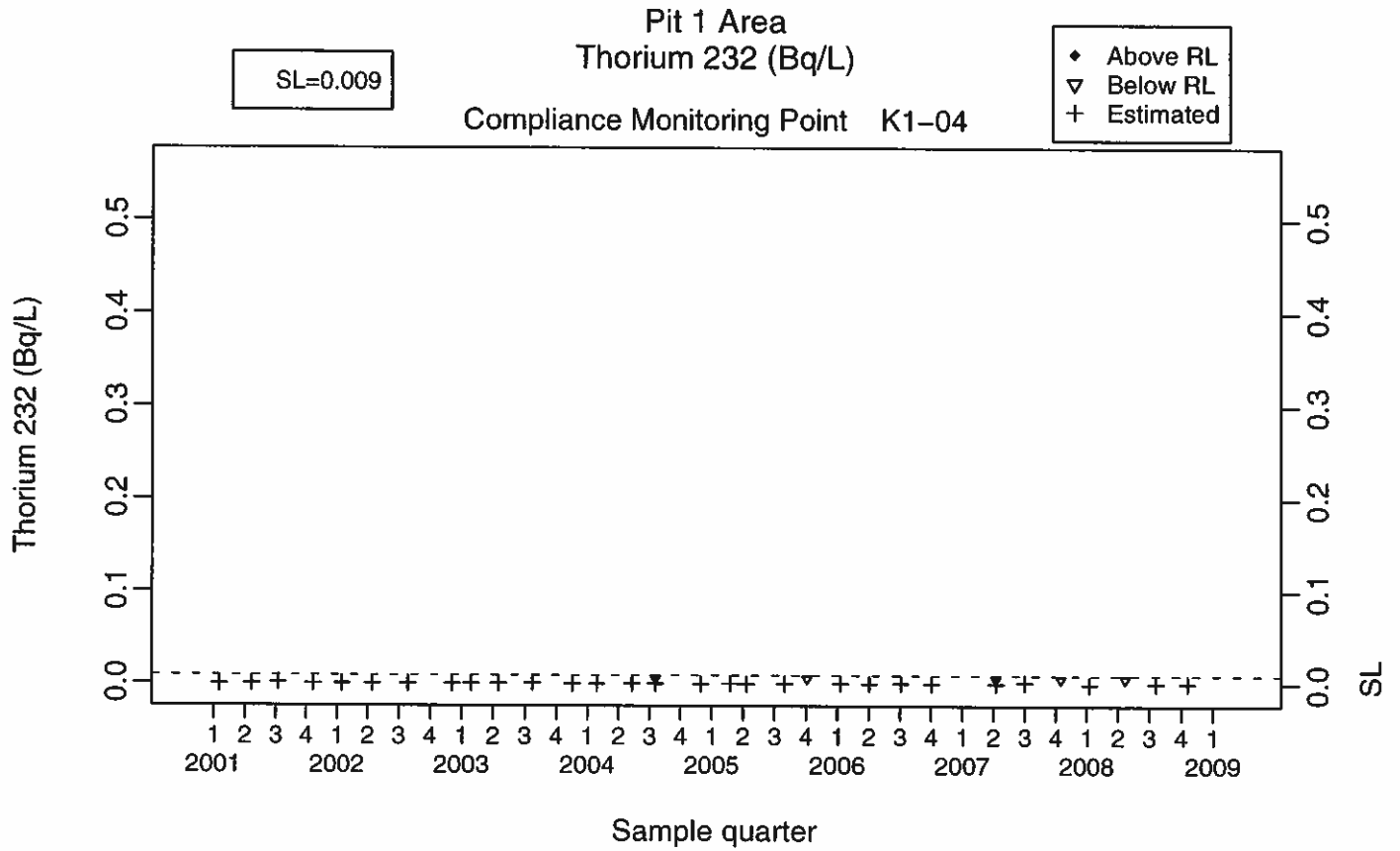


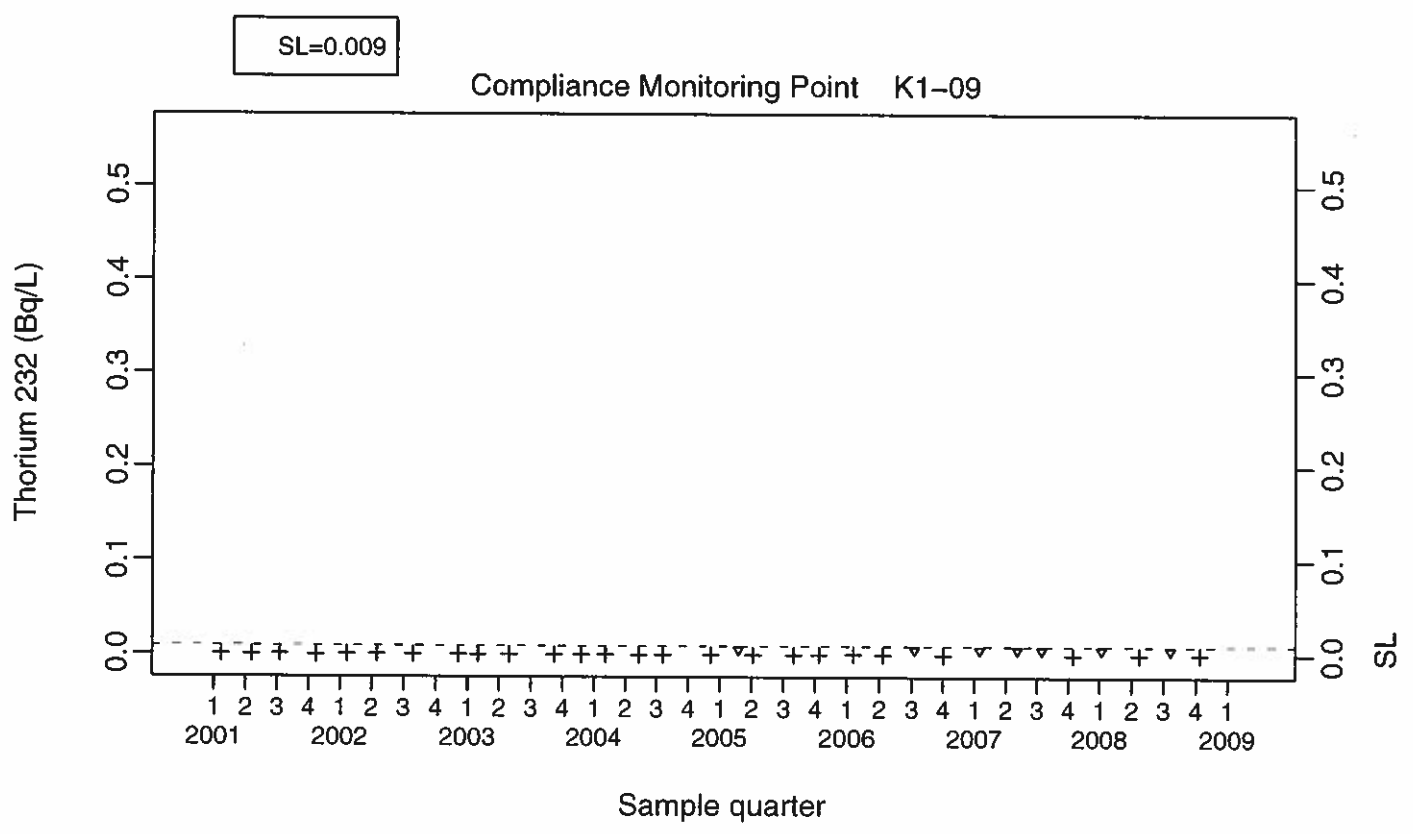
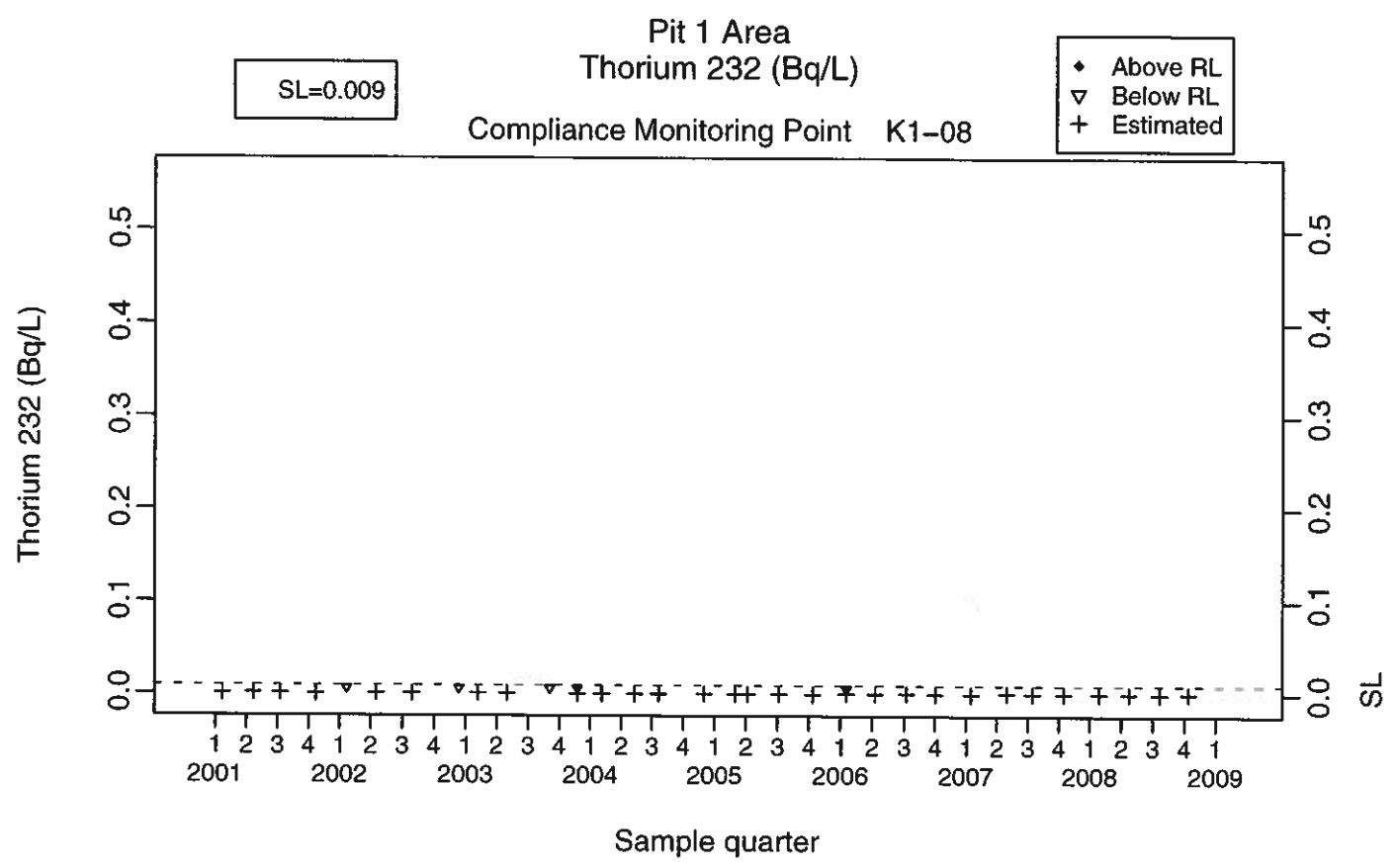


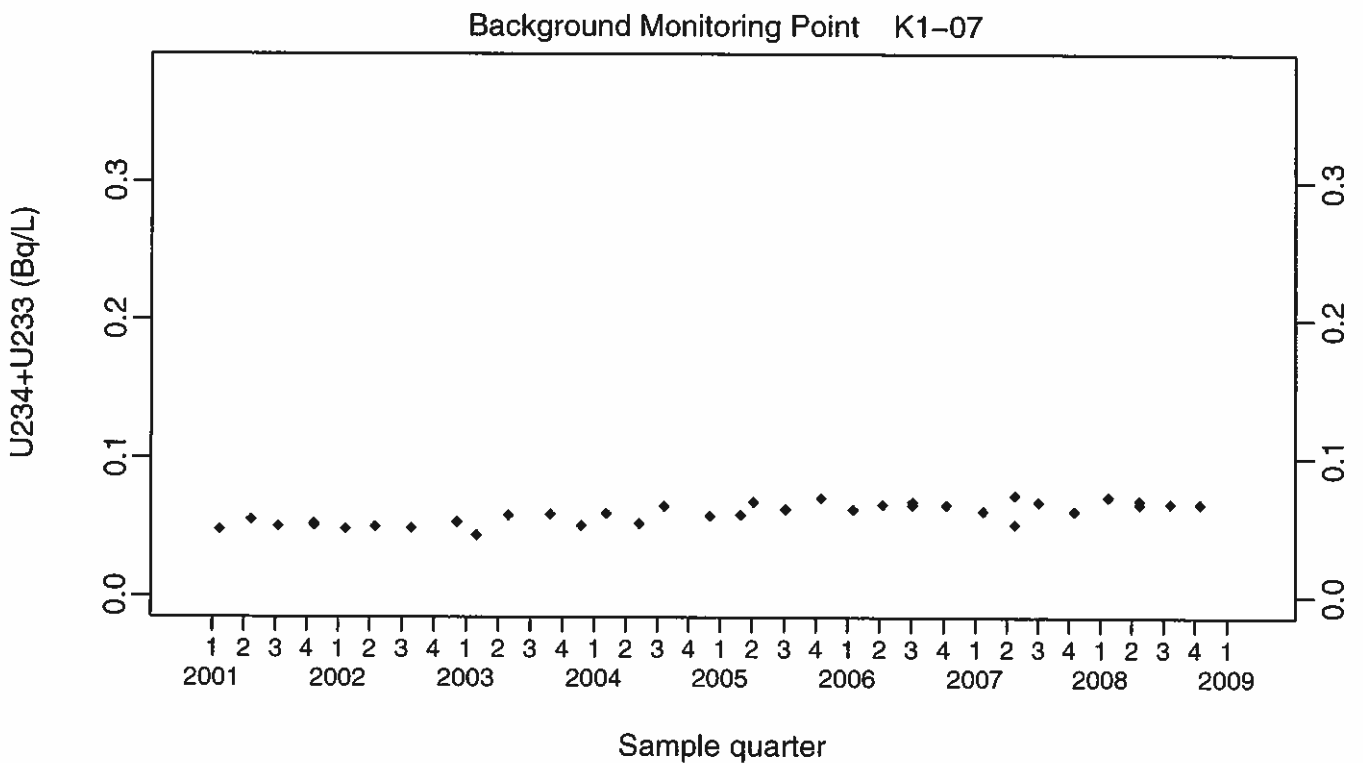
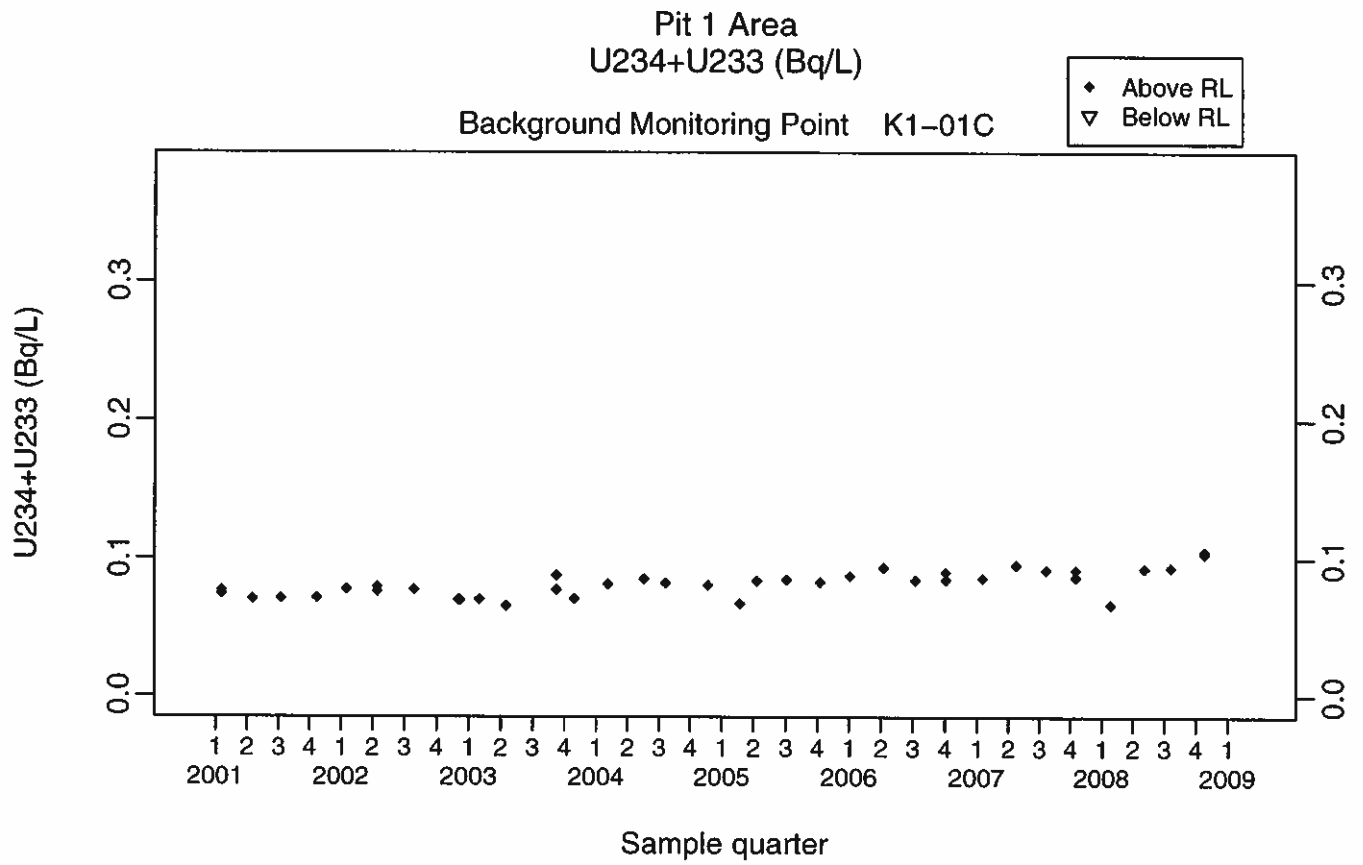


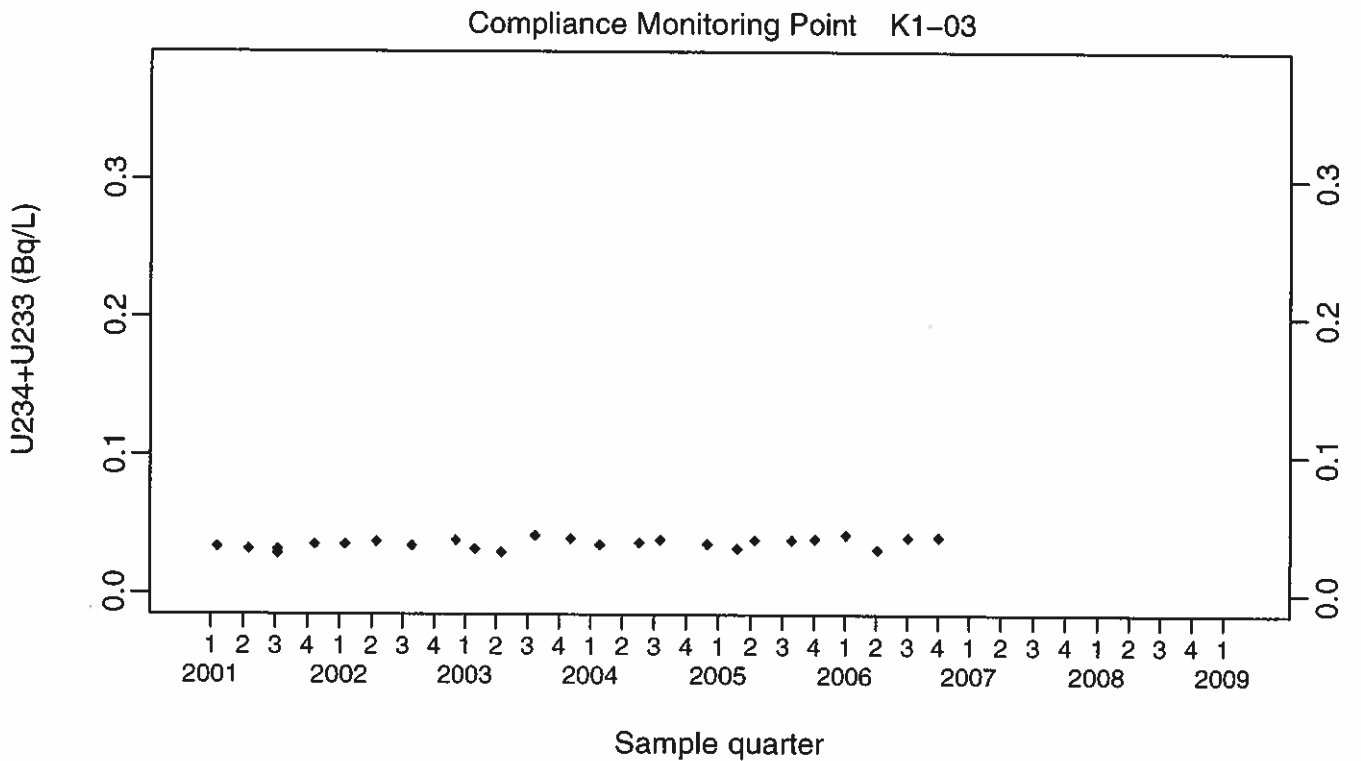
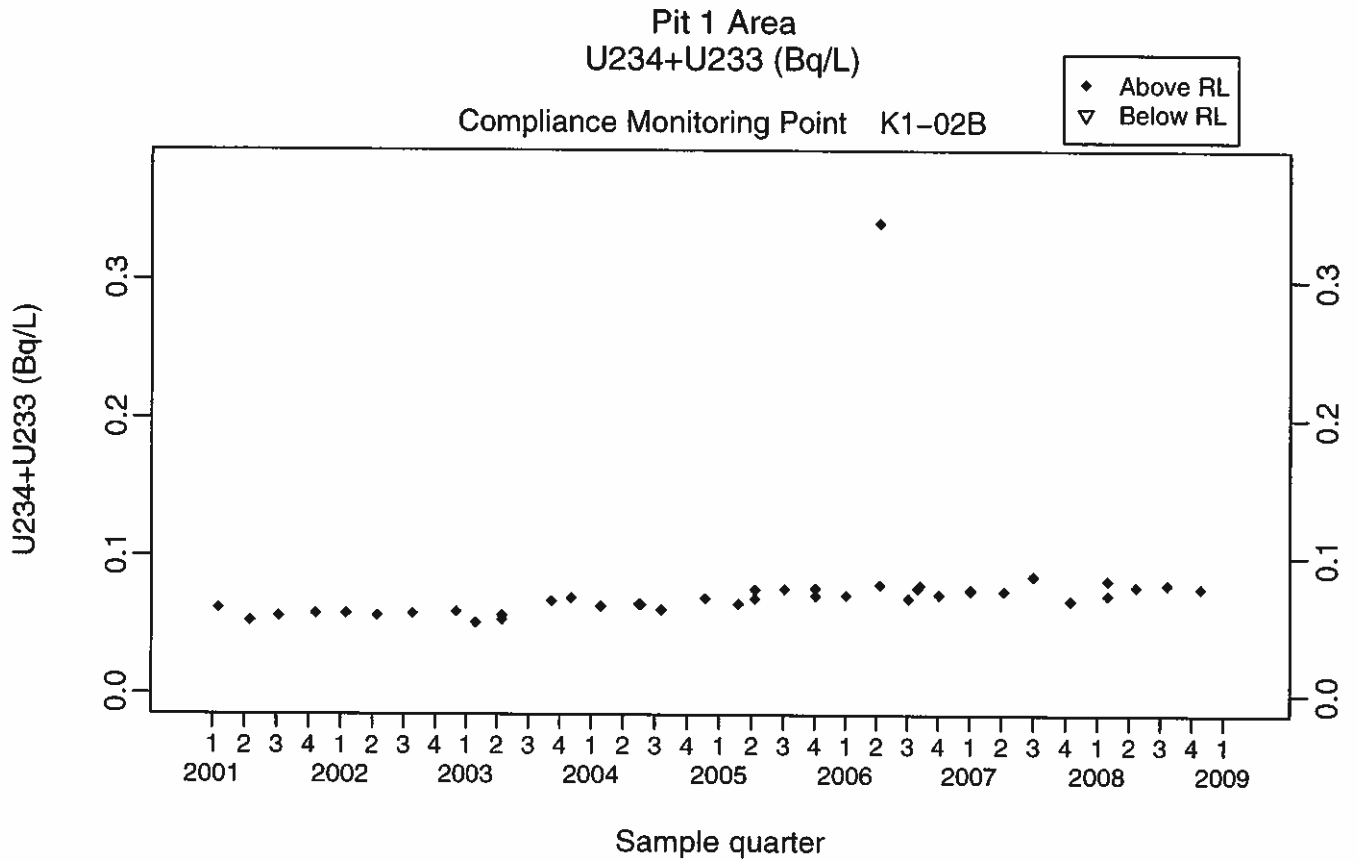


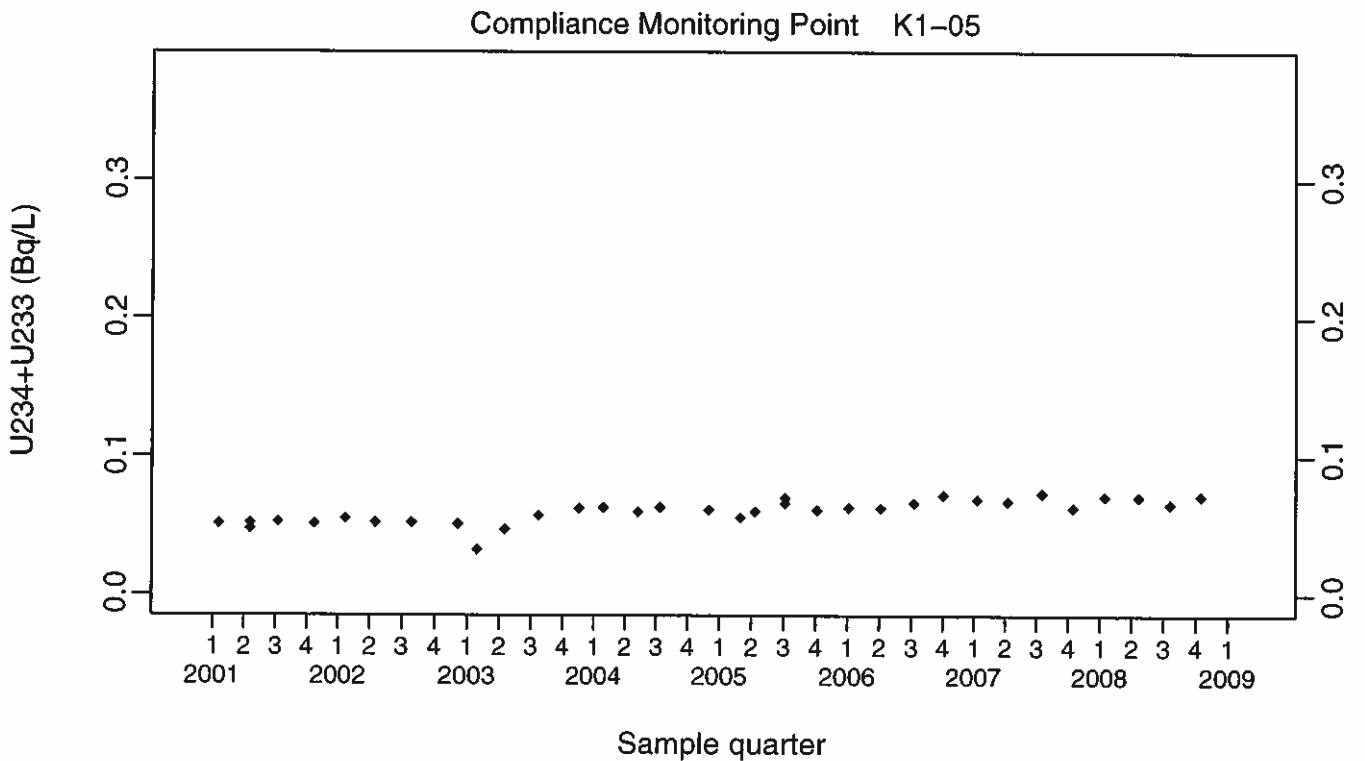
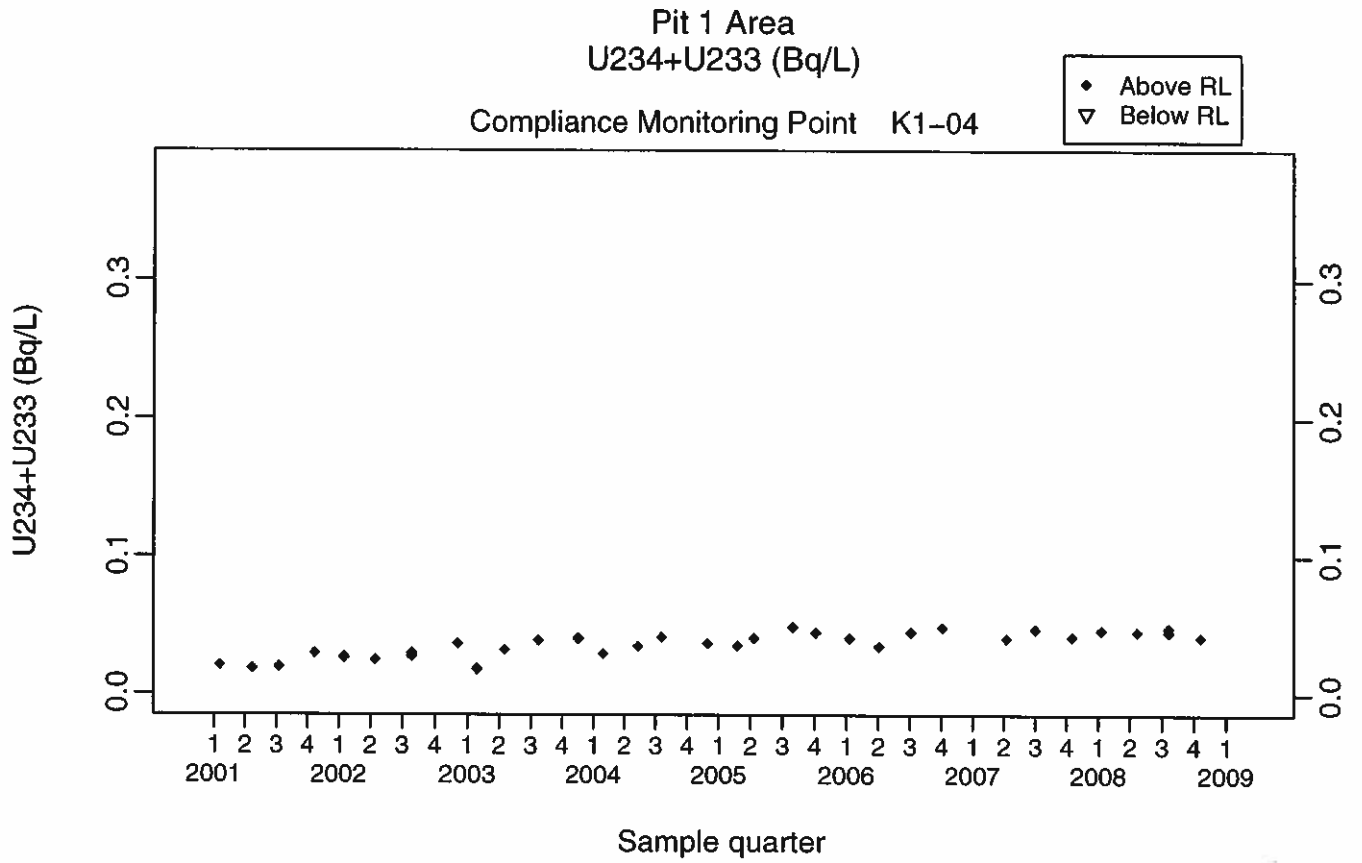


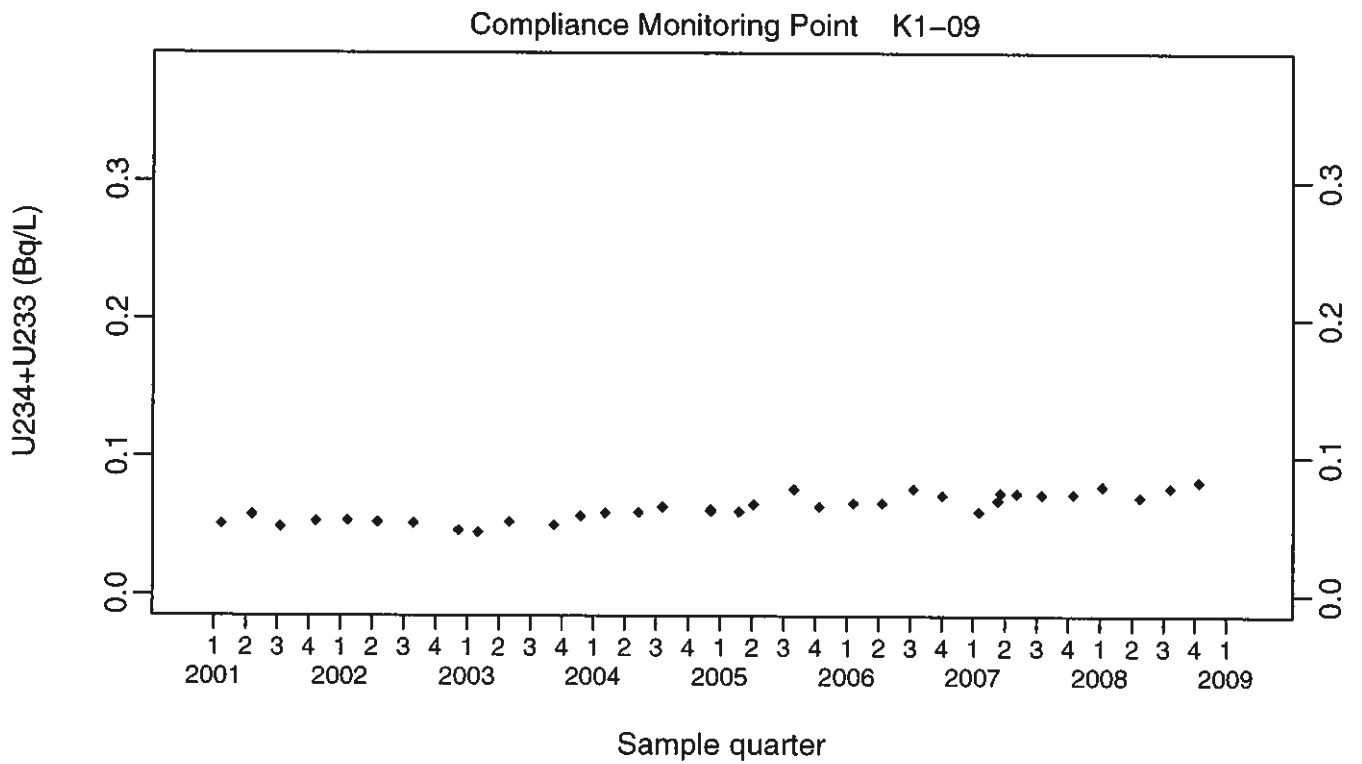
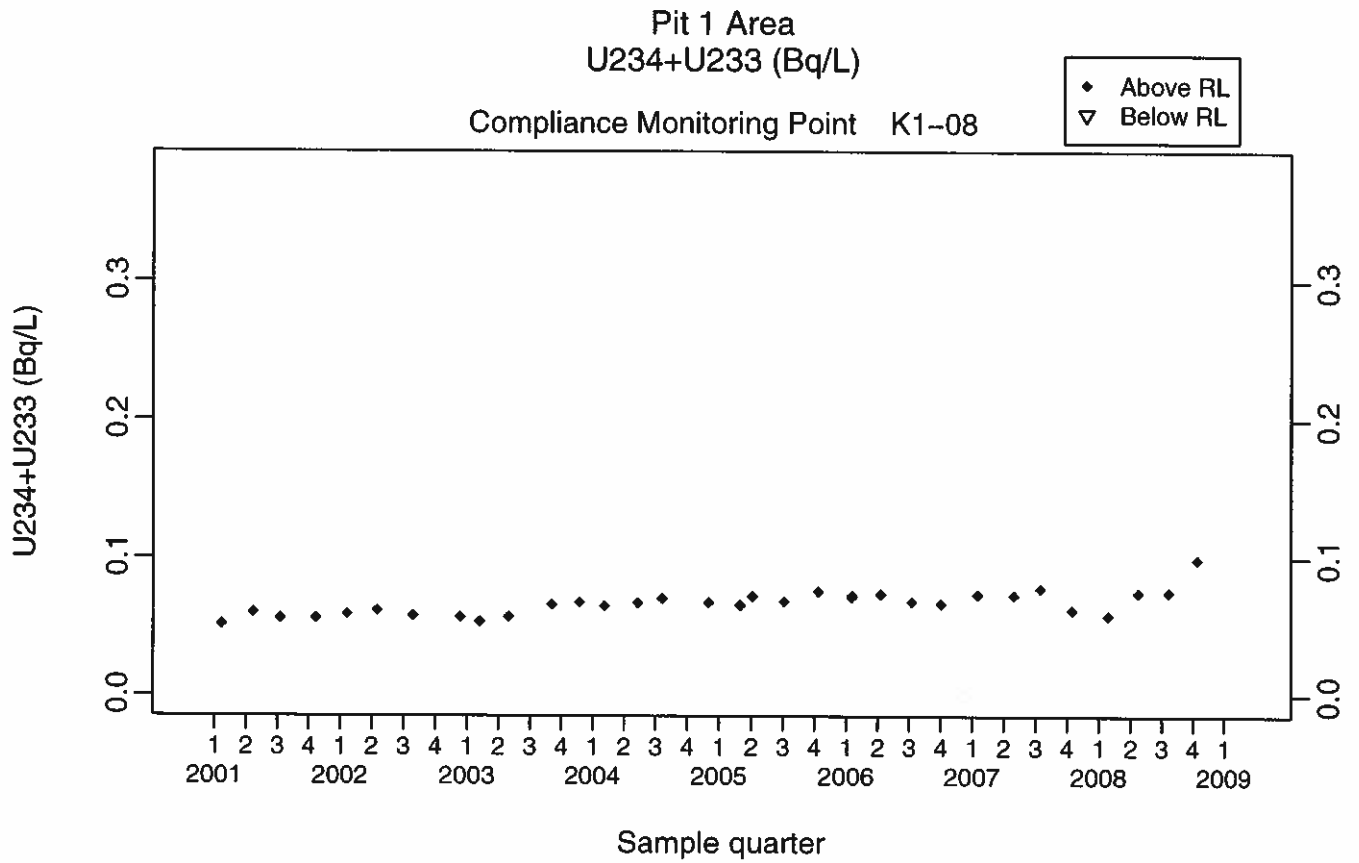


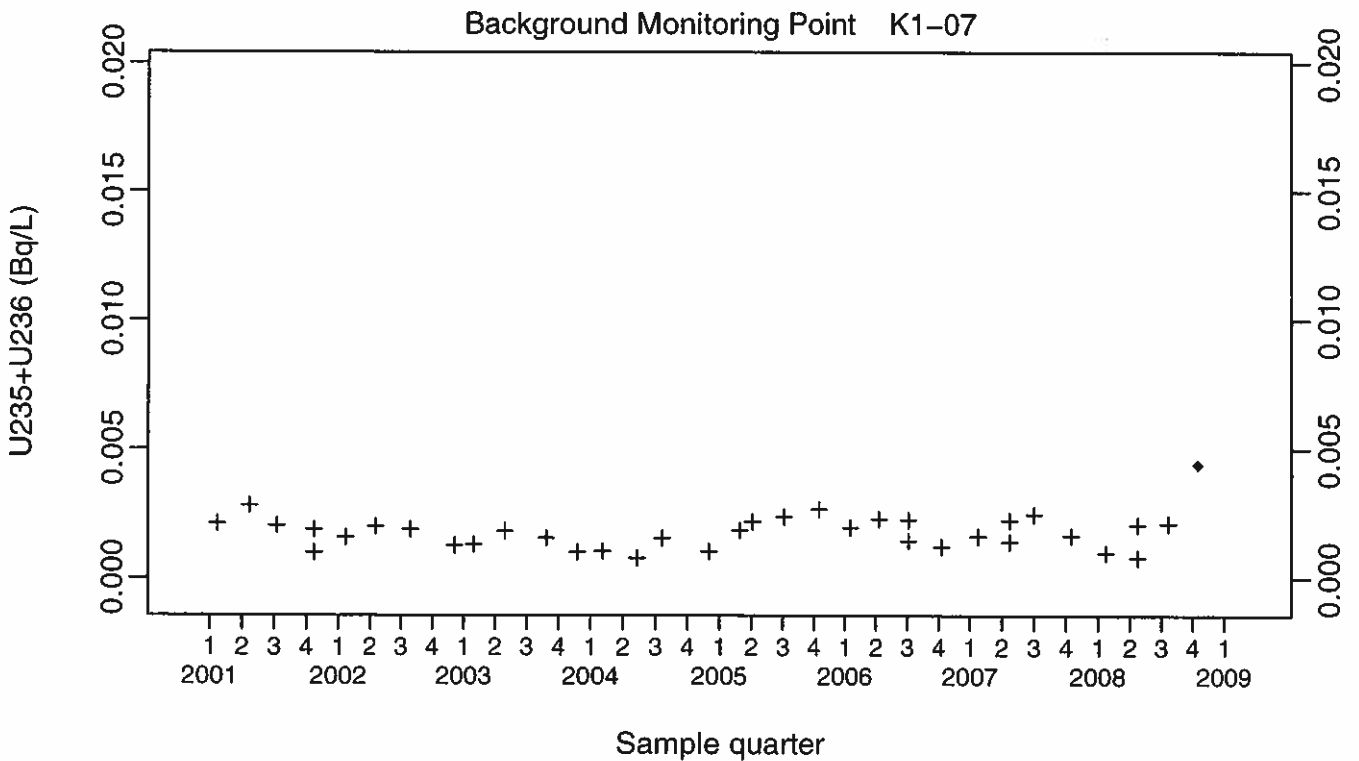
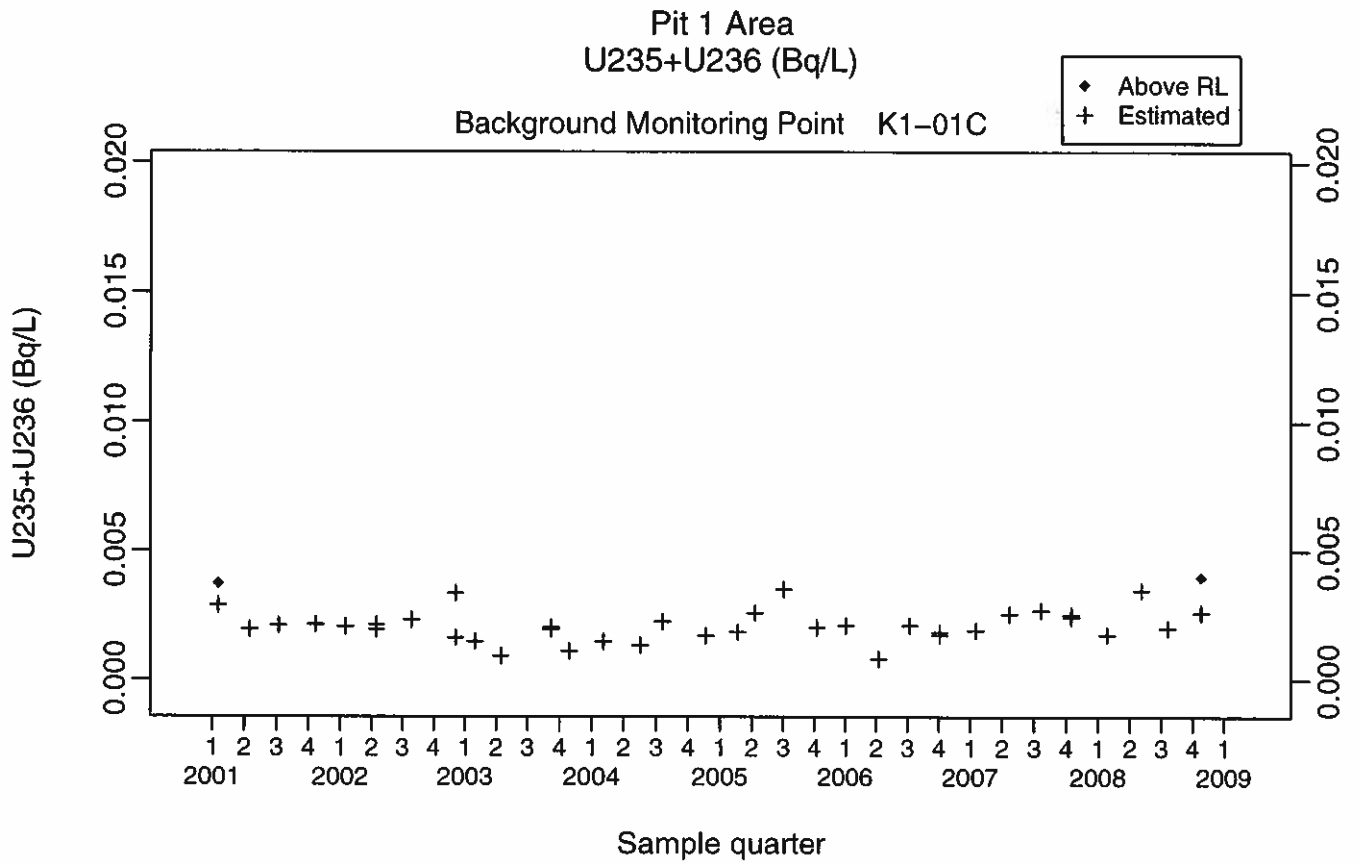


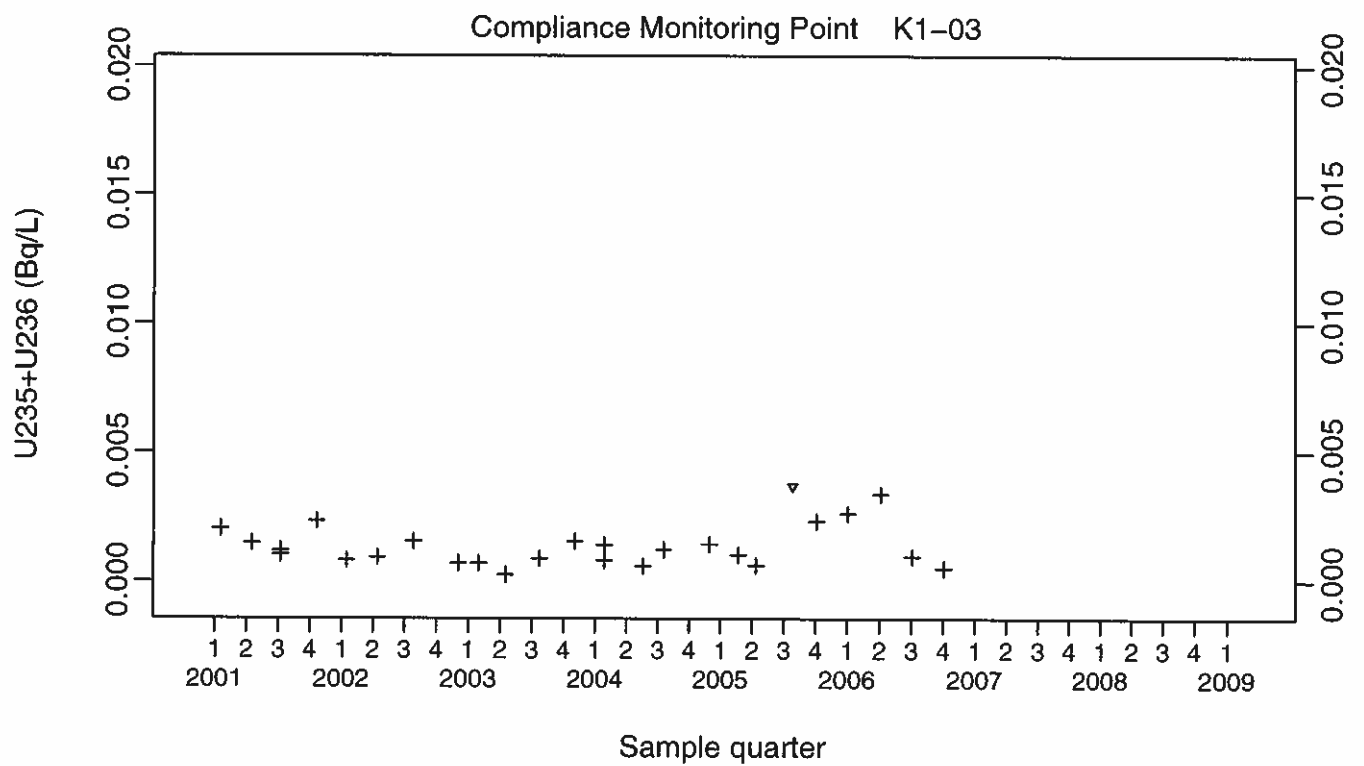
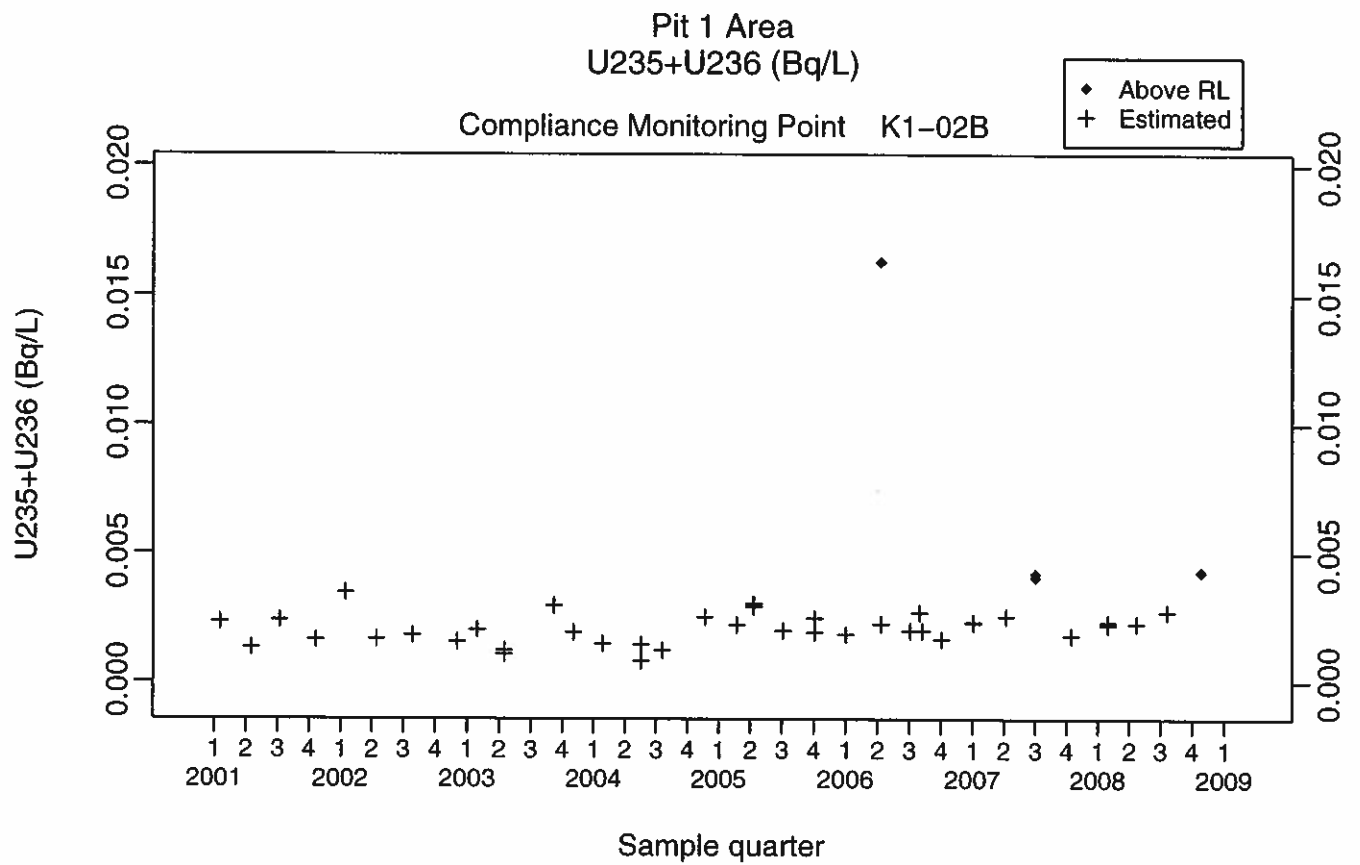


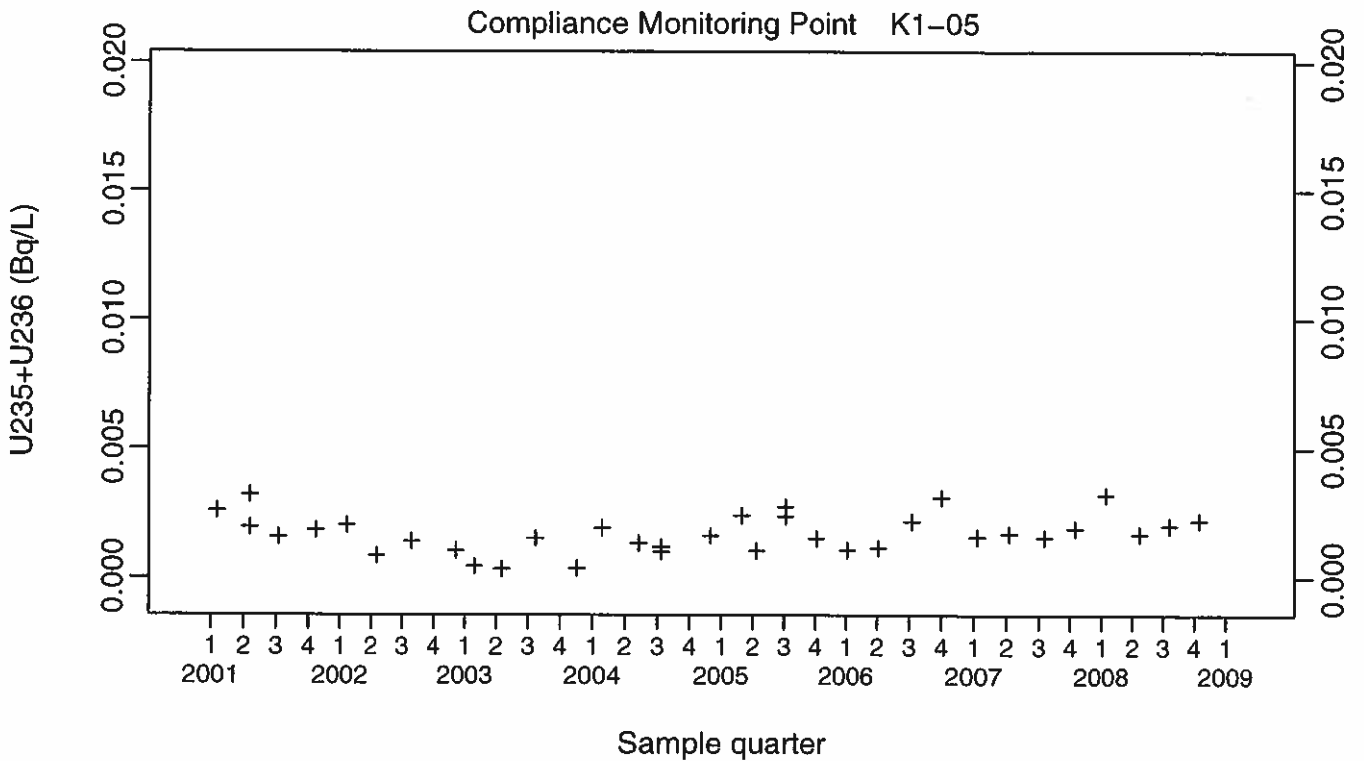
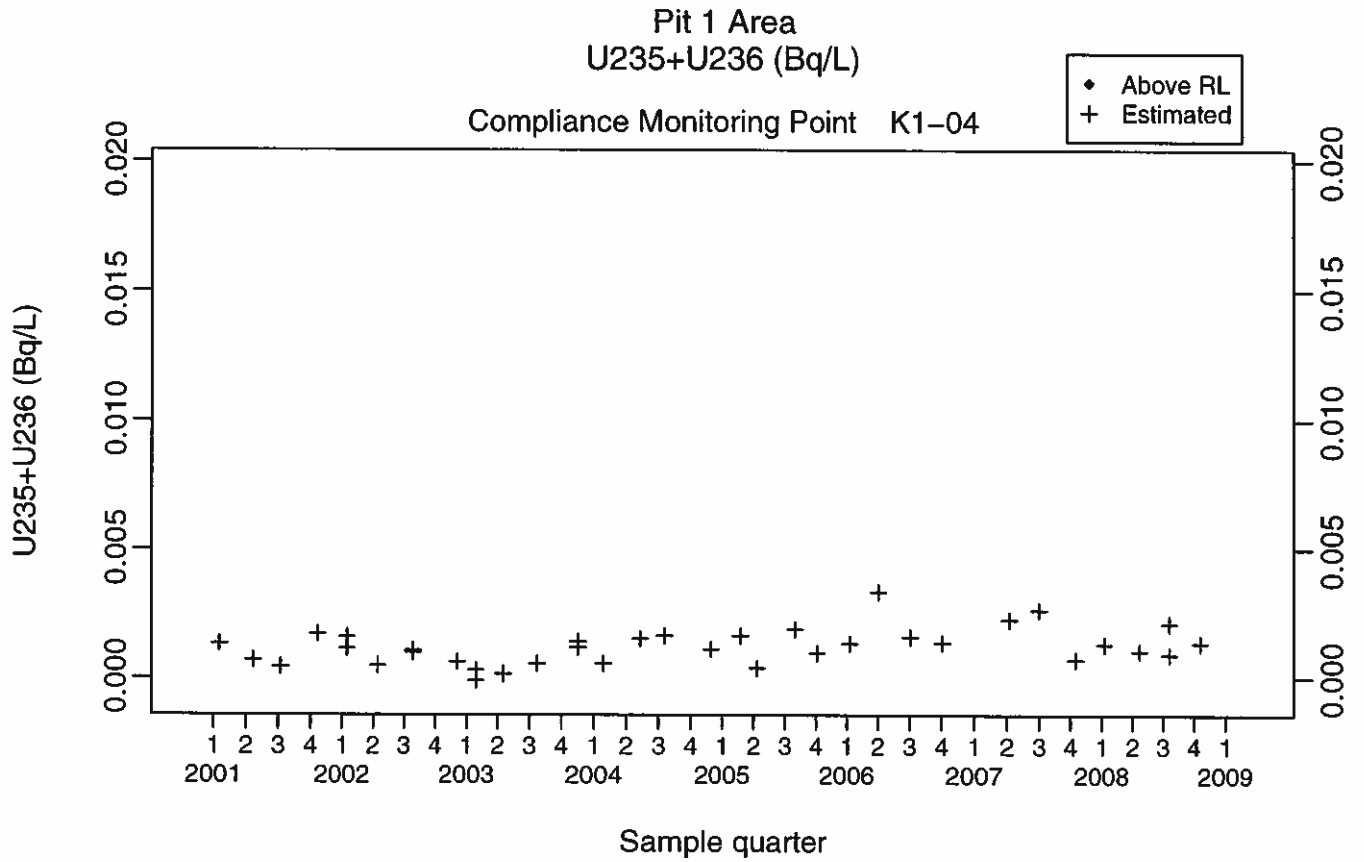


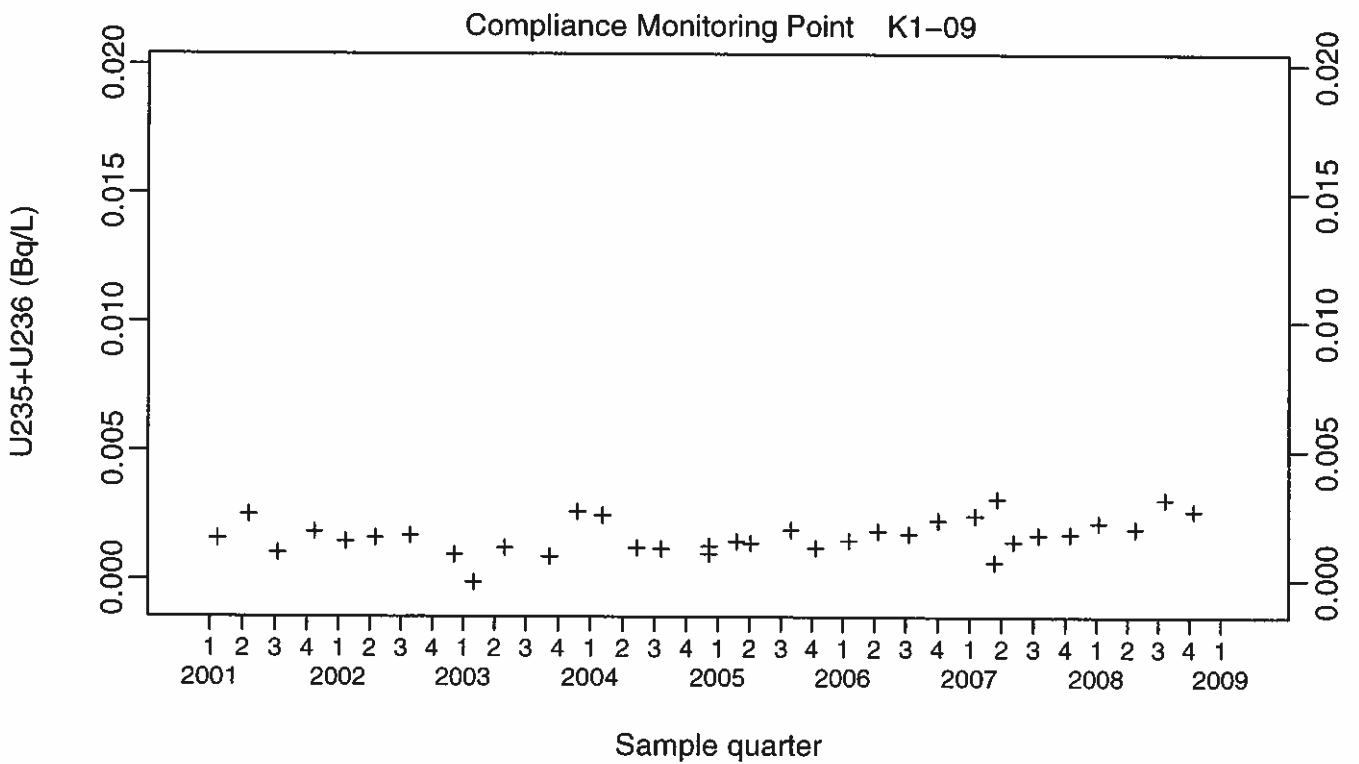
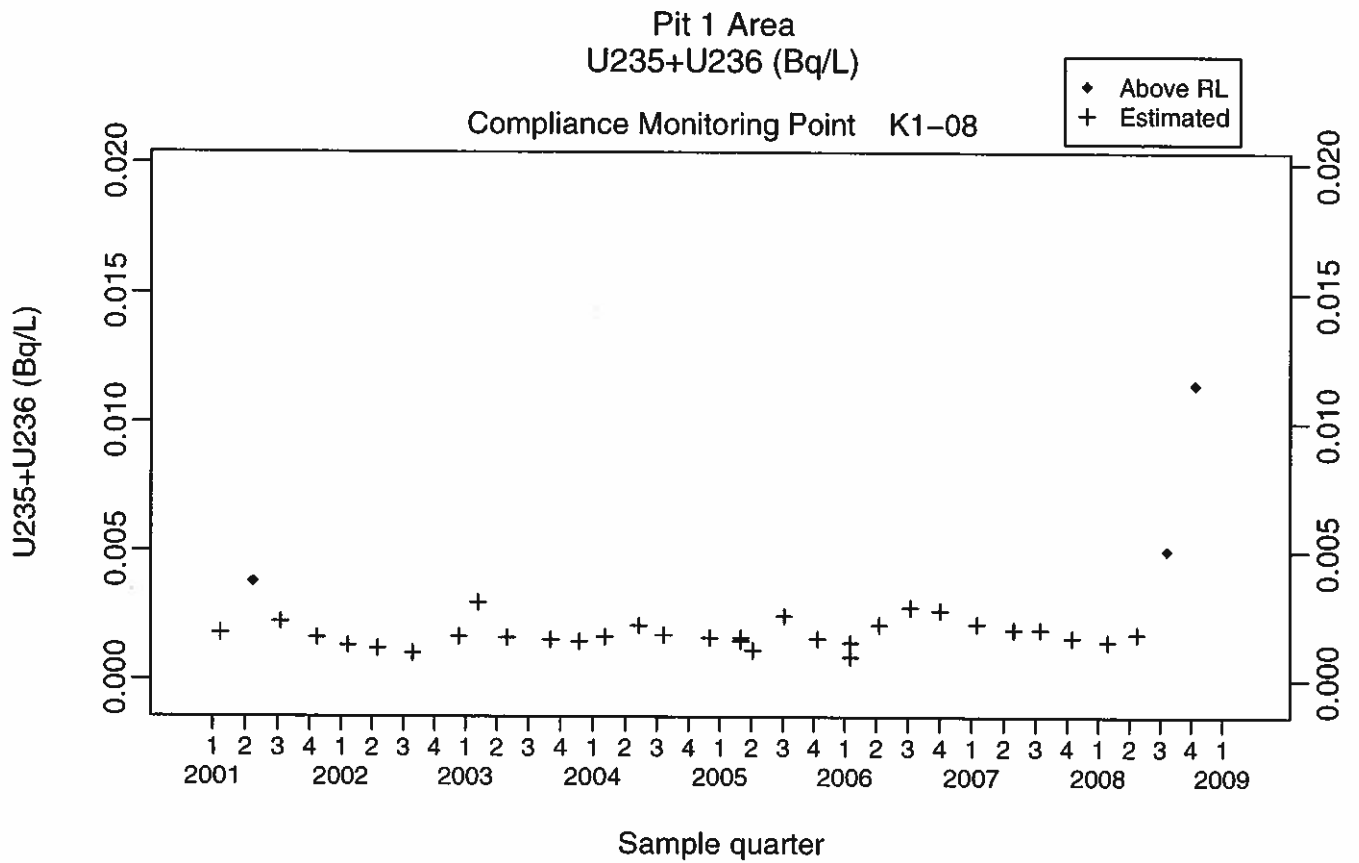


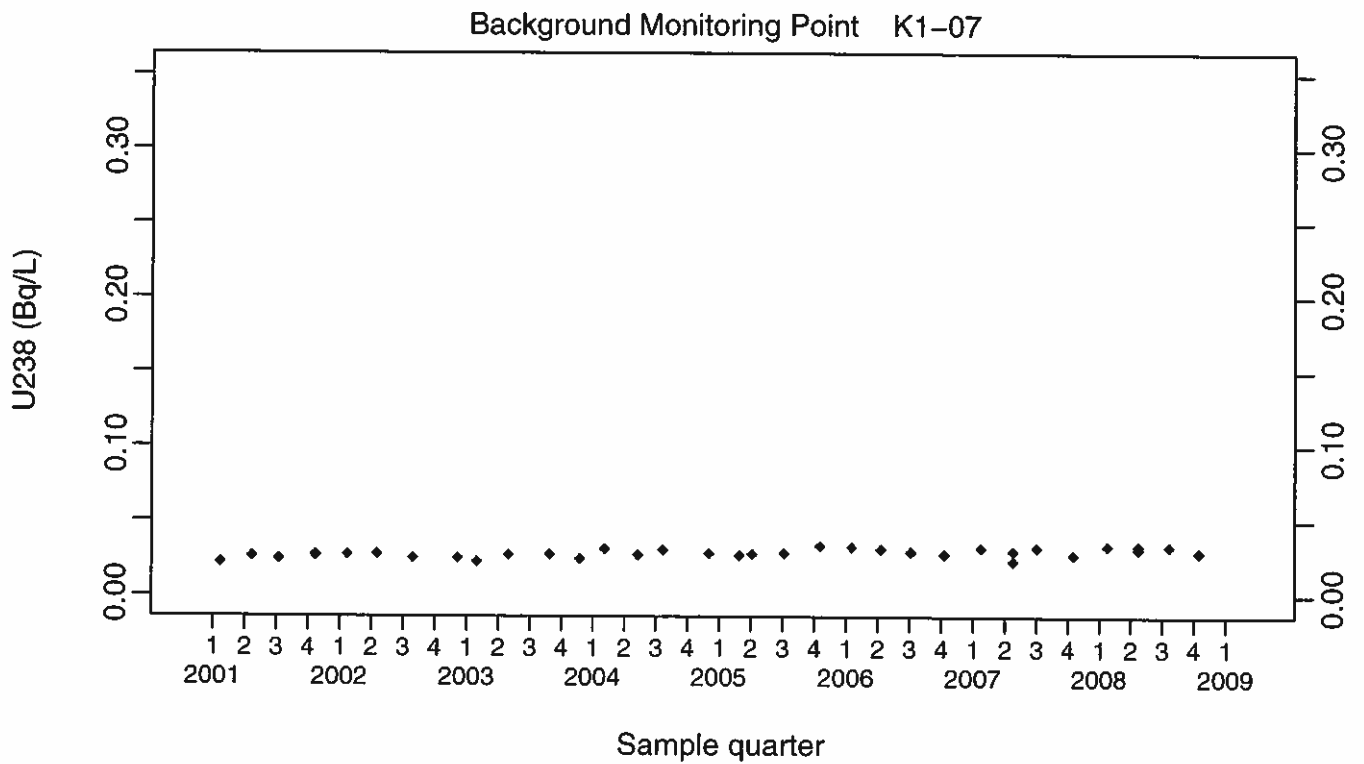
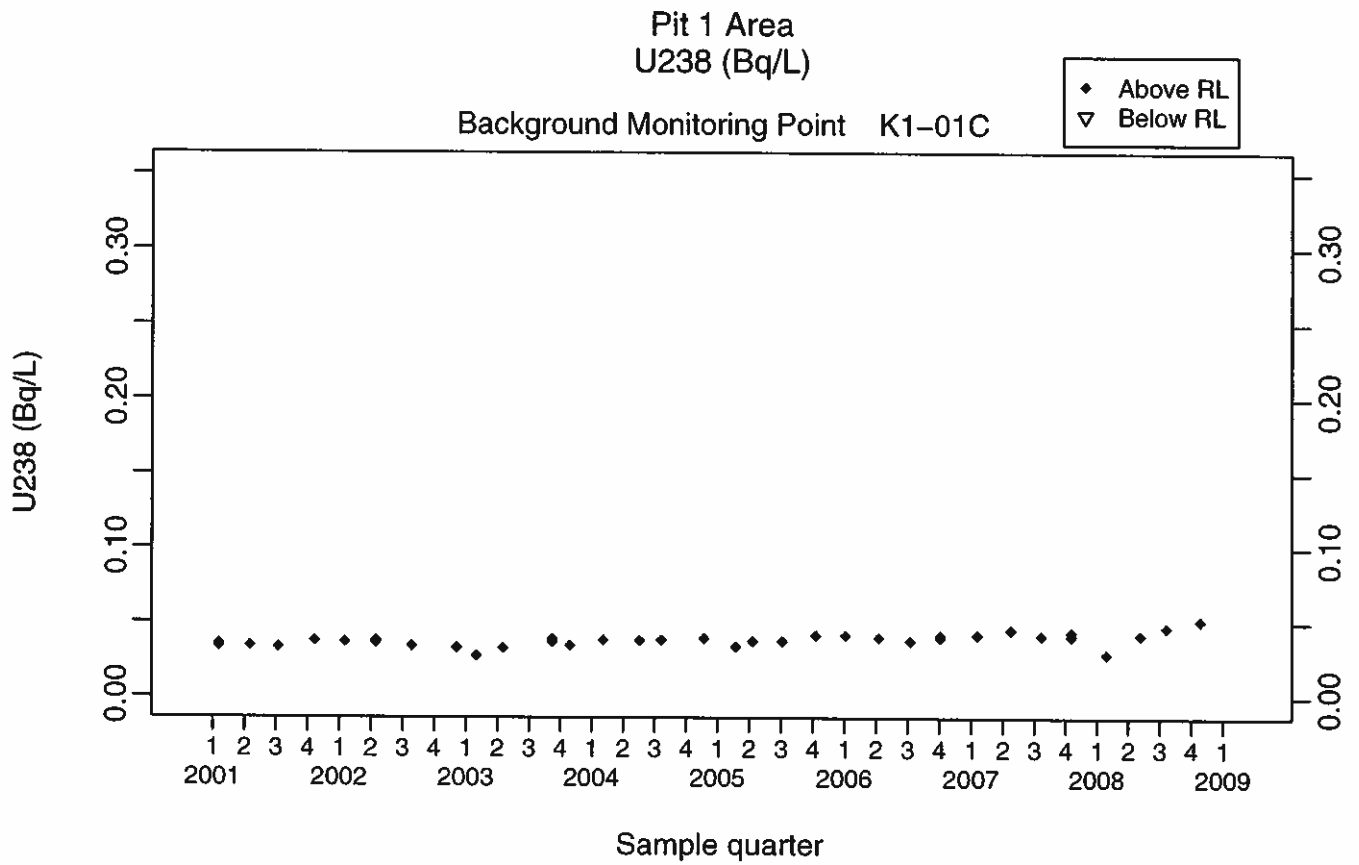


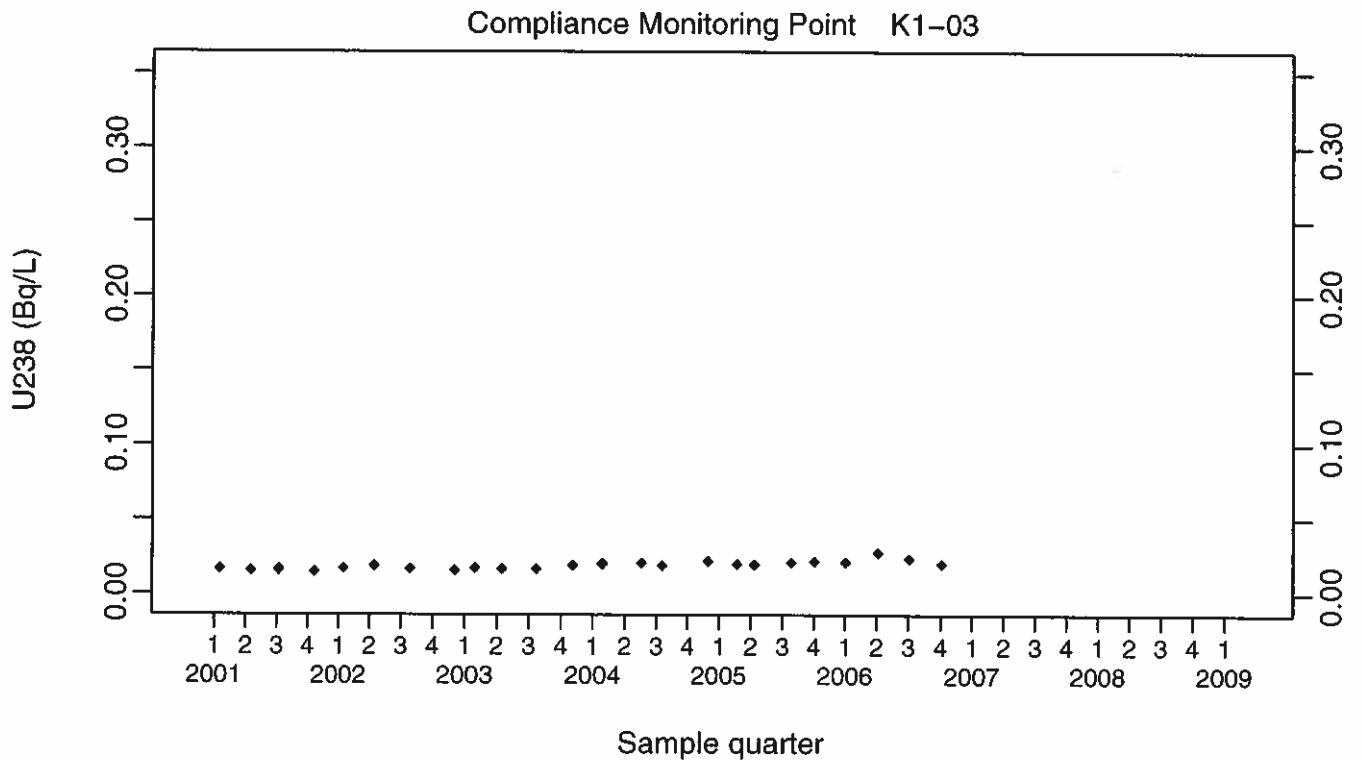
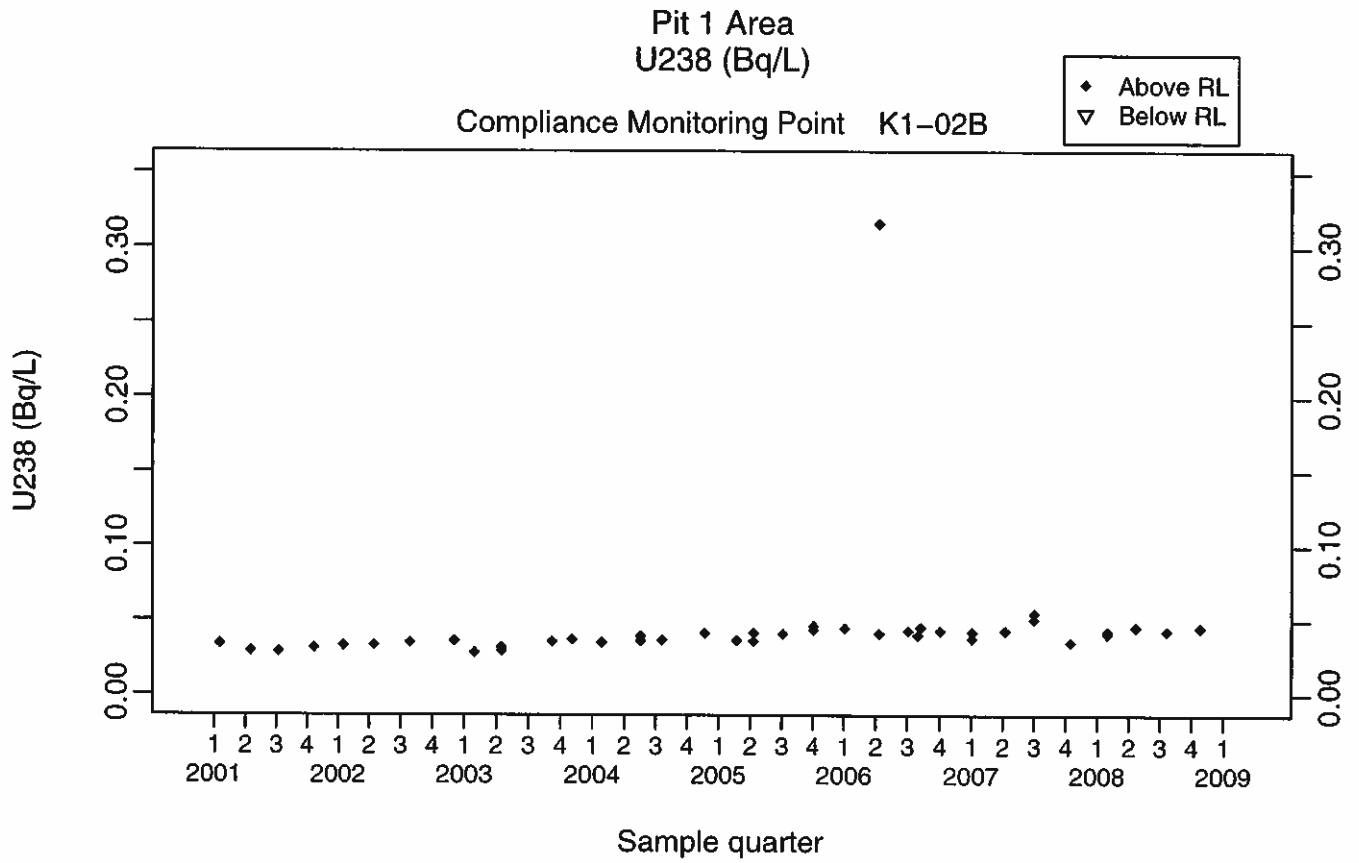


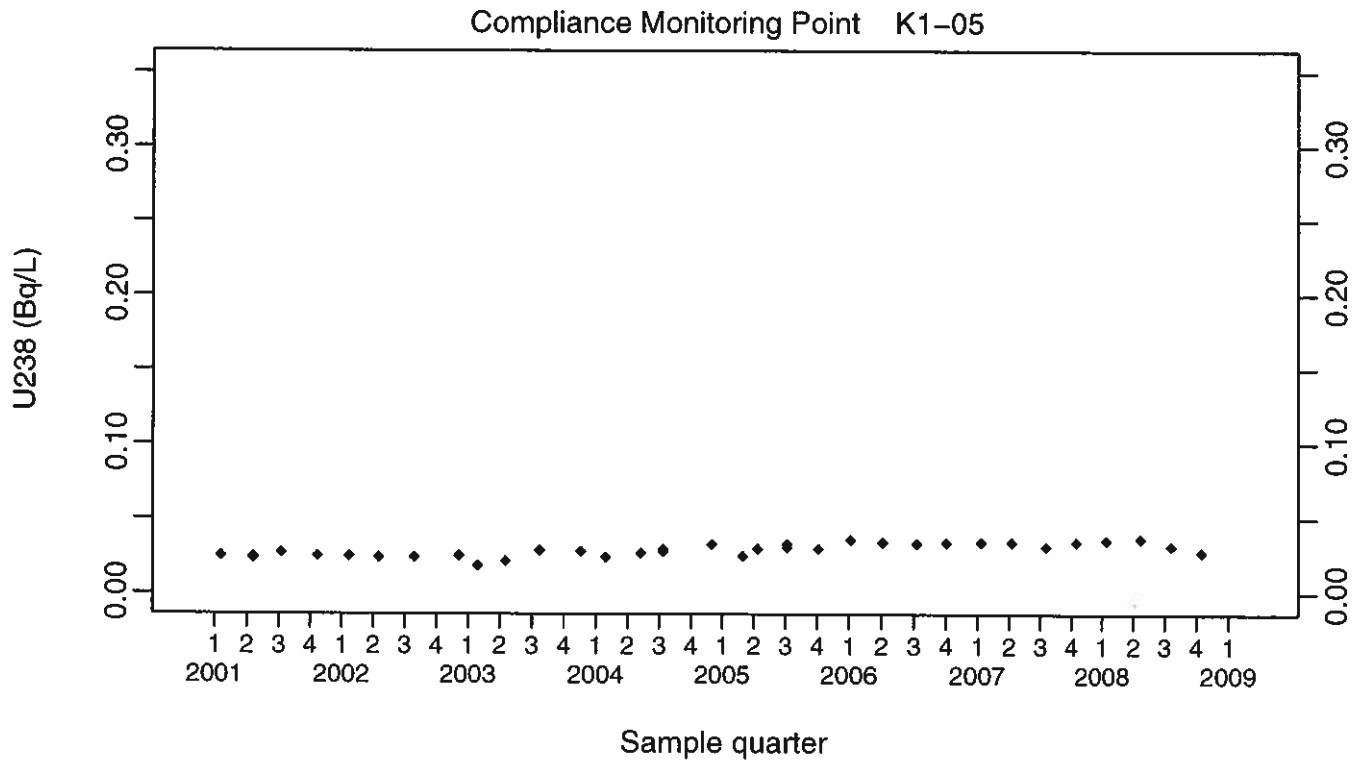
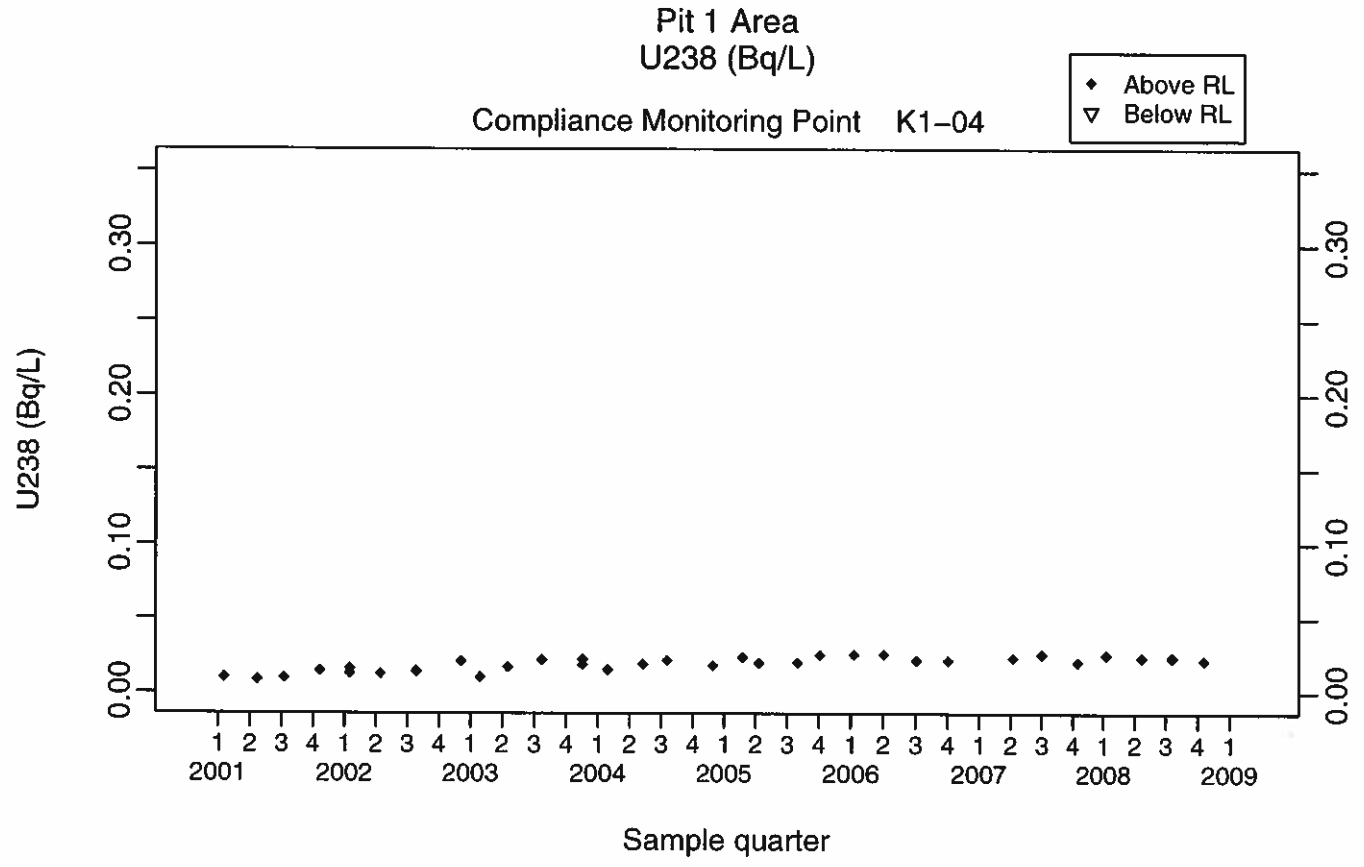


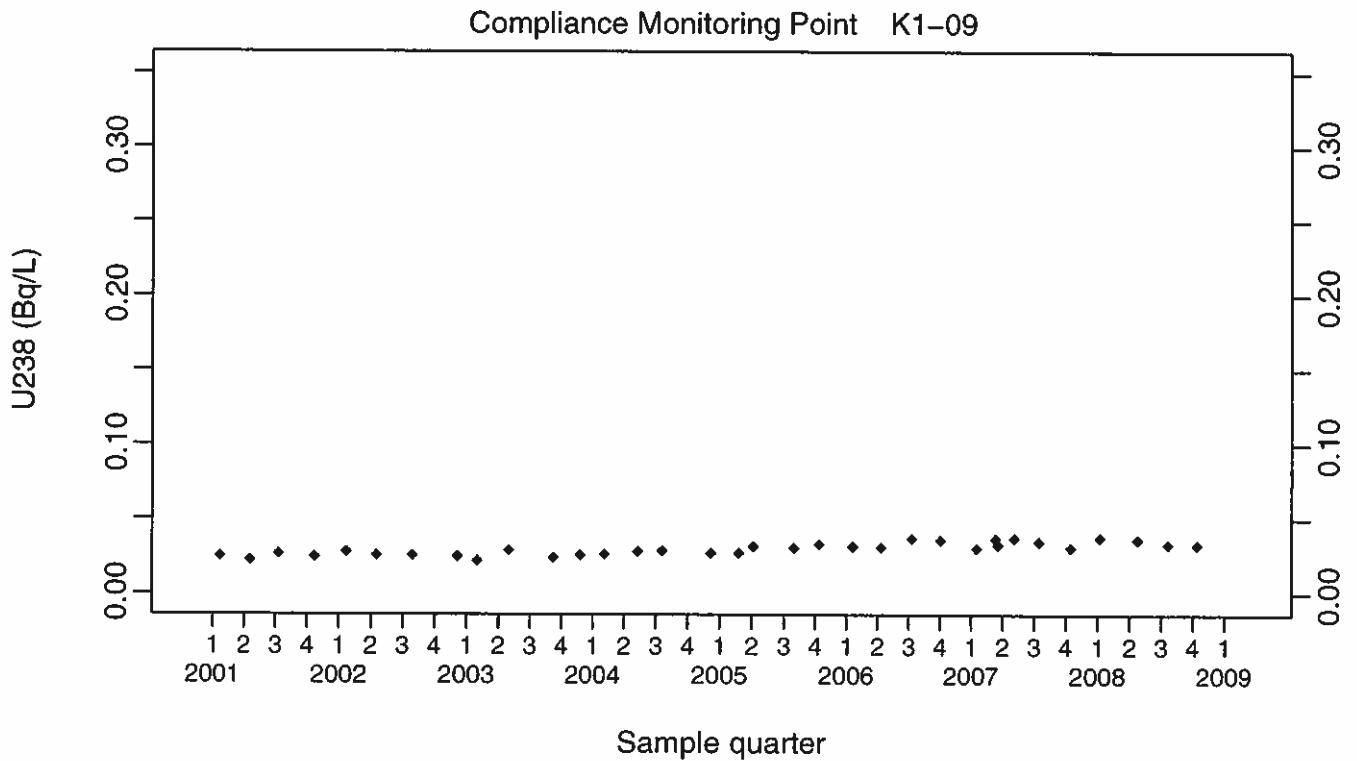
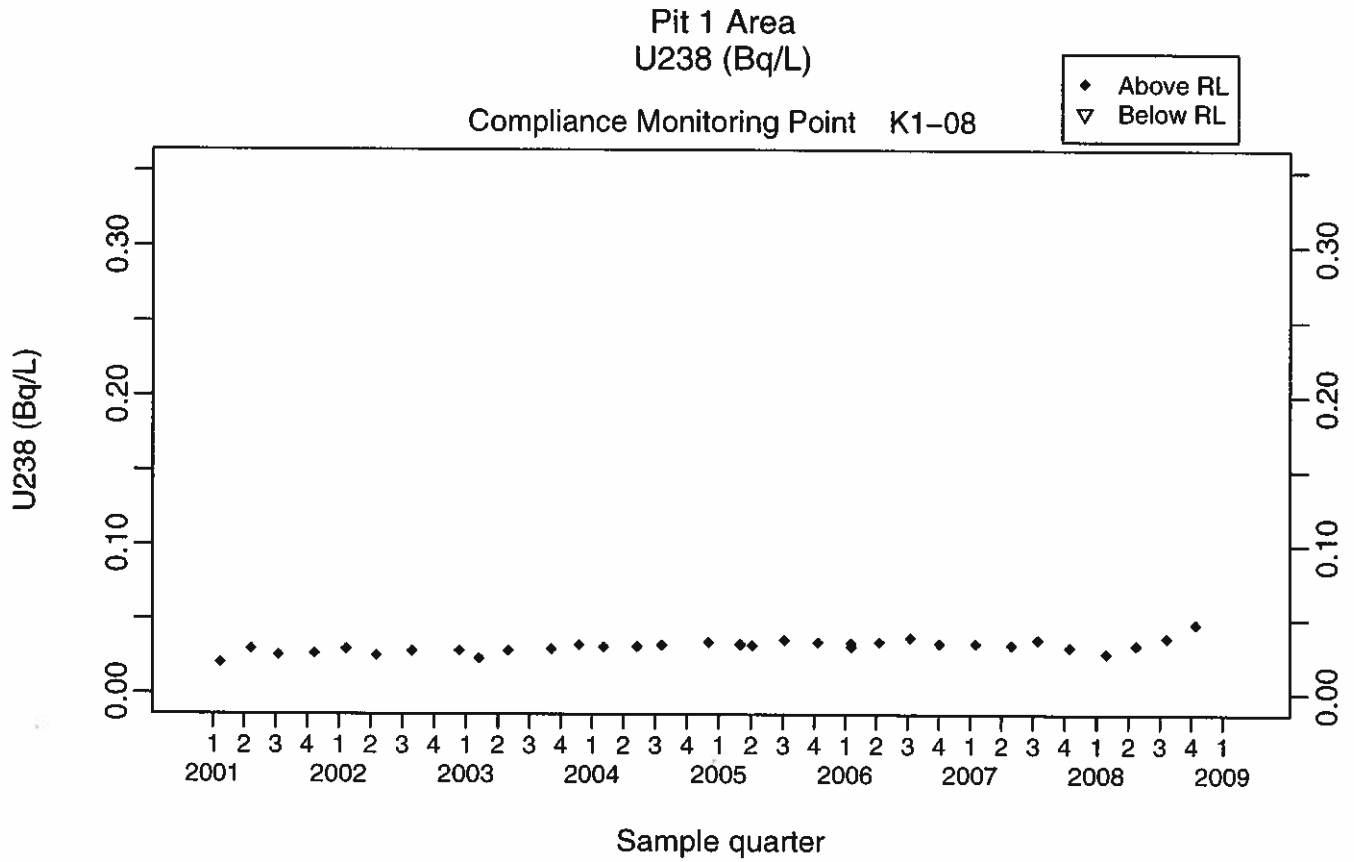


