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Water Quality Objective Derivation for the South McQuesten River, Yukon

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Whitehorse, Yukon

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December 2022

Water Quality Objective Derivation for the South McQuesten River, Yukon

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EXECUTIVE SUMMARY

The Yukon Guide for Developing Water Quality Objectives and Effluent Quality Standards for Quartz Mining Projects (hereafter "The Guide") was recently submitted to Government of Yukon. The Guide represents a standard for deriving Water Quality Objectives (WQO) and Effluent Quality Standards (EQS)[1] for quartz mining projects in Yukon Territory (YT) but may be applied to other projects that are expected to have similar surface water impacts. The WQO consist of narrative and numerical components that define acceptable conditions of freshwater quality.

From 2020 to 2022, Slater Environmental Consulting (Slater) collaborated with Minnow Environmental Inc. (Minnow) to complete a case study wherein The Guide was used to derive WQO for Contaminants of Potential Concern (COPCs) in the South McQuesten River (Et'o Nyäk Tagé), YT. The South McQuesten River was selected because the watershed has a long history of intensive quartz and placer mining and is considered an important hunting, trapping, fishing, and recreational area. The river is also the focus of an ongoing Cumulative Impacts Study being completed by Government of Yukon.

Routine water quality data from South McQuesten River between McQuesten Lake and approximately 2 kilometres (km) downstream from Haggart Creek were reviewed, along with data from Cache, Christal, Flat, and Haggart creeks (tributaries to the South McQuesten River). Data to support characterization of baseline conditions and derivation of WQO were available from 1981 to 2020, depending on the station. Data for individual stations and water quality parameters were evaluated to determine the frequency of sampling and identify changes in data quality, temporal data gaps, and parameters or parameter groups that were not analyzed (e.g., dissolved metals). The evaluation relied on the requirements for data quantity and frequency of sampling laid out in The Guide. Additionally, station locations relative to tributaries and other potential inputs (e.g., surface runoff) were considered.

Overall, the water quality data were considered to be of sufficient quality for calculating summary statistics and identifying candidate COPCs. Because relatively few stations were sampled at least quarterly prior to 2004, data sets were truncated to 2004 through the end of 2019. Dissolved metal concentrations were not routinely reported at Environment and Climate Change Canada's (ECCC) long-term monitoring station (YT09DD0008) on the South McQuesten River downstream from Flat Creek. Additionally, depending on the station and year, concentrations of physicochemical parameters (e.g., pH), ions, and nutrients were not consistently reported and flow data were reported infrequently, if at all.

[1] Discussion of EQS is outside the scope of this project.

The ECCC long-term monitoring station (YT09DD0008) was identified as the most appropriate location for WQO derivation for the South McQuesten River based on the requirements of The Guide and the characteristics of the data sets for individual stations. Station YT09DD0008 was one of only two stations with a data set that met the recommendation for three years of continuous monthly monitoring (2013 to 2018). Of these two stations (the other being [KNO]KV-2, which is between Christal and Flat creeks), YT09DD0008 is the furthest downstream and encompasses inputs from Cache, Christal, and Flat creeks.[2] However, the study team acknowledges short-comings in the YT09DD0008 data set related to the lack of dissolved metals data, flow data, and more frequent sampling during periods of high variability (e.g., freshet). These short-comings were considered throughout subsequent data analysis and interpretation steps.

To support derivation of WQO, one of the three water management approaches identified in The Guide must be applied. Each of these is linked to a corresponding narrative WQO, as follows:

- <u>“Non-Degradation”,</u> wherein baseline water quality must be maintained.
- <u>“Use-Protection”,</u> wherein water quality conditions must be maintained to protect the most sensitive designated water use.
- <u>“Use-Restoration”,</u> wherein water quality conditions must be managed to avoid any further degradation of baseline water quality conditions and to facilitate restoration of designated uses where practical.

Consistent with The Guide, social, economic, and environmental values were considered during the selection of a water management approach for the South McQuesten River. Two public engagement sessions[3] were held in fall 2020 to introduce the case study and seek input about water management approaches. Attendees at these sessions included representatives from government departments and agencies, the First Nation of Na-cho Nyäk Dun, mining companies, environmental consultants, non-government and industry organizations, and researchers.

Following the fall 2020 engagement sessions, the non-degradation water management approach was selected for use in deriving WQO at the long-term monitoring station (YT09DD0008). This is because the South McQuesten River is a river of significant cultural and ecological importance for the First Nation of Na-cho Nyäk Dun and other users. Additionally, the Fish Habitat Management System for Yukon Placer Mining identifies the upper main stem of the South

[2] The long-term monitoring station on the South McQuesten River does not incorporate inputs from Haggart Creek, which flows into the South McQuesten River mainstem at the downstream end of the study area and is mine-influenced.

[3] A separate meeting was also held with the First Nation of Na-cho Nyäk Dun in November 2020.

McQuesten River as containing “ecologically or culturally important fisheries or aquatic resources or significant, critical linkages to upstream habitats for fish”.

Summary statistics were calculated for each parameter within each station[4] to support the identification of candidate COPCs. Candidate COPCs were identified based on concentrations that exceeded the 95th percentile baseline concentration[5] by a factor of two or more in any given sample and/or concentrations that exceeded applicable water quality guidelines (WQG) in two or more months within a three-year period, or for any period greater than 30 days. The comparisons included WQG that were derived in Canada or adopted for use by Canadian jurisdictions; WQG were selected according to the hierarchy of sources specified in The Guide and the most relevant water uses (i.e., freshwater aquatic life and wildlife/livestock).

Concentrations of total arsenic, chromium, iron, lead, manganese, silver, thallium, and vanadium at the long-term monitoring station (YT09DD0008) on the South McQuesten River main stem had concentrations that exceeded the 95th percentile baseline concentration by a factor of two or more in any given sample. Additionally, 95th percentile and maximum concentrations for fluoride, cyanide, and total aluminum, cadmium, cobalt, copper, iron, lead, and zinc exceeded relevant WQG, based on the data set for YT09DD0008. Maximum concentrations of total arsenic, chromium, manganese, and silver also exceeded the relevant WQG. Therefore, the following 14 parameters were carried forward as COPCs for WQO derivation[6]: fluoride and total aluminum, arsenic, cadmium, chromium, cobalt, copper, iron, lead, manganese, silver, thallium, vanadium, and zinc.

Prior to deriving WQO for total, rather than dissolved, metals, the study team considered the potential influence of suspended particulate matter[7] on total metal concentrations and whether or not the WQO would be applicable at different times of the year or only under certain conditions (e.g., clear-flow versus turbid-flow). It was decided that laboratory turbidity would be used to identify samples representative of clear versus turbid-flow (e.g., freshet) periods. The WQO would be derived using data representing clear-flow conditions only (i.e., from samples with

[4] Summary statistics were calculated for all stations, not just the long-term monitoring station (YT09DD0008), to provide a weight-of-evidence for the identification of candidate COPCs.

[5] The 95th percentile baseline concentration represents the concentration that is exceeded by only 5 percent (%) of the data values in the baseline data set for a given parameter.

[6] Cyanide was ruled out as a candidate COPC for inclusion in WQO derivation because the WQG exceedance was attributed to a single outlier and only one year of data were available at the long-term station.

[7] Total metal concentrations tend to be more variable than dissolved concentrations due to the relationship between suspended sediments and adsorbed metals. Total metal concentrations may be much higher than dissolved concentrations during periods of elevated total suspended solids (TSS) concentrations and turbidity and may not accurately reflect the bioavailable fraction of some COPCs.

laboratory turbidity less than 4 Nephelometric Turbidity Units [NTU]); consequently, the WQO would only apply to clear-flow conditions following implementation.

Because the non-degradation water management approach was selected for the long-term monitoring station on the South McQuesten River, all preliminary WQO were calculated using the background concentration procedure and data for clear-flow conditions only. The average and maximum preliminary WQO were set equal to the 95% upper confidence limit of the mean [UCLM]) and the 95th percentile concentration, respectively, of the baseline data set.[8] Calculations were completed using methods consistent with The Guide; however, because the data for most COPCs (i.e., except fluoride) were log-normally distributed, the measure of central tendency was calculated as the geometric, rather than arithmetic mean. The resulting preliminary WQO were compared to the WQG that were originally used to identify COPCs, as well as previously-derived WQO that exist for the South McQuesten River.

The preliminary average and maximum clear-flow WQO for total arsenic, chromium, silver, thallium, and vanadium and the preliminary average WQO for iron, lead, and manganese are recommended as final WQO (Table ES.1), because they were lower than the most conservative WQG that were used to identify COPCs. Preliminary maximum WQO for the remaining COPCs were greater than the most conservative WQG that were used to identify COPCs. However, they were less than short-term or acute freshwater aquatic life and wildlife/livestock guidelines compiled during the COPC identification step. The preliminary average WQO for most COPCs other than cadmium were less than or only slightly greater than the most conservative WQG that were used to screen the data and identify COPCs.

The study team recommends using dissolved concentration data (once available) to derive WQO for aluminum, cadmium, cobalt, copper, and iron[9] and potentially lead and zinc; the WQO derived using dissolved concentrations would then replace the preliminary WQO derived herein. Derivation of WQO based on dissolved concentrations is preferable because the dissolved forms of these metals are the forms most likely to be released by mining operations and are typically more representative of the bioavailable fraction. This recommendation is consistent with recommendations in The Guide for finalizing WQO.

[8] Exceedances of the WQO are identified by comparing mean and maximum concentrations in recently-collected samples to the average and maximum WQO, respectively.

[9] For iron, this applies to the maximum WQO only since the preliminary average WQO met the criteria for a final average WQO (Government of Yukon 2021a).

Table ES.1: Water Quality Objectives Derived for Contaminants of Potential Concern using Background Concentrations in the South McQuesten River (YT09DD0008), 2005 to 2020

Parameter	Units	Transformation	MCT [a]	95% UCLM [b]	Upper 95th Percentile [c]
Fluoride	µg/L	Untransformed	126	132	180
Total Aluminum	µg/L	Log_{10}	87	107	629
Total Arsenic	µg/L	Log_{10}	1.8	1.8	2.3
Total Cadmium	µg/L	Log_{10}	0.47	0.50	0.84
Total Chromium	µg/L	Log_{10}	0.057	0.063	0.14
Total Cobalt	µg/L	Log_{10}	1.2	1.4	5.0
Total Copper	µg/L	Log_{10}	1.9	2.1	6.2
Total Iron	µg/L	Log_{10}	224	231	308
Total Lead	µg/L	Log_{10}	1.2	1.3	3.0
Total Manganese	µg/L	Log_{10}	162	174	304
Total Silver	µg/L	Log_{10}	0.011	0.012	0.046
Total Thallium	µg/L	Log_{10}	0.0017	0.0018	0.0040
Total Vanadium	µg/L	Log_{10}	0.088	0.095	0.19
Total Zinc	µg/L	Log_{10}	75	80	144

Notes: MCT = measure of central tendency; UCLM = upper confidence limit of the mean; µg/L = micrograms per litre; % = percent.

[a] The MCT was calculated as the mean (untransformed) or geometric mean (log_{10} transformed).

[b] Back-transformed one-tailed 95% UCLM.

[c] Calculated using the Kaplan-Meier method.

Because uncertainties related to the data sets and the process for development of numerical WQO have potential to influence the validity of the numerical estimates, The Guide recommends confirming that numerical WQO achieve the defined narrative outcome. In this study, there is uncertainty related to whether the data set accurately represents water quality conditions in the South McQuesten River and around the assumption that baseline water quality is protective of the existing uses in the watercourse. It is recommended that the numerical WQO are recalculated periodically using existing and newly-collected data to confirm that the numerical WQO remain valid.[10] The validation process should also include reconsideration of the list of COPCs (e.g., inclusion of additional COPCs following completion of the same COPC identification steps described herein, but with newer data included). In some cases, it will be necessary to consider factors related to attainment of WQO and/or regional data and conditions. Methods for validating that non-degradation numerical WQO are, in fact, protective of existing uses in the South McQuesten River should follow the validation methods described in The Guide for use-protection WQO. In the case of the South McQuesten River, surface water toxicity testing using sensitive life stages of present or representative species should be completed. If water quality conditions fail to achieve the narrative WQO for use-protection, despite meeting the numerical WQO, then the WQO are deemed invalid and should be revisited.

Because achievement of the narrative WQO relies on COPC concentrations achieving their respective numerical WQO, the most direct method of evaluating attainment is by monitoring water quality conditions. Yukon Government is committing to monitoring water quality monthly over the long-term at station YT09DD0008. Site-specific water chemistry data collected from this station in 2020 and 2021 were used to complete an initial assessment of attainment (i.e., to confirm whether the numerical WQO derived for clear-flow conditions attain the narrative WQO).

Attainment of the maximum WQO was achieved for all COPCs except total manganese[11]; for the average WQO, the evaluation of attainment was complicated by incompatibilities in the methods used to calculate the WQO and for assessing attainment. Specifically, the WQO were calculated using approximately 100 samples collected over 15 years, whereas attainment is meant to be assessed based on the most recent 20 samples. To address the issues arising from differences in sample sizes and trends/cycling in COPC concentrations over time, the study team calculated and reviewed alternative screening values and the use of larger sample sizes (e.g., 50 samples, instead of 20) for evaluating attainment of the average WQO.

[10] This is at least until the WQO for total metals can be replaced with WQO for dissolved metals.

[11] Total manganese concentrations in each of the monthly samples collected in January and February 2020 exceeded the WQO (304 micrograms per litre [µg/L]). Subsequent samples representing clear-flow conditions (n = 5) had total manganese concentrations that were less than the maximum WQO.

Based on the initial assessment of attainment, it is recommended that monitoring results be evaluated based on the following triggers or thresholds for non-attainment:

- Two or more of the 20 most recent clear-flow samples with concentrations greater than the maximum WQO;
- A rolling geometric mean concentration (which is continually updated to include the most recent 20 clear-flow samples) that exceeds the 95th percentile of the 20-sample rolling means from the baseline data set by more than 5 percent (%);
- A rolling geometric mean concentration (which is continually updated to include the most recent 50 clear-flow samples) that exceeds the average WQO (i.e., the 95% UCLM of the baseline data set) by more than 5%; or
- A concentration that exceeds the maximum COPC concentration in the baseline data set or thresholds for toxic effects to biota.

Continued water quality monitoring to confirm attainment should include collection of data as indicated in The Guide (e.g., monthly sampling complemented by concurrent flow measurements).

As part of this case study, consideration was given to the broader spatial and temporal application of the WQO derived at the long-term monitoring station. Because the non-degradation water management approach was used, it is expected that achievement of the numerical and narrative WQO at all areas upstream of YT09DD0008 would support achievement of WQO at YT09DD0008. It is not recommended that the WQO be applied downstream, given that inputs from along the main stem downstream of YT09DD0008 or from Haggart Creek will be captured. Additionally, the study team cautions that the WQO derived for YT09DD0008 are not transferrable to other systems, even those within the Yukon River drainage, and that the approaches employed specifically for this case study may not be applicable or suitable for use on other projects.

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ACRONYMS AND ABBREVIATIONS

AEMP – Aquatic Effects Monitoring Program

AKHM – Alexco Keno Hill Mining Corporation

AMP – Adaptive Management Plan

BCMOECCS – British Columbia Ministry of Environment and Climate Change Strategy

CCME – Canadian Council of Ministers of the Environment

COPC – Contaminant of Potential Concern

COSEWIC – Committee on the Status of Endangered Wildlife in Canada

ECCC – Environment and Climate Change Canada

EEM – Environmental Effects Monitoring

EQS – Effluent Quality Standards

FEQG – Federal Environmental Quality Guideline

K-M – Kaplan-Meier

LRL – Laboratory Reporting Limit

Minnow – Minnow Environmental Inc.

SARA – *Species at Risk Act*

Slater – Slater Environmental Consulting

TRV – Toxicity Reference Value

TSS – Total Suspended Solids

UCLM – Upper Confidence Limit of the Mean

WQG – Water Quality Guideline

WQO – Water Quality Objective

YESAB – Yukon Environmental and Socio-economic Assessment Board

YT – Yukon Territory

GLOSSARY

95TH percentile concentration – The concentration that is exceeded by 5 percent (%) of the data values in the data set for a given parameter.

95% upper confidence limit of the mean (UCLM) – The concentration below which the mean of a population of values will exist 95% of the time.

Acute exposure – When an organism is exposed to a toxic substance or harmful environmental condition for a short period of time in a natural, field, or laboratory setting (e.g., for less than 24 hours).

Adaptive Management Plan – A plan that addresses uncertainty around attainment of water quality objectives (WQO) by describing specific triggers, responses, and schedules for management actions (i.e., so that unacceptable changes in surface water quality and/or adverse effects to aquatic organisms are addressed in a timely manner) in the event of unexpected performance.

Area of Special Consideration – Are "…watercourses that contain ecologically or culturally important fisheries or aquatic resources"[12]…including those that support habitats for species that are rare, of local significance, or support a fishery.

Assimilative capacity – The quantity of a substance that can be released into the aquatic environment over a specific time-frame without exceeding maximum WQO for Use-Protection.

Attainment – A status that is achieved when recently-collected data support the conclusion that concentrations of contaminants of potential concern (COPCs) in the watercourse are less than the defined WQO.