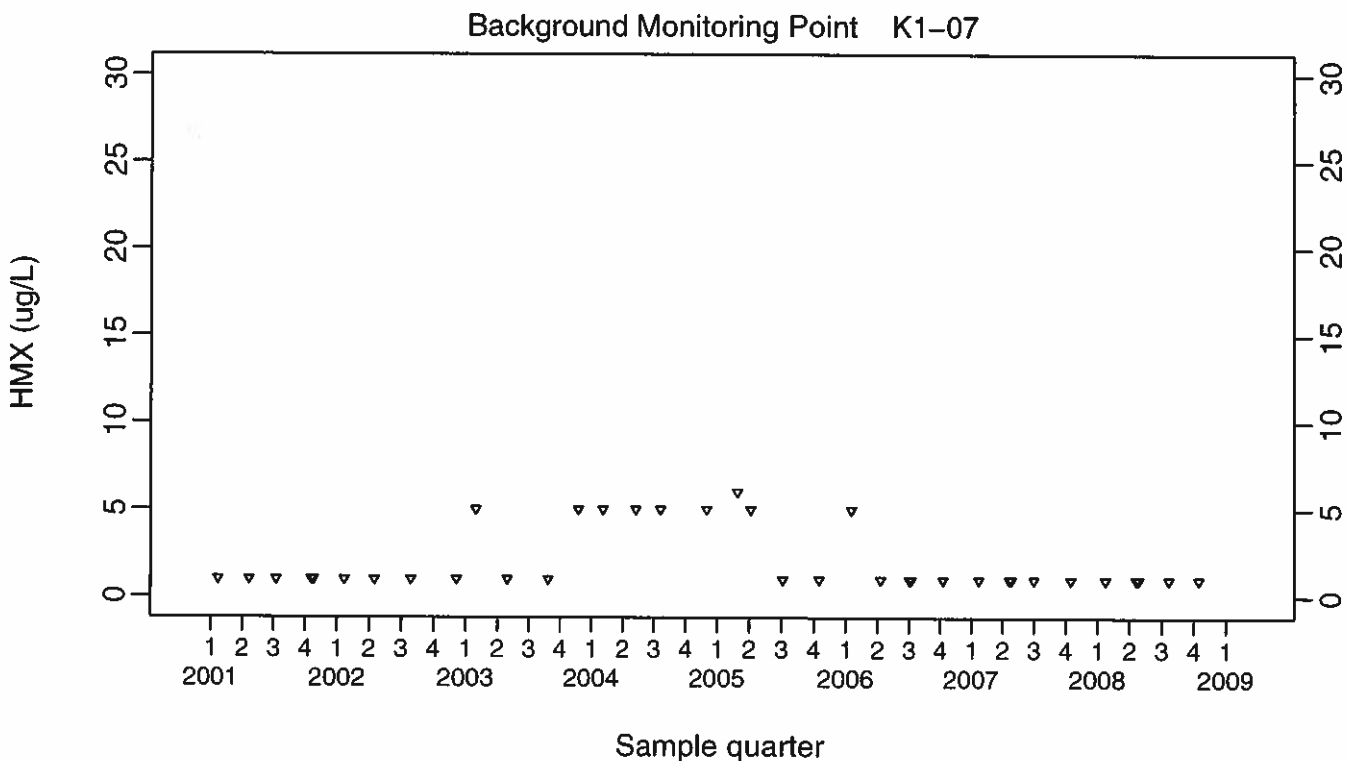
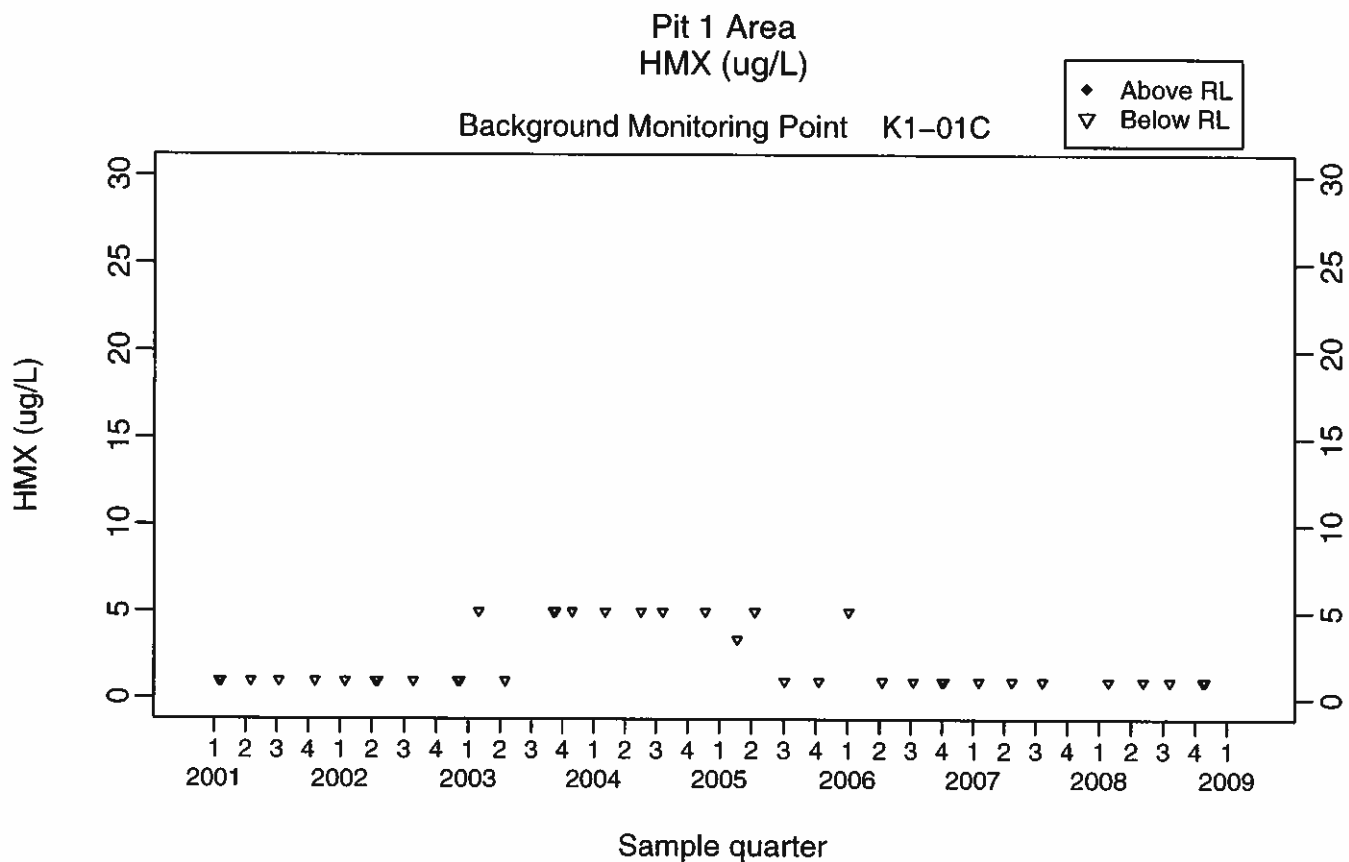


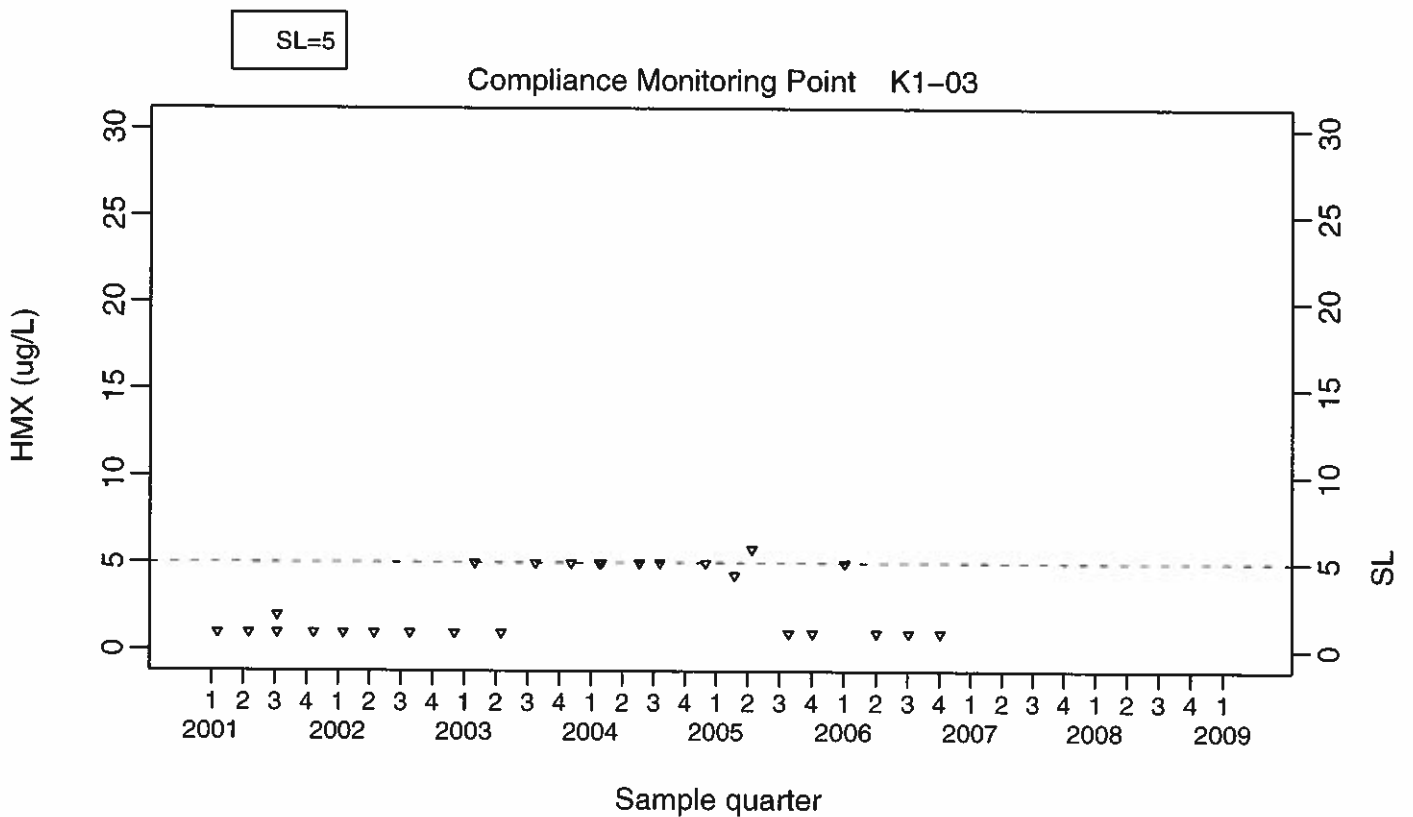
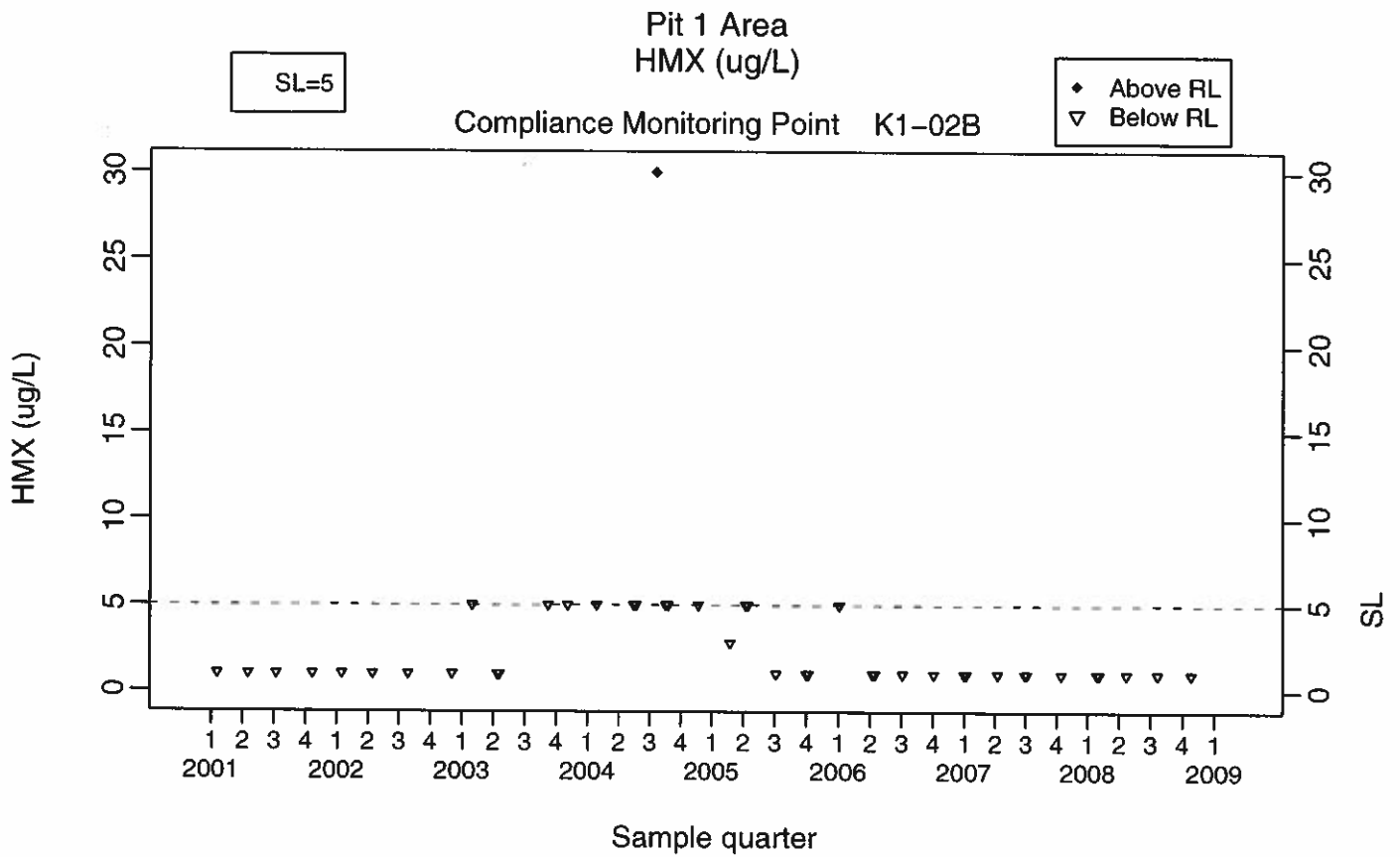


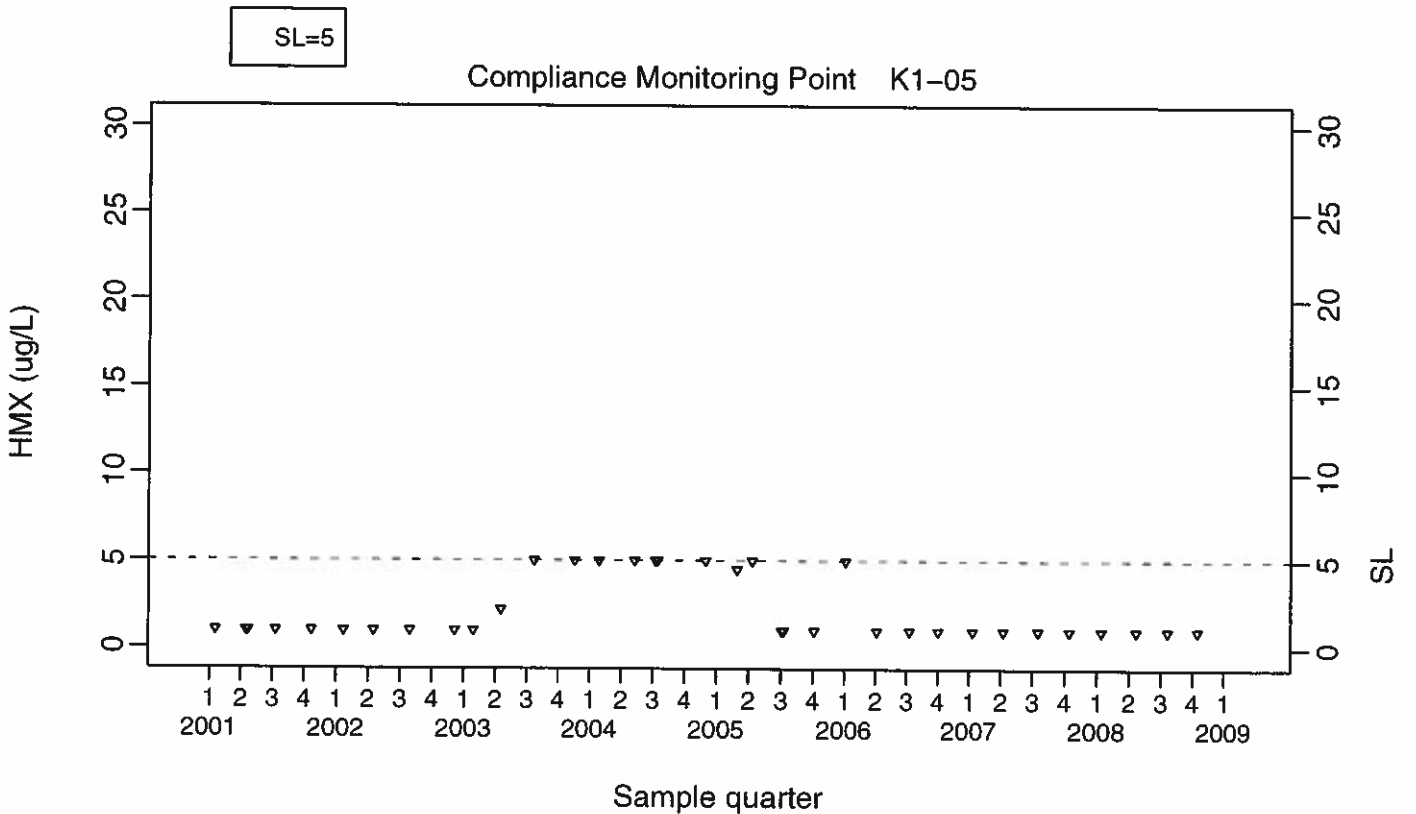
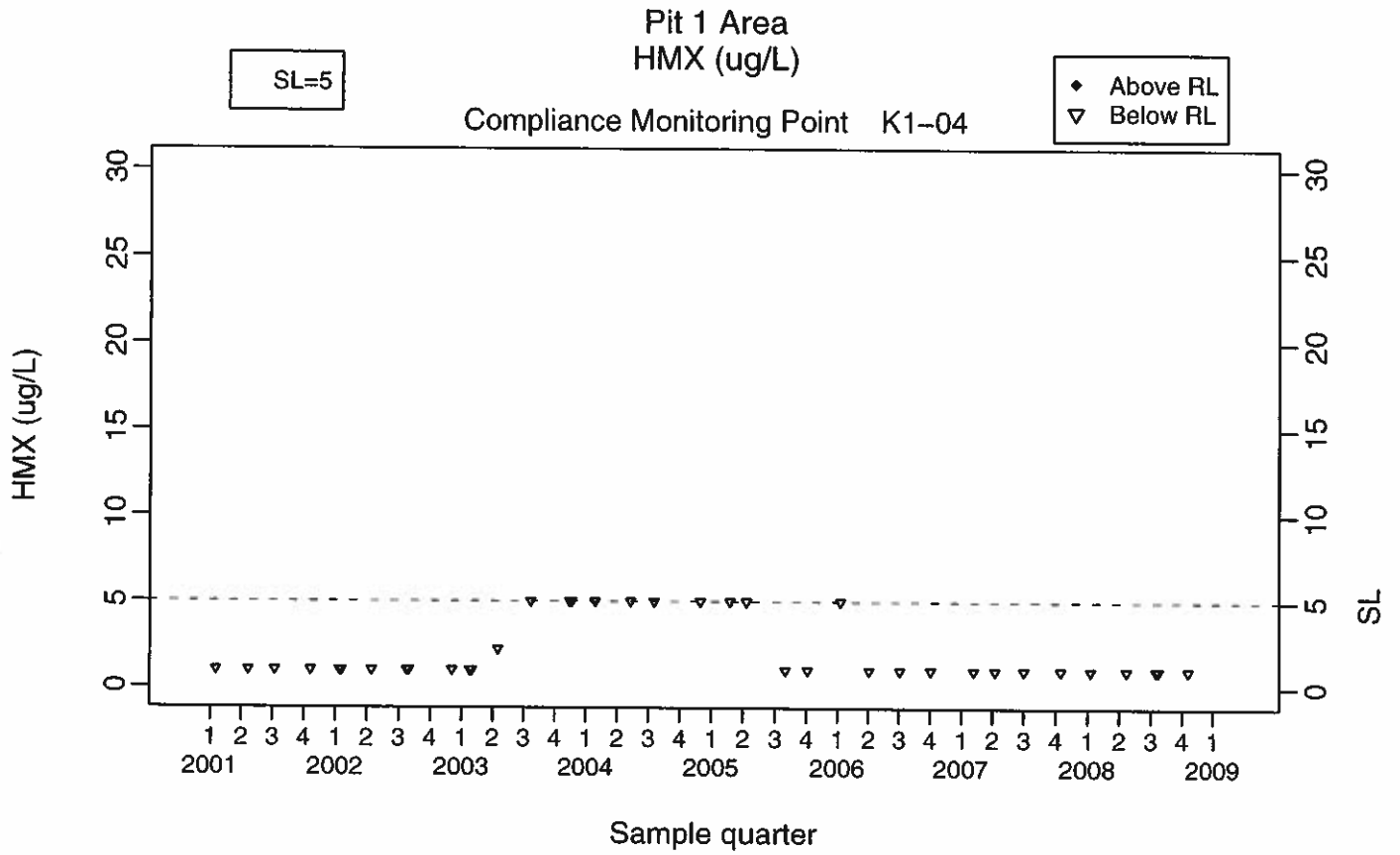


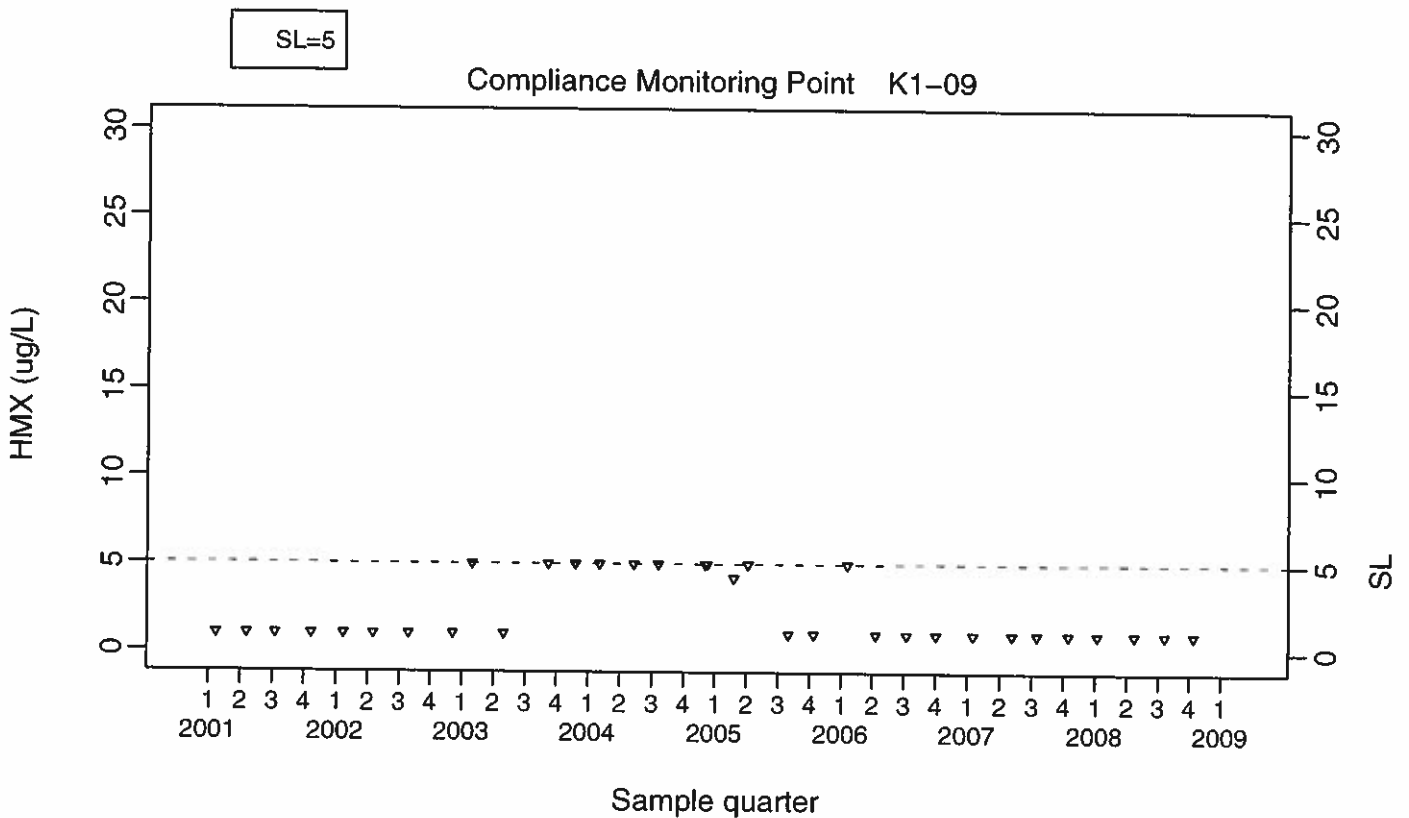
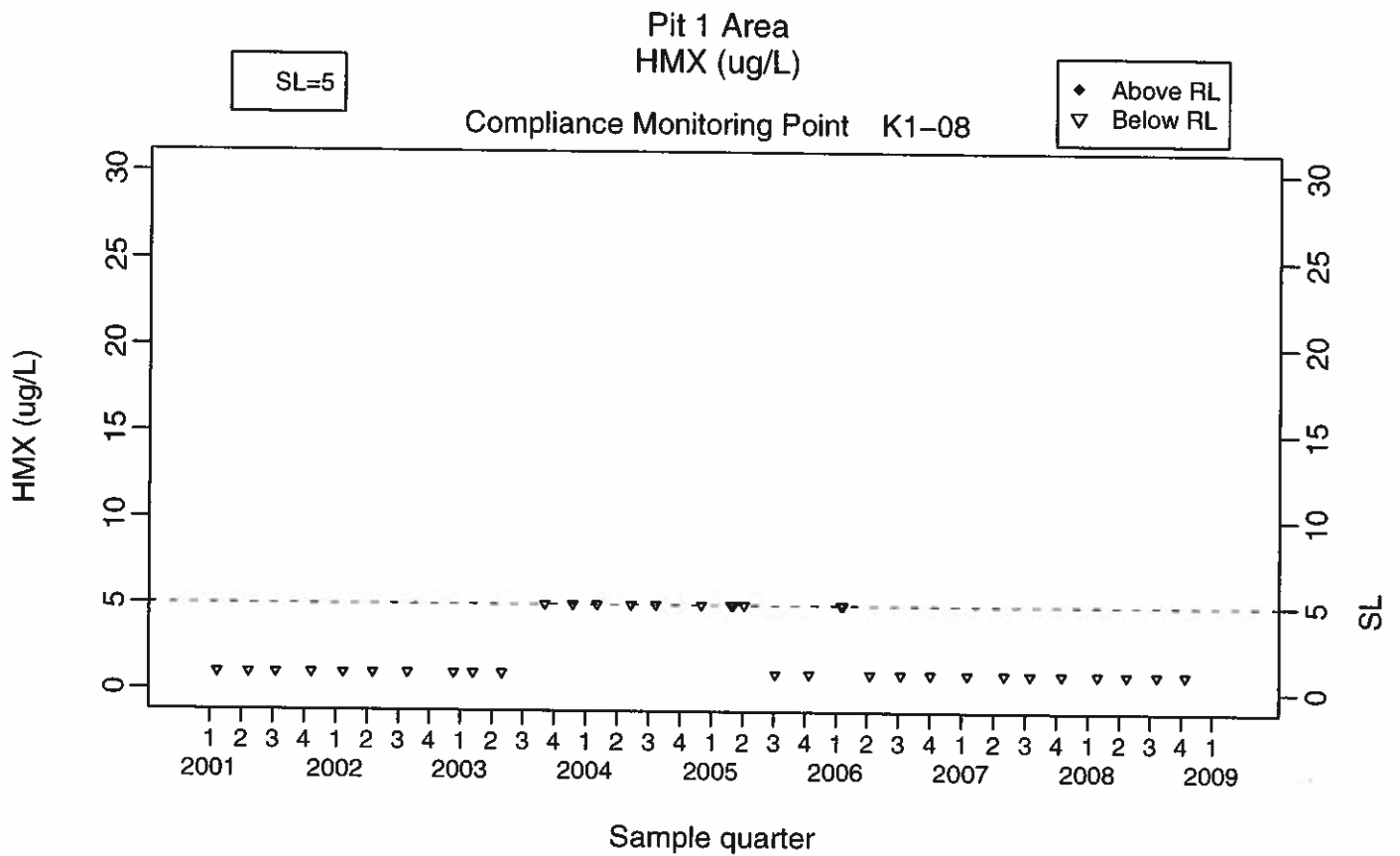


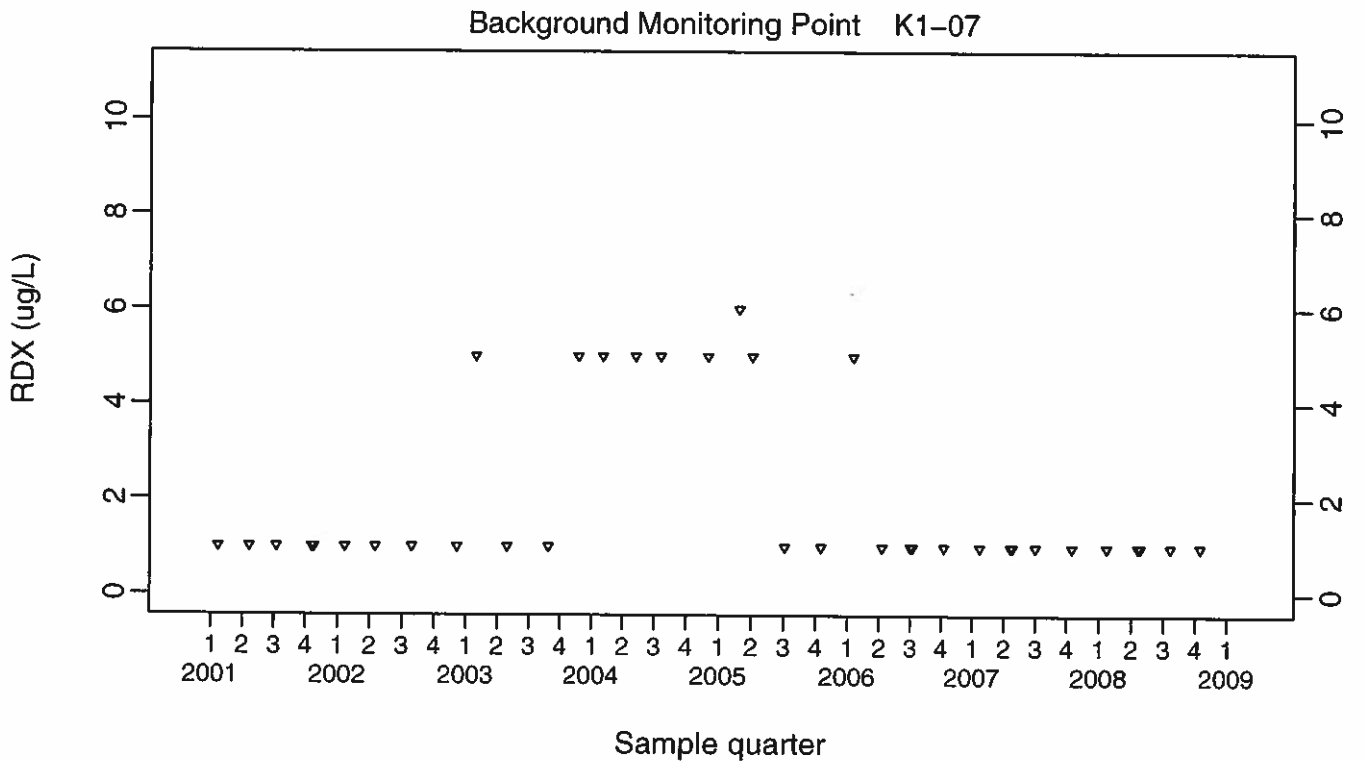
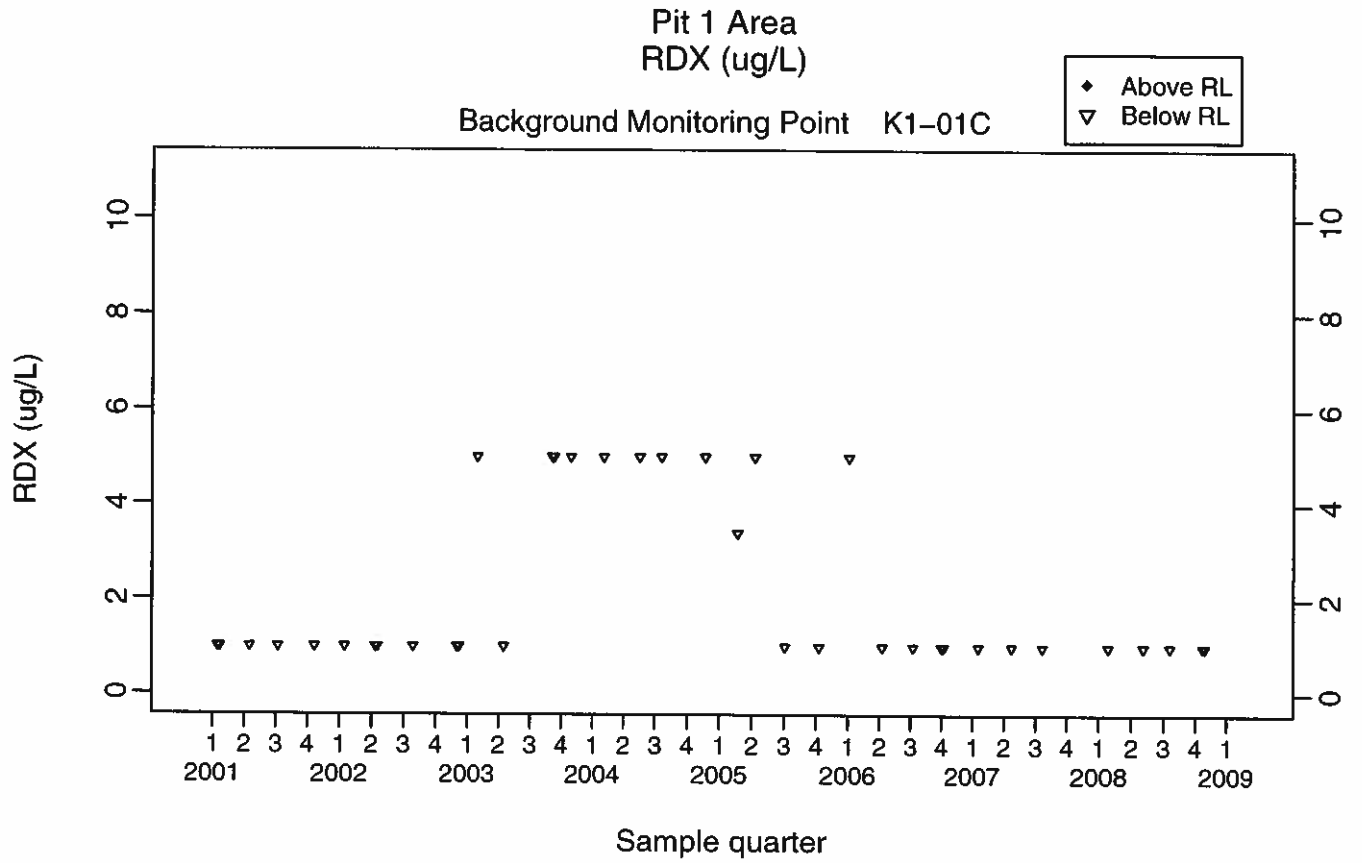


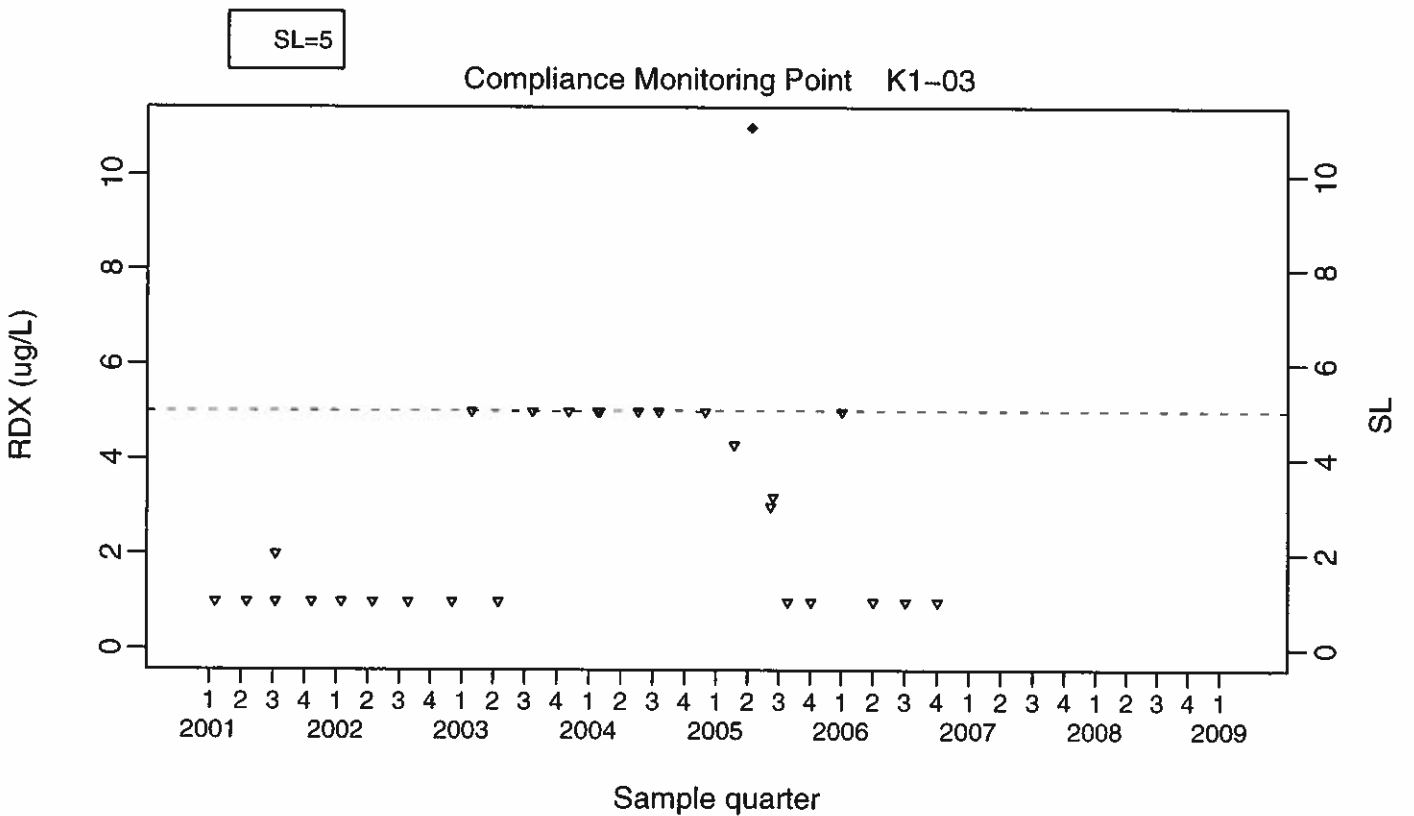
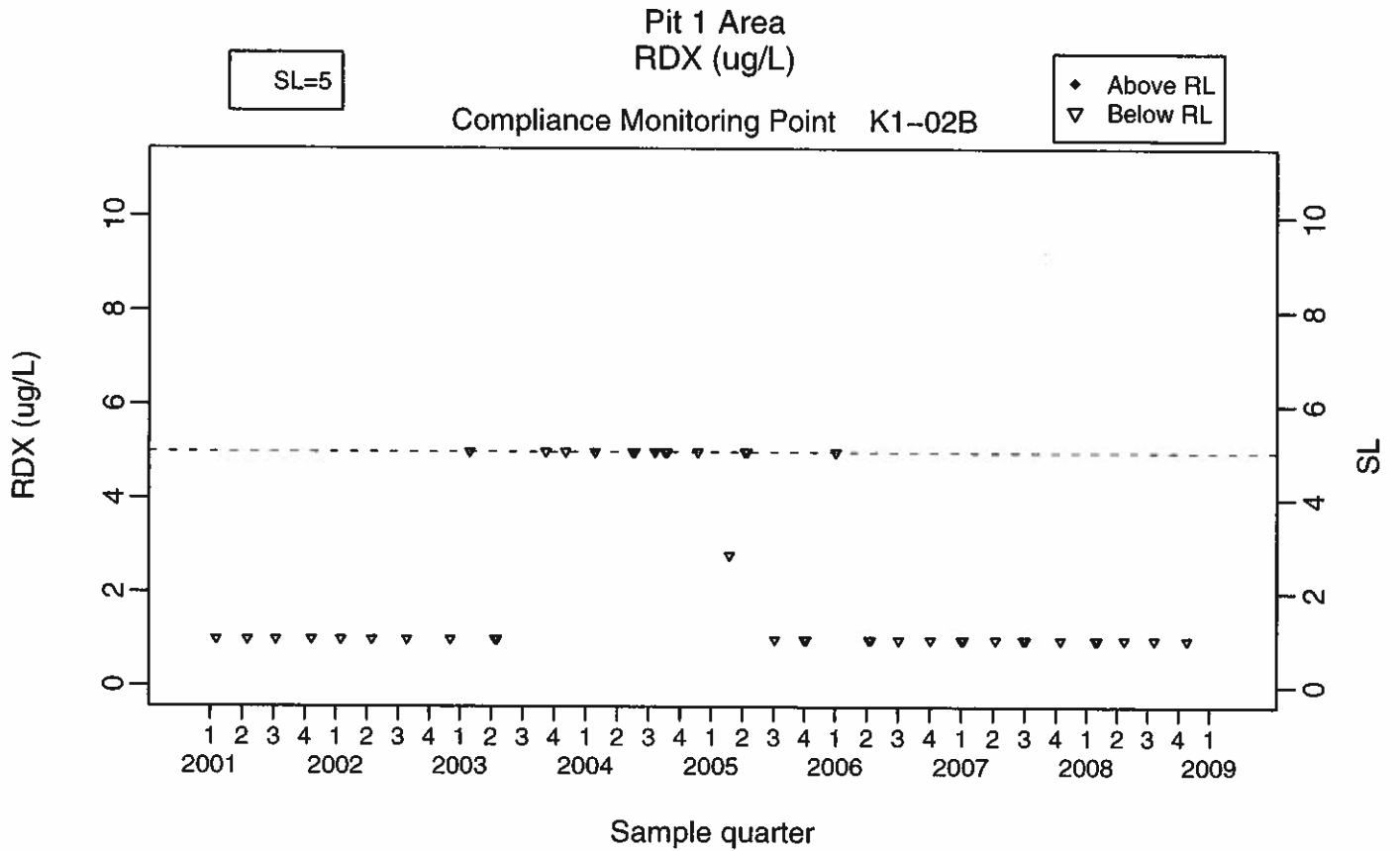


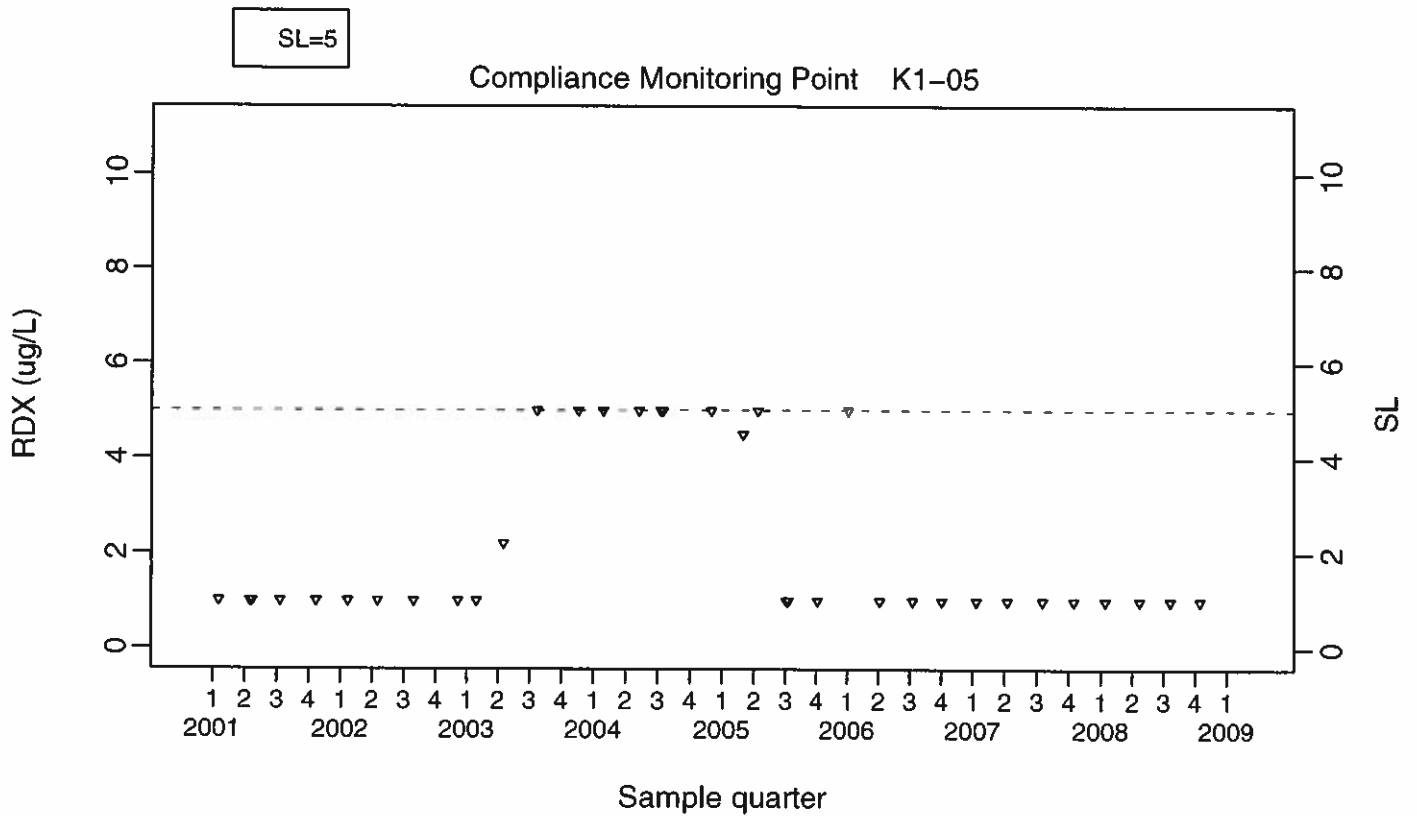
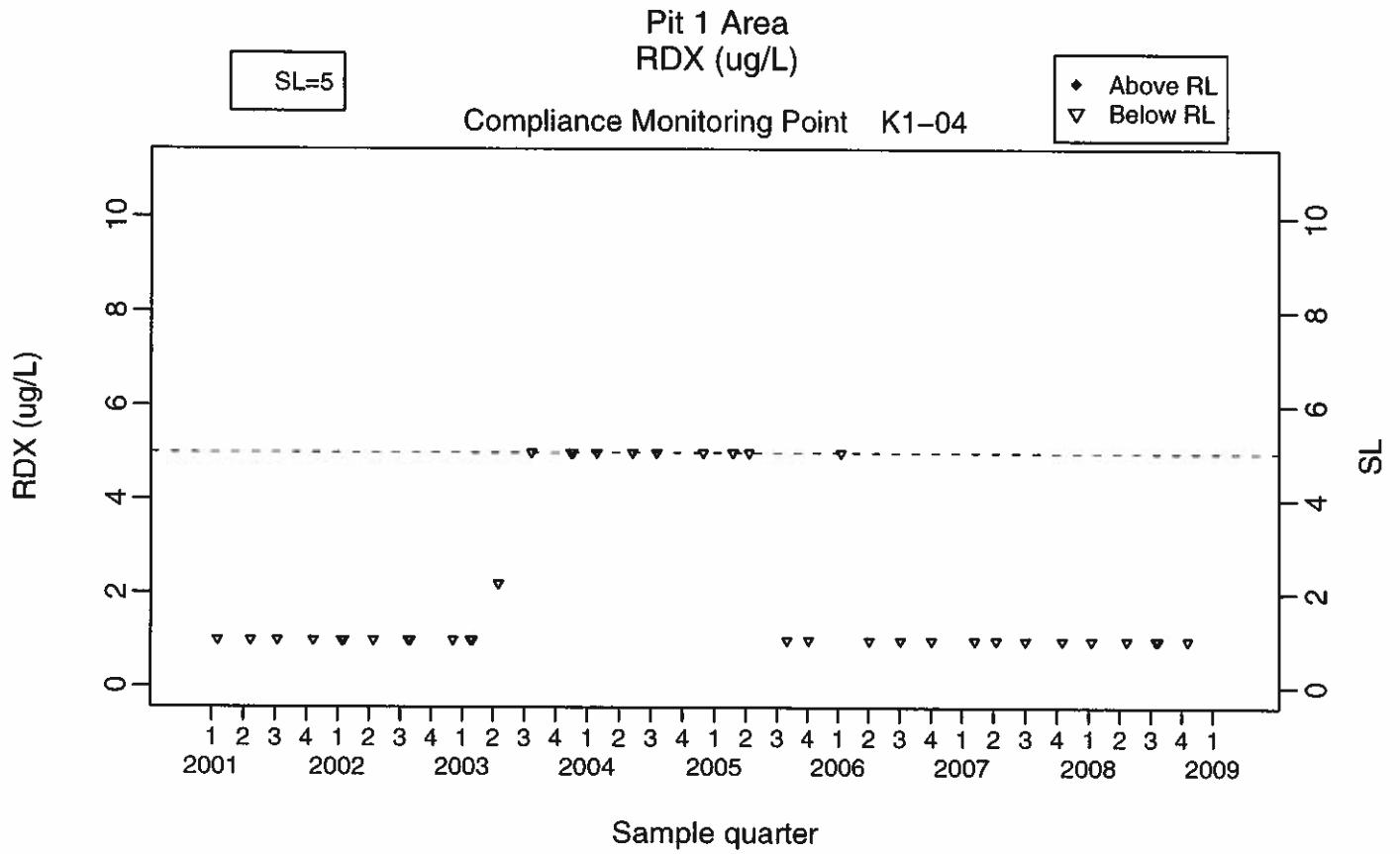


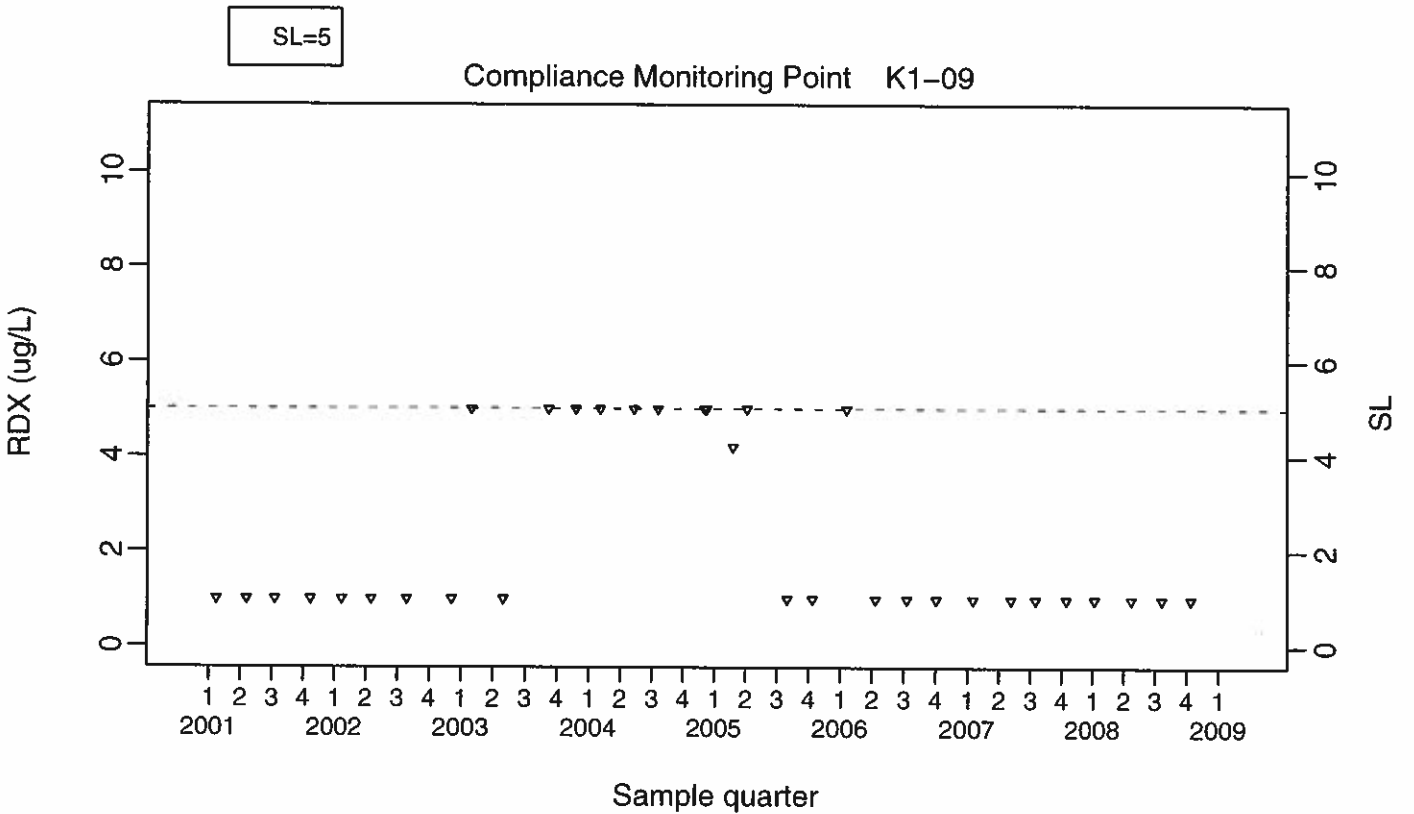
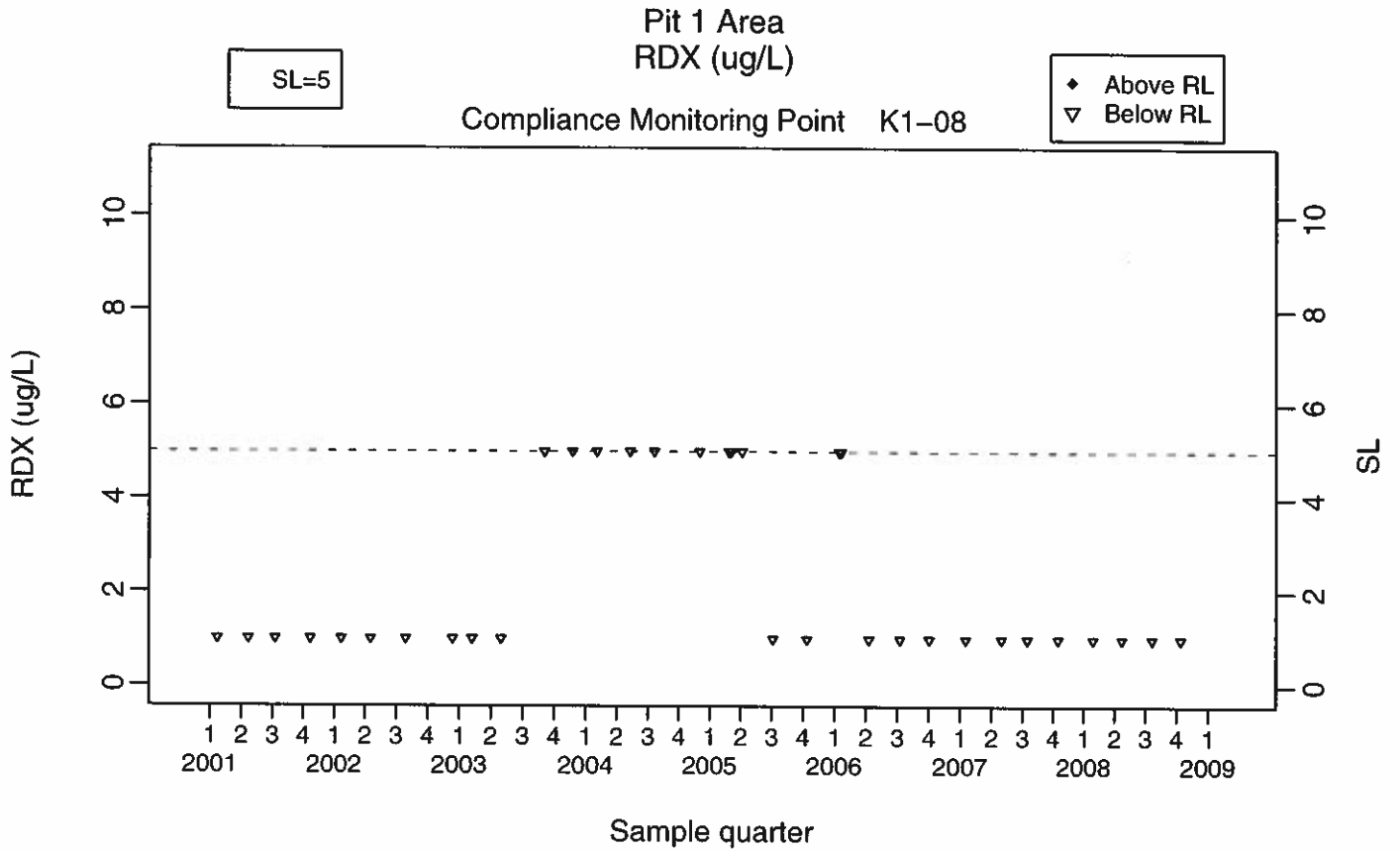






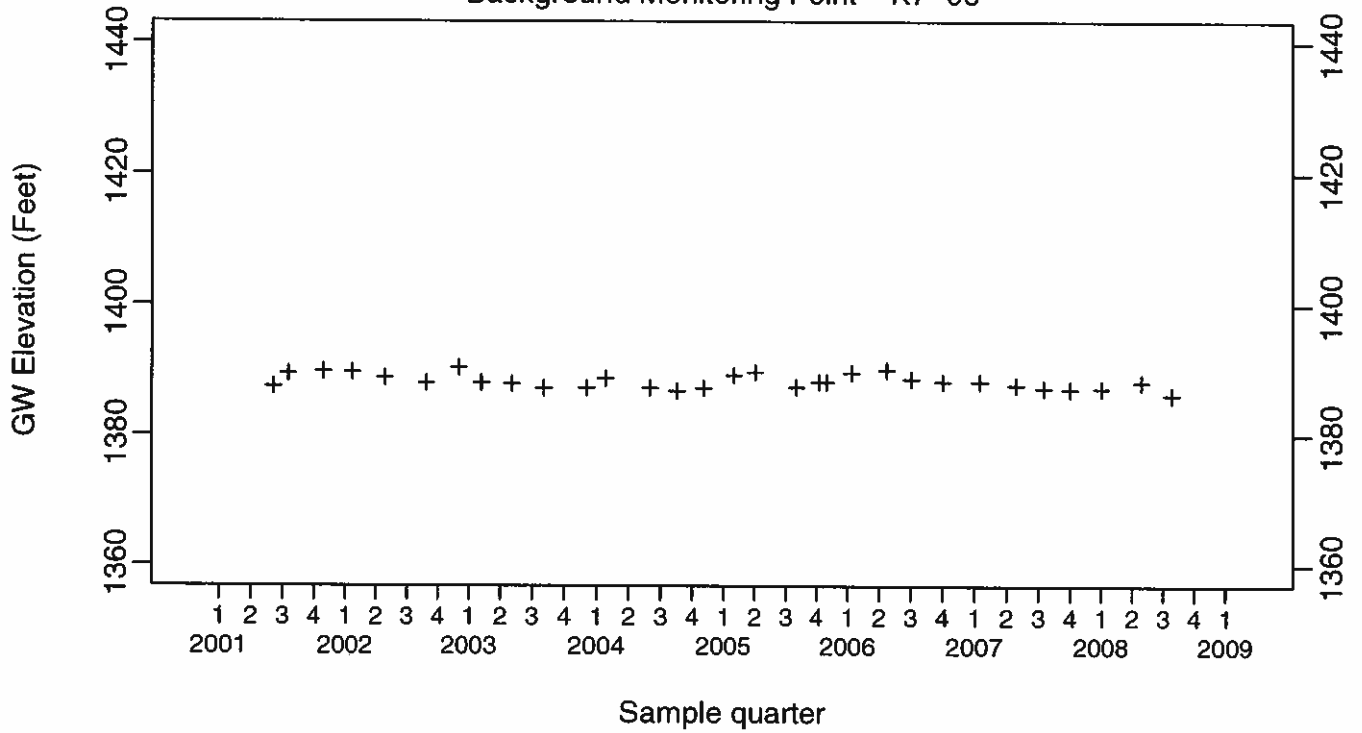




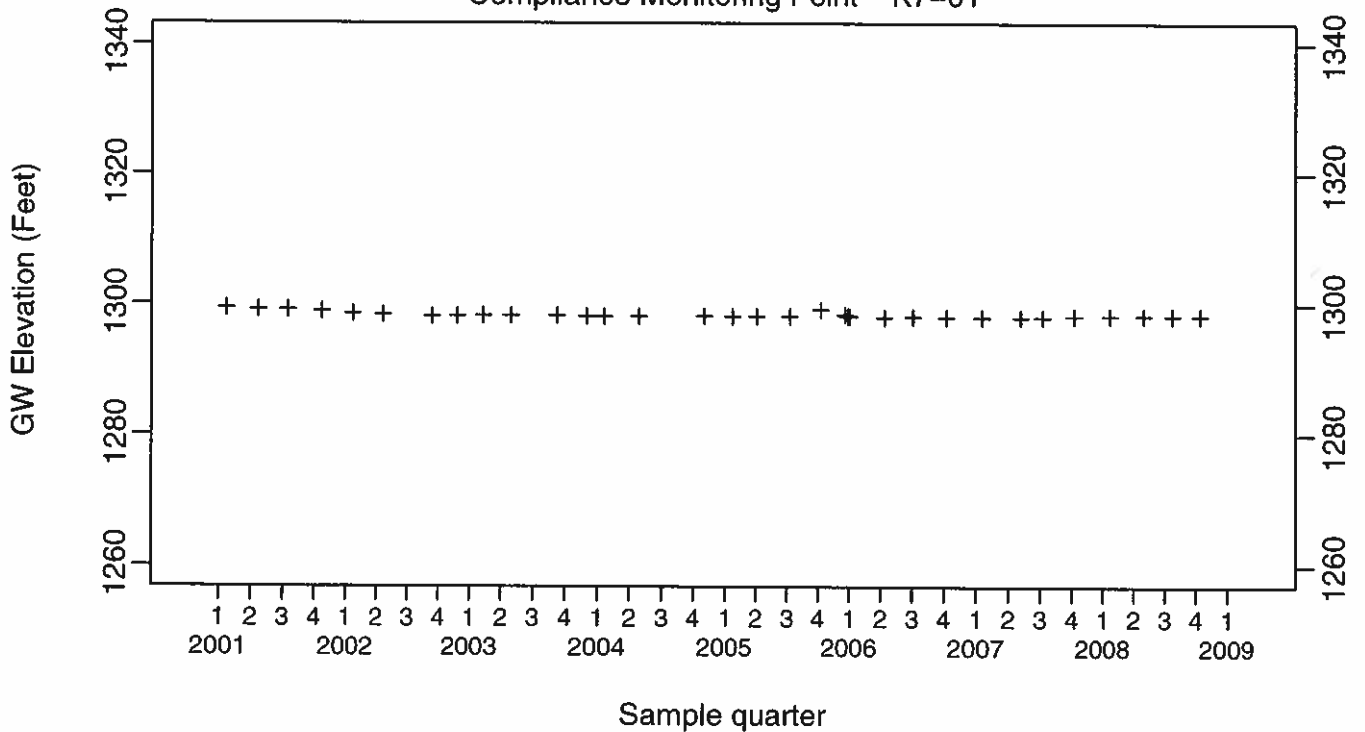


Pit 7 Complex GW Elevation (Feet)

Background Monitoring Point K7-06

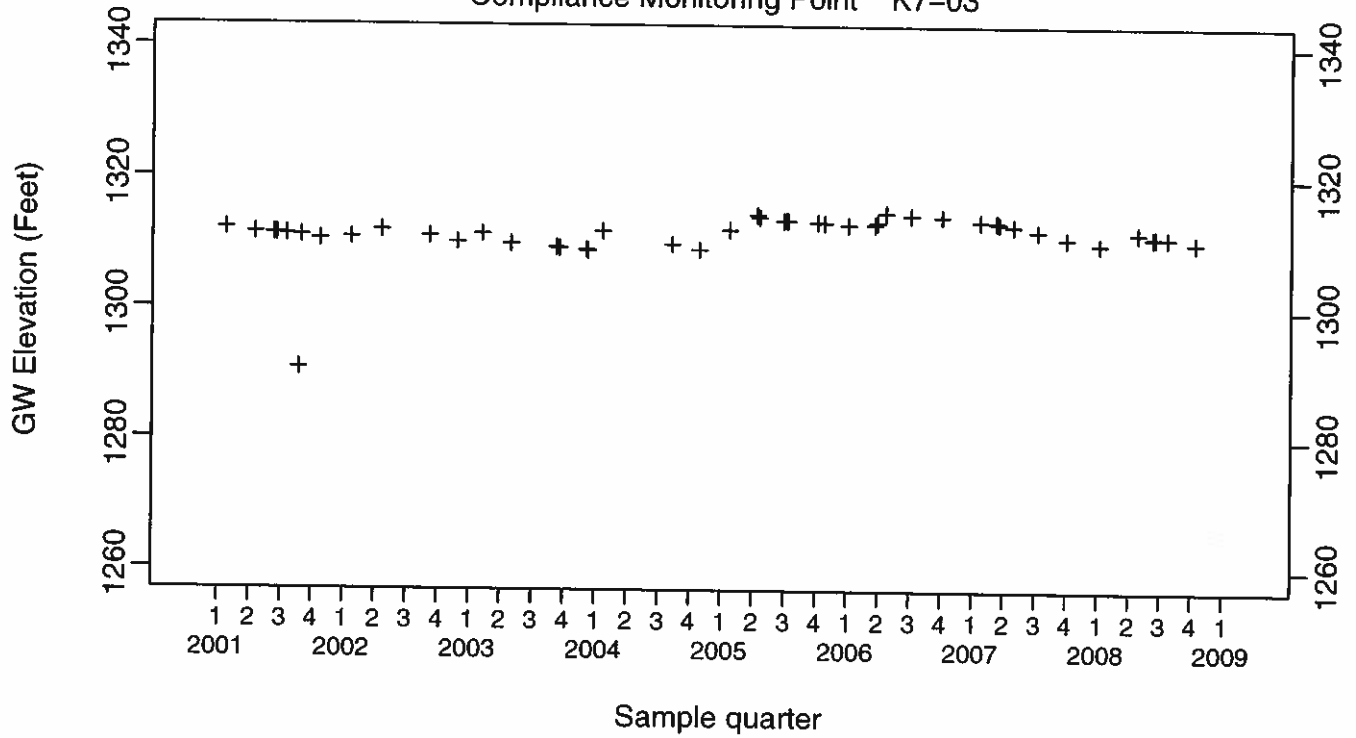


Compliance Monitoring Point K7-01

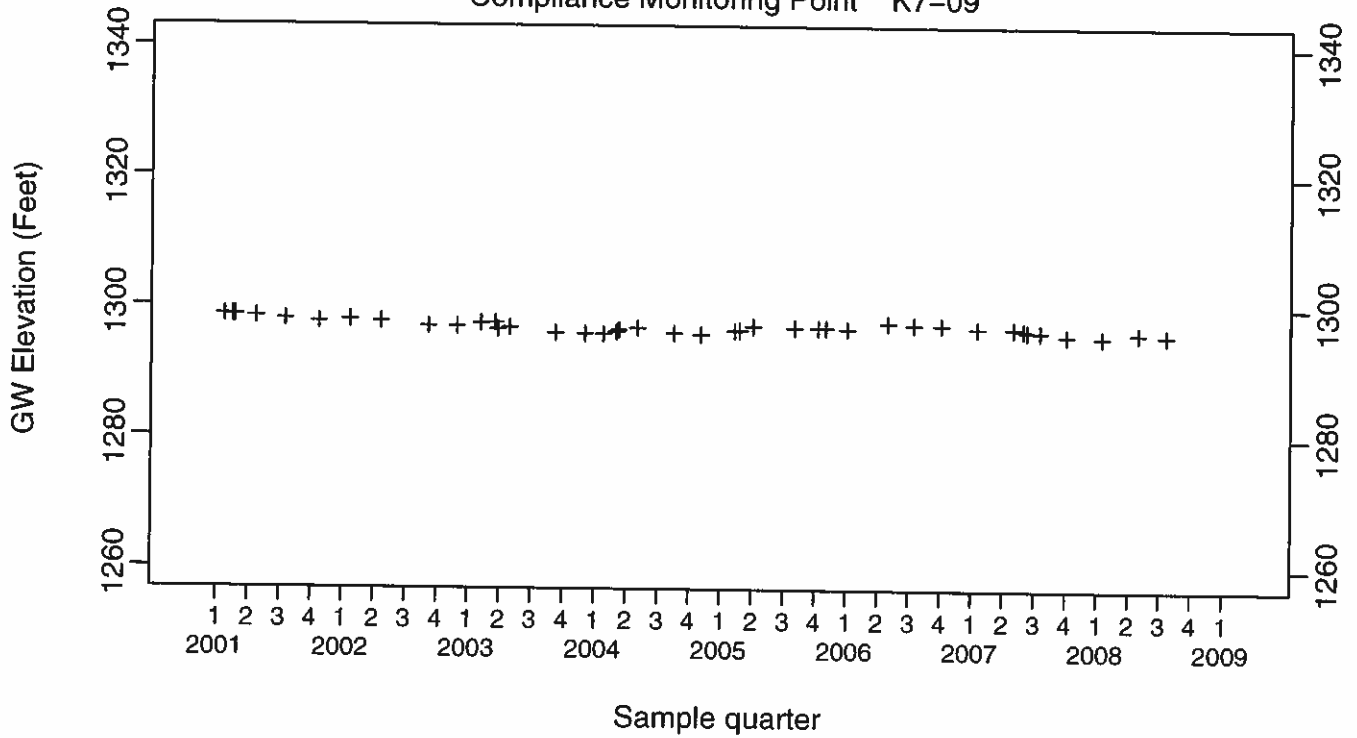


Pit 7 Complex GW Elevation (Feet)

Compliance Monitoring Point K7-03

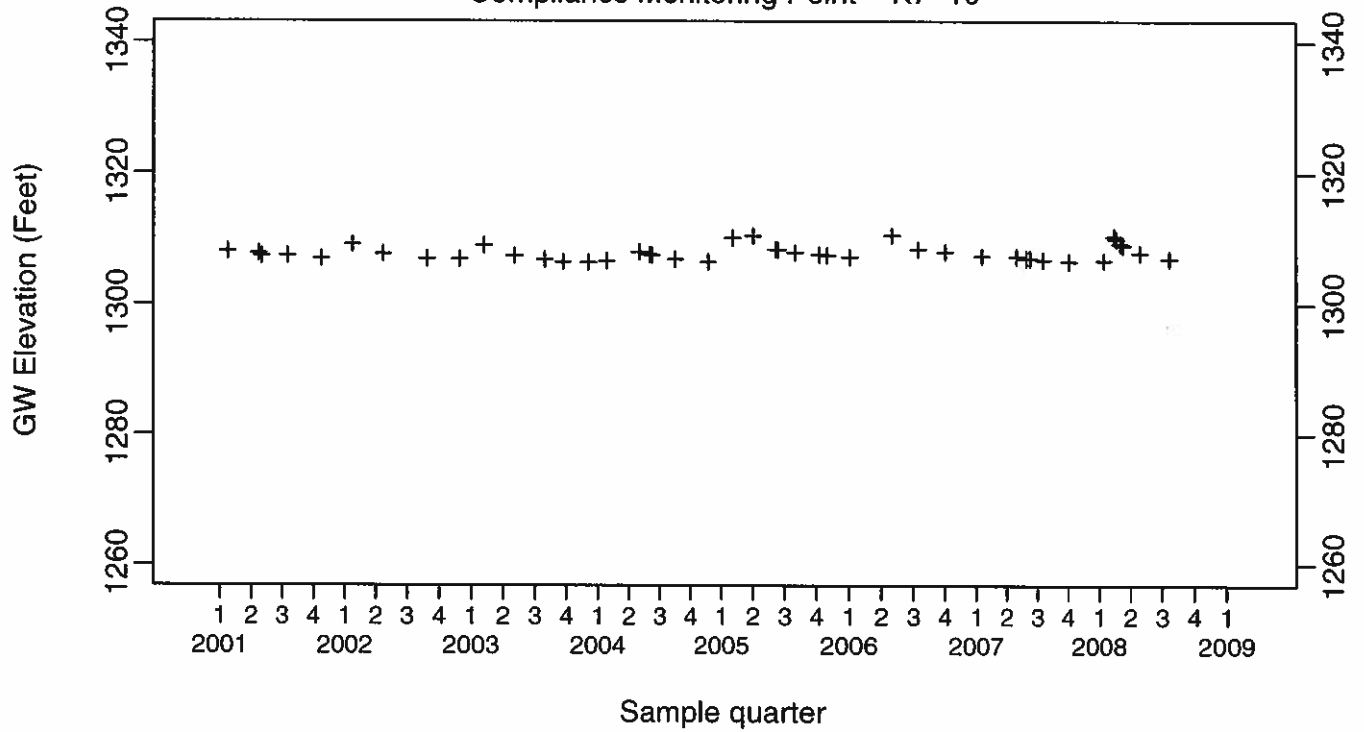


Compliance Monitoring Point K7-09

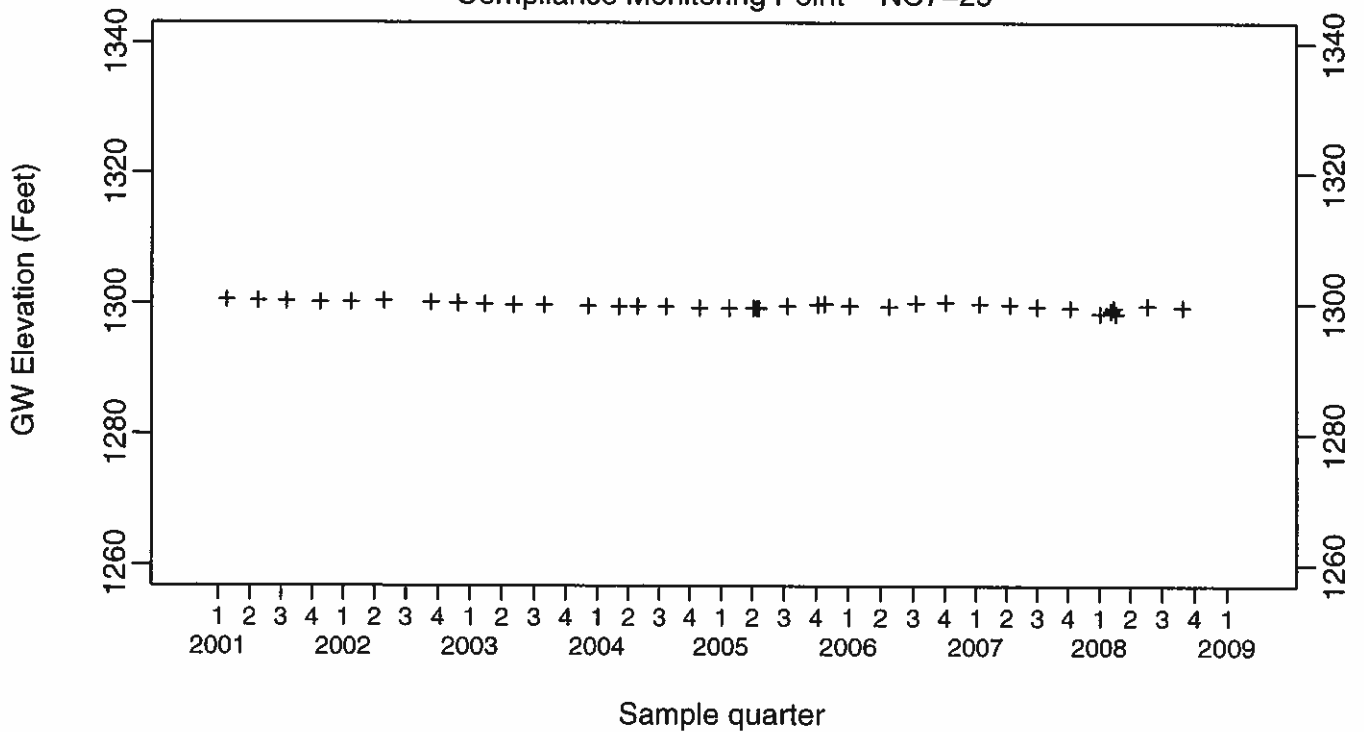


Pit 7 Complex GW Elevation (Feet)

Compliance Monitoring Point K7-10

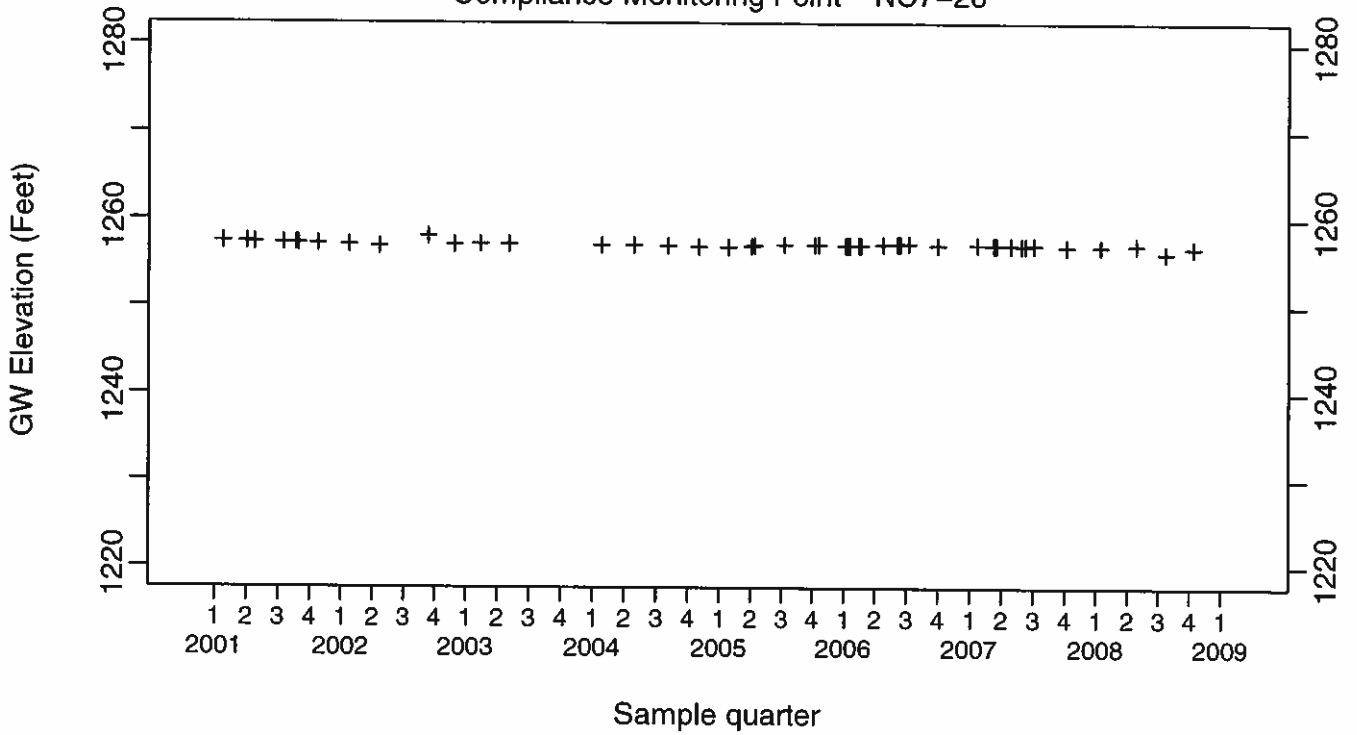


Compliance Monitoring Point NC7-25

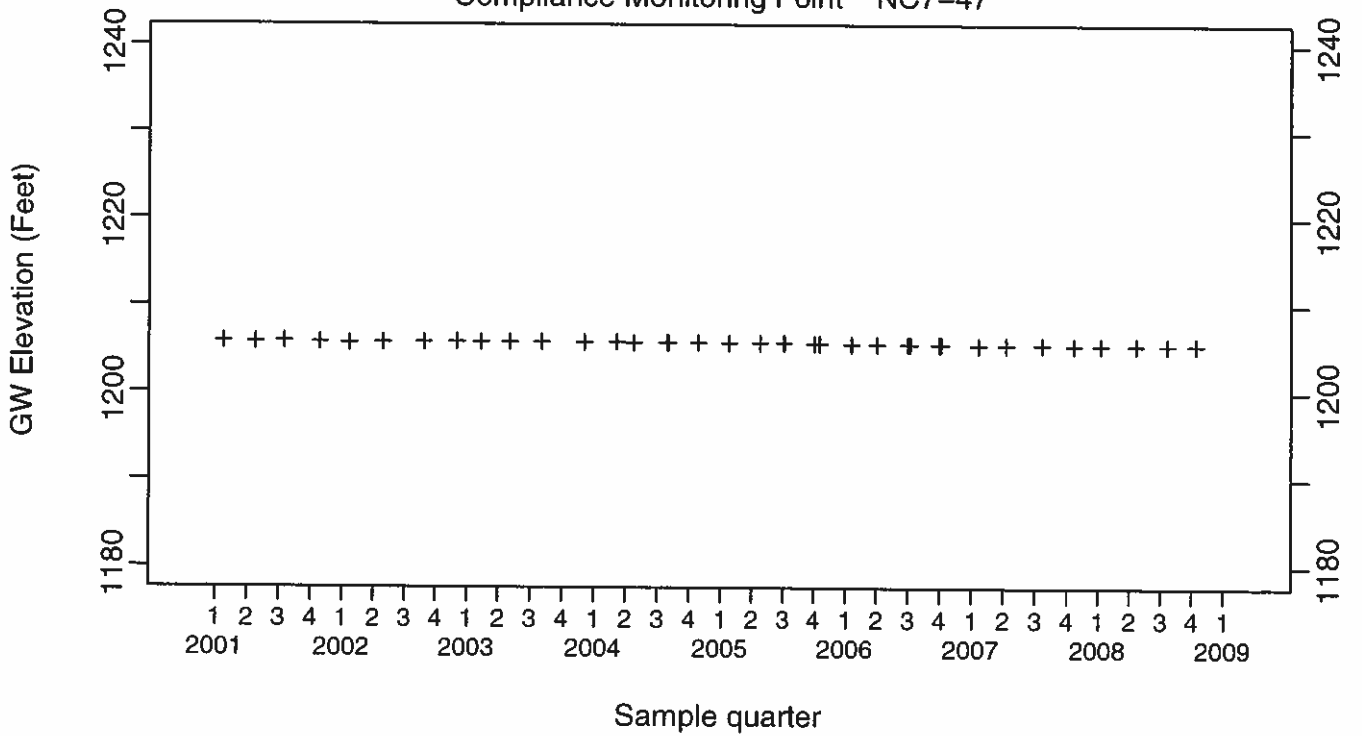


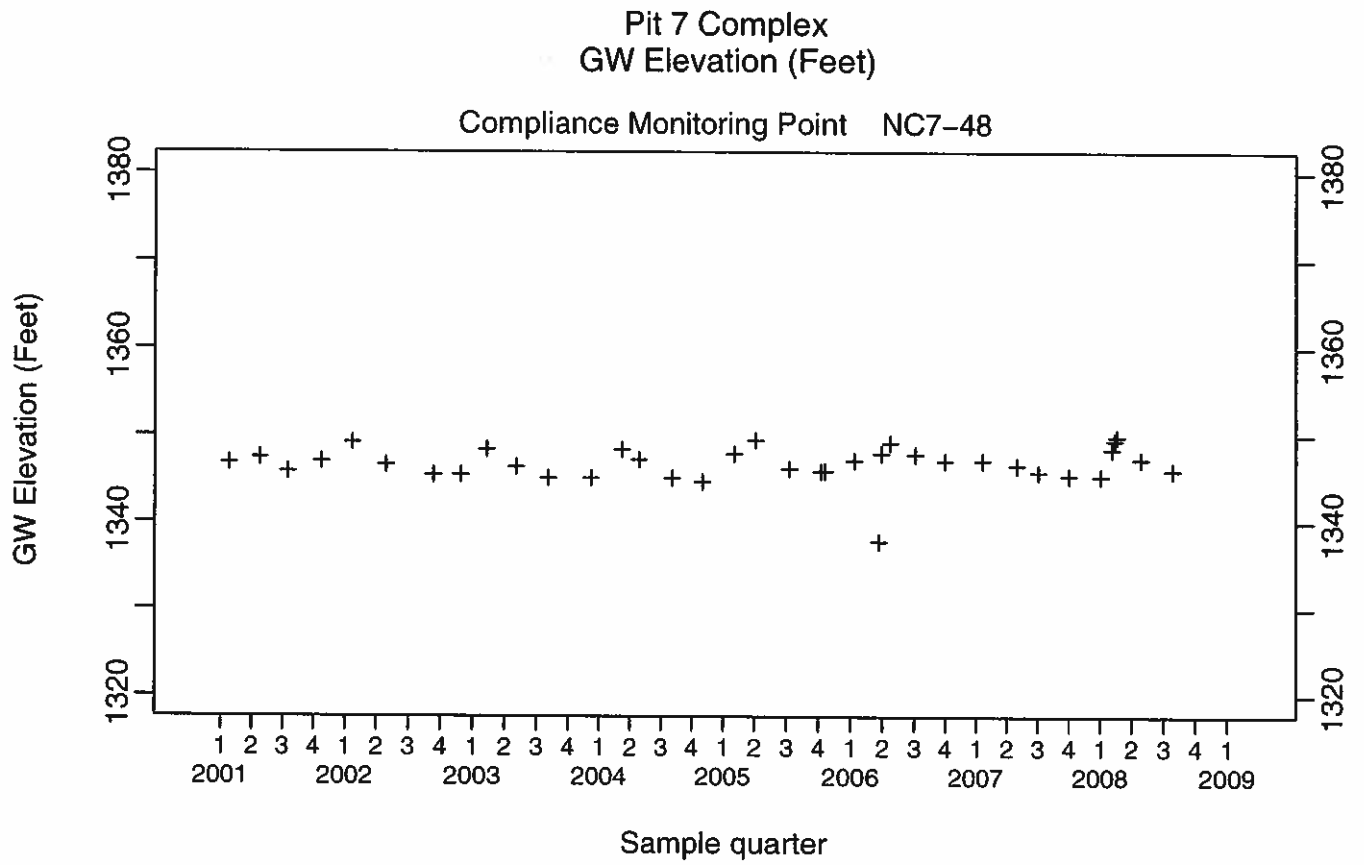
Pit 7 Complex GW Elevation (Feet)

Compliance Monitoring Point NC7-26



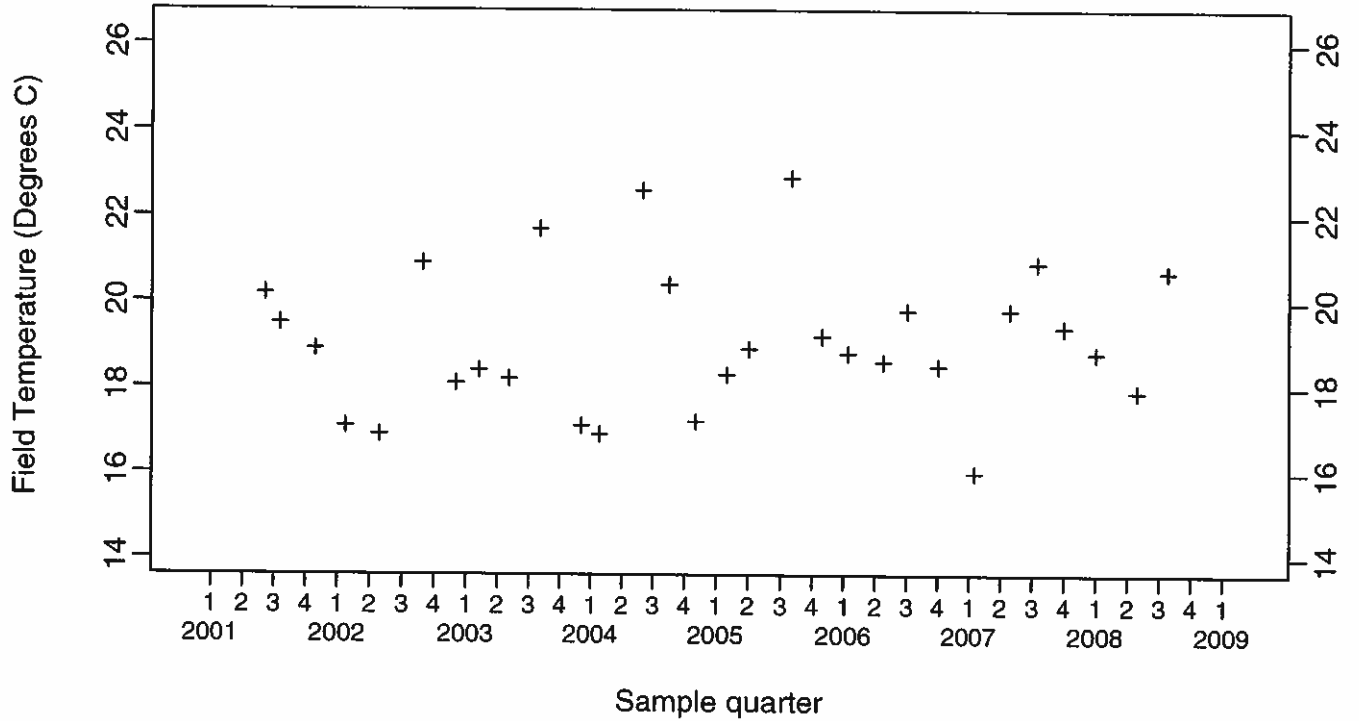
Compliance Monitoring Point NC7-47



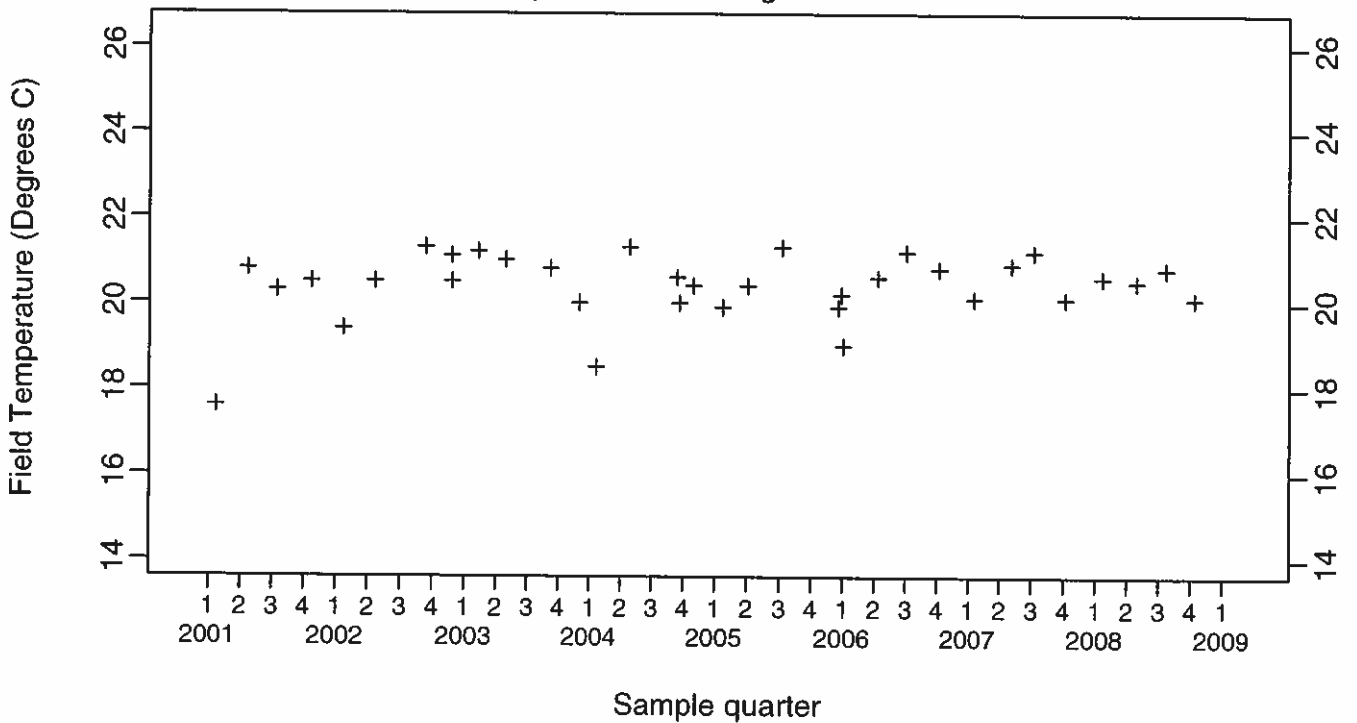


Pit 7 Complex Field Temperature (Degrees C)

Background Monitoring Point K7-06

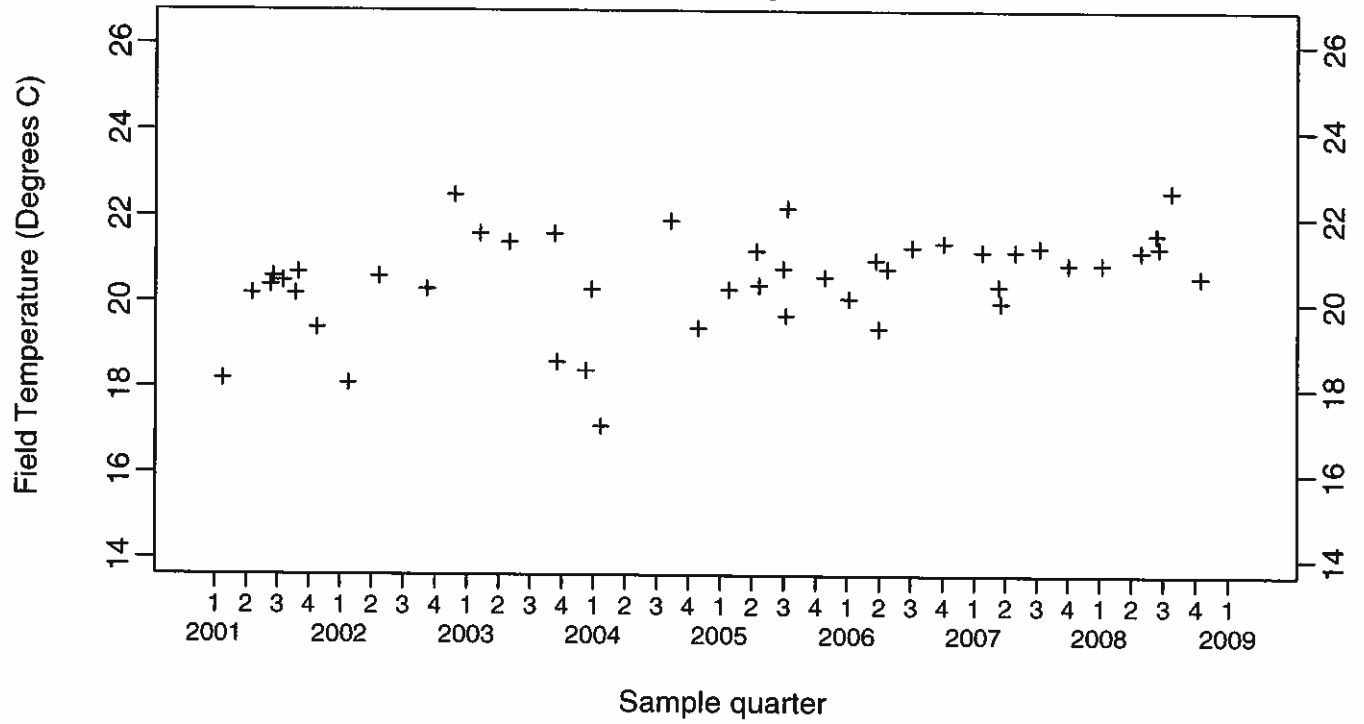


Compliance Monitoring Point K7-01

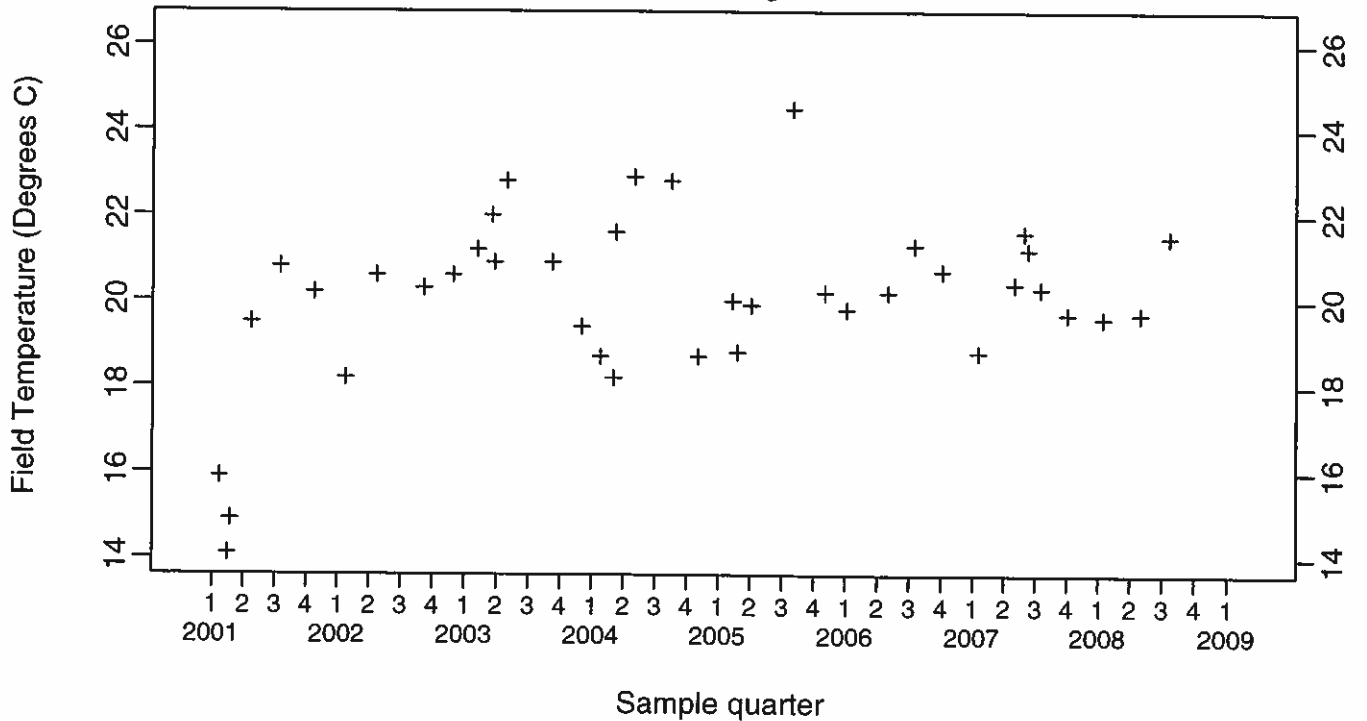


Pit 7 Complex Field Temperature (Degrees C)

Compliance Monitoring Point K7-03

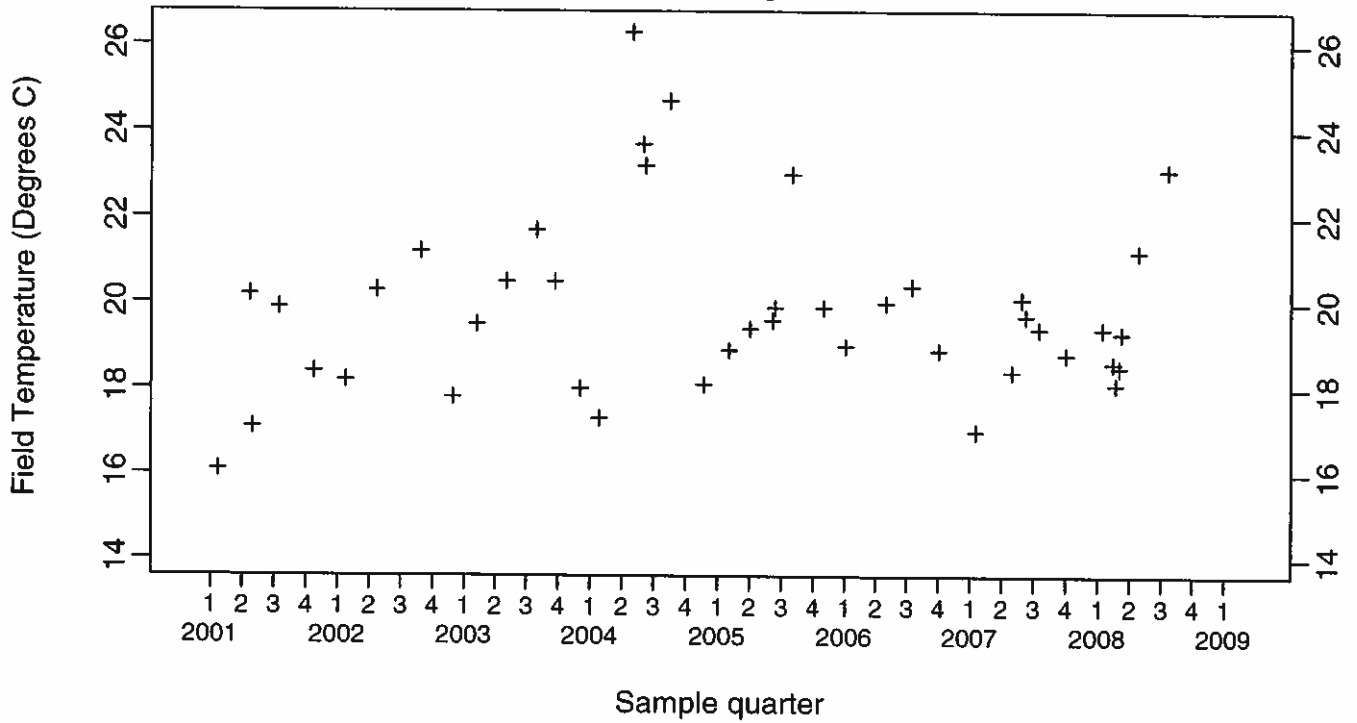


Compliance Monitoring Point K7-09

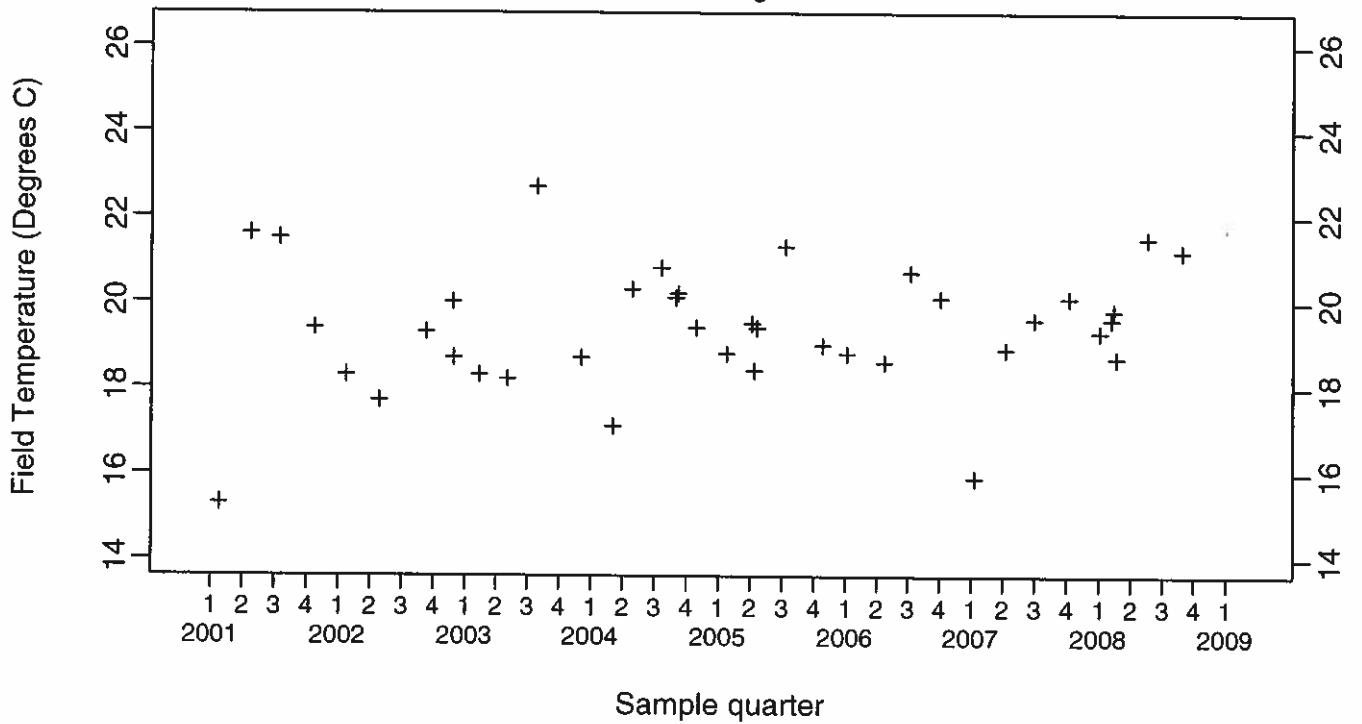


Pit 7 Complex Field Temperature (Degrees C)

Compliance Monitoring Point K7-10

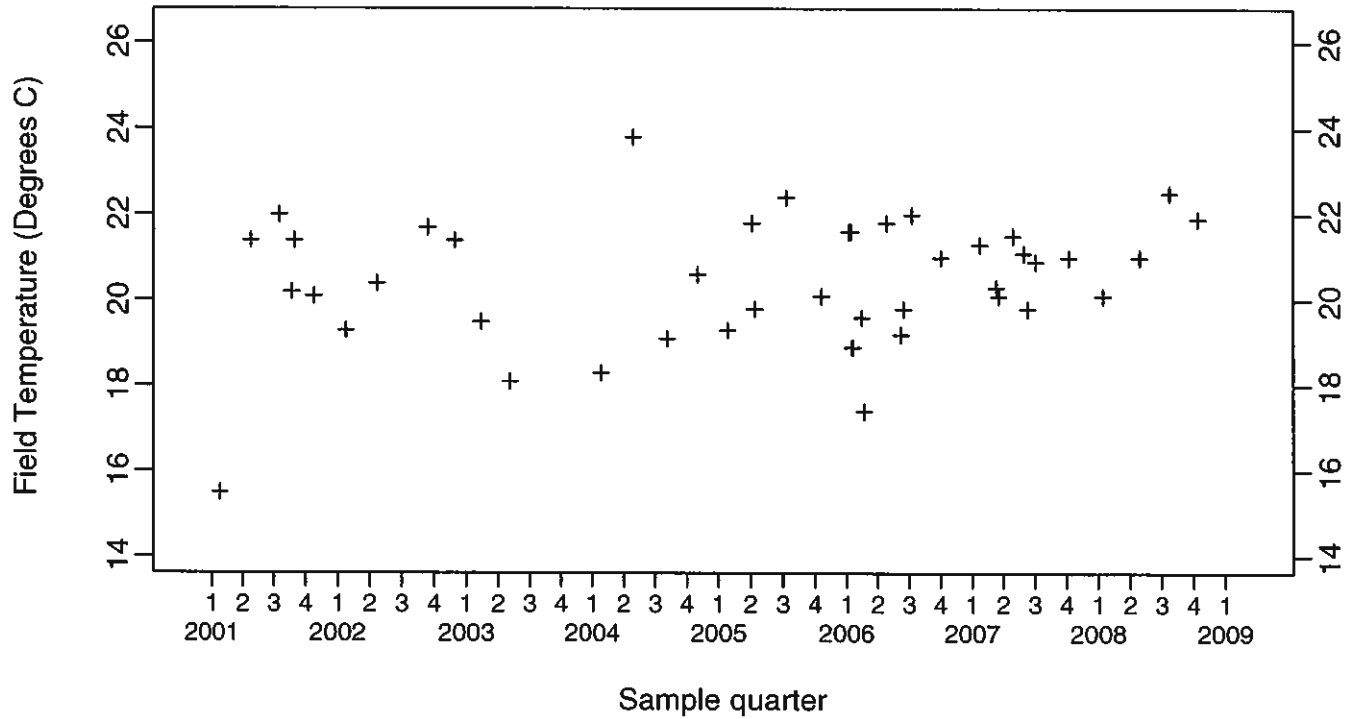


Compliance Monitoring Point NC7-25

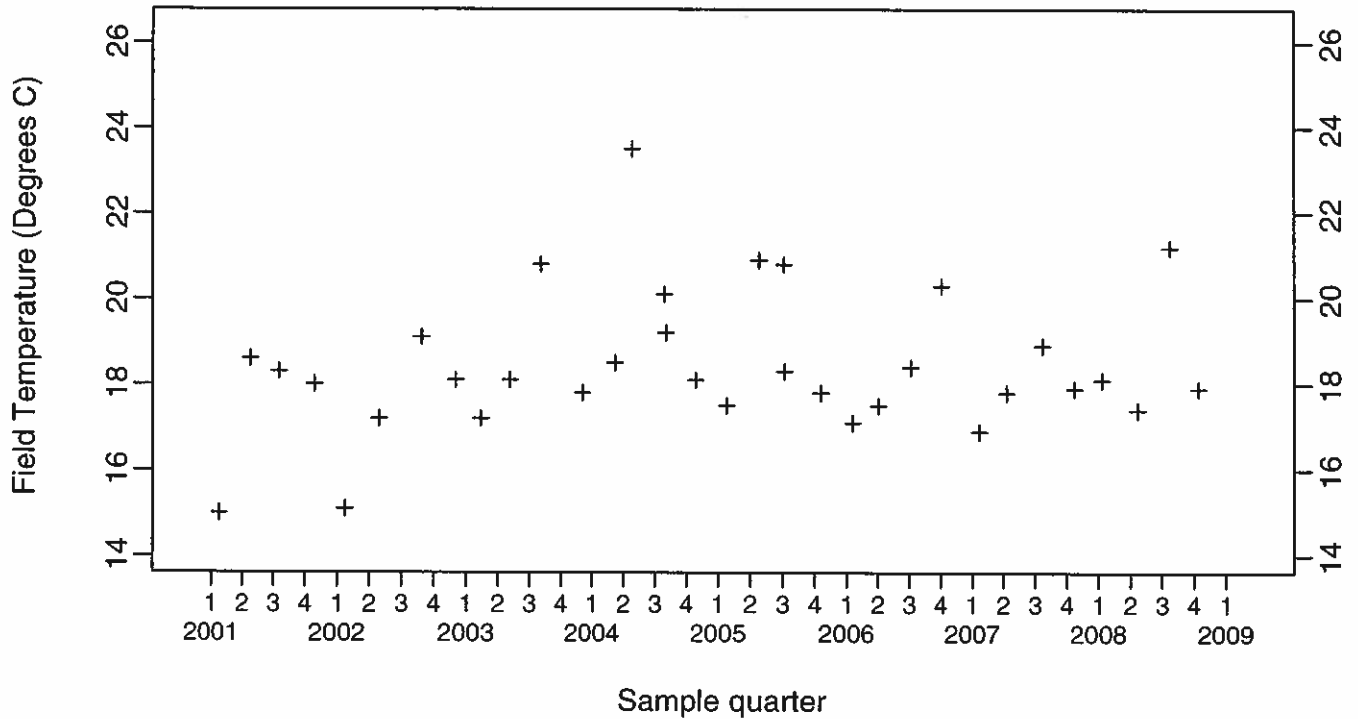


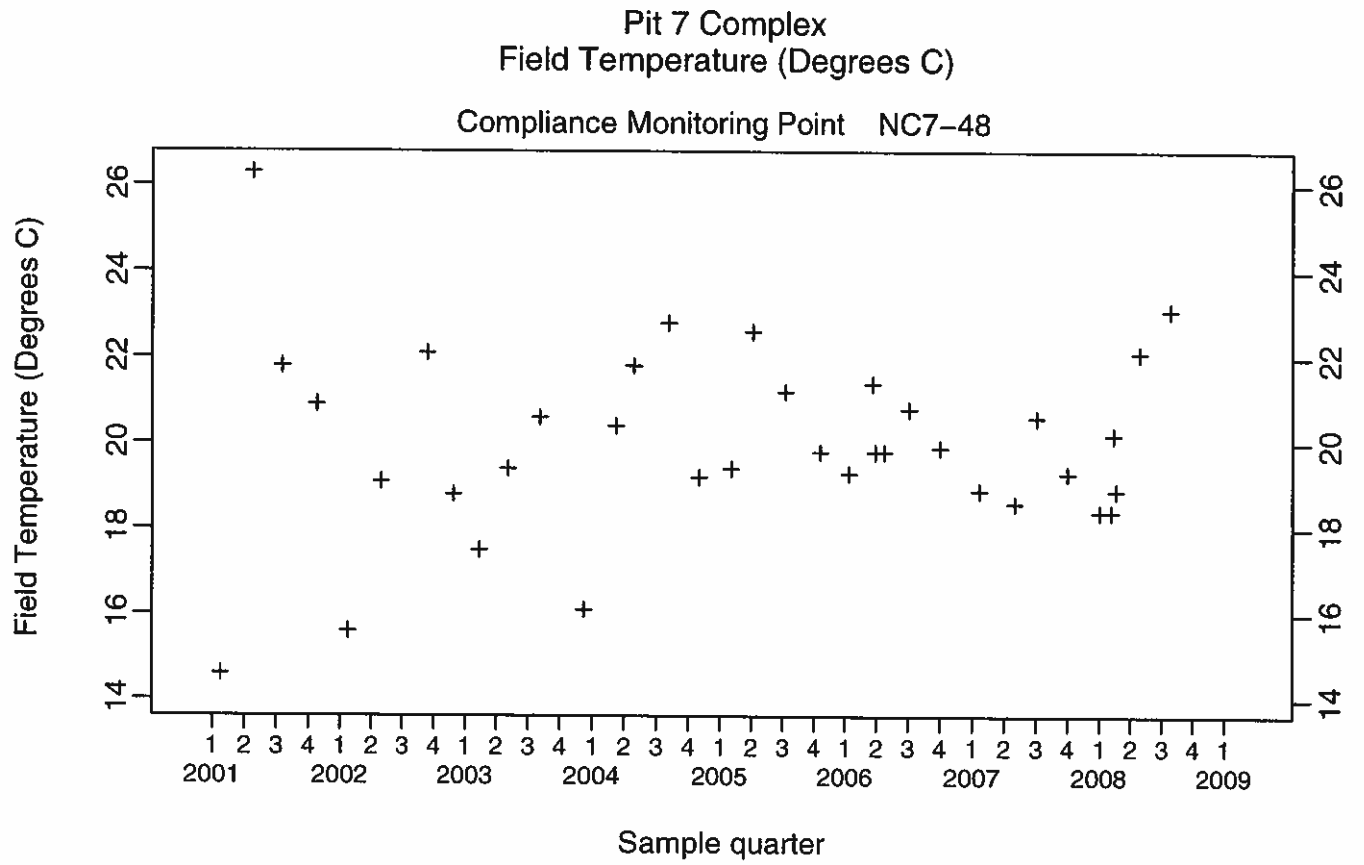
Pit 7 Complex Field Temperature (Degrees C)

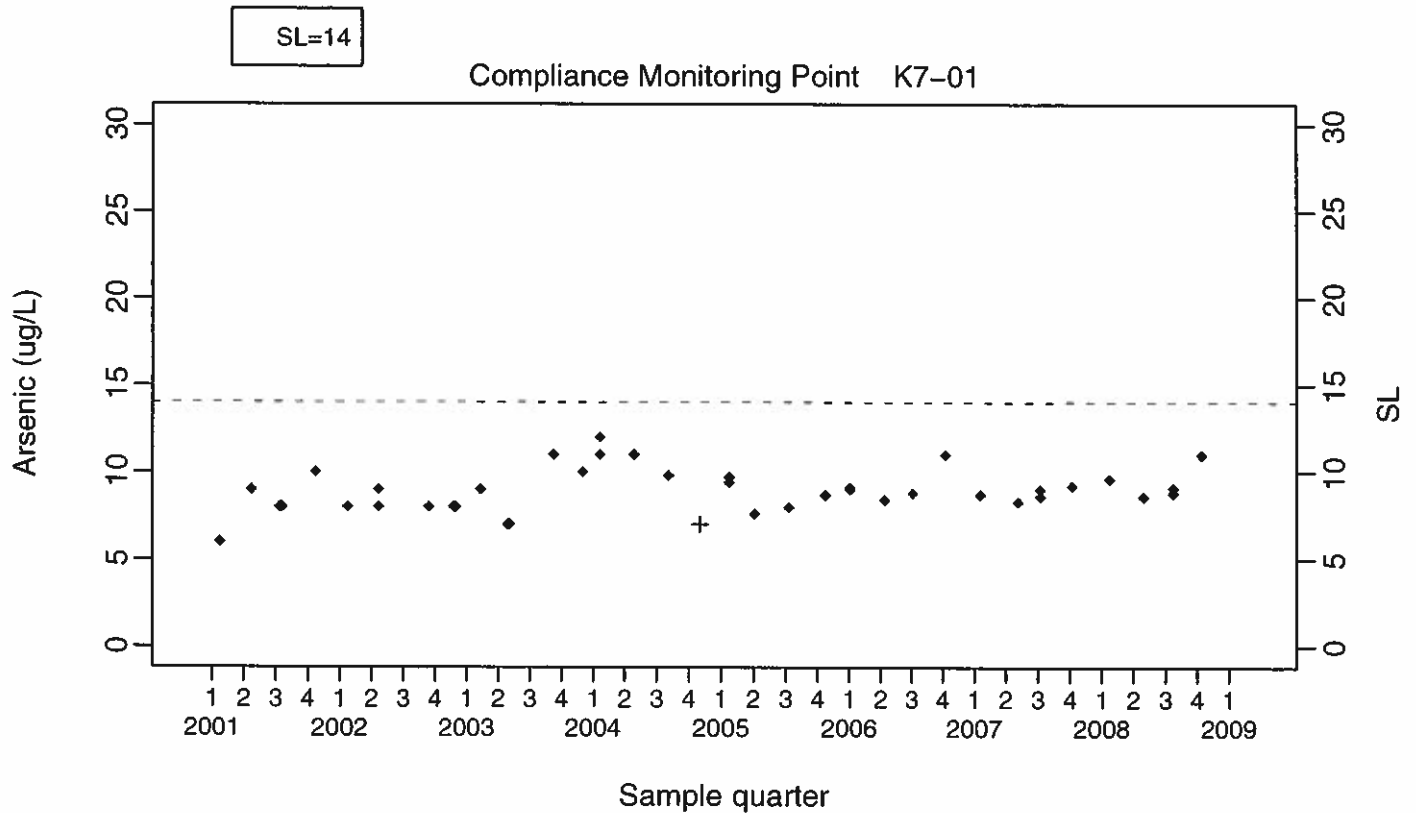
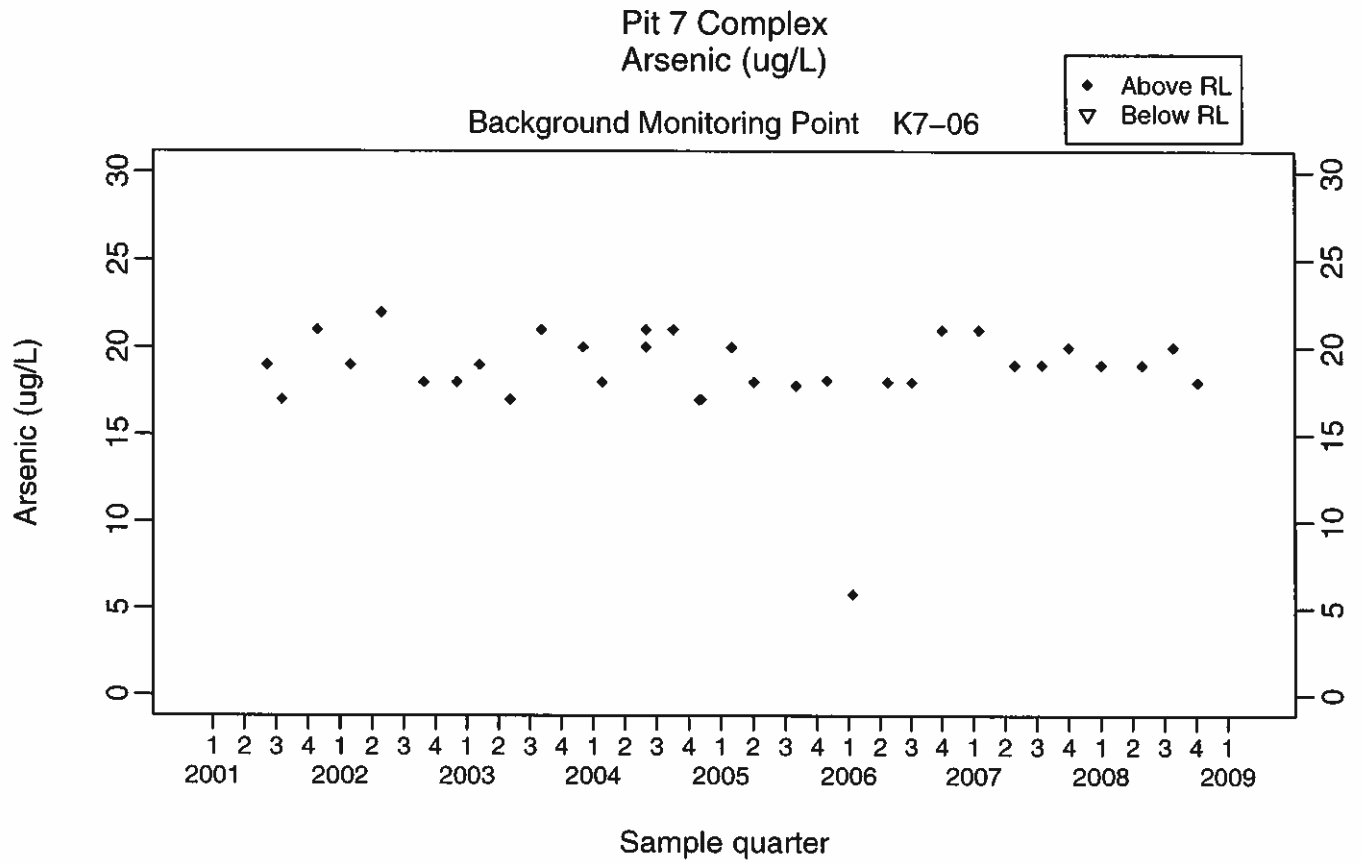
Compliance Monitoring Point NC7-26

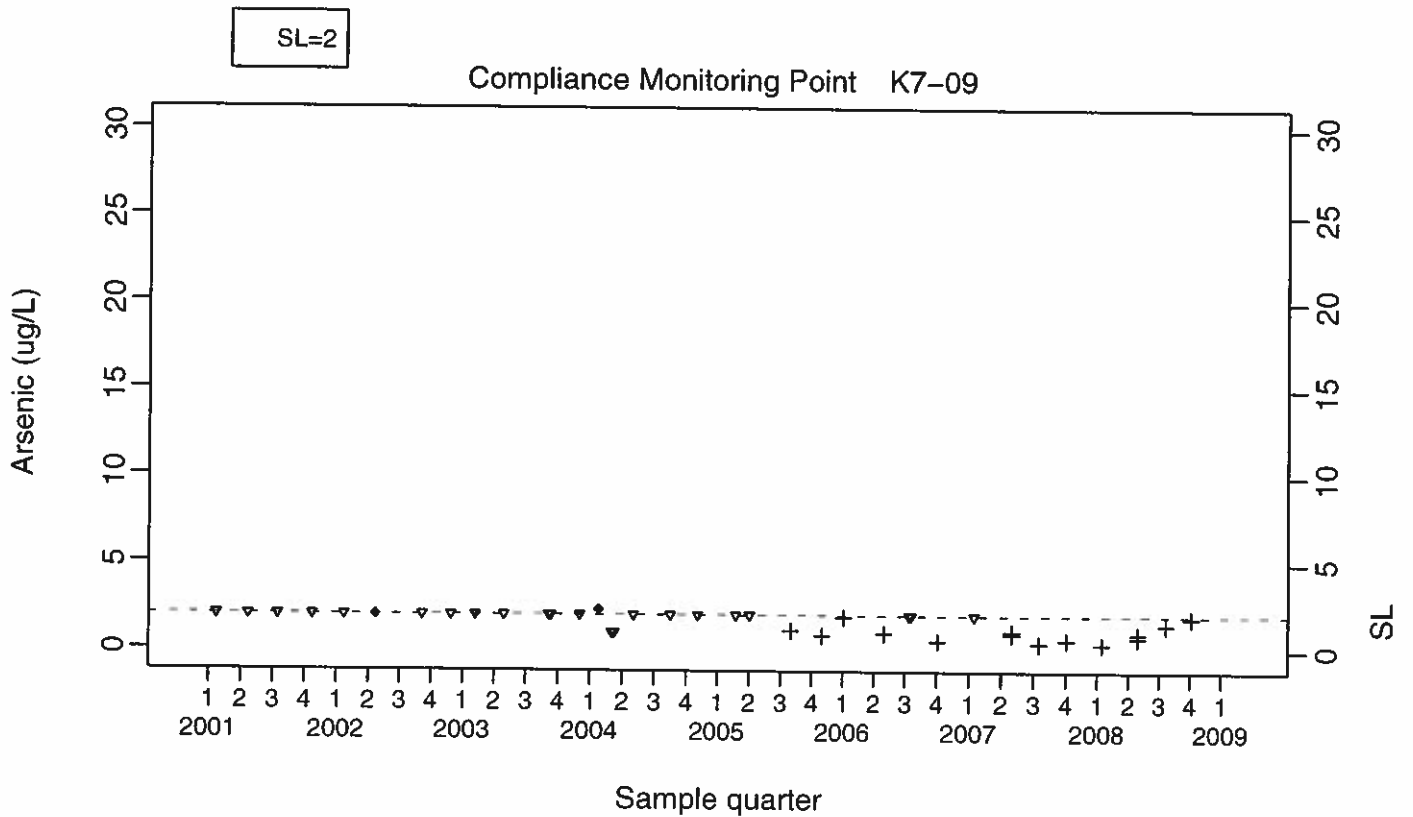
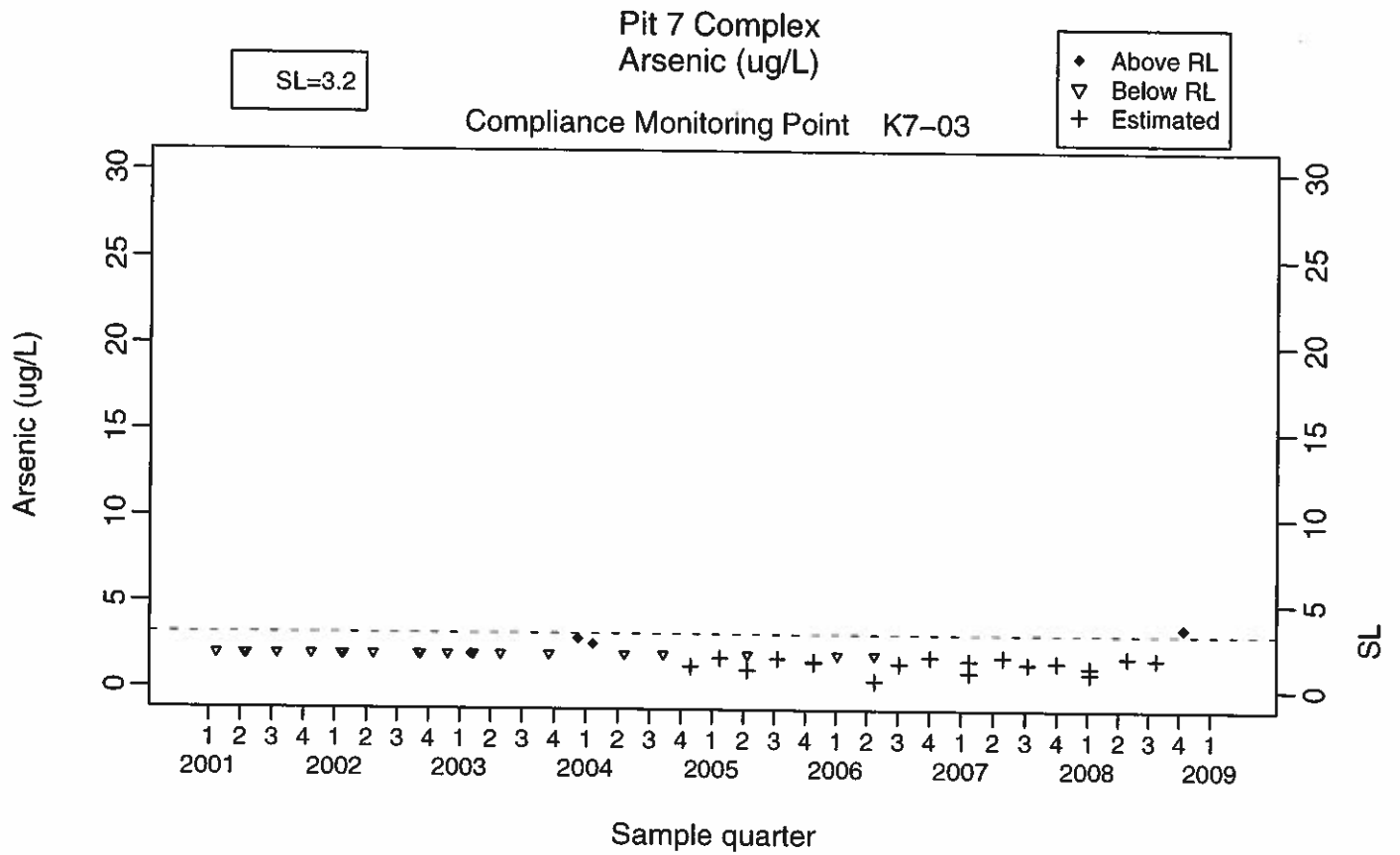


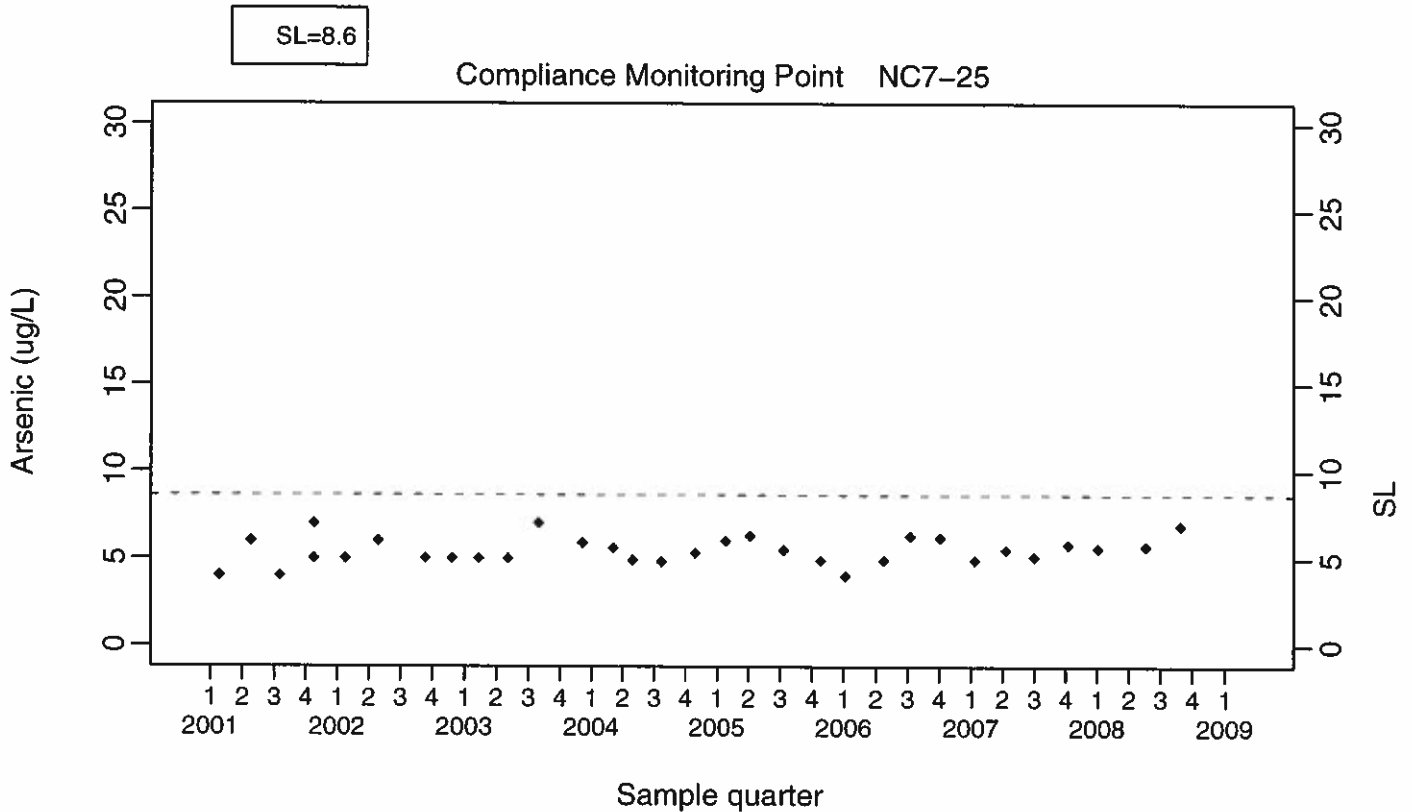
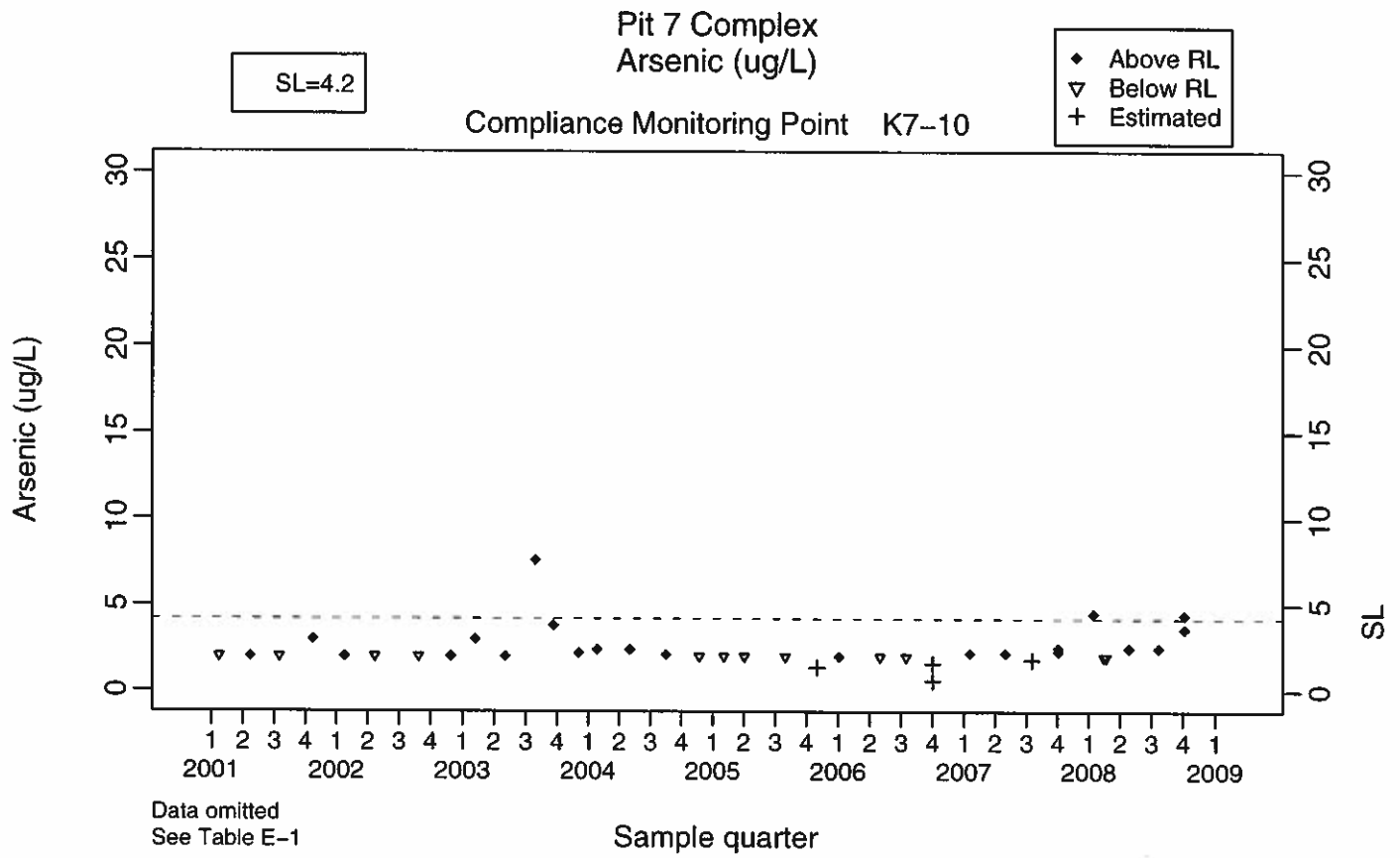
Compliance Monitoring Point NC7-47

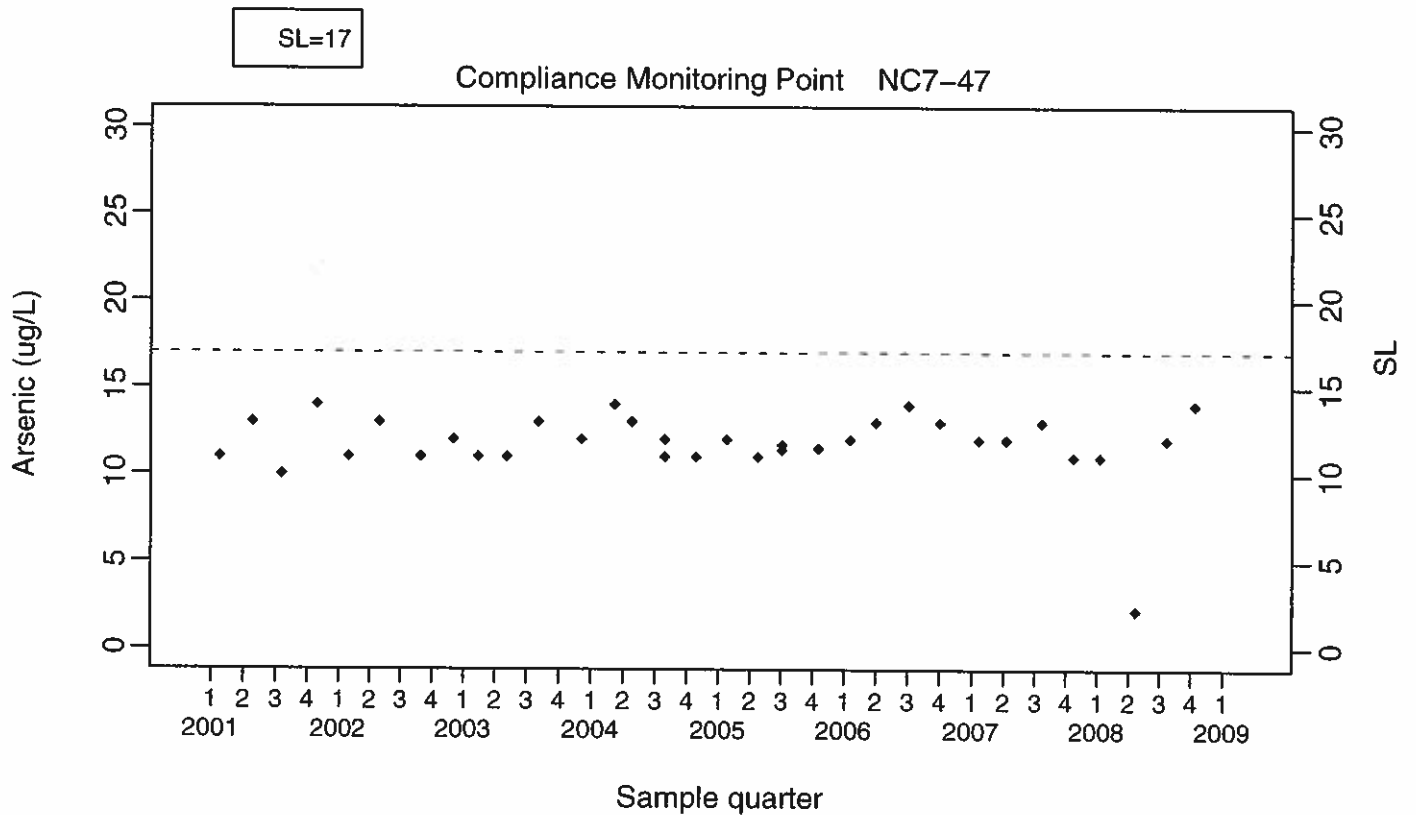
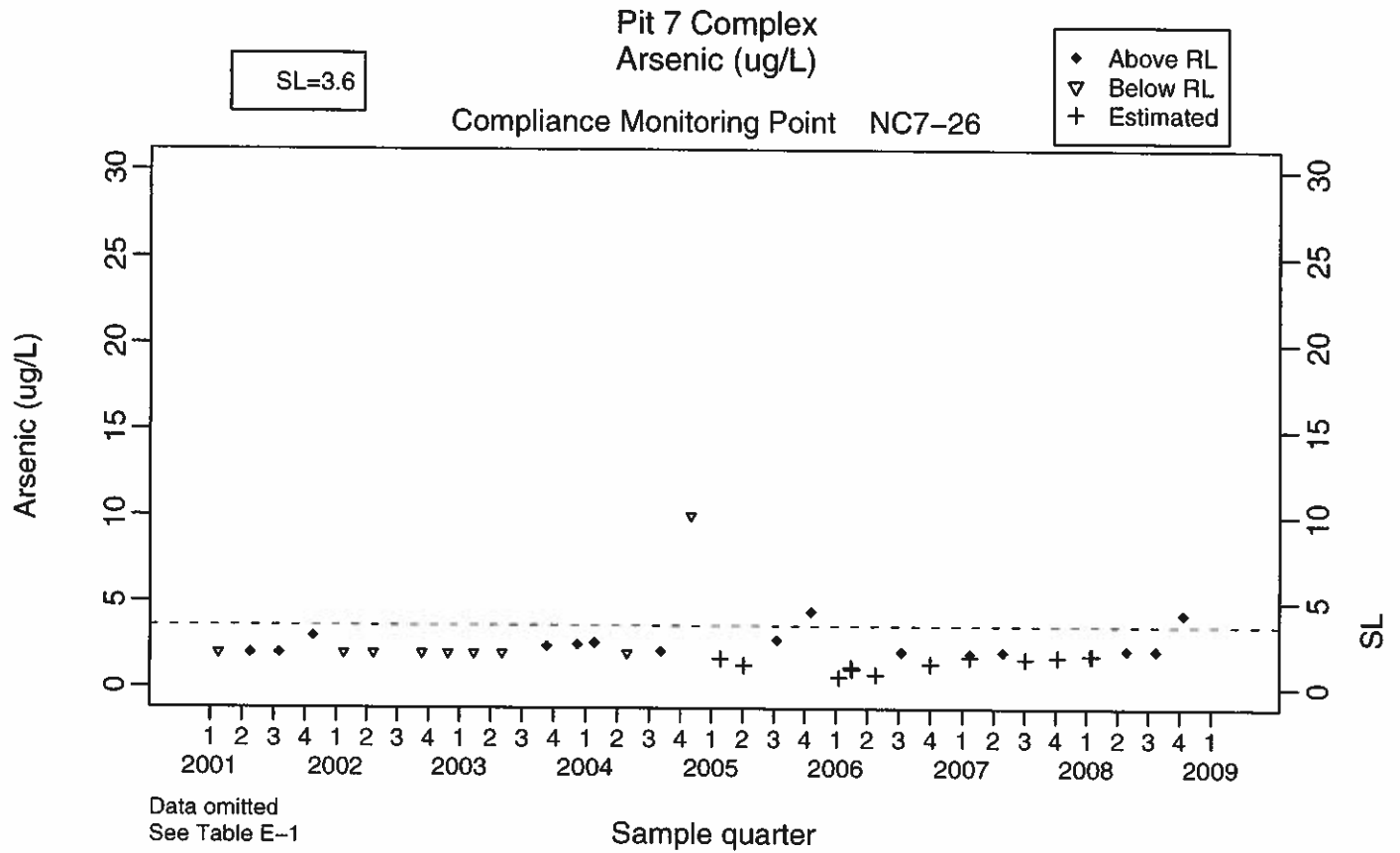


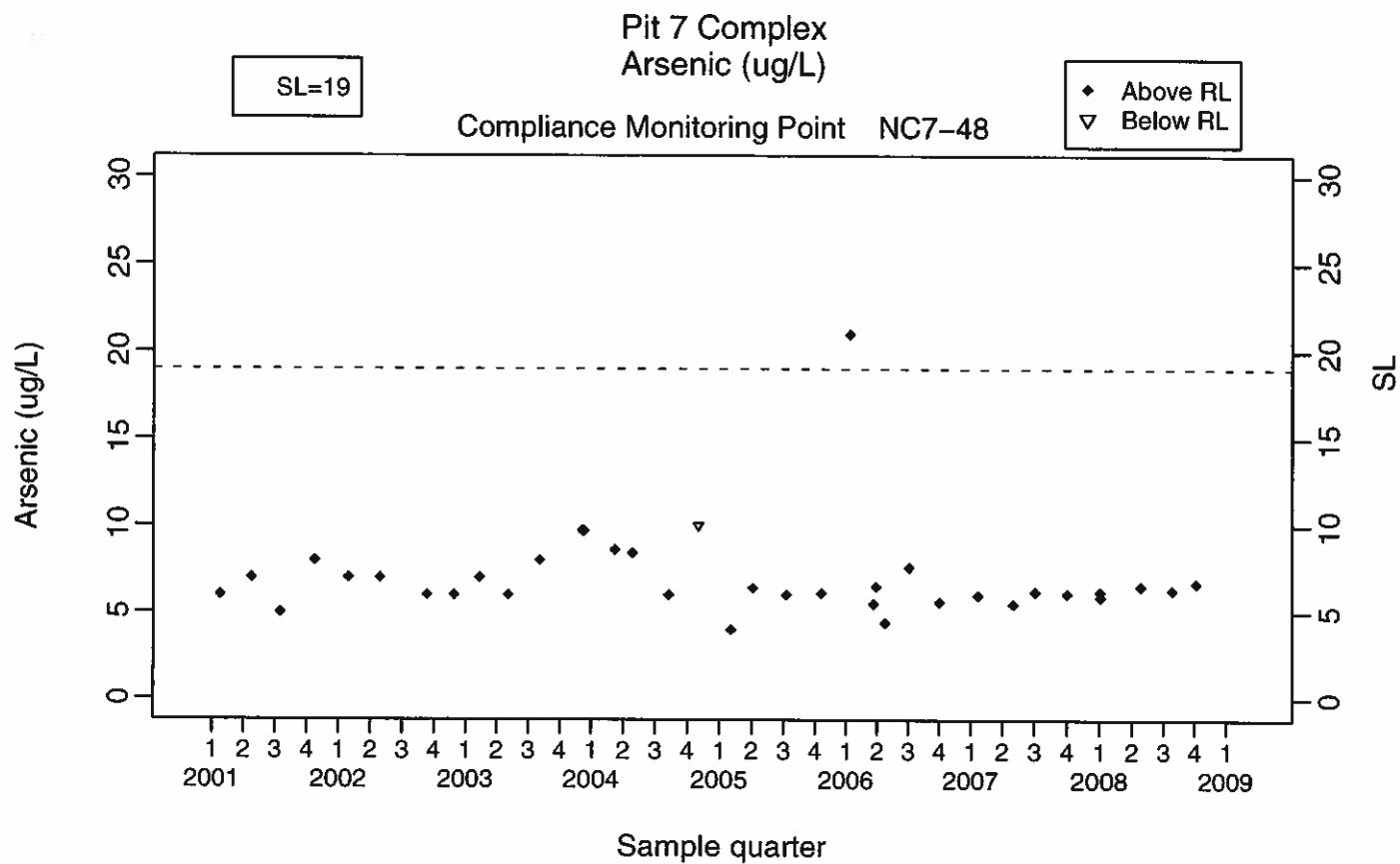


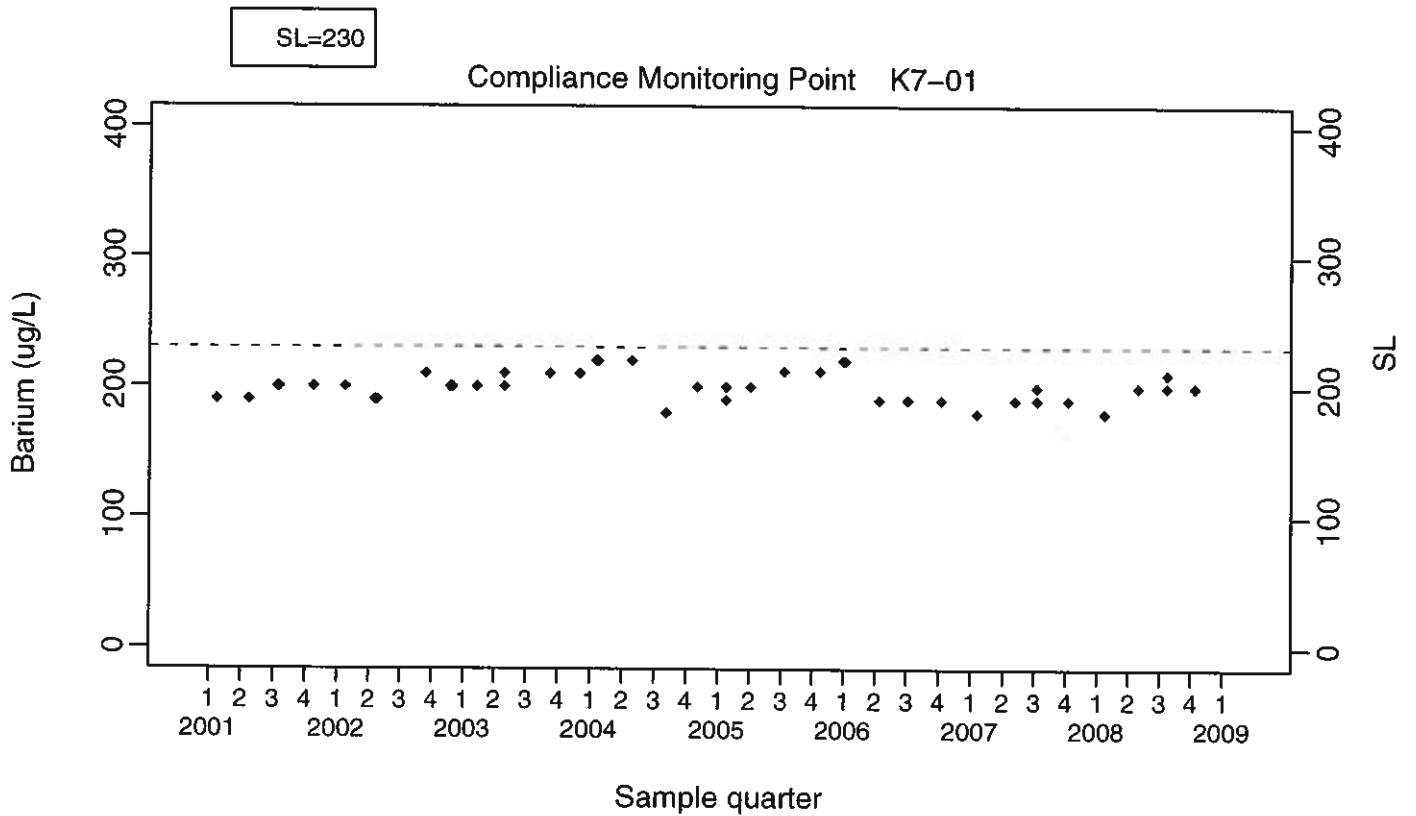
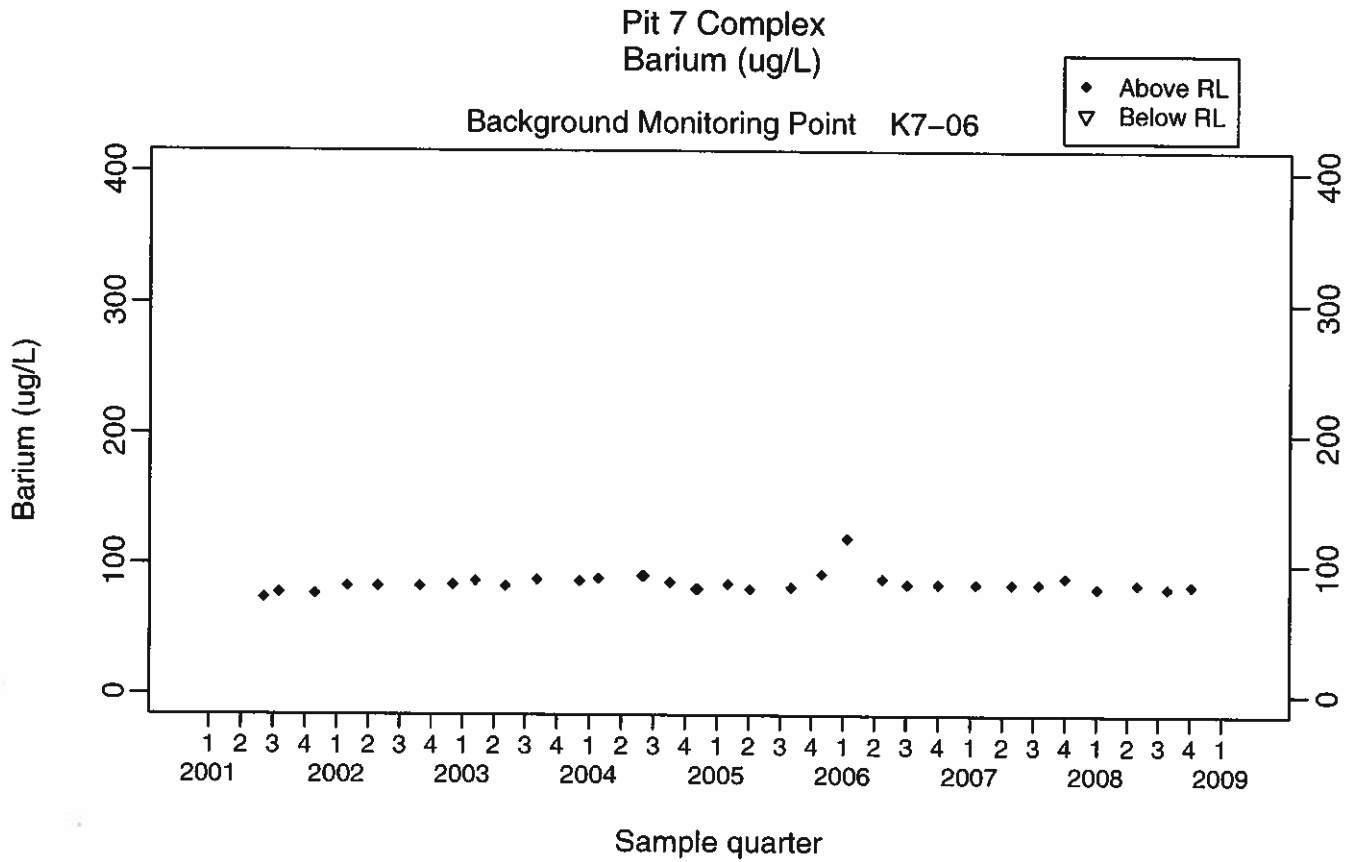


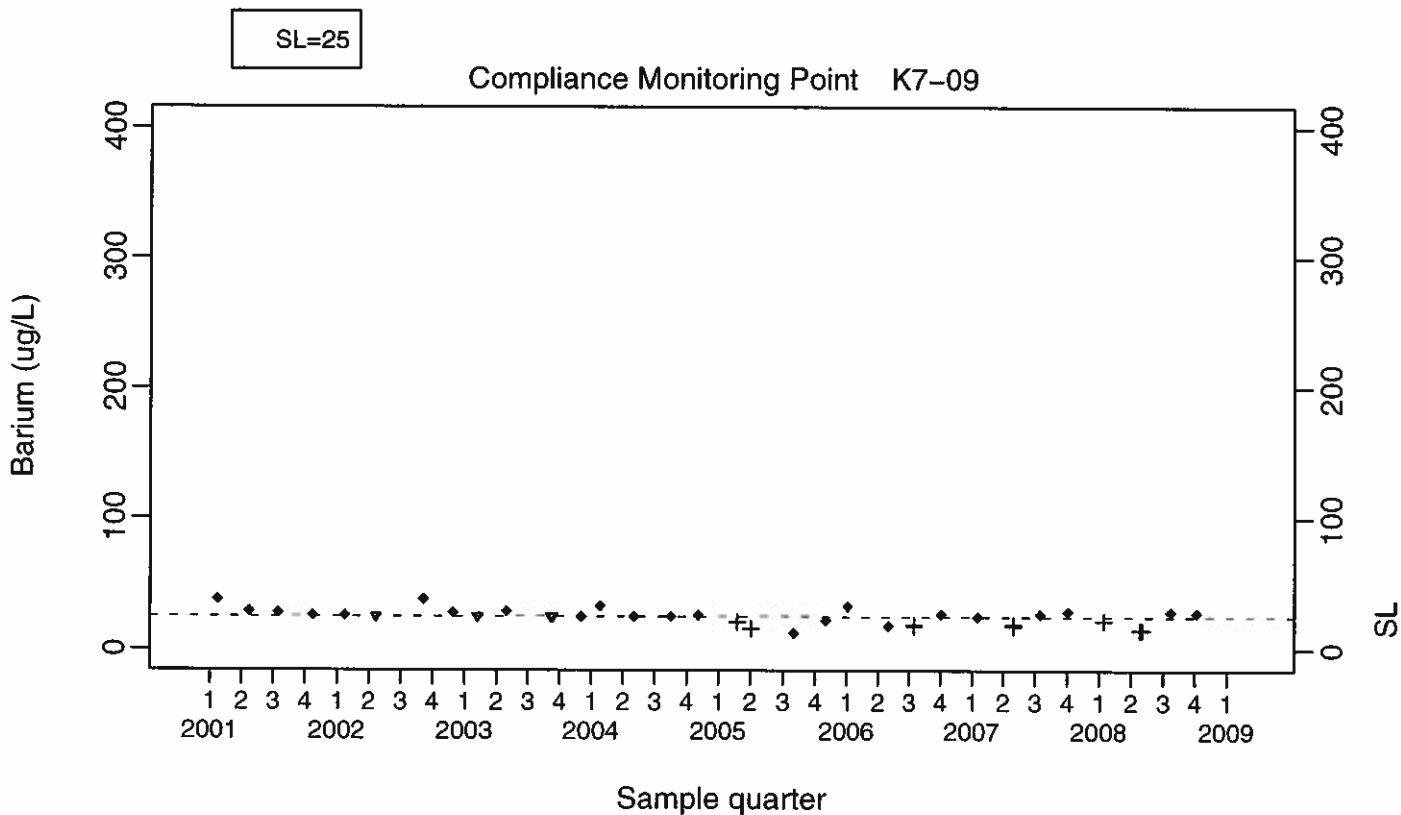
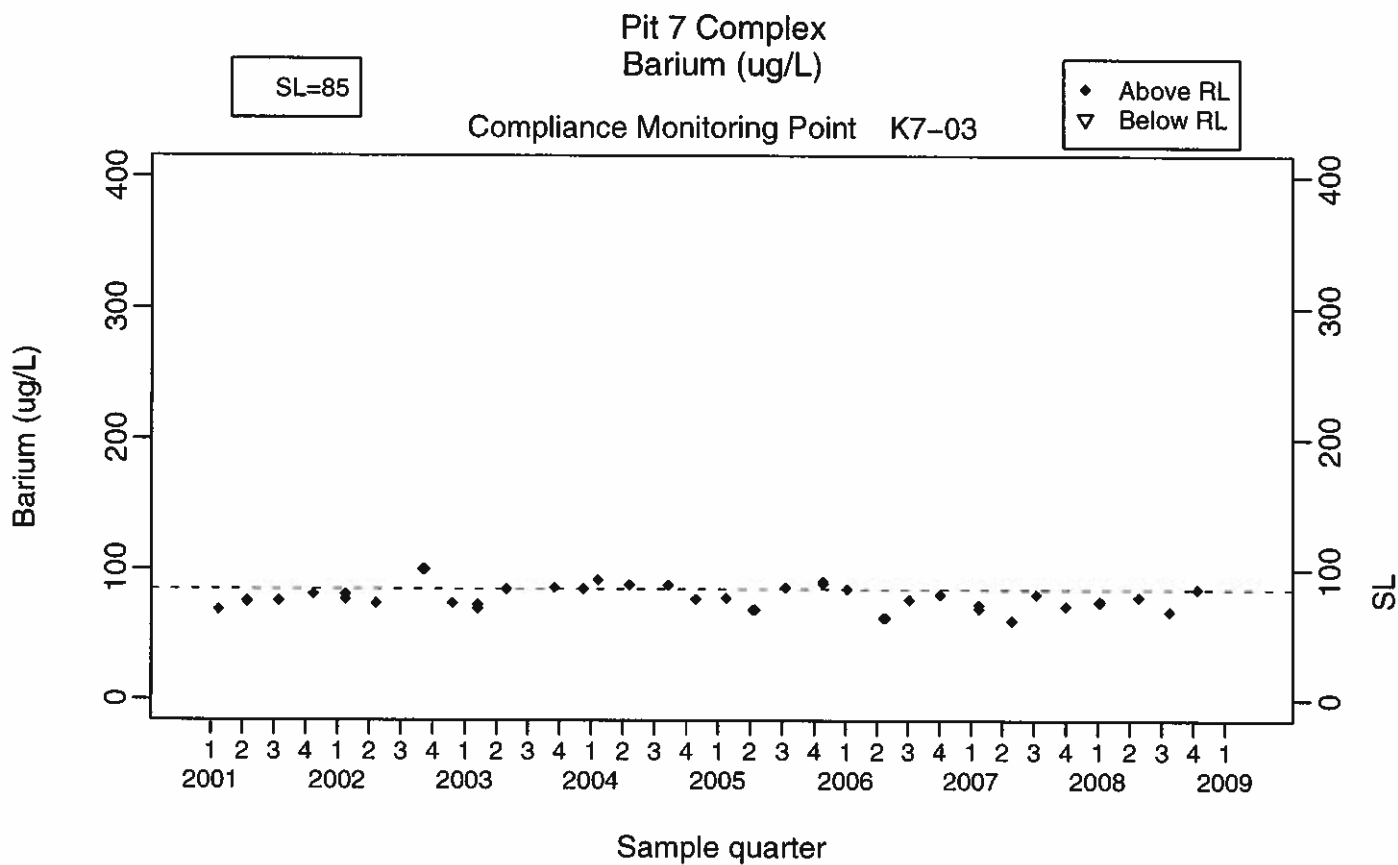


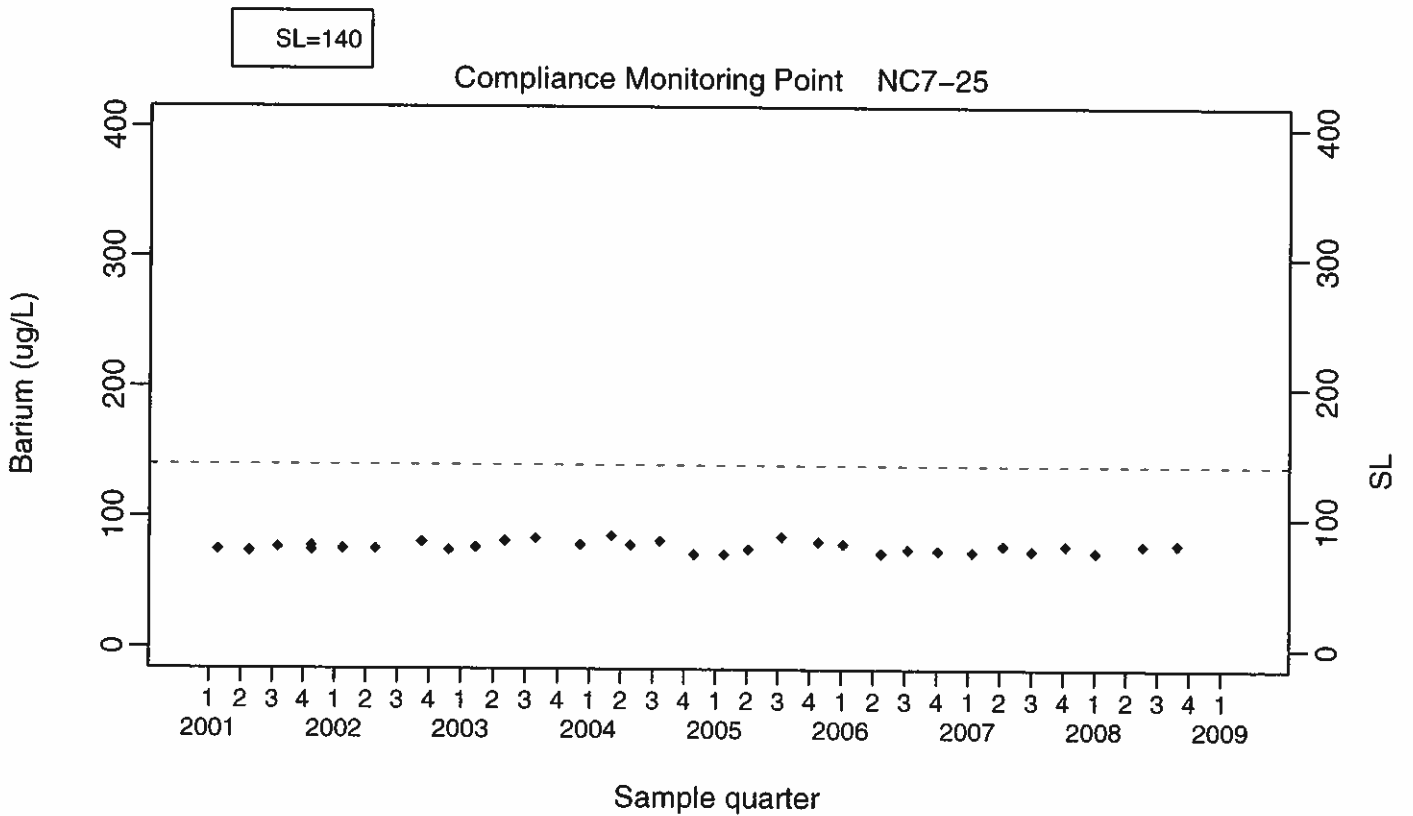
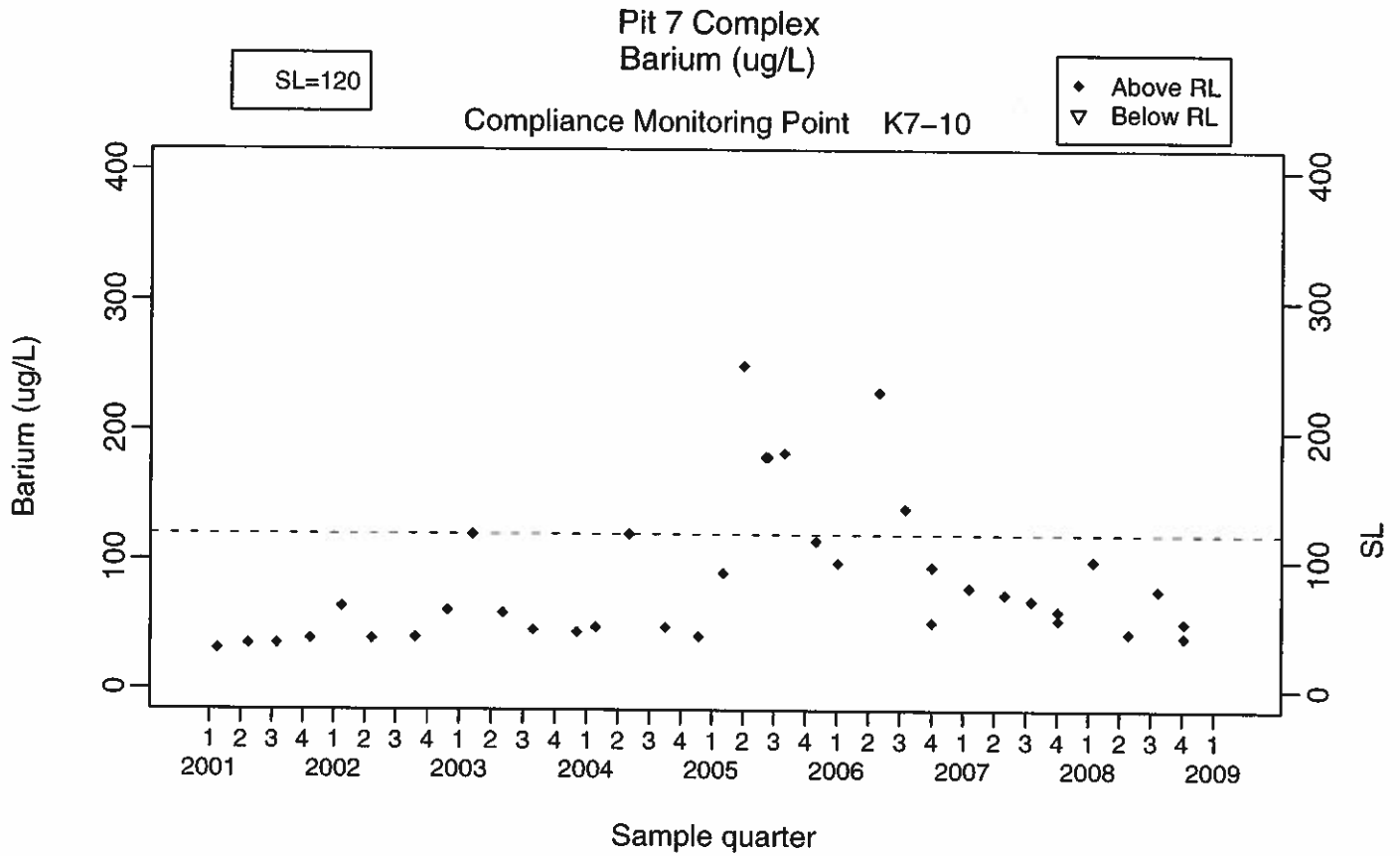


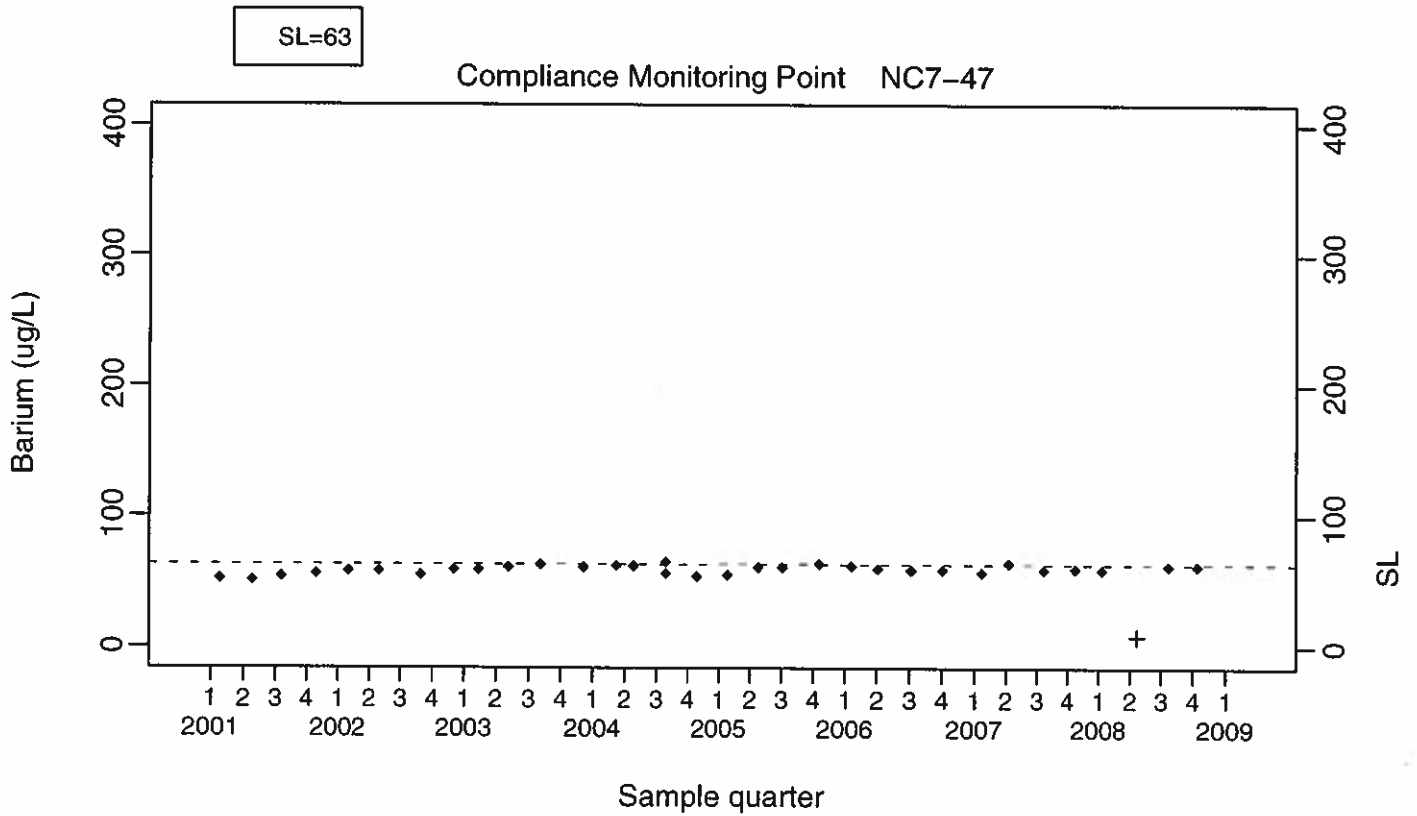
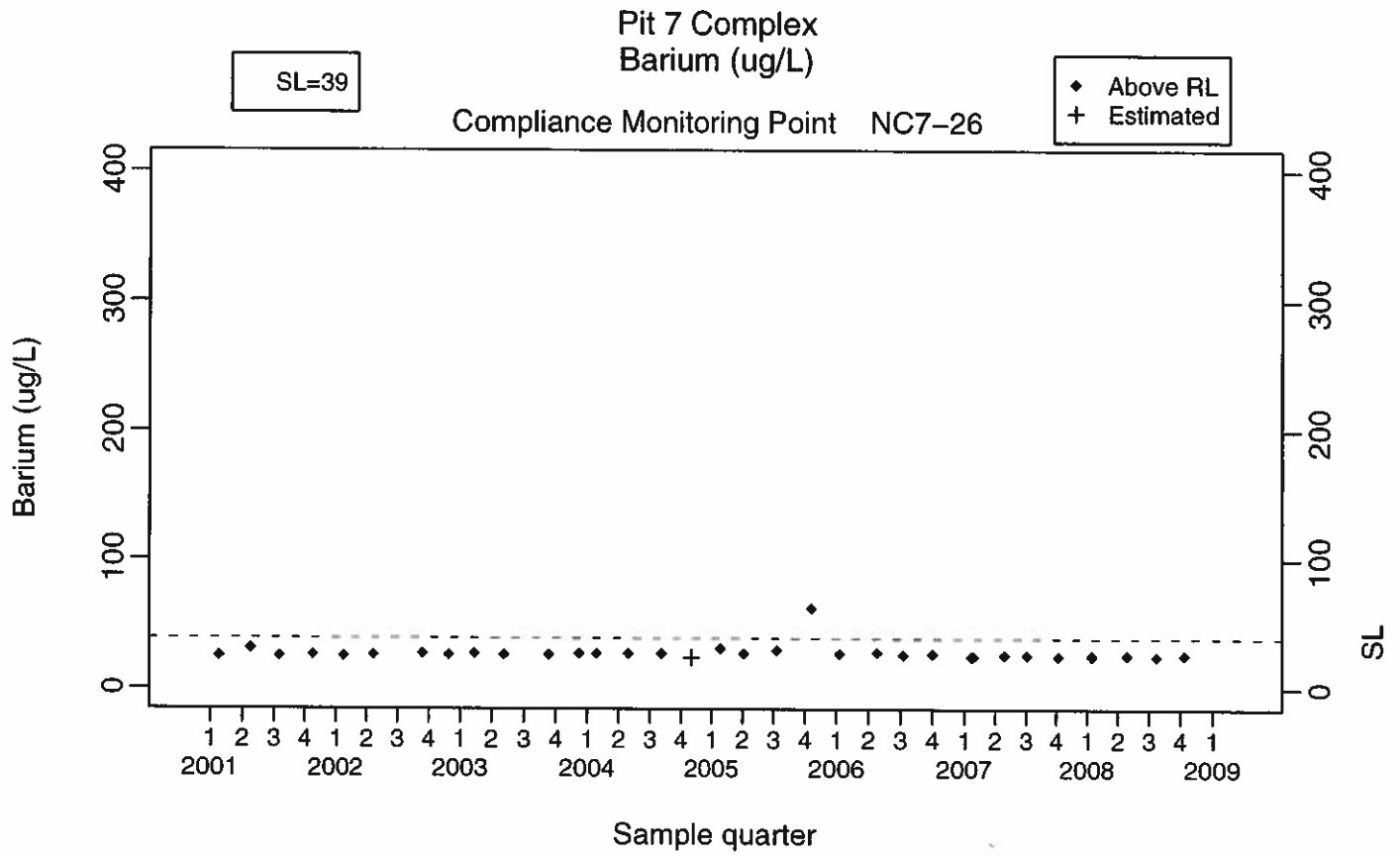