Average WQO – Equal to the one-tailed 95% UCLM of the baseline or background data set when WQO are calculated using the background concentration procedure.

Baseline water quality – Water quality conditions in a watercourse before the initiation of any project activities that may affect water quality. Baseline water quality is equivalent to background water quality if the water quality in the watercourse is not already measurably affected by local human activities.

Bioaccumulative substances – Substances that tend to accumulate in the tissues of aquatic or terrestrial organisms.

[12] DFO (Fisheries and Oceans Canada). 2010. McQuesten River Watershed Authorization for Works or Undertakings Affecting Fish Habitat for Specified Streams in the Yukon Territory.

Bioavailability – An expression of the fraction of a substance that is considered to be available for uptake by biota (i.e., the relevant exposure concentration).

Chronic exposure – When an organism is exposed to toxic substance or harmful environmental condition over an extended period of time in a natural, field, or laboratory setting (e.g., days, years).

Contaminant of Potential Concern – A substance that a project may release into surface waters at concentrations that may adversely affect achievement of the narrative WQO.

Cumulative impacts – The combined effects of harmful impacts to ecosystems or species that are likely to result from multiple projects or activities that have been or are being carried out.

Dissolved metals – The fraction of metals within a water sample that is determined by passing the water through a 0.45 micrometre (µm) filter and then analyzing the filtered fraction.

Exceedance – When concentrations of parameters are greater than (e.g., as in the case for metals) or less than (e.g., dissolved oxygen) a specified threshold (e.g., WQO or water quality guidelines [WQG]). Exceed or Exceedance can also refer to conditions outside of a specified range (e.g., WQO or WQG for pH).

Effluent – Water released from a mining project into a watercourse.

Geometric mean – A method of averaging values that are not independent of each other or exhibit a broad range. The geometric mean indicates the central tendency of a set of numbers by raising the product of their values to the inverse of the total number of values.

Leachate – Water that accumulated metals or other potentially harmful substances as it passed through mine infrastructure (e.g., waste rock).

Management Response Plan – A document describing the mitigation and management actions that will be implemented in response to an action level trigger being reached in an Adaptive Management Plan.

Non-degradation approach - A water management approach in which WQO are established based on the baseline concentrations of COPCs at the location of interest, thereby ensuring that environmental receptors are not exposed to elevated concentrations of COPCs.

Placer mining – Mining that occurs within a watercourse to extract mineral deposits.

Preliminary WQO – A newly-derived WQO that has not yet been finalized based on comparisons to WQG.

Site-specific WQO – WQO that account for local physical and/or biological characteristics, and water management approaches.

Total metals – The concentration of metals in an unfiltered water sample.

Water management approach – Non-degradation, use-protection, or use-restoration water management approaches may be selected to support WQO derivation based on social, economic, and environmental values and the condition of a receiving watercourse or waterbody. The choice of water management approach defines the broad water management goal (i.e., the narrative WQO) and influences decisions and methods for calculating numerical WQO.

Water Quality Guidelines – Numerical concentrations or narratives that are generally recommended and applied to protect various uses (e.g., aquatic life) for freshwater or marine aquatic environments.

Water Quality Objectives – Thresholds of acceptable water quality conditions in specific receiving waters that may be affected by a project, including both narrative descriptions of expectations for acceptable water quality conditions and numerical benchmarks that define specific chemical or physical characteristics of acceptable water quality.

1 INTRODUCTION

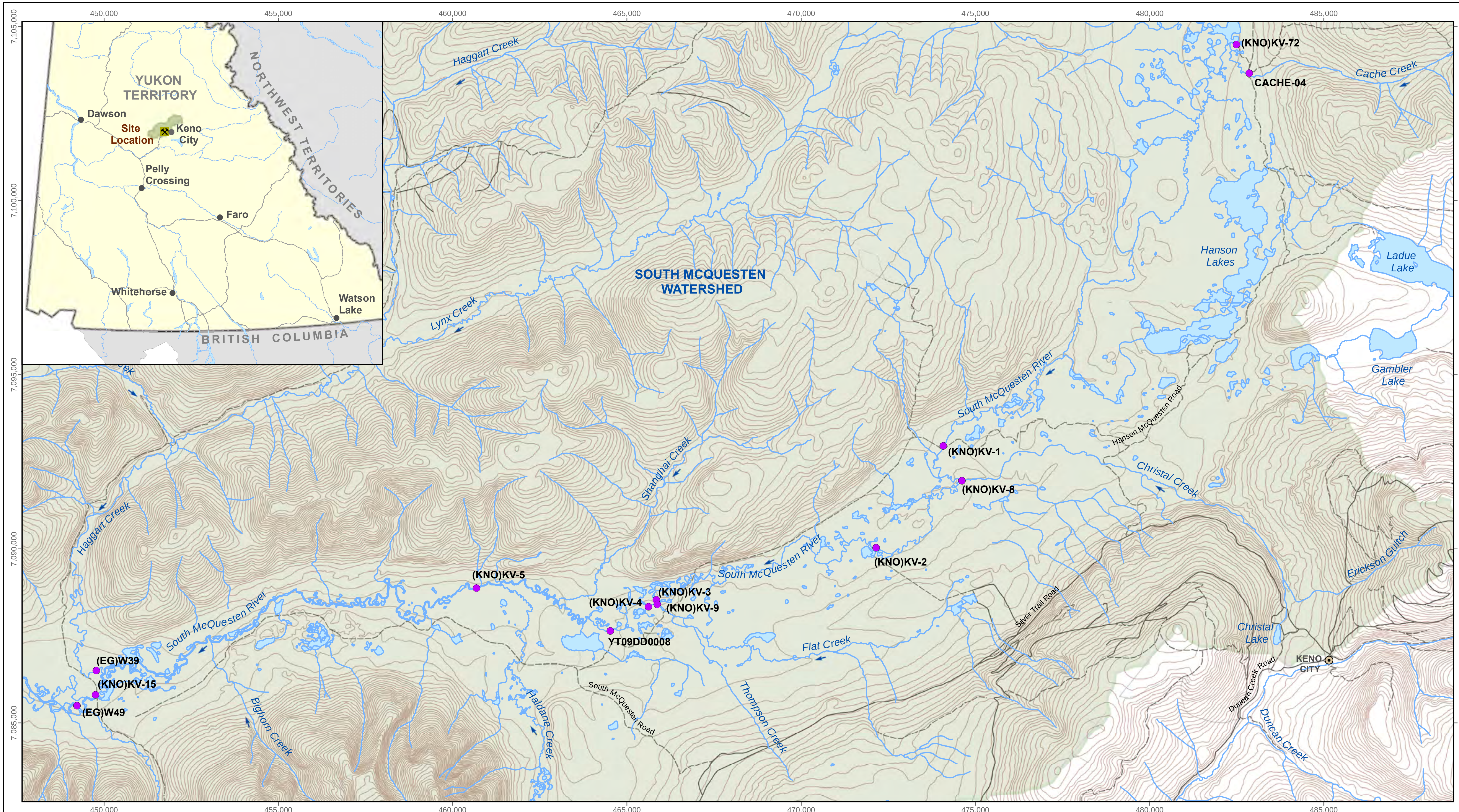
1.1 Background and Objectives

In December 2019, the draft Yukon Guide for Developing Water Quality Objectives and Effluent Quality Standards for Quartz Mining Projects (hereafter "The Guide") was submitted to Government of Yukon. The Guide was finalized in October 2021 (Government of Yukon 2021a). The purpose of The Guide is to provide a standardized framework and guidance for deriving Water Quality Objectives (WQO) and Effluent Quality Standards (EQS)[13] for quartz mining projects in Yukon Territory (YT). The WQO apply to freshwater environments that may be impacted by a project and consist of narrative (i.e., qualitative or descriptive) and numerical (i.e., quantitative) components that describe acceptable conditions and benchmarks, respectively, of water quality. Because WQO can be developed to account for site-specific physical, chemical, and biological conditions, they can be applied at locations and in situations where existing generic guidelines (e.g., Canadian Council of Ministers of the Environment [CCME] Canadian Environmental Quality Guidelines) may be under-protective or overly protective. Although The Guide was developed for quartz mining projects, the approaches and methods for WQO derivation described therein may be applied more broadly to other developments or activities that are expected to influence freshwater quality in YT.

In May 2020, the Government of Yukon requested Slater Environmental Consulting (Slater) collaborate with an aquatic scientist to complete a case study wherein The Guide would be used to derive WQO for Contaminants of Potential Concern (COPCs) in the South McQuesten River (Et'o Nyäk Tagé), YT (Figure 1.1). The South McQuesten River was selected for COPC derivation, in part, to support the South McQuesten River Cumulative Impacts Study (Government of Yukon 2022). Additionally, the South McQuesten River watershed has a long history of intensive quartz and placer mining and is considered an important hunting, trapping, fishing, and recreational area. The river is also an Area of Special Consideration under the Fish Habitat Management System (DFO 2010).

The case study for deriving WQO for the South McQuesten River was completed by Slater and Minnow Environmental Inc. (Minnow) between August 2020 and December 2022. An interim report describing the initial steps associated with data review, selection of a water management approach, and identification of COPCs was submitted to Government of Yukon in January 2021

[13] Derivation of EQS, which are used to define the allowable concentrations of COPCs that can be released in effluent discharges, are outside the scope of this study and are not discussed further in this report.



LEGEND

- Water Quality Monitoring Station
- South McQuesten Watershed

0 2 4 8
km

N W E S

Projection: North American Datum 1983 UTM Zone 8V
Reproduced under licence from Her Majesty the Queen in Right of Canada, Department of Natural Resources Canada.

Water Quality Monitoring Stations on the South McQuesten River and Major Tributaries

Date: November 2022
Project 227202.0049

minnow environmental inc.

Figure 1.1

Document Path: C:\Users\Mlapalme\Trinity Consultants, Inc\Slater Environmental - 227202.0049 - WQO Engagement and Reporting\D - GIS\Report\Report\22-49 Figure 1.1 Water Quality Monitoring Stations.mxd

(Slater and Minnow 2021). The objectives of this final report are to describe each of the steps that were taken to apply The Guide to the South McQuesten River, YT, report on the WQO that were derived, and provide recommendations to refine/validate the WQO and monitor attainment of the WQO in the years to come.

1.2 Study Area

1.2.1 Environmental Conditions

The South McQuesten River is located approximately 450 kilometres (km) north of Whitehorse, YT (Figure 1.1) and within the Yukon Plateau-North Ecoregion and the Boreal Cordillera Ecozone (Yukon Conservation Data Centre 2021). The regional climate is characterized by short, mild summers and long, cold winters and permafrost is typically found on north and east-facing slopes, areas higher than 1,370 metres above sea level (masl), and in valleys with poor drainage (Weston 1999). Soil types in the area include brunisolic, cryosolic, and fibrisolic soils (Weston 1999). The McQuesten River valley in particular is characterized by silty, glaciolacustrine deposits (Pendray 1983) and the area is highly mineralized (hence its attractiveness for mineral extraction; Government of Yukon 2022). Mixed deciduous and coniferous forest cover much of the watershed (Weston 1999) and the region provides habitat for a variety of wildlife, including various species of ungulates, fur-bearers, game birds, raptors, songbirds, and waterfowl (StrataGold Corporation 2017).

The South McQuesten River is part of the Yukon River drainage basin and flows south and then west from McQuesten Lake (Et'o Nyäk Män) until it joins with the North McQuesten River before flowing into the Stewart River (Nacho Nyäk gé; Bond 1997; Elson 1974; Pendray 1983). Much of the South McQuesten River downstream from McQuesten Lake is characterized as low-gradient and meandering with abundant pool/glide habitat, a marshy floodplain, and numerous oxbows (Government of Yukon 2022; Pendray 1983). However, one high-velocity canyon was identified approximately 7.4 km downstream from McQuesten Lake (Pendray 1983). Larger tributaries to the South McQuesten River between McQuesten Lake and the confluence with the North McQuesten River include Cache, Christal, Flat, Shanghai, Haldane, North Star, Bighorn, Haggart, Ross, Goodman, Seattle, and Rodin creeks (CCME 2003; Government of Yukon 2022; Weston 1999).

Flows in the South McQuesten River are typically highest in spring, between May and June, and lowest between November and April (CCME 2003) and the water has been described as clear, slightly alkaline, and moderately hard (Laberge 2004). However, water hardness can vary considerably depending on location along the river and flow conditions (CCME 2003). The section of the river upstream from Haggart Creek typically has little suspended sediment, but the suspended sediment loads within and downstream from Haggart Creek are higher, especially in May (Government of Yukon 2022). Over the last 10 years, turbidity and concentrations of total nitrogen, total dissolved nitrogen, beryllium, copper, chromium, and rare earth elements (cerium, lanthanum, and yttrium) have increased significantly in the South McQuesten River (Government of Yukon 2022). An earlier investigation of water quality in the South McQuesten River main stem (1994 to 2007) indicated that conductivity and concentrations of total suspended solids (TSS) and total arsenic, iron, lead, phosphorous, silver, and zinc exceed background concentrations and CCME water quality guidelines in at least 10 percent (%) of samples (Minnow 2009). Hardness, conductivity, and concentrations of TSS and a number of ions, nutrients, and metals were similarly elevated relative to background conditions and/or guidelines in Christal and Flat creeks (Minnow 2009).

Sediment quality data for the South McQuesten River and its tributaries are reflective of the long history of mining activities within the watershed (see Section 1.2.2). A study completed in 2007 indicated that several sediment quality constituents, including arsenic, cadmium, lead, manganese, nickel, selenium, and zinc, exceeded applicable CCME sediment quality guidelines (Minnow 2009). Although there was no discernable temporal trend between 1985 and 2007, the aforementioned exceedances were also present in previous years (Minnow 2009).

Biological monitoring data compiled by the CCME indicate that invertebrate taxa found in the South McQuesten River include oligochaetes (aquatic worms), Cladocera (water fleas), copepods, ostracods, water mites, Plecoptera (stoneflies), Ephemeroptera (mayflies), Trichoptera (caddisflies), Diptera (true flies), gastropods (snails), and bivalves (CCME 2003). A more recent evaluation of benthic invertebrate community composition in the South McQuesten River also indicated that a variety of taxa (i.e., molluscs caddisflies, stoneflies, mayflies, true flies, annelids, and arthropods), were present, including species that are considered less tolerant of poor water quality conditions (Government of Yukon 2022).

Traditional knowledge and results of biological monitoring programs indicate that 14 fish species use or could potentially use habitats in the South McQuesten River watershed. Lake whitefish (*Coregonus clupeaformis*) have been captured at the outlet of McQuesten Lake (Figure 1.1; Elson 1974). Slimy sculpin (*Cottus cognatus*) occur in the South McQuesten River main stem and in tributaries like Christal and Flat creeks (Figure 1.1; White Mountain 2006; Minnow 2009). Arctic grayling (*Thymallus arcticus*) are also widespread and have been captured from the South McQuesten River and Haggart, Lynx[14], Flat, and Christal creeks (Pendray 1983; White Mountain 2006; Minnow 2009); spawning and rearing occur in the South McQuesten River

[14] Lynx Creek is an extension of Haggart Creek (Weston 1999).

and Christal Creek, respectively (Figure 1.1; Laberge 2004). Chinook salmon (*Oncorhynchus tshawytscha*), which are culturally important to the Na-cho Nyäk Dun First Nation, are often observed in and downstream from Haggart Creek (Connors et al. 2016; Government of Yukon 2022; Minnow 2009). Burbot (*Lota lota*) and northern pike (*Esox lucius*) have been captured from Christal Creek, Flat Creek, and the South McQuesten River (White Mountain 2006; Minnow 2009). Round whitefish (*Prosopium cylindraceum*) have been found in Christal Creek and arctic lamprey (*Lethenteron camtschaticum*) have been found the South McQuesten River (Minnow 2009). Other reports indicate that arctic charr (*Salvelinus alpinus*), Dolly Varden (*Salvelinus malma*), inconnu (*Stenodus leucichthys*), least cisco (*Coregonus sardinella*), longnose sucker (*Catostomus catostomus*), and rainbow trout (*Oncorhynchus mykiss*) potentially access and use habitats within South McQuesten River and its tributaries (Government of Yukon 2022; Lindsey et al. 1981; Pendray 1983; StrataGold Corporation 2015; White Mountain 2006).

There are no known records of Species of Conservation Concern in the South McQuesten River or its tributaries (Yukon Conservation Data Centre 2021). Additionally, Government of Yukon has confirmed that the South McQuesten River does not provide key aquatic habitat for threatened, endangered, or sensitive species, or species of special concern, including species listed under the *Species at Risk Act* (SARA) (Janin 2020a, pers. comm.). However, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) has recently identified Yukon River populations of chinook salmon as high priority candidates for assessment (COSEWIC 2021).

1.2.2 Land Use

The South McQuesten River and its tributaries are in the Traditional Territory of the Na-cho Nyäk Dun First Nation (Yukon Conservation Data Centre 2021) and are of significant cultural importance (see Section 4). Areas throughout the watershed are used for hunting, trapping, and fishing and there are multiple fish camps along the South McQuesten River main stem (Government of Yukon 2022; StrataGold Corporation 2015; rightsholder and stakeholder engagement meeting participants [see Section 4]). The South McQuesten River also hosts an arctic grayling fishery downstream from Haggart Creek. Cultural features listed in the Yukon Conservation Data Centre (2021) database include a cabin near the outflow of McQuesten Lake and the study team suspects that there are numerous heritage sites along the South McQuesten River and its tributaries for which the information is not publicly shared.

Mining in the South McQuesten River watershed dates back to at least 1906 (CCME 2003) and quartz and placer mining activities have occurred throughout the watershed (Government of Yukon 2022). The Keno Hill Silver District, which overlaps with the South McQuesten watershed, was very productive throughout the 20th century (i.e., from about 1913 to 1989) and remains the second largest silver producer in the history of Canada (Alexco Resources Corporation 2021, 2022). Surface runoff and leachate from abandoned mine infrastructure (e.g., waste rock dumps, tailings piles, and underground mine works) are known to influence surface water quality in the South McQuesten River and its tributaries (CCME 2003; Minnow 2009). Christal and Flat creeks receive mine-influenced surface water from multiple sources in the Keno Valley and tailings were likely deposited in Flat Creek in 1961 and 1978 following a tailings pond washout and dam breach, respectively (Laberge 2004). There are currently two operational quartz mining projects along the South McQuesten River and one along Haggart Creek (Government of Yukon 2022). Placer mining in the watershed is concentrated in the Haggart Creek area (Government of Yukon 2022).

There are currently 22 active water use licenses in the watershed, four of which were approved for quartz mining projects and another 16 for placer mining projects; these, along with two miscellaneous licenses, were approved by the Yukon Environmental and Socio-economic Assessment Board (YESAB; Government of Yukon 2022). The South McQuesten River is rarely used as a source of drinking water for humans (i.e., only during recreational or hunting/fishing trips) but is considered an important drinking water source for wildlife (CCME 2003).

The South McQuesten River is not located within a World Heritage Site (UNESCO 2021), National Park (Parks Canada 2020), or Territorial Park (Government of Yukon 2021b).

1.3 Report Structure

This report is presented in 13 sections, the first of which is this introduction (Section 1). Because the use of The Guide to derive WQO involves a step-wise or staged approach, individual Sections 2 through 6 include the methods associated with particular steps in the derivation process, as well as the results associated with that step. These results then inform the methods and outcomes in subsequent steps or sections. Validation and attainment of the WQO are addressed in Sections 7 and 8, respectively. A summary of the results of this case study is provided in Section 10. Key uncertainties are discussed in Section 11. Conclusions and recommendations are compiled in Section 12. Section 13 includes all references cited in this report.

2 INITIAL DATA REVIEW

2.1 Methods

Water quality data sets for routine monitoring stations on the South McQuesten River main stem between McQuesten Lake and station (EG)W49, approximately 2 km downstream from the Haggart Creek mouth, were reviewed to support characterization of baseline water quality conditions.[15] These water quality data sets were provided by Government of Yukon, along with data sets for stations on tributaries to the South McQuesten River, specifically Cache, Christal, Flat, and Haggart creeks (Table 2.1; Figure 1.1). Each data set corresponds with an existing water license (e.g., Victoria Gold's water licence QZ14-041-1, Elsa Reclamation and Development Company's water licence QZ17-076, and Alexco Keno Hill Mining Corporation's [AKHM's] water licence QZ18-044) or ongoing, long-term monitoring completed as part of Environment and Climate Change Canada's (ECCC's) Freshwater Quality Monitoring and Surveillance network (e.g., station YT09DD0008). Data to support derivation of WQO were available from 1981 to the end of 2019, depending on the station (Table 2.1).

Each of the water quality data sets were reviewed for completeness, consistency, and overall data quality to determine which station(s) had data of sufficient quality and quantity to support calculation of summary statistics and meet the data requirements of The Guide (Government of Yukon 2021a).[16] Data for individual stations and water quality parameters were plotted and assessed visually to support identification of the following:

- frequency of sampling;
- step-changes in parameter concentrations over time that were potentially indicative of changes in data quality (e.g., a sudden change in concentrations attributed to a change in analytical laboratories or methods);
- gaps (e.g., years with missing or no data) in the data set; and
- parameters (e.g., ammonia) and/or parameter groups (e.g., dissolved metals) that were not analyzed.

[15] Given that mining activities upstream of the stations listed in Table 2.1 predate the available data sets, it was recognized at the outset of this case study that these stations represent baseline, rather than background or reference conditions.

[16] Government of Yukon also requested that Minnow review the data sets and provide recommendations on whether it is reasonable to compare data from multiple stations along the South McQuesten River main stem. These comparisons are being completed by Government of Yukon in parallel with the WQO derivation activities described herein but will be reported by Government of Yukon under separate cover.

Table 2.1: Water Quality Monitoring Stations on the South McQuesten River and Its Major Tributaries, Yukon Territory [a]

Station Code	Watercourse/Station ID	Years with Data	Total No. of Sampling Events
(KNO)KV-72	S. McQuesten @ McQuesten Lake	2011 to 2019	33
CACHE-04	Cache Ck	2015 to 2020	14
(KNO)KV-1	S. McQuesten u/s Christal Ck	1995 to 2020	189
(KNO)KV-8	Christal Ck @ Mouth	1998 to 2019	144
(KNO)KV-2	S. McQuesten @ pumphouse	1981 to 2019	236
(KNO)KV-3	S. McQuesten u/s Flat Ck	1997 to 2020	52
(KNO)KV-9	Flat Ck u/s S. McQuesten	1981 to 2020	252
(KNO)KV-4	S. McQuesten 350m d/s Flat Ck	1981 to 2020	226
YT09DD0008	South McQuesten River below Flat Creek	2005 to 2019	149
(KNO)KV-5	S.McQuesten 9 km d/s Flat Ck	2004 to 2019	55
(EG)W39	Haggart Ck, above S. McQuesten	2011 to 2019	20
(KNO)KV-15	S. McQuesten @ bridge below Haggart Ck	1998 to 2020	51
(EG)W49	S. McQuesten below Haggart Ck	2011 to 2019	32

Notes: ID = identifier; No. = number; S. = south; @ = at; Ck = creek; u/s = upstream; m = metres; d/s = downstream; km = kilometres.

[a] Stations are listed in order from upstream to downstream based on their location along the South McQuesten River main stem or, in the case of tributaries (e.g., Cache Creek), where the tributary flows into the main stem.

The Guide outlines minimum requirements for data quantity and frequency of sampling to support characterization of baseline conditions. At a minimum, three consecutive years of recent, continuous monthly monitoring data with more frequent sampling (i.e., at least five additional samples collected over a 30-day period) during freshet or other known periods of naturally high variability in water quality conditions is recommended (Government of Yukon 2021). The requirement for a minimum of three years of data is based on a statistical evaluation of the variability associated with water chemistry data sets from YT, which concluded that 95th percentile concentrations from a three-year, monthly-monitoring data set provided a reasonable approximation of the true 95th percentile concentration over the longer term (Zajdlik and Associates Inc. 2017).

The absence of particular parameters or parameter groups in the data sets is an important consideration for station selection as well as establishing the conditions under which the WQO would be applied (or not; see Section 6). Ideally, WQO for most metals, for example, would be derived using dissolved, rather than total, concentration data. This is because the dissolved forms are typically more representative of the bioavailable fraction (Adams et al. 2020) and are the forms typically used in the toxicity tests that underly water quality guidelines (WQG; Sinclair et al. 2015). Additionally, total metal concentrations tend to be more variable than dissolved concentrations due to the relationship between suspended sediments and adsorbed metals (i.e., total metal concentrations may be much higher than dissolved concentrations during periods of elevated TSS and turbidity, such as freshet [Kerr and Cooke 2017; Sinclair et al. 2015]). However, if dissolved metals data do not meet the requirements of The Guide, it may be necessary to use total metals data and derive WQO that are only applicable at certain times of the year or under certain conditions (see Section 6).

In addition to the criteria set out above, station location and the availability and seasonality of flow data were considered in reviewing the data sets for individual stations and selecting a location for WQO derivation. Ideally, the station selected for WQO derivation would be far enough downstream to incorporate inputs from the multiple mining operations within the watershed. Additionally, flow data would be available for the selected station to support interpretation of variability in parameter concentrations (i.e., to determine if flow is a key modifying factor that needs to be considered in the WQO derivation).

2.2 Results

Overall, the water quality data sets for the South McQuesten River and its tributaries were considered to be of sufficient quality for use in calculating summary statistics to support identification of candidate COPCs. Step-changes in laboratory reporting limits (LRLs) were identified for some parameters, like total beryllium, mercury, and molybdenum and dissolved beryllium, chromium, and molybdenum (see Appendix Figures A.1 to A.98). These changes were likely attributed to changes in analytical laboratories and methods over time and were not identified as negatively impacting the utility of the data. Relatively few stations were sampled at least annually prior to 2004; exceptions were (KNO)KV-2, (KNO)KV-9, and (KNO)KV-4 (Table 2.2). Therefore, the data sets used to calculate summary statistics were truncated to include the years 2004 to 2020 only. Each of the water quality monitoring stations on the South McQuesten main stem had at least one year with no data between 2004 and 2020, with the exception of (KNO)KV-1 just upstream of Christal Creek (Table 2.2; Figure 1.1). Concentrations of physicochemical parameters (e.g., pH), ions, and nutrients were not consistently reported within a given year or at a given station. Concentrations of total and dissolved metals were typically reported at the same frequency (i.e., were measured concurrently) for most stations, with the exception of the ECCC long-term monitoring station (YT09DD0008; see below), where concentrations of most dissolved metals were only reported from 2005 to 2007 (see Appendix A). Flow data were reported infrequently, if at all; (KNO)KV-8 (2012, 2015, and 2016) at the Christal Creek mouth and (KNO)KV-9 (1995 and 2015 only) on Flat Creek were the only stations where flow data were reported at least quarterly over the course of at least one year (Appendix Figure A.1).

Only two of the data sets met the recommendation for three years of continuous monthly monitoring data set out in The Guide (Table 2.2; Figure 1.1). Samples were collected at least monthly at (KNO)KV-2, downstream of Christal Creek, from 1991 to 1993[17] and at the long-term monitoring station (YT09DD0008) downstream from Flat Creek from 2013 to 2018 (Table 2.2; Figure 1.1). However, neither data set met the recommendation for more frequent sampling during periods of high expected short-term water quality variability (i.e., at least five additional samples collected over a 30-day period; Government of Yukon 2021). Additionally, the monthly monitoring data for (KNO)KV-2 are relatively old (i.e., more than 25 years old) and few parameters were measured between 1991 and 1993 (i.e., extractable cadmium, copper, iron, lead, manganese, and zinc). Station (KNO)KV-2 is also upstream from the long-term monitoring station and does not encompass inputs from Flat Creek. For these reasons, the long-term monitoring station (YT09DD0008) was carried forward for further consideration as the potential location for WQO derivation.

As indicated above, the long-term monitoring station is far enough downstream on the South McQuesten River to represent inputs from Cache, Christal, and Flat creeks (Figure 1.1). However, the station does not incorporate inputs from Haggart Creek, which is at the downstream

[17] Although n = 12 or more samples were collected from (KNO)KV-2 per year between 1994 and 1996, inclusive, these samples were not collected on a monthly basis.

Table 2.2: Sampling Event Summary for Water Quality Monitoring Stations on the South McQuesten River and Its Major Tributaries, Yukon Territory [a]

Station Code	Number of Sampling Events by Year																			
	1981	1982	1983	1984	1985	1986	1987	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	2001	2002	2003
(KNO)KV-72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CACHE-04	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
(KNO)KV-1	-	-	-	-	-	-	-	-	-	-	-	-	-	4	16	8	5	1	-	-
(KNO)KV-8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-
(KNO)KV-2	3	12	10	9	6	7	5	9	12	13	14	13	12	14	22	2	4	1	-	-
(KNO)KV-3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	1	-	1
(KNO)KV-9	3	8	6	8	6	7	5	9	12	10	12	13	11	17	27	3	4	1	1	25
(KNO)KV-4	3	10	5	8	6	7	5	9	12	10	13	13	11	20	34	2	4	1	-	2
YT09DD0008	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
(KNO)KV-5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
(EG)W39	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
(KNO)KV-15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	1	-
(EG)W49	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Notes: - = no data.

[a] Stations are listed in order from upstream to downstream based on their location along the South McQuesten River mainstem or, in the case of tributaries (e.g., Cache Creek), where the tributary flows into the main stem.

Table 2.2: Sampling Event Summary for Water Quality Monitoring Stations on the South McQuesten River and Its Major Tributaries, Yukon Territory [a]

Station Code	Number of Sampling Events by Year																
	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
(KNO)KV-72	-	-	-	-	-	-	-	2	4	3	4	4	3	5	4	4	-
CACHE-04	-	-	-	-	-	-	-	-	-	-	-	1	1	-	2	1	9
(KNO)KV-1	11	3	4	9	10	9	11	10	12	10	4	12	15	11	11	11	2
(KNO)KV-8	9	3	3	8	8	10	9	11	12	11	9	11	12	8	9	9	-
(KNO)KV-2	12	3	2	1	4	4	4	4	4	4	4	4	6	4	4	4	-
(KNO)KV-3	1	1	2	1	4	4	3	3	3	4	-	4	4	4	5	4	1
(KNO)KV-9	1	-	2	1	4	4	4	6	4	4	-	4	8	11	6	4	1
(KNO)KV-4	1	-	2	1	4	4	4	6	4	4	-	4	4	4	4	4	1
YT09DD0008	-	6	9	9	8	11	9	9	6	12	12	12	12	12	12	10	-
(KNO)KV-5	7	2	2	1	4	4	4	4	4	4	-	4	3	4	4	4	-
(EG)W39	-	-	-	-	-	-	-	2	5	3	3	-	-	1	3	3	-
(KNO)KV-15	1	1	2	1	4	4	3	3	4	4	-	4	4	4	4	4	1
(EG)W49	-	-	1	-	-	-	-	4	9	5	4	-	-	1	2	4	2

Notes: - = no data.

[a] Stations are listed in order from upstream to downstream based on their location along the South McQuesten River mainstem or, in the case of tributaries (e.g., Cache Creek), where the tributary flows into the main stem.

end of the study reach and is mine-influenced. Station [EG]W49, which is the furthest downstream station, incorporates inputs from McQuesten Lake to downstream of the Haggart Creek mouth; however, the data set for [EG]W49 fails to meet the minimum data requirements of The Guide (i.e., the data set is composed primarily of quarterly data with a 2.5-year gap between 2015 and 2017; Table 2.2).

In summary, the initial data evaluation suggested that the long-term monitoring station (YT09DD0008) is the most appropriate location for WQO derivation for the South McQuesten River, based on the requirements of The Guide and the characteristics of the available data sets. This station was the only station that met the requirements for at least three years of relatively recent, continuous, monthly monitoring and is located far enough downstream to incorporate inputs from Cache, Christal, and Flat creeks. However, the following short-comings in the long-term water quality monitoring data set were identified:

- dissolved metals data, which are the preferred data type for deriving WQO for metals, were reported infrequently (i.e., for a maximum of n = 18 samples collected between 2005 and the end of 2019);
- flow data to support interpretation in variability in parameter concentrations were not available for this station;
- the data set does not meet the requirement for more frequent sampling during known periods of high variability (e.g., freshet); and
- impacts to water quality at YT09DD0008 were expected following the 2019 Shanghai Creek Fire, which burned along the section of the South McQuesten River that includes this station (Government of Yukon 2022).

These factors were considered, to the extent possible, during the identification of candidate COPCs (see Section 5) and WQO derivation (see Section 6).

3 SELECTION OF WATER MANAGEMENT APPROACH

3.1 Methods

A central requirement of The Guide (Government of Yukon 2021a) is the consideration of social, economic, and environmental value and condition of the watershed to support selection of a water management approach. The choice of water management approach defines the broad water management goal (i.e., the narrative objective) and influences decisions and methods for development of WQO, for example the identification of COPCs and selection of methods for deriving WQO. The Guide describes three possible water management approaches, the conditions in which each approach should be applied, and the narrative objectives associated with each approach. The three approaches and their narrative objectives are summarized as follows:

- "Non-Degradation", in which baseline water quality must be maintained.
- "Use-Protection", in which water quality conditions must be maintained to protect the most sensitive designated water use.
- "Use-Restoration", in which water quality conditions must be managed to avoid any further degradation of baseline water quality conditions and to facilitate restoration of designated uses where practical.

Because the selection of a water management approach relies on a combination of scientific, social, and cultural factors, The Guide specifies that engagement with relevant governments, communities, groups, and individuals (i.e., rightsholders and stakeholders) about the water management approach is essential. It notes that the selection of the water management approach must occur early in the process of developing WQO because it influences many of the other steps and procedures for developing WQO. To support selection of a water management approach, Government of Yukon and the Slater/Minnow team conducted an engagement process to seek input from interested individuals, groups, and agencies (Section 4).