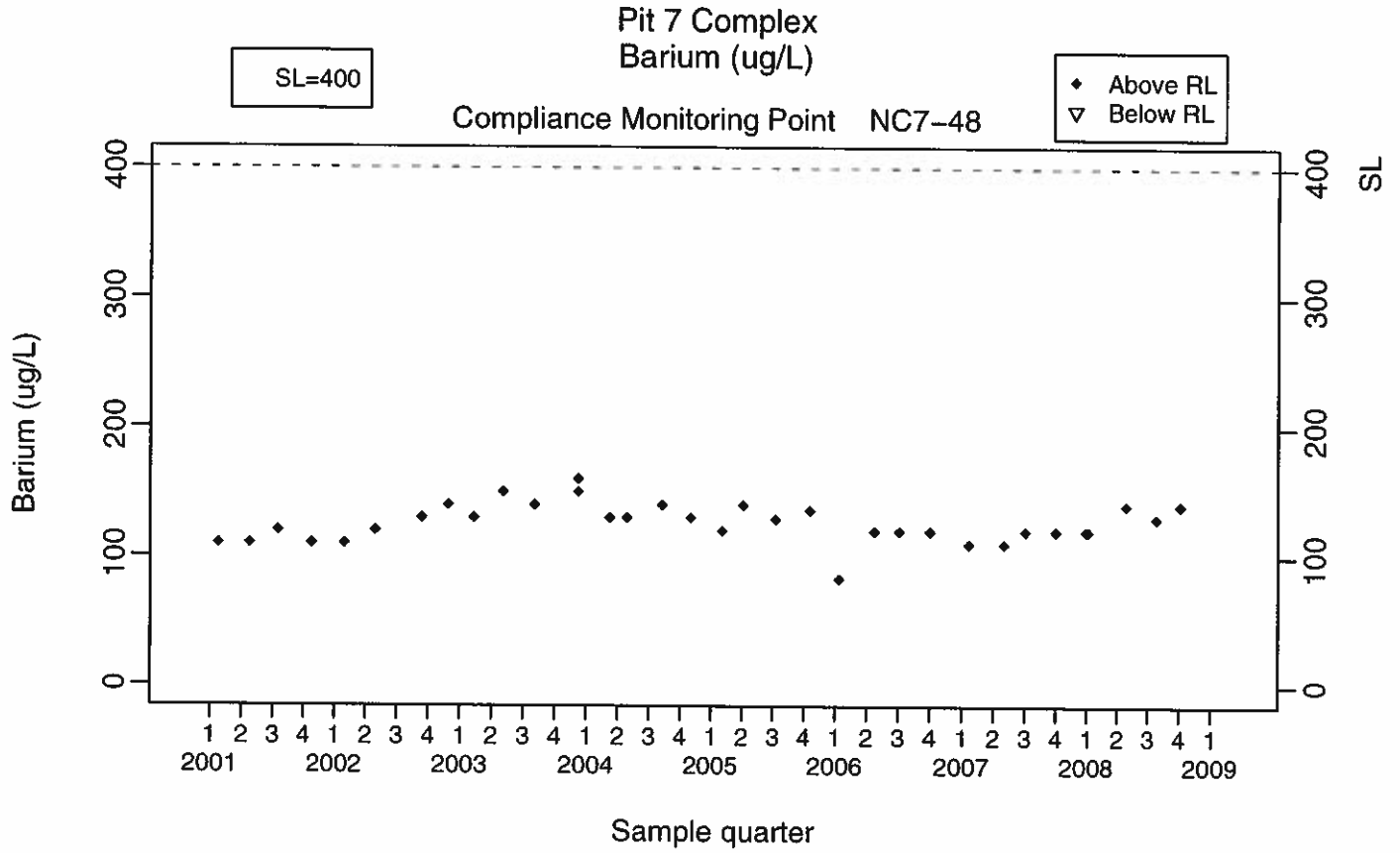


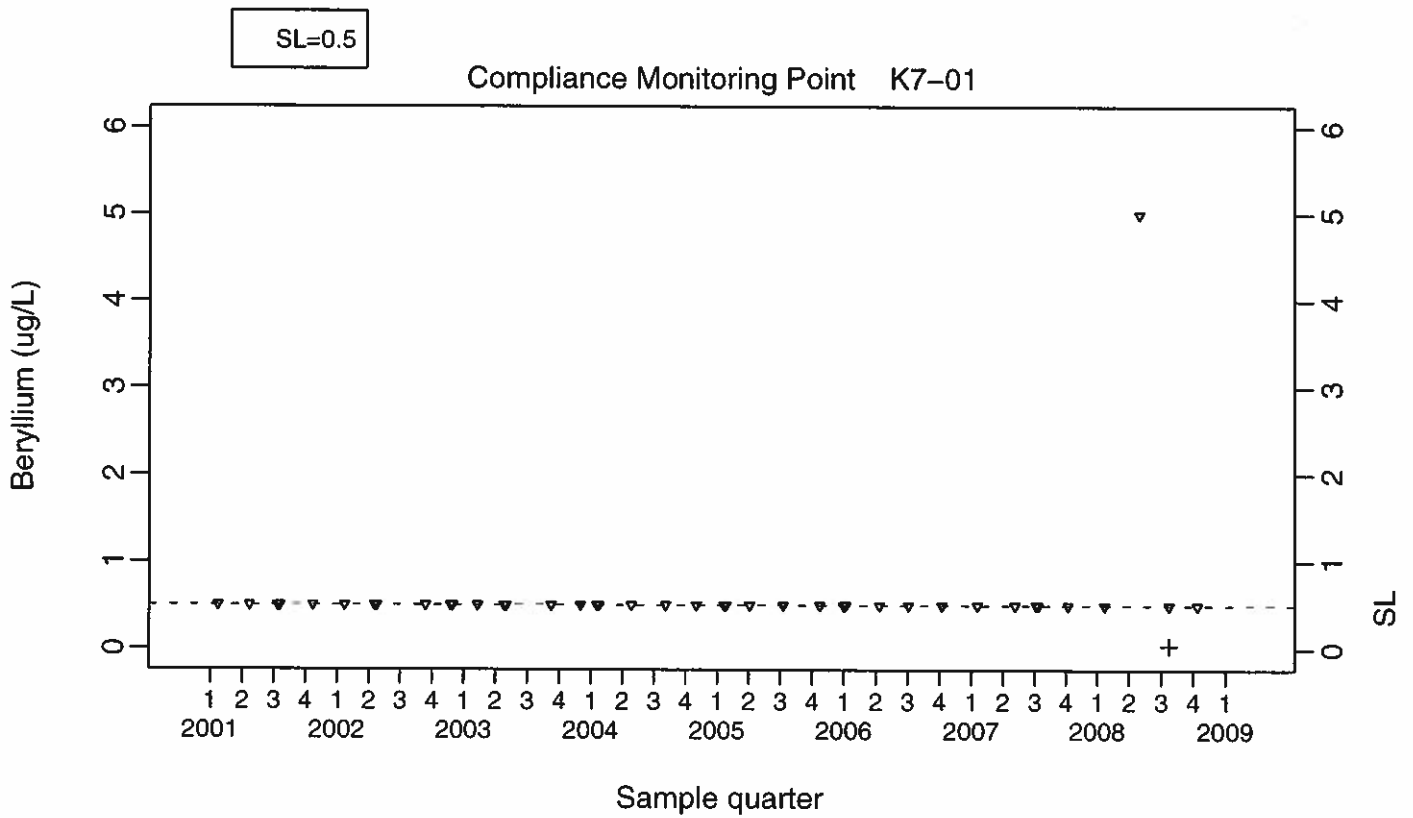
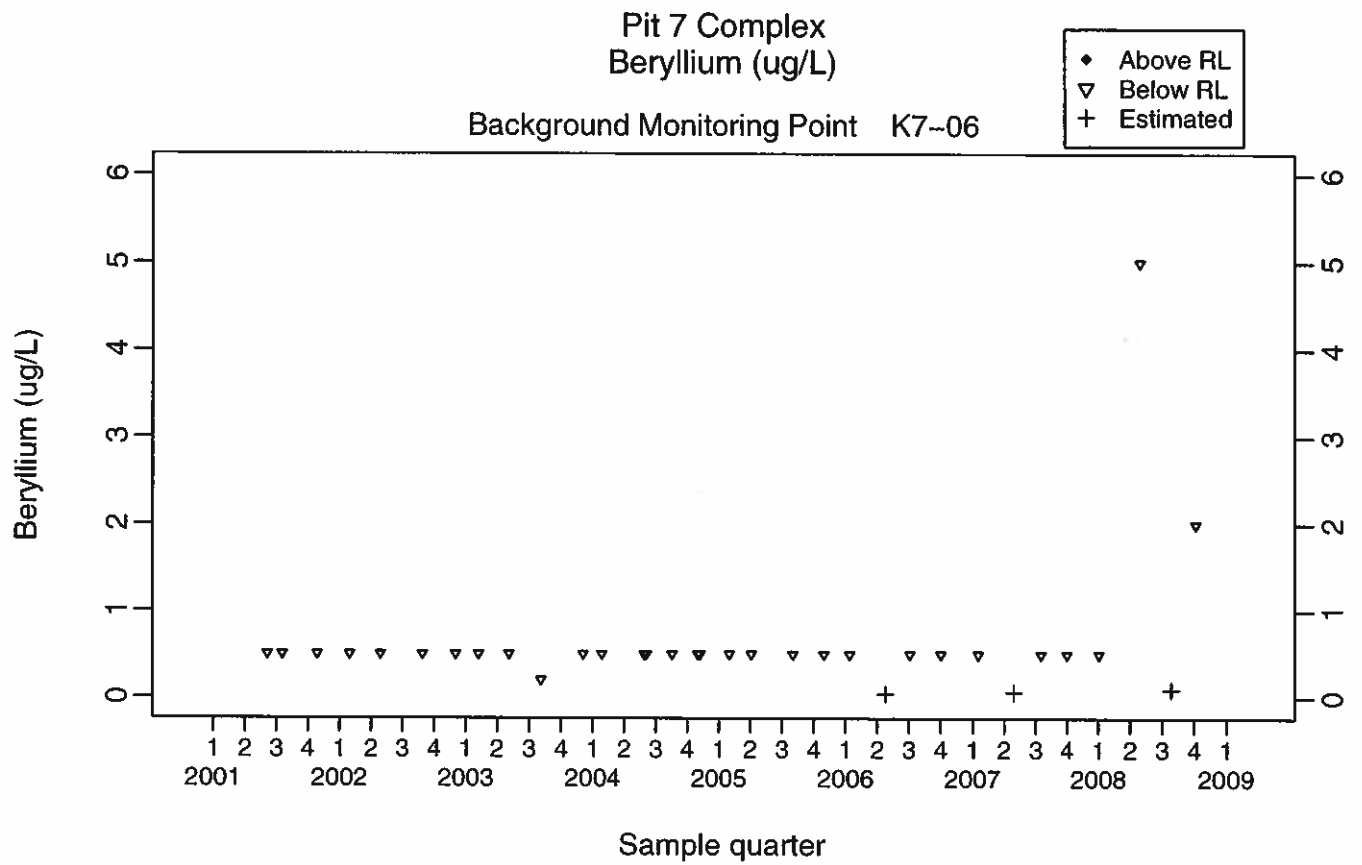


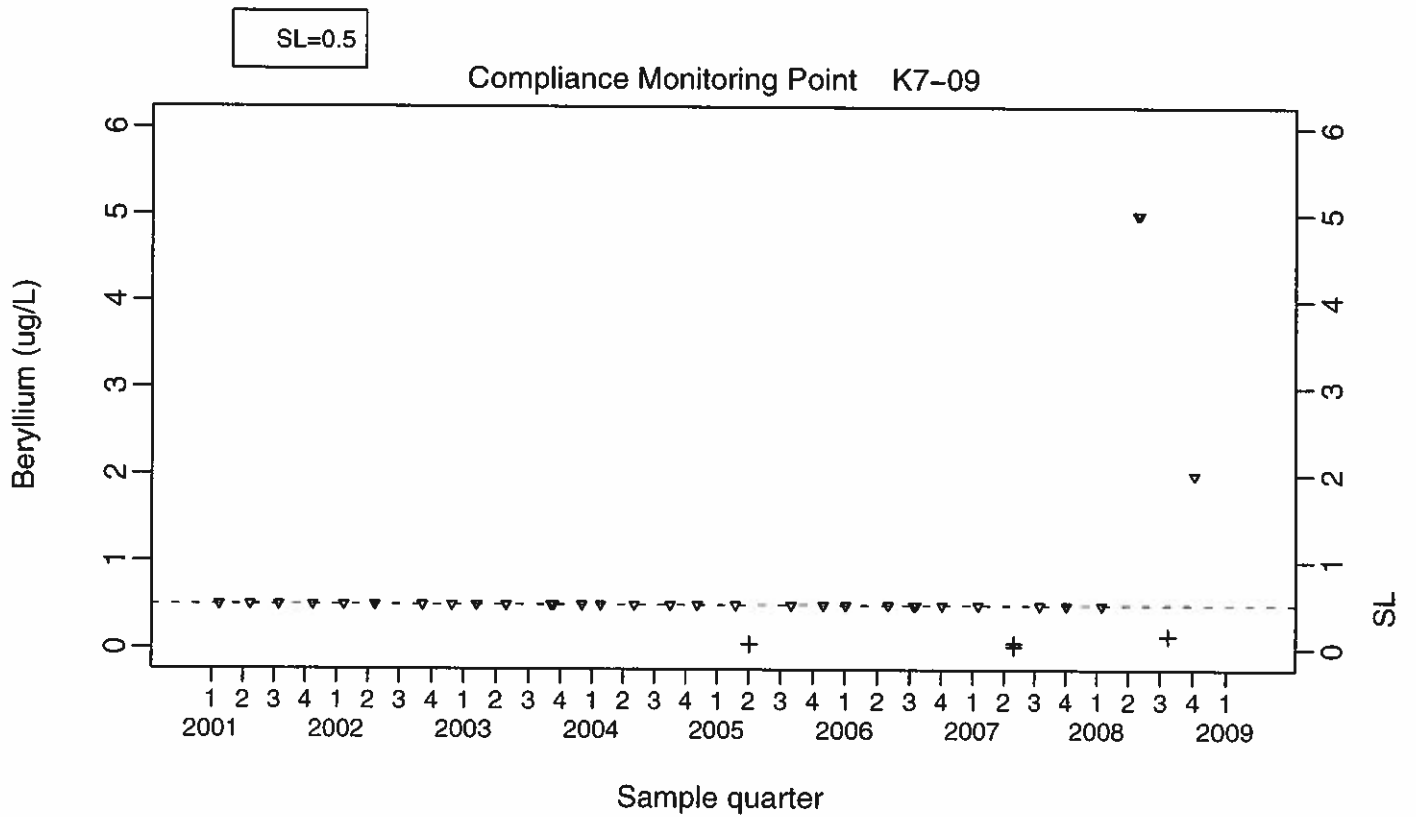
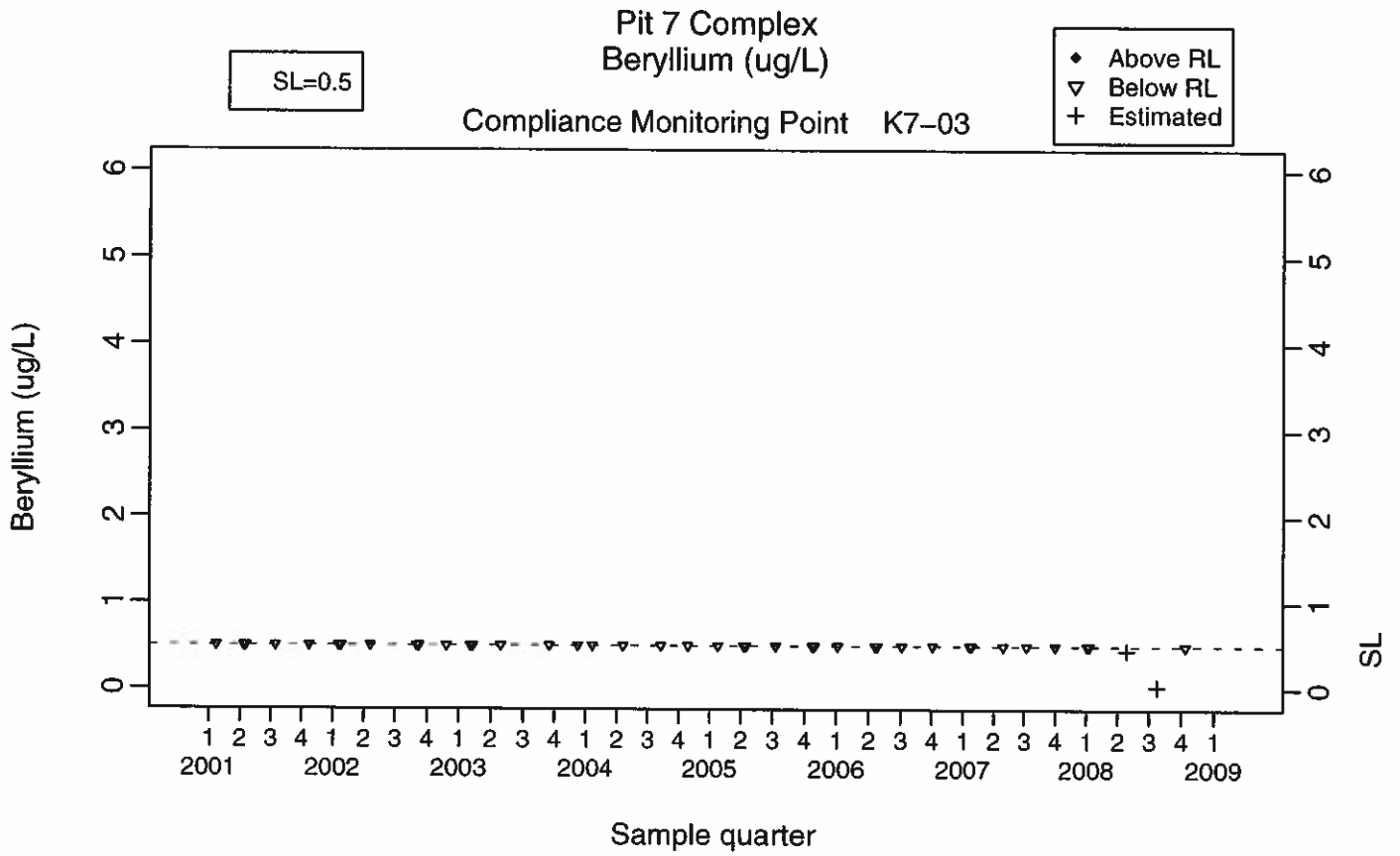


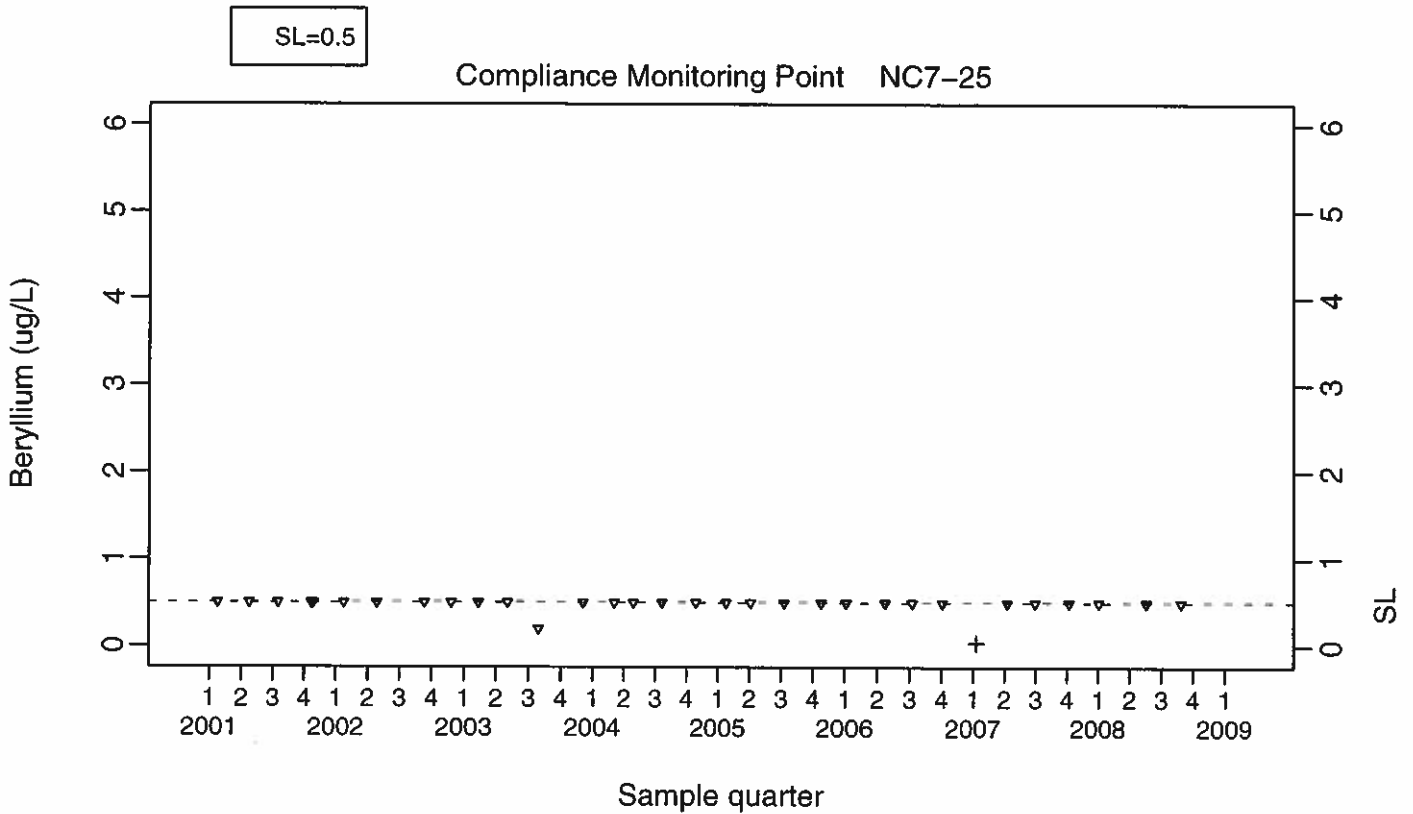
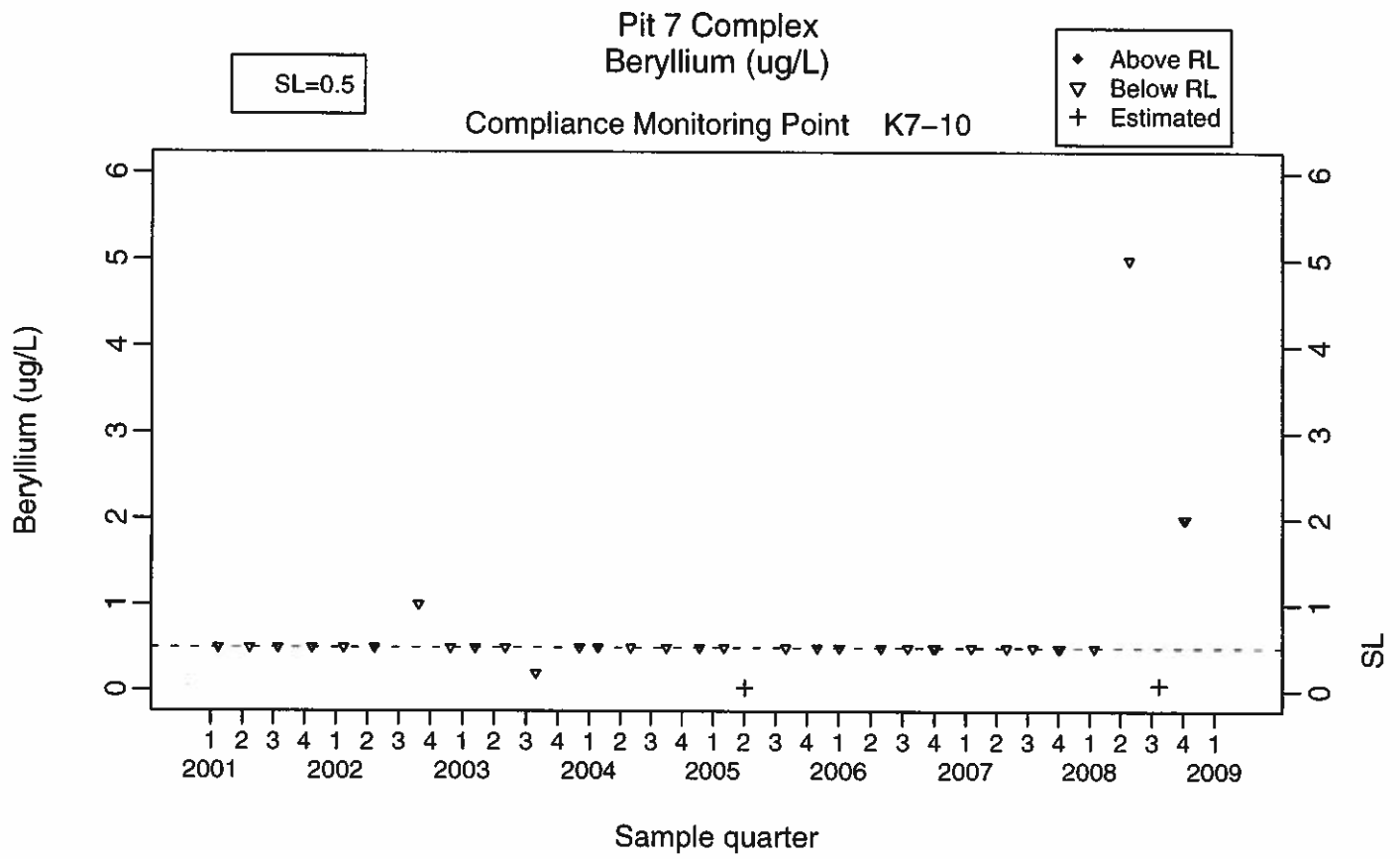


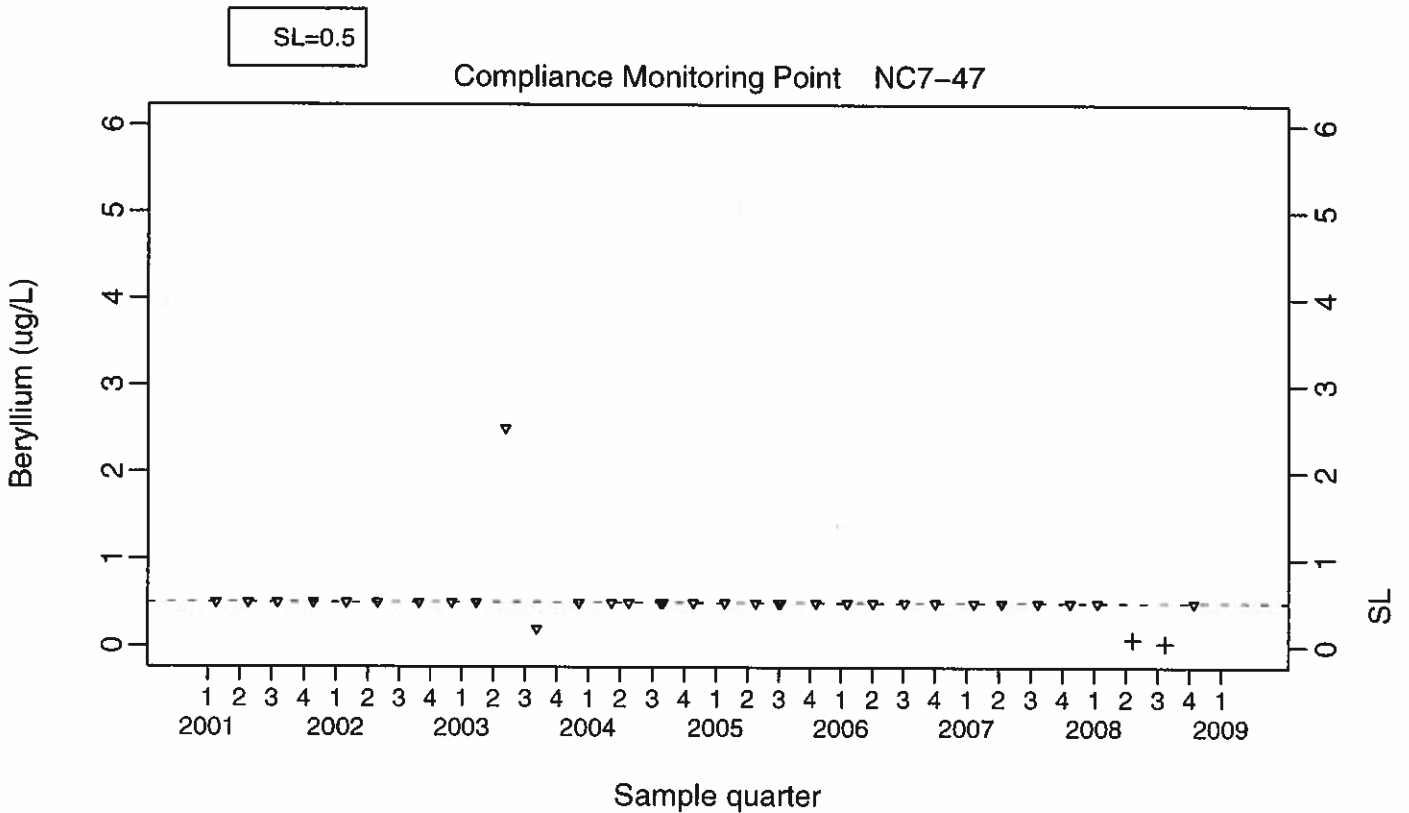
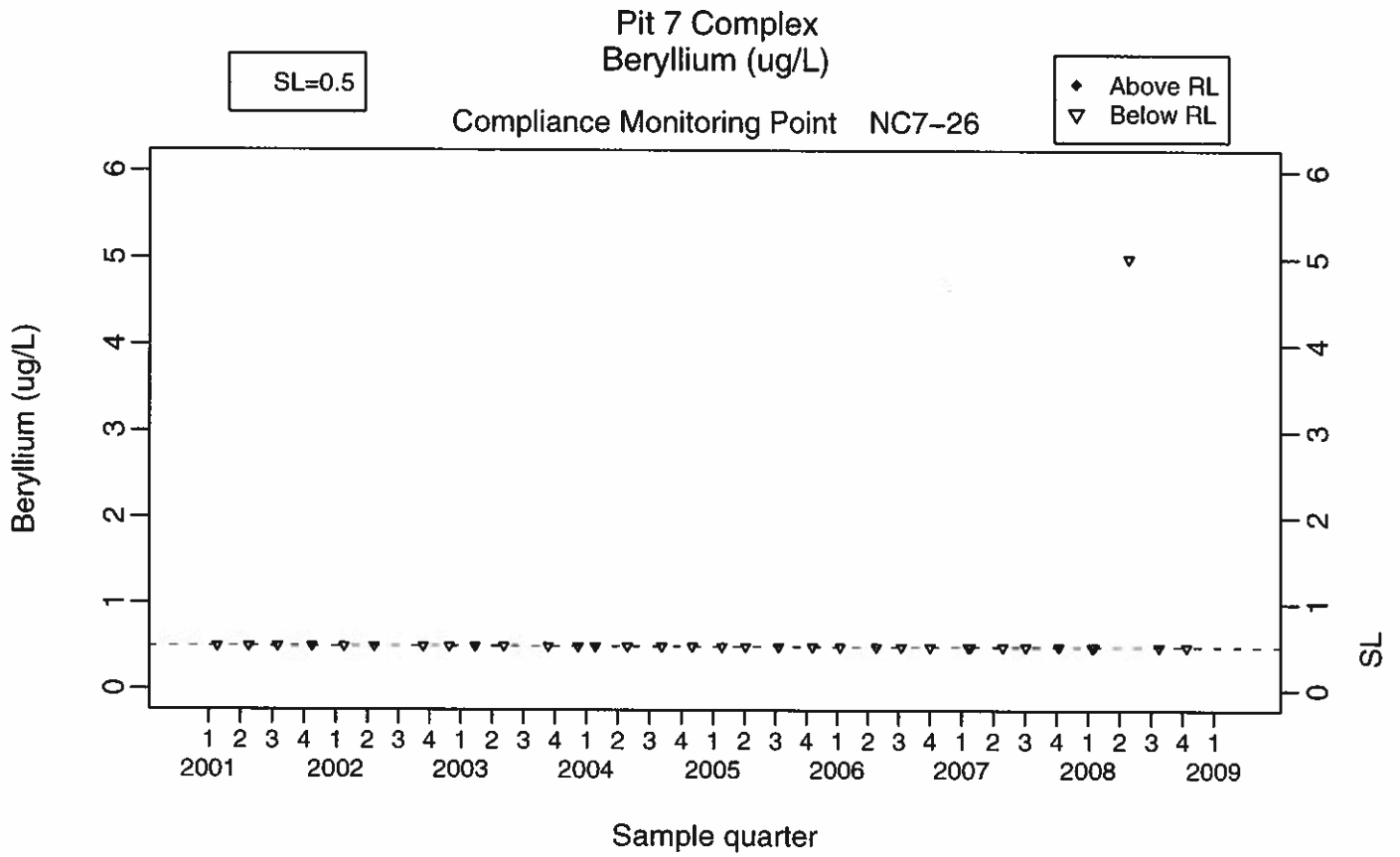


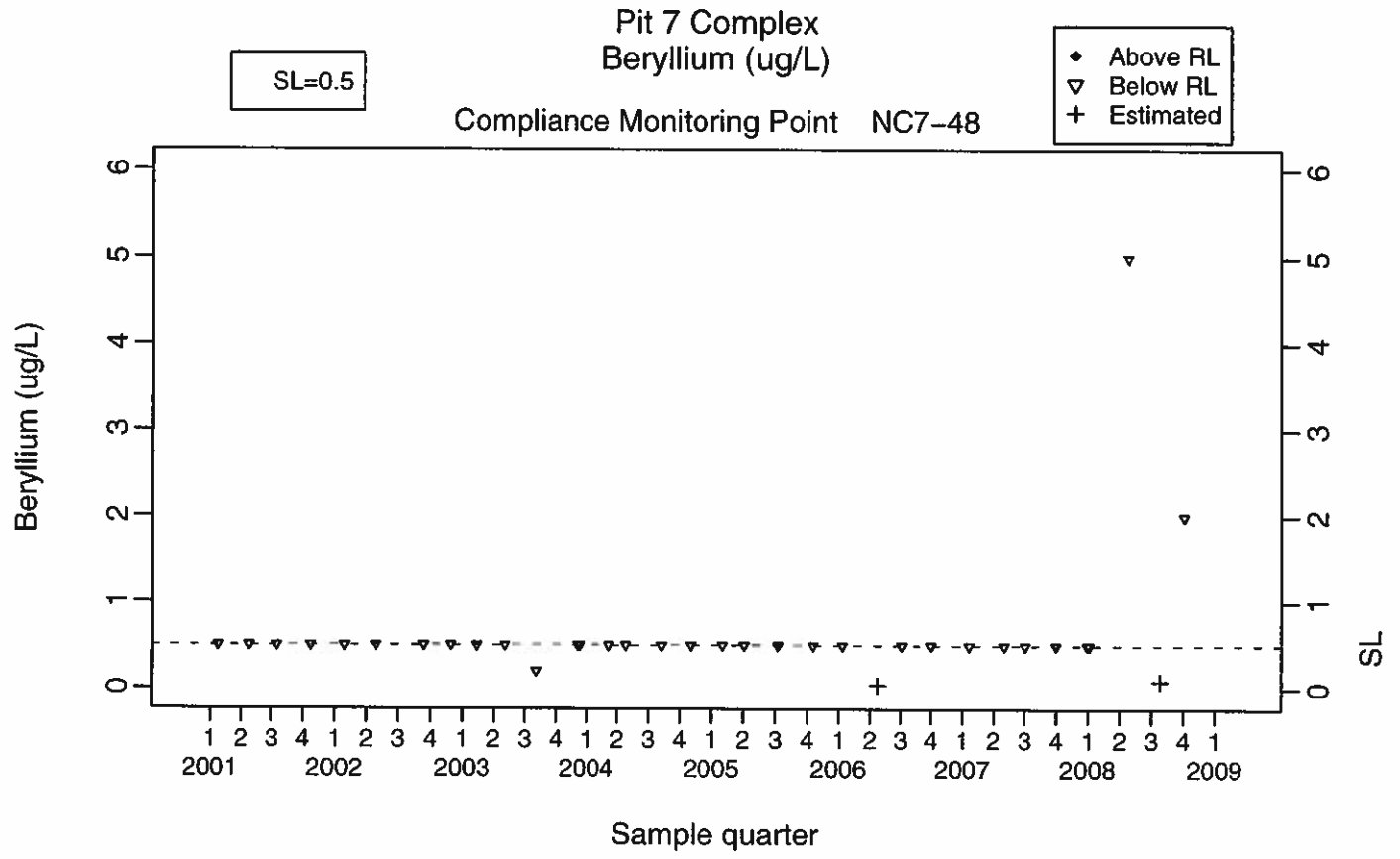


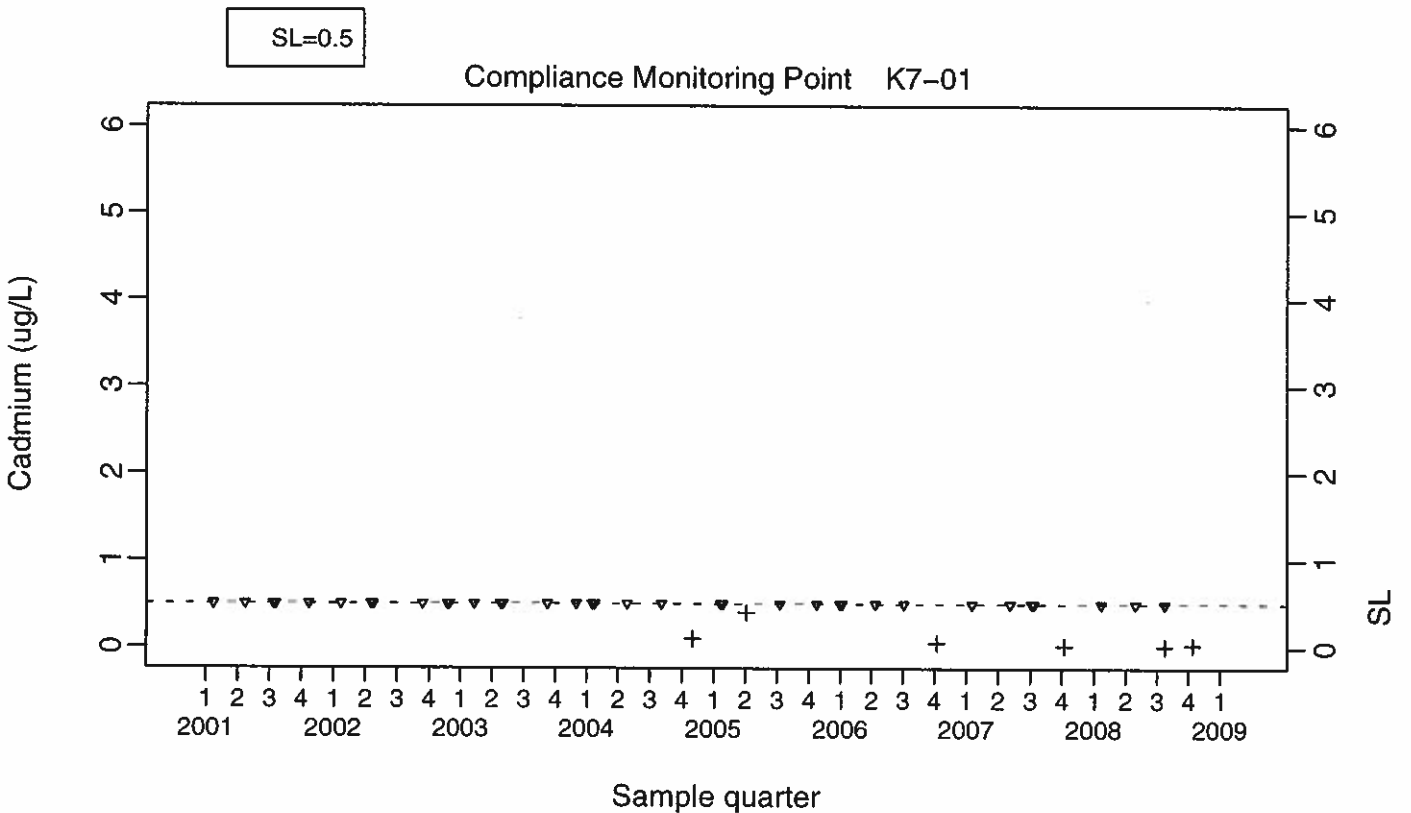
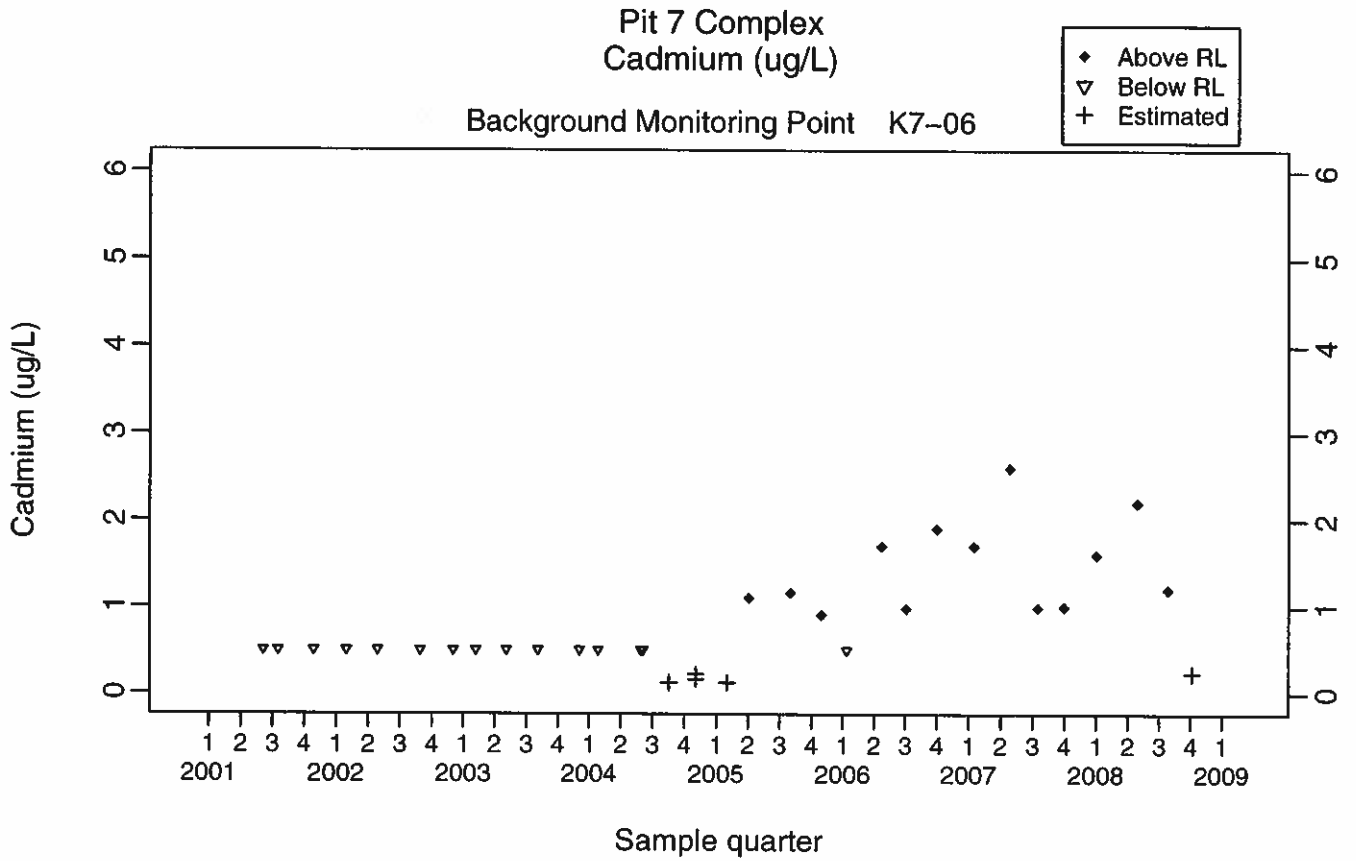


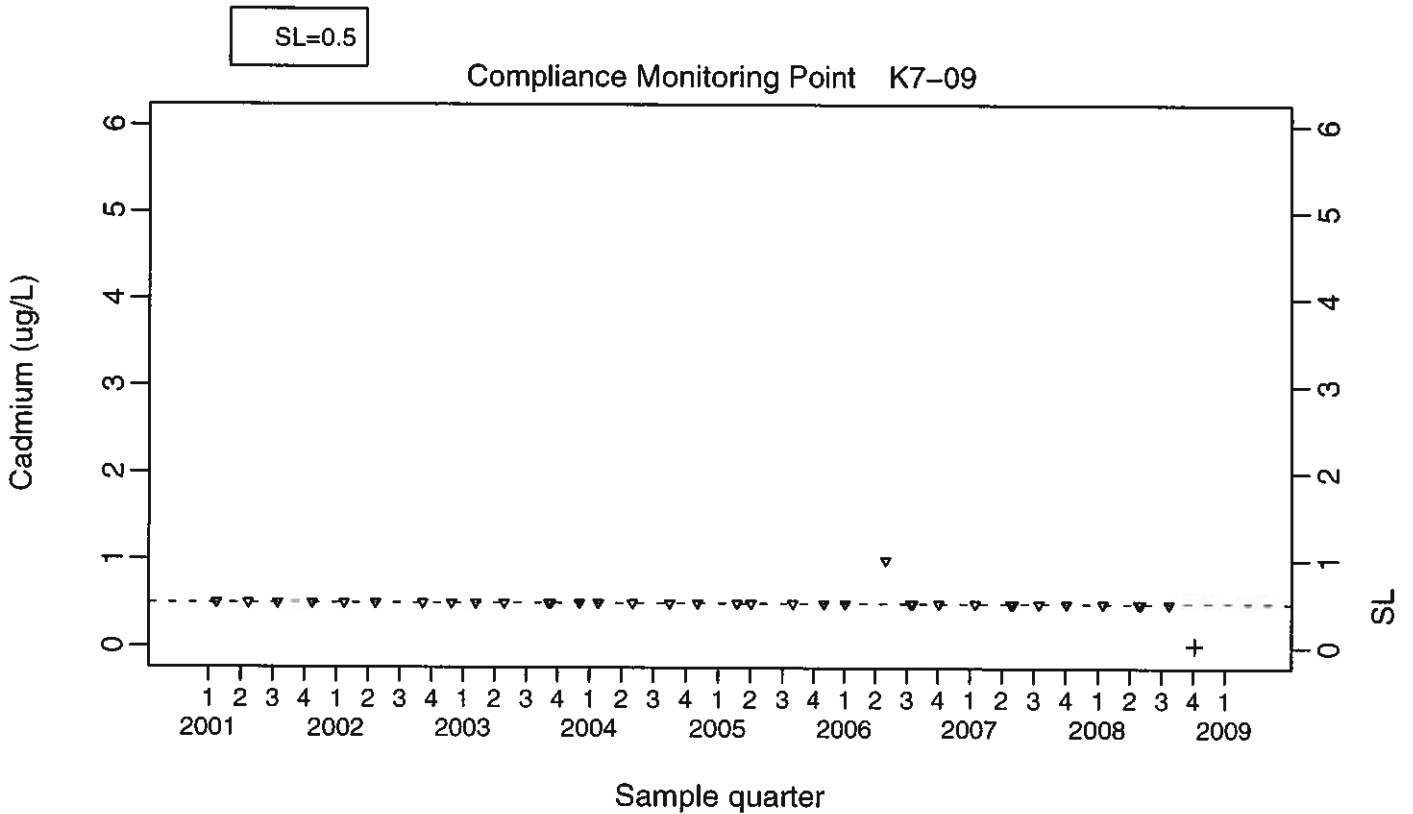
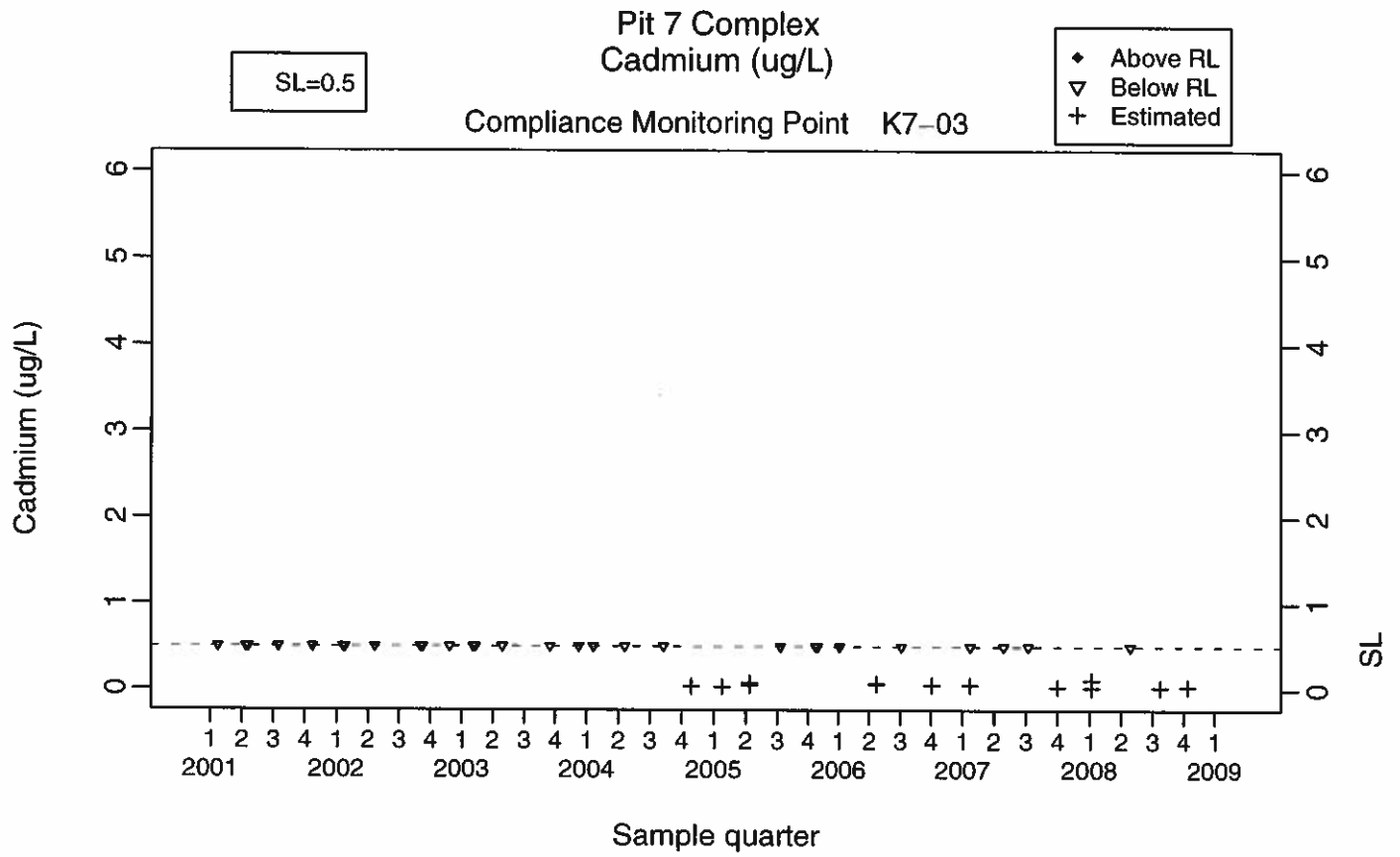


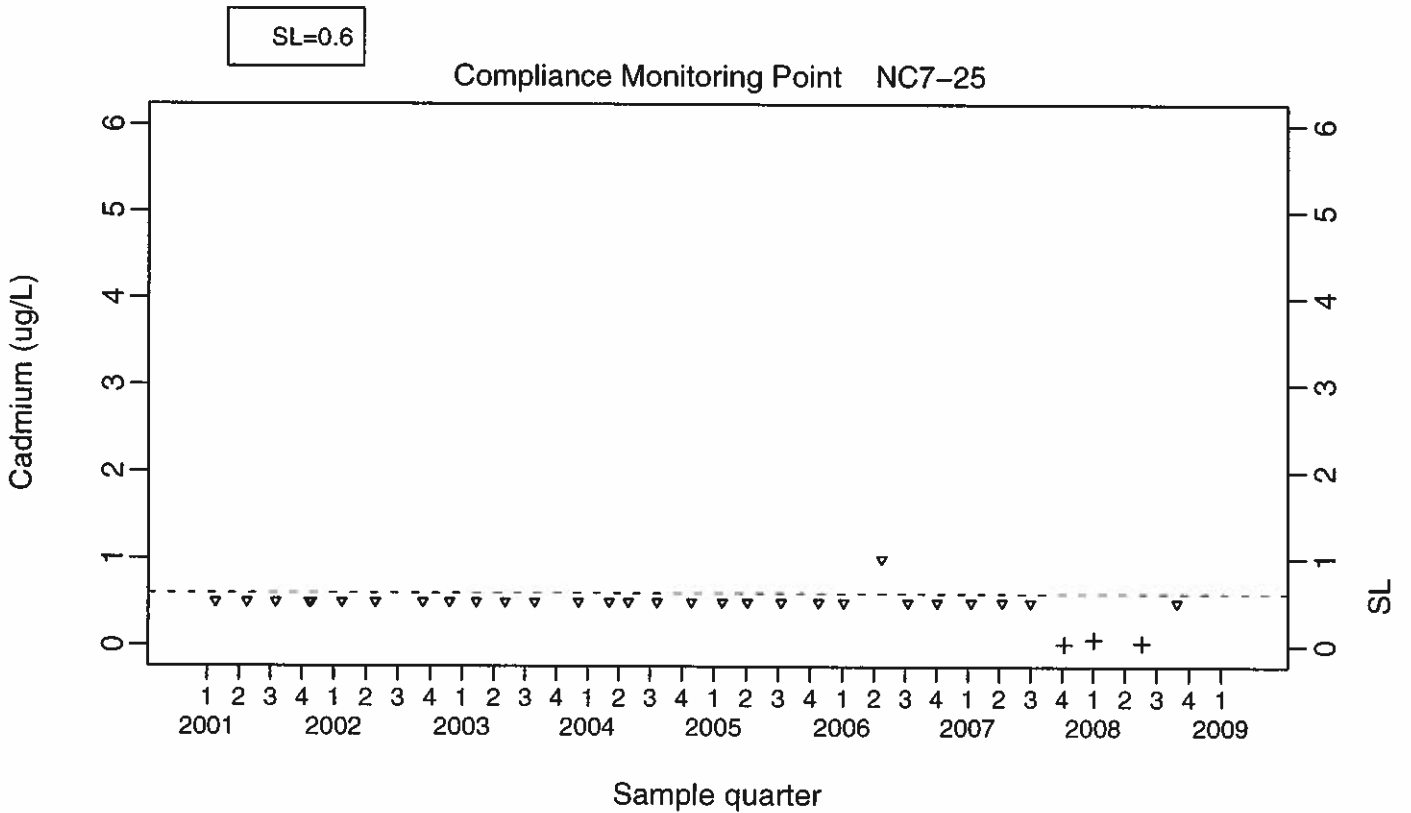
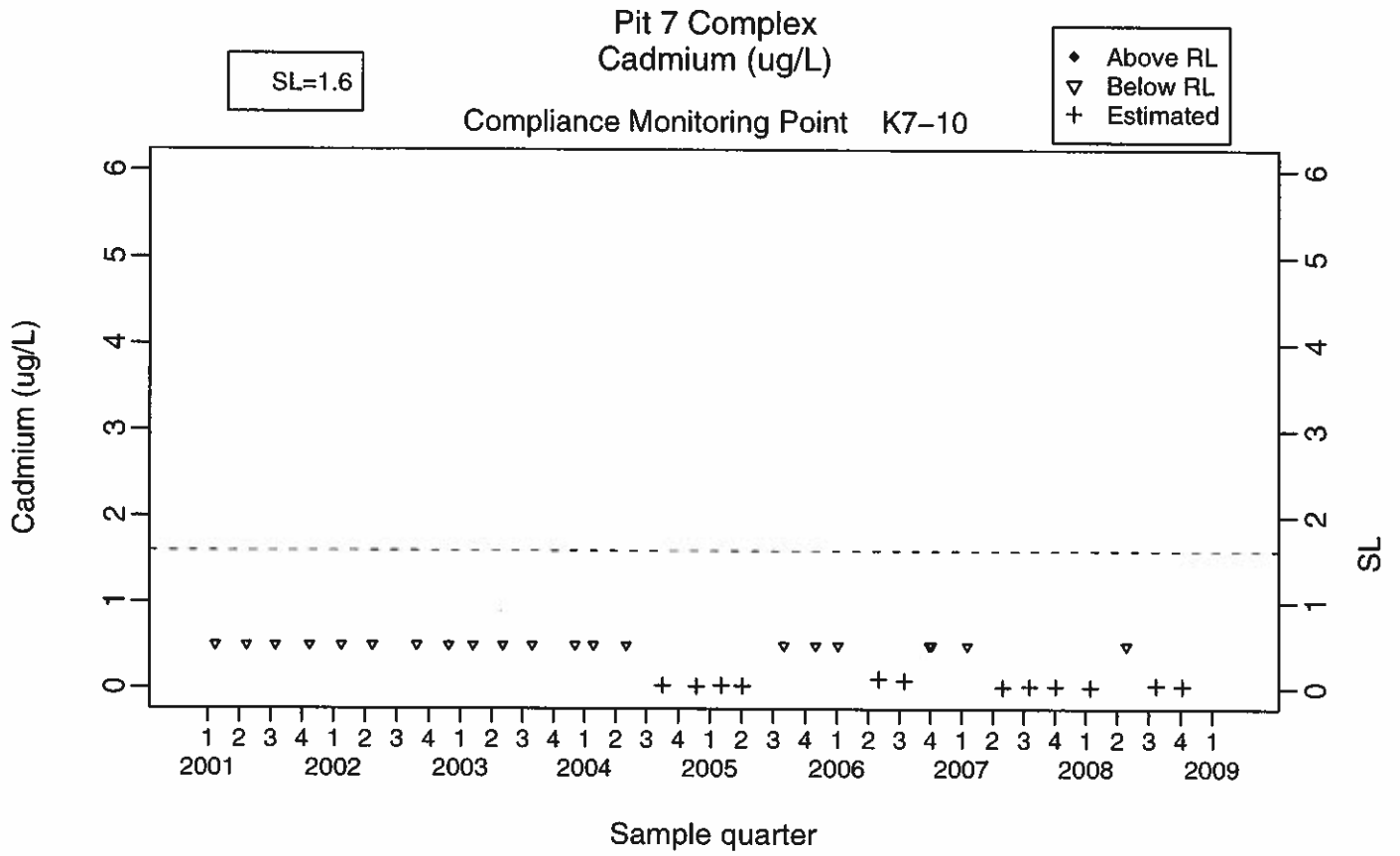


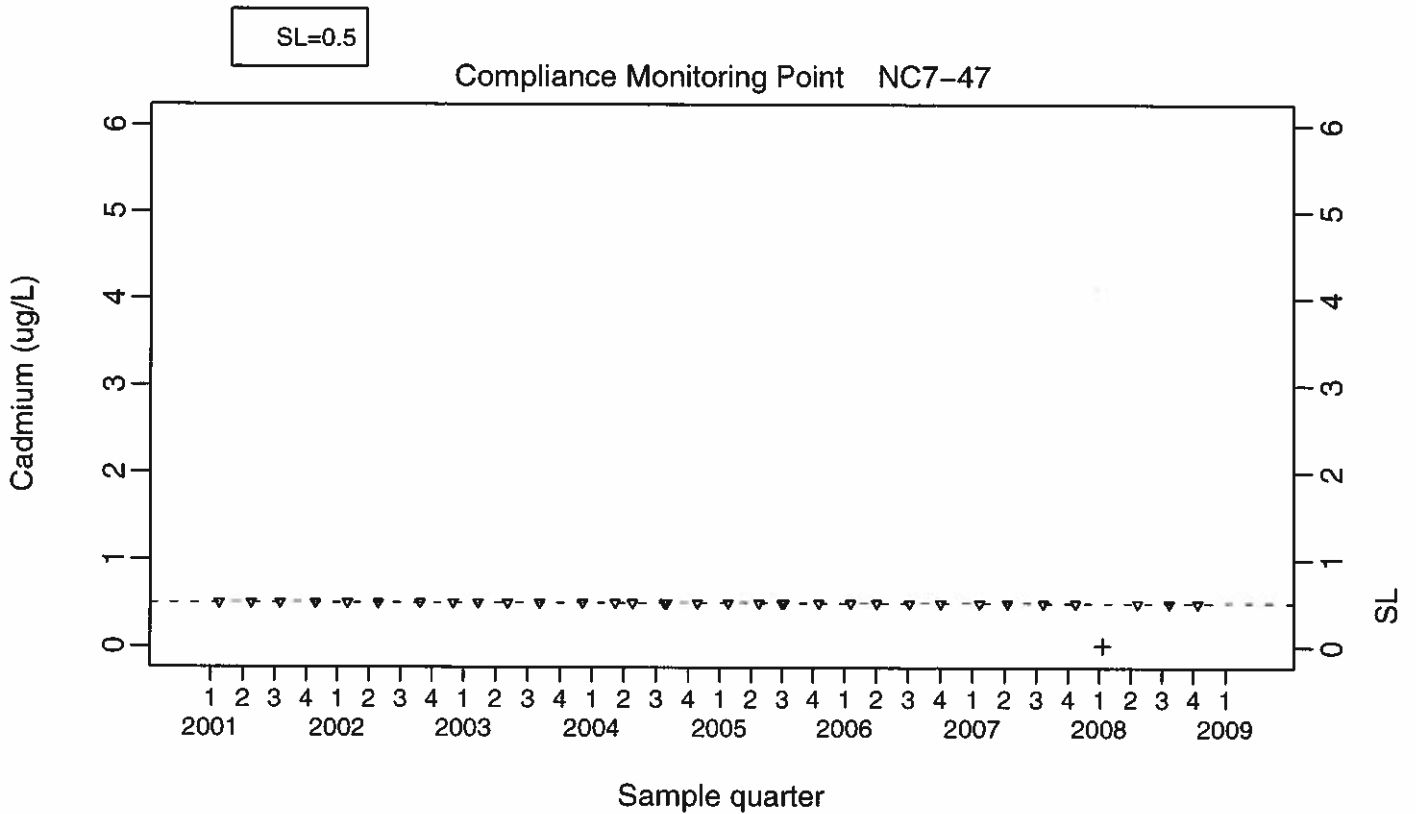
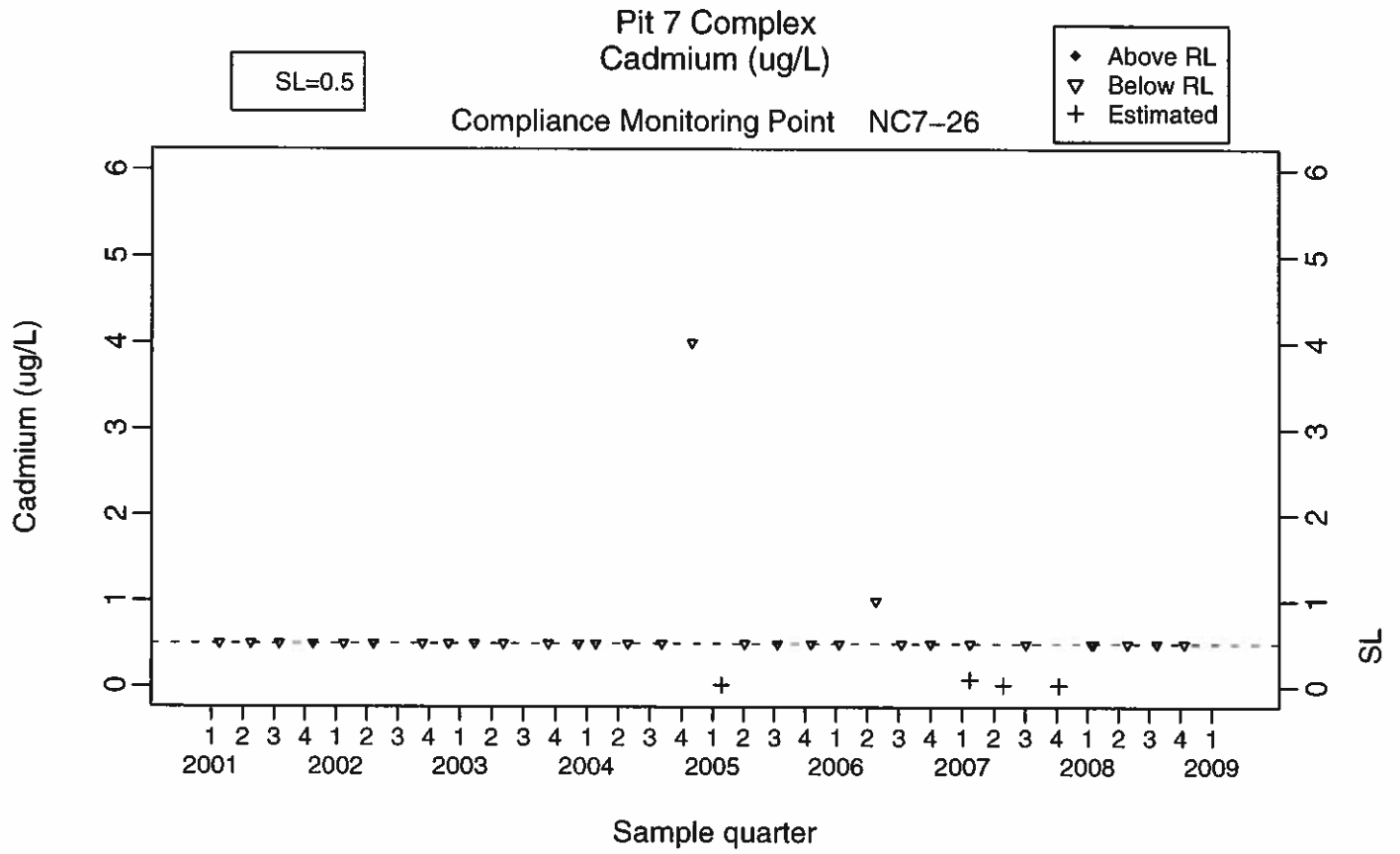


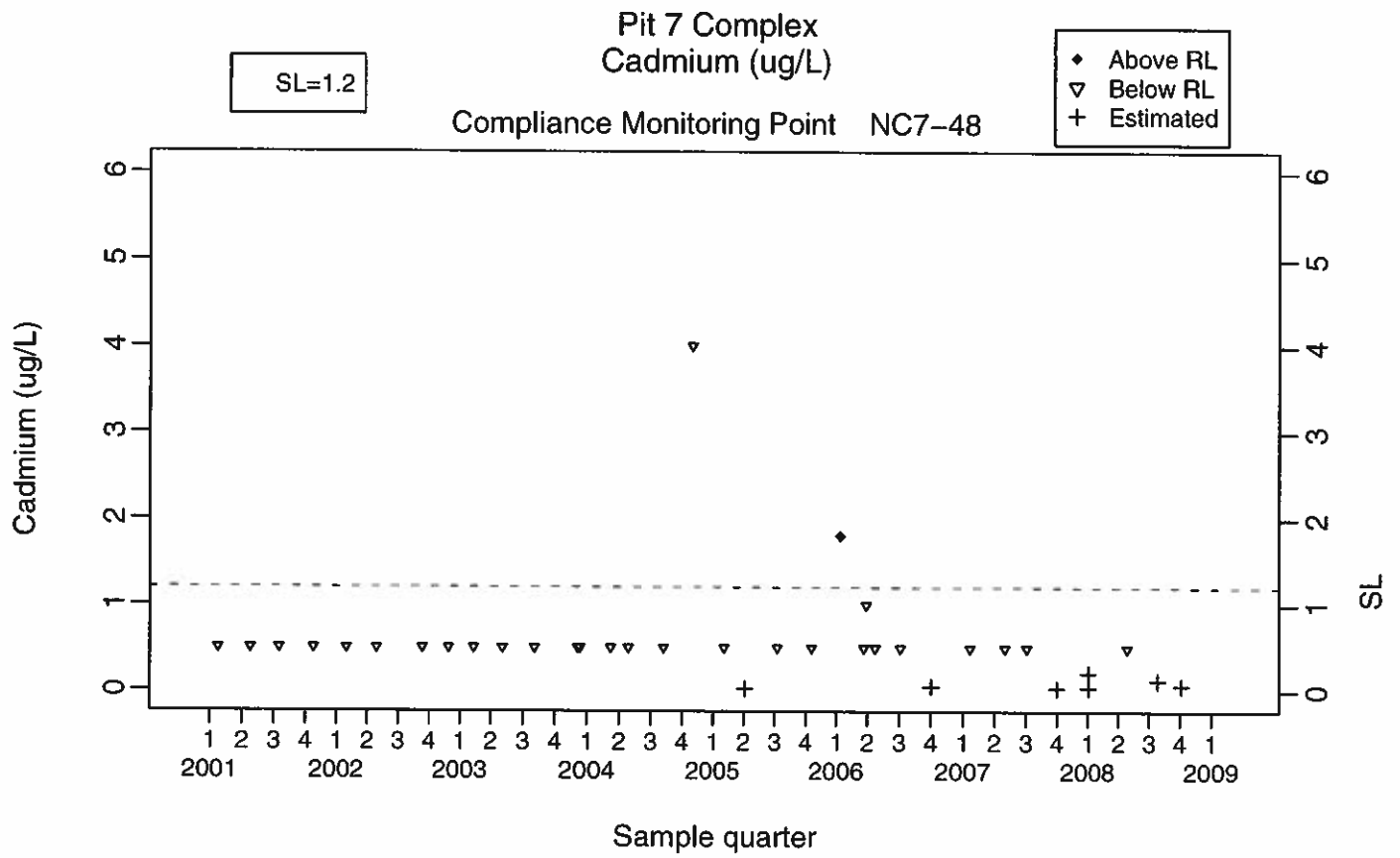


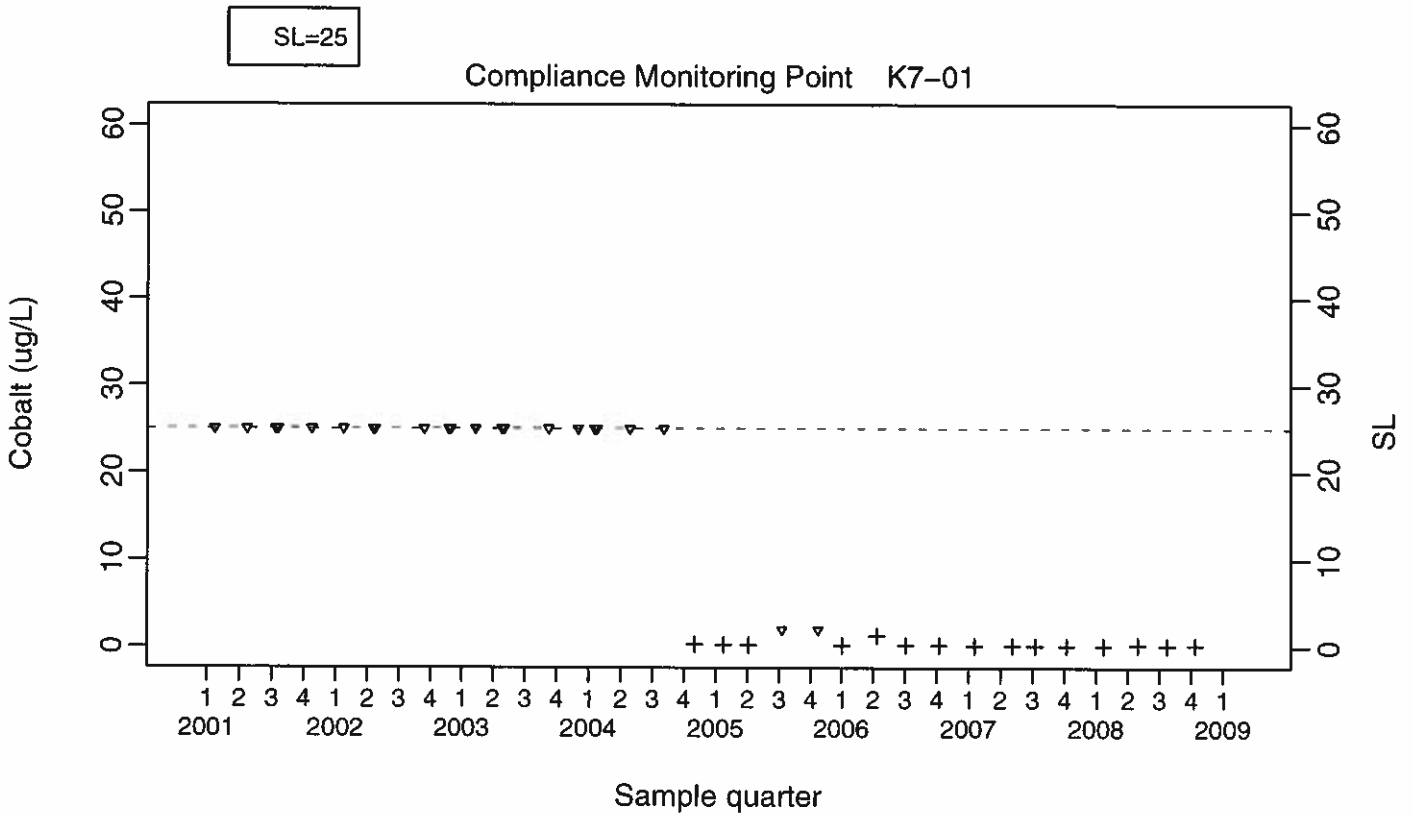
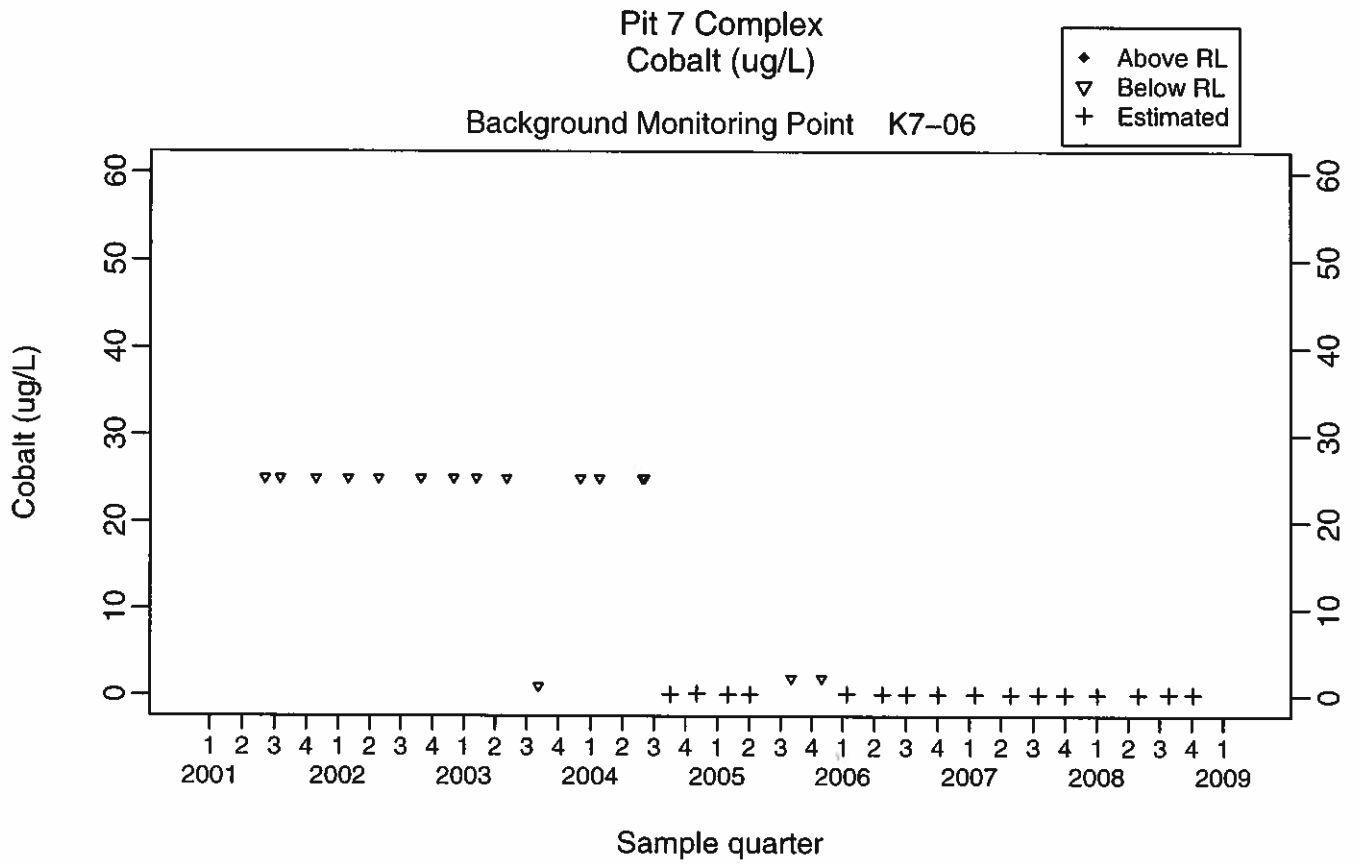


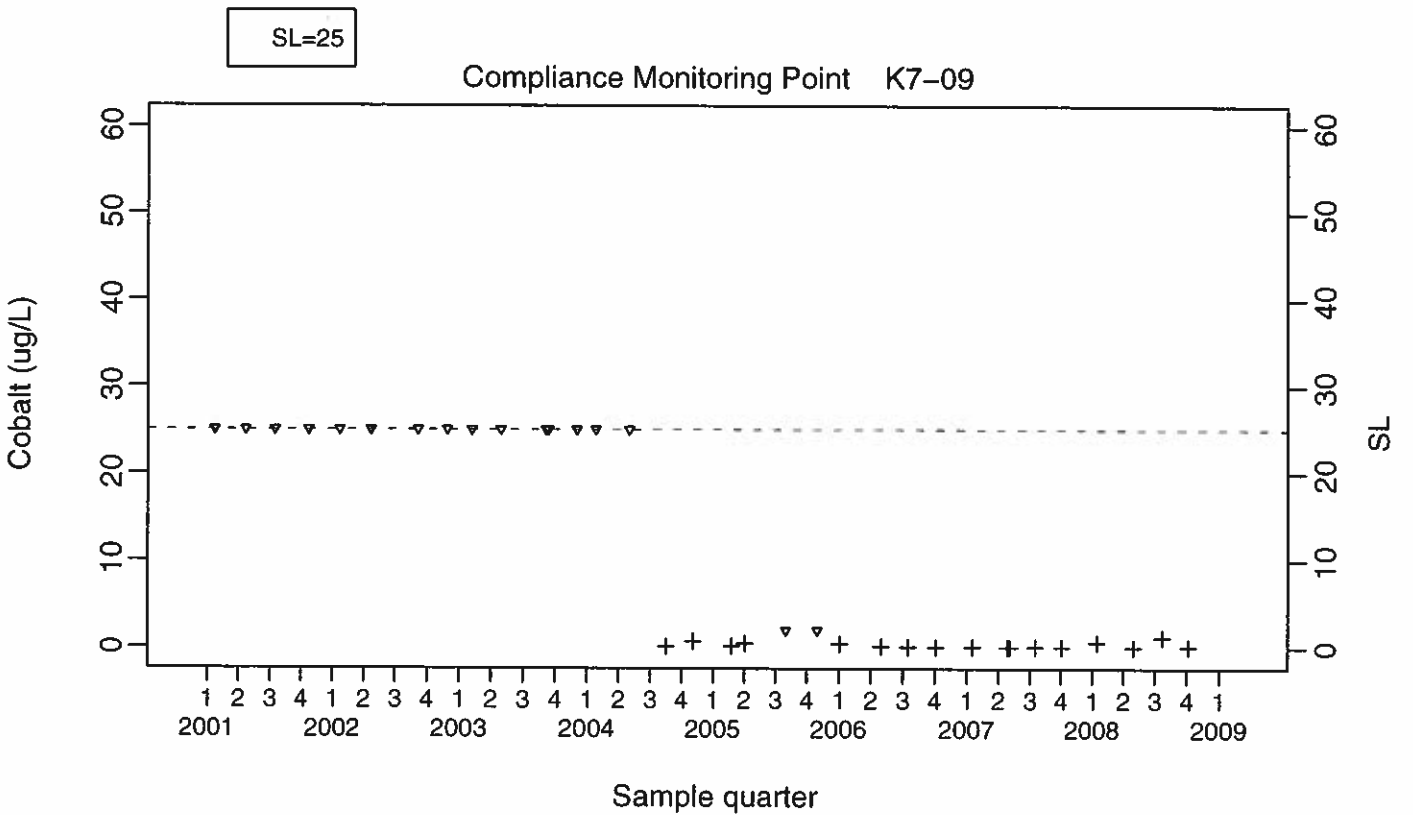
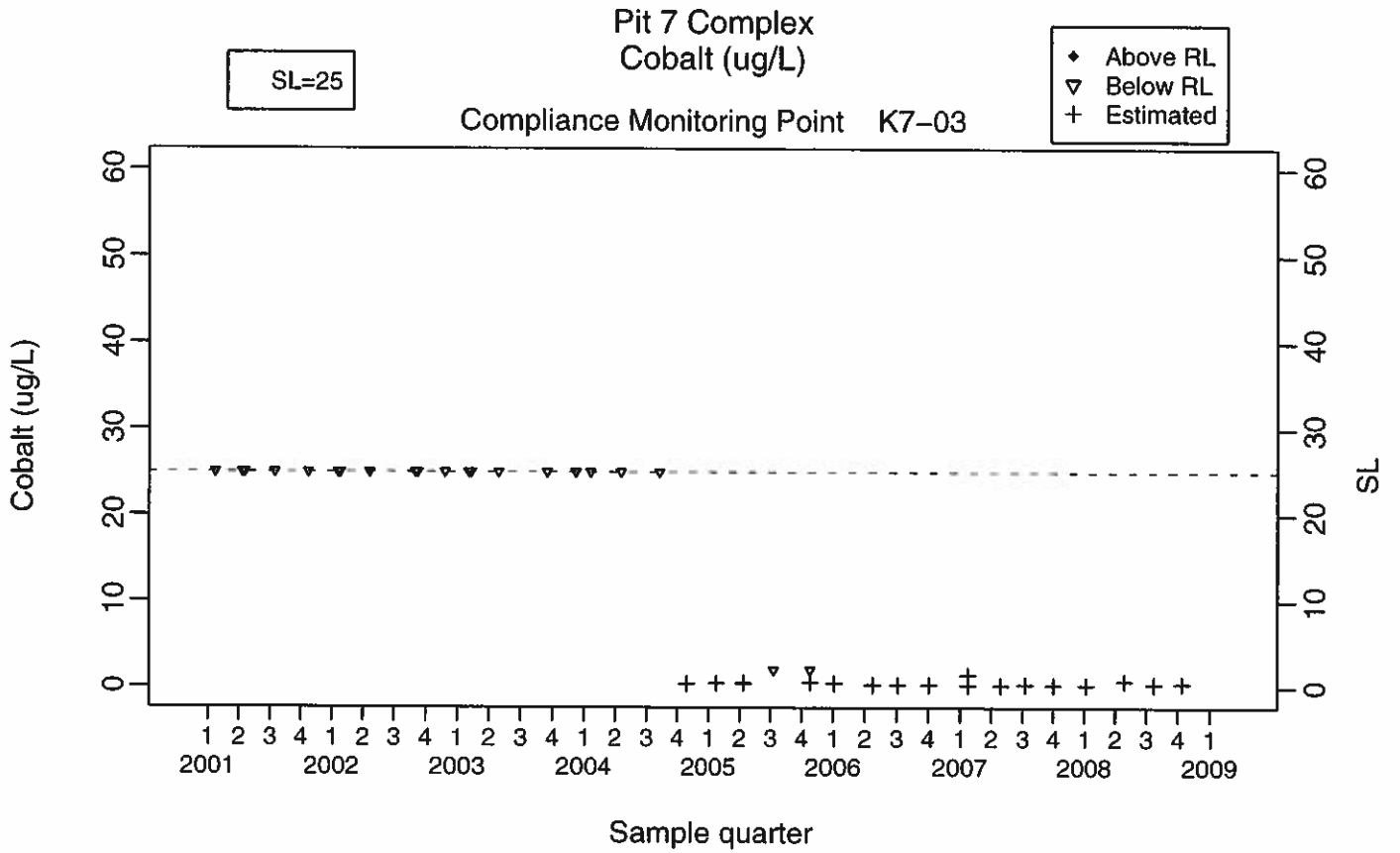


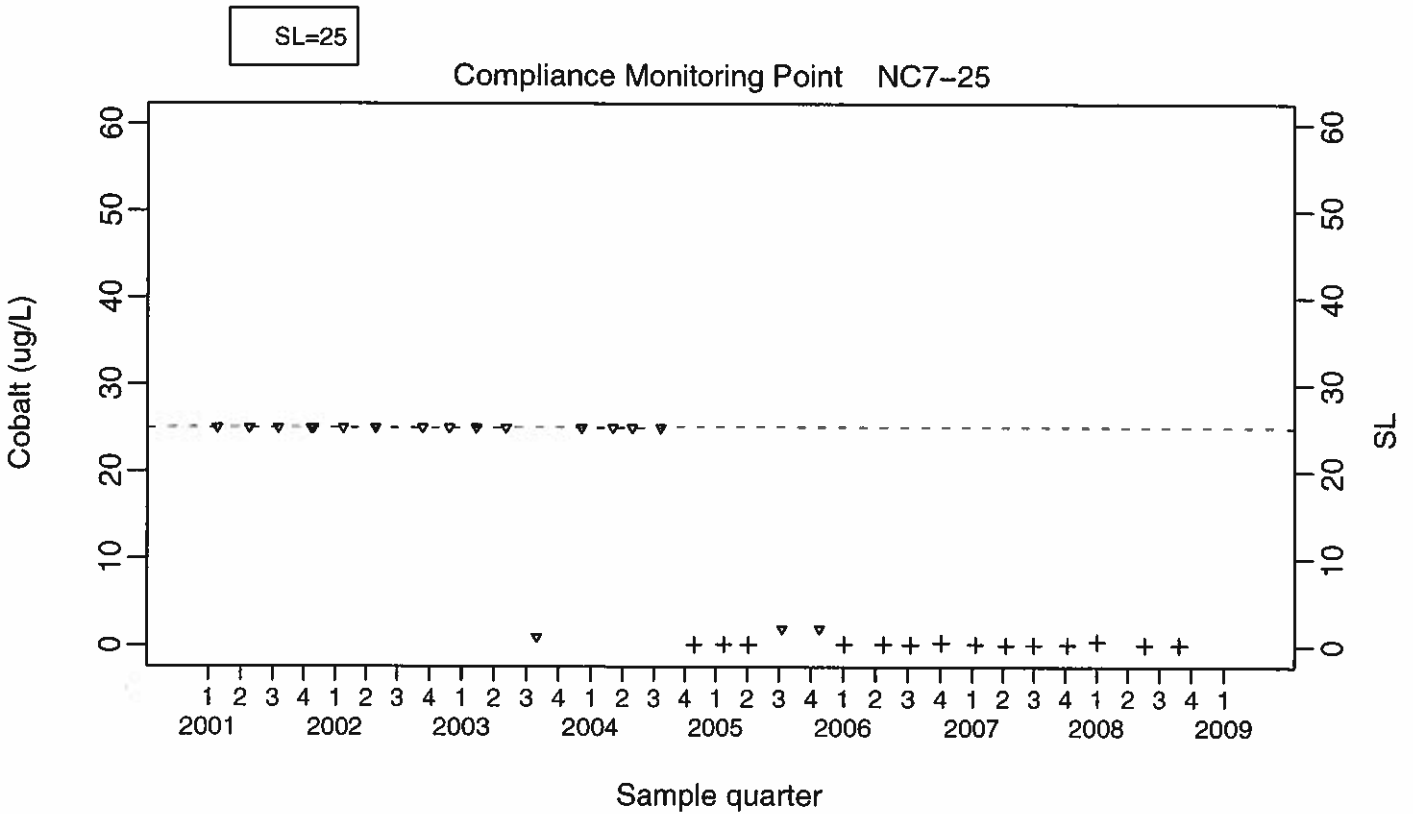
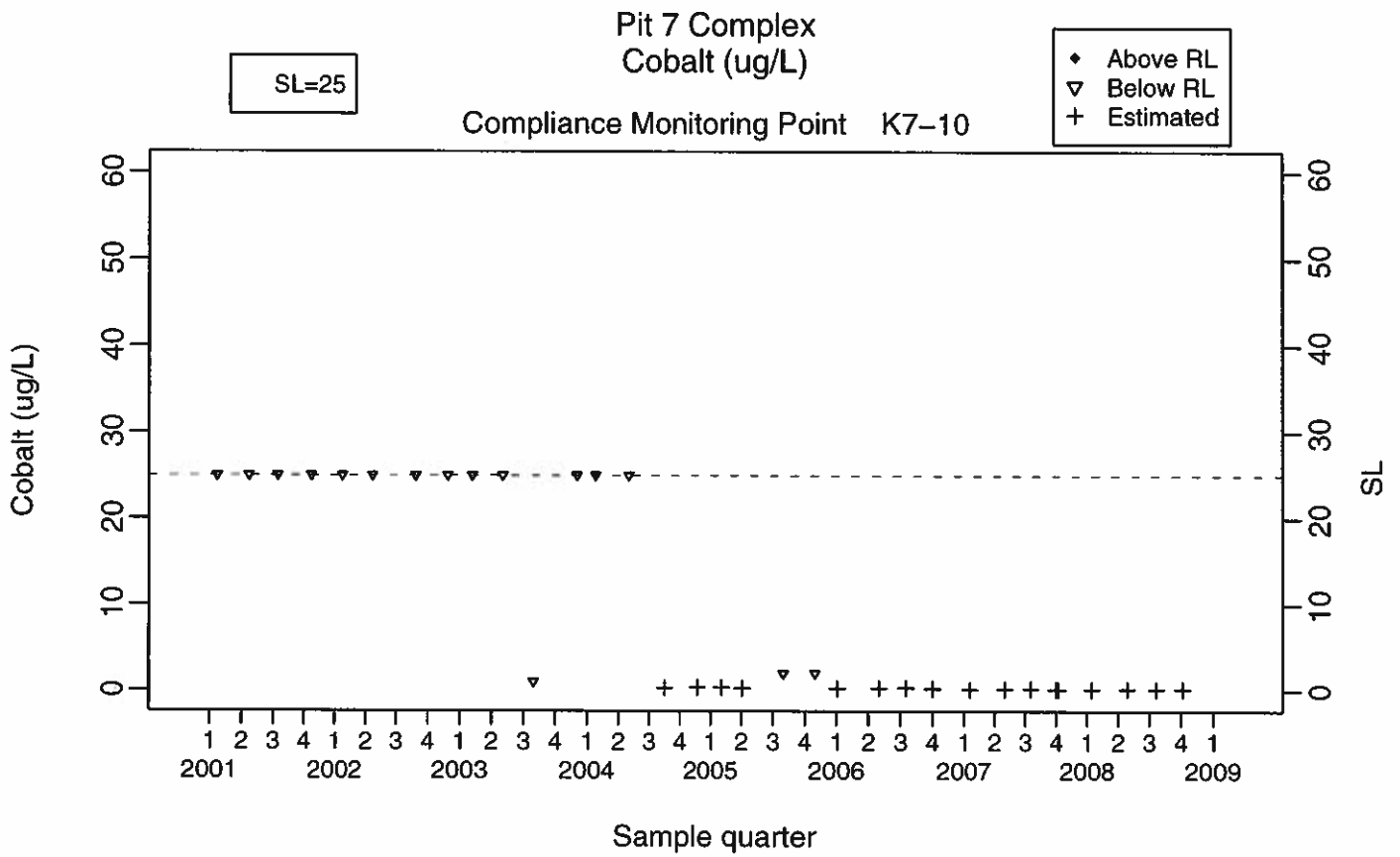


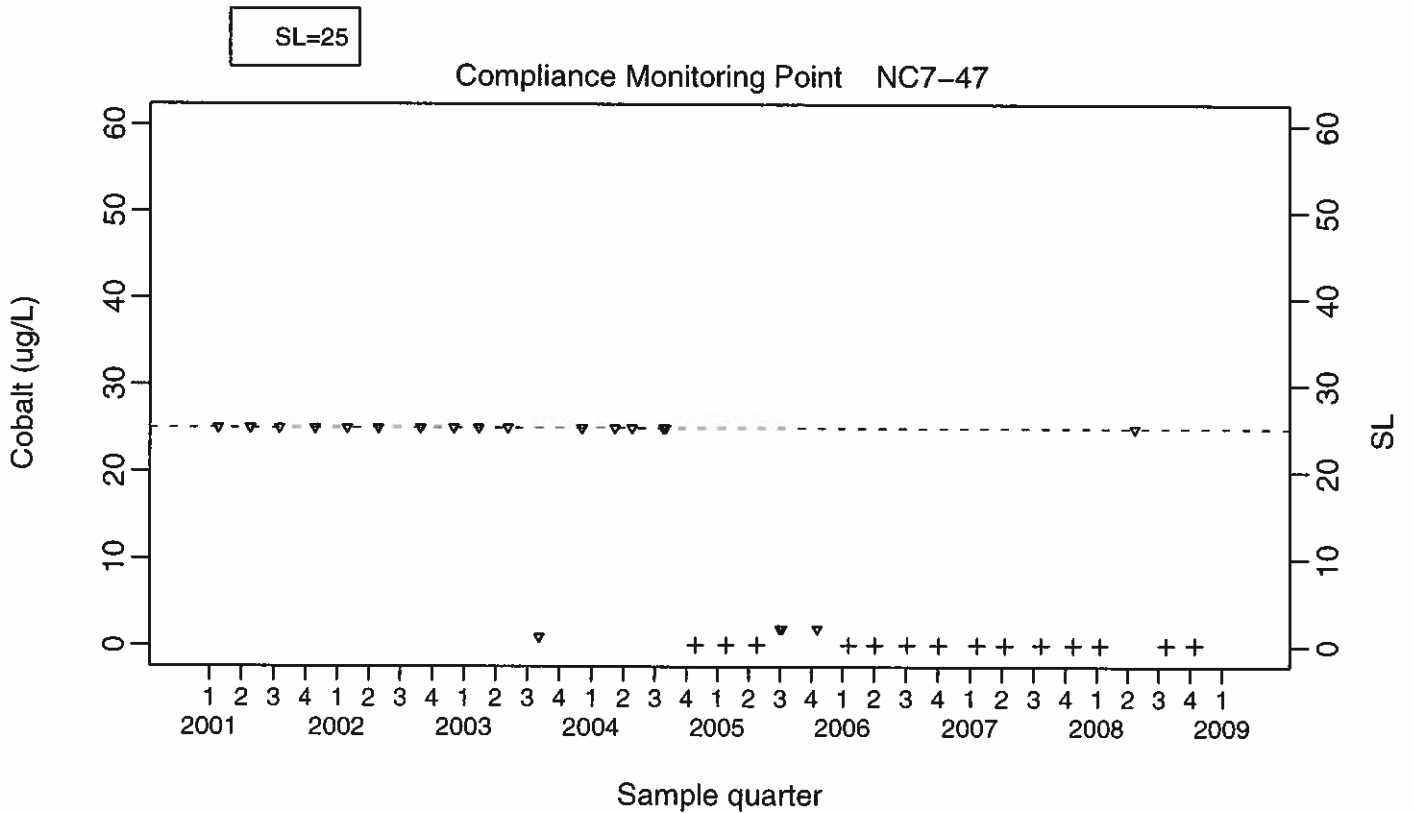
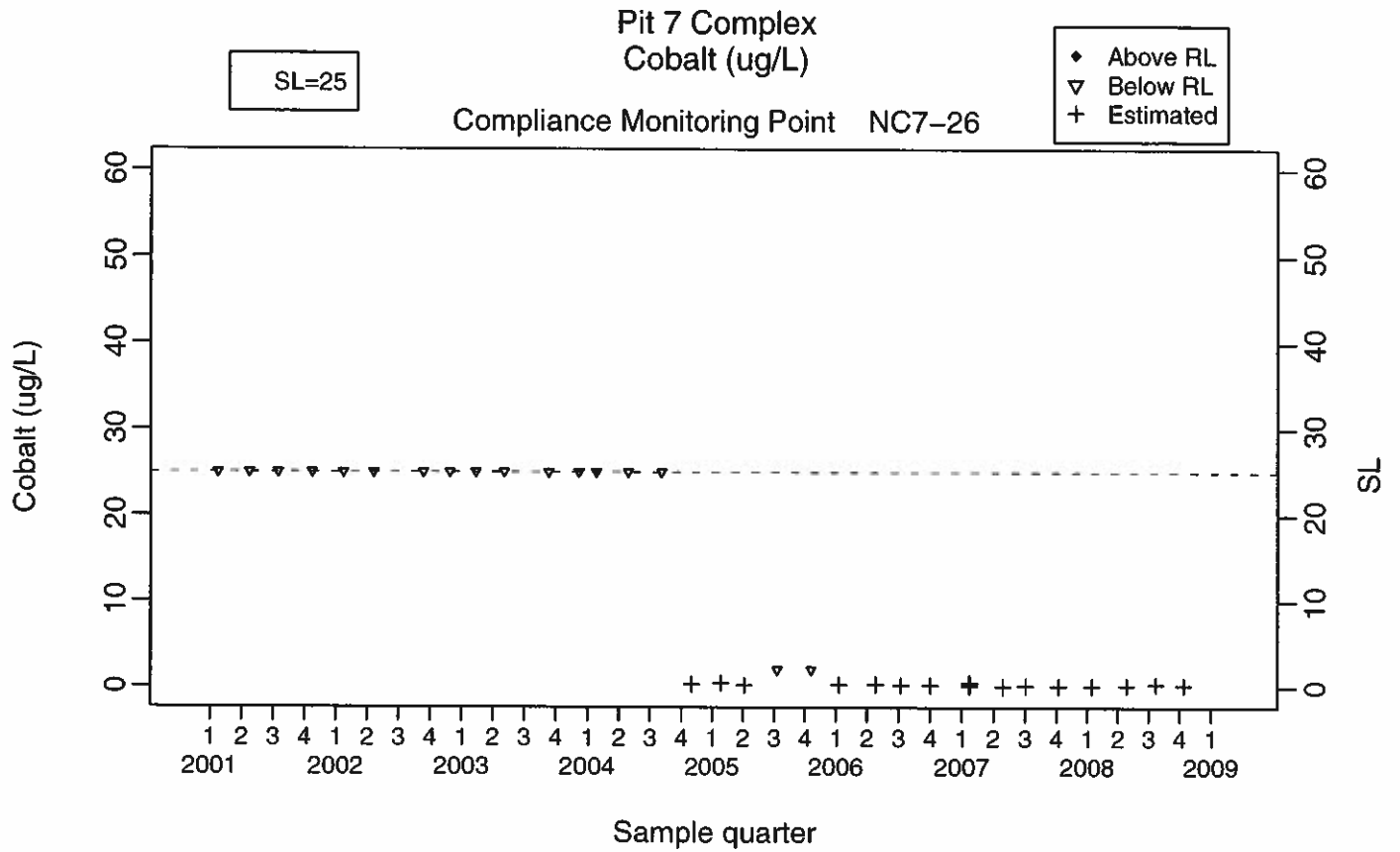


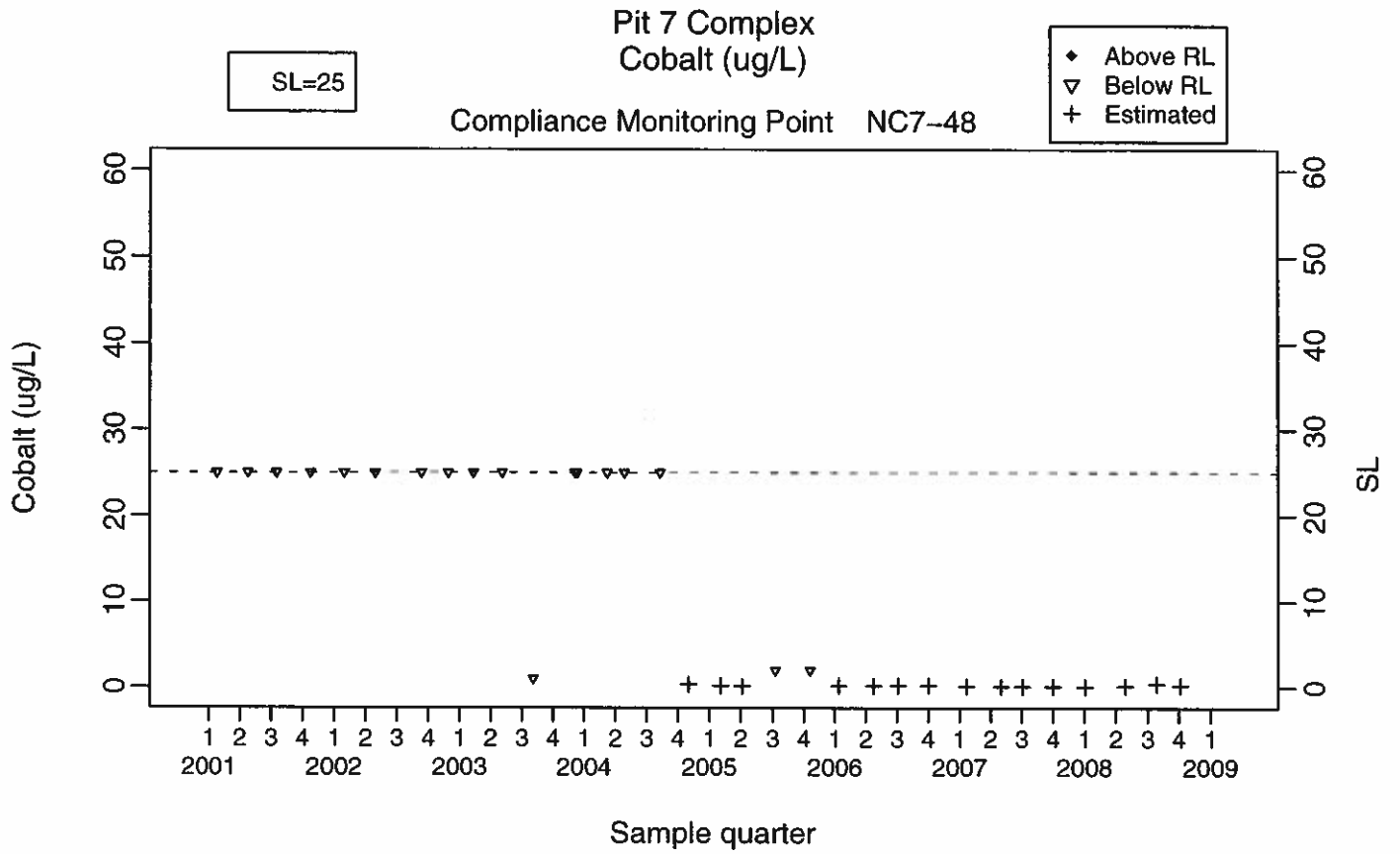


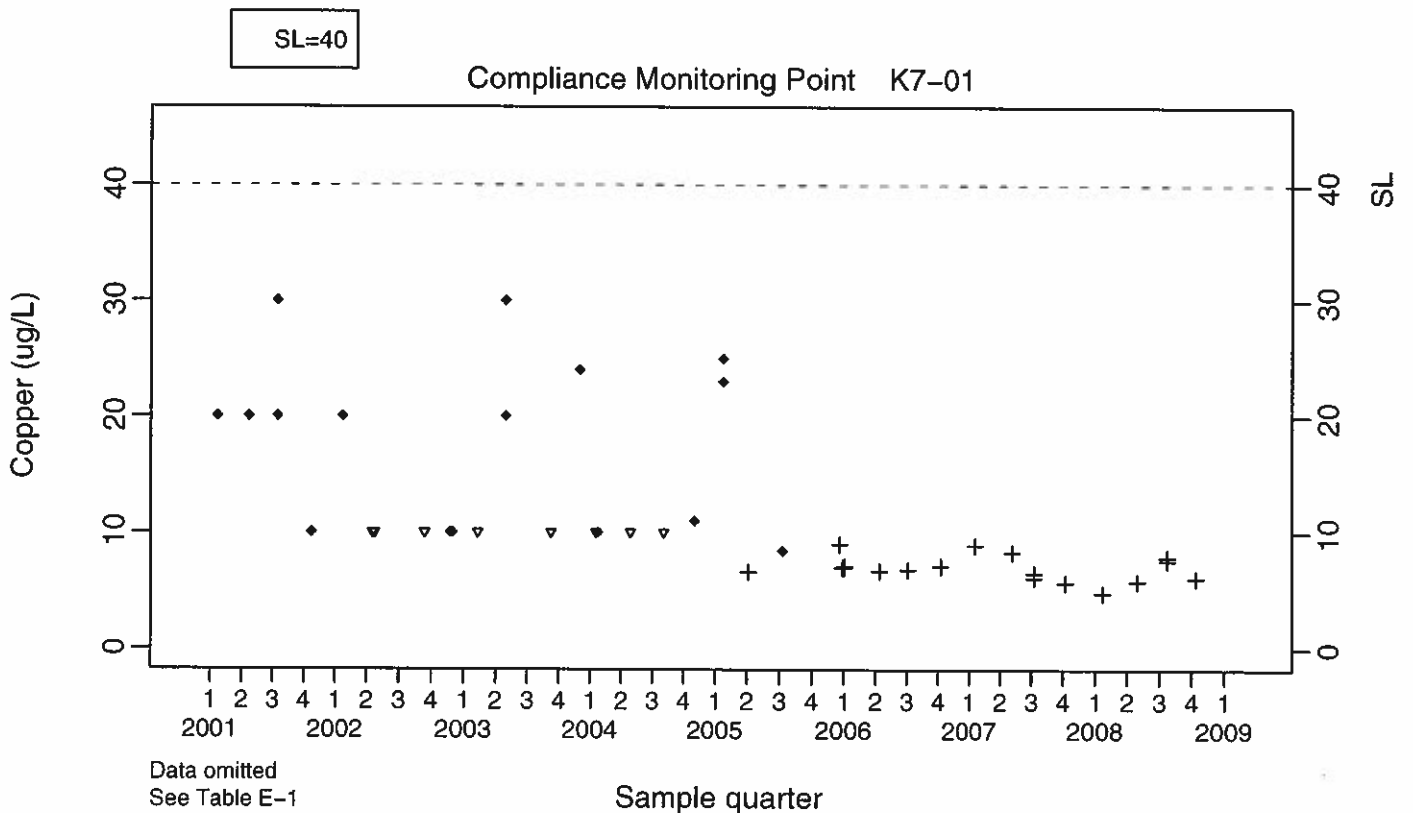
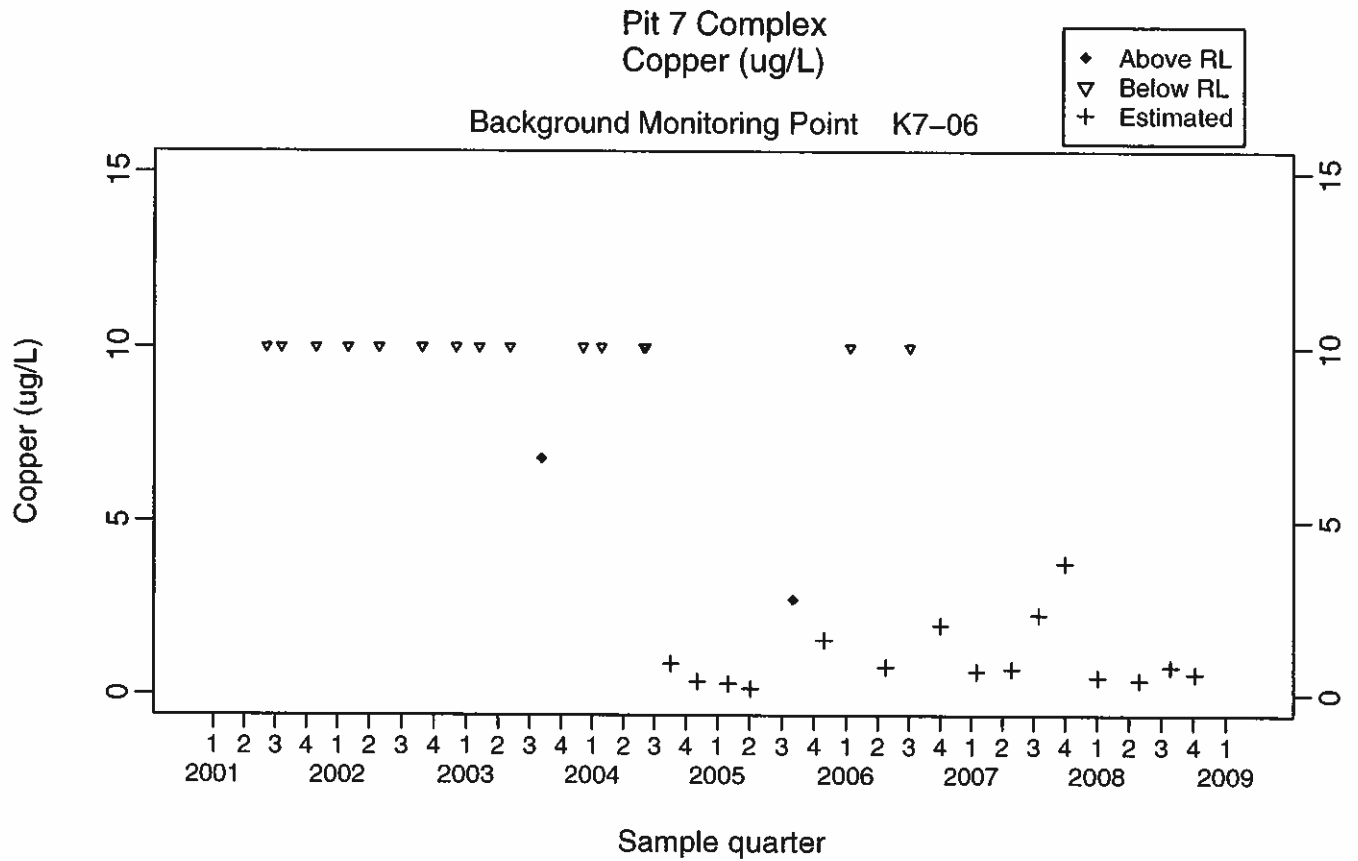


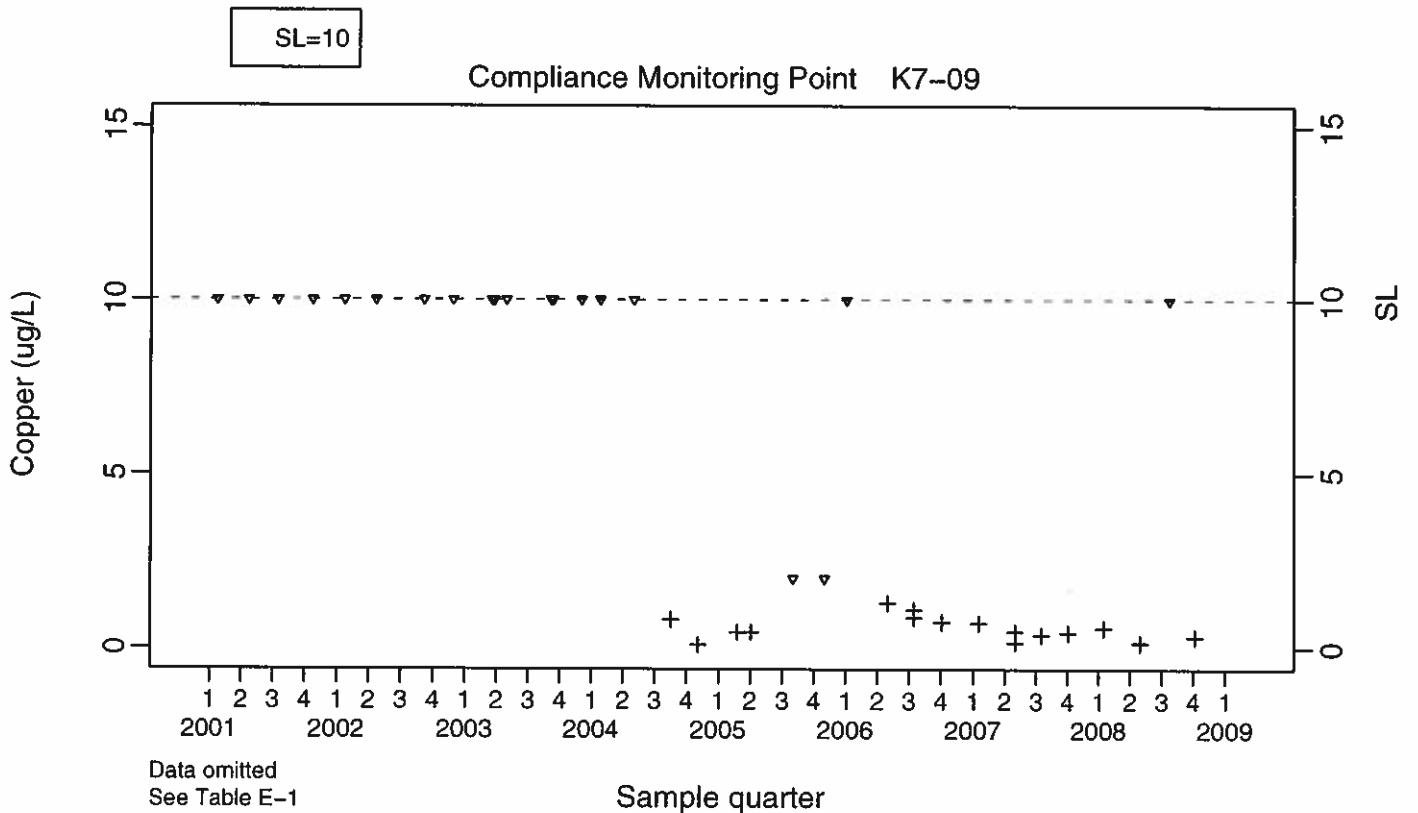
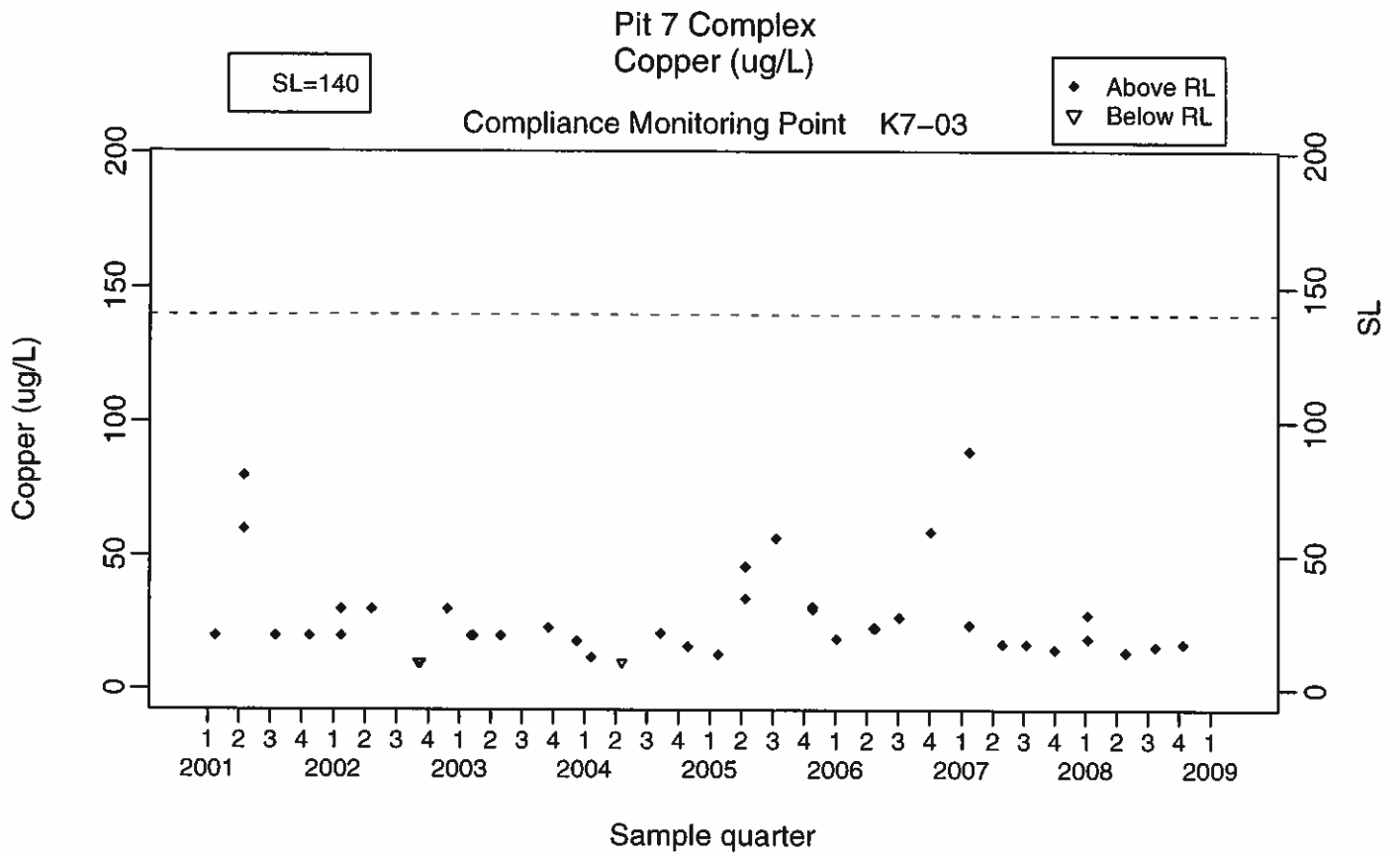


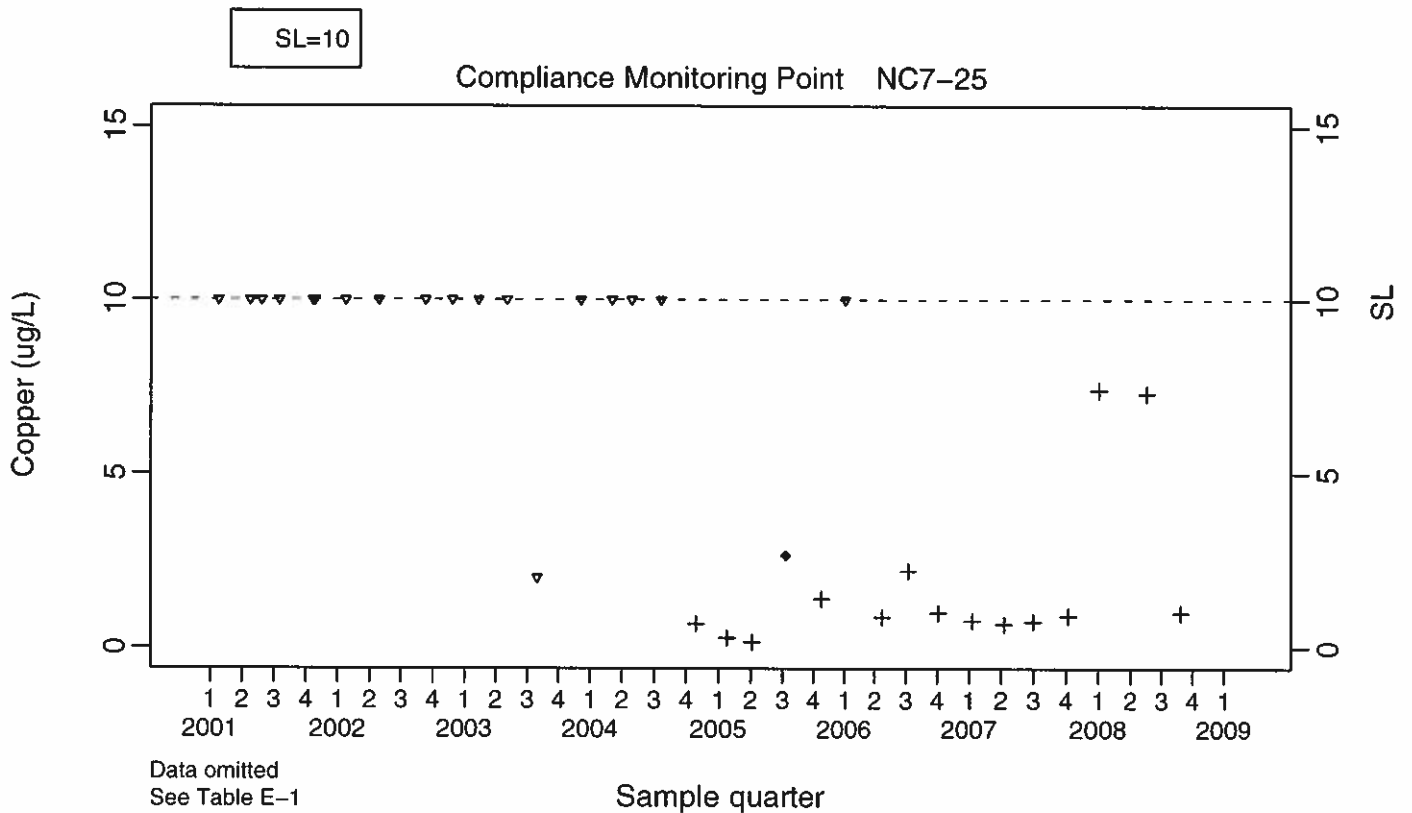
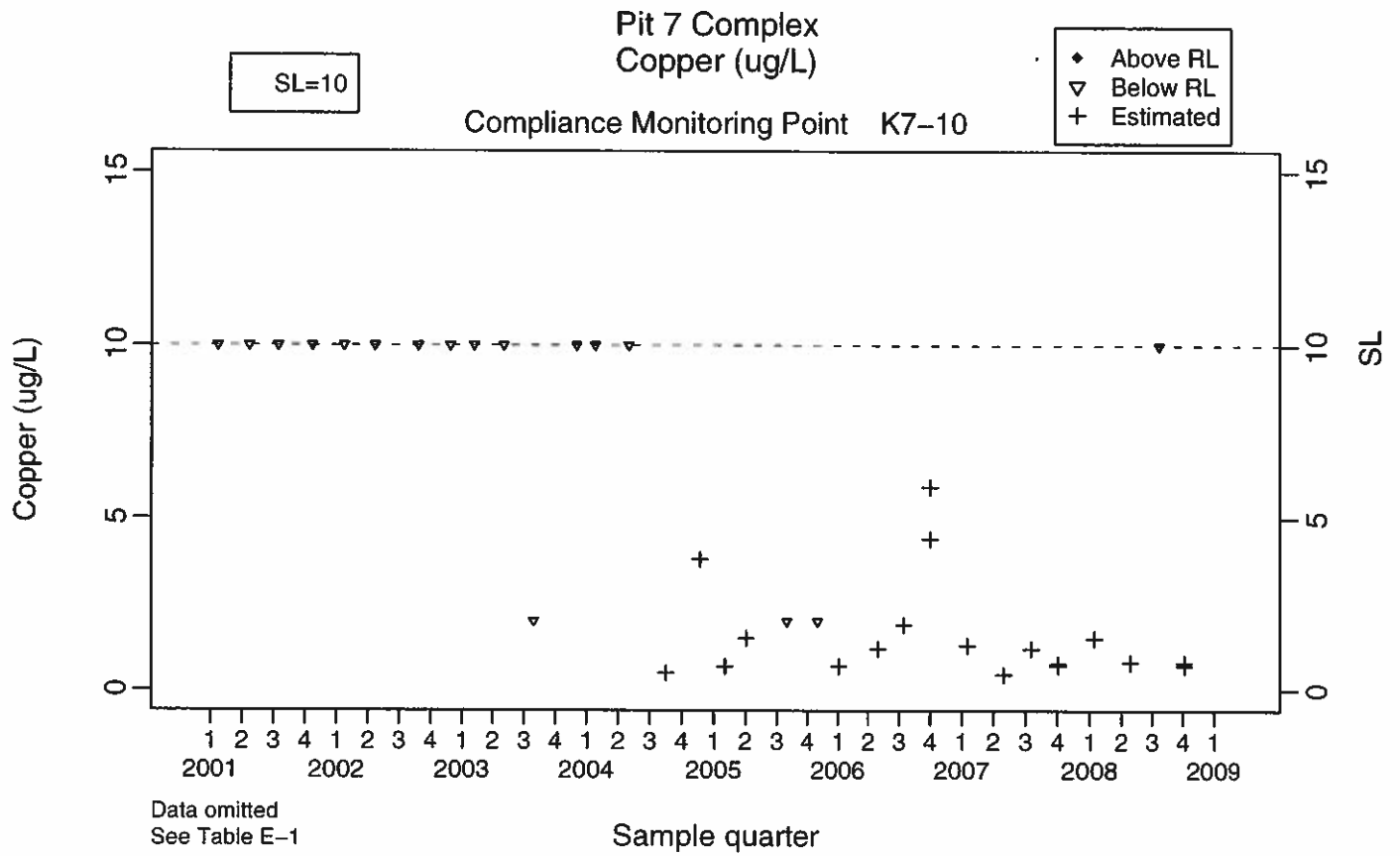


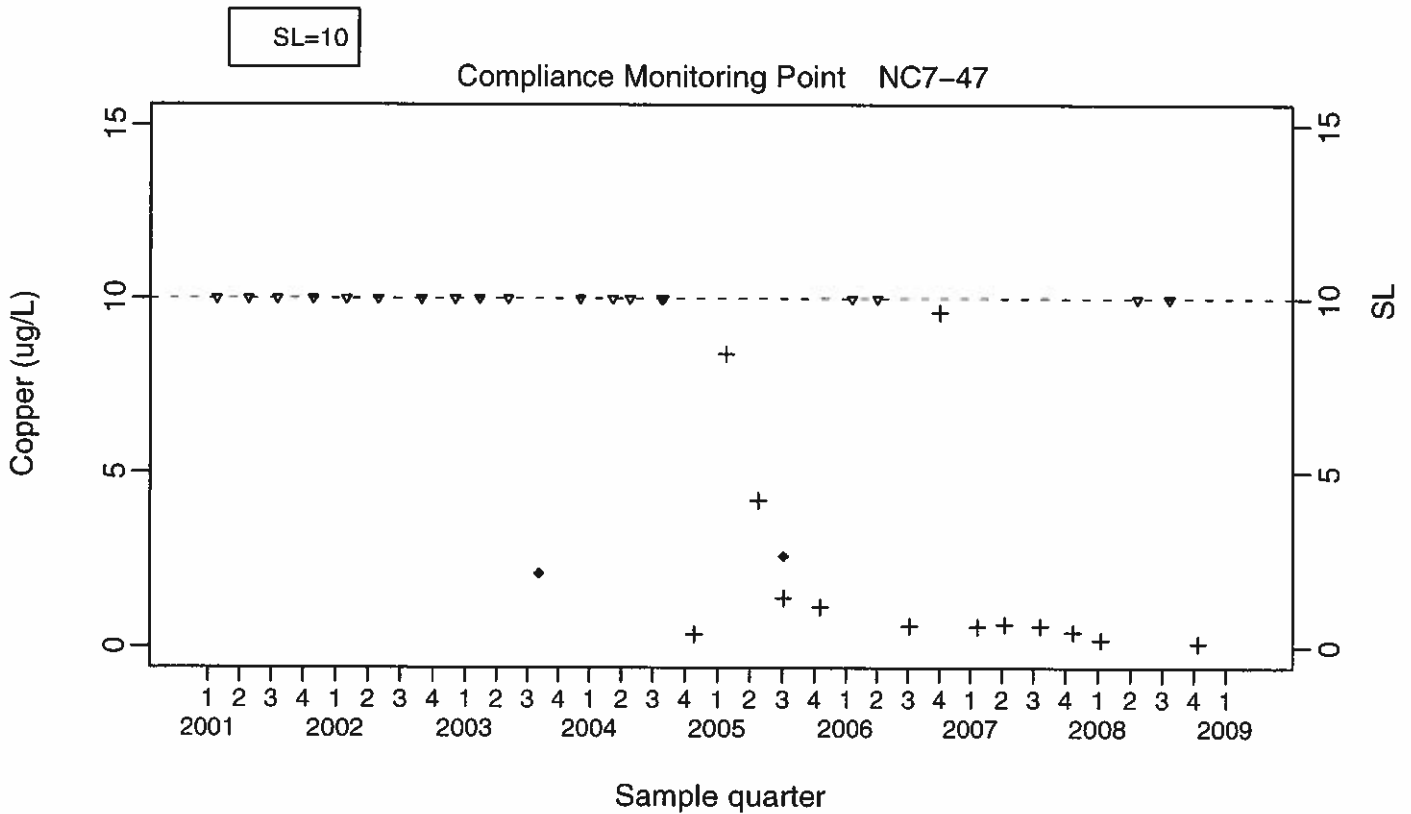
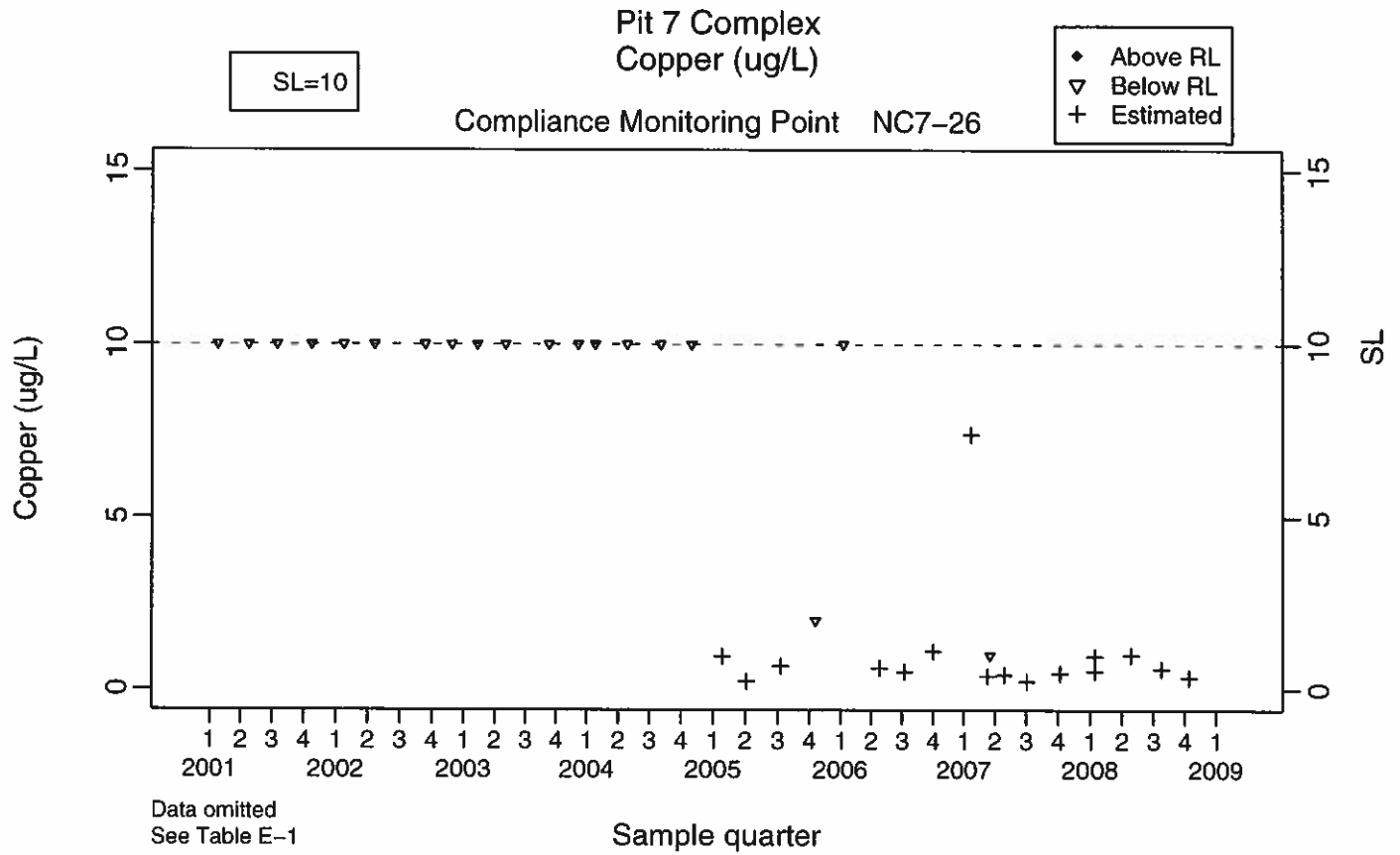


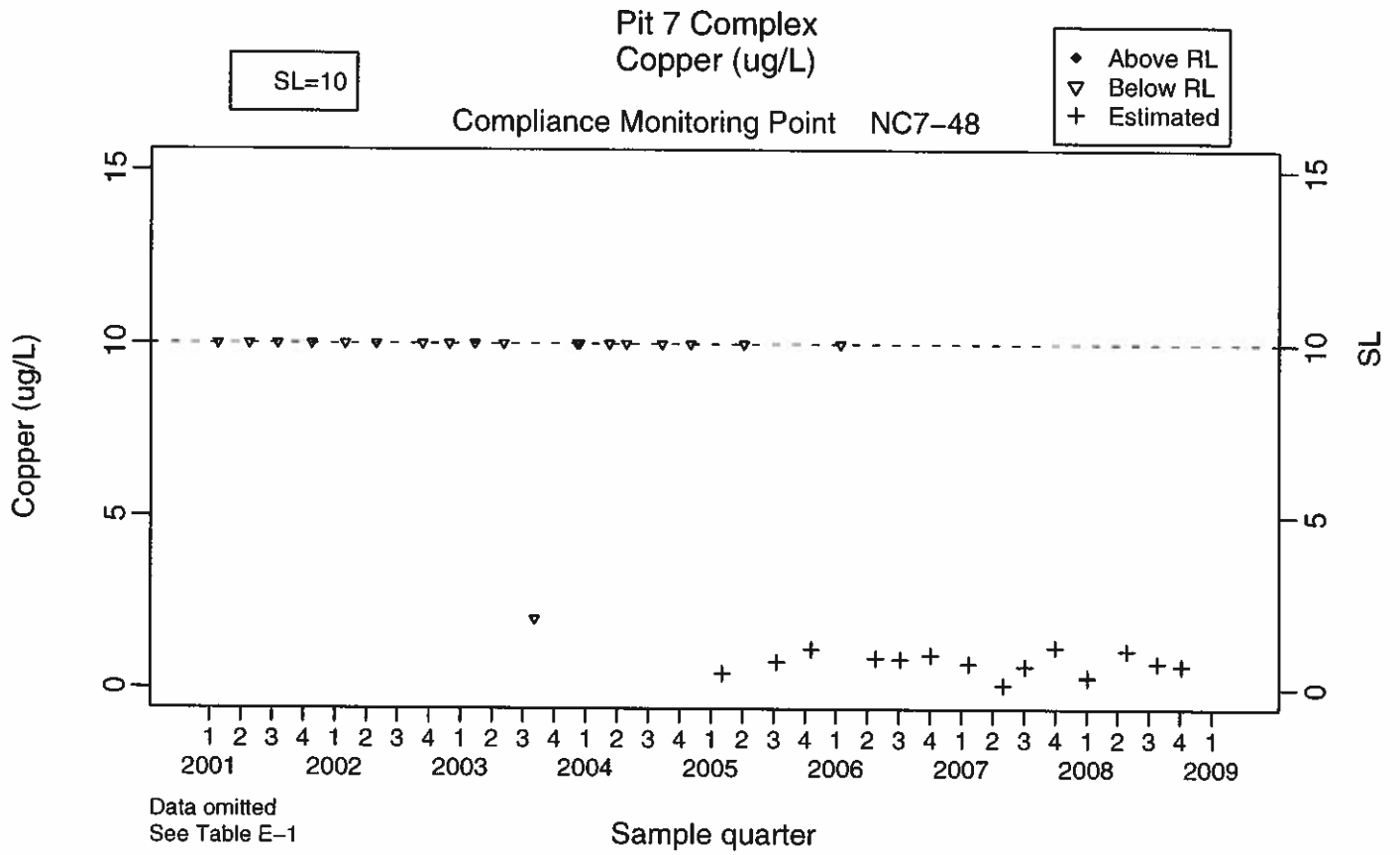


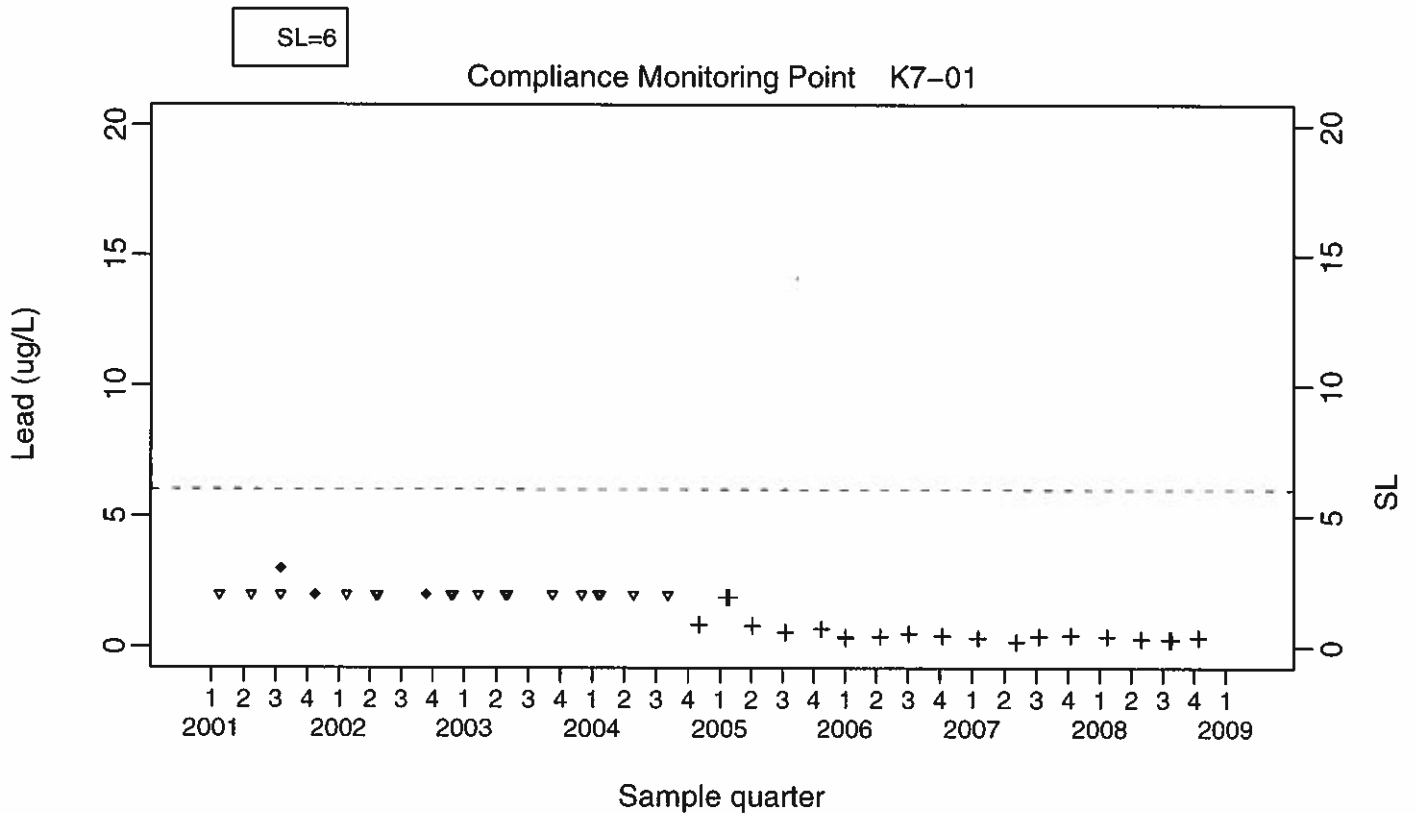
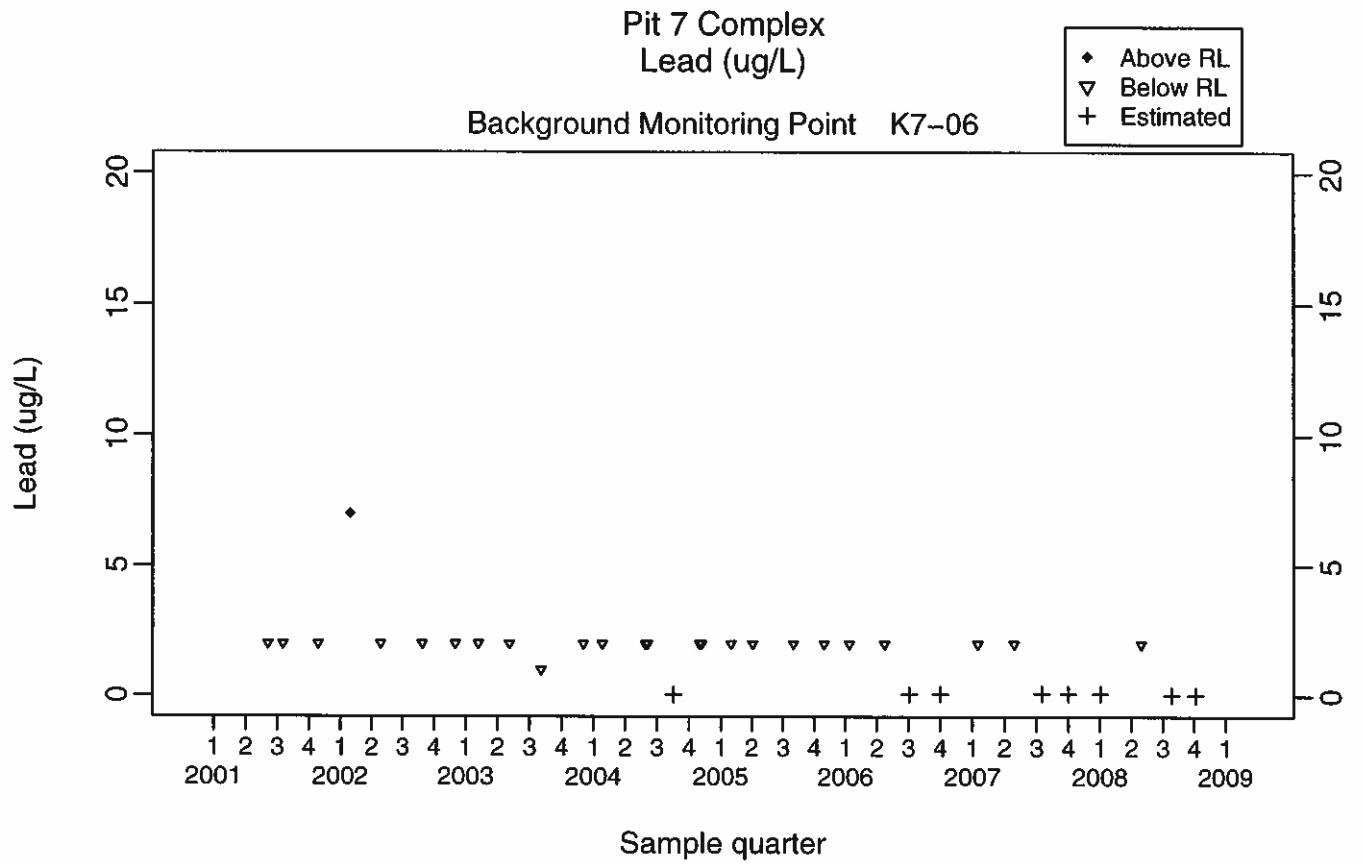


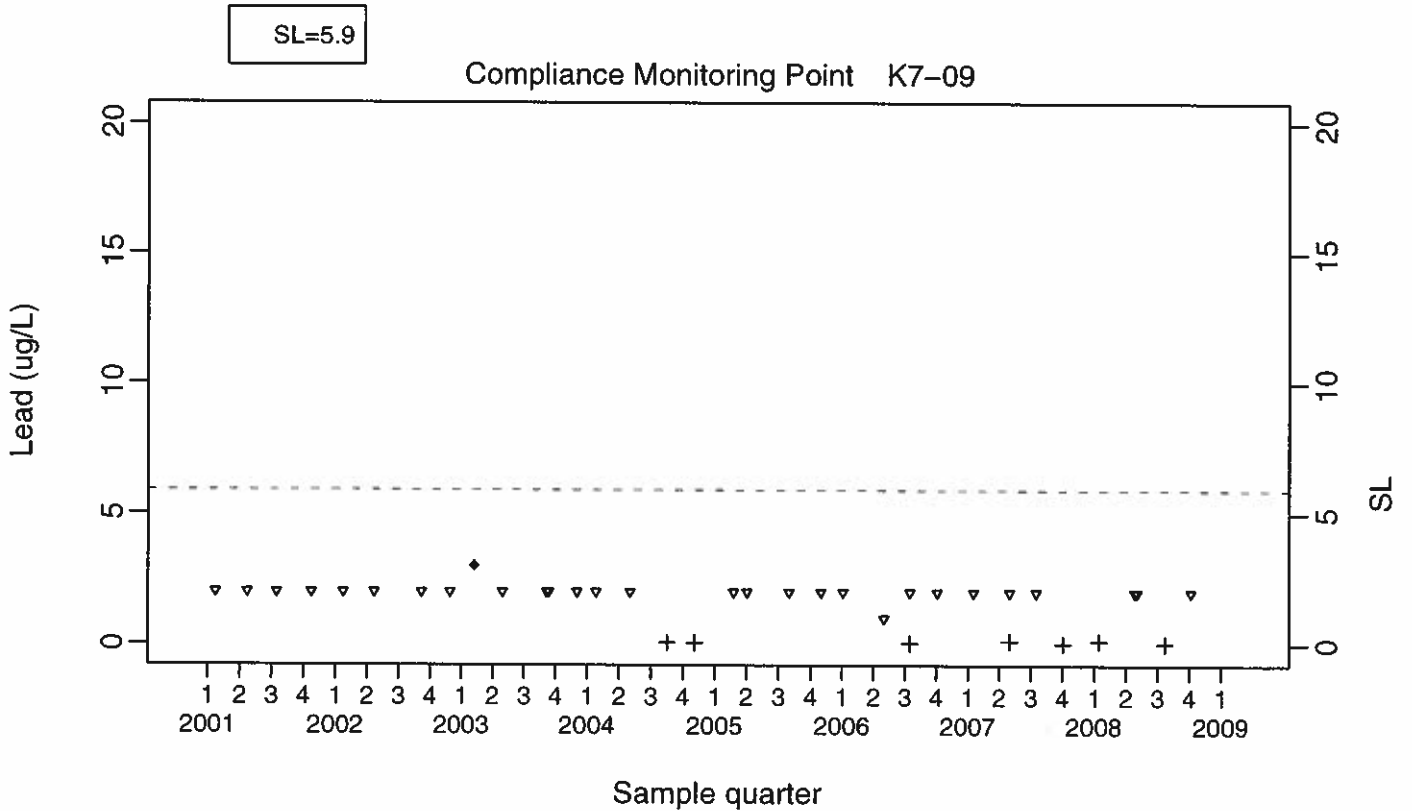
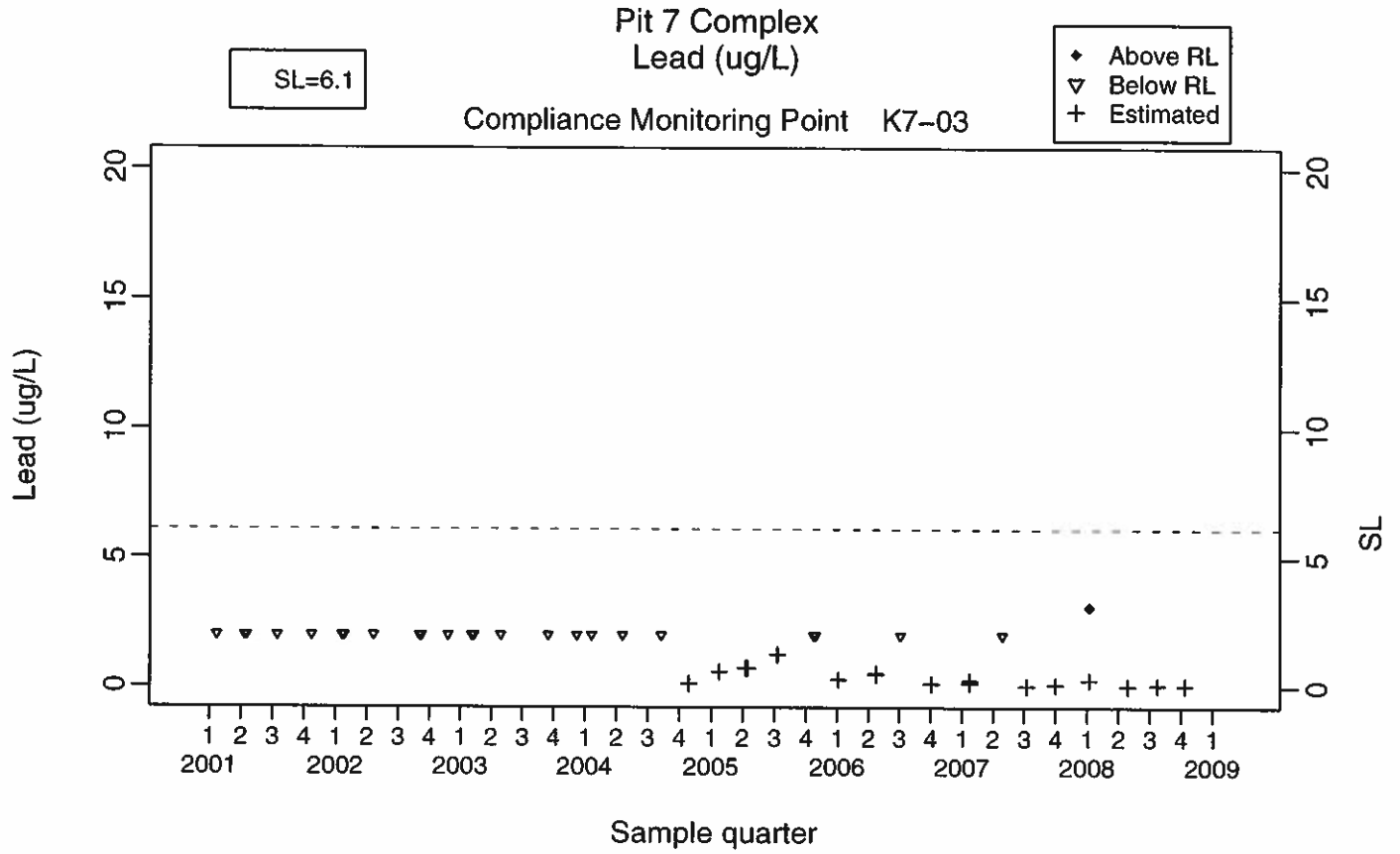


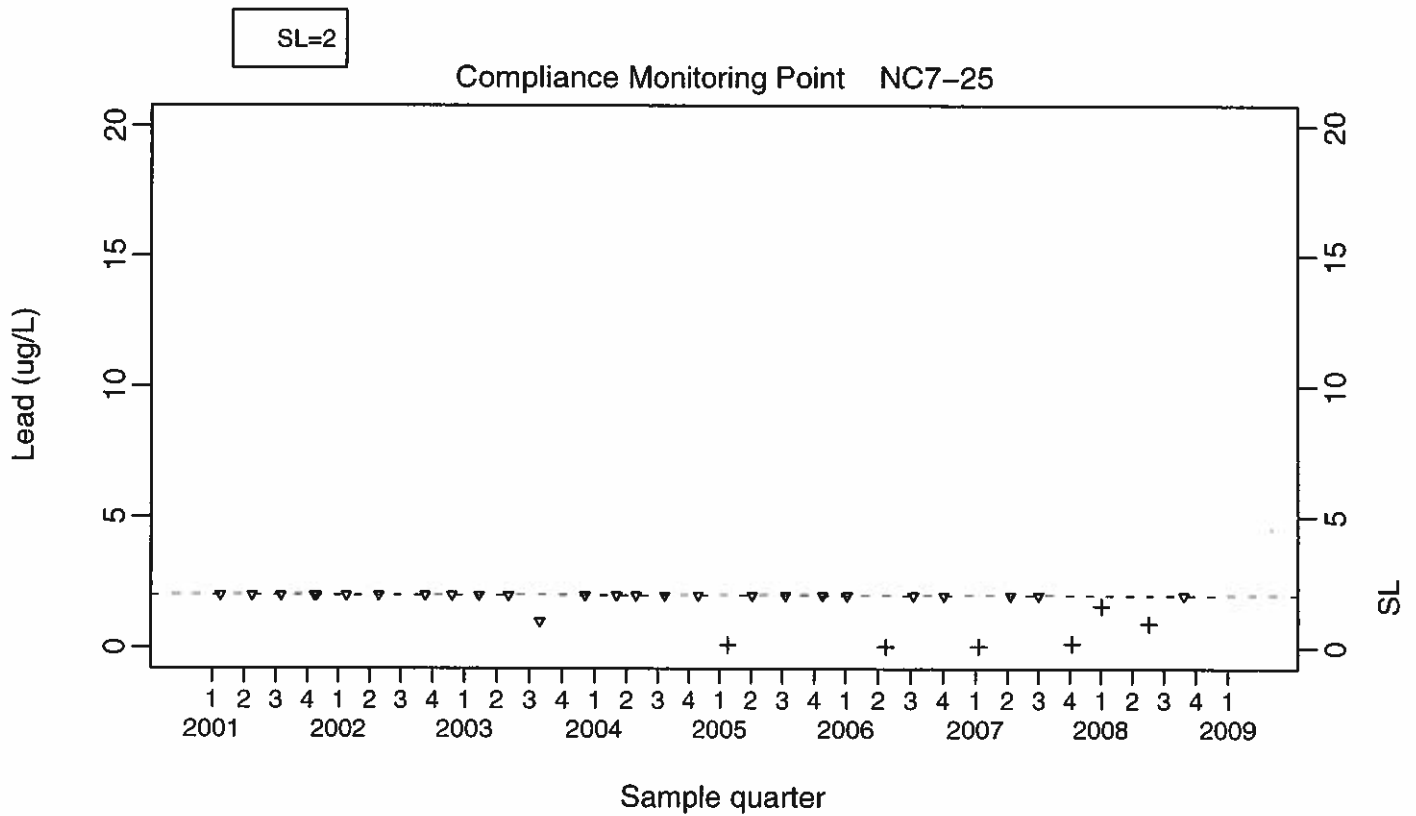
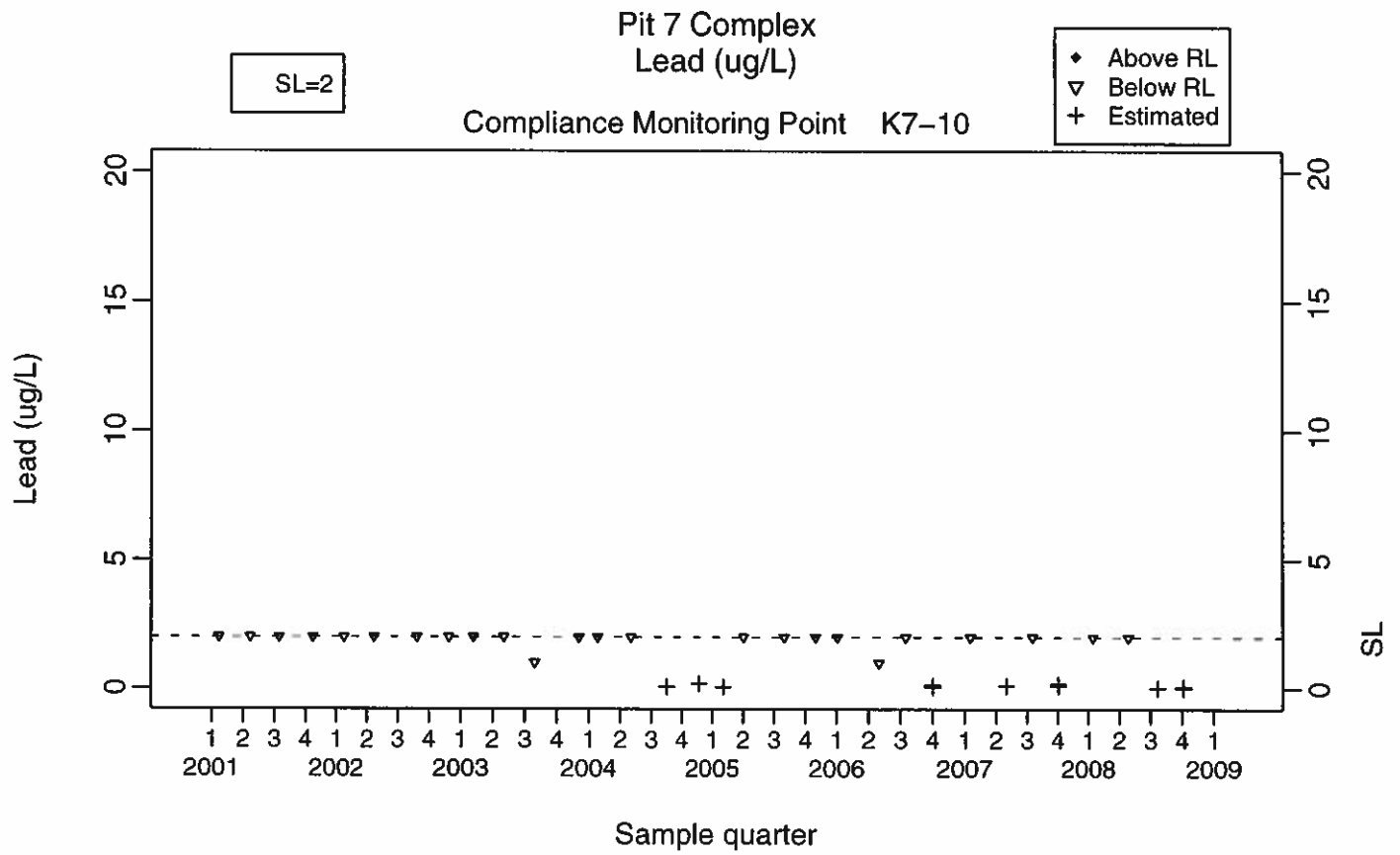


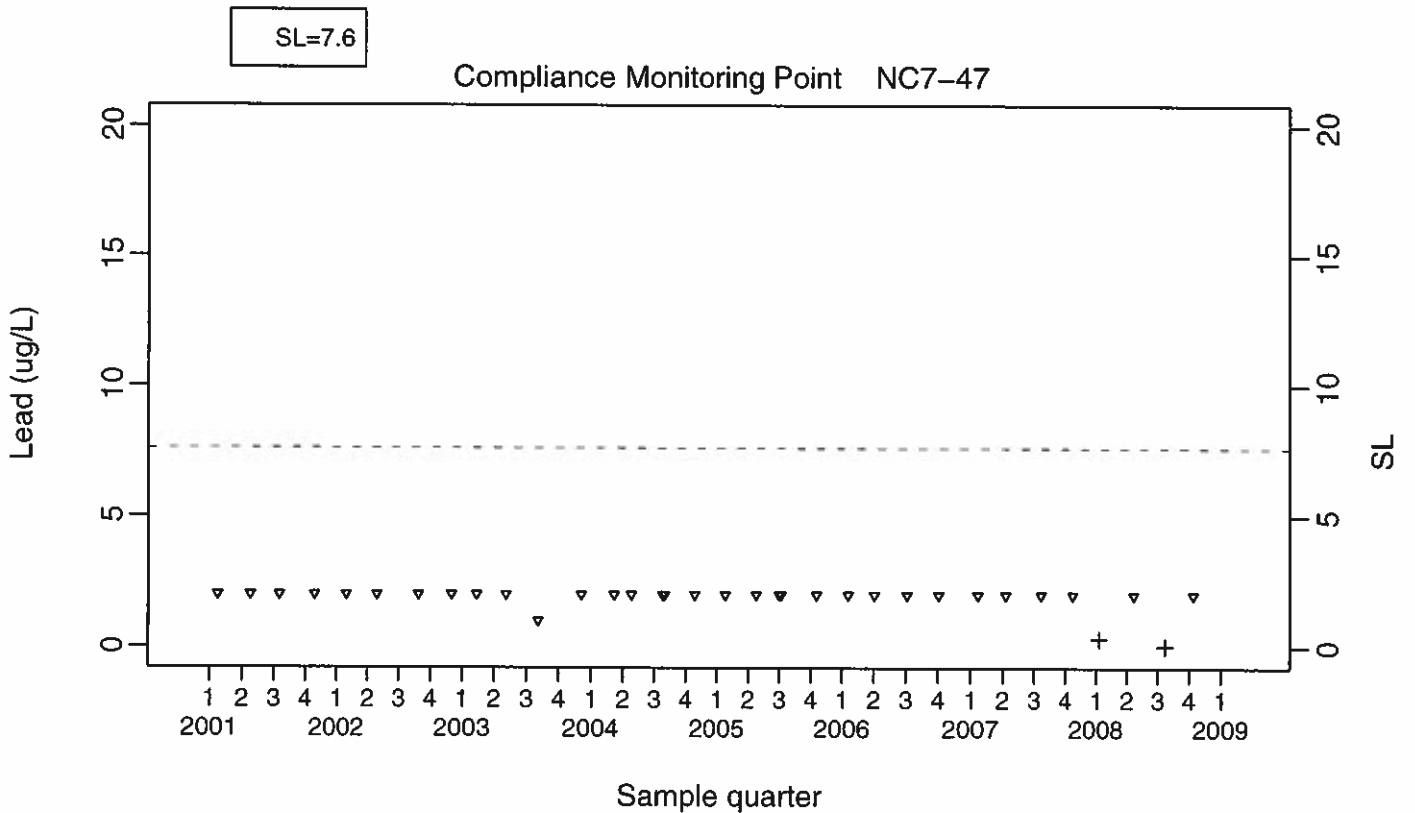
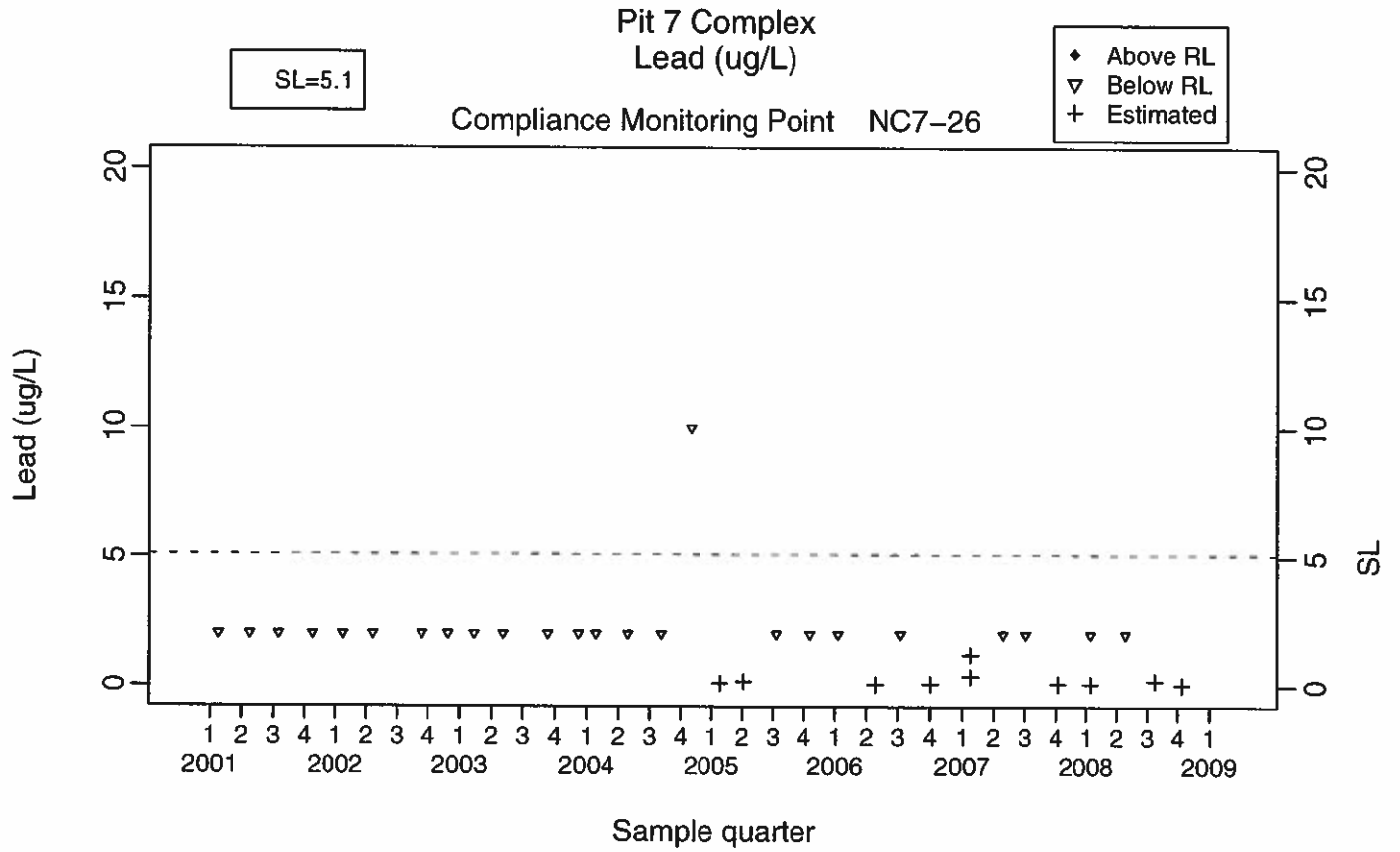


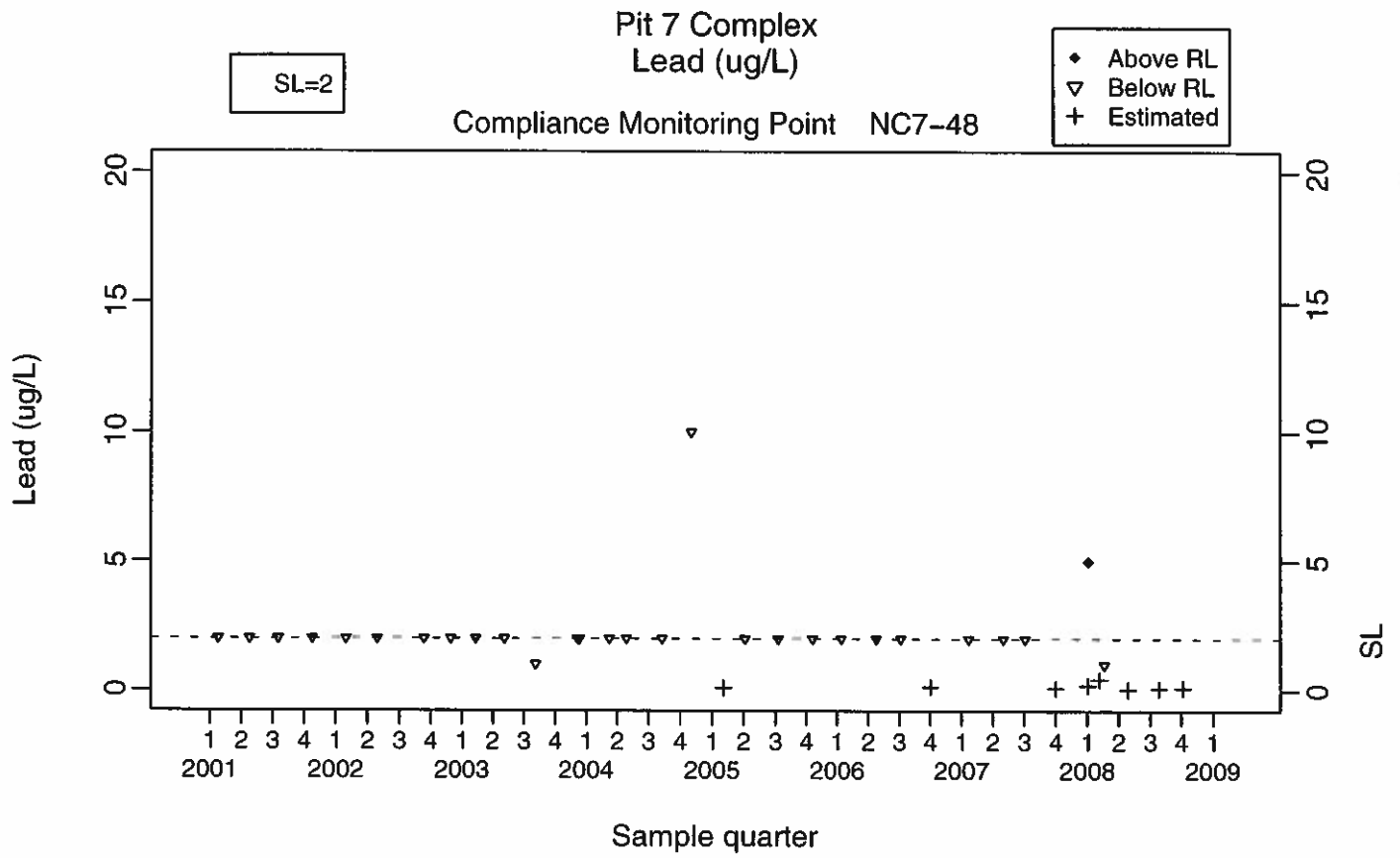


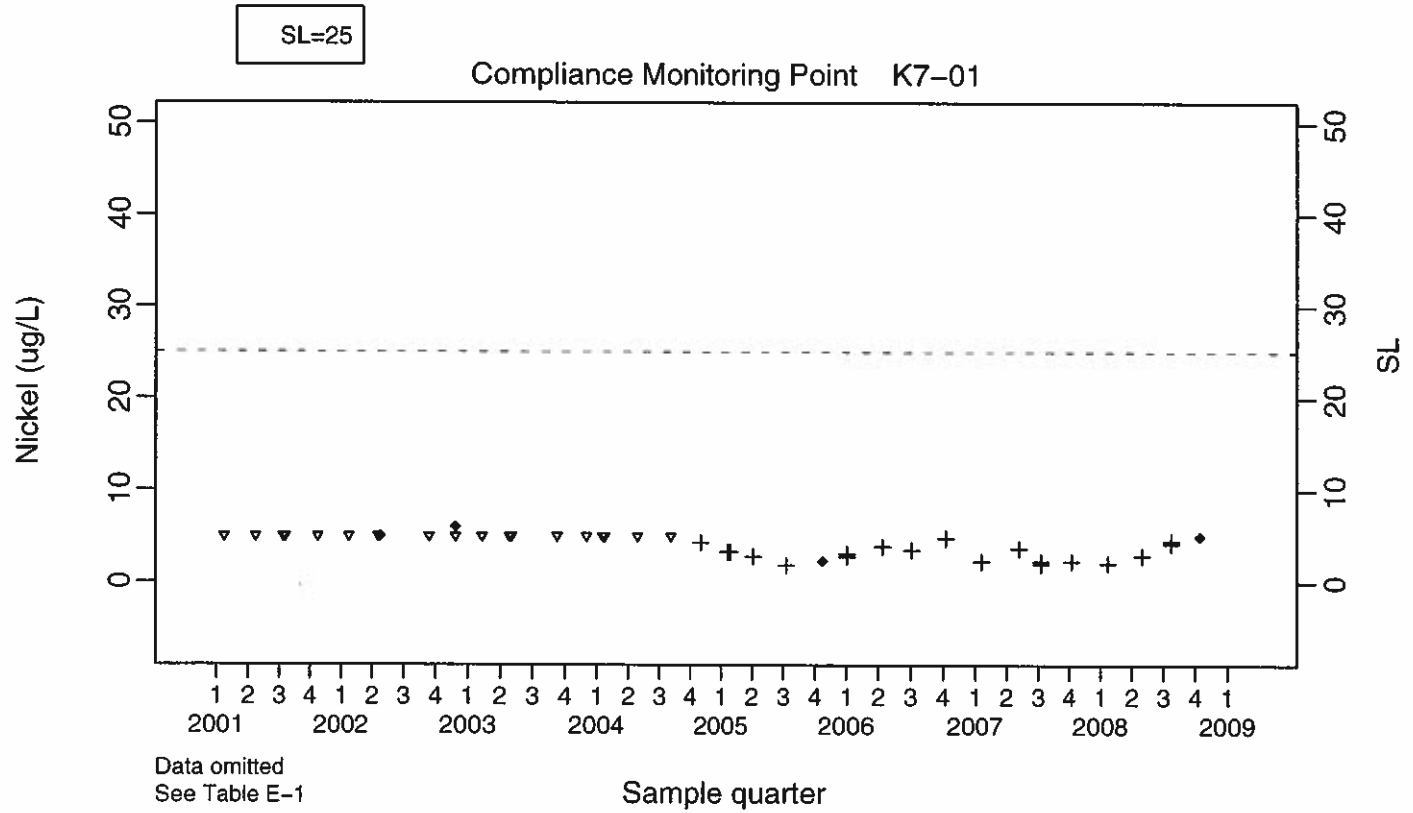
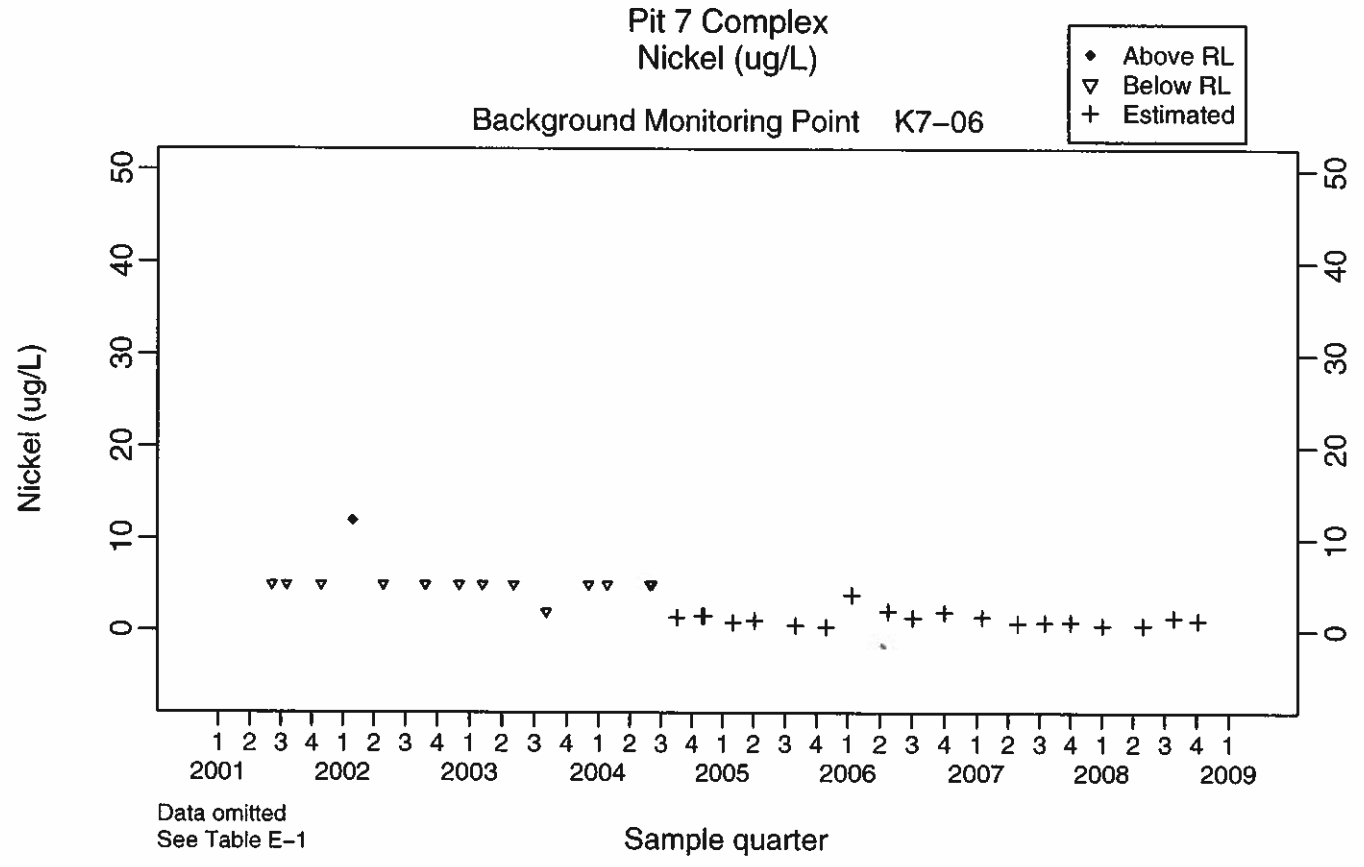


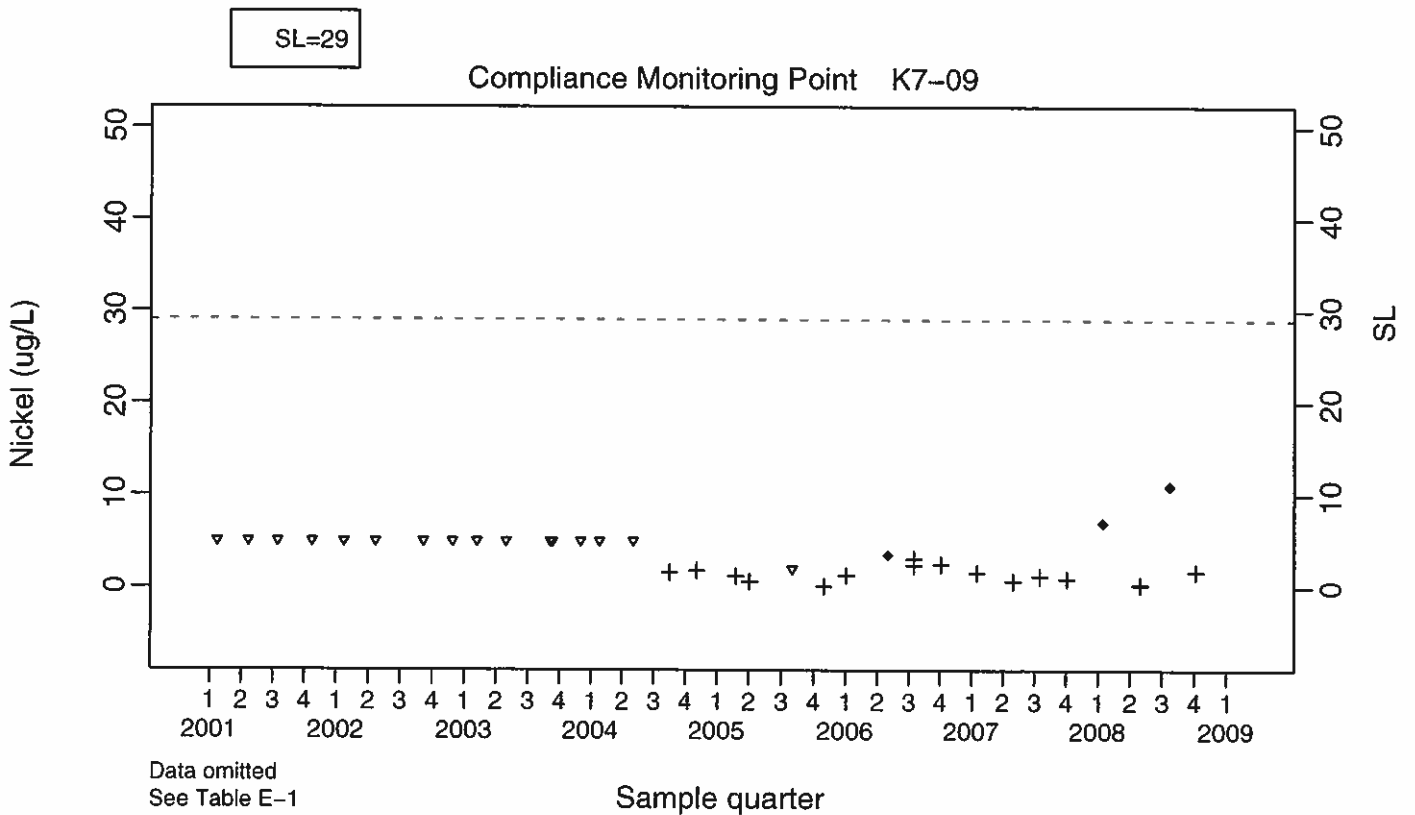
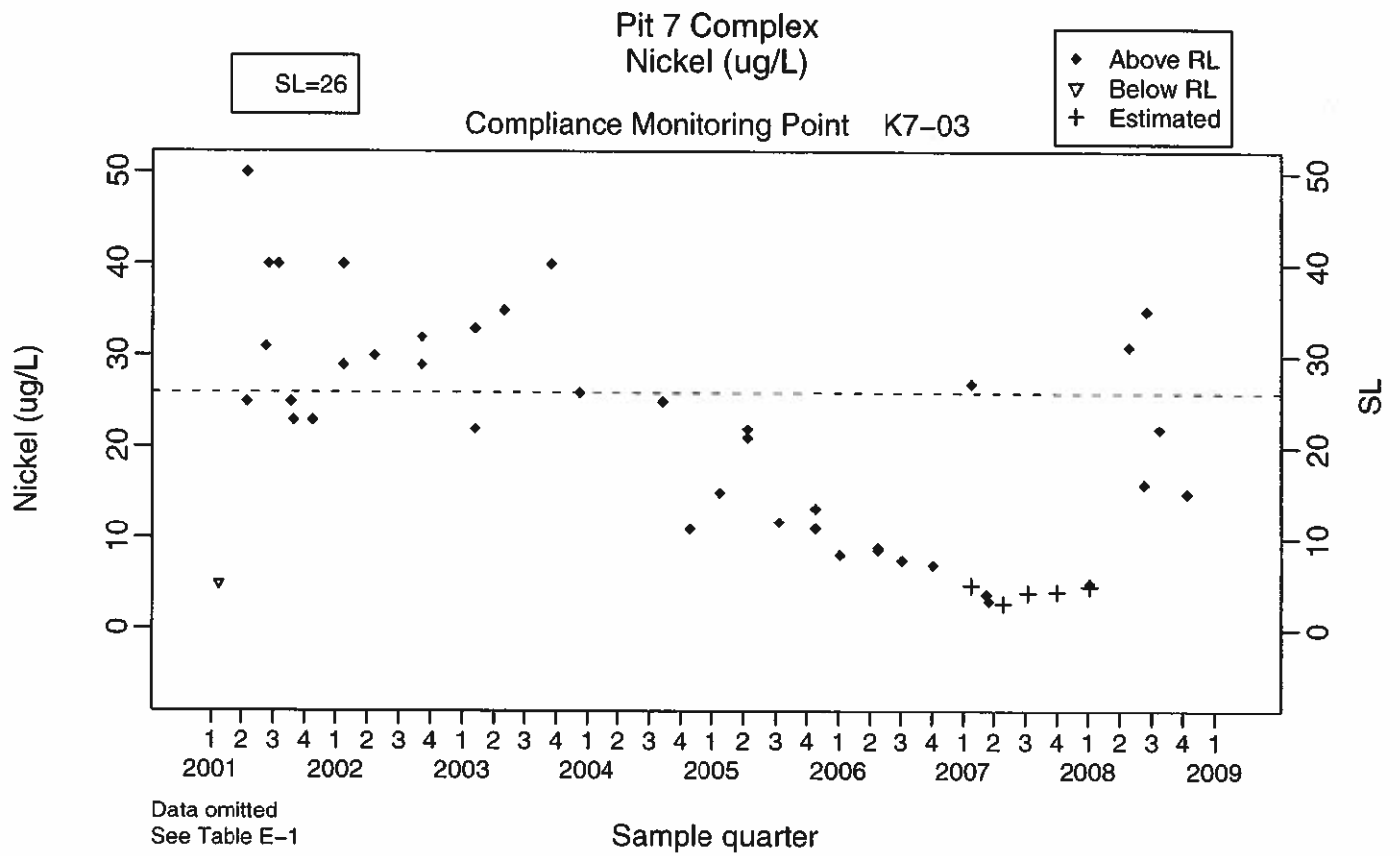