3.2 Results

After considering the input received during engagement activities (Section 4) and based on the direction provided in The Guide, Government of Yukon and the Slater/Minnow team concluded that the non-degradation water management approach is appropriate for WQO that will apply at the long-term monitoring station (YT09DD0008). This conclusion leads logically to application of the non-degradation approach for locations on the South McQuesten River main stem upstream of this location. Selecting a water management approach for locations further downstream would require further analysis and consideration. The rationale for the selection of the water management approach, including consideration of input received during engagement activities (Section 4) is described in this section.

The results of the engagement activities (Section 4) supported a conclusion that the use-restoration approach is not warranted for the South McQuesten River. The use-restoration approach aims to improve the quality of impaired waters to support restoration of water uses. It applies to waters where human-induced changes in water quality have already caused adverse effects on designated uses (e.g., where water quality has already caused adverse effects to aquatic species). Mining activities began in the South McQuesten River watershed more than 100 years ago, and there is little compiled information about conditions that may have influenced water quality prior to these activities. Information about current status of values (e.g., aquatic ecosystem health of the river) is also very limited. As a result, it is not possible to make a direct determination of whether water quality has affected designated uses (e.g., the fish community). What is known is that, prior to mining activities and land disturbances, citizens of the First Nation of Na-cho Nyäk Dun lived in the South McQuesten River watershed and relied on the water, land, plants, wildlife, and fish to survive. Input received during rightsholder and stakeholder engagement confirms that First Nation citizens continue to use the main stem of the South McQuesten River for similar activities like hunting and fish camps (Section 4). Other people also use the river for recreational, fishing, and hunting activities. The continued use indirectly indicates that the river continues to support its designated uses.

The non-degradation approach aims to maintain water quality in a condition consistent with baseline conditions. The Guide makes a distinction between baseline conditions that represent conditions in the stream or river at the time that WQO are established and background conditions that represent conditions in the stream or river before the onset of any human activities that may alter water quality. The non-degradation approach is premised on comparison with baseline conditions, not background conditions. The Guide lists the following definitive criteria that require application of the non-degradation approach:

- Provides or may provide water for a drinking water supply that has or requires a permit or licence under either the *Drinking Water Regulation* or the *Waters Act*.
- Provides critical aquatic habitat for threatened species or endangered species as listed under Schedule 1 of the federal SARA. Critical aquatic habitat is defined as the aquatic habitat that is identified as the species' critical habitat in the Recovery Strategy or in an Action Plan for the species.
- Is located within a World Heritage Site, a National Park or a Territorial Park, where the site or park was designated for ecological reasons.

Government of Yukon has confirmed that the South McQuesten River does not meet any of these definitive criteria. The Guide also lists the following subjective criteria where the non-degradation approach may be appropriate:

- Provides key aquatic habitat for threatened, endangered, or sensitive species as listed under Schedules 1, 2, or 3 of the SARA and species of conservation concern identified by the Yukon Conservation Data Centre. Key aquatic habitat is aquatic habitat that is used by a species for necessary, seasonal life functions.
- Located within an area designated for the protection of aquatic species or aquatic habitat under Yukon legislation, in accordance with a management plan developed and approved under a First Nation Final Agreement, in accordance with an approved Regional Land Use Plan, or in accordance with a Canadian Heritage River management plan.
- Identified as being of exceptional importance to First Nations or local residents (e.g., a unique watercourse that supports culturally or spiritually important water uses, such as medicine-making or spiritual activities).

Government of Yukon has confirmed that the South McQuesten River does not provide key aquatic habitat for threatened, endangered, or sensitive species, or species of special concern. The South McQuesten River is not located within an area designated for the protection of aquatic species or aquatic habitat. However, the Fish Habitat Management System for Yukon Placer Mining identifies the upper main stem of the South McQuesten River as an Area of Special Consideration (DFO 2010), which is an area within a watercourse that contains "ecologically or culturally important fisheries or aquatic resources or provide[s] significant, critical linkages to upstream habitats for fish" (Yukon Placer Secretariat 2015). The McQuesten River Watershed Authorization for Works or Undertakings Affecting Fish Habitat (DFO 2010) prohibits any discharges of effluent with total suspended solids concentrations that exceed the natural background concentration. From a water quality perspective, this is consistent with the non-degradation approach. Additionally, feedback from engagement activities provided valuable input about whether the South McQuesten River should be considered a watercourse of exceptional importance (Section 4).

The use-protection approach aims to maintain water quality in a condition that will not adversely affect the designated water uses. The Guide identifies five uses: drinking water, recreational use, freshwater aquatic life, agricultural (irrigation and livestock water), and consumption by wildlife. As described in Section 5, freshwater aquatic life, agriculture, and consumption by wildlife are the most relevant water uses for the South McQuesten River and feedback from engagement activities provided valuable input about the applicability of the use-protection approach to the location of interest.

After considering the input received (Section 4), the South McQuesten River WQO case study team concluded that the South McQuesten River is a river of significant cultural and ecological importance for the First Nation of Na-cho Nyäk Dun and other users, and that the non-degradation approach should be applied. Assimilative capacity that can be applied under the use-protection approach is an important consideration when evaluating proposed developments but is more critical for smaller streams, while the values represented by larger rivers like the South McQuesten River warrant management goals aimed at maintaining water quality. The non-degradation approach is consistent with the Fish Habitat Management System that designates the upper main stem of the South McQuesten River as an area of special consideration (DFO 2010).

4 RIGHTSHOLDER AND STAKEHOLDER ENGAGEMENT

4.1 Methods

Engagement with rightsholders and stakeholders is considered a key component of the decision-making process that underlies WQO derivation (Government of Yukon 2021a). Government of Yukon and the Slater/Minnow team held two public engagement sessions (October 30, 2020 and November 5, 2020) to introduce the South McQuesten River WQO case study and to discuss and seek input about water management approaches. The sessions began with presentations about the South McQuesten River WQO case study and possible water management approaches. Following the presentations, the sessions provided opportunities for participants to discuss and provide input about interests, values, and water management approaches for the South McQuesten River. Attendees at these sessions included representatives from federal government departments and agencies, the First Nation of Na-cho Nyäk Dun, Government of Yukon departments and agencies, the Village of mayo, mining companies active In the South McQuesten River watershed, environmental consulting companies, environmental non-government organizations, industry organizations, and researchers. Following the public engagement sessions, the team provided opportunities for participants to provide further input in writing or at individual meetings. Several participants provided written input. Only the First Nation of Na-cho Nyäk Dun requested a separate meeting, held on November 16, 2020.

Another engagement session was held on August 25, 2022, to present the outcomes of the cumulative impact study for the South McQuesten River, along with the WQO developed as part of this project. The parties who participated in the October and November 2020 discussions about water management approaches were invited to attend the August 25, 2022 session. An additional separate meeting was held with representatives from the First Nation of Na-cho Nyäk Dun on August 30, 2022. Following the August 2022 presentations and discussion sessions, participants were invited to provide written input on the cumulative impact study and WQO derivation reports. Written input was received from the Yukon Conservation Society.

4.2 Results

The rightsholder and stakeholder engagement activities completed in October and November 2020 yielded valuable input about applicability of all three water management approaches (non-degradation, use-protection, and use-restoration) and aspects of COPC identification. Parties involved in the 2020 engagement sessions also highlighted the importance of the South McQuesten River for hunting, fishing, and recreational activities. The South McQuesten River and its tributaries are culturally important for the First Nation of Nacho Nyäk Dun and citizens have fish camps along the river and use the valley for hunting. The long history of mining activities and associated effects to surface water quality in the South McQuesten River watershed were also emphasized by meeting participants.

Arguments in support of the non-degradation approach focused on the importance of the South McQuesten River to First Nations and local residents; it was also stressed that the WQO derivation work should align with the Fish Habitat Management System (DFO 2010). Rightsholders and stakeholders indicated that further degradation of surface water quality should be prevented and baseline water quality must be maintained. The thresholds for acceptable water quality under the non-degradation approach were viewed as more protective than thresholds that would be developed following the use-protection approach. However, others questioned the applicability of the non-degradation approach to a location that is within a highly-mineralized area and has a long history of mine-related impacts to water quality.

A sub-set of the meeting participants argued that the use-protection approach is the most logical and suitable because it allows evaluation of specific existing and proposed development/uses within the context of available assimilative capacity and the protection of fish and aquatic habitat. In this case, the use-protection approach was viewed as achieving balance between economic and environmental values. Others also argued that the use-protection approach is superior in that it considers aquatic toxicity, rather than relying primarily on water quality data. It was recognized that implementation of the use-protection approach would likely require the collection of additional data (e.g., samples for analysis of surface water chemistry and toxicity testing) from locations upstream or away from mine-influence to support a fulsome assessment of baseline conditions.

Arguments in support of the use-restoration approach were based primarily on the historical nature of mining development and exploration in the watershed. Christal and Flat creeks, both of which are tributaries to the South McQuesten River, were discussed as specific examples of locations where deterioration of designated uses was attributed to historical mining activities.

The rightsholder and stakeholder input received during and after the August 2022 engagement sessions focused primarily on aspects of WQO validation, implementation, and attainment, in addition to various aspects of the cumulative effects study report, the latter of which are outside the scope of this report. Overall, there was general interest in the types of toxicity tests already being completed in the study area (e.g., as part of Environmental Effects Monitoring [EEM]), the types of toxicity tests that could be used to validate the WQO (see Section 7), and the financial costs of completing these tests. At the time of writing, toxicity testing information (including estimated costs) is being compiled by the case study team. Additionally, this report has been updated to address rightsholder and stakeholder input and questions related to other aspects of WQO validation, including those related to the process for adding new COPCs (see

Section 7). There was also some discussion in the meetings regarding what the proposed course of action might be in the absence of a watershed-wide Adaptive Management Plan (AMP) (i.e., what do we do if thresholds for attainment are exceeded? [see Section 8]).

Finally, one concern expressed by meeting participants following the August 2022 engagement sessions was whether proponents would be required to meet WQOs and monitor attainment as part of their AMPs. To address this concern, a commitment was made by the Government of Yukon (Section 12) to continue monitoring YT09DD0008 in partnership with ECCC. There is, however, an expectation that proponents will demonstrate their proposed projects are expected to meet the WQOs developed as part of, and subsequent to, this study.

5 CONTAMINANTS OF POTENTIAL CONCERN

5.1 Methods

To characterize baseline conditions and support identification of candidate COPCs, summary statistics (e.g., mean, 95th percentile, minimum, and maximum concentrations) were calculated for each station (Table 5.1) and parameter. To derive unbiased estimates of summary statistics, non-detects were transformed from left censored (i.e., “<” or “less than”) to right censored (i.e., “>” or “greater than”) data values and then the Kaplan-Meier (K-M) estimator was used to estimate the mean survival time in survival analysis (Helsel 2012). The survfit function in the *survival* package (Therneau 2017) in R was used to complete the calculations, which involved calculating the area under the K-M survival curve. Summary statistics were not calculated for parameters with data sets comprised of >75% non-detects. The number and proportion (%) of non-detects per parameter per station were reported.

Once summary statistics were calculated for each station and parameter, candidate COPCs were identified following the procedures outlined in The Guide (Government of Yukon 2021a). The Guide specifies which procedure(s) may be used to identify candidate COPCs, depending on which water management approach (i.e., non-degradation, use-protection, or use-restoration) is selected. One procedure involves the comparison of parameter concentrations in “*project contaminant sources*” (e.g., planned discharges or runoff from mine-affected areas) to mean and 95th percentile baseline concentrations measured in the watercourse (Government of Yukon 2021). This procedure could not be employed here because WQO were not being derived in response to a new development (e.g., a quartz mining project) that would be expected to impact the South McQuesten River (i.e., via direct discharges, site runoff, or aerial deposition pathways). Instead, candidate COPCs were identified based on two other types of comparisons described in The Guide. Specifically, parameters with concentrations that exceeded the 95th percentile baseline concentration by a factor of two or more in any given sample and/or had concentrations that exceeded applicable WQG in two or more months within a three-year period, or for any period greater than 30 days, at any station (Table 2.1) were identified as candidate COPCs (Figure 5.1). Both sets of comparisons focused on parameters for which there are WQG.

To support identification of candidate COPCs, WQG derived in Canada or adopted for use by Canadian jurisdictions were compiled from the following sources:

- CCME (1999, with updates) Canadian Environmental Quality Guidelines;
- Health Canada (2012) Guidelines for Canadian Recreational Water Quality;
- Health Canada (2020) Guidelines for Canadian Drinking Water Quality;

Table 5.1: Summary Statistics and Comparisons to Identify Contaminants of Potential Concern (COPCs) in the South McQuesten River, 2004 to 2020[a]

Station	Summary Statistic	Physicochemical parameters			Anions and Nutrients							Cyanide
		Dissolved Oxygen (field) (mg/L) [b]	Field pH [c]	Total Dissolved Solids (mg/L)	Total Alkalinity (mg $CaCO_3$/L) [b]	Un-ionized Ammonia, as N (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Nitrate, as N (mg/L)	Nitrite, as N (mg/L)	Dissolved Sulphate (mg/L)	Total Cyanide (mg/L)
Guidelines [d]		**>9.5**	**6.5 - 9.0**	**1,000**	**>20**	**0.0190**	**120**	**0.120**	**3.00**	**0.0200**	**309 to 429**	**0.00500**
(KNO)KV-72	Total n	16	26	0	33	16	14	14	30	24	19	0
	n Detected	16	26	0	32	16	1	14	24	4	19	0
	% Non-detects	0	0	-	3.03	0	93	0	20	83	0	-
	Mean	10.0	7.72	-	79	0.000170	-	0.210	0.0563	-	73	-
	SD	1.97	0.719	-	36	0.000321	-	0.0741	0.0571	-	30	-
	Minimum	7.22	5.02	-	***<1***	0.0000000651	0.180	0.0950	<0.005	<0.001	24	-
	5th Percentile	7.22	7.00	-	9.50	0.0000000651	-	0.0950	<0.005	-	24	-
	95th Percentile	13.8	8.53	-	127	0.00127	-	0.357	0.186	-	156	-
	Maximum	13.8	8.73	-	135	0.00127	<0.5	0.357	0.187	0.00200	156	-
CACHE-04	Total n	6	6	10	14	3	12	2	13	4	14	0
	n Detected	6	6	10	1	3	2	2	13	1	14	0
	% Non-detects	0	0	0	93	0	83	0	0	75	0	-
	Mean	12.3	5.16	361	-	0.0000319	-	0.900	0.114	0.00518	258	-
	SD	1.02	1.09	91	-	0.0000546	-	-	0.0230	-	95	-
	Minimum	10.9	4.49	275	<1	0.0000000842	<0.1	0.900	0.0830	<0.005	149	-
	5th Percentile	10.9	4.49	275	-	0.0000000842	-	0.900	0.0830	<0.005	149	-
	95th Percentile	13.6	7.36	551	-	0.0000949	-	0.900	0.146	0.00570	508	-
	Maximum	13.6	7.36	551	26	0.0000949	4.51	0.900	0.146	0.00570	508	-
(KNO)KV-1	Total n	34	106	1	37	30	37	37	56	49	25	0
	n Detected	34	106	1	37	30	21	36	52	11	25	0
	% Non-detects	0	0	0	0	0	43	2.70	7.14	78	0	-
	Mean	10.0	7.75	282	117	0.000271	1.08	0.149	0.0571	-	84	-
	SD	2.44	0.319	-	39	0.000348	1.45	0.0299	0.0615	-	26	-
	Minimum	***1.35***	6.82	282	53	0.0000226	0.200	<0.02	<0.005	<0.001	35	-
	5th Percentile	6.00	7.12	282	57	0.0000313	0.200	0.0840	0.00570	-	36	-
	95th Percentile	13.4	8.19	282	193	0.00111	5.77	0.192	0.214	-	120	-
	Maximum	13.7	8.31	282	199	0.00158	6.00	0.230	0.330	0.693	121	-
(KNO)KV-8	Total n	40	100	1	68	19	17	1	7	16	63	0
	n Detected	40	100	1	68	19	15	1	7	9	63	0
	% Non-detects	0	0	0	0	0	12	0	0	44	0	-
	Mean	12.2	7.80	460	137	0.000153	0.752	0.0970	0.162	0.171	216	-
	SD	1.38	0.370	-	45	0.000327	0.177	-	0.0334	0.220	85	-
	Minimum	9.80	7.01	460	35	0.0000260	0.480	0.0970	0.120	<0.005	36	-
	5th Percentile	10.1	7.25	460	62	0.0000260	0.480	0.0970	0.120	<0.005	79	-
	95th Percentile	14.3	8.27	460	180	0.00148	1.10	0.0970	0.206	0.810	321	-
	Maximum	15.2	9.73	460	356	0.00148	1.10	0.0970	0.206	0.810	577	-
(KNO)KV-2	Total n	17	39	2	39	17	11	12	33	23	27	0
	n Detected	17	39	2	39	17	5	12	29	4	27	0
	% Non-detects	0	0	0	0	0	55	0	12	83	0	-
	Mean	10.7	7.77	289	128	0.000214	0.757	0.130	0.0741	-	90	-
	SD	2.03	0.448	1.41	44	0.000288	0.737	0.0344	0.0716	-	31	-
	Minimum	6.80	6.54	288	55	0.00000755	0.330	0.0680	<0.005	<0.001	32	-
	5th Percentile	6.80	6.91	288	59	0.00000755	0.330	0.0680	0.0134	-	39	-
	95th Percentile	15.4	8.61	290	212	0.000936	2.07	0.169	0.164	-	122	-
	Maximum	15.4	8.93	290	230	0.000936	2.07	0.169	0.320	0.00190	170	-

The 95th percentile concentration exceeds the WQG.