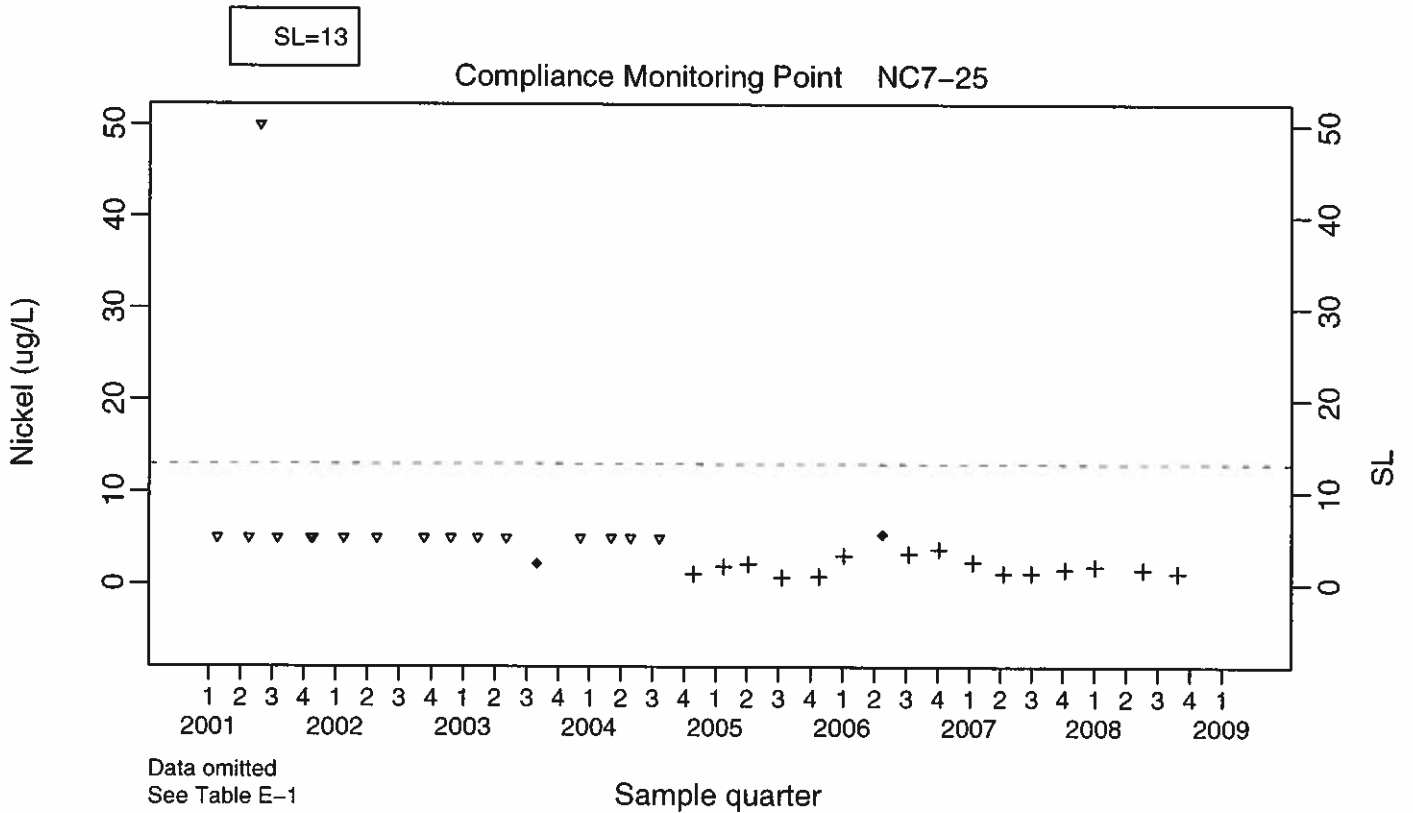
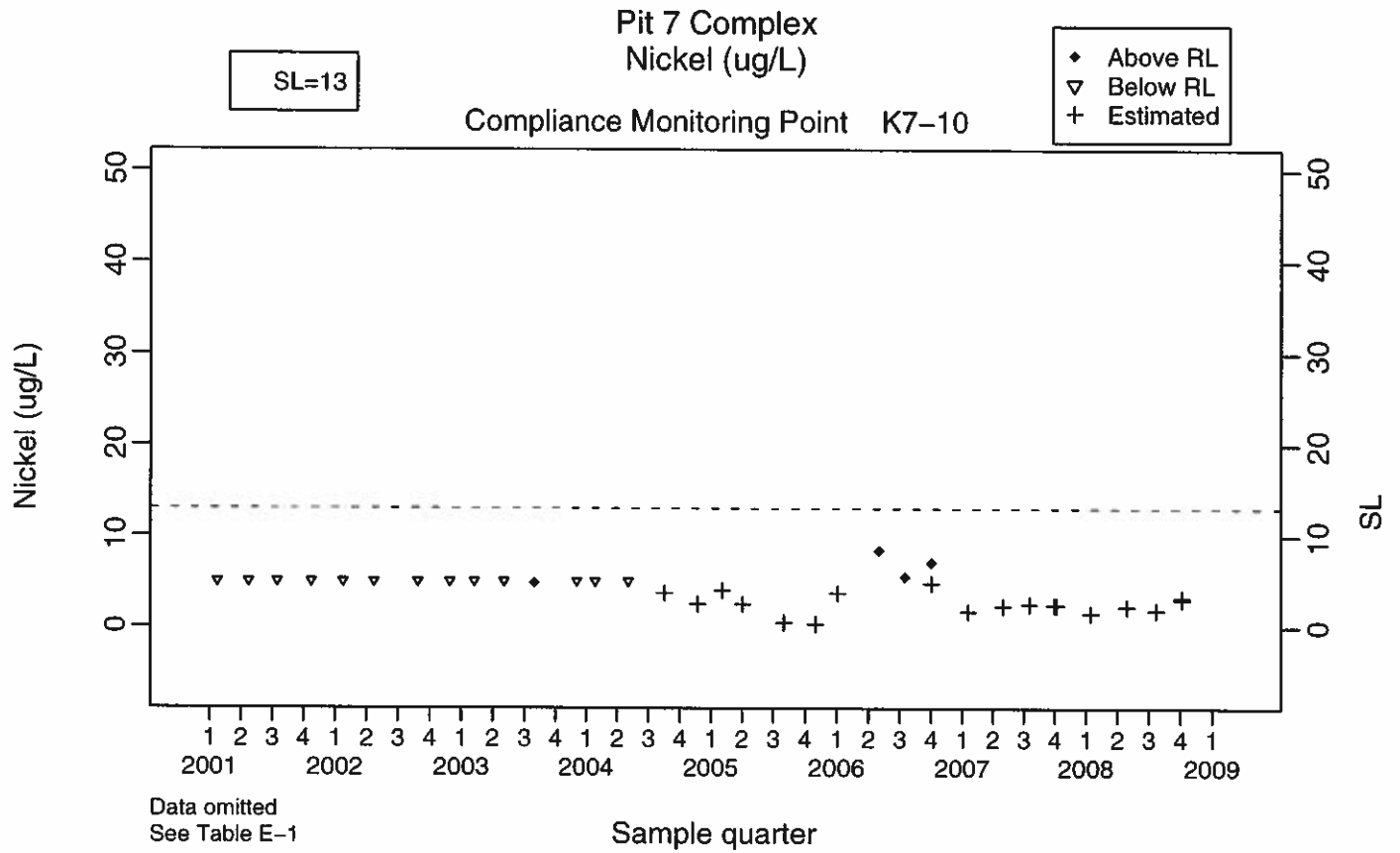


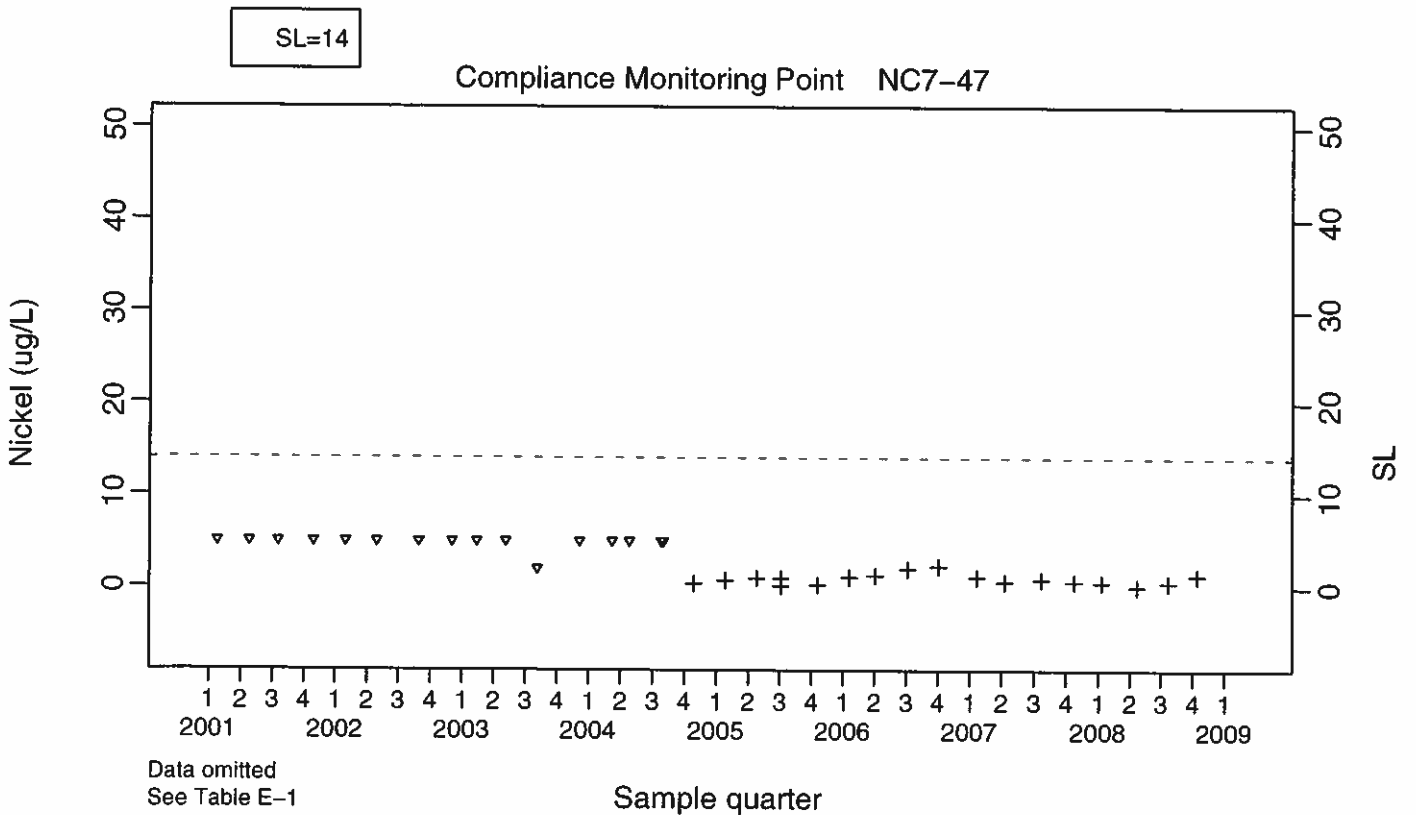
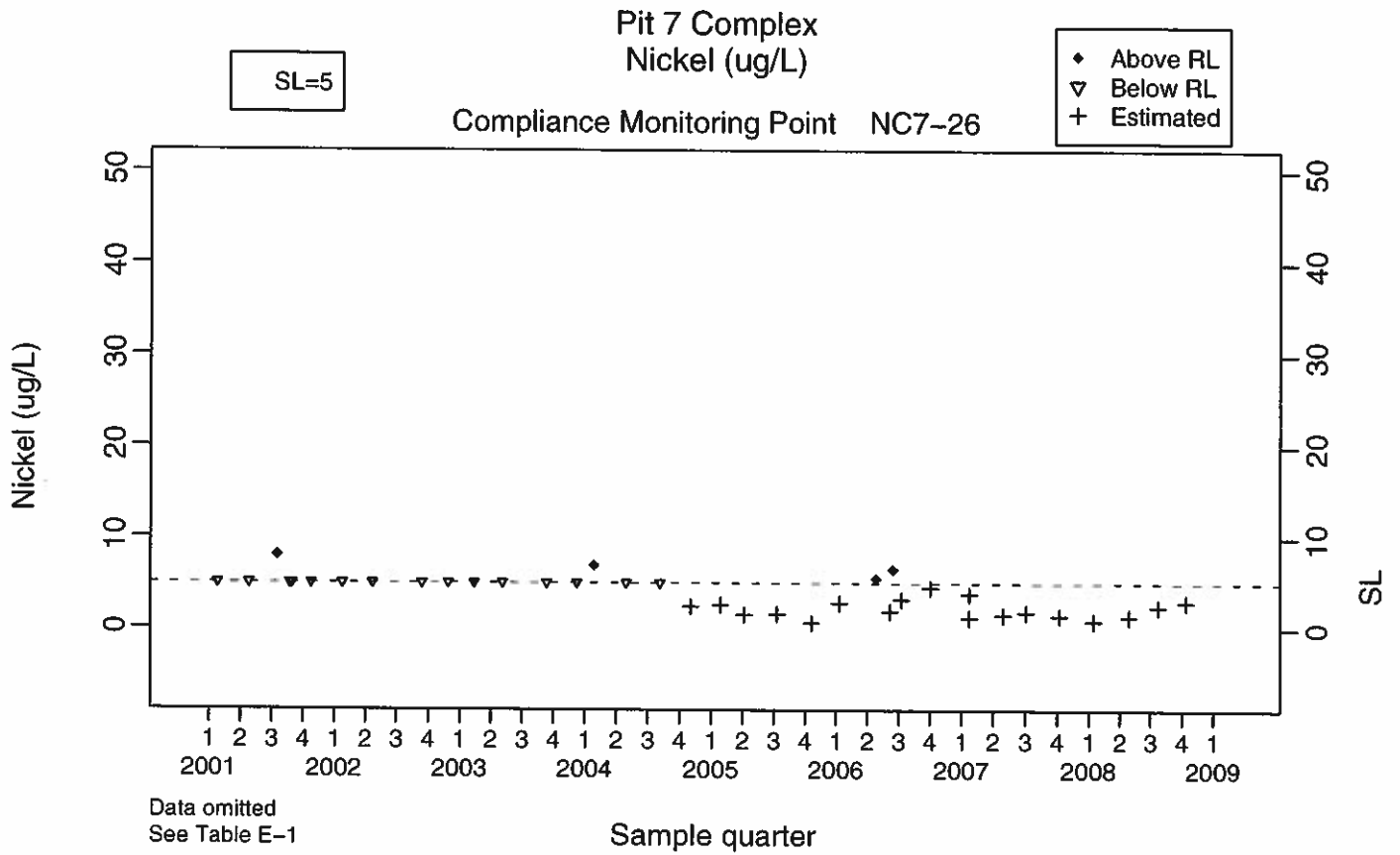


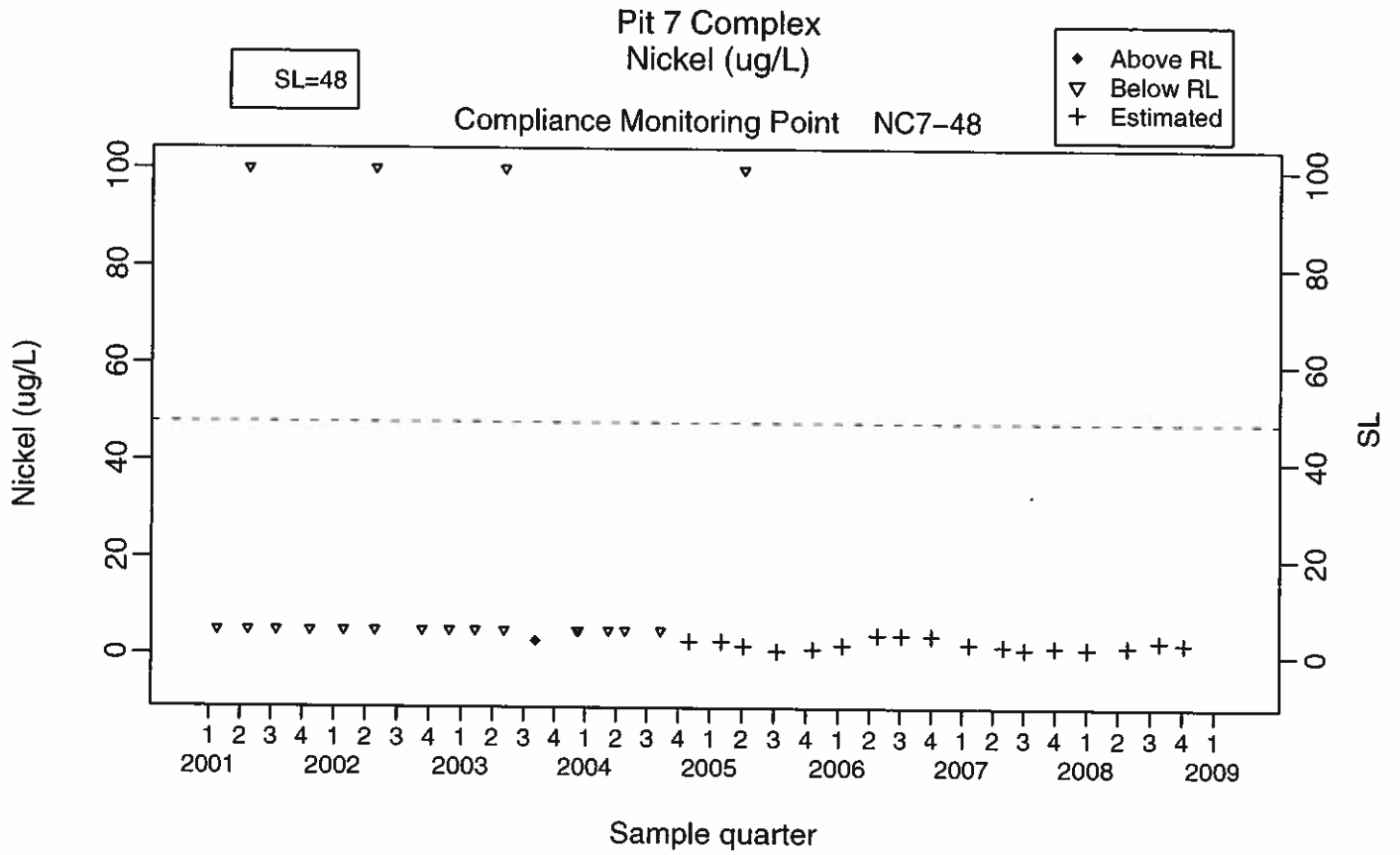


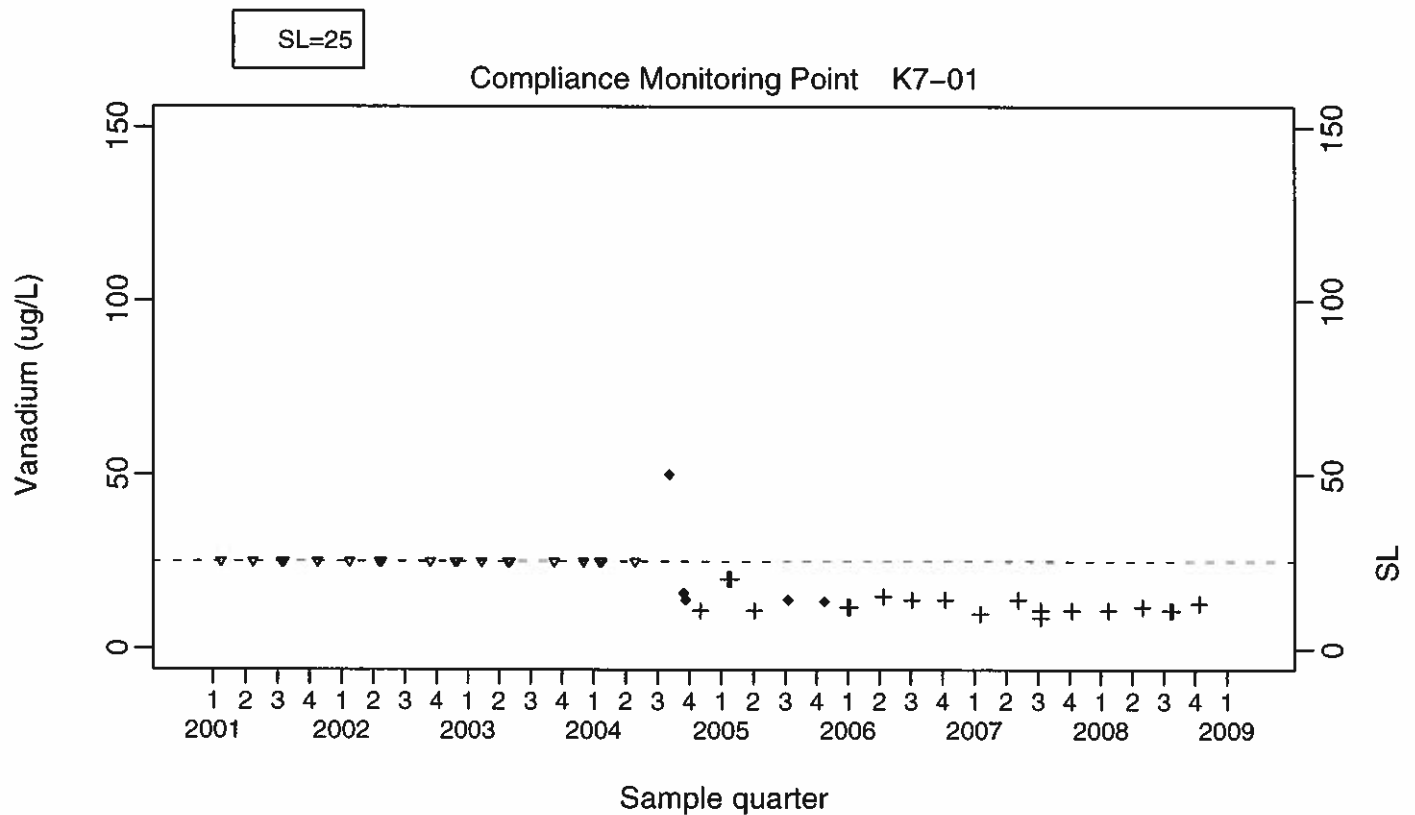
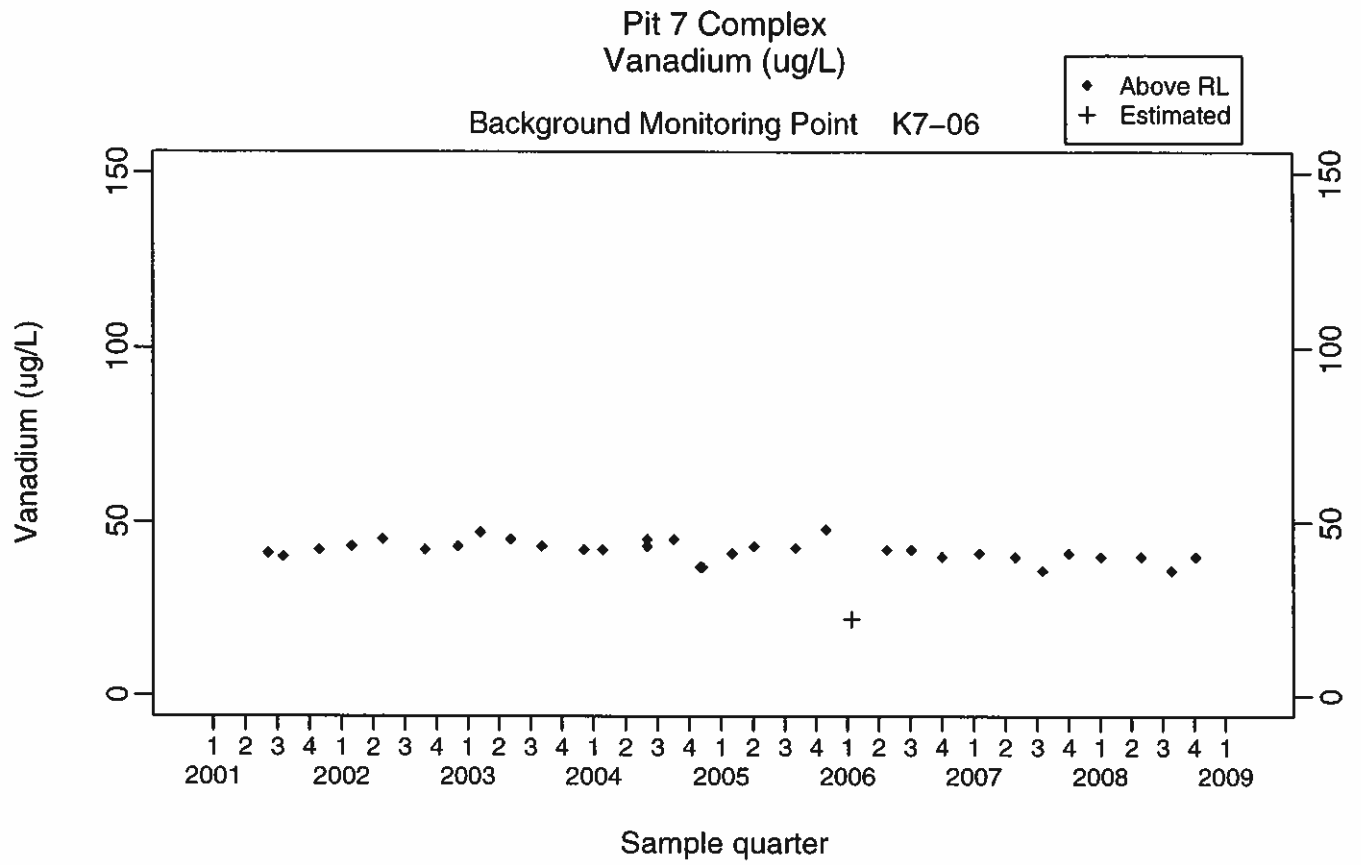


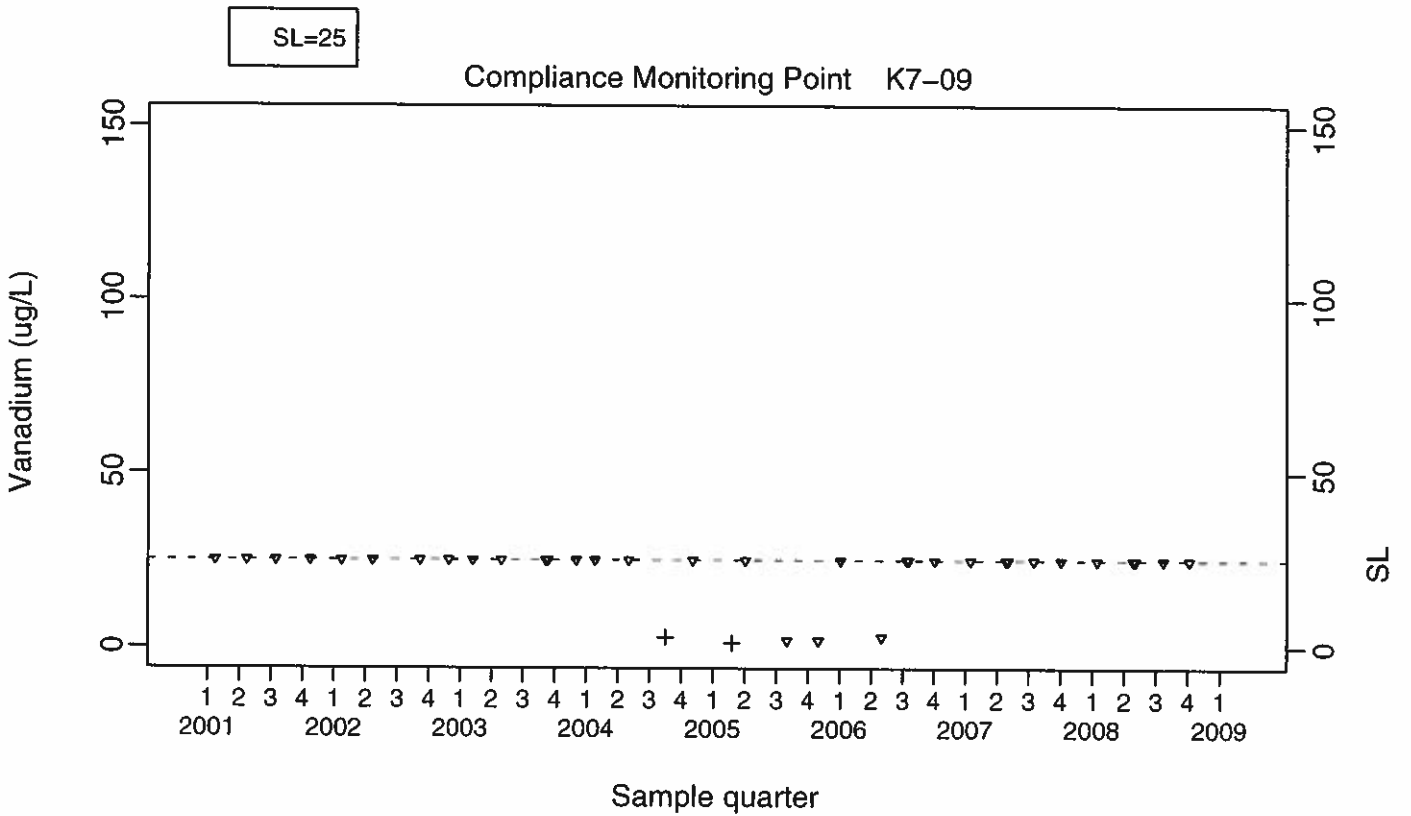
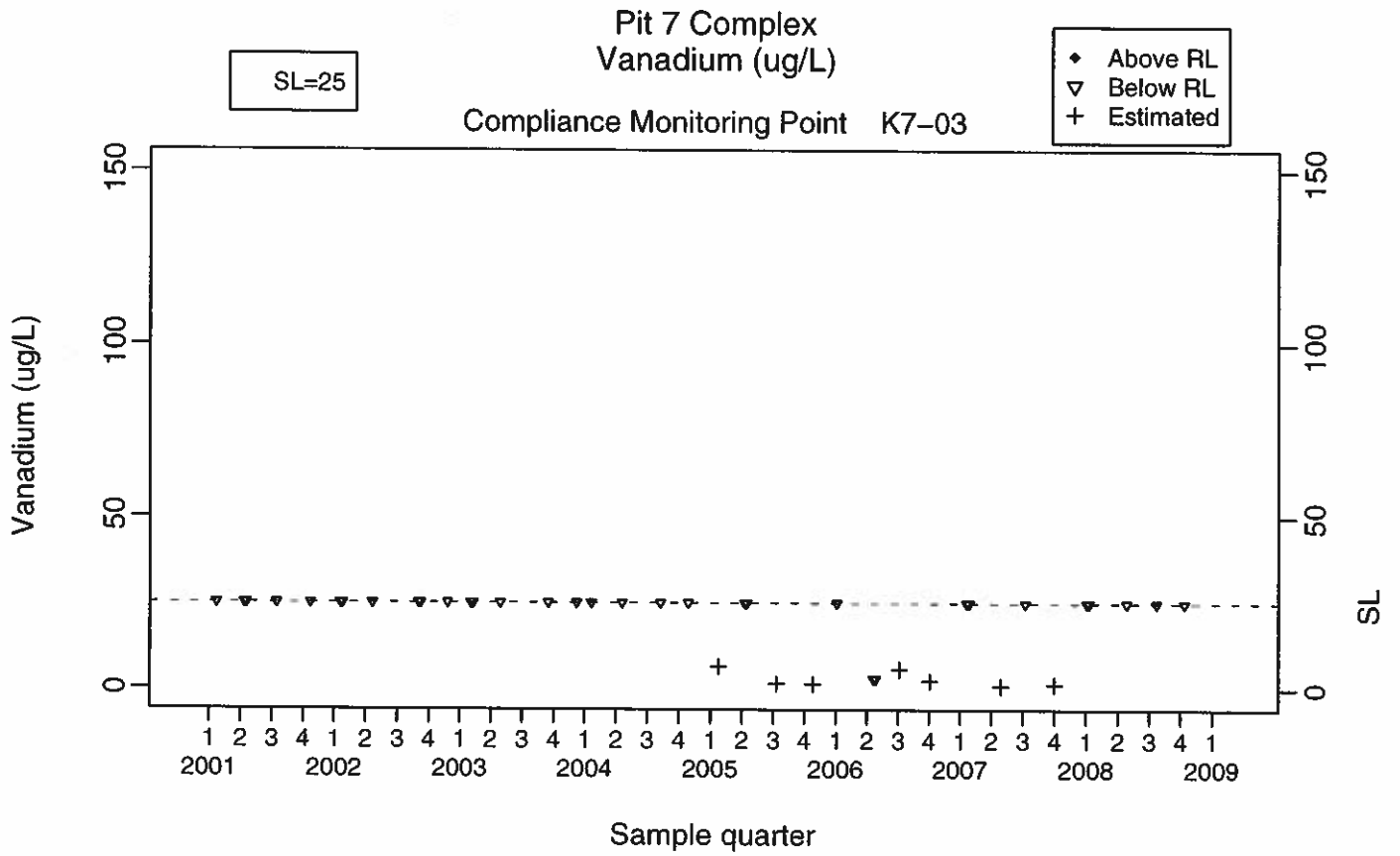


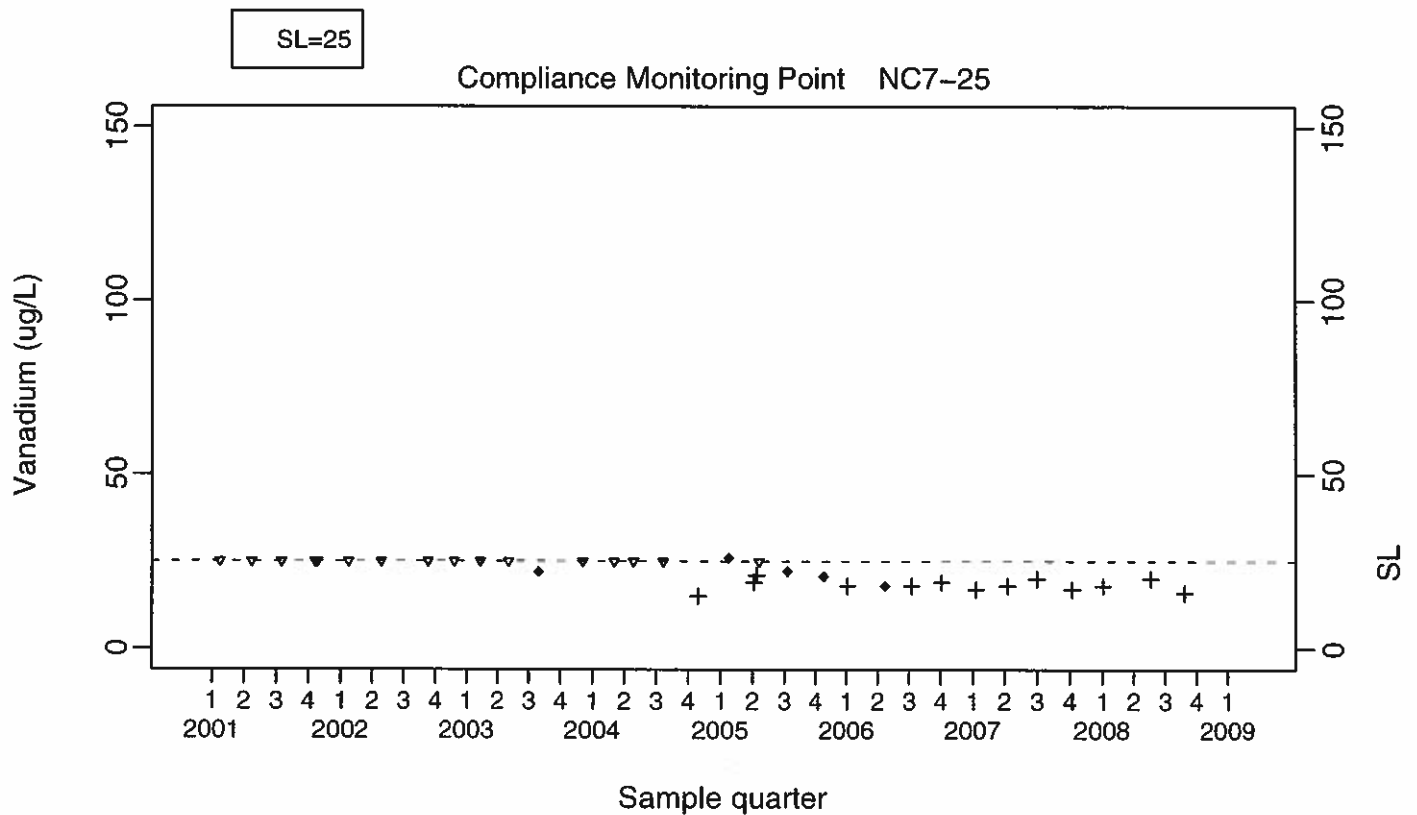
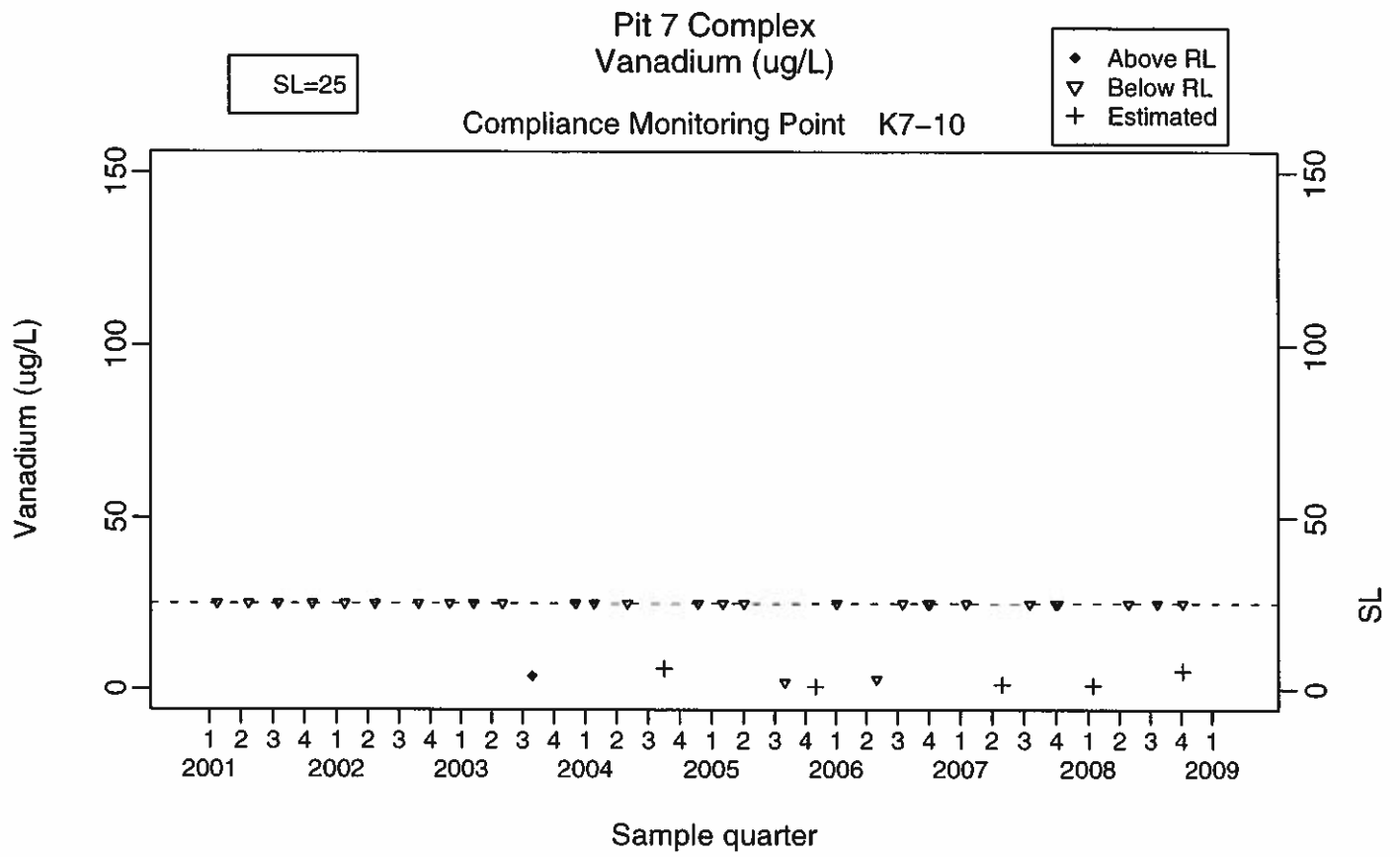


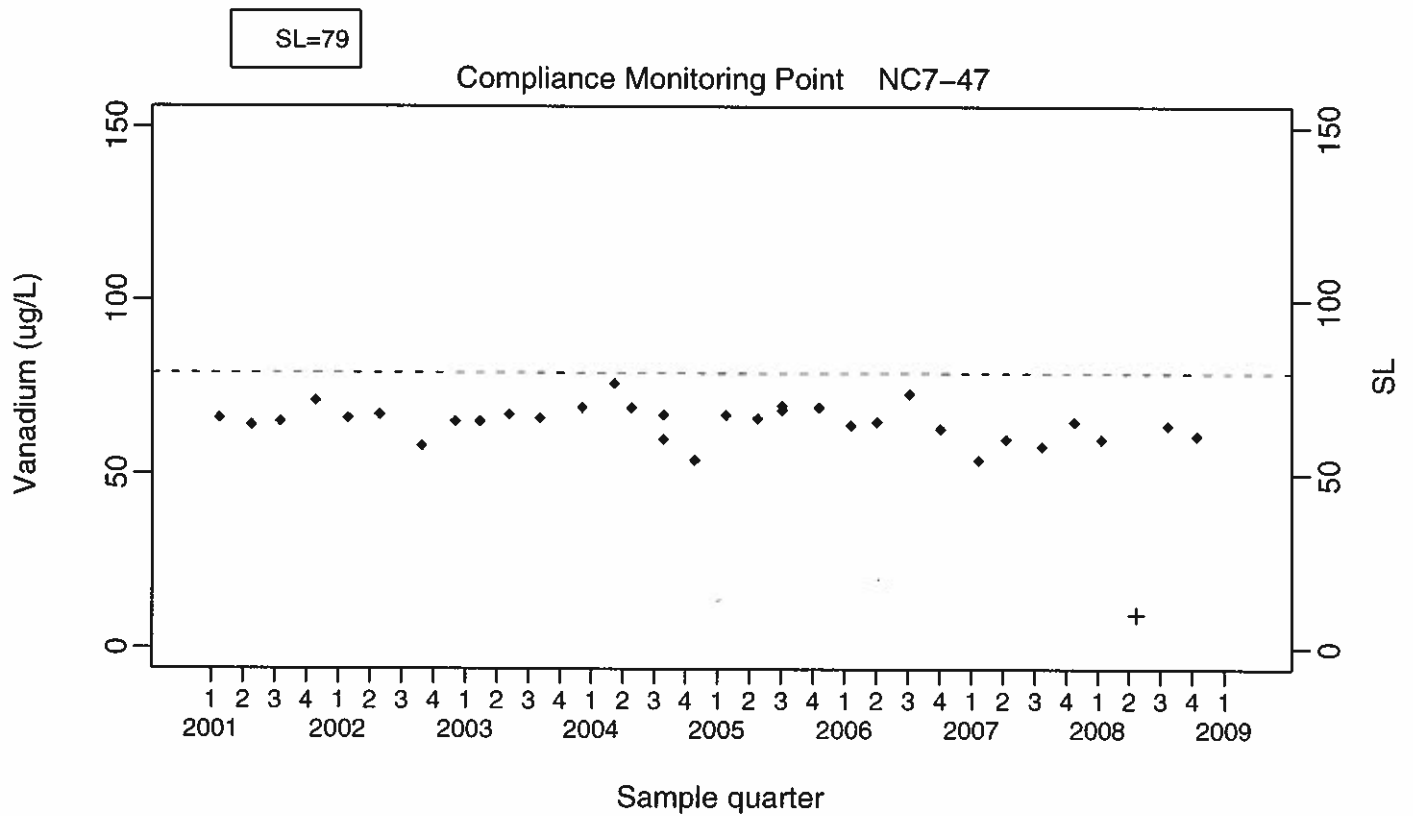
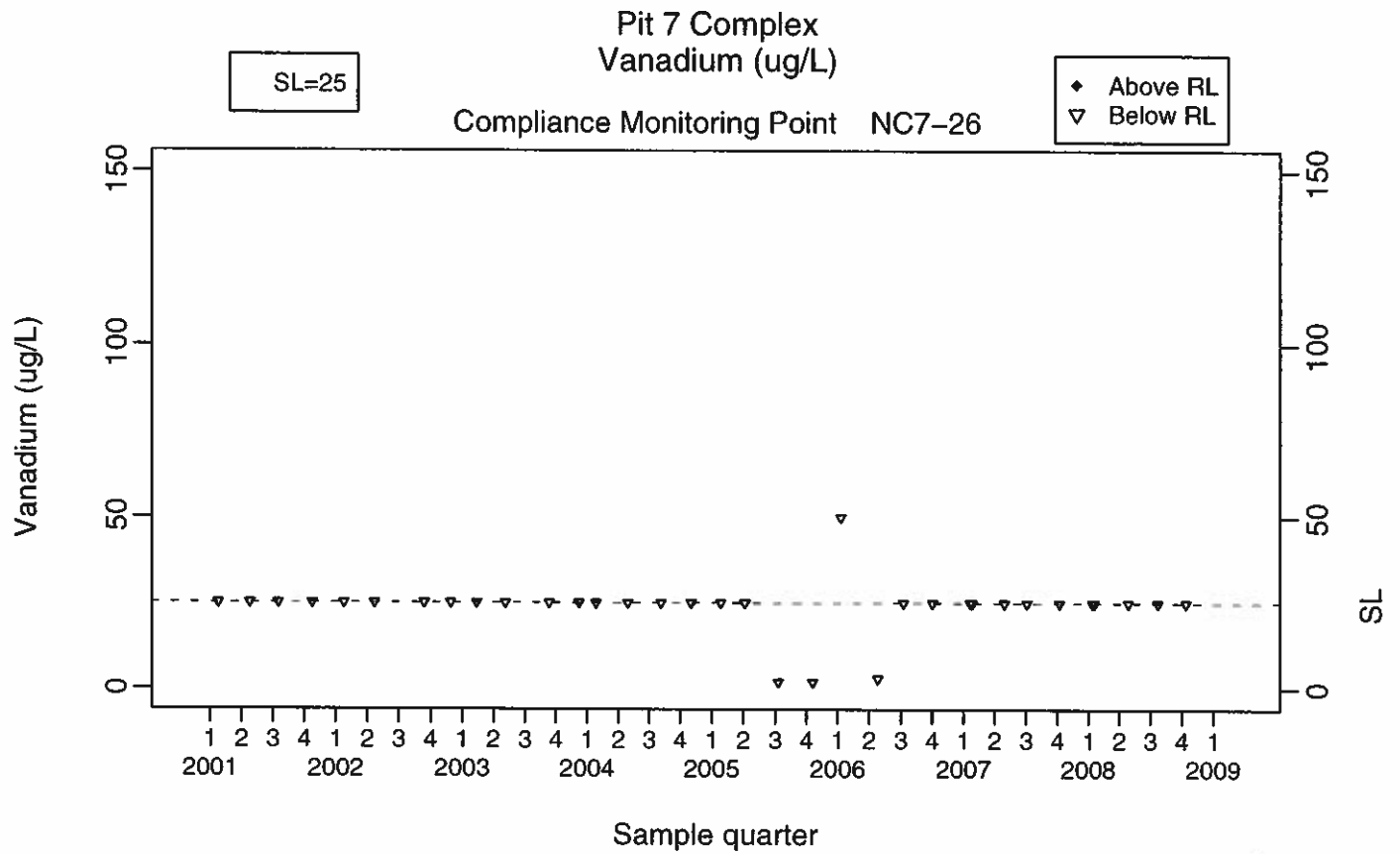


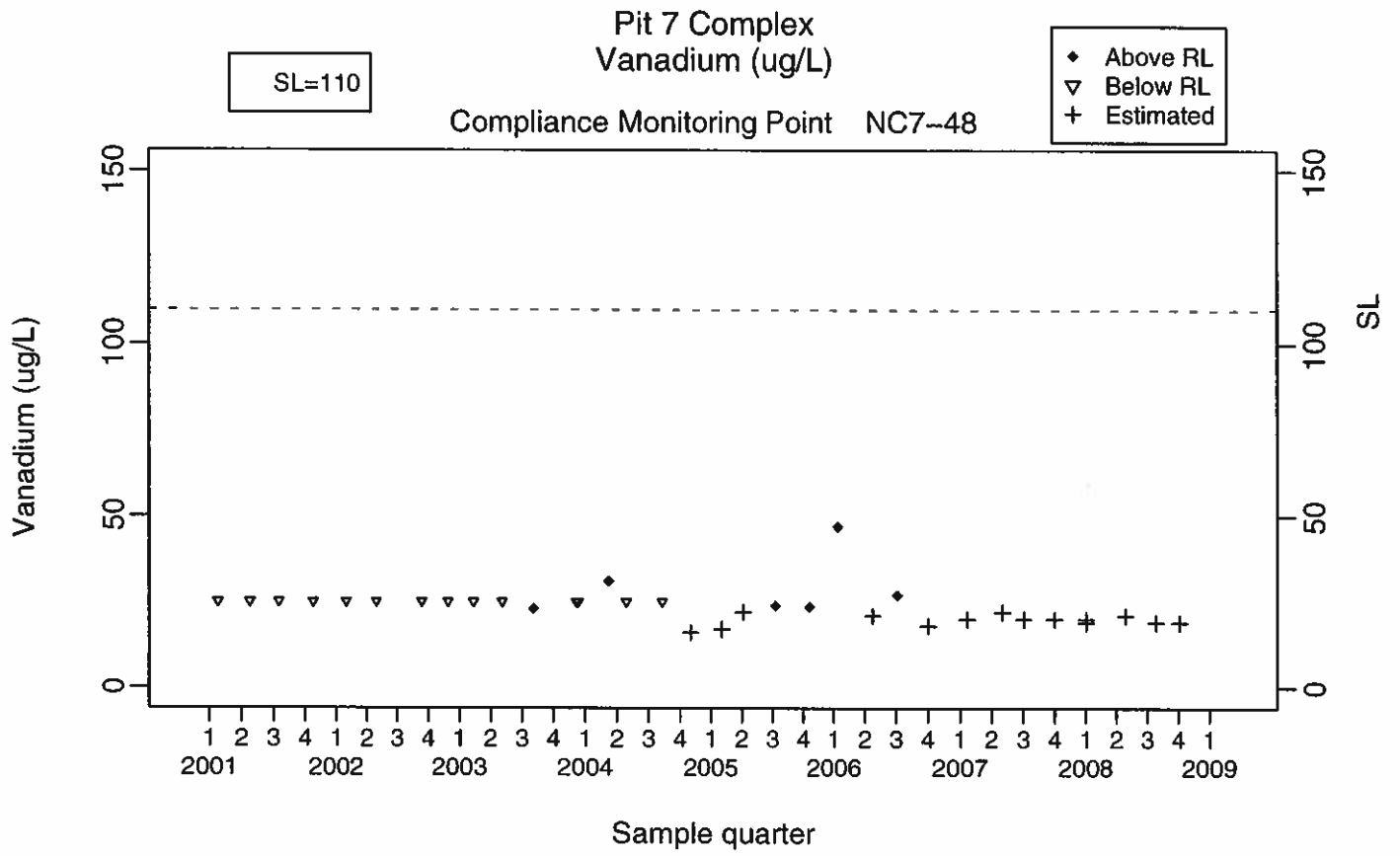


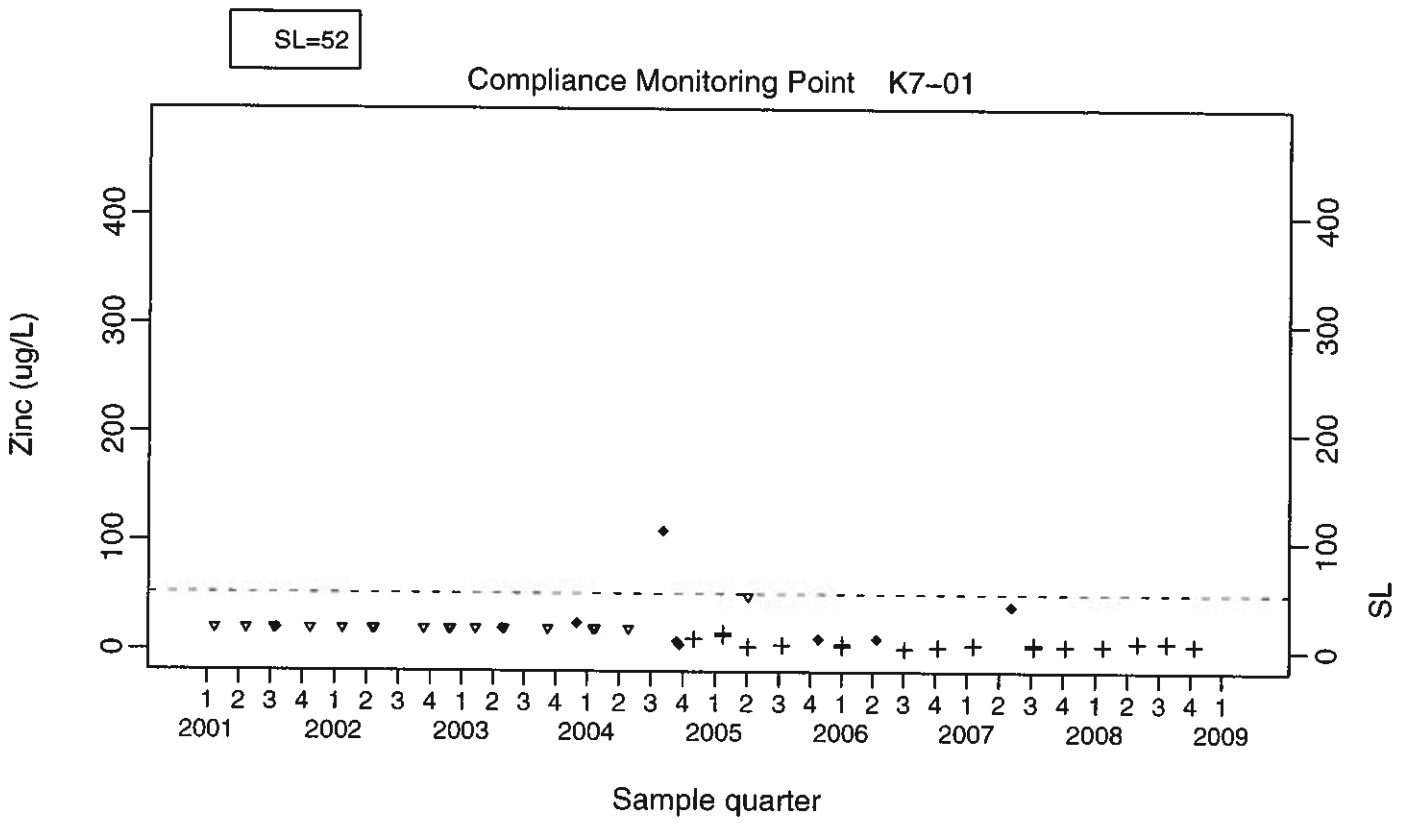
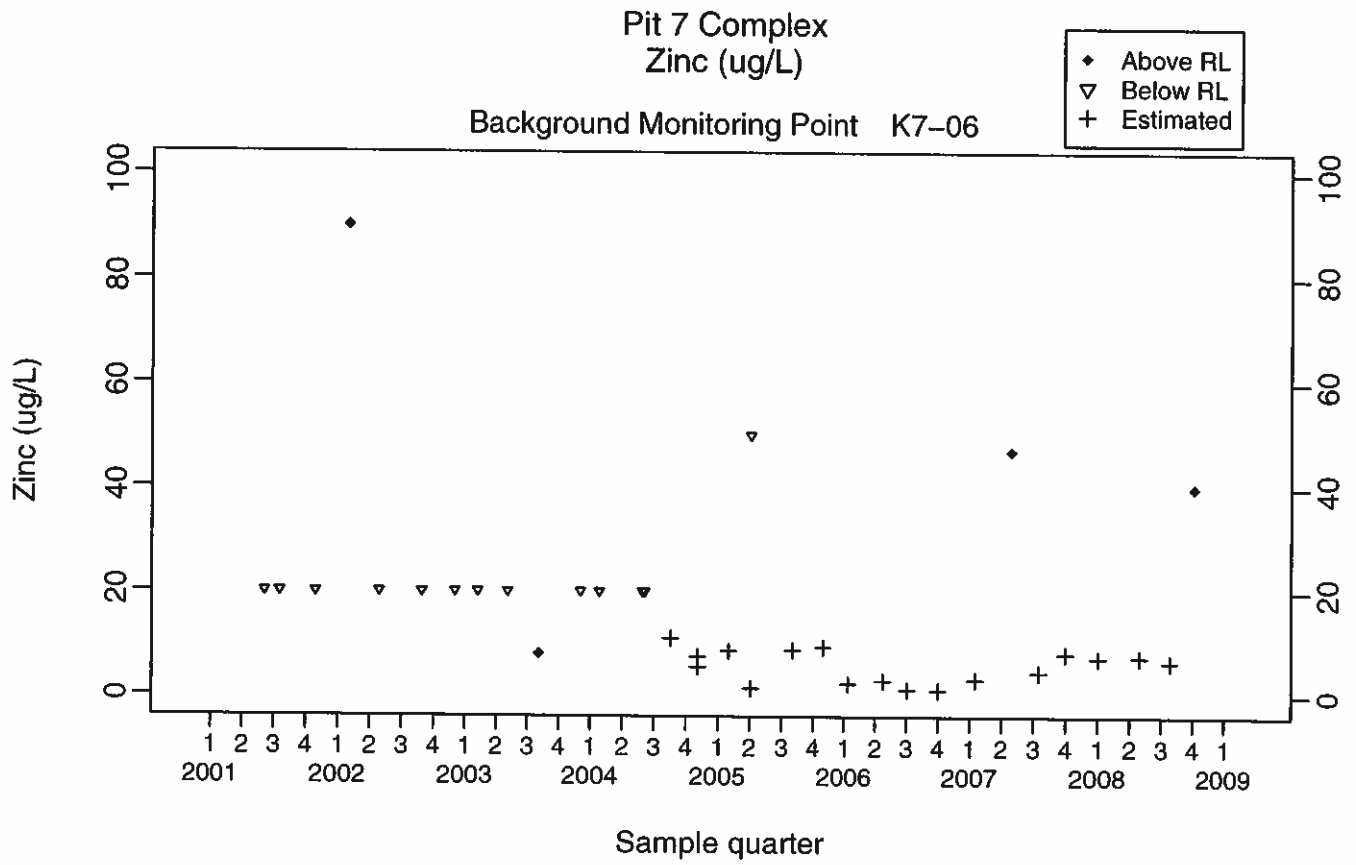


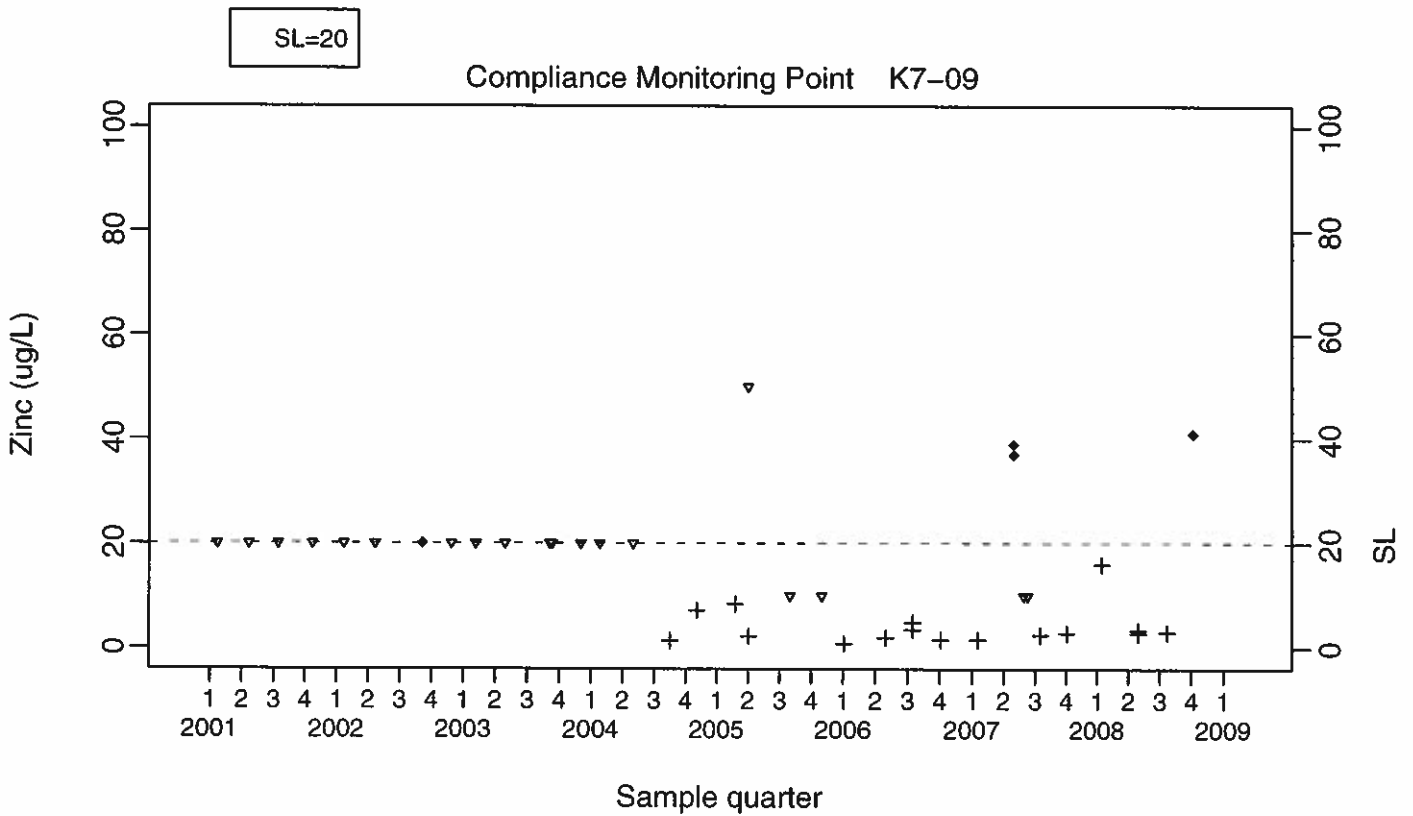
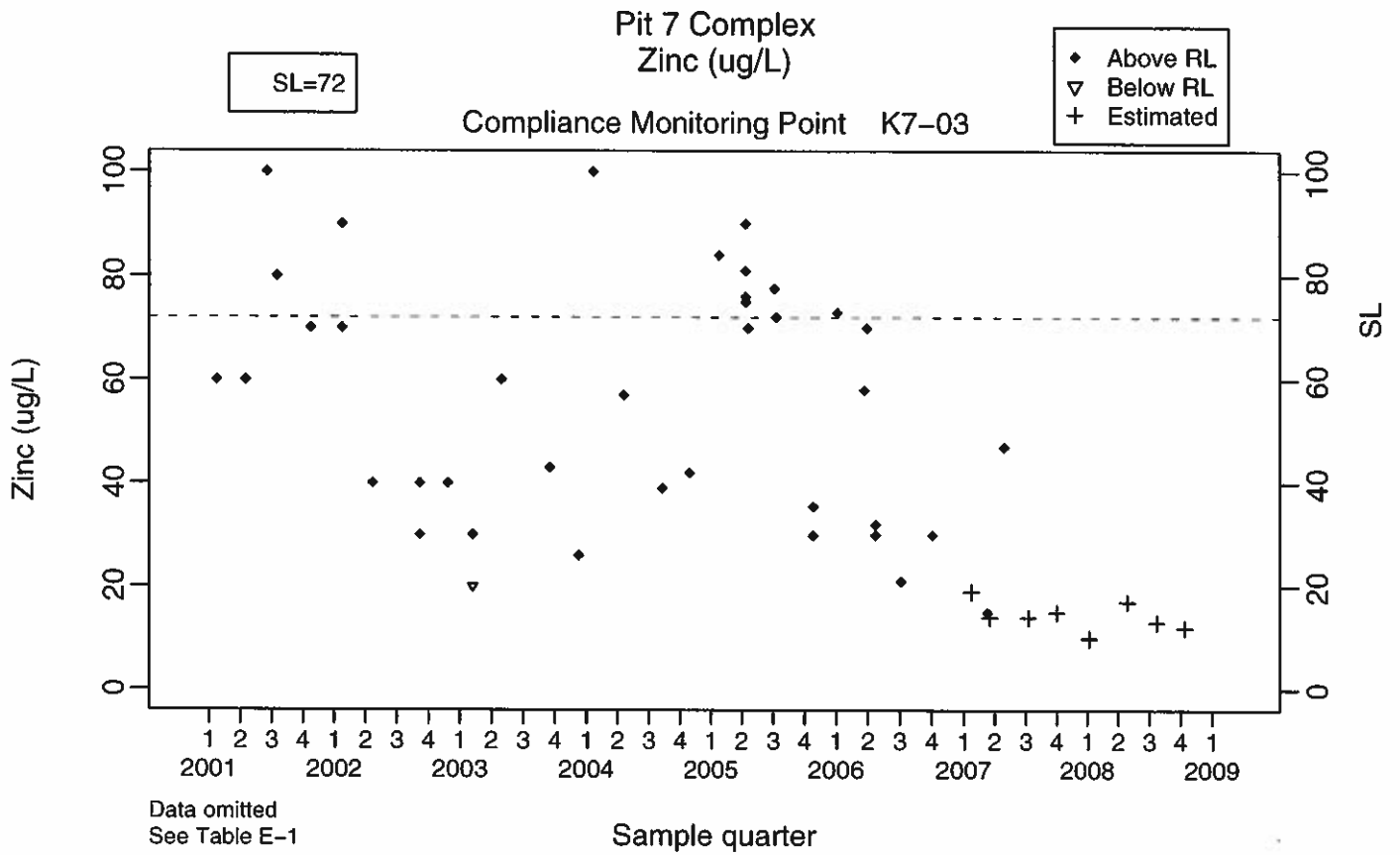


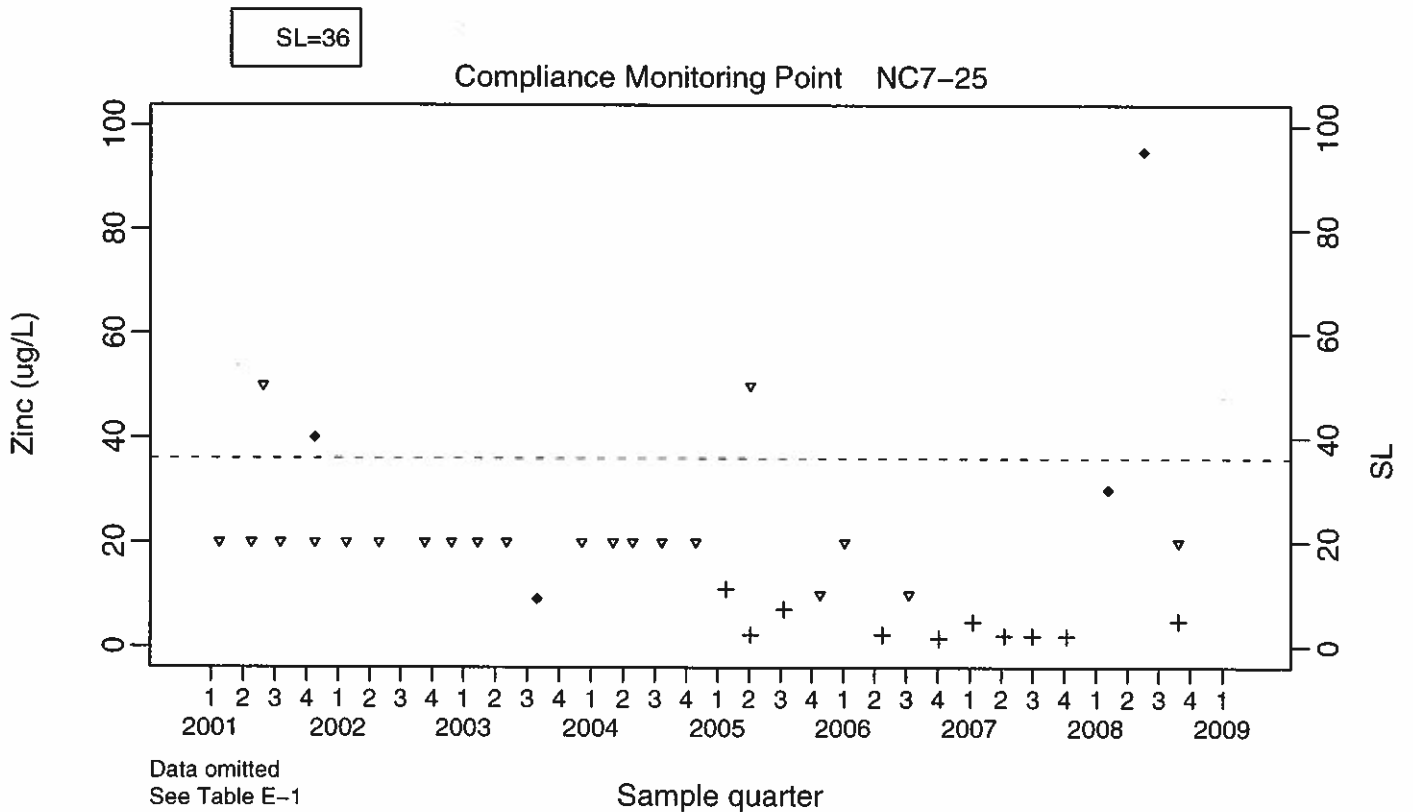
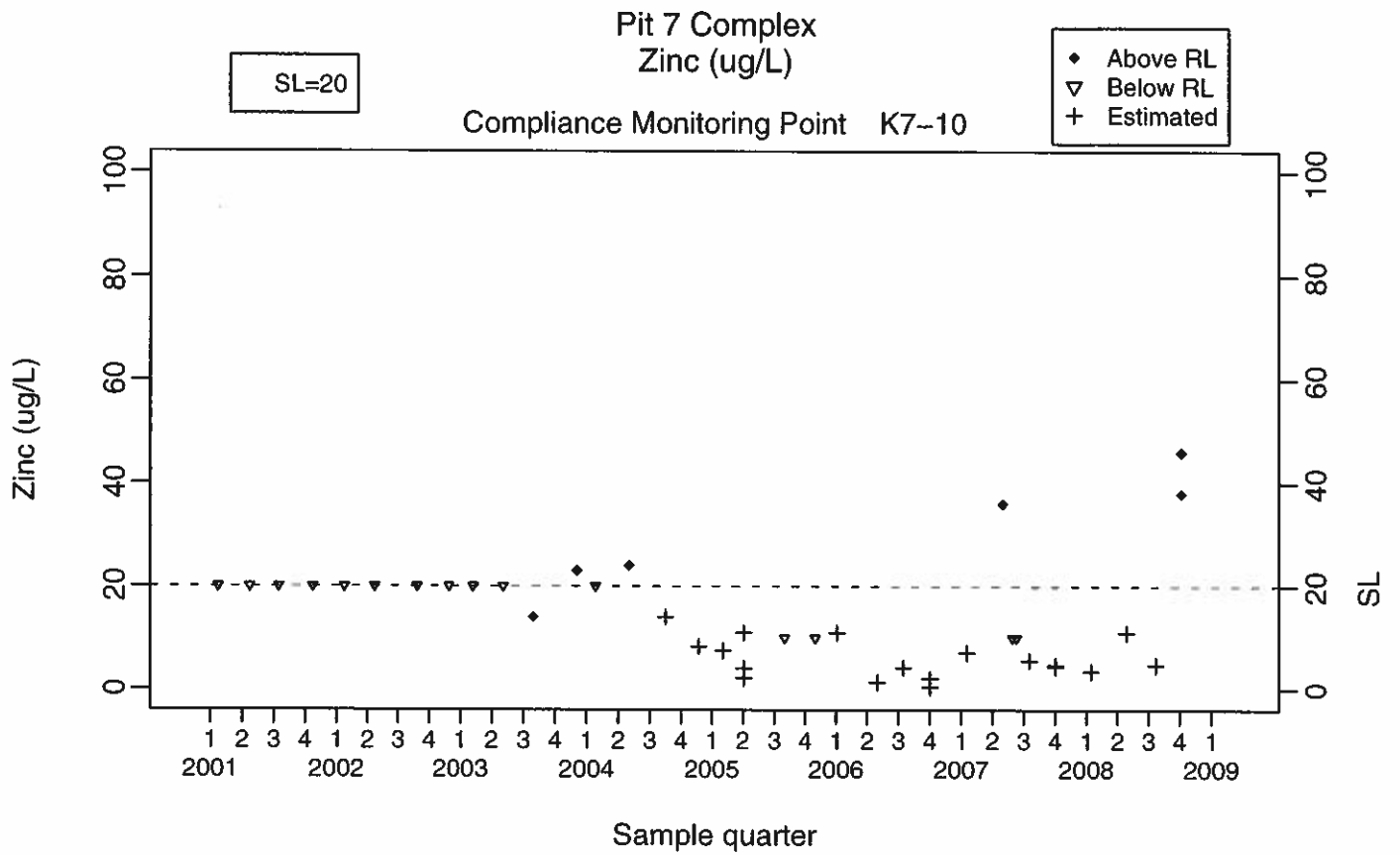




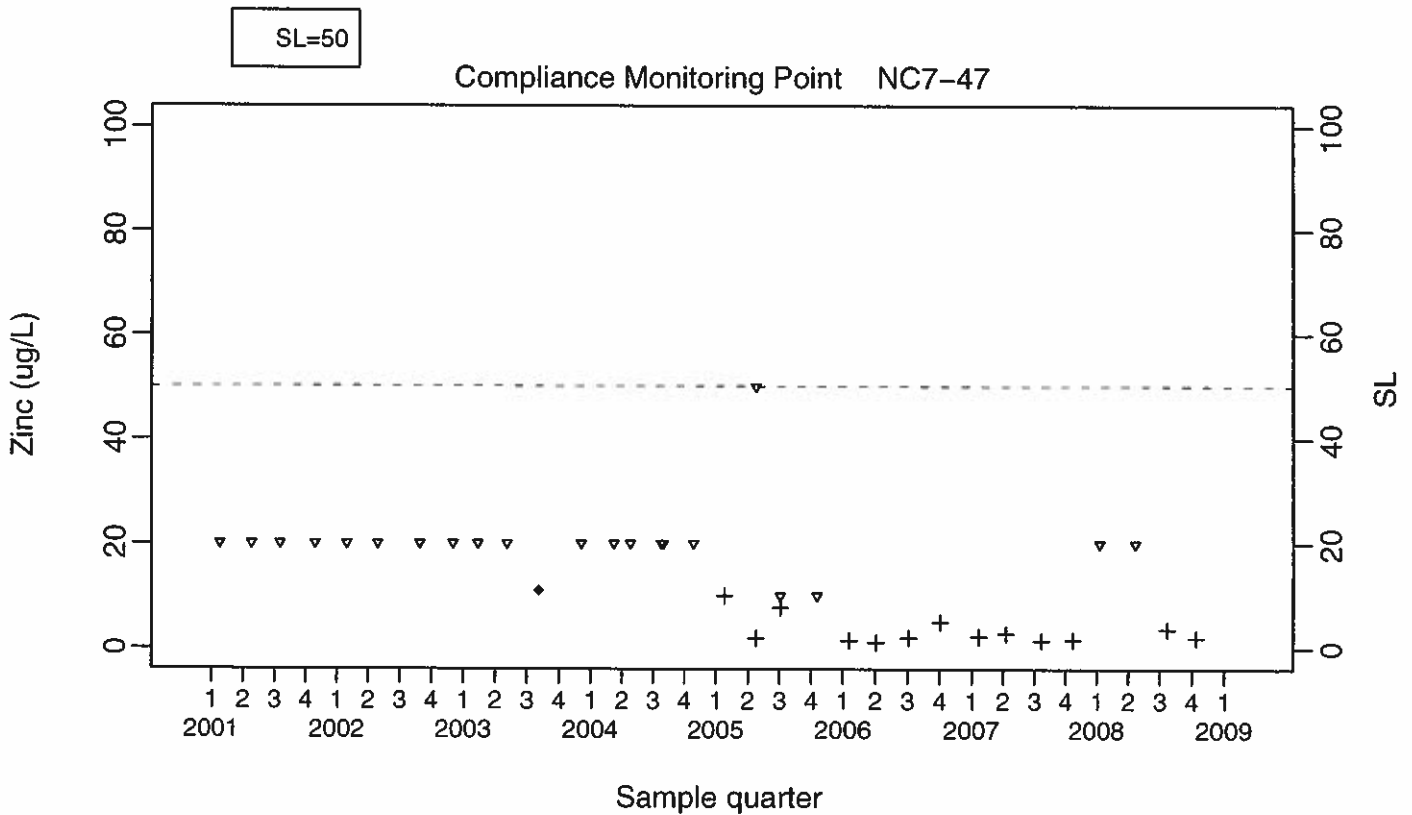
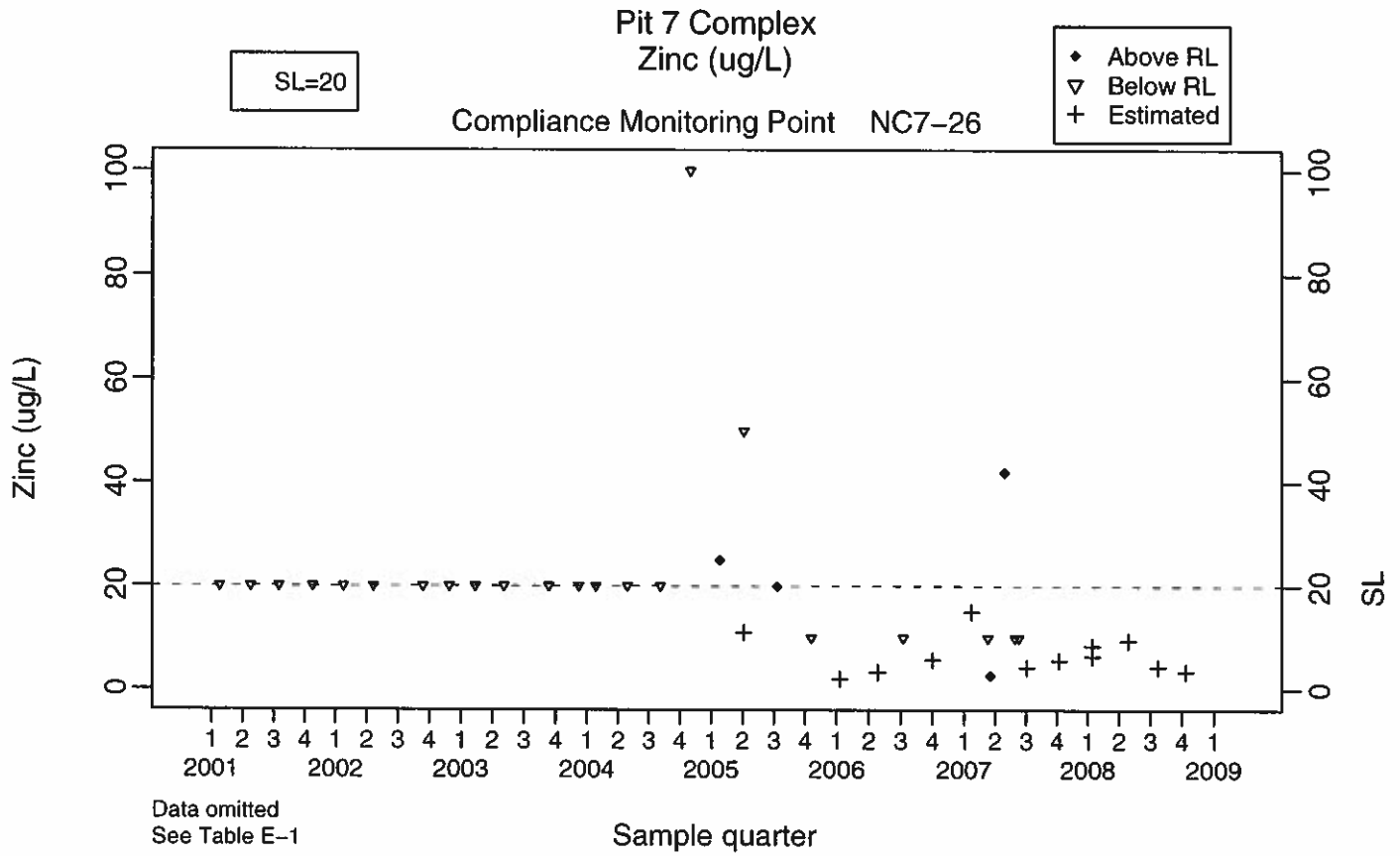


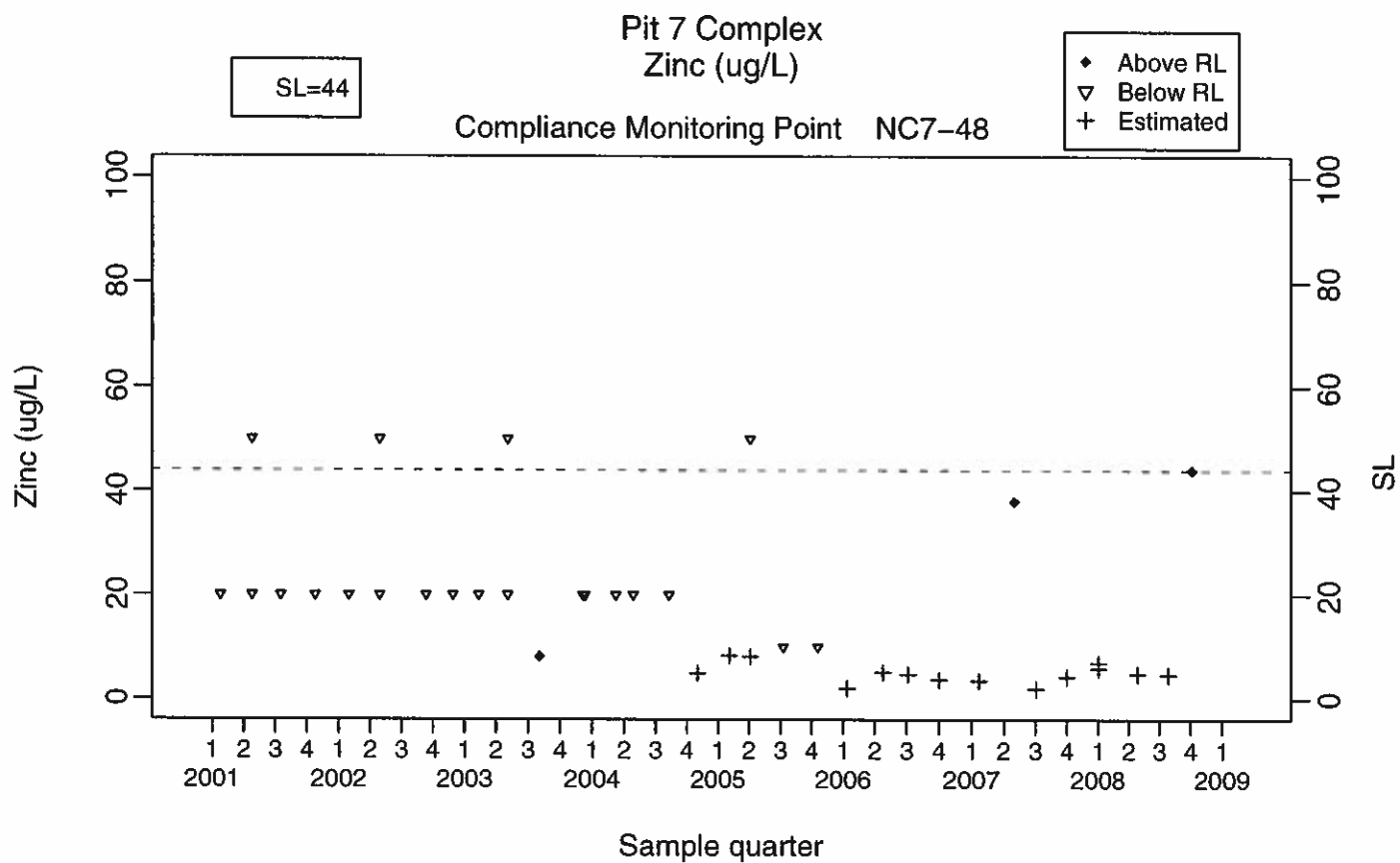


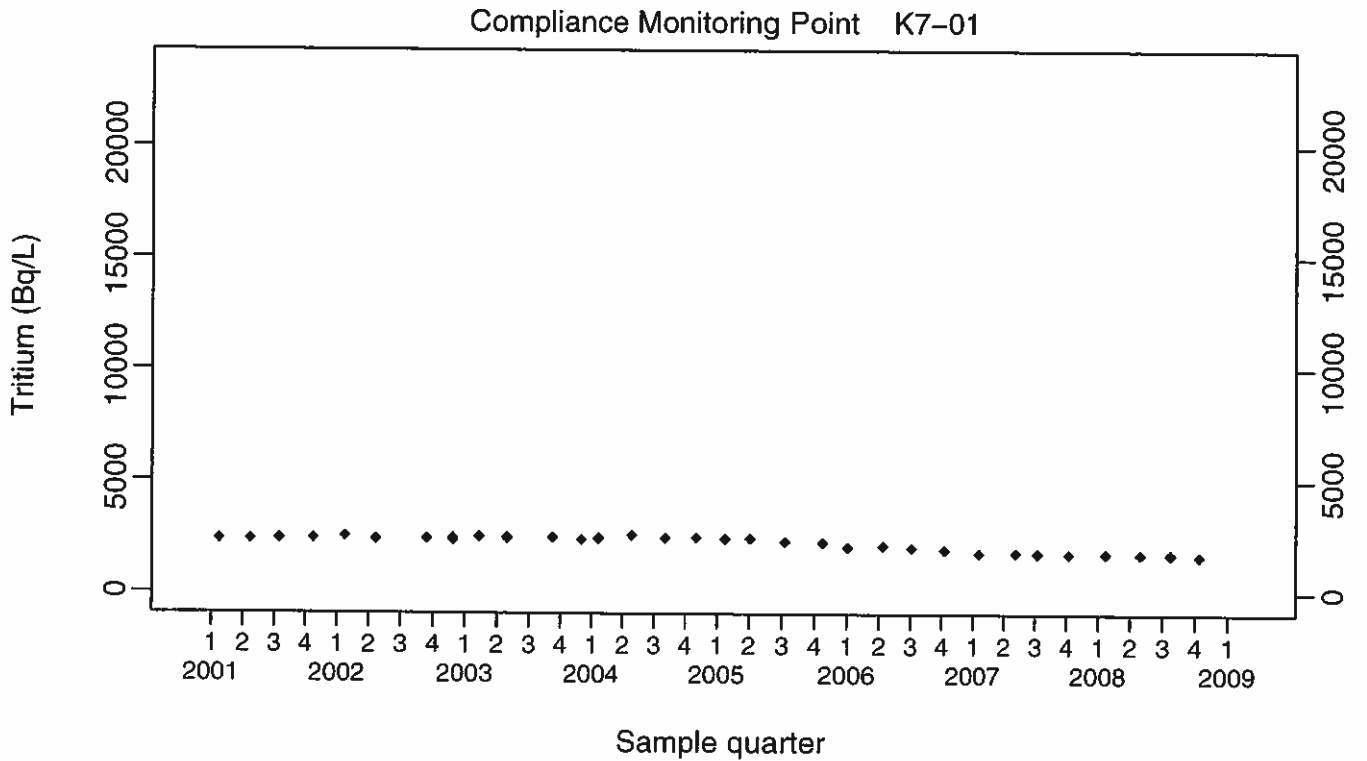
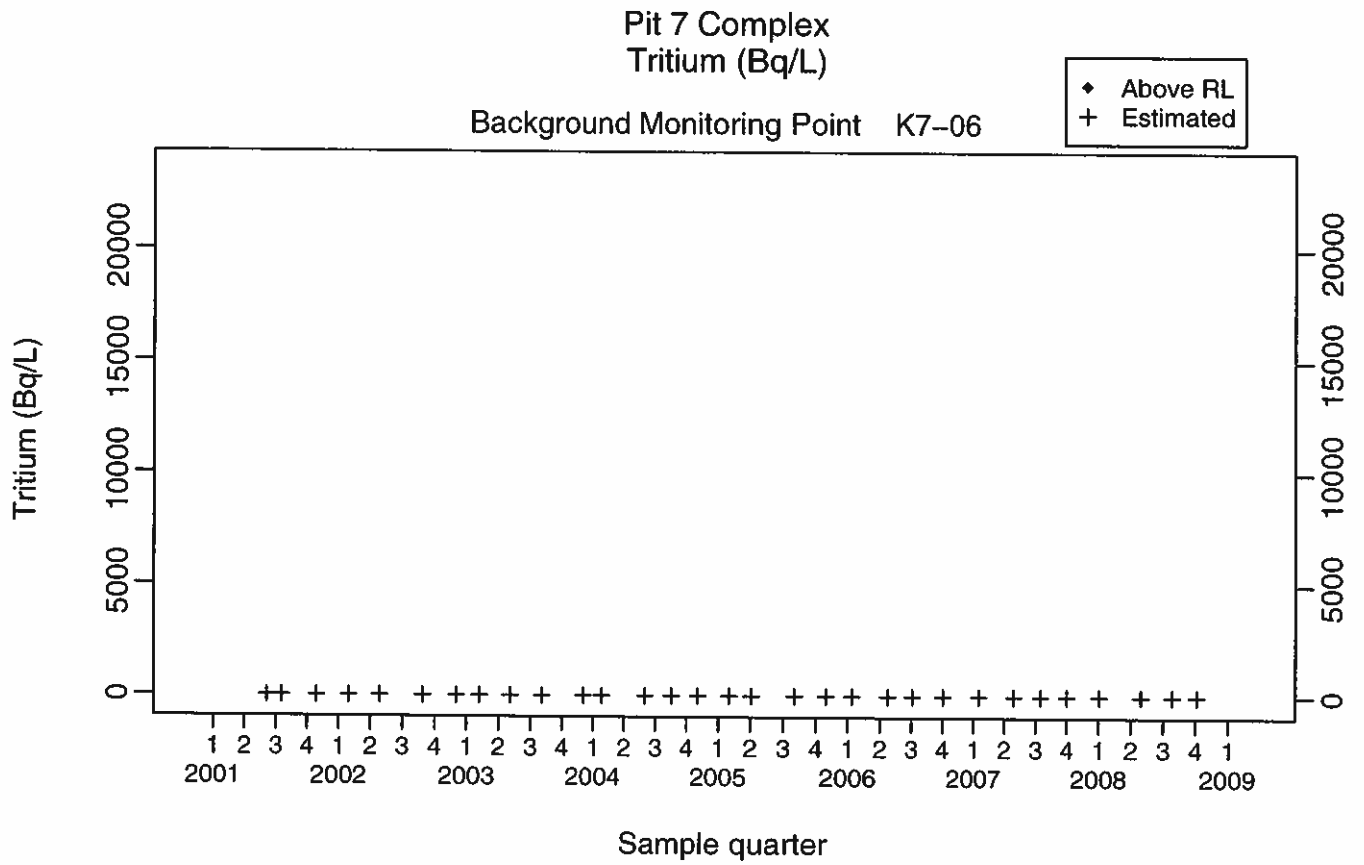