The maximum concentration exceeds the WQG.

Notes: mg/L = milligrams per litre; $CaCO_3$ = calcium carbonate; > = greater than;% = percent; - = no data/not applicable; SD = standard deviation; < = less than; WQG = water quality guideline. ***Bold italics*** = the maximum concentration exceeds the 95th percentile concentration by a factor of at least two times.

[a] Stations are listed in order from upstream to downstream based on their location along the South McQuesten River mainstem or, in the case of tributaries (e.g., Cache Creek), where the tributary flows into the main stem.

[b] The minimum concentration was screened against the 5th percentile concentration. Additionally, the 5th percentile concentration was screened to the WQG.

[c] The minimum and maximum concentrations were screened against the 5th and 95th percentile concentrations, respectively. Additionally, the 5th and 95th percentile concentrations were screened to the minimum and maximum WQG, respectively.

[d] For guidelines that are dependent on other water quality parameters (see Table 5.2) median guidelines based on concurrent values were used for screening.

Table 5.1: Summary Statistics and Comparisons to Identify Contaminants of Potential Concern (COPCs) in the South McQuesten River, 2004 to 2020[a]

Station	Summary Statistic	Physicochemical parameters			Anions and Nutrients							Cyanide
		Dissolved Oxygen (field) (mg/L) [b]	Field pH [c]	Total Dissolved Solids (mg/L)	Total Alkalinity (mg $CaCO_3$/L) [b]	Un-ionized Ammonia, as N (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Nitrate, as N (mg/L)	Nitrite, as N (mg/L)	Dissolved Sulphate (mg/L)	Total Cyanide (mg/L)
Guidelines [d]		**>9.5**	**6.5 - 9.0**	**1,000**	**>20**	**0.0190**	**120**	**0.120**	**3.00**	**0.0200**	**309 to 429**	**0.00500**
(KNO)KV-3	Total n	12	32	0	2	7	16	16	16	13	1	0
	n Detected	12	32	0	2	7	7	16	15	2	1	0
	% Non-detects	0	0	-	0	0	56	0	6.25	85	0	-
	Mean	10.9	7.78	-	122	0.000172	0.742	0.129	0.0582	-	97	-
	SD	2.15	0.266	-	72	0.000210	0.733	0.0304	0.0500	-	-	-
	Minimum	7.13	7.28	-	72	0.0000192	0.300	0.0760	<0.005	<0.001	97	-
	5th Percentile	7.13	7.34	-	72	0.0000192	0.300	0.0760	<0.0099	-	97	-
	95th Percentile	15.1	8.14	-	173	0.000627	2.39	0.184	0.162	-	97	-
	Maximum	15.1	8.29	-	173	0.000627	2.39	0.184	0.162	0.00160	97	-
(KNO)KV-9	Total n	13	36	2	2	9	28	27	30	18	2	0
	n Detected	13	36	2	2	9	28	27	22	1	2	0
	% Non-detects	0	0	0	0	0	0	0	27	94	0	-
	Mean	8.89	7.60	220	110	0.0000307	1.35	0.0598	0.120	-	70	-
	SD	2.81	0.329	-	-	0.0000200	1.42	0.0112	0.555	-	-	-
	Minimum	3.28	6.70	220	110	0.00000541	0.560	0.0300	<0.005	<0.001	70	-
	5th Percentile	3.28	6.95	220	110	0.00000541	0.590	0.0350	<0.005	-	70	-
	95th Percentile	14.2	8.06	220	110	0.0000616	5.80	0.0750	0.0519	-	70	-
	Maximum	14.2	8.23	220	110	0.0000616	6.79	0.0790	***3.04***	0.00100	70	-
(KNO)KV-4	Total n	13	36	2	2	9	15	15	17	14	2	0
	n Detected	13	36	2	2	9	10	15	14	3	2	0
	% Non-detects	0	0	0	0	0	33	0	18	79	0	-
	Mean	10.4	7.74	160	74	0.000191	3.45	0.114	0.0447	-	54	-
	SD	2.47	0.287	-	-	0.000228	11	0.0364	0.0438	-	-	-
	Minimum	6.20	7.04	160	74	0.0000138	0.290	0.0350	<0.005	<0.001	54	-
	5th Percentile	6.20	7.25	160	74	0.0000138	0.290	0.0350	<0.005	-	54	-
	95th Percentile	15.1	8.24	160	74	0.000718	43	0.175	0.137	-	54	-
	Maximum	15.1	8.32	160	74	0.000718	43	0.175	0.137	0.00500	54	-
YT09DD0008	Total n	0	1	0	149	0	149	148	128	29	145	6
	n Detected	0	1	0	149	0	147	146	113	0	145	3
	% Non-detects	-	0	-	0	-	1.34	1.35	12	100	0	50
	Mean	-	6.90	-	129	-	0.826	0.124	0.0612	-	96	0.334
	SD	-	-	-	35	-	0.598	0.0410	0.0547	-	26	0.913
	Minimum	-	6.90	-	56	-	<0.1	<0.01	<0.002	<0.005	27	<0.0005
	5th Percentile	-	6.90	-	75	-	0.240	0.0700	<0.002	-	50	<0.0005
	95th Percentile	-	6.90	-	192	-	2.10	0.180	0.165	-	129	2.00
	Maximum	-	6.90	-	229	-	2.60	0.340	0.194	<0.005	179	2.00
(KNO)KV-5	Total n	12	33	0	2	7	14	14	14	11	2	0
	n Detected	12	33	0	2	7	6	14	14	2	2	0
	% Non-detects	0	0	-	0	0	57	0	0	82	0	-
	Mean	11.0	7.78	-	176	0.000184	0.584	0.119	0.0566	-	89	-
	SD	2.38	0.382	-	4.95	0.000292	0.423	0.0347	0.0480	-	-	-
	Minimum	7.54	6.70	-	173	0.00000531	0.370	0.0560	0.00720	<0.001	89	-
	5th Percentile	7.54	7.11	-	173	0.00000531	0.370	0.0560	0.00720	-	89	-
	95th Percentile	15.6	8.31	-	180	0.000837	1.72	0.171	0.148	-	89	-
	Maximum	15.6	8.60	-	180	0.000837	1.72	0.171	0.148	0.00150	89	-

(grey) The 95th percentile concentration exceeds the WQG.
(yellow) The maximum concentration exceeds the WQG.

Notes: mg/L = milligrams per litre; $CaCO_3$ = calcium carbonate; > = greater than;% = percent; - = no data/not applicable; SD = standard deviation; < = less than; WQG = water quality guideline. ***Bold italics*** = the maximum concentration exceeds the 95th percentile concentration by a factor of at least two times.

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[b] The minimum concentration was screened against the 5th percentile concentration. Additionally, the 5th percentile concentration was screened to the WQG.

[c] The minimum and maximum concentrations were screened against the 5th and 95th percentile concentrations, respectively. Additionally, the 5th and 95th percentile concentrations were screened to the minimum and maximum WQG, respectively.

[d] For guidelines that are dependent on other water quality parameters (see Table 5.2) median guidelines based on concurrent values were used for screening.

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Guidelines [d]		**>9.5**	**6.5 - 9.0**	**1,000**	**>20**	**0.0190**	**120**	**0.120**	**3.00**	**0.0200**	**309 to 429**	**0.00500**
(EG)W39	Total n	1	1	17	19	0	19	19	19	17	0	12
	n Detected	1	1	17	19	0	0	17	19	1	0	0
	% Non-detects	0	0	0	0	-	100	11	0	94	-	100
	Mean	13.4	8.52	182	95	-	-	0.0932	0.0858	-	-	-
	SD	-	-	43	30	-	-	0.0191	0.0598	-	-	-
	Minimum	13.4	8.52	73	25	-	<0.5	0.0440	0.0139	<0.001	-	<0.005
	5th Percentile	13.4	8.52	73	25	-	-	0.0440	0.0139	-	-	-
	95th Percentile	13.4	8.52	259	134	-	-	0.114	0.241	-	-	-
	Maximum	13.4	8.52	259	134	-	<2.5	0.114	0.241	0.00110	-	<0.005
(KNO)KV-15	Total n	13	33	0	1	0	0	0	0	0	1	0
	n Detected	13	33	0	1	0	0	0	0	0	1	0
	% Non-detects	0	0	-	0	-	-	-	-	-	0	-
	Mean	11.1	7.65	-	178	-	-	-	-	-	76	-
	SD	2.27	0.416	-	-	-	-	-	-	-	-	-
	Minimum	7.43	6.54	-	178	-	-	-	-	-	76	-
	5th Percentile	7.43	6.75	-	178	-	-	-	-	-	76	-
	95th Percentile	15.0	8.24	-	178	-	-	-	-	-	76	-
	Maximum	15.0	8.25	-	178	-	-	-	-	-	76	-
(EG)W49	Total n	1	2	26	30	0	27	29	29	27	0	21
	n Detected	1	2	26	30	0	15	27	29	9	0	0
	% Non-detects	0	0	0	0	-	44	6.90	0	67	-	100
	Mean	12.6	8.15	244	128	-	0.744	0.101	0.0834	0.00131	-	-
	SD	-	0.389	67	49	-	0.332	0.0220	0.0509	0.000556	-	-
	Minimum	12.6	7.88	71	26	-	<0.5	0.0440	0.0107	<0.001	-	<0.005
	5th Percentile	12.6	7.88	121	33	-	<0.5	0.0720	0.0151	<0.001	-	-
	95th Percentile	12.6	8.43	319	193	-	1.46	0.144	0.169	0.00280	-	-
	Maximum	12.6	8.43	336	200	-	1.48	0.157	0.173	0.00340	-	<0.005

The 95th percentile concentration exceeds the WQG.

The maximum concentration exceeds the WQG.

Notes: mg/L = milligrams per litre; $CaCO_3$ = calcium carbonate; > = greater than;% = percent; - = no data/not applicable; SD = standard deviation; < = less than; WQG = water quality guideline. ***Bold italics*** = the maximum concentration exceeds the 95th percentile concentration by a factor of at least two times.

[a] Stations are listed in order from upstream to downstream based on their location along the South McQuesten River mainstem or, in the case of tributaries (e.g., Cache Creek), where the tributary flows into the main stem.

[b] The minimum concentration was screened against the 5th percentile concentration. Additionally, the 5th percentile concentration was screened to the WQG.

[c] The minimum and maximum concentrations were screened against the 5th and 95th percentile concentrations, respectively. Additionally, the 5th and 95th percentile concentrations were screened to the minimum and maximum WQG, respectively.

[d] For guidelines that are dependent on other water quality parameters (see Table 5.2) median guidelines based on concurrent values were used for screening.

Table 5.1: Summary Statistics and Comparisons to Identify Contaminants of Potential Concern (COPCs) in the South McQuesten River, 2004 to 2020[a]

Station	Summary Statistic	Total Metals											
		Aluminum (mg/L)	Arsenic (mg/L)	Barium (mg/L)	Beryllium (mg/L)	Boron (mg/L)	Cadmium (mg/L)	Calcium (mg/L)	Chromium (mg/L)	Cobalt (mg/L)	Copper (mg/L)	Iron (mg/L)	Lead (mg/L)
Guidelines [d]		**0.0050 to 0.10**	**0.00500**	**1.00**	**0.000130**	**1.50**	**0.00013 to 0.00037**	**1,000**	**0.00100**	**0.00100**	**0.0020 to 0.0040**	**0.300**	**0.0024 to 0.0070**
(KNO)KV-72	Total n	33	33	33	33	33	33	33	33	33	33	33	33
	n Detected	33	33	33	12	0	33	33	22	30	33	33	32
	% Non-detects	0	0	0	64	100	0	0	33	9.09	0	0	3.03
	Mean	1.95	0.000665	0.0476	0.0000892	-	0.00226	44	0.000533	0.0144	0.0115	0.895	0.00112
	SD	2.64	0.000538	0.00806	0.000124	-	0.00340	12	0.000764	0.0208	0.0146	1.31	0.00107
	Minimum	0.0145	0.000290	0.0318	<0.00001	<0.01	0.0000130	22	<0.0001	0.0000550	0.000945	0.0410	0.0000390
	5th Percentile	0.0189	0.000320	0.0331	<0.00001	-	0.0000150	23	<0.0001	0.0000550	0.000968	0.0412	0.0000390
	95th Percentile	7.17	0.00231	0.0611	0.000370	-	0.00895	59	0.00254	0.0578	0.0441	3.80	0.00372
	Maximum	9.58	0.00254	0.0701	0.000430	<0.05	0.0128	61	0.00334	0.0774	0.0508	5.27	0.00376
CACHE-04	Total n	14	14	14	14	10	14	14	14	14	14	14	14
	n Detected	14	12	14	14	6	14	14	13	14	14	14	14
	% Non-detects	0	14	0	0	40	0	0	7.14	0	0	0	0
	Mean	9.77	0.000595	0.0388	0.000545	0.00835	0.0120	35	0.000958	0.0887	0.0683	2.75	0.00278
	SD	2.84	0.000292	0.00535	0.000149	0.00408	0.00328	12	0.000413	0.0316	0.0207	1.52	0.000894
	Minimum	4.70	0.000200	0.0291	0.000230	<0.005	0.00760	22	<0.0005	0.0410	0.0282	0.410	0.00130
	5th Percentile	4.70	0.000200	0.0291	0.000230	<0.005	0.00760	22	<0.0006	0.0410	0.0282	0.410	0.00130
	95th Percentile	15	0.00104	0.0455	0.000910	0.0172	0.0188	61	0.00187	0.162	0.101	5.77	0.00438
	Maximum	15	0.00104	0.0455	0.000910	0.0172	0.0188	61	0.00187	0.162	0.101	5.77	0.00438
(KNO)KV-1	Total n	142	142	142	142	99	142	141	142	142	142	142	142
	n Detected	141	140	141	38	16	140	140	102	141	139	141	141
	% Non-detects	0.704	1.41	0.704	73	84	1.41	0.709	28	0.704	2.11	0.704	0.704
	Mean	1.13	0.00204	0.0645	0.000642	-	0.000859	55	0.000517	0.00483	0.00530	0.696	0.00104
	SD	5.60	0.00266	0.0232	0.00729	-	0.00112	18	0.000798	0.00773	0.00679	1.29	0.00184
	Minimum	<0.003	<0.0001	<0.00005	<0.00001	<0.0005	<0.000005	0.000250	<0.0001	0.0000380	0.000250	<0.01	0.0000360
	5th Percentile	0.0270	0.000790	0.0443	<0.00001	-	0.000256	31	<0.0001	0.000600	0.00100	0.140	0.000100
	95th Percentile	2.23	0.00617	0.107	0.0000900	-	0.00184	82	0.00199	0.0108	0.0115	2.40	0.00537
	Maximum	***66***	***0.0272***	0.187	***0.0860***	0.0200	***0.0128***	126	***0.00512***	***0.0889***	***0.0766***	***11***	***0.0117***
(KNO)KV-8	Total n	128	128	128	128	24	128	127	127	128	128	128	128
	n Detected	124	127	128	5	8	128	127	94	103	114	121	128
	% Non-detects	3.13	0.781	0	96	67	0	0	26	20	11	5.47	0
	Mean	0.130	0.00332	0.0539	-	0.00248	0.000977	103	0.000521	0.000242	0.00166	0.373	0.00668
	SD	0.268	0.00196	0.0146	-	0.00116	0.000558	37	0.000627	0.000312	0.00175	0.630	0.0141
	Minimum	0.00240	0.00122	0.0230	<0.00001	<0.002	0.000298	23	<0.0001	0.0000350	0.000180	<0.01	0.000107
	5th Percentile	0.00330	0.00175	0.0342	-	<0.002	0.000375	38	<0.0001	0.0000510	0.000390	0.0440	0.000800
	95th Percentile	0.611	0.00779	0.0836	-	0.00500	0.00219	161	0.00200	0.000710	0.00553	1.34	0.0286
	Maximum	***1.52***	0.0155	0.133	<0.001	0.00500	0.00327	268	0.00348	***0.00225***	0.0103	***4.06***	***0.121***
(KNO)KV-2	Total n	55	55	55	55	38	55	54	55	55	55	55	55
	n Detected	55	55	55	11	9	55	54	45	54	53	55	55
	% Non-detects	0	0	0	80	76	0	0	18	1.82	3.64	0	0
	Mean	0.448	0.00250	0.0677	0.0000233	-	0.000588	55	0.000522	0.00245	0.00404	0.543	0.00297
	SD	0.477	0.00184	0.0203	0.0000275	-	0.000312	18	0.000573	0.00187	0.00306	0.685	0.00525
	Minimum	0.0120	0.000910	0.0392	<0.00001	0.00200	0.0000140	27	<0.0001	0.0000660	0.000320	0.0620	0.000100
	5th Percentile	0.0130	0.00109	0.0451	<0.00001	-	0.0000900	31	<0.0001	0.000100	0.000500	0.100	0.000210
	95th Percentile	1.74	0.00771	0.108	0.0000495	-	0.00112	88	0.00200	0.00660	0.0100	1.85	0.0143
	Maximum	2.06	0.00876	0.122	***<0.001***	0.0140	0.00144	100	0.00258	0.00786	0.0160	***3.81***	***0.0290***

The 95th percentile concentration exceeds the WQG.