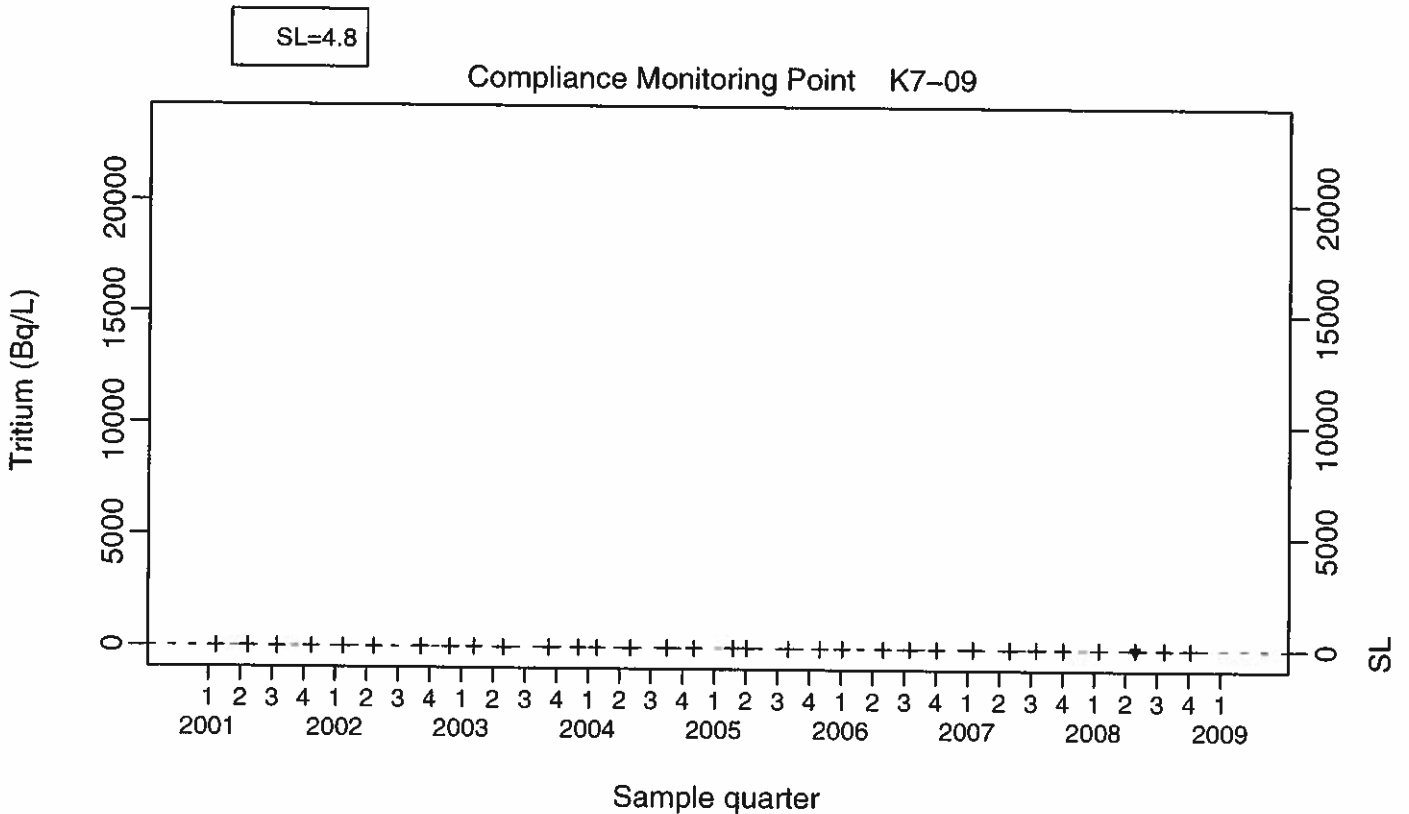
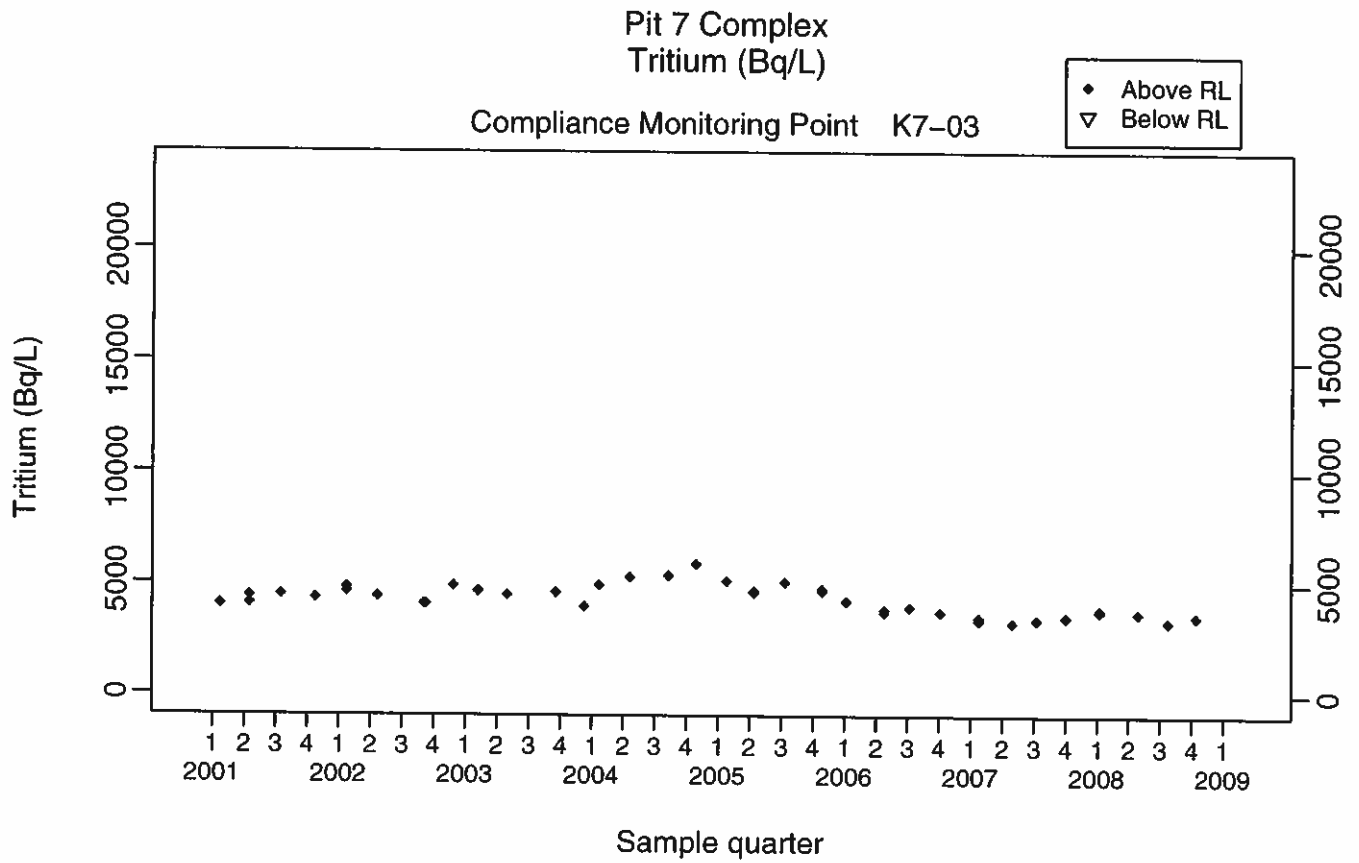


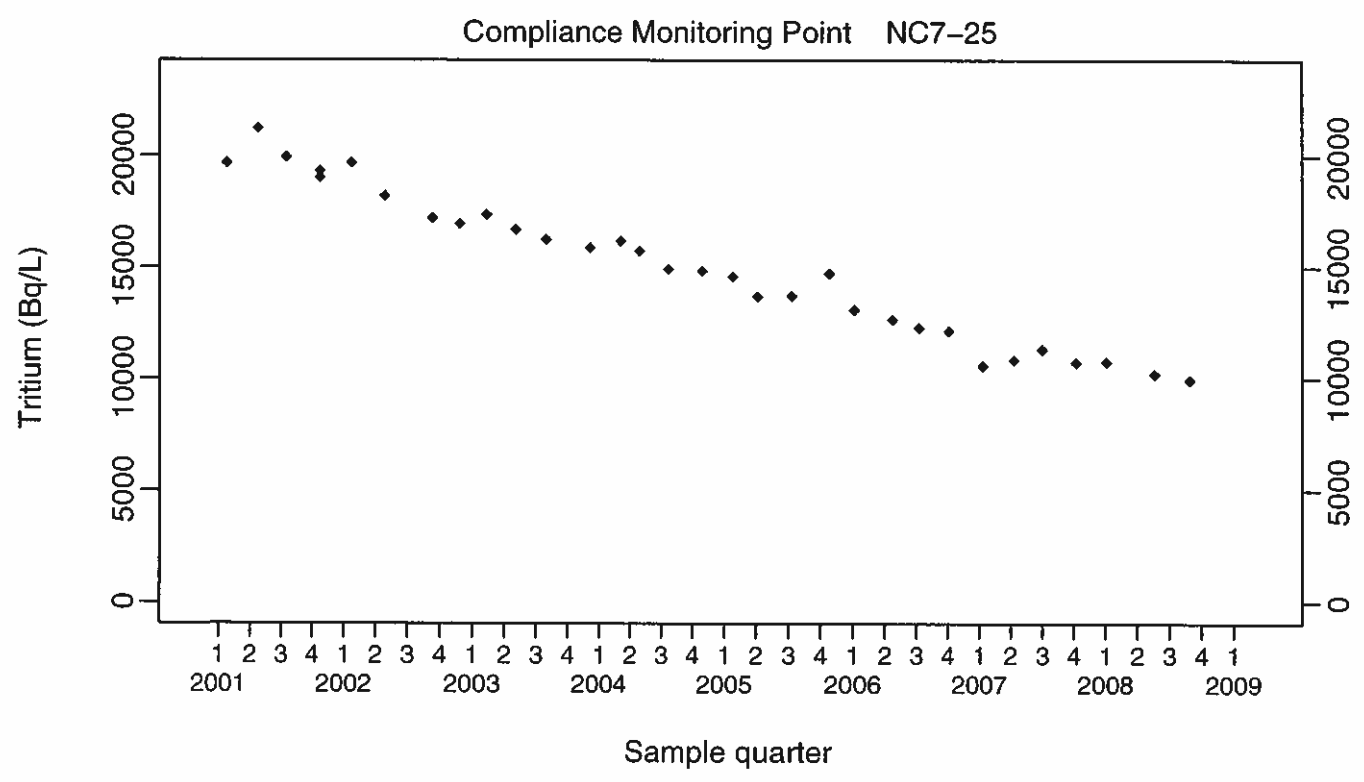
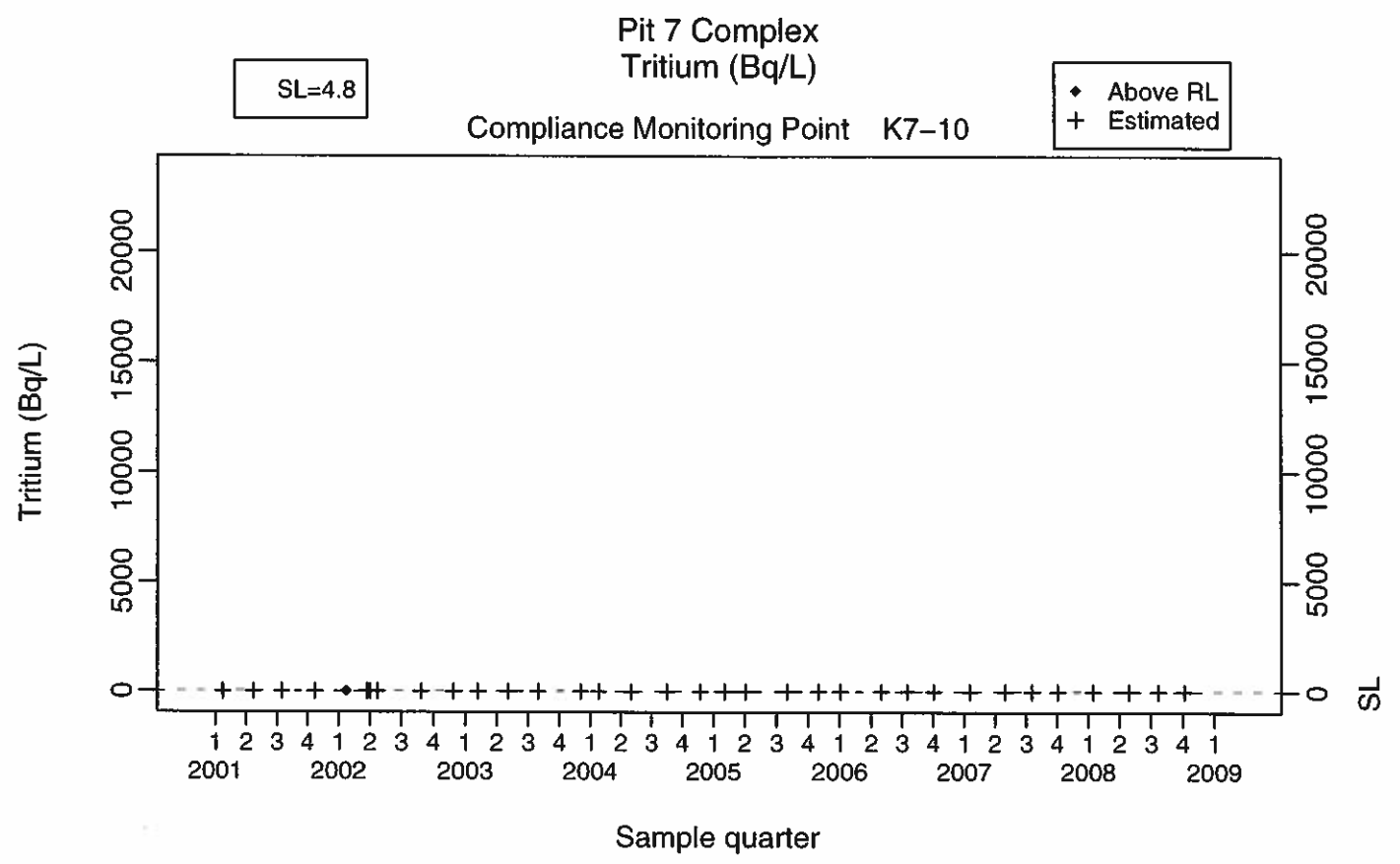
Data omitted
See Table E-1

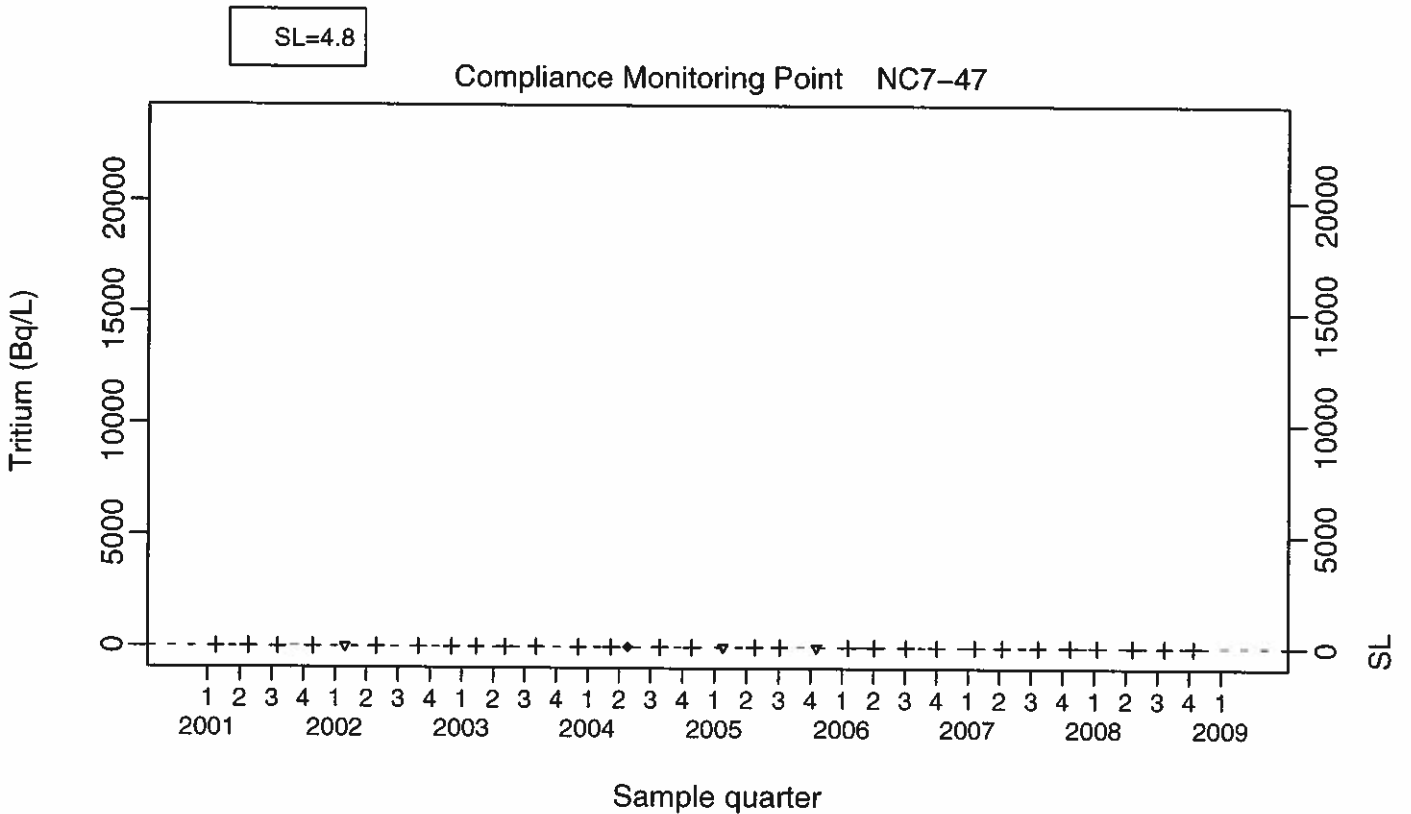
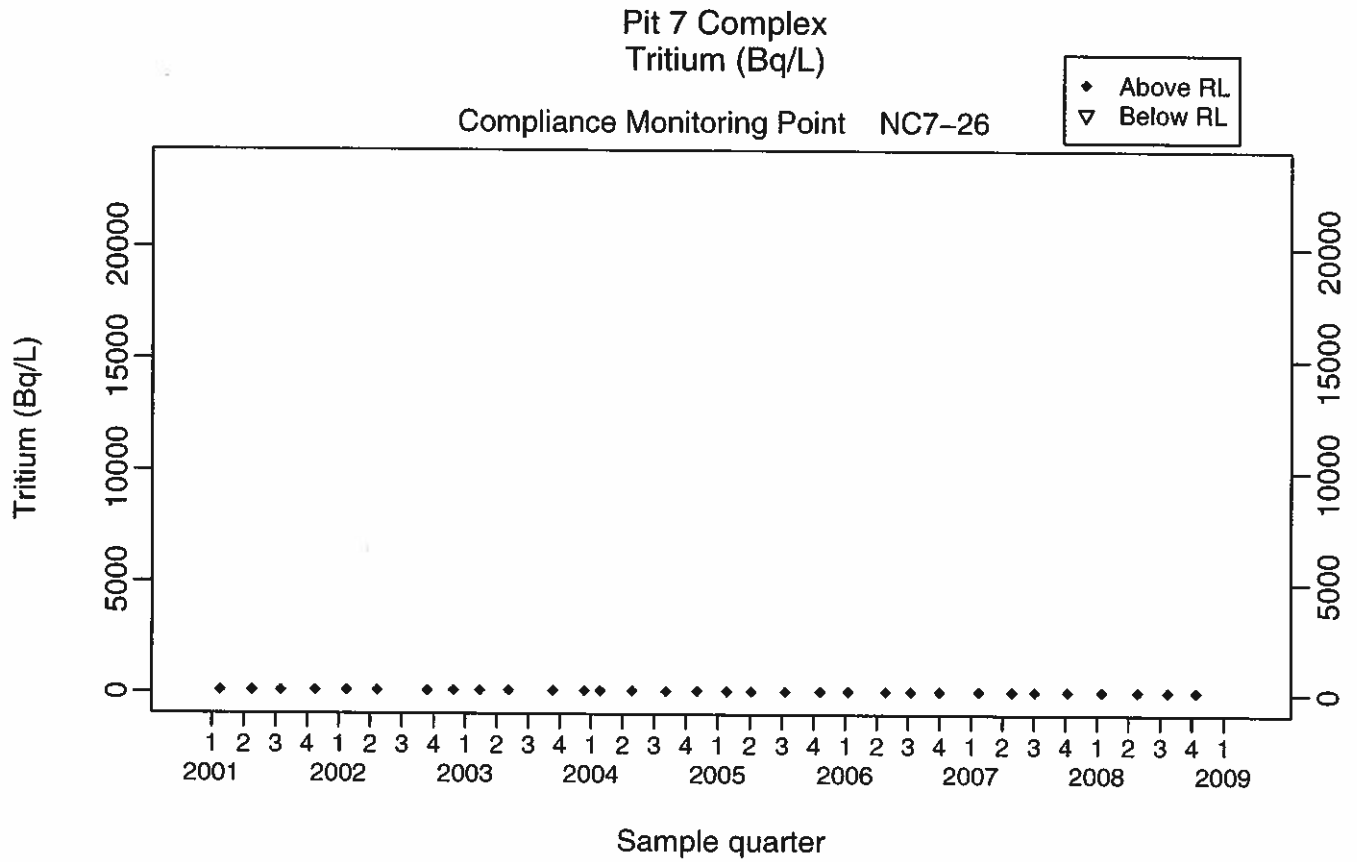


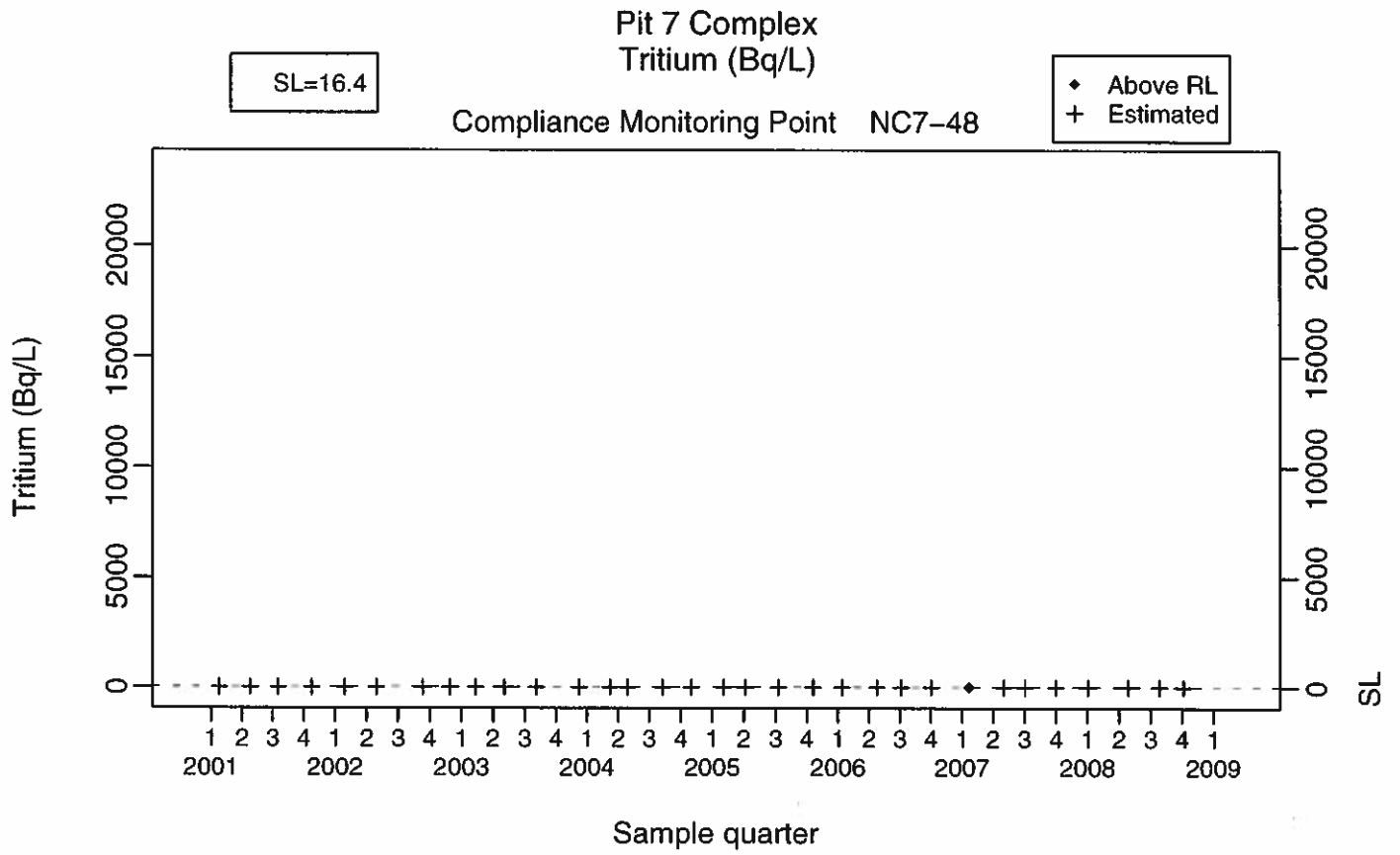


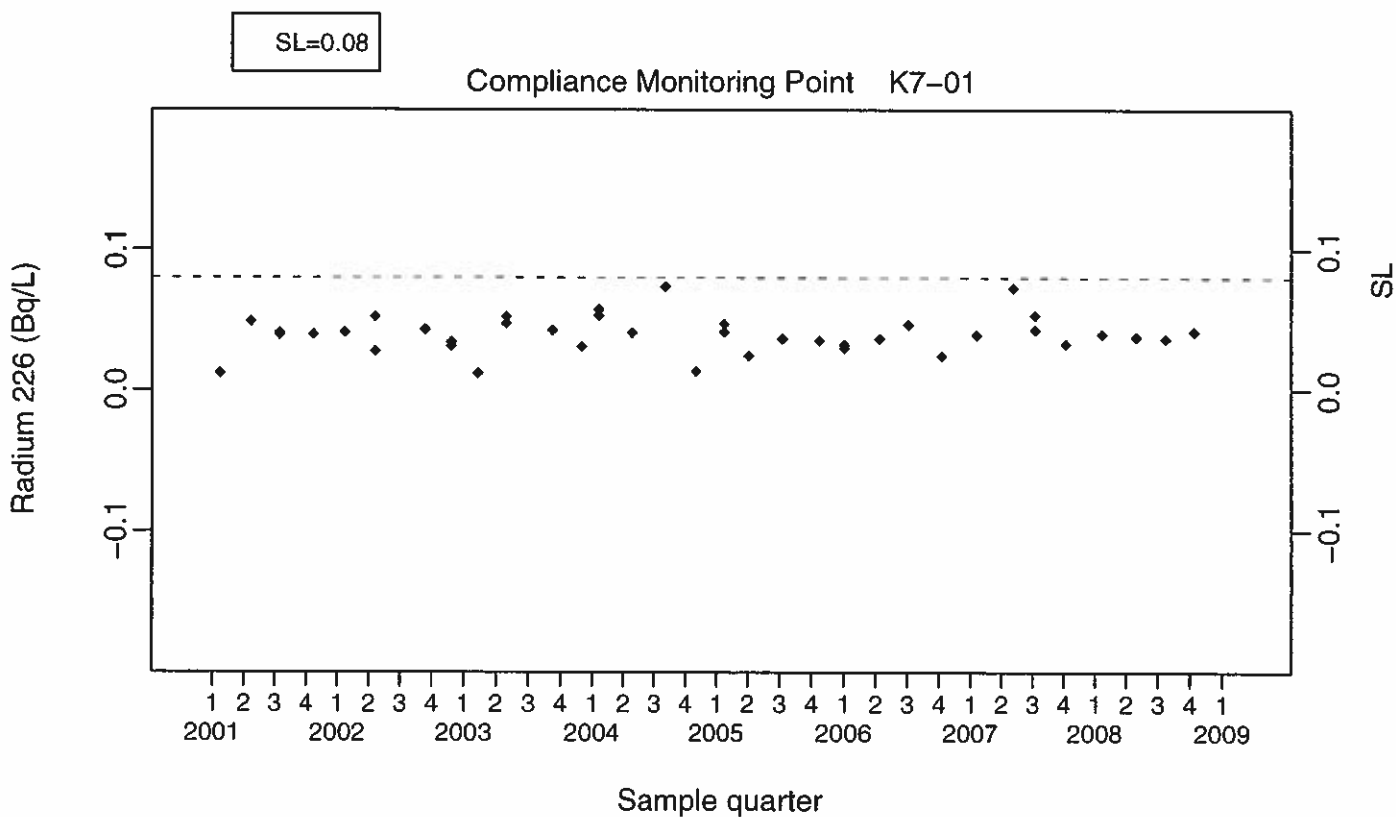
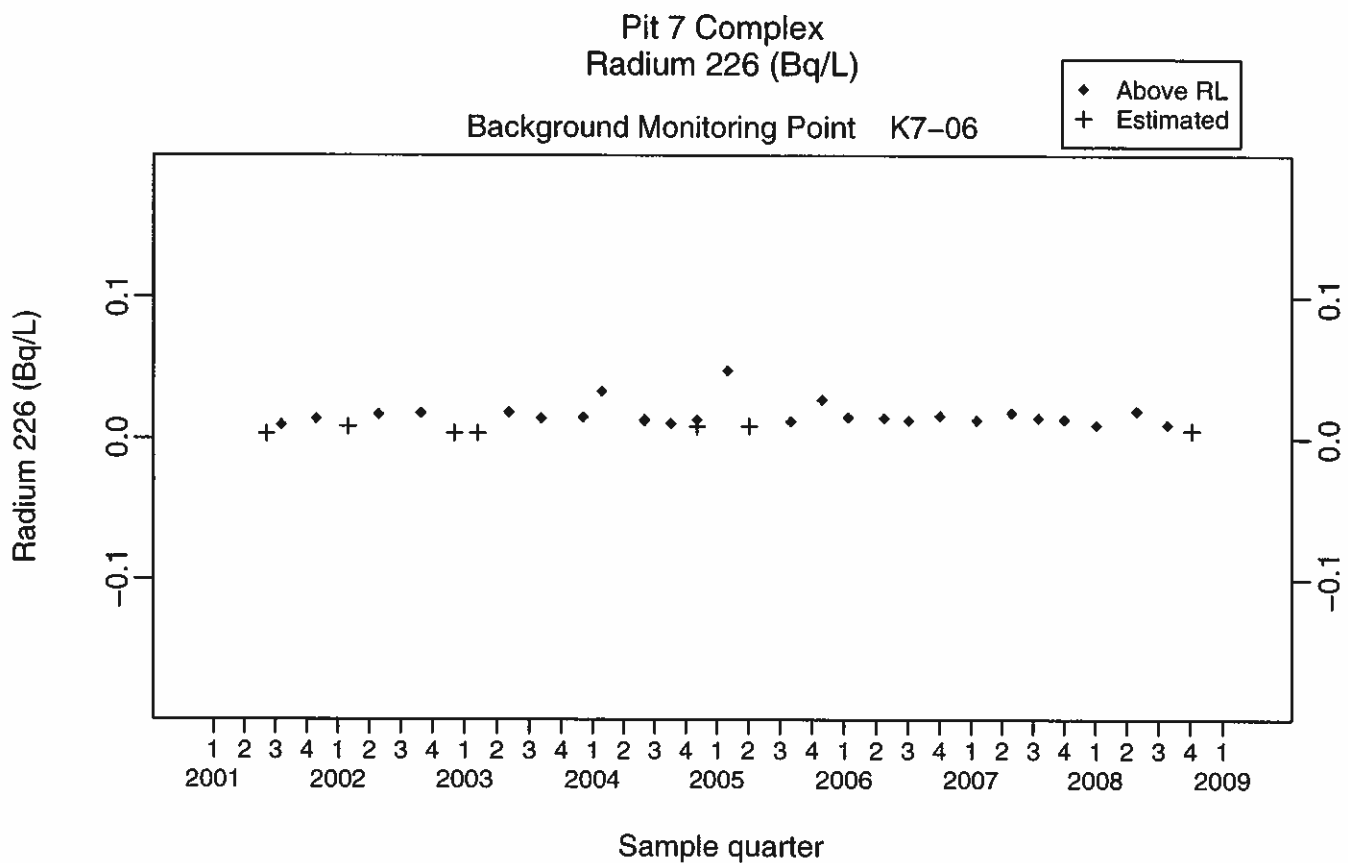


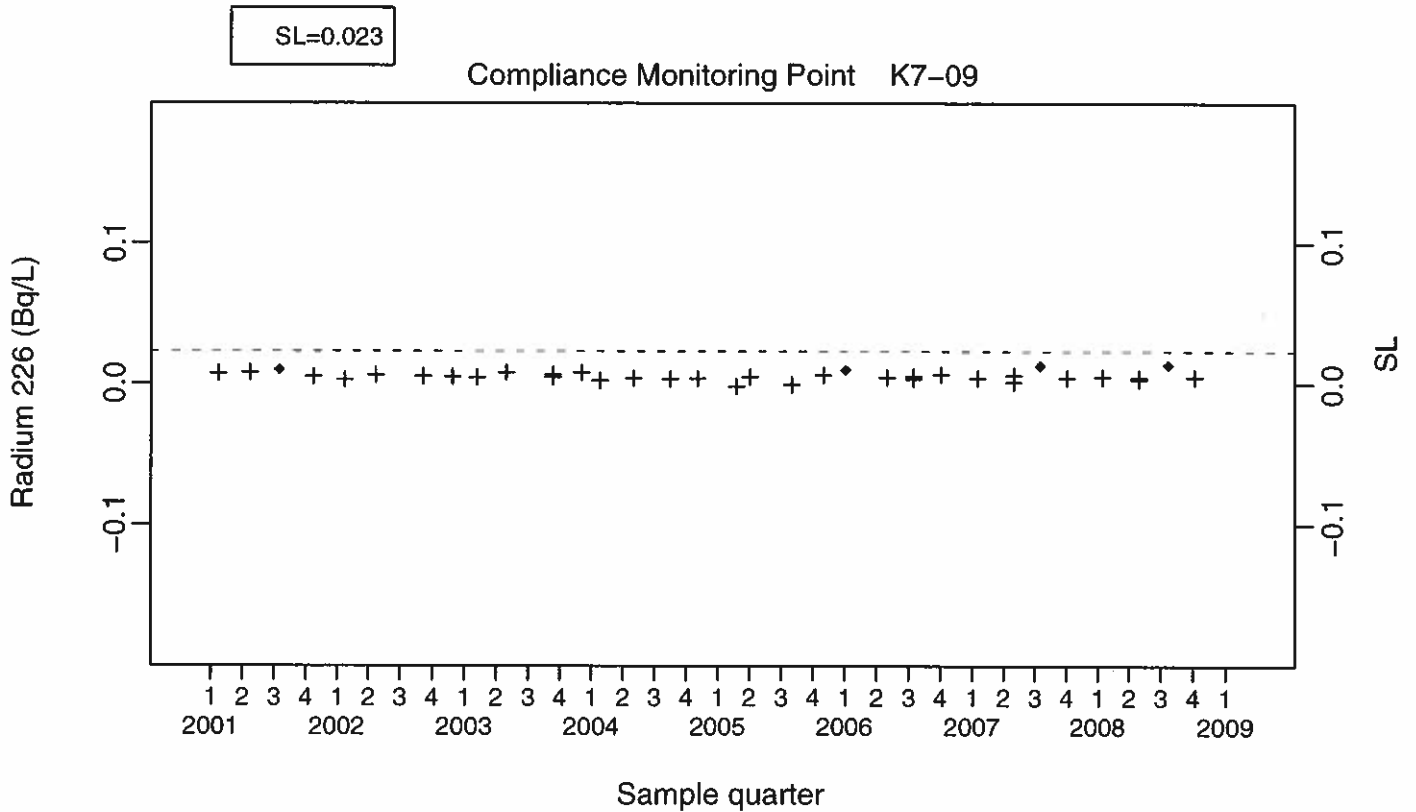
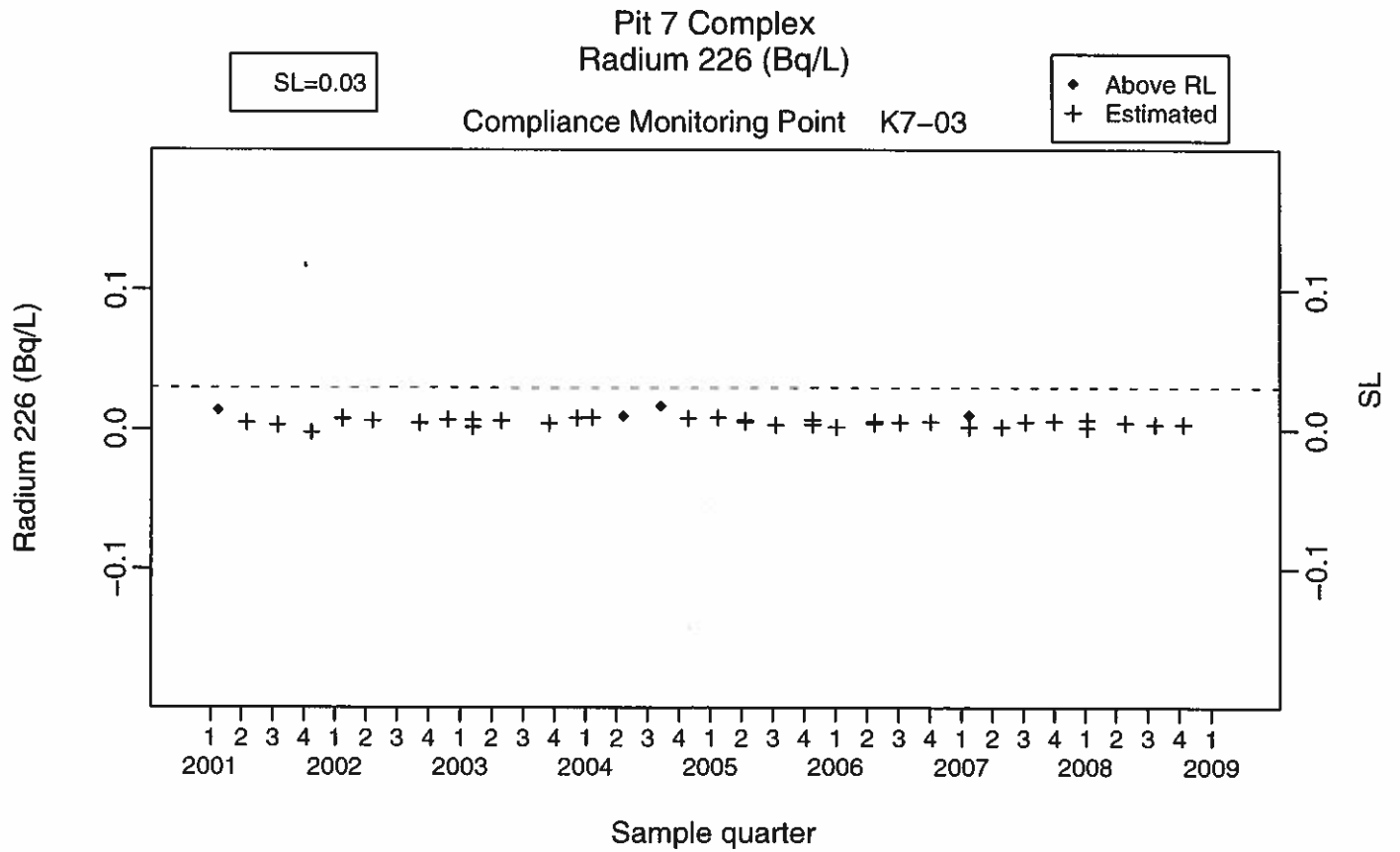


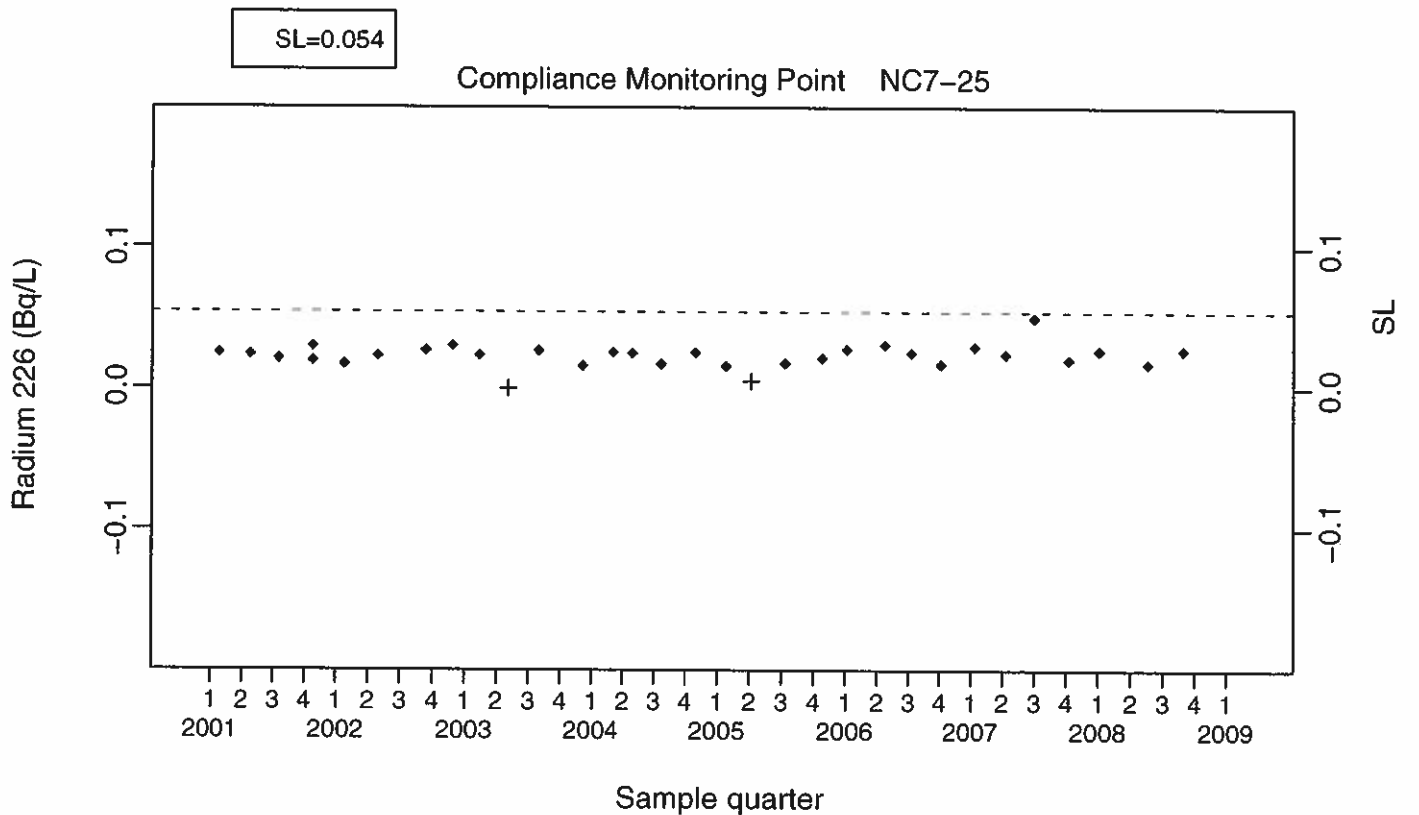
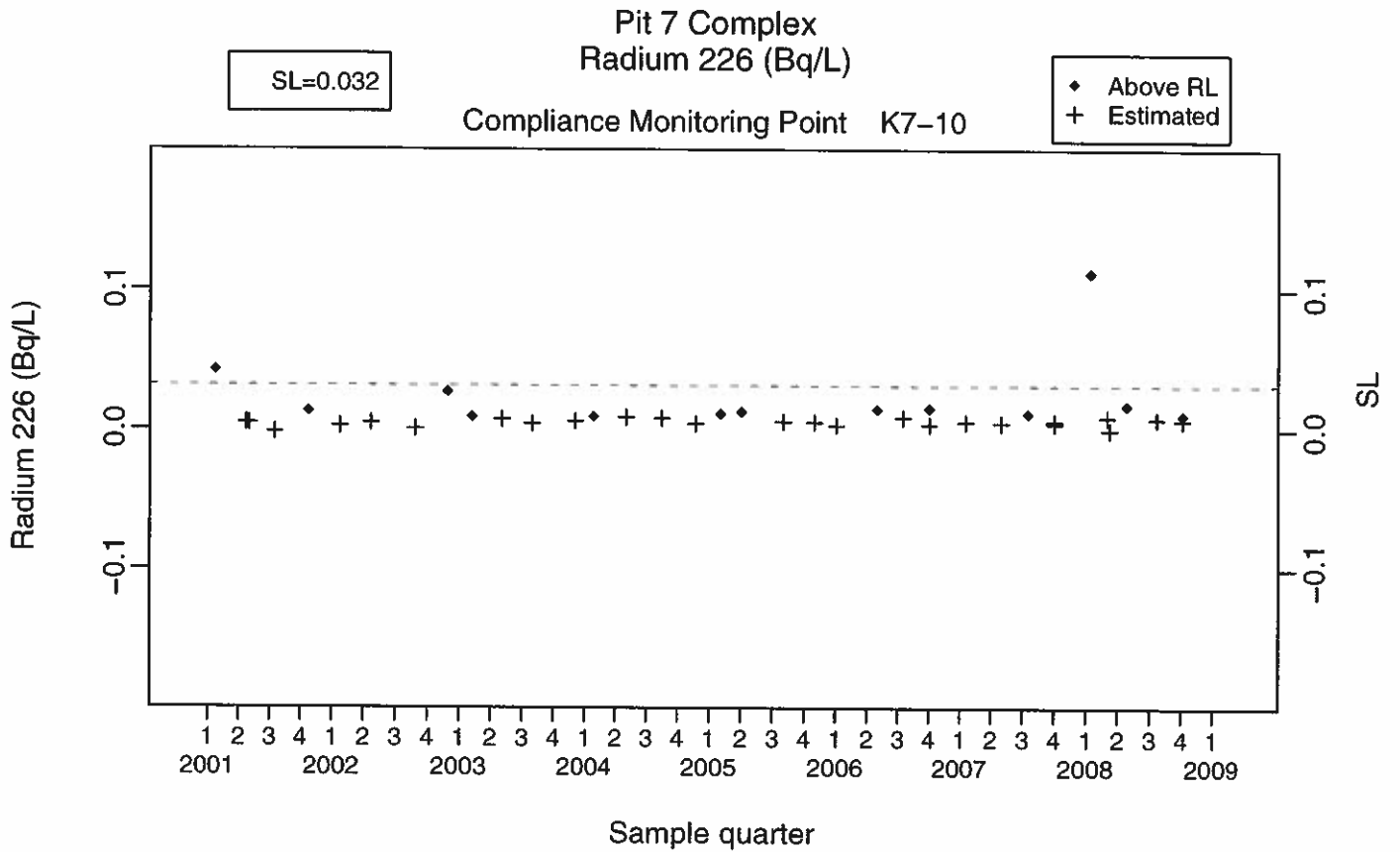


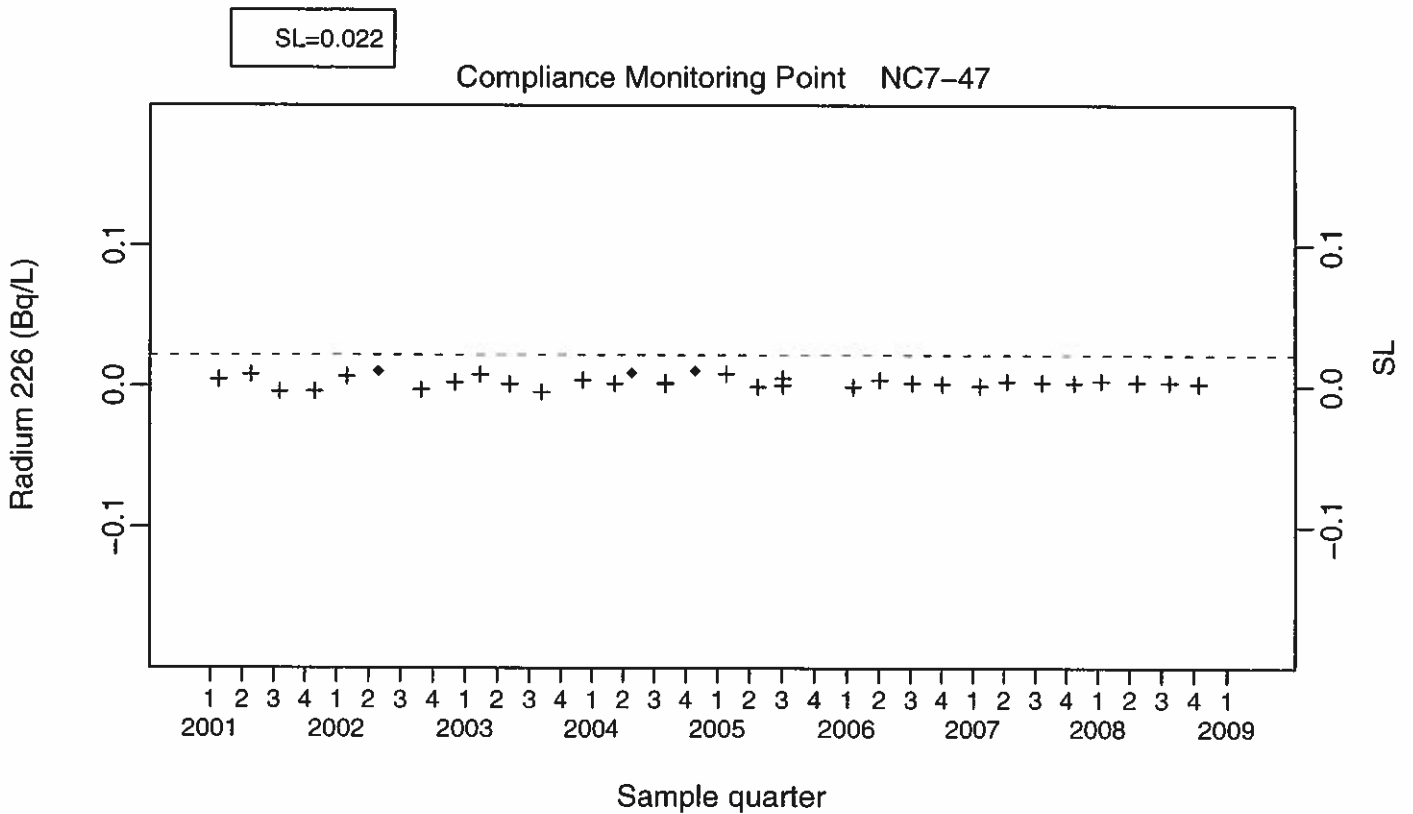
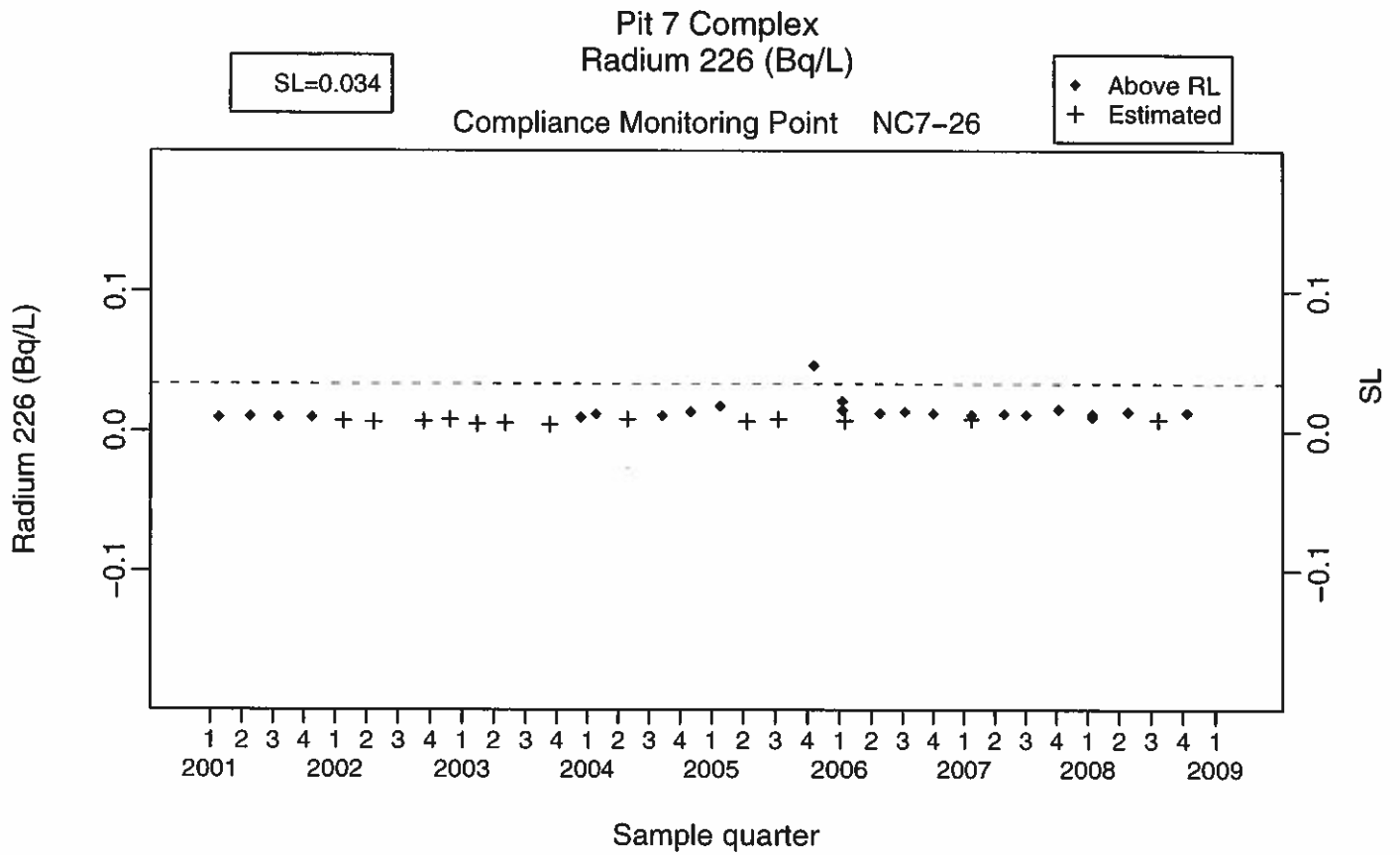


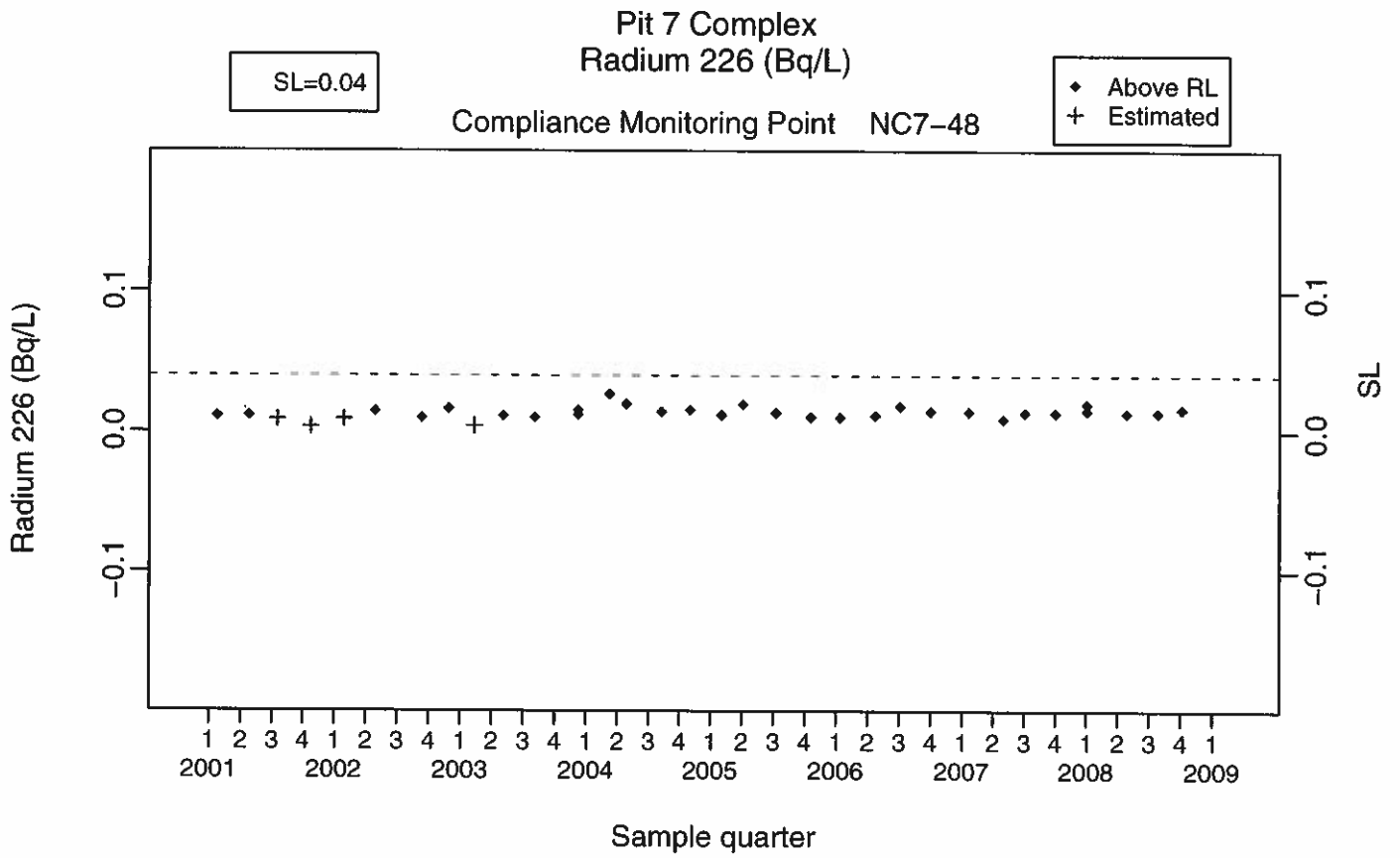


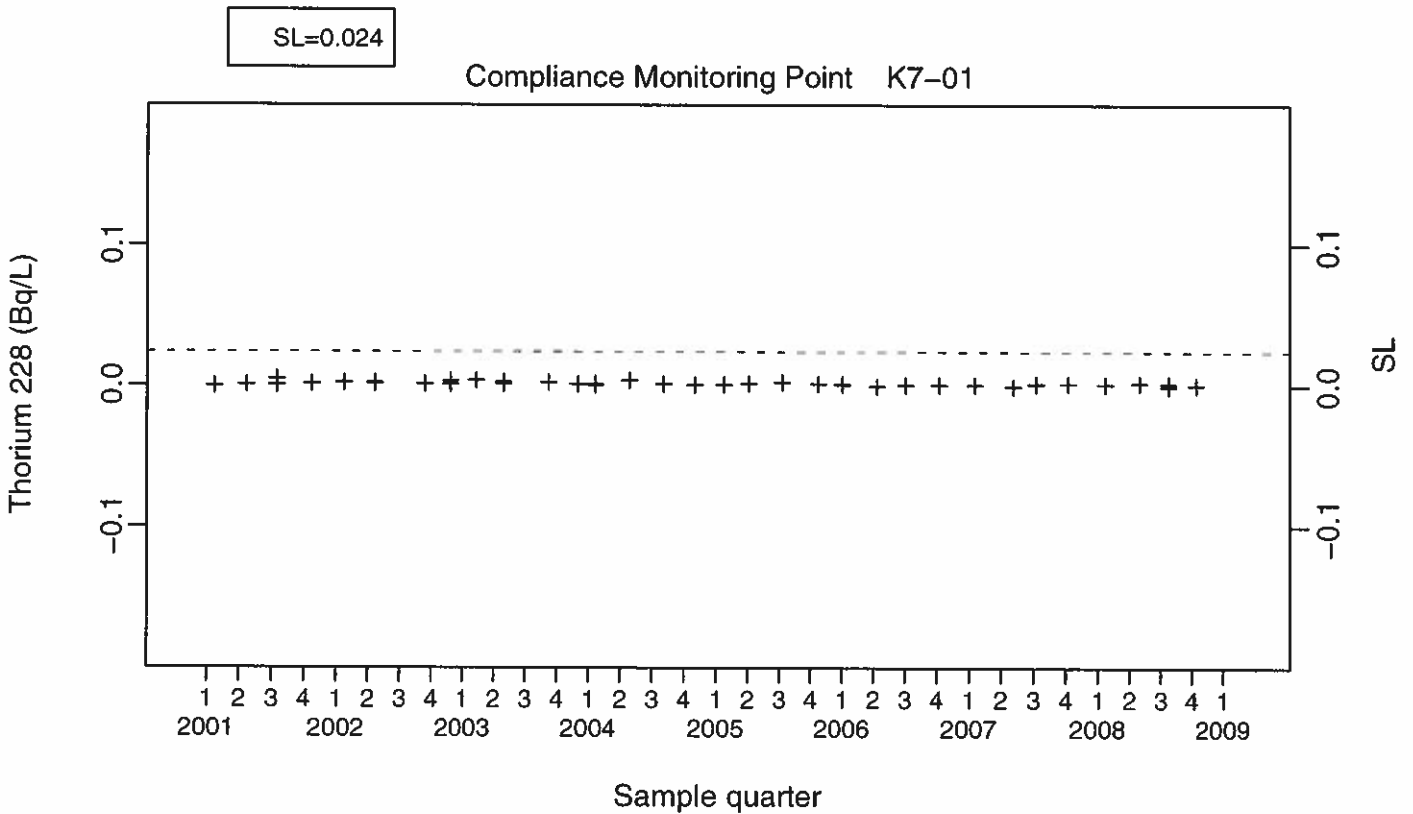
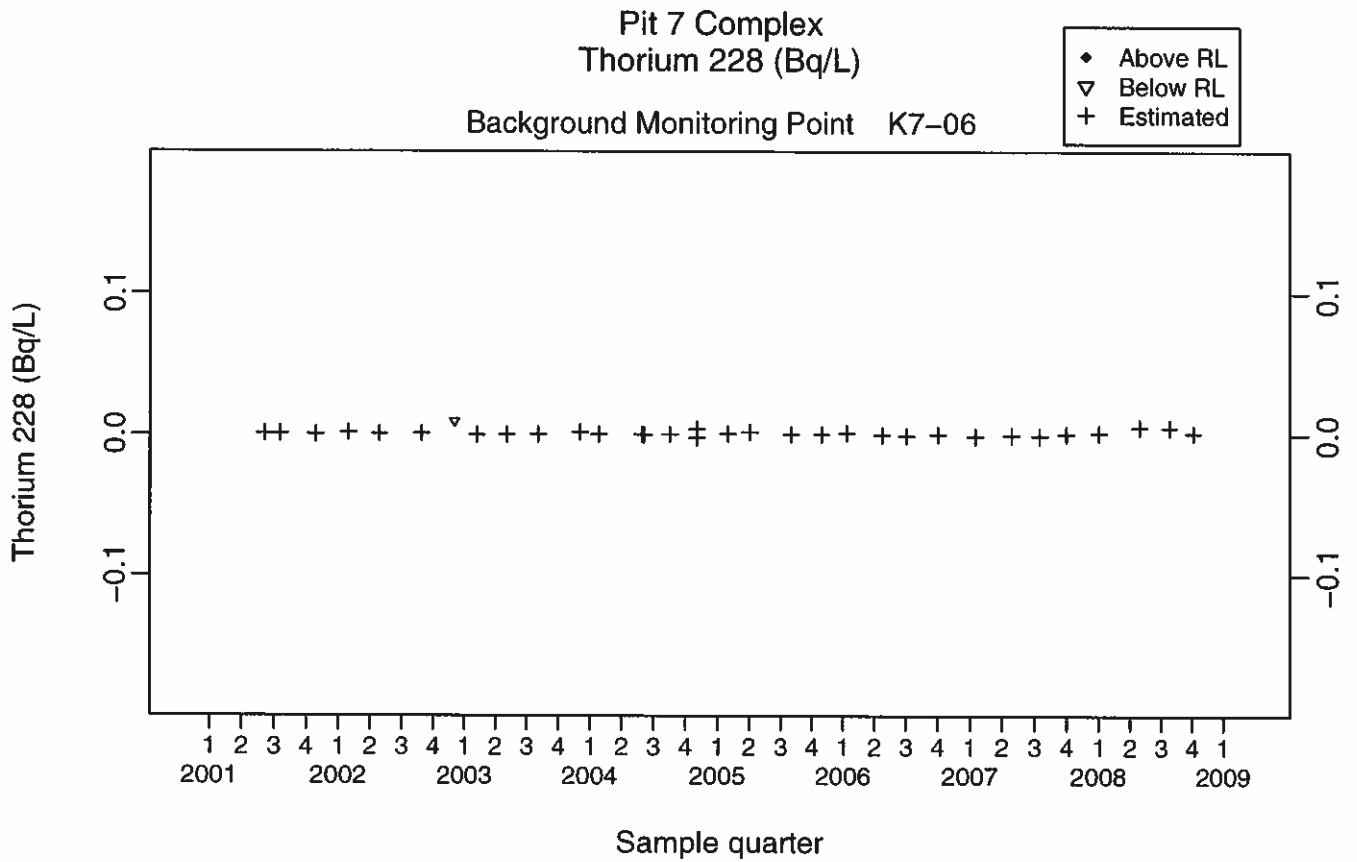


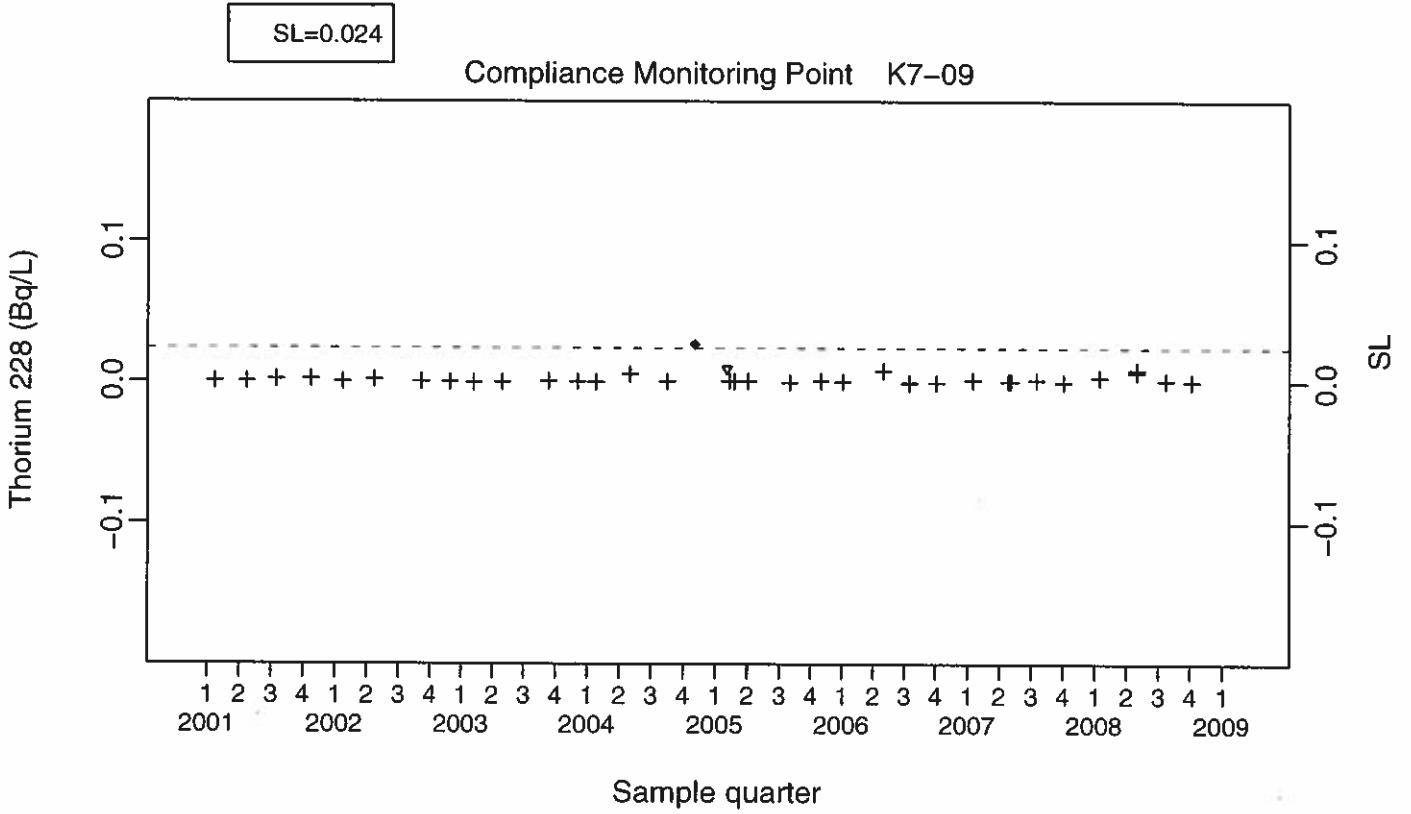
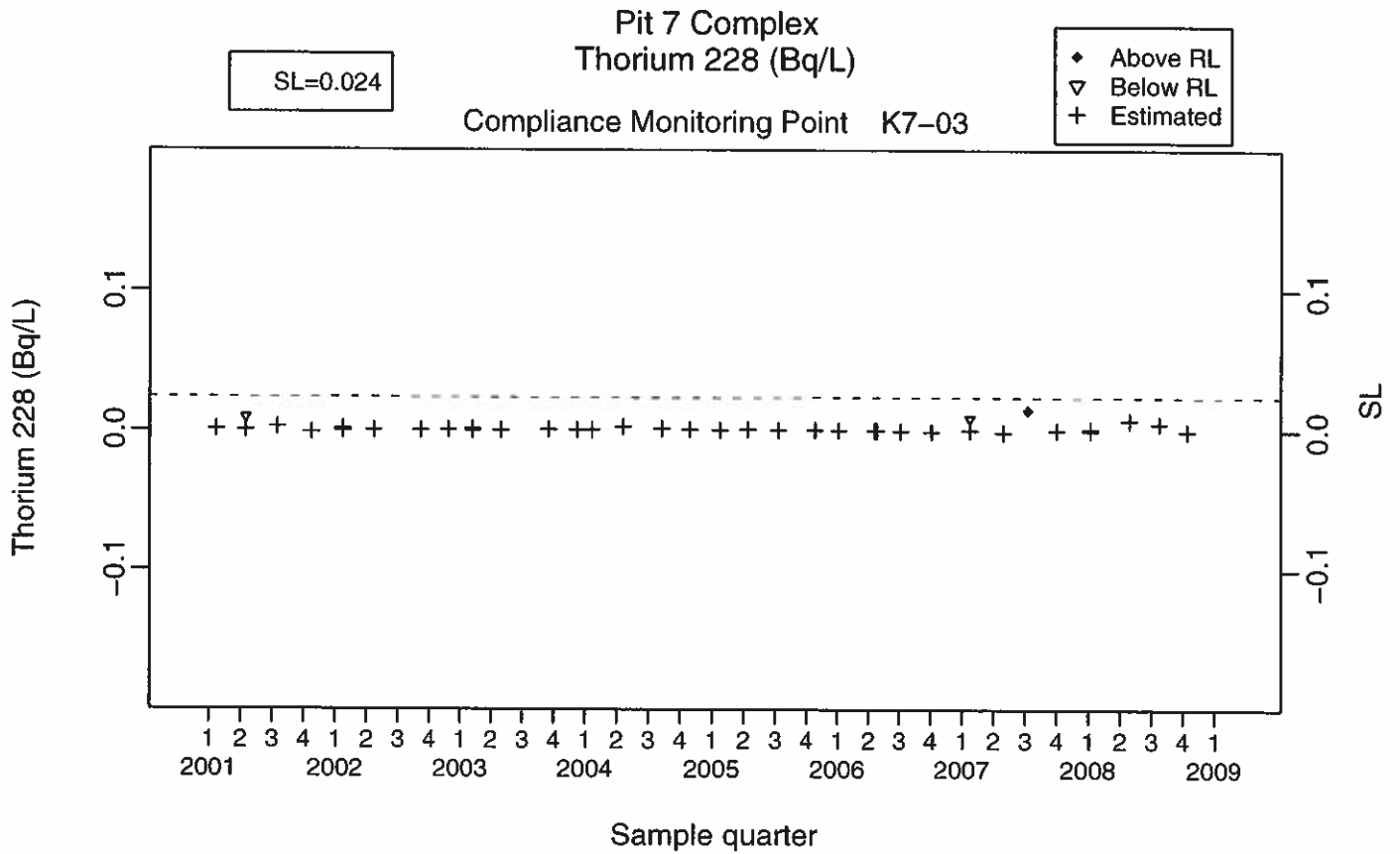


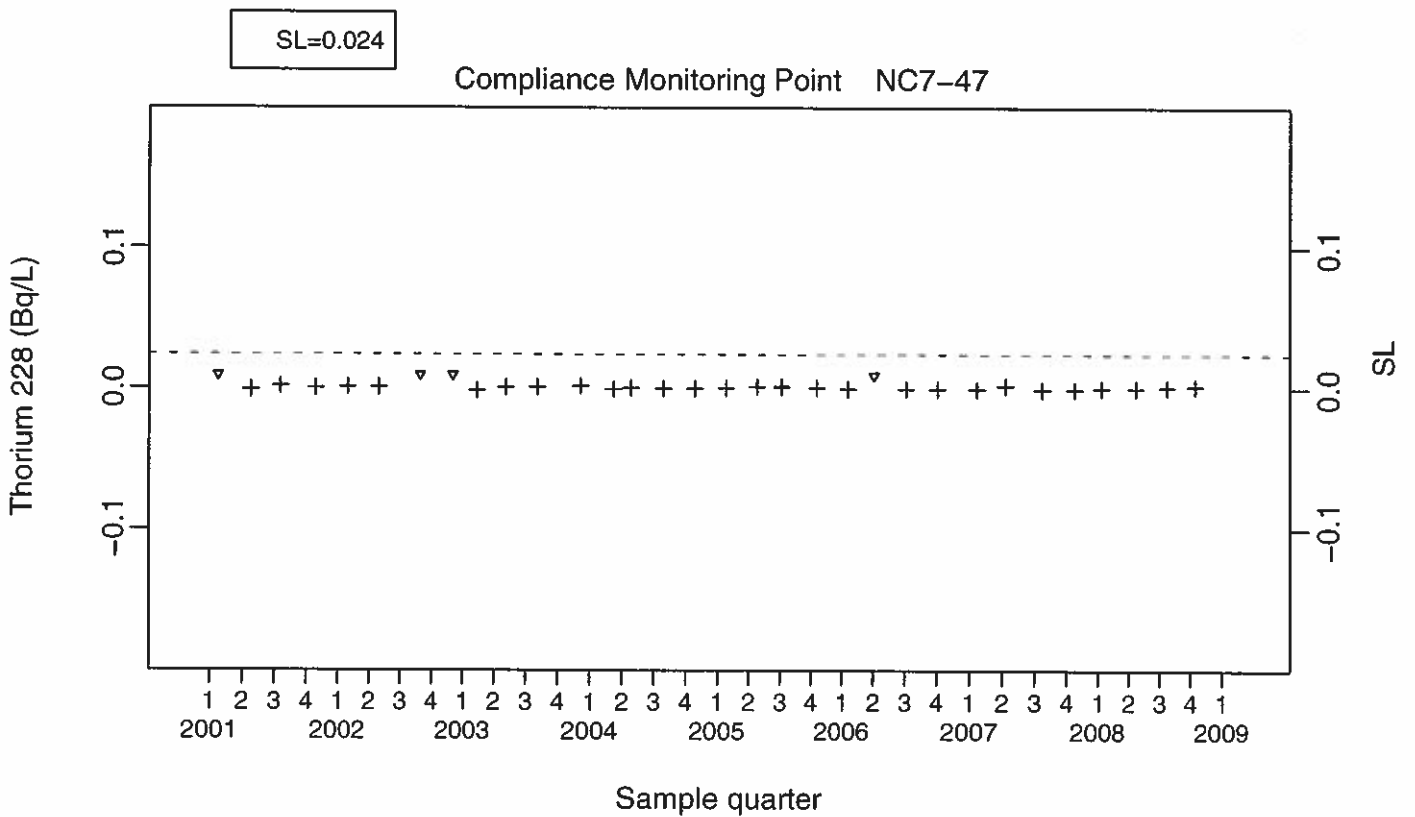
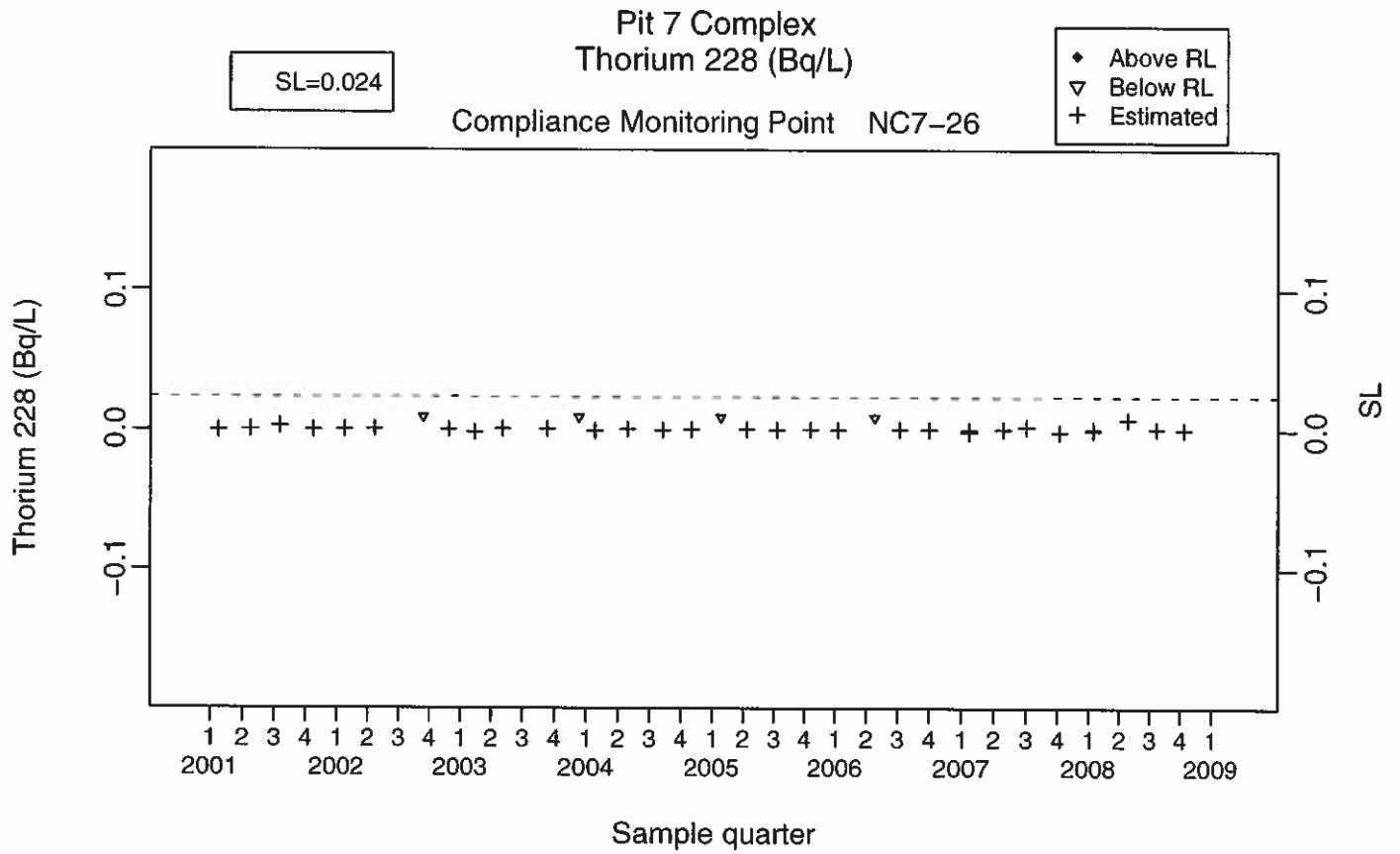


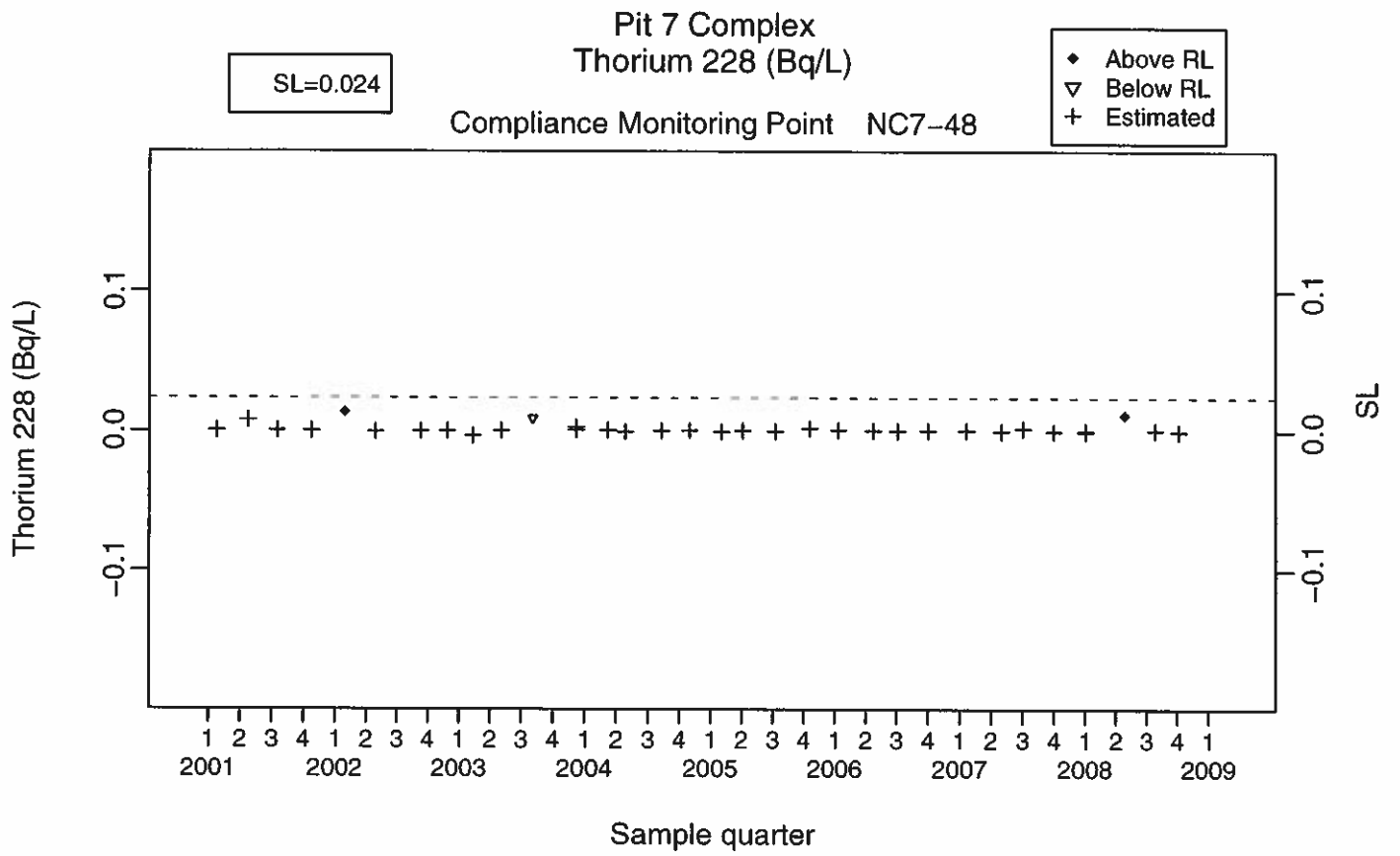


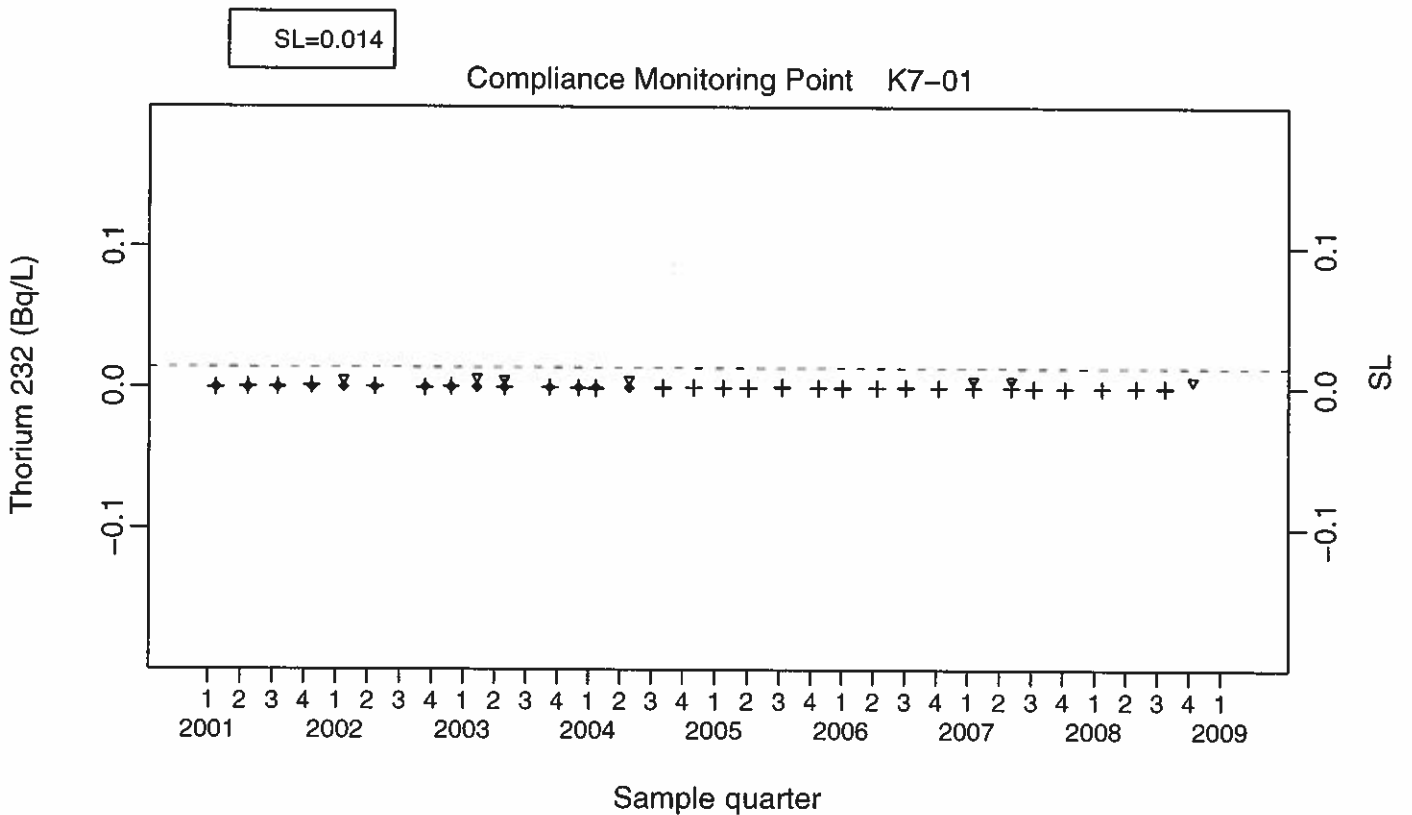
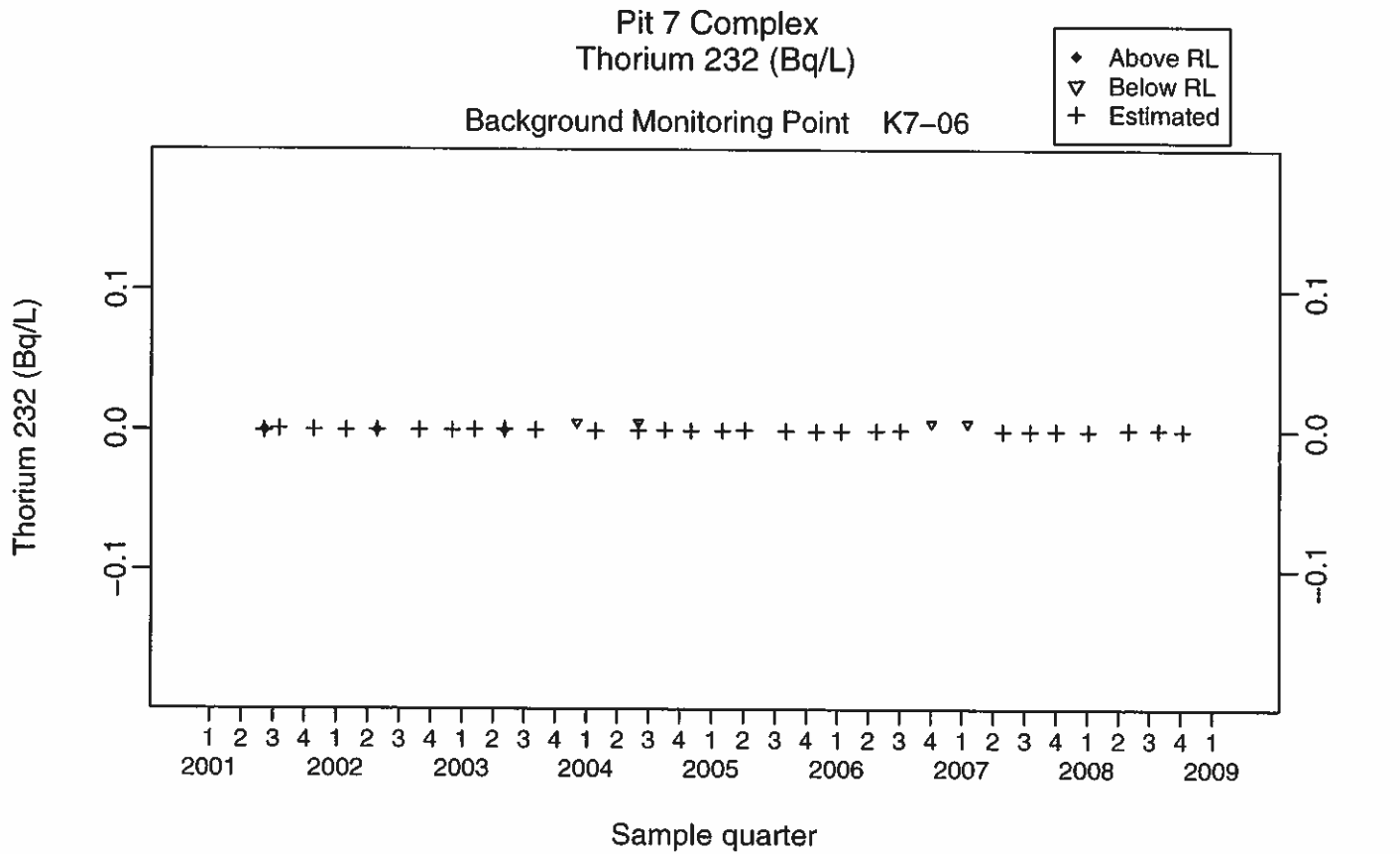