The maximum concentration exceeds the WQG.

Notes: mg/L = milligrams per litre; $CaCO_3$ = calcium carbonate; > = greater than;% = percent; - = no data/not applicable; SD = standard deviation; < = less than; WQG = water quality guideline. ***Bold italics*** = the maximum concentration exceeds the 95th percentile concentration by a factor of at least two times.

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Table 5.1: Summary Statistics and Comparisons to Identify Contaminants of Potential Concern (COPCs) in the South McQuesten River, 2004 to 2020[a]

Station	Summary Statistic	Total Metals											
		Aluminum (mg/L)	Arsenic (mg/L)	Barium (mg/L)	Beryllium (mg/L)	Boron (mg/L)	Cadmium (mg/L)	Calcium (mg/L)	Chromium (mg/L)	Cobalt (mg/L)	Copper (mg/L)	Iron (mg/L)	Lead (mg/L)
Guidelines [d]		**0.0050 to 0.10**	**0.00500**	**1.00**	**0.000130**	**1.50**	**0.00013 to 0.00037**	**1,000**	**0.00100**	**0.00100**	**0.0020 to 0.0040**	**0.300**	**0.0024 to 0.0070**
(KNO)KV-3	Total n	47	47	47	15	47	47	47	47	47	47	47	47
	n Detected	47	47	47	11	6	47	47	34	47	46	45	47
	% Non-detects	0	0	0	27	87	0	0	28	0	2.13	4.26	0
	Mean	0.438	0.00243	0.0680	0.0000241	-	0.000627	55	0.000475	0.00248	0.00376	0.540	0.00426
	SD	0.389	0.00141	0.0206	0.0000128	-	0.000257	16	0.000497	0.00148	0.00213	0.613	0.00614
	Minimum	0.0100	0.00126	0.0426	<0.00001	<0.002	0.000140	24	<0.0001	0.000200	0.000600	0.120	0.000603
	5th Percentile	0.0163	0.00132	0.0459	<0.00001	-	0.000240	32	<0.0001	0.000500	0.000846	0.171	0.000698
	95th Percentile	1.29	0.00596	0.112	0.0000500	-	0.00113	85	0.00160	0.00476	0.00900	1.57	0.0186
	Maximum	1.61	0.00766	0.122	0.0000500	<0.1	0.00119	92	0.00200	0.00666	0.00900	2.87	0.0279
(KNO)KV-9	Total n	63	63	63	63	45	63	63	63	63	63	63	63
	n Detected	50	63	63	0	5	63	63	33	27	63	60	63
	% Non-detects	21	0	0	100	89	0	0	48	57	0	4.76	0
	Mean	0.0255	0.00283	0.0634	-	-	0.000508	78	0.000248	0.0000842	0.00211	0.251	0.0217
	SD	0.0791	0.00444	0.0312	-	-	0.000534	22	0.000330	0.000108	0.00167	0.874	0.0611
	Minimum	0.00130	0.000600	0.0151	<0.00001	<0.002	0.000176	24	<0.0001	0.0000330	0.000570	0.00980	0.000460
	5th Percentile	0.00130	0.000700	0.0202	-	-	0.000231	34	<0.0001	0.0000330	0.000850	0.0410	0.000617
	95th Percentile	0.0751	0.00532	0.107	-	-	0.00126	100	0.000800	0.000150	0.00433	0.539	0.0759
	Maximum	***0.621***	***0.0356***	0.147	<0.0001	<0.01	***0.00385***	108	***0.00210***	***0.000870***	***0.0120***	***6.99***	***0.470***
(KNO)KV-4	Total n	50	50	50	50	32	50	50	50	50	50	50	50
	n Detected	50	50	50	10	5	50	50	37	50	48	50	50
	% Non-detects	0	0	0	80	84	0	0	26	0	4.00	0	0
	Mean	0.307	0.00251	0.0627	-	-	0.000622	58	0.000351	0.00180	0.00336	0.407	0.0106
	SD	0.295	0.00153	0.0223	-	-	0.000311	18	0.000298	0.00133	0.00192	0.406	0.0183
	Minimum	0.00534	0.00120	0.0200	<0.00001	<0.002	0.000251	24	<0.0001	0.000168	0.000495	0.0393	0.000103
	5th Percentile	0.0180	0.00136	0.0349	-	-	0.000300	31	<0.0001	0.000300	0.000730	0.100	0.000843
	95th Percentile	1.03	0.00468	0.107	-	-	0.00122	86	0.000930	0.00409	0.00750	1.11	0.0457
	Maximum	1.13	0.00890	0.118	<0.0001	<0.01	0.00199	91	0.00131	0.00614	0.00800	***2.27***	***0.0938***
YT09DD0008	Total n	148	148	148	146	148	148	0	144	148	146	148	147
	n Detected	148	148	148	143	144	148	0	144	148	146	148	147
	% Non-detects	0	0	0	2.05	2.70	0	-	0	0	0	0	0
	Mean	0.285	0.00199	0.0754	0.0000150	0.00197	0.000566	-	0.000154	0.00203	0.00308	0.357	0.00283
	SD	0.326	0.000877	0.0224	0.0000153	0.00108	0.000272	-	0.000280	0.00174	0.00222	0.414	0.00546
	Minimum	0.00600	0.000400	0.0322	<0.000001	<0.0005	0.0000200	-	0.0000100	0.000100	0.000410	0.132	0.000231
	5th Percentile	0.0132	0.00137	0.0510	0.00000100	0.000900	0.000246	-	0.0000290	0.000299	0.000680	0.158	0.000632
	95th Percentile	1.02	0.00337	0.120	0.0000460	0.00420	0.00112	-	0.000580	0.00547	0.00733	1.21	0.0129
	Maximum	1.73	***0.00809***	0.124	0.0000800	0.00530	0.00162	-	***0.00224***	0.00845	0.0105	***3.32***	***0.0458***
(KNO)KV-5	Total n	48	48	48	48	10	48	47	48	48	48	48	48
	n Detected	48	48	48	13	7	48	47	34	47	46	48	48
	% Non-detects	0	0	0	73	30	0	0	29	2.08	4.17	0	0
	Mean	0.369	0.00430	0.0704	0.0000230	0.00460	0.000457	54	0.000425	0.00172	0.00327	0.550	0.00373
	SD	0.420	0.00249	0.0207	0.0000216	0.00197	0.000192	15	0.000543	0.00113	0.00200	0.562	0.00457
	Minimum	0.00424	0.00127	0.0277	<0.00001	<0.002	0.0000900	25	<0.0001	<0.0001	0.000650	0.0600	0.000106
	5th Percentile	0.0100	0.00176	0.0473	<0.00001	<0.002	0.000170	27	<0.0001	0.000200	0.000656	0.167	0.000616
	95th Percentile	1.04	0.00914	0.104	0.0000400	0.00900	0.000810	75	0.00130	0.00370	0.00700	2.02	0.0139
	Maximum	***2.48***	0.0133	0.122	***0.000100***	0.00900	0.000980	84	***0.00320***	0.00499	0.00900	2.70	0.0195

The 95th percentile concentration exceeds the WQG.
The maximum concentration exceeds the WQG.

Notes: mg/L = milligrams per litre; $CaCO_3$ = calcium carbonate; > = greater than;% = percent; - = no data/not applicable; SD = standard deviation; < = less than; WQG = water quality guideline. ***Bold italics*** = the maximum concentration exceeds the 95th percentile concentration by a factor of at least two times.

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Table 5.1: Summary Statistics and Comparisons to Identify Contaminants of Potential Concern (COPCs) in the South McQuesten River, 2004 to 2020[a]

Station	Summary Statistic	Total Metals											
		Aluminum (mg/L)	Arsenic (mg/L)	Barium (mg/L)	Beryllium (mg/L)	Boron (mg/L)	Cadmium (mg/L)	Calcium (mg/L)	Chromium (mg/L)	Cobalt (mg/L)	Copper (mg/L)	Iron (mg/L)	Lead (mg/L)
Guidelines [d]		**0.0050 to 0.10**	**0.00500**	**1.00**	**0.000130**	**1.50**	**0.00013 to 0.00037**	**1,000**	**0.00100**	**0.00100**	**0.0020 to 0.0040**	**0.300**	**0.0024 to 0.0070**
(EG)W39	Total n	19	19	19	19	19	19	19	19	19	19	19	19
	n Detected	19	19	19	1	0	17	19	18	9	18	19	17
	% Non-detects	0	0	0	95	100	11	0	5.26	53	5.26	0	11
	Mean	0.420	0.00570	0.0496	-	-	0.0000356	41	0.000812	0.000588	0.00231	0.928	0.00116
	SD	0.908	0.00607	0.0115	-	-	0.0000536	12	0.00153	0.00116	0.00303	1.94	0.00239
	Minimum	0.00880	0.00183	0.0402	<0.00002	<0.01	0.00000800	14	<0.0001	<0.0001	<0.0005	0.0200	<0.00005
	5th Percentile	0.00880	0.00183	0.0402	-	-	0.00000800	14	<0.00011	<0.0001	<0.00074	0.0200	<0.00005
	95th Percentile	3.64	0.0267	0.0928	-	-	0.000207	59	0.00626	0.00442	0.0125	7.64	0.00914
	Maximum	3.64	0.0267	0.0928	0.000150	<0.01	0.000207	59	0.00626	0.00442	0.0125	7.64	0.00914
(KNO)KV-15	Total n	47	47	47	47	47	47	47	47	47	47	47	47
	n Detected	47	47	47	7	8	47	47	33	45	44	47	47
	% Non-detects	0	0	0	85	83	0	0	30	4.26	6.38	0	0
	Mean	0.261	0.00539	0.0705	-	-	0.000213	48	0.000497	0.000872	0.00226	0.598	0.00230
	SD	0.330	0.00463	0.0310	-	-	0.000164	18	0.000556	0.000735	0.00148	0.626	0.00220
	Minimum	0.00286	0.00270	0.0336	<0.00001	0.00200	0.0000103	15	<0.0001	0.0000450	0.000262	0.0430	0.0000820
	5th Percentile	0.0129	0.00286	0.0350	-	-	0.0000130	20	<0.0001	0.0000450	0.000550	0.105	0.000114
	95th Percentile	0.952	0.00740	0.126	-	-	0.000565	72	0.00169	0.00243	0.00500	2.15	0.00732
	Maximum	1.61	***0.0344***	0.137	0.000100	<0.05	0.000629	80	0.00268	0.00312	0.00690	3.32	0.00980
(EG)W49	Total n	30	30	30	29	30	30	30	30	30	30	30	30
	n Detected	30	30	30	2	2	30	30	21	29	27	30	30
	% Non-detects	0	0	0	93	93	0	0	30	3.33	10	0	0
	Mean	0.342	0.00612	0.0819	-	-	0.000231	55	0.000631	0.000979	0.00223	0.917	0.00224
	SD	0.798	0.00516	0.0287	-	-	0.000100	19	0.00139	0.000948	0.00263	1.67	0.00208
	Minimum	0.0168	0.00327	0.0355	<0.00002	0.00500	0.0000267	14	<0.0001	<0.0001	<0.0005	0.0740	0.000221
	5th Percentile	0.0184	0.00341	0.0415	-	-	0.0000304	15	<0.0001	0.000360	<0.0005	0.221	0.000878
	95th Percentile	1.69	0.0153	0.132	-	-	0.000391	75	0.00307	0.00249	0.00729	3.71	0.00634
	Maximum	***4.12***	***0.0310***	0.135	0.000190	0.0110	0.000392	77	***0.00707***	***0.00540***	0.0141	***8.89***	0.0113

The 95th percentile concentration exceeds the WQG.

The maximum concentration exceeds the WQG.

Notes: mg/L = milligrams per litre; $CaCO_3$ = calcium carbonate; > = greater than;% = percent; - = no data/not applicable; SD = standard deviation; < = less than; WQG = water quality guideline. ***Bold italics*** = the maximum concentration exceeds the 95th percentile concentration by a factor of at least two times.

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[d] For guidelines that are dependent on other water quality parameters (see Table 5.2) median guidelines based on concurrent values were used for screening.

Table 5.1: Summary Statistics and Comparisons to Identify Contaminants of Potential Concern (COPCs) in the South McQuesten River, 2004 to 2020[a]

Station	Summary Statistic	Total Metals											
		Manganese (mg/L)	Mercury (mg/L)	Molybdenum (mg/L)	Nickel (mg/L)	Selenium (mg/L)	Silver (mg/L)	Strontium (mg/L)	Thallium (mg/L)	Tin (mg/L)	Uranium (mg/L)	Vanadium (mg/L)	Zinc (mg/L)
Guidelines [d]		**0.18 to 0.79**	**0.0000260**	**0.0500**	**0.081 to 0.15**	**0.00100**	**0.000250**	**2.50**	**0.000800**	**0.00000800**	**0.00850**	**0.100**	**0.0075 to 0.19**
(KNO)KV-72	Total n	33	26	33	33	33	33	33	19	27	33	33	33
	n Detected	33	4	32	33	33	13	33	5	2	33	8	31
	% Non-detects	0	85	3.03	0	0	61	0	74	93	0	76	6.06
	Mean	0.635	-	0.000258	0.0786	0.000777	0.0000153	0.192	0.00000461	-	0.000696	-	0.420
	SD	0.897	-	0.000124	0.108	0.000588	0.0000170	0.0610	0.00000501	-	0.000216	-	0.638
	Minimum	0.00625	<0.000005	<0.00005	0.00390	0.000230	<0.000005	0.0788	<0.000002	<0.0001	0.000276	<0.0002	0.00155
	5th Percentile	0.0116	-	0.0000510	0.00448	0.000283	<0.000005	0.0843	<0.000002	-	0.000319	-	0.00155
	95th Percentile	2.26	-	0.000510	0.269	0.00248	0.0000650	0.279	0.0000170	-	0.00114	-	1.63
	Maximum	3.75	0.0000145	0.000528	0.433	0.00275	0.0000650	0.293	0.0000170	0.000140	0.00114	0.00507	2.37
CACHE-04	Total n	14	2	14	14	14	14	14	14	12	14	14	14
	n Detected	14	0	2	14	14	0	14	5	0	14	4	14
	% Non-detects	0	100	86	0	0	100	0	64	100	0	71	0
	Mean	3.36	-	-	0.423	0.00182	-	0.134	0.0000214	-	0.00138	0.00138	2.45
	SD	1.31	-	-	0.131	0.000473	-	0.0605	0.00000229	-	0.000381	0.00136	0.684
	Minimum	1.87	<0.00001	<0.0001	0.257	0.00112	<0.00002	0.0670	<0.00002	<0.0002	0.000690	<0.001	1.52
	5th Percentile	1.87	-	-	0.257	0.00112	-	0.0670	<0.00002	-	0.000690	<0.001	1.52
	95th Percentile	6.09	-	-	0.712	0.00256	-	0.248	0.0000280	-	0.00212	0.00560	3.86
	Maximum	6.09	<0.00001	0.000140	0.712	0.00256	<0.00005	0.248	0.0000280	<0.0002	0.00212	0.00560	3.86
(KNO)KV-1	Total n	141	71	142	142	142	142	142	83	139	142	141	142
	n Detected	140	4	120	141	133	41	141	30	24	139	58	141
	% Non-detects	0.709	94	15	0.704	6.34	71	0.704	64	83	2.11	59	0.704
	Mean	0.286	-	0.000596	0.0312	0.000507	0.0000157	0.227	0.00000474	-	0.000888	0.000607	0.154
	SD	0.375	-	0.000313	0.0231	0.000153	0.0000365	0.0633	0.00000630	-	0.000440	0.00115	0.215
	Minimum	<0.0001	<0.000005	<0.00005	<0.0005	<0.00005	<0.000005	<0.0002	<0.000002	<0.00001	<0.00001	0.000100	0.00130
	5th Percentile	0.112	-	0.000347	0.00852	0.000220	<0.000005	0.115	<0.000002	-	0.000586	0.000100	0.0460
	95th Percentile	0.627	-	0.00102	0.0521	0.000750	0.0000840	0.303	0.0000150	-	0.00144	0.00287	0.355
	Maximum	***4.25***	0.0000380	***0.00240***	***0.251***	0.00100	***0.000360***	0.470	***0.0000400***	0.00180	***0.00464***	***0.00800***	***2.54***
(KNO)KV-8	Total n	127	59	108	128	128	128	128	86	106	128	127	128
	n Detected	127	7	107	127	122	89	128	25	23	126	43	128
	% Non-detects	0	88	0.926	0.781	4.69	30	0	71	78	1.56	66	0
	Mean	0.145	-	0.000390	0.00196	0.000728	0.0000628	0.219	0.00000447	-	0.00223	0.000435	0.145
	SD	0.0871	-	0.0000773	0.00113	0.000339	0.000139	0.0764	0.00000712	-	0.000957	0.000777	0.0747
	Minimum	0.0262	<0.000005	0.000212	0.000700	0.000130	<0.000005	0.0522	<0.000002	<0.00001	0.000279	<0.0001	0.0289
	5th Percentile	0.0420	-	0.000241	0.000980	0.000230	<0.000005	0.0808	<0.000002	-	0.000591	<0.0001	0.0659
	95th Percentile	0.323	-	0.000548	0.00431	0.00125	0.000320	0.319	0.0000190	-	0.00340	0.00191	0.310
	Maximum	0.571	0.0000164	0.000635	0.00733	0.00210	***0.00101***	0.529	***0.0000480***	0.000600	0.00580	***0.00437***	0.480
(KNO)KV-2	Total n	54	24	55	55	54	55	55	33	53	55	55	55
	n Detected	54	3	49	55	51	27	55	7	7	54	19	55
	% Non-detects	0	88	11	0	5.56	51	0	79	87	1.82	65	0
	Mean	0.189	-	0.000662	0.0189	0.000476	0.0000313	0.207	-	-	0.000832	0.000447	0.0970
	SD	0.0924	-	0.000284	0.00971	0.000182	0.0000652	0.0621	-	-	0.000275	0.000781	0.0535
	Minimum	0.0255	<0.000005	0.000350	0.00103	0.0000600	<0.000005	0.0956	<0.000002	<0.00001	0.0000950	0.0000800	0.00140
	5th Percentile	0.0570	-	0.000369	0.00338	0.0000700	<0.000005	0.108	-	-	0.000259	0.0000800	0.0213
	95th Percentile	0.365	-	0.00127	0.0386	0.000700	0.000192	0.338	-	-	0.00120	0.00180	0.176
	Maximum	0.479	0.0000113	0.00153	0.0426	0.000969	0.000373	0.356	0.0000120	<0.001	0.00146	***<0.01***	0.325

The 95th percentile concentration exceeds the WQG.

The maximum concentration exceeds the WQG.

Notes: mg/L = milligrams per litre; $CaCO_3$ = calcium carbonate; > = greater than;% = percent; - = no data/not applicable; SD = standard deviation; < = less than; WQG = water quality guideline. ***Bold italics*** = the maximum concentration exceeds the 95th percentile concentration by a factor of at least two times.

[a] Stations are listed in order from upstream to downstream based on their location along the South McQuesten River mainstem or, in the case of tributaries (e.g., Cache Creek), where the tributary flows into the main stem.

[b] The minimum concentration was screened against the 5th percentile concentration. Additionally, the 5th percentile concentration was screened to the WQG.

[c] The minimum and maximum concentrations were screened against the 5th and 95th percentile concentrations, respectively. Additionally, the 5th and 95th percentile concentrations were screened to the minimum and maximum WQG, respectively.

[d] For guidelines that are dependent on other water quality parameters (see Table 5.2) median guidelines based on concurrent values were used for screening.

Table 5.1: Summary Statistics and Comparisons to Identify Contaminants of Potential Concern (COPCs) in the South McQuesten River, 2004 to 2020[a]

Station	Summary Statistic	Total Metals											
		Manganese (mg/L)	Mercury (mg/L)	Molybdenum (mg/L)	Nickel (mg/L)	Selenium (mg/L)	Silver (mg/L)	Strontium (mg/L)	Thallium (mg/L)	Tin (mg/L)	Uranium (mg/L)	Vanadium (mg/L)	Zinc (mg/L)
Guidelines [d]		**0.18 to 0.79**	**0.0000260**	**0.0500**	**0.081 to 0.15**	**0.00100**	**0.000250**	**2.50**	**0.000800**	**0.00000800**	**0.00850**	**0.100**	**0.0075 to 0.19**
(KNO)KV-3	Total n	47	25	45	47	46	47	47	13	39	47	46	47
	n Detected	47	4	42	47	44	25	47	9	5	45	18	47
	% Non-detects	0	84	6.67	0	4.35	47	0	31	87	4.26	61	0
	Mean	0.204	0.00000606	0.000648	0.0197	0.000459	0.0000469	0.199	0.00000277	-	0.000829	0.000420	0.0977
	SD	0.0889	0.00000427	0.000270	0.00786	0.000113	0.0000977	0.0500	0.00000119	-	0.000174	0.000540	0.0390
	Minimum	0.0580	<0.000005	0.000360	0.00440	0.000200	<0.000005	0.0768	<0.000002	<0.00001	0.000400	<0.0001	0.0340
	5th Percentile	0.0810	<0.000005	0.000420	0.00803	0.000240	<0.000005	0.110	<0.000002	-	0.000555	<0.0002	0.0344
	95th Percentile	0.430	0.00000900	0.00109	0.0351	0.000622	0.000222	0.272	0.00000500	-	0.00110	0.00140	0.167
	Maximum	0.461	***0.0000238***	0.00158	0.0386	0.000661	***0.000576***	0.291	0.00000500	0.000450	0.00123	0.00278	0.202
(KNO)KV-9	Total n	63	36	57	63	63	63	63	35	63	63	63	63
	n Detected	63	5	56	55	46	50	63	23	8	61	9	63
	% Non-detects	0	86	1.75	13	27	21	0	34	87	3.17	86	0
	Mean	0.117	-	0.000221	0.00122	0.0000939	0.000241	0.179	0.0000151	-	0.000801	-	0.0376
	SD	0.270	-	0.0000426	0.00310	0.0000465	0.000872	0.0479	0.0000116	-	0.000309	-	0.0331
	Minimum	0.0229	<0.000005	0.000140	0.000300	<0.00004	<0.000005	0.0575	<0.000002	<0.00001	0.000115	<0.0001	0.0133
	5th Percentile	0.0255	-	0.000150	0.000300	<0.00004	<0.000005	0.0777	<0.000002	-	0.000193	-	0.0156
	95th Percentile	0.271	-	0.000283	0.00191	0.000179	0.000769	0.233	0.0000310	-	0.00112	-	0.0979
	Maximum	***2.12***	0.0000239	0.000381	***0.0250***	<0.0006	***0.00682***	0.239	0.0000600	<0.001	0.00147	0.00209	***0.242***
(KNO)KV-4	Total n	50	24	50	50	50	50	50	30	44	50	50	50
	n Detected	50	5	45	50	47	38	50	16	5	49	18	50
	% Non-detects	0	79	10	0	6.00	24	0	47	89	2.00	64	0
	Mean	0.175	-	0.000520	0.0159	0.000373	0.000105	0.190	0.00000705	-	0.000774	0.000349	0.0854
	SD	0.0826	-	0.000240	0.00889	0.000143	0.000203	0.0561	0.00000576	-	0.000246	0.000432	0.0356
	Minimum	0.0600	<0.000005	0.000170	0.00173	0.0000700	<0.000005	0.0727	<0.000002	<0.00001	0.000182	0.000100	0.0310
	5th Percentile	0.0844	-	0.000230	0.00302	0.000104	<0.000005	0.0781	<0.000002	-	0.000319	0.000100	0.0331
	95th Percentile	0.372	-	0.00100	0.0337	0.000553	0.000461	0.266	0.0000180	-	0.00110	0.00110	0.147
	Maximum	0.468	0.0000268	0.00123	0.0412	<0.0006	***0.00116***	0.284	0.0000260	0.000310	0.00120	0.00202	0.186
YT09DD0008	Total n	148	0	148	148	147	146	148	145	115	147	147	148
	n Detected	148	0	148	148	147	146	148	139	21	147	147	148
	% Non-detects	0	-	0	0	0	0	0	4.14	82	0	0	0
	Mean	0.183	-	0.000665	0.0186	0.000467	0.0000343	0.216	0.00000314	-	0.000863	0.000220	0.0896
	SD	0.0873	-	0.000268	0.00934	0.0000875	0.0000753	0.0447	0.00000444	-	0.000174	0.000409	0.0423
	Minimum	0.0267	-	0.000345	0.000990	0.000190	0.00000300	0.0784	<0.000001	<0.000005	0.000376	0.0000330	0.00170
	5th Percentile	0.0780	-	0.000380	0.00492	0.000310	0.00000400	0.125	0.00000100	-	0.000550	0.0000470	0.0361
	95th Percentile	0.308	-	0.00125	0.0379	0.000600	0.000155	0.274	0.0000100	-	0.00115	0.000940	0.167
	Maximum	***0.803***	-	0.00158	0.0473	0.000670	***0.000509***	0.303	***0.0000450***	0.0000370	0.00126	***0.00317***	0.265
(KNO)KV-5	Total n	47	17	48	48	48	48	48	27	40	48	48	48
	n Detected	47	2	43	48	45	32	48	12	3	48	21	48
	% Non-detects	0	88	10	0	6.25	33	0	56	93	0	56	0
	Mean	0.164	-	0.000673	0.0148	0.000425	0.0000371	0.202	0.00000351	-	0.000845	0.000501	0.0694
	SD	0.0654	-	0.000307	0.00620	0.000108	0.0000584	0.0542	0.00000277	-	0.000210	0.000864	0.0277
	Minimum	0.0500	<0.000005	0.000230	0.00240	<0.0002	<0.000005	0.0928	<0.000002	<0.00001	0.000379	0.0000600	0.0220
	5th Percentile	0.0660	-	0.000350	0.00380	0.000237	<0.000005	0.101	<0.000002	-	0.000473	0.0000600	0.0239
	95th Percentile	0.293	-	0.00107	0.0272	0.000574	0.000162	0.272	0.0000110	-	0.00110	0.00185	0.110
	Maximum	0.351	0.00000970	0.00200	0.0337	0.000623	0.000276	0.276	0.0000120	0.000350	0.00130	***0.00480***	0.152

The 95th percentile concentration exceeds the WQG.

The maximum concentration exceeds the WQG.

Notes: mg/L = milligrams per litre; $CaCO_3$ = calcium carbonate; > = greater than;% = percent; - = no data/not applicable; SD = standard deviation; < = less than; WQG = water quality guideline. ***Bold italics*** = the maximum concentration exceeds the 95th percentile concentration by a factor of at least two times.

[a] Stations are listed in order from upstream to downstream based on their location along the South McQuesten River mainstem or, in the case of tributaries (e.g., Cache Creek), where the tributary flows into the main stem.

[b] The minimum concentration was screened against the 5th percentile concentration. Additionally, the 5th percentile concentration was screened to the WQG.

[c] The minimum and maximum concentrations were screened against the 5th and 95th percentile concentrations, respectively. Additionally, the 5th and 95th percentile concentrations were screened to the minimum and maximum WQG, respectively.

[d] For guidelines that are dependent on other water quality parameters (see Table 5.2) median guidelines based on concurrent values were used for screening.

Table 5.1: Summary Statistics and Comparisons to Identify Contaminants of Potential Concern (COPCs) in the South McQuesten River, 2004 to 2020[a]

Station	Summary Statistic	Total Metals											
		Manganese (mg/L)	Mercury (mg/L)	Molybdenum (mg/L)	Nickel (mg/L)	Selenium (mg/L)	Silver (mg/L)	Strontium (mg/L)	Thallium (mg/L)	Tin (mg/L)	Uranium (mg/L)	Vanadium (mg/L)	Zinc (mg/L)
Guidelines [d]		**0.18 to 0.79**	**0.0000260**	**0.0500**	**0.081 to 0.15**	**0.00100**	**0.000250**	**2.50**	**0.000800**	**0.00000800**	**0.00850**	**0.100**	**0.0075 to 0.19**
(EG)W39	Total n	19	15	19	19	19	19	19	16	19	19	19	19
	n Detected	19	3	19	19	19	4	19	4	2	19	5	7
	% Non-detects	0	80	0	0	0	79	0	75	89	0	74	63
	Mean	0.0440	-	0.000399	0.00211	0.000259	-	0.202	0.0000152	-	0.00109	0.00124	0.00658
	SD	0.0742	-	0.0000850	0.00275	0.0000541	-	0.0638	0.0000125	-	0.000378	0.00195	0.00841
	Minimum	0.00796	<0.000005	0.000258	0.000610	0.000210	<0.00001	0.0659	<0.00001	<0.0001	0.000556	<0.0005	<0.003
	5th Percentile	0.00796	-	0.000258	0.000610	0.000210	-	0.0659	<0.00001	-	0.000556	<0.0005	<0.003
	95th Percentile	0.296	-	0.000636	0.0111	0.000433	-	0.288	0.0000570	-	0.00200	0.00800	0.0334
	Maximum	0.296	0.0000310	0.000636	0.0111	0.000433	0.0000870	0.288	0.0000570	0.000200	0.00200	0.00800	0.0334
(KNO)KV-15	Total n	47	24	47	47	45	47	47	26	47	47	47	47
	n Detected	47	5	42	47	42	33	47	11	4	47	19	44
	% Non-detects	0	79	11	0	6.67	30	0	58	91	0	60	6.38
	Mean	0.130	-	0.000589	0.00813	0.000341	0.0000241	0.196	0.00000387	-	0.000783	0.000477	0.0351
	SD	0.0883	-	0.000264	0.00559	0.000123	0.0000334	0.0611	0.00000358	-	0.000206	0.000754	0.0285
	Minimum	0.00712	<0.000005	0.000178	0.000750	0.000168	<0.000005	0.0748	<0.000002	<0.00001	0.000345	0.0000600	0.000500
	5th Percentile	0.0132	-	0.000260	0.00100	0.000178	<0.000005	0.0792	<0.000002	-	0.000401	0.0000600	0.000500
	95th Percentile	0.261	-	0.00100	0.0204	0.000510	0.0000920	0.273	0.0000130	-	0.00102	0.00200	0.0968
	Maximum	0.361	0.0000260	0.00112	0.0213	0.000568	0.000170	0.279	0.0000160	<0.001	0.00110	0.00361	0.115
(EG)W49	Total n	30	25	30	30	28	30	30	25	30	30	30	30
	n Detected	30	2	30	30	28	18	30	4	3	30	6	29
	% Non-detects	0	92	0	0	0	40	0	84	90	0	80	3.33
	Mean	0.165	-	0.000676	0.00878	0.000380	0.0000212	0.215	-	-	0.000879	0.00103	0.0365
	SD	0.0893	-	0.000254	0.00435	0.0000885	0.0000190	0.0575	-	-	0.000157	0.00172	0.0182
	Minimum	0.0172	<0.000005	0.000262	0.00158	0.000190	<0.00001	0.0695	<0.00001	<0.0001	0.000460	<0.0005	<0.003
	5th Percentile	0.0226	-	0.000274	0.00160	0.000190	<0.00001	0.0774	-	-	0.000555	<0.0005	0.00680
	95th Percentile	0.292	-	0.00111	0.0197	0.000480	0.0000570	0.268	-	-	0.00108	0.00380	0.0692
	Maximum	0.347	0.0000250	0.00116	0.0209	0.000480	0.000103	0.280	0.0000650	0.000200	0.00116	***0.00910***	0.0763

The 95th percentile concentration exceeds the WQG.

The maximum concentration exceeds the WQG.

Notes: mg/L = milligrams per litre; $CaCO_3$ = calcium carbonate; > = greater than;% = percent; - = no data/not applicable; SD = standard deviation; < = less than; WQG = water quality guideline. ***Bold italics*** = the maximum concentration exceeds the 95th percentile concentration by a factor of at least two times.

[a] Stations are listed in order from upstream to downstream based on their location along the South McQuesten River mainstem or, in the case of tributaries (e.g., Cache Creek), where the tributary flows into the main stem.

[b] The minimum concentration was screened against the 5th percentile concentration. Additionally, the 5th percentile concentration was screened to the WQG.

[c] The minimum and maximum concentrations were screened against the 5th and 95th percentile concentrations, respectively. Additionally, the 5th and 95th percentile concentrations were screened to the minimum and maximum WQG, respectively.

[d] For guidelines that are dependent on other water quality parameters (see Table 5.2) median guidelines based on concurrent values were used for screening.