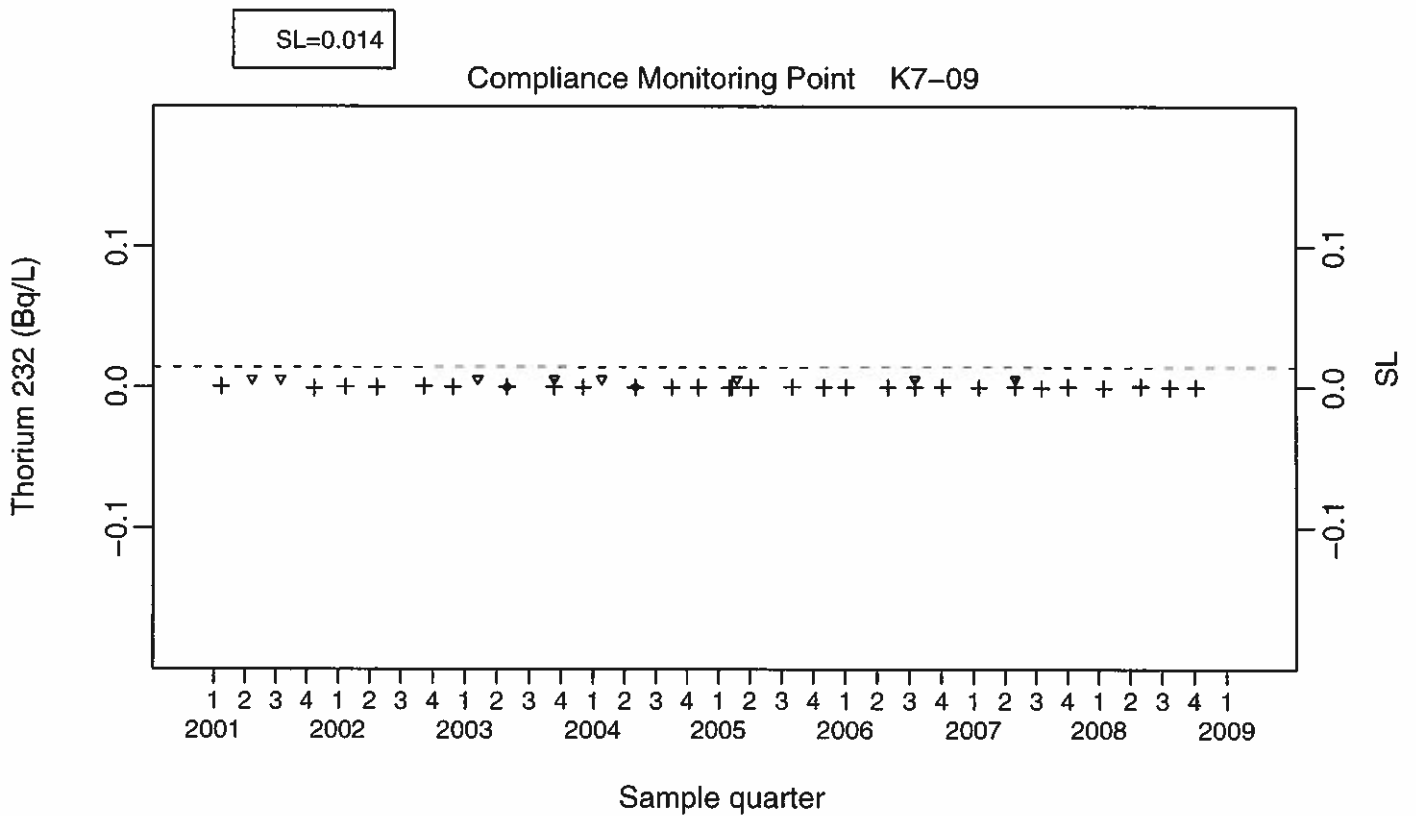
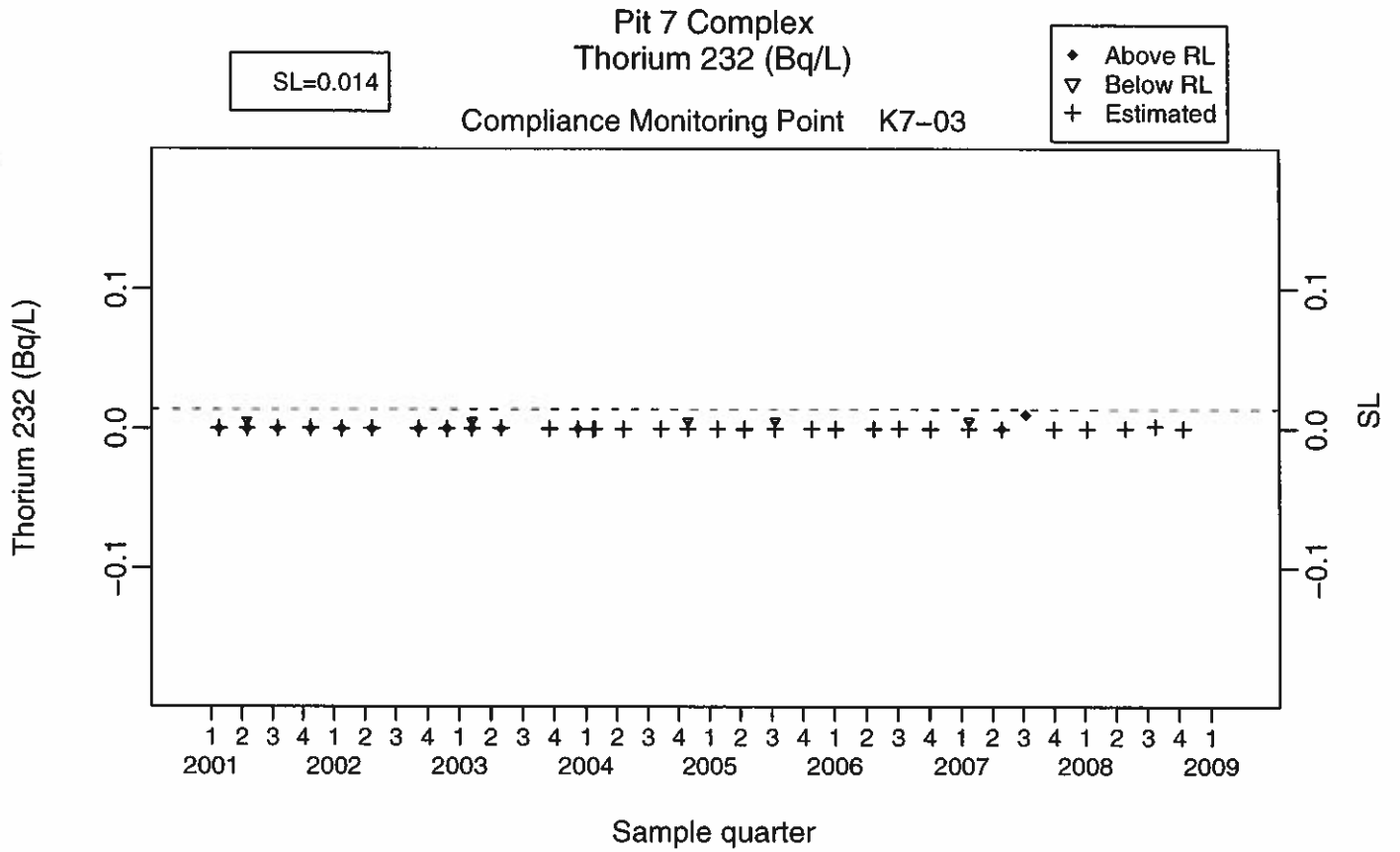


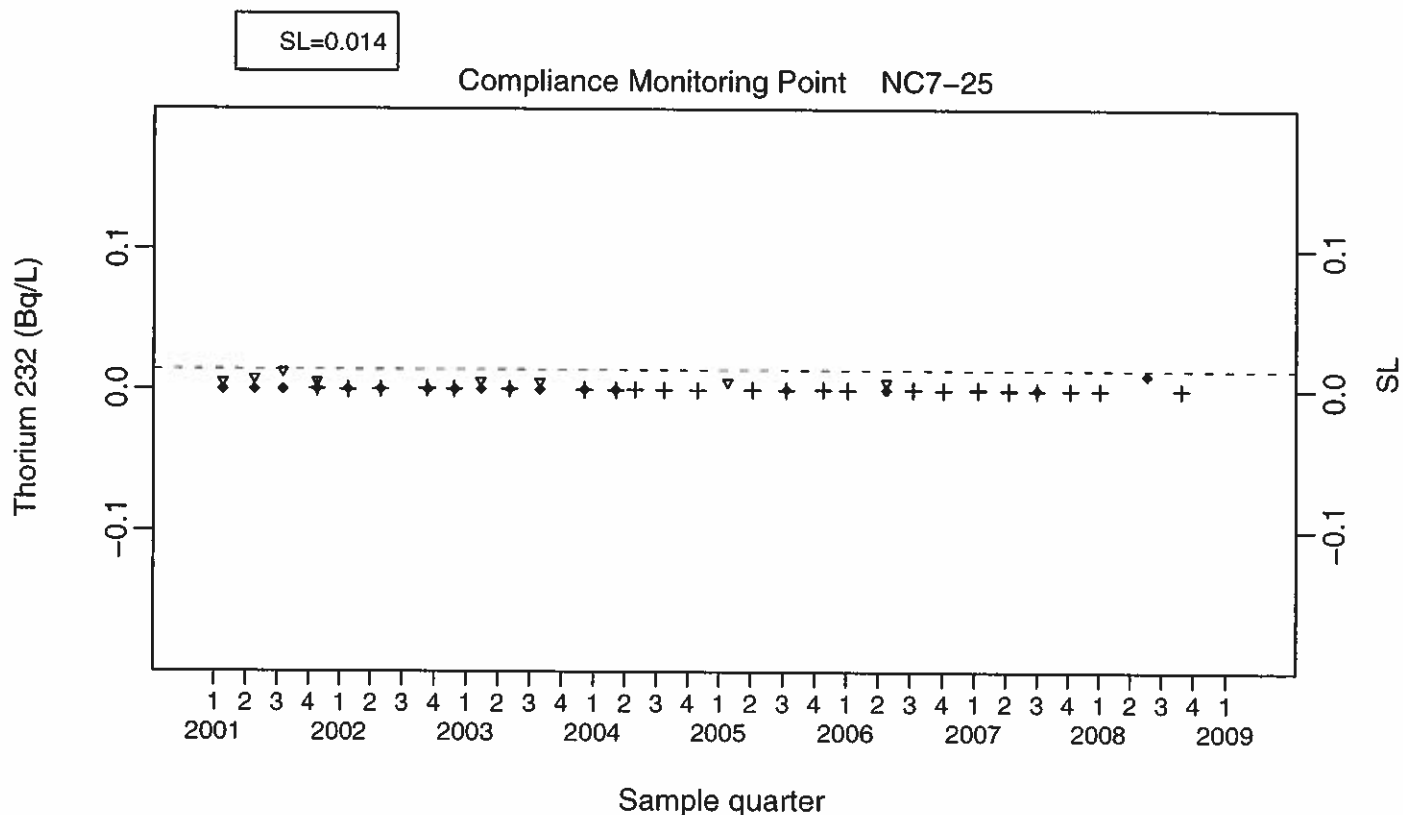
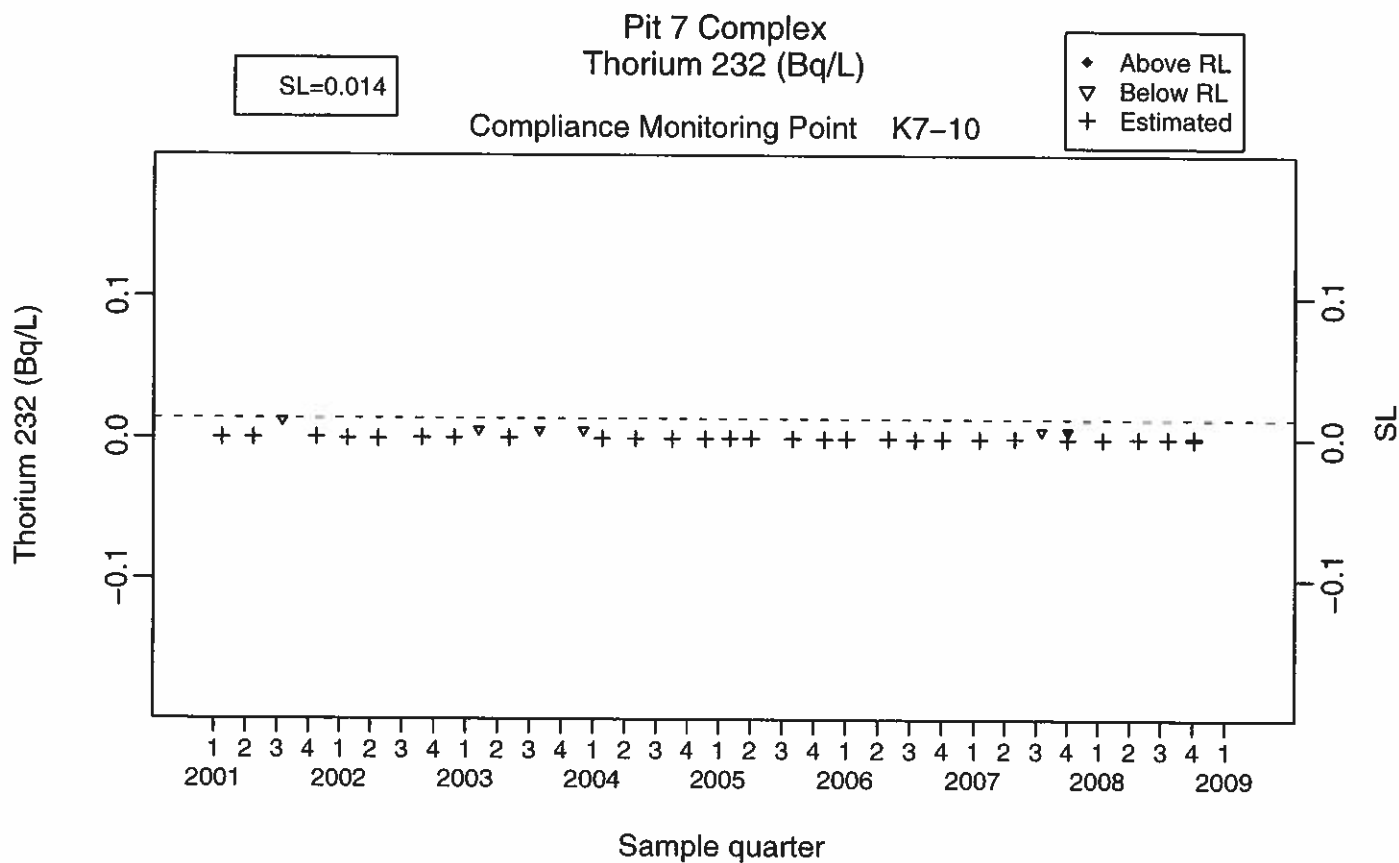


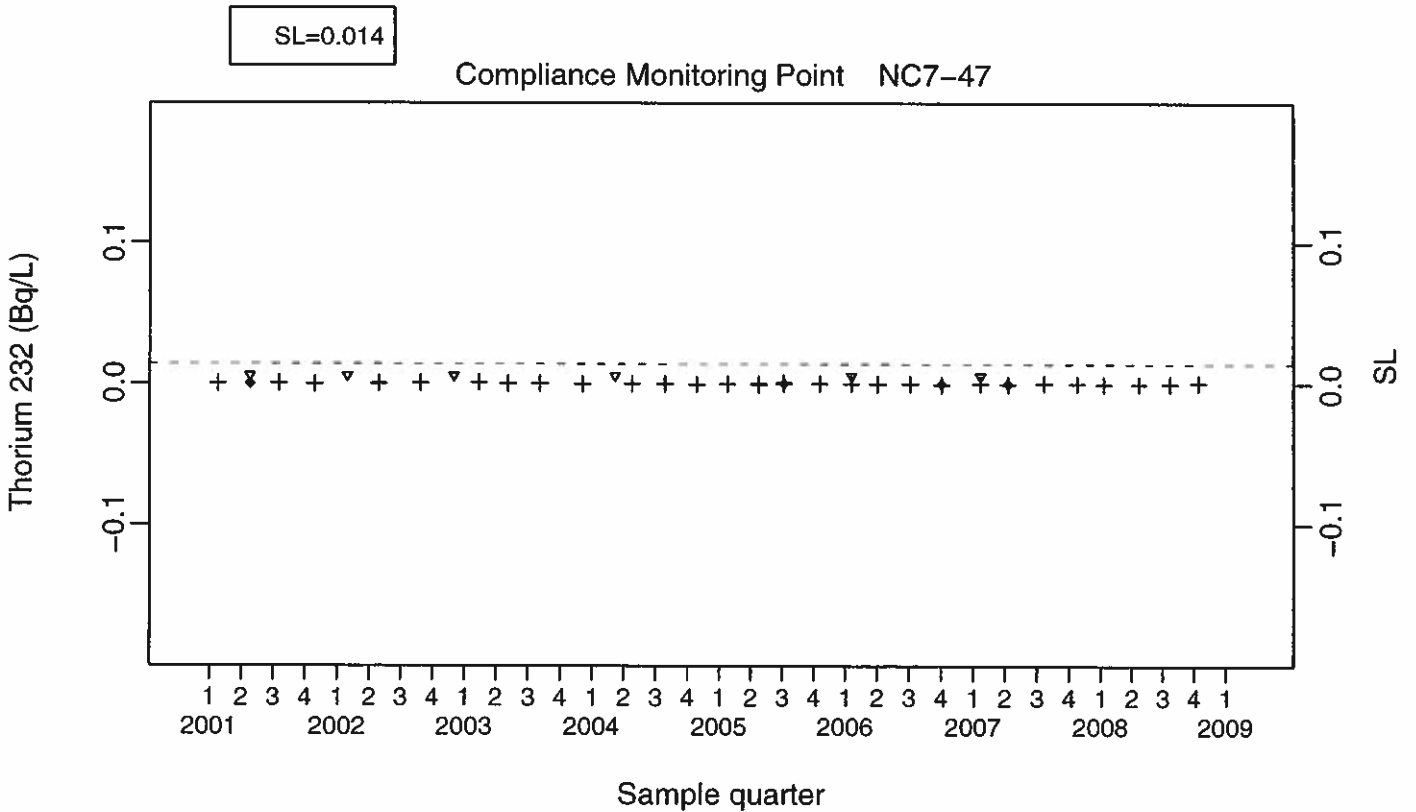
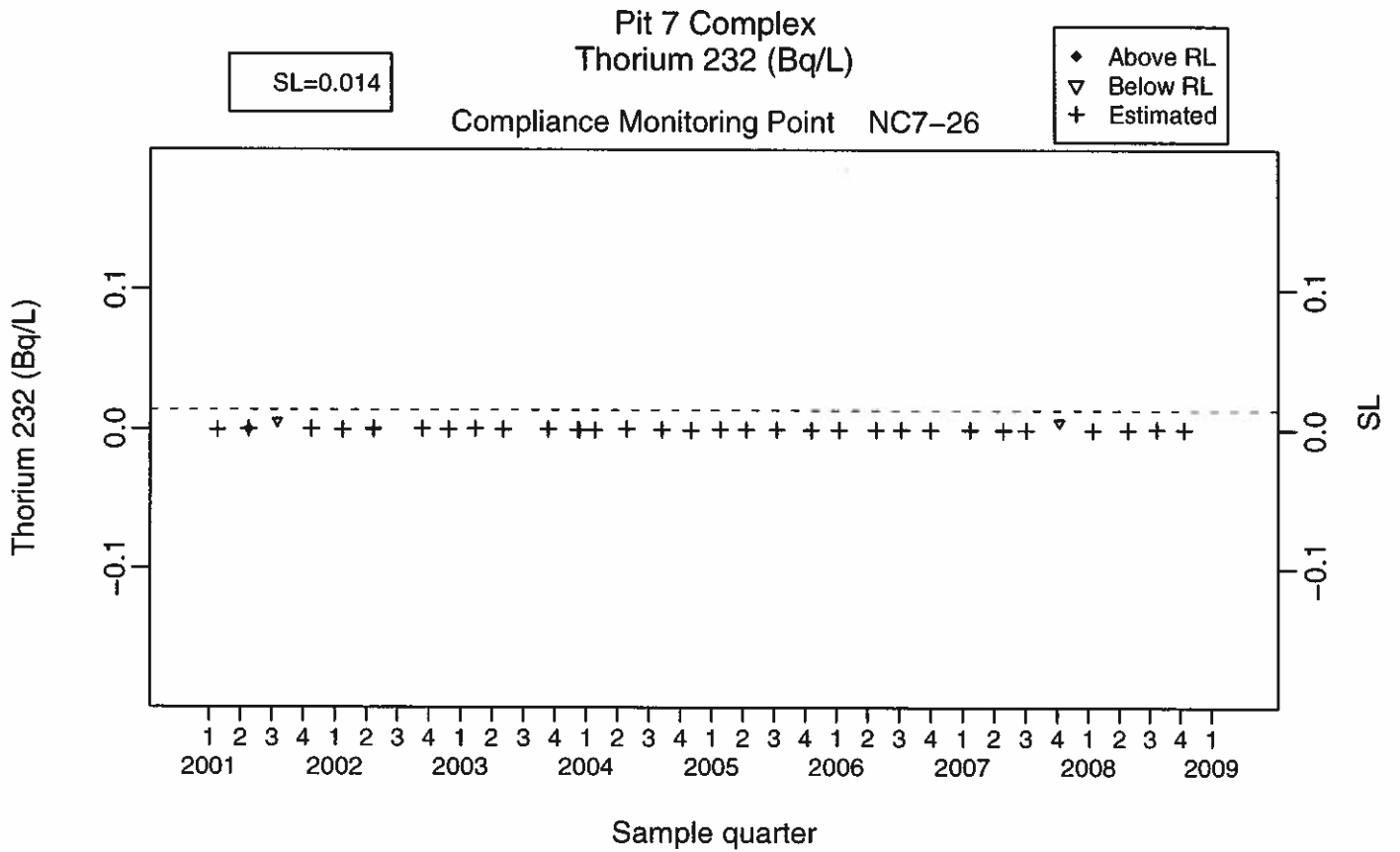


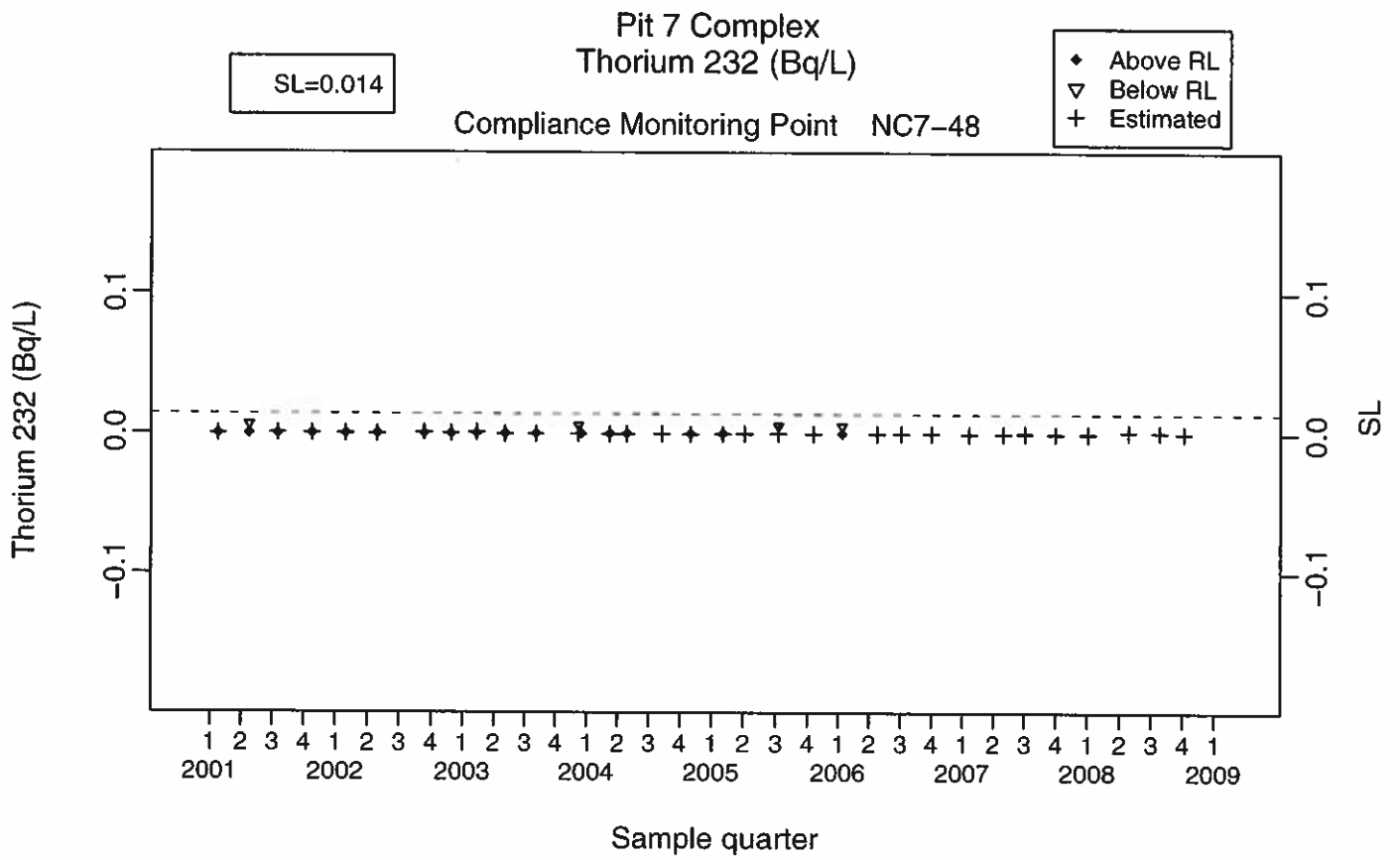


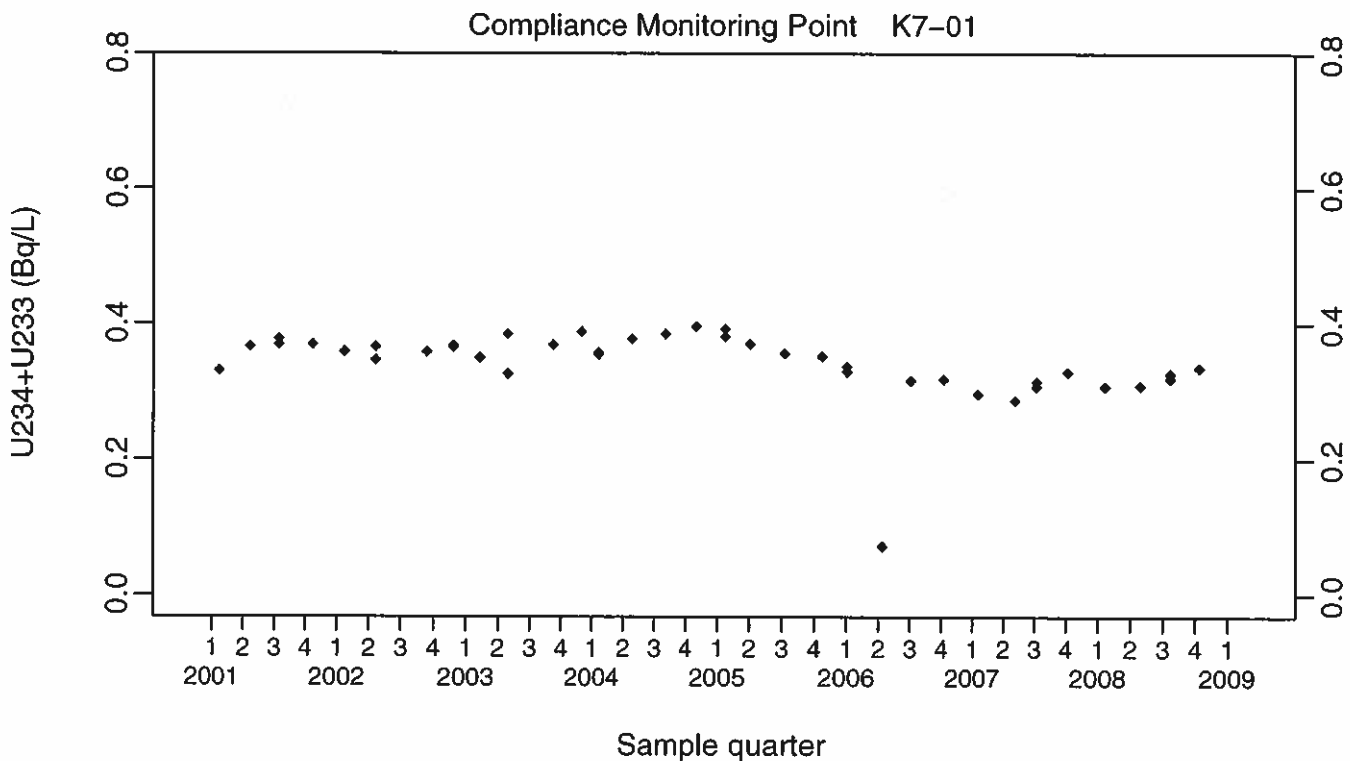
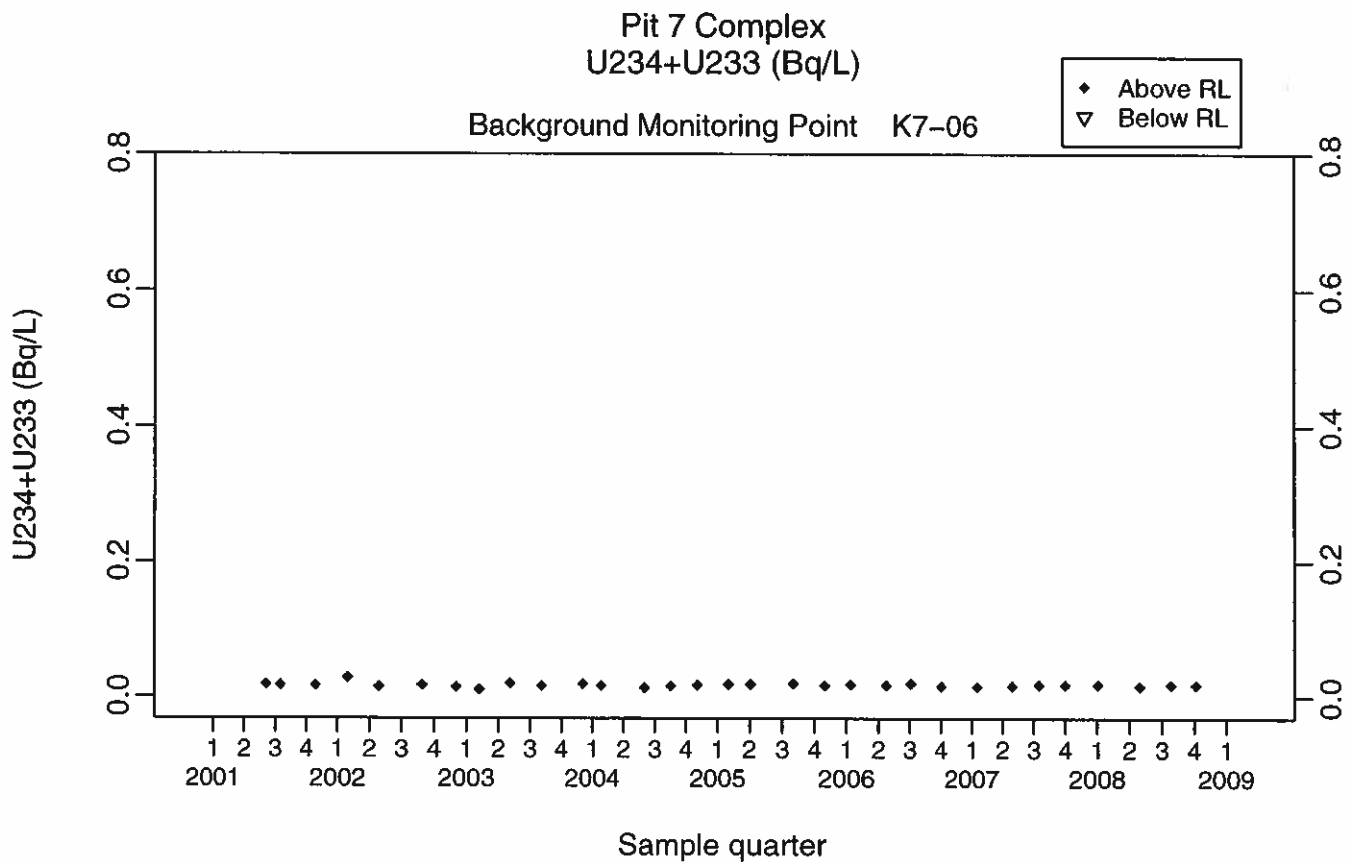


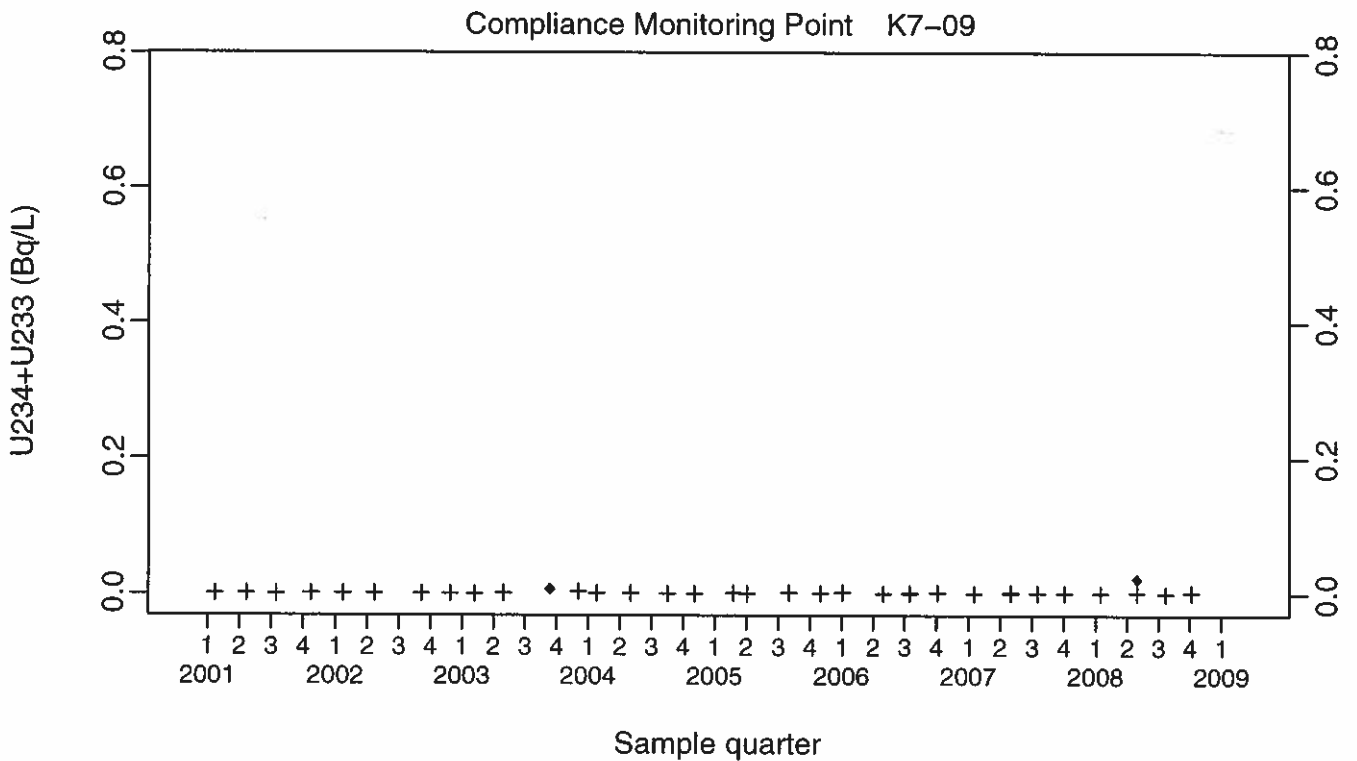
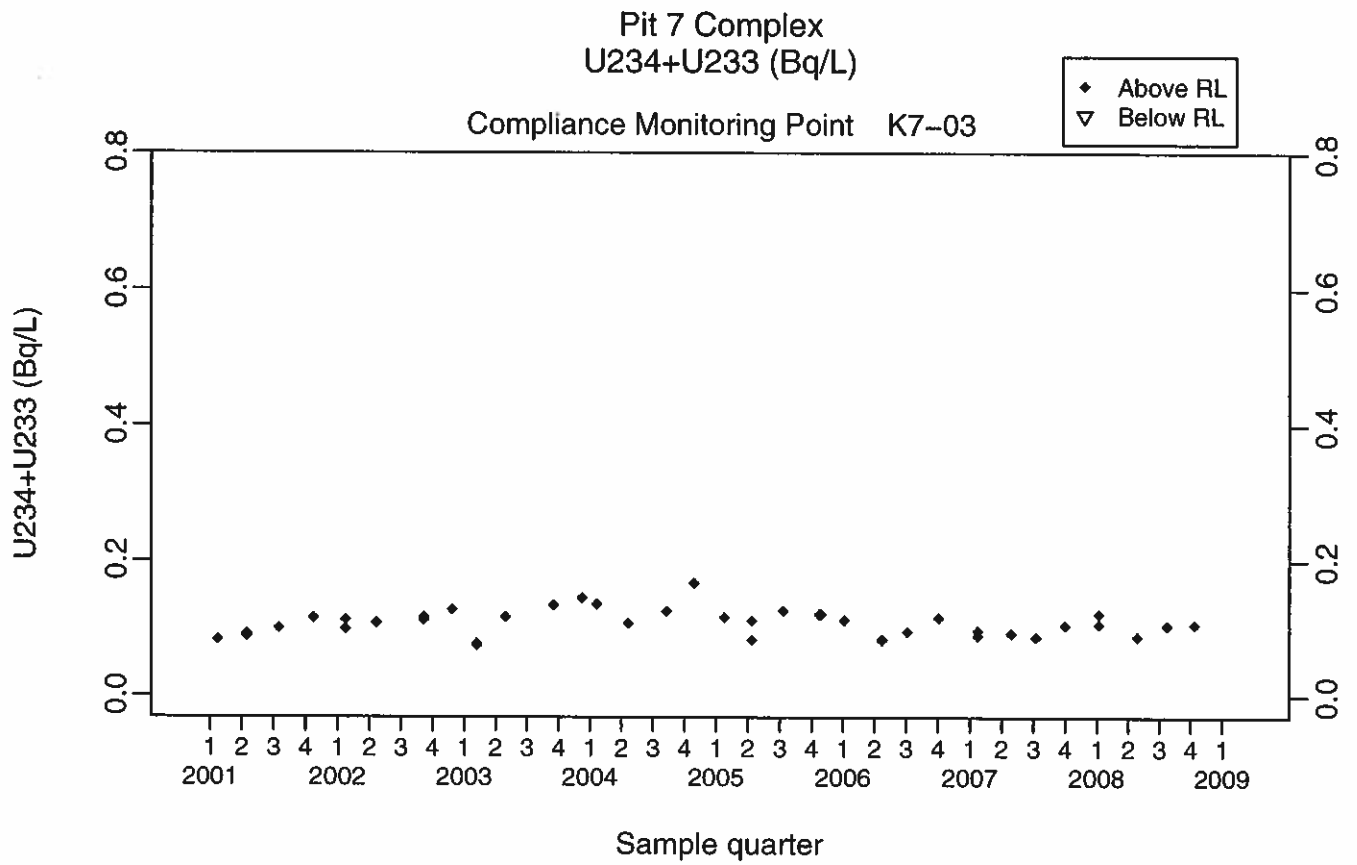


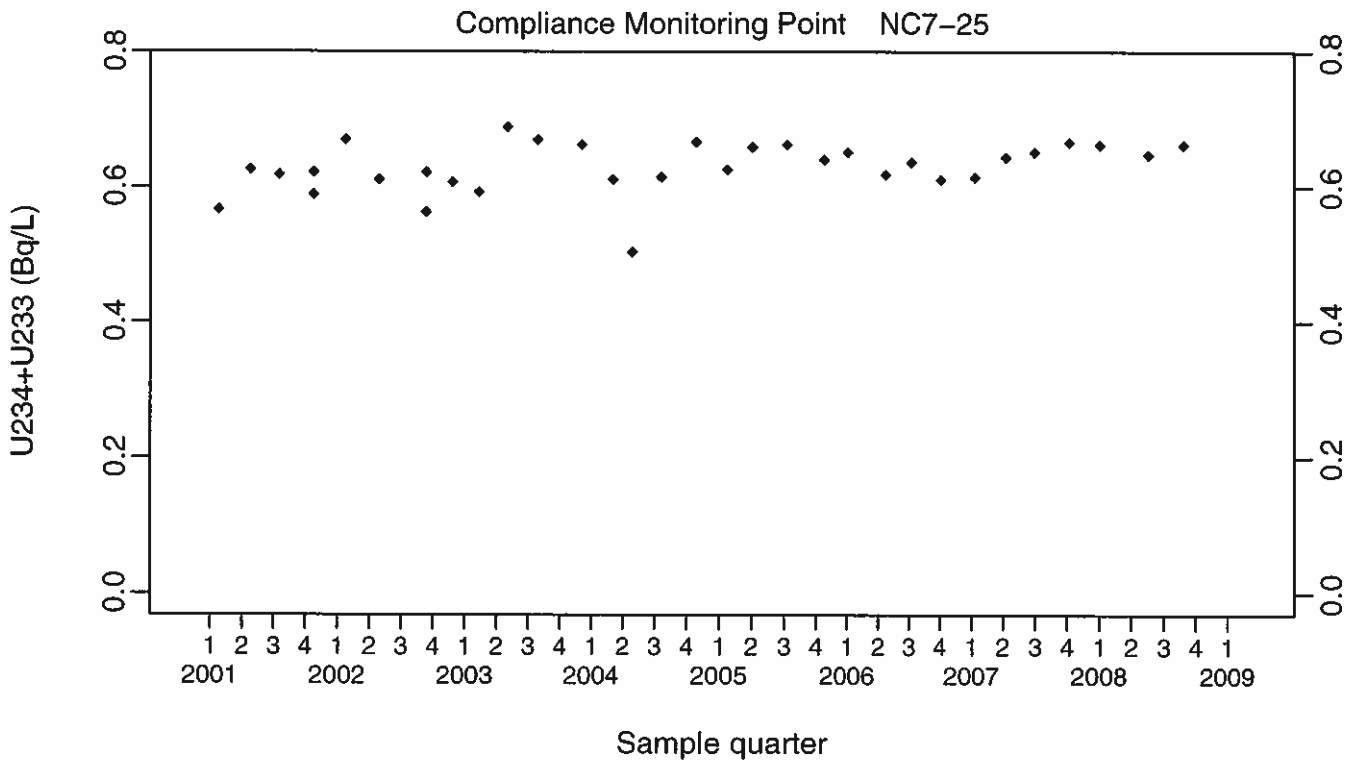
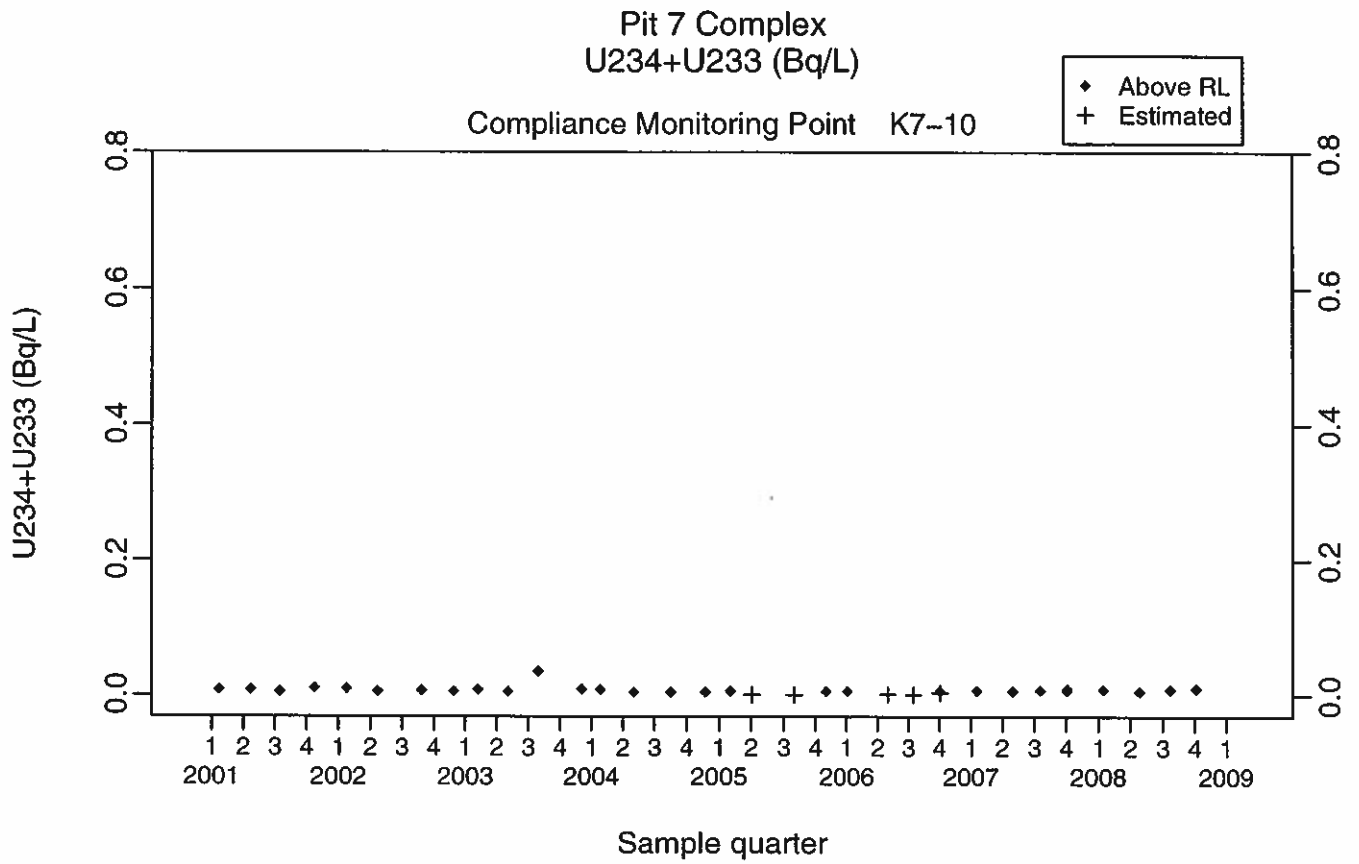








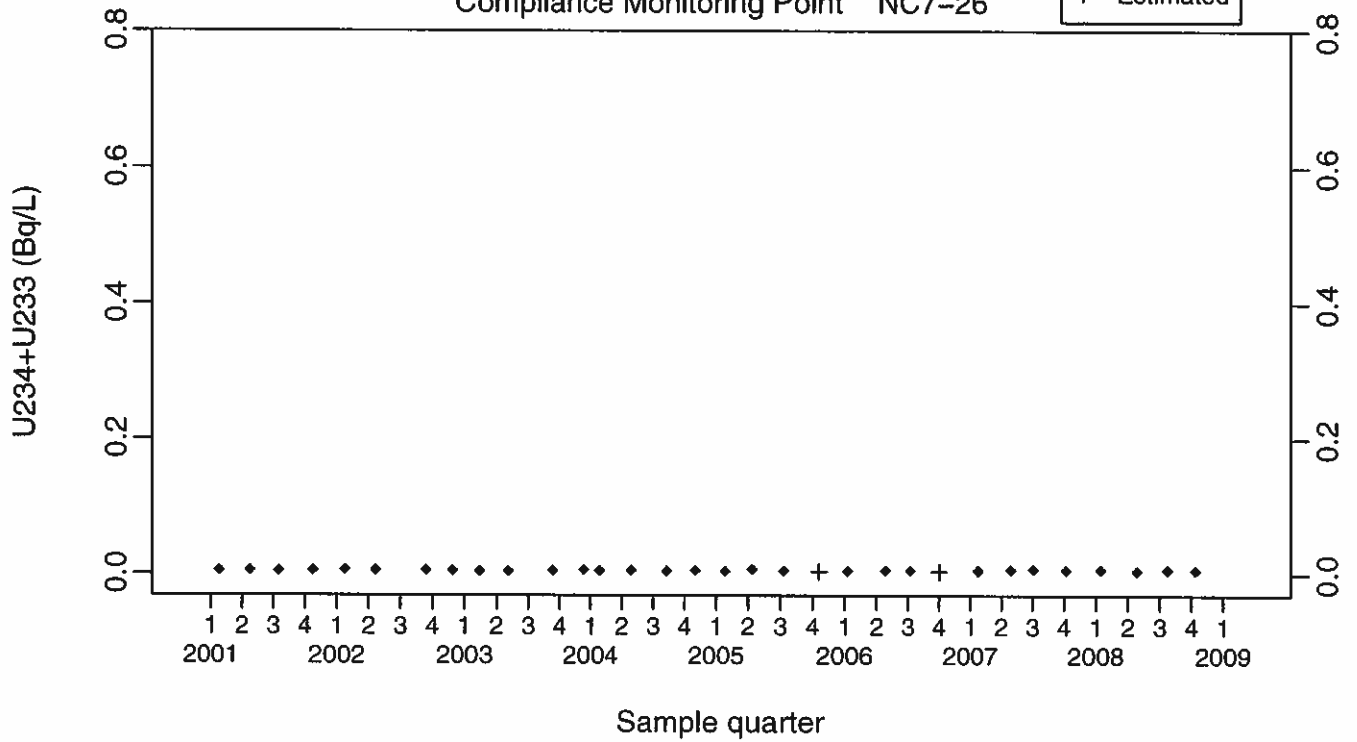




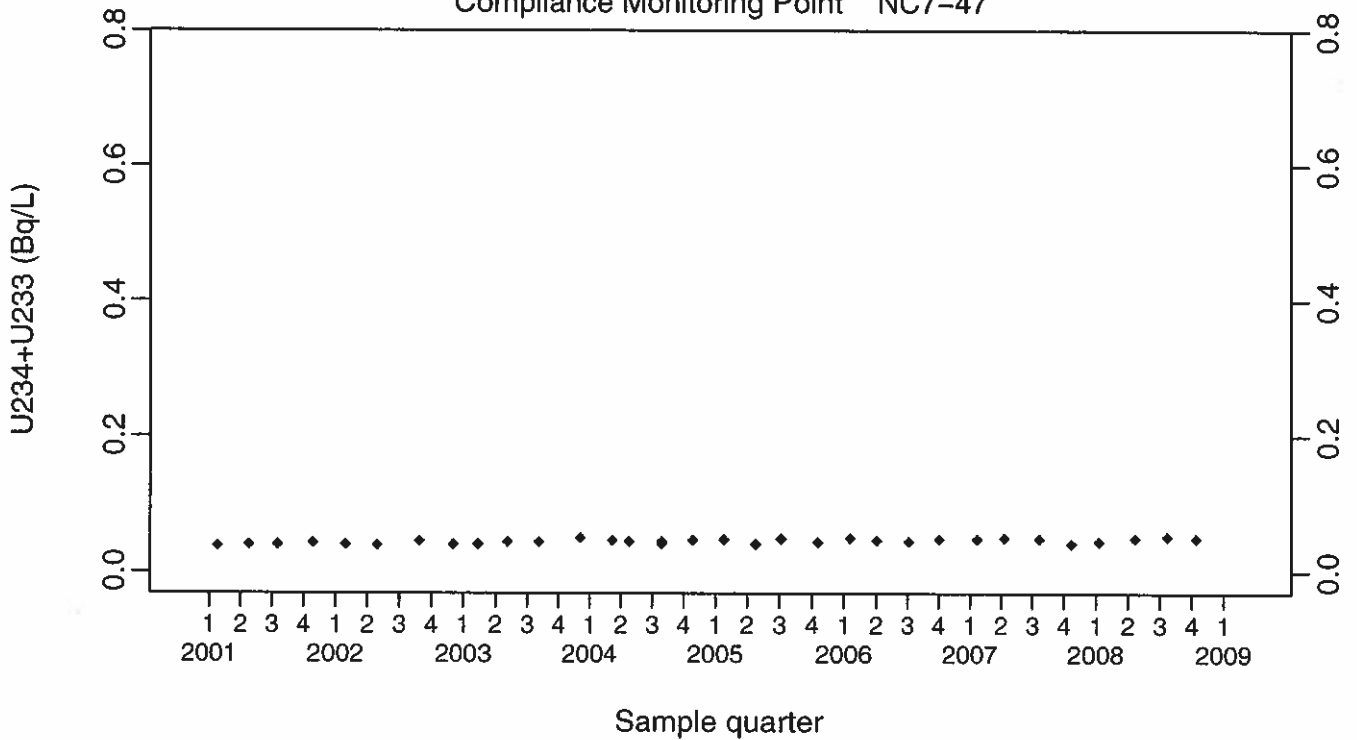
Pit 7 Complex
U234+U233 (Bq/L)

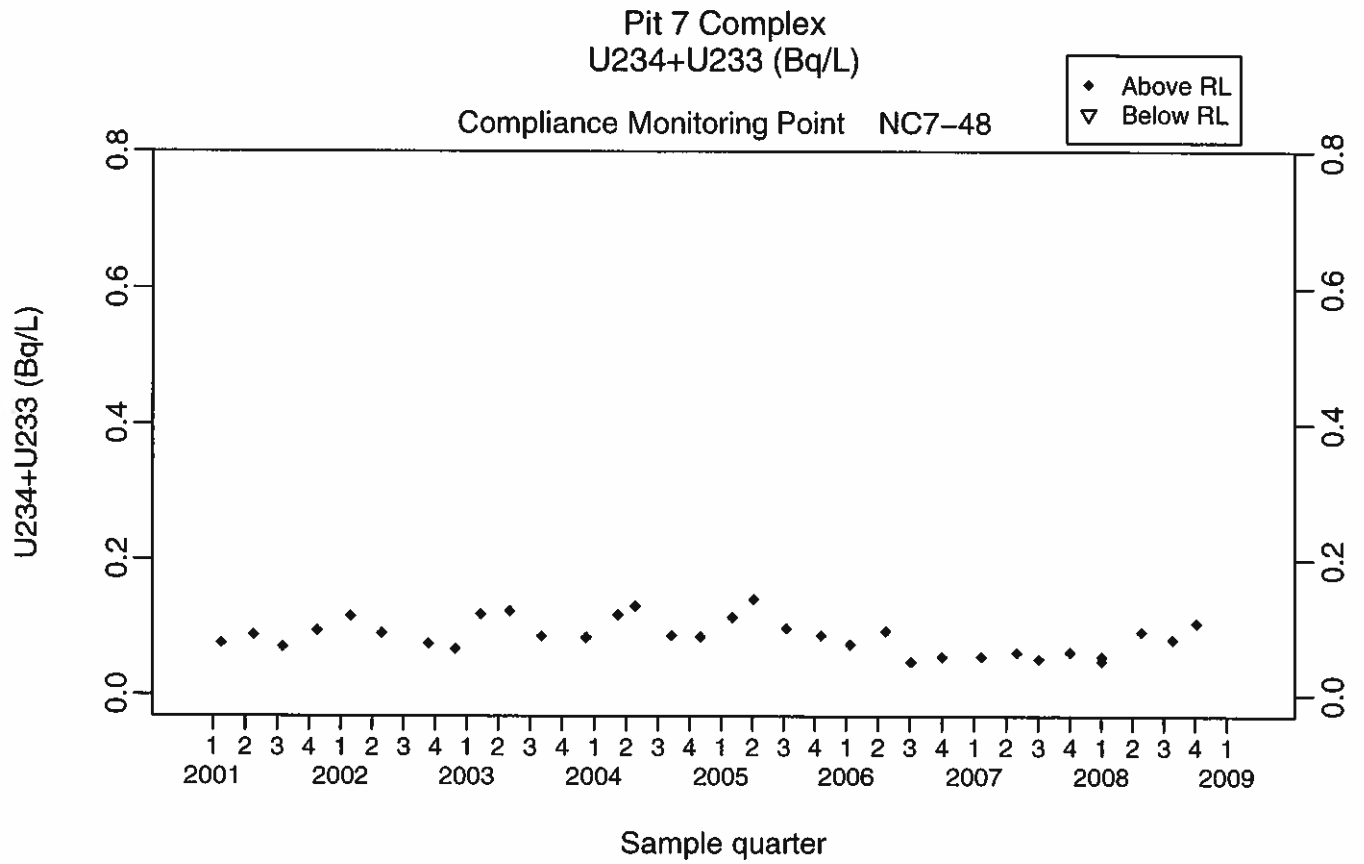
Compliance Monitoring Point NC7-26

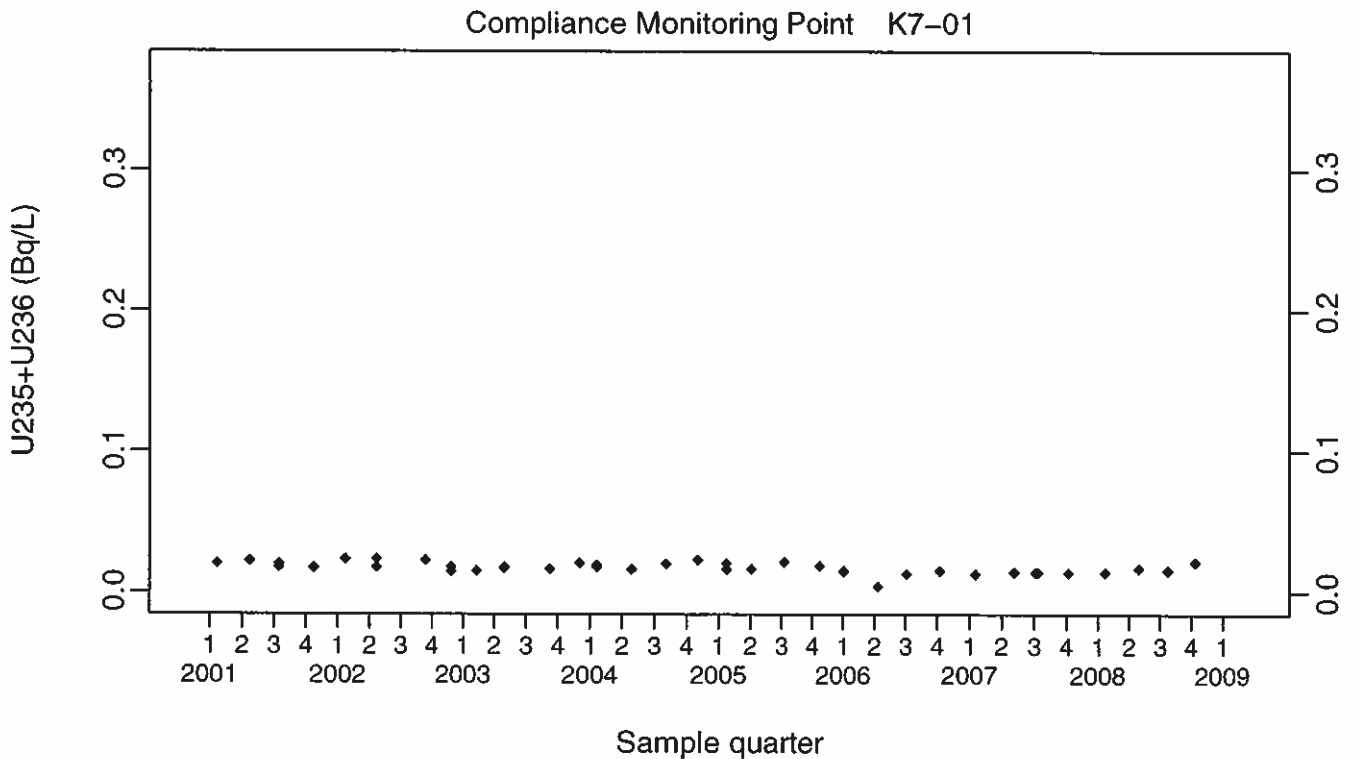
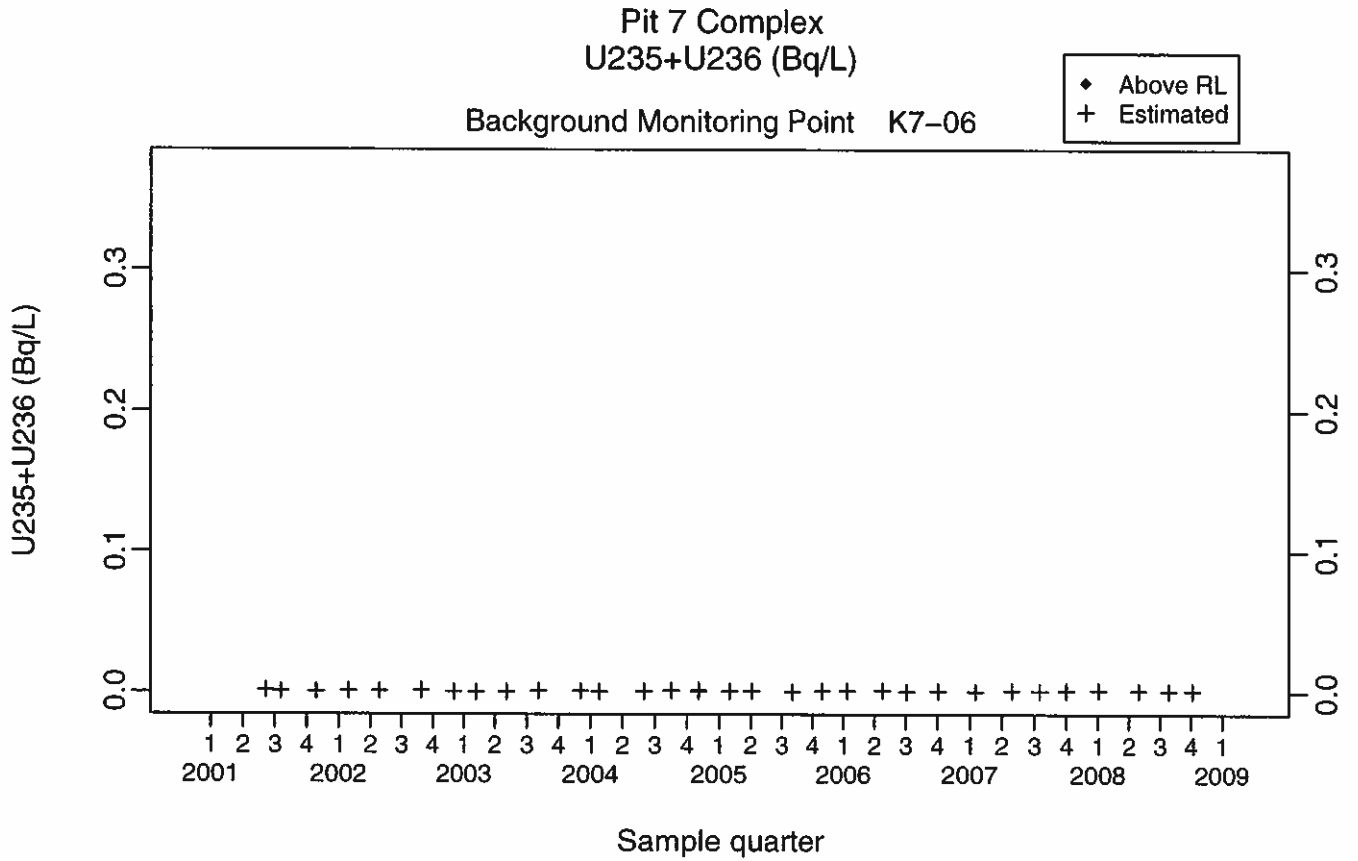
◆ Above RL
+ Estimated

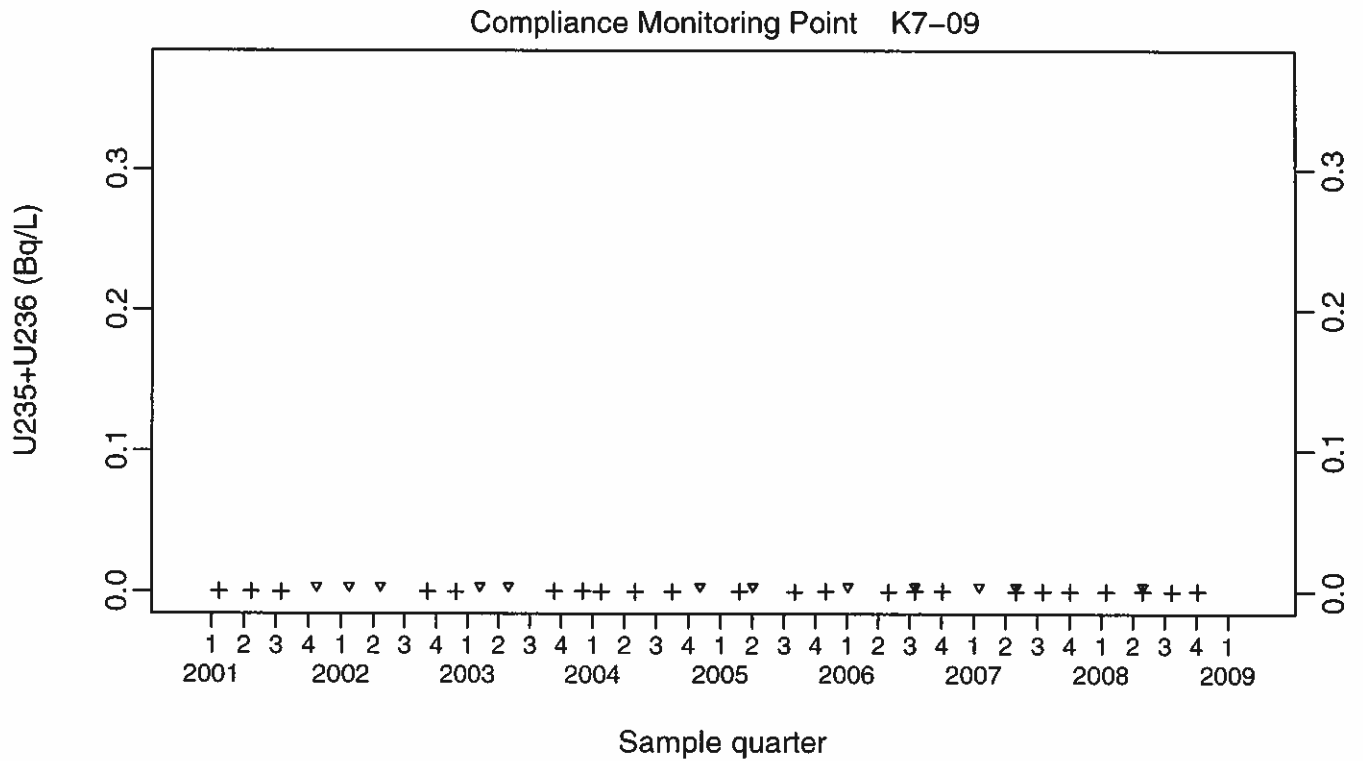
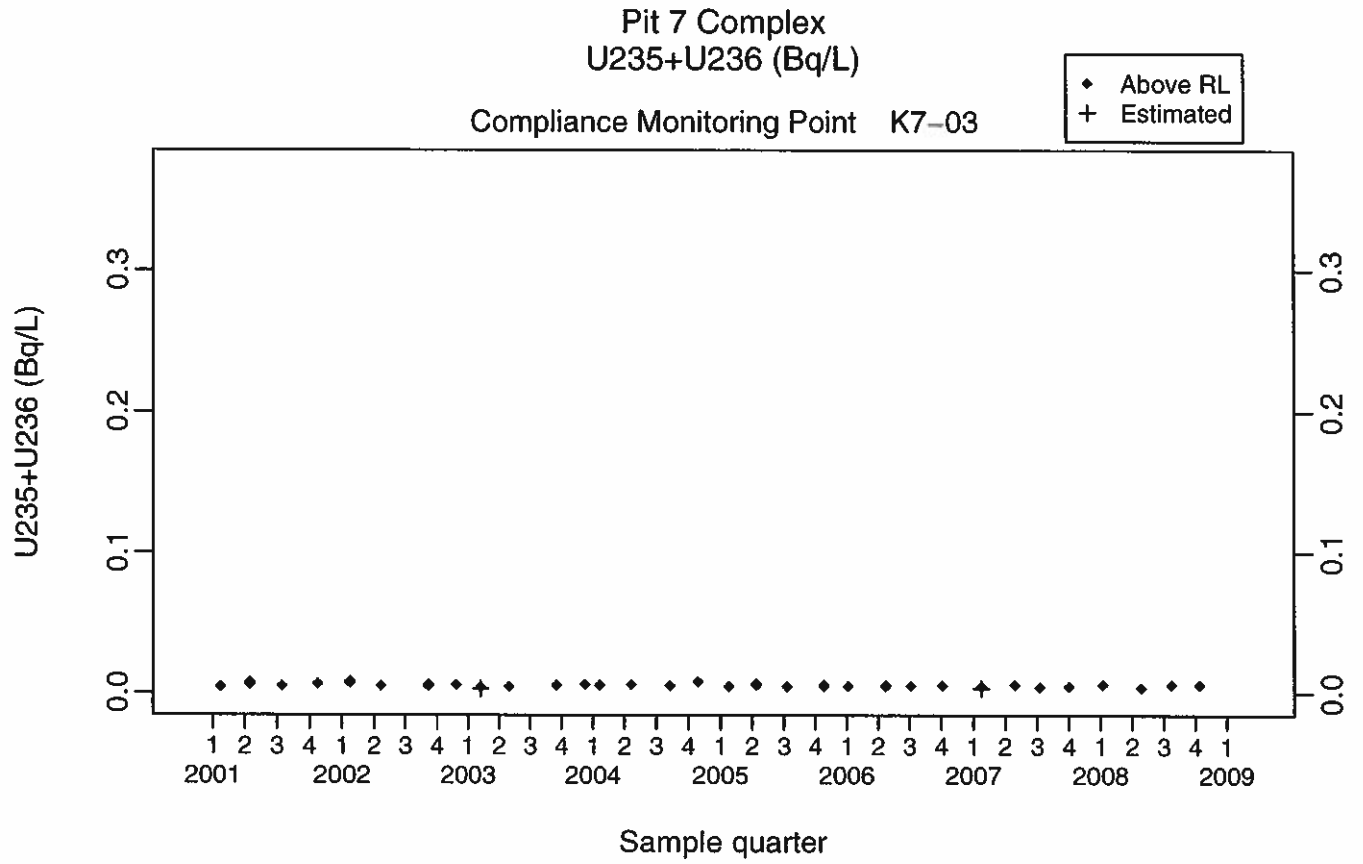


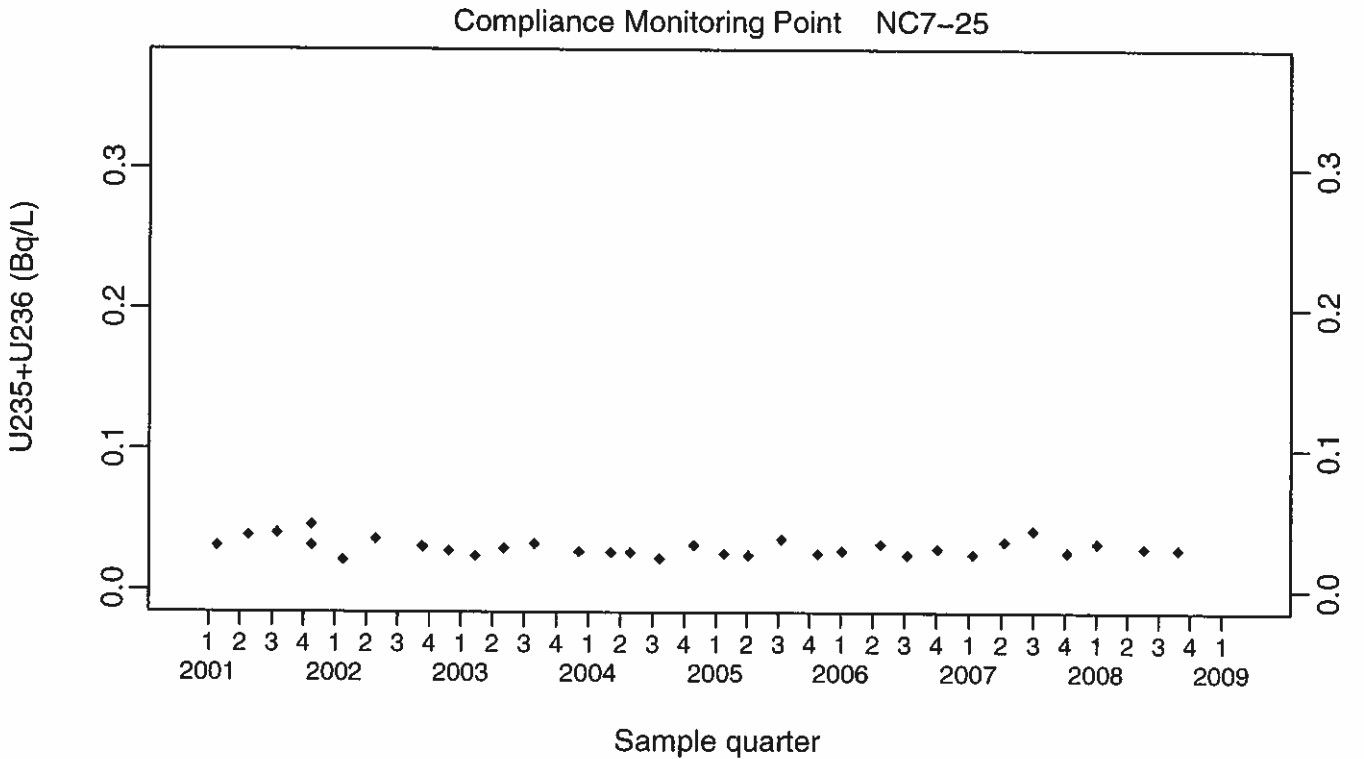
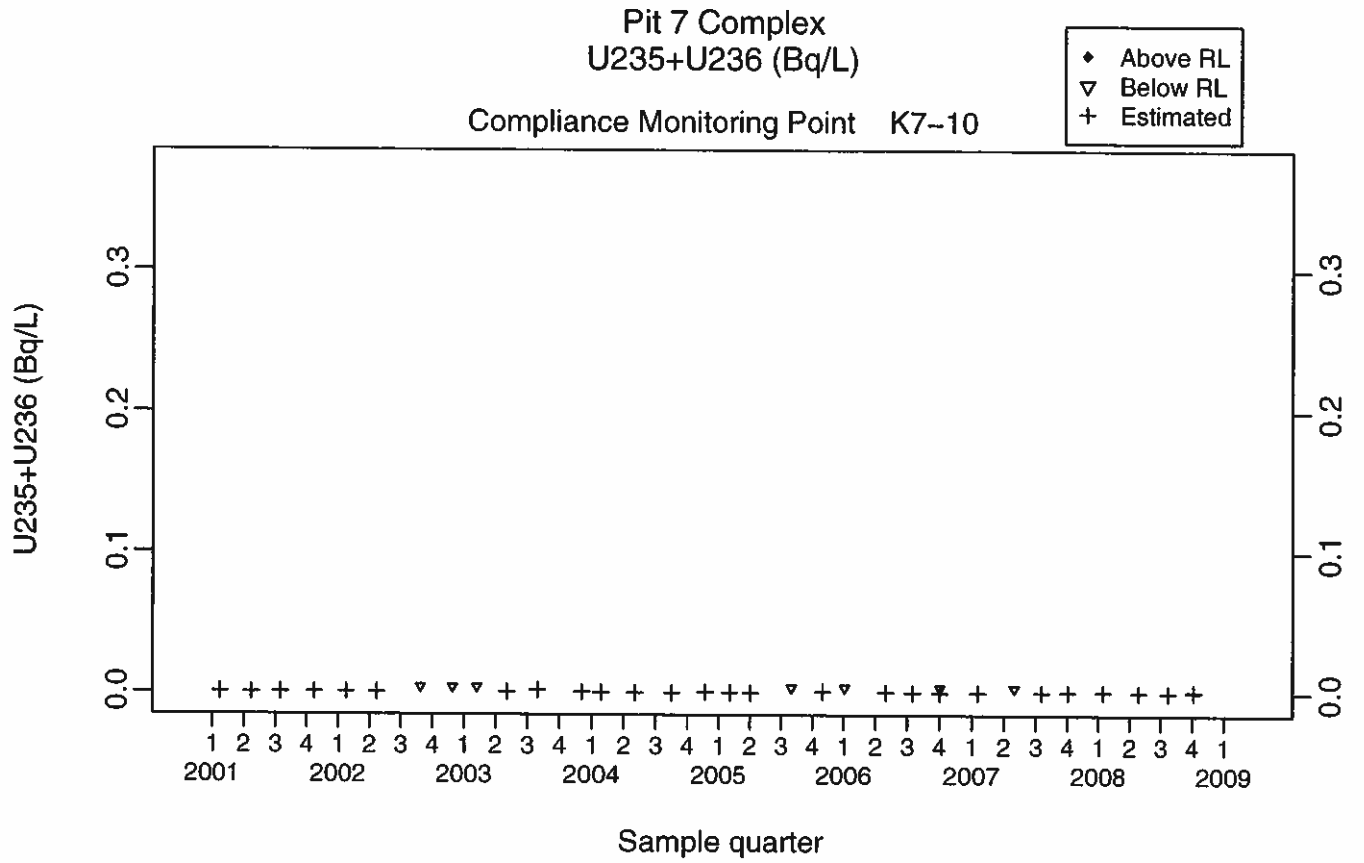
Compliance Monitoring Point NC7-47







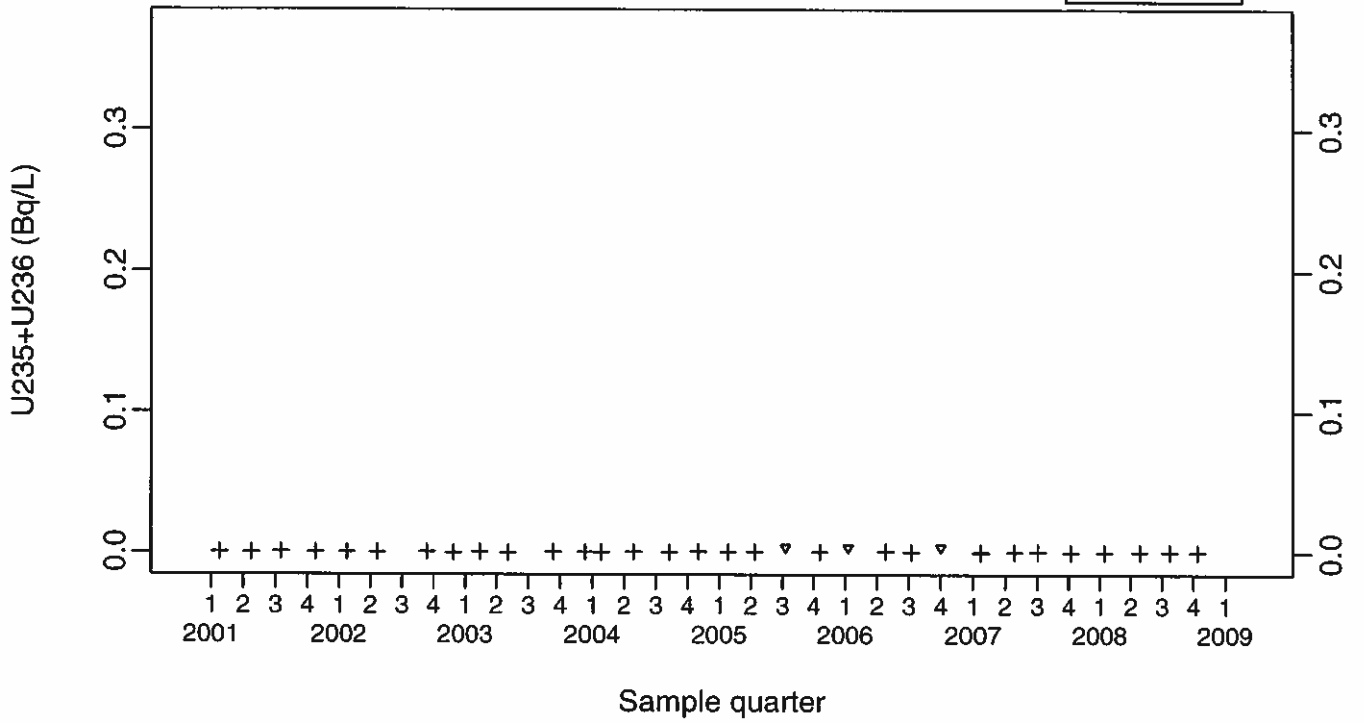




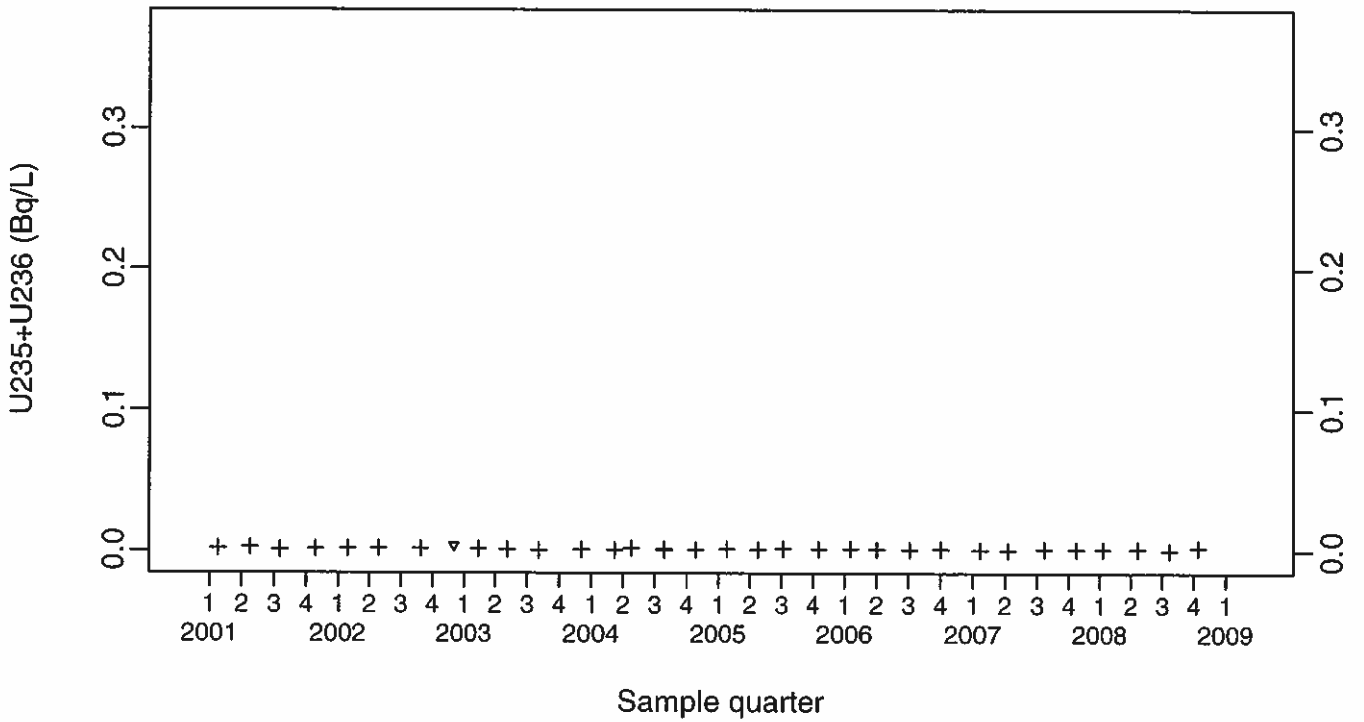
Pit 7 Complex
U235+U236 (Bq/L)

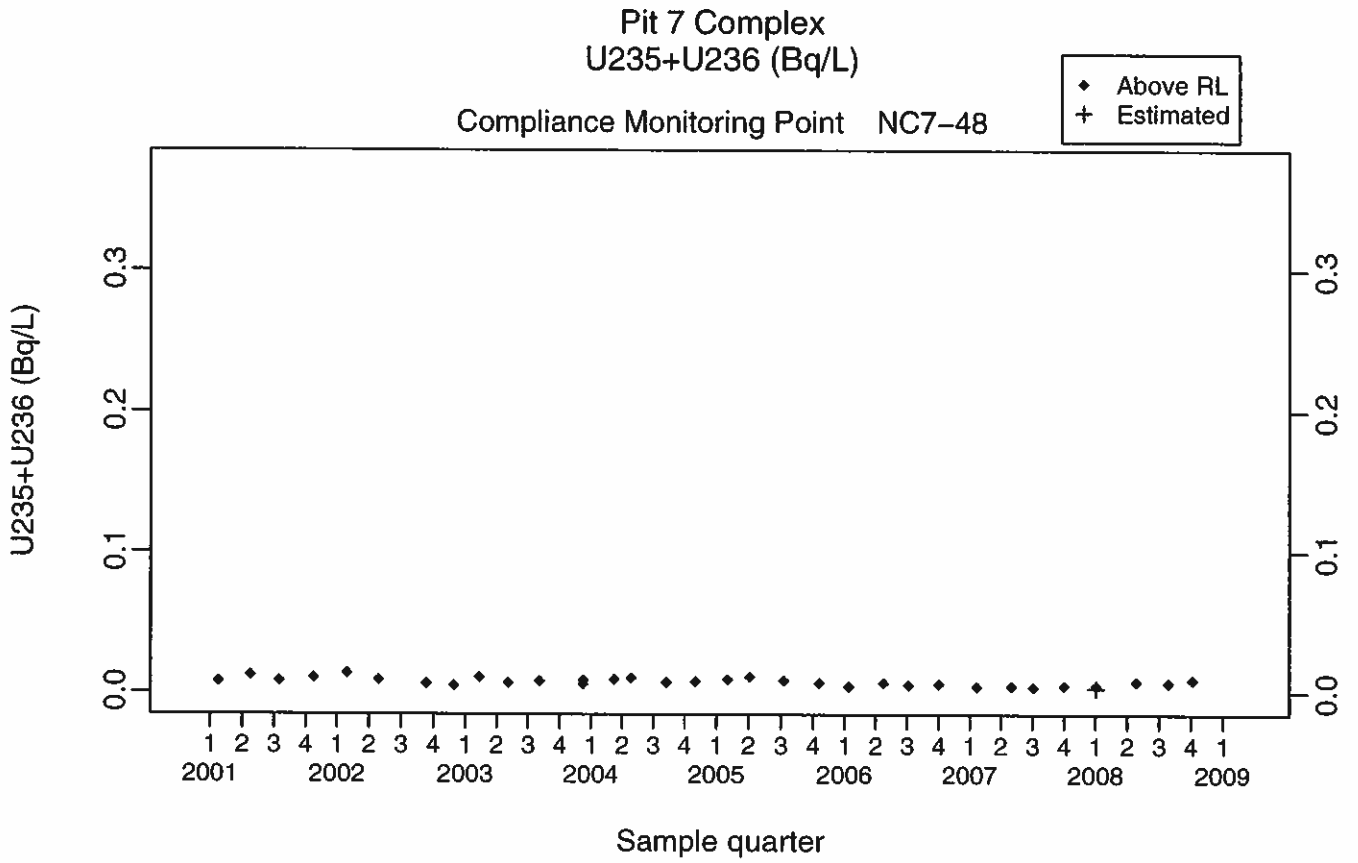
Compliance Monitoring Point NC7-26

- ◆ Above RL
- ▽ Below RL
- + Estimated



Compliance Monitoring Point NC7-47

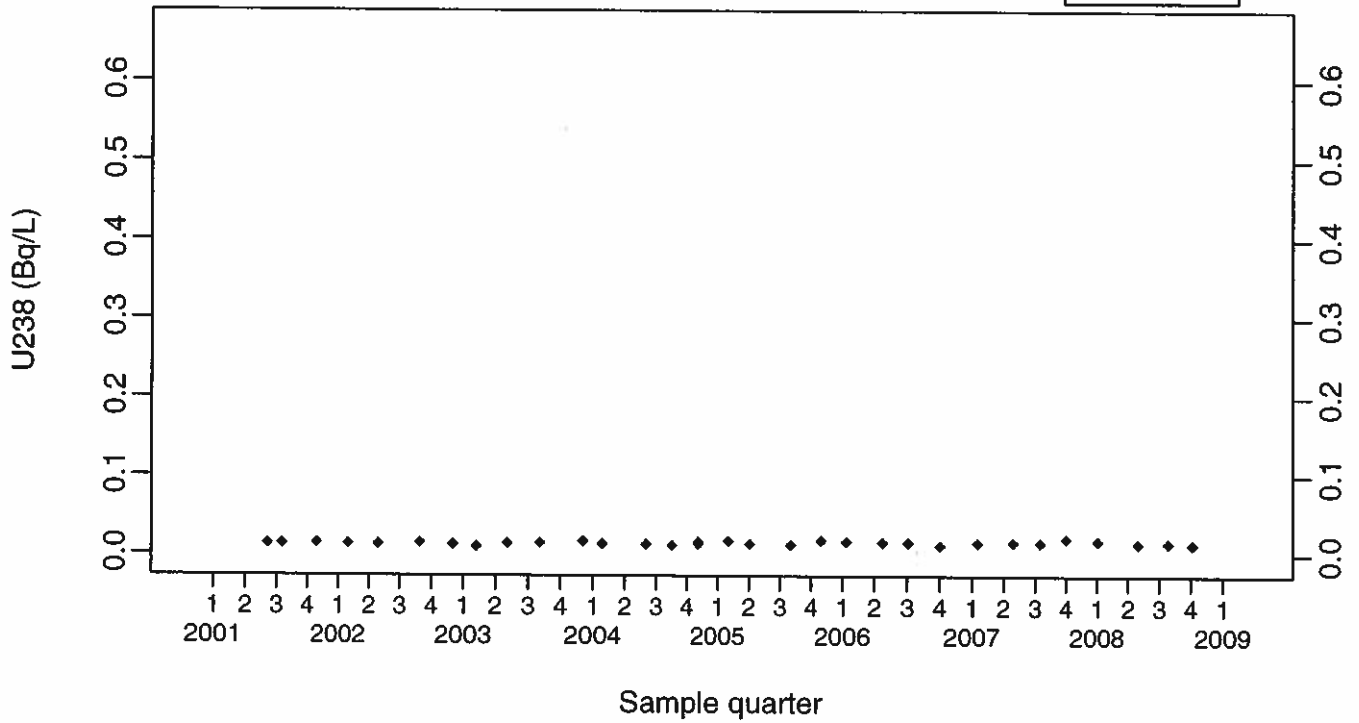




Pit 7 Complex
U238 (Bq/L)

Background Monitoring Point K7-06

◆ Above RL
▽ Below RL



Compliance Monitoring Point K7-01