Table 5.1: Summary Statistics and Comparisons to Identify Contaminants of Potential Concern (COPCs) in the South McQuesten River, 2004 to 2020[a]

Station	Summary Statistic	Dissolved Metals						
		Aluminum (mg/L)	Cadmium (mg/L)	Calcium (mg/L)	Copper (mg/L)	Iron (mg/L)	Manganese (mg/L)	Zinc (mg/L)
Guidelines [d]		**0.0053 to 0.050**	**0.00018 to 0.00046**	**1,000**	**0.00020 to 0.0073**	**0.350**	**5.5 to 20**	**0.019 to 0.32**
(KNO)KV-72	Total n	33	33	33	33	33	33	33
	n Detected	33	33	33	33	28	33	33
	% Non-detects	0	0	0	0	15	0	0
	Mean	0.208	0.00196	44	0.00454	0.0815	0.551	0.342
	SD	0.802	0.00312	12	0.00814	0.0940	0.812	0.559
	Minimum	0.00700	0.0000110	21	0.000633	<0.01	0.00229	0.00110
	5th Percentile	0.00868	0.0000119	23	0.000850	<0.01	0.00342	0.00141
	95th Percentile	0.443	0.00847	61	0.0108	0.299	2.23	1.61
	Maximum	***4.65***	0.0120	63	***0.0474***	0.377	3.36	2.12
CACHE-04	Total n	14	14	14	14	14	14	14
	n Detected	14	14	14	14	14	14	14
	% Non-detects	0	0	0	0	0	0	0
	Mean	7.03	0.0115	34	0.0605	0.614	3.16	2.40
	SD	4.47	0.00349	12	0.0251	0.467	1.27	0.741
	Minimum	0.0158	0.00716	22	0.00236	0.0200	1.79	1.39
	5th Percentile	0.0158	0.00716	22	0.00236	0.0200	1.79	1.39
	95th Percentile	15	0.0189	60	0.0991	1.61	5.94	4.00
	Maximum	15	0.0189	60	0.0991	1.61	5.94	4.00
(KNO)KV-1	Total n	142	142	142	142	141	142	142
	n Detected	137	140	141	135	138	141	141
	% Non-detects	3.52	1.41	0.704	4.93	2.13	0.704	0.704
	Mean	0.0909	0.000543	56	0.00259	0.0696	0.209	0.0899
	SD	0.0978	0.000268	19	0.00141	0.0751	0.110	0.0461
	Minimum	<0.001	<0.000005	<0.05	0.000170	<0.01	<0.0001	<0.001
	5th Percentile	0.00410	0.000165	31	0.000400	0.0160	0.100	0.0266
	95th Percentile	0.253	0.000966	83	0.00500	0.231	0.424	0.154
	Maximum	0.491	0.00160	140	0.00700	0.440	***0.865***	***0.376***
(KNO)KV-8	Total n	128	128	128	128	127	128	128
	n Detected	112	128	128	117	115	128	128
	% Non-detects	13	0	0	8.59	9.45	0	0
	Mean	0.00911	0.000737	103	0.00120	0.0494	0.105	0.130
	SD	0.0124	0.000420	37	0.00296	0.0419	0.0646	0.0714
	Minimum	0.000710	0.000157	23	0.000140	<0.01	0.00711	0.0237
	5th Percentile	0.00120	0.000277	40	0.000240	<0.01	0.0286	0.0567
	95th Percentile	0.0330	0.00157	154	0.00251	0.123	0.222	0.276
	Maximum	***0.0702***	0.00270	273	***0.0330***	0.227	0.332	0.513
(KNO)KV-2	Total n	55	55	55	55	54	55	55
	n Detected	50	55	55	51	54	55	55
	% Non-detects	9.09	0	0	7.27	0	0	0
	Mean	0.0804	0.000390	55	0.00228	0.0766	0.155	0.0614
	SD	0.0754	0.000223	18	0.00115	0.0739	0.0834	0.0318
	Minimum	0.00360	0.0000354	27	0.000260	0.0100	0.0123	0.00550
	5th Percentile	0.00360	0.0000570	30	0.000530	0.0180	0.0540	0.0160
	95th Percentile	0.194	0.000761	85	0.00420	0.238	0.332	0.117
	Maximum	0.282	0.00114	101	0.00560	0.345	0.458	0.166

The 95th percentile concentration exceeds the WQG.

The maximum concentration exceeds the WQG.

Notes: mg/L = milligrams per litre; $CaCO_3$ = calcium carbonate; > = greater than;% = percent; - = no data/not applicable; SD = standard deviation; < = less than; WQG = water quality guideline. ***Bold italics*** = the maximum concentration exceeds the 95th percentile concentration by a factor of at least two times.

[a] Stations are listed in order from upstream to downstream based on their location along the South McQuesten River mainstem or, in the case of tributaries (e.g., Cache Creek), where the tributary flows into the main stem.

[b] The minimum concentration was screened against the 5th percentile concentration. Additionally, the 5th percentile concentration was screened to the WQG.

[c] The minimum and maximum concentrations were screened against the 5th and 95th percentile concentrations, respectively. Additionally, the 5th and 95th percentile concentrations were screened to the minimum and maximum WQG, respectively.

[d] For guidelines that are dependent on other water quality parameters (see Table 5.2) median guidelines based on concurrent values were used for screening.

Table 5.1: Summary Statistics and Comparisons to Identify Contaminants of Potential Concern (COPCs) in the South McQuesten River, 2004 to 2020[a]

Station	Summary Statistic	Dissolved Metals Aluminum (mg/L)	Cadmium (mg/L)	Calcium (mg/L)	Copper (mg/L)	Iron (mg/L)	Manganese (mg/L)	Zinc (mg/L)
Guidelines [d]		**0.0053 to 0.050**	**0.00018 to 0.00046**	**1,000**	**0.00020 to 0.0073**	**0.350**	**5.5 to 20**	**0.019 to 0.32**
(KNO)KV-3	Total n	47	47	47	47	47	47	47
	n Detected	44	47	47	44	46	47	47
	% Non-detects	6.38	0	0	6.38	2.13	0	0
	Mean	0.0844	0.000376	56	0.00221	0.0678	0.167	0.0584
	SD	0.0736	0.000170	16	0.00115	0.0642	0.0710	0.0283
	Minimum	0.00320	0.0000700	26	0.000390	<0.01	0.0620	0.0160
	5th Percentile	0.00320	0.000145	32	0.000490	0.0130	0.0707	0.0182
	95th Percentile	0.217	0.000709	83	0.00410	0.211	0.286	0.104
	Maximum	0.269	0.000770	85	0.00500	0.245	0.435	0.180
(KNO)KV-9	Total n	63	63	63	63	63	63	63
	n Detected	46	63	63	62	62	63	63
	% Non-detects	27	0	0	1.59	1.59	0	0
	Mean	0.00388	0.000331	79	0.00163	0.0518	0.0602	0.0288
	SD	0.00583	0.000203	22	0.000896	0.0455	0.0680	0.0150
	Minimum	0.000700	0.0000811	25	0.000350	<0.01	0.00915	0.0109
	5th Percentile	0.000700	0.000162	33	0.000790	0.0190	0.0112	0.0140
	95th Percentile	0.0134	0.000560	102	0.00325	0.136	0.224	0.0630
	Maximum	***0.0330***	***0.00123***	111	0.00500	0.245	0.327	0.0776
(KNO)KV-4	Total n	50	50	49	49	49	50	50
	n Detected	48	50	49	48	49	50	50
	% Non-detects	4.00	0	0	2.04	0	0	0
	Mean	0.0645	0.000414	60	0.00217	0.0657	0.141	0.0579
	SD	0.0609	0.000191	19	0.000957	0.0523	0.0844	0.0307
	Minimum	0.00370	0.000128	25	0.000480	0.0190	0.0315	0.0160
	5th Percentile	0.00440	0.000177	30	0.000780	0.0210	0.0517	0.0179
	95th Percentile	0.182	0.000805	86	0.00342	0.185	0.278	0.0965
	Maximum	0.257	0.00111	96	0.00422	0.210	***0.558***	***0.218***
YT09DD0008	Total n	18	18	149	18	18	18	18
	n Detected	18	18	149	18	18	18	18
	% Non-detects	0	0	0	0	0	0	0
	Mean	0.185	0.000409	59	0.00251	0.296	0.108	0.0608
	SD	0.237	0.000236	14	0.00197	0.346	0.0464	0.0322
	Minimum	0.00560	0.000143	24	0.000370	0.0316	0.0597	0.0132
	5th Percentile	0.00560	0.000143	33	0.000370	0.0316	0.0597	0.0132
	95th Percentile	0.921	0.00106	81	0.00643	1.65	0.249	0.130
	Maximum	0.921	0.00106	86	0.00643	1.65	0.249	0.130
(KNO)KV-5	Total n	48	48	48	48	47	48	48
	n Detected	44	48	48	44	46	48	48
	% Non-detects	8.33	0	0	8.33	2.13	0	0
	Mean	0.0778	0.000298	55	0.00208	0.105	0.131	0.0437
	SD	0.0714	0.000128	16	0.000990	0.0939	0.0546	0.0192
	Minimum	0.00350	0.0000900	25	0.000450	<0.01	0.0460	0.0100
	5th Percentile	0.00480	0.000143	29	0.000730	0.0300	0.0490	0.0108
	95th Percentile	0.194	0.000587	79	0.00400	0.276	0.246	0.0790
	Maximum	0.346	0.000590	83	<0.005	0.440	0.285	0.0861

The 95th percentile concentration exceeds the WQG. (grey)
The maximum concentration exceeds the WQG. (yellow)

Notes: mg/L = milligrams per litre; $CaCO_3$ = calcium carbonate; > = greater than;% = percent; - = no data/not applicable; SD = standard deviation; < = less than; WQG = water quality guideline. ***Bold italics*** = the maximum concentration exceeds the 95th percentile concentration by a factor of at least two times.

[a] Stations are listed in order from upstream to downstream based on their location along the South McQuesten River mainstem or, in the case of tributaries (e.g., Cache Creek), where the tributary flows into the main stem.

[b] The minimum concentration was screened against the 5th percentile concentration. Additionally, the 5th percentile concentration was screened to the WQG.

[c] The minimum and maximum concentrations were screened against the 5th and 95th percentile concentrations, respectively. Additionally, the 5th and 95th percentile concentrations were screened to the minimum and maximum WQG, respectively.

[d] For guidelines that are dependent on other water quality parameters (see Table 5.2) median guidelines based on concurrent values were used for screening.

Table 5.1: Summary Statistics and Comparisons to Identify Contaminants of Potential Concern (COPCs) in the South McQuesten River, 2004 to 2020[a]

Station	Summary Statistic	Dissolved Metals						
		Aluminum (mg/L)	Cadmium (mg/L)	Calcium (mg/L)	Copper (mg/L)	Iron (mg/L)	Manganese (mg/L)	Zinc (mg/L)
Guidelines [d]		**0.0053 to 0.050**	**0.00018 to 0.00046**	**1,000**	**0.00020 to 0.0073**	**0.350**	**5.5 to 20**	**0.019 to 0.32**
(EG)W39	Total n	19	19	19	19	19	19	19
	n Detected	19	13	19	19	13	19	9
	% Non-detects	0	32	0	0	32	0	53
	Mean	0.0272	0.0000149	41	0.00108	0.0567	0.0176	0.00146
	SD	0.0448	0.0000133	13	0.000707	0.0746	0.0171	0.000780
	Minimum	0.00190	<0.000005	12	0.000350	<0.01	0.00528	<0.001
	5th Percentile	0.00190	<0.000005	12	0.000350	<0.01	0.00528	<0.001
	95th Percentile	0.146	0.0000560	60	0.00268	0.228	0.0675	0.00380
	Maximum	0.146	0.0000560	60	0.00268	0.228	0.0675	0.00380
(KNO)KV-15	Total n	47	47	47	47	47	47	47
	n Detected	44	46	47	44	47	47	44
	% Non-detects	6.38	2.13	0	6.38	0	0	6.38
	Mean	0.0486	0.000140	49	0.00156	0.122	0.117	0.0253
	SD	0.0460	0.000115	19	0.000858	0.117	0.0969	0.0205
	Minimum	0.00170	<0.000005	15	0.000240	0.0200	0.00586	<0.001
	5th Percentile	0.00250	0.00000890	16	0.000520	0.0290	0.00863	<0.0018
	95th Percentile	0.148	0.000334	79	0.00300	0.300	0.312	0.0651
	Maximum	0.165	0.000517	82	***<0.005***	0.551	0.403	0.0739
(EG)W49	Total n	30	30	30	30	30	30	30
	n Detected	28	30	30	28	30	30	30
	% Non-detects	6.67	0	0	6.67	0	0	0
	Mean	0.0321	0.000128	56	0.00111	0.104	0.141	0.0285
	SD	0.0391	0.0000799	19	0.000685	0.0562	0.0906	0.0208
	Minimum	0.00150	0.00000710	12	0.000200	0.0220	0.00735	0.00110
	5th Percentile	0.00170	0.0000167	15	0.000210	0.0380	0.00800	0.00140
	95th Percentile	0.145	0.000276	75	0.00250	0.232	0.286	0.0714
	Maximum	0.146	0.000305	77	0.00269	0.233	0.317	0.0756

The 95th percentile concentration exceeds the WQG.

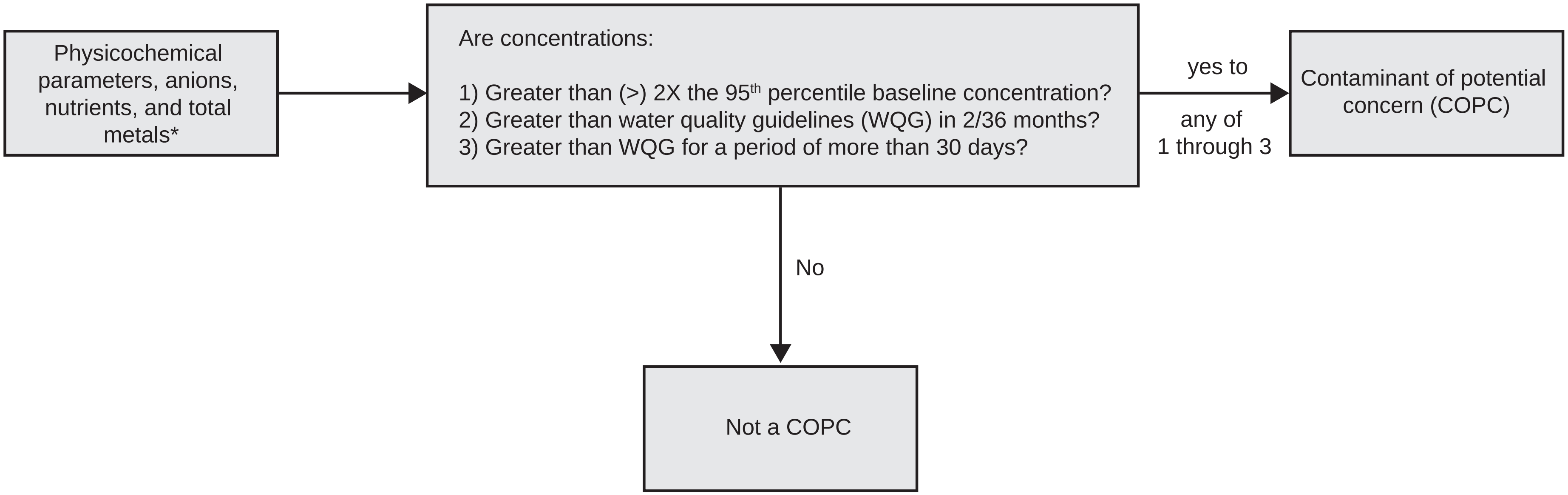
The maximum concentration exceeds the WQG.

Notes: mg/L = milligrams per litre; $CaCO_3$ = calcium carbonate; > = greater than;% = percent; - = no data/not applicable; SD = standard deviation; < = less than; WQG = water quality guideline. ***Bold italics*** = the maximum concentration exceeds the 95th percentile concentration by a factor of at least two times.

[a] Stations are listed in order from upstream to downstream based on their location along the South McQuesten River mainstem or, in the case of tributaries (e.g., Cache Creek), where the tributary flows into the main stem.

[b] The minimum concentration was screened against the 5th percentile concentration. Additionally, the 5th percentile concentration was screened to the WQG.

[c] The minimum and maximum concentrations were screened against the 5th and 95th percentile concentrations, respectively. Additionally, the 5th and 95th percentile concentrations were screened to the minimum and maximum WQG, respectively.



* The dissolved metals dataset was insufficient for COPC identification and Water Quality Objective (WQO) derivation.

Aqueous Contaminants of Potential Concern, South McQuesten River

Date: November 2022
Project 227202.0049

Figure 5.1

Trinity Consultants, Inc\Slater Environmental - 227202.0049 - WQO Engagement and Reporting\D - GIS\Report\Graphics\22-49 Figure 5.1 Aqueous Contaminants of Potential Concern.pdf

- British Columbia Ministry of Environment and Climate Change Strategy (BCMOECCS 2021a,b) working and approved WQG for aquatic life, wildlife, and agriculture;
- BCMOECCS (2020) Source Drinking WQGs;
- Government of Canada (2020) Federal Environmental Quality Guidelines (FEQGs);
- Provincial Water Quality Objectives from the Ontario Ministry of Environment and Energy (1994, with updates); and
- Ministère du Développement durable, de ''Environnement de la Faune et des Parcs (MDDEFP 2013) Critères de qualité de ''eau de surface.

The WQG compiled from these sources were tabulated and reviewed based on the framework set out in The Guide; advice and input received from Government of Yukon and engagement activities were also considered. The Guide includes a hierarchy of sources from which WQG can be selected for use in screening data and identifying candidate COPCs. However, The Guide also allows for consideration of WQG from other sources if they are more relevant (e.g., for a water use that is of particular concern) or up-to-date (e.g., based on more recent toxicity testing). The primary WQG sources identified within the hierarchy include the CCME (1999, with updates) guidelines, the Guidelines for Canadian Recreational Water Quality (Health Canada 2012), and the Guidelines for Canadian Drinking Water Quality (Health Canada 2020). The BCMOECCS (2020, 2021a,b) WQG may be used if a primary source does not have a WQG for a particular parameter of interest, the BCMOECCS WQG was derived using newer information (e.g., more recent toxicity testing), and/or the BCMOECCS WQG is more relevant to specific conditions within the watercourse of interest. Other sources of WQGs (e.g., the FEQGs) may be used if they represent protection goals similar to the primary and secondary WQG sources (e.g., the protection of freshwater aquatic life) and were derived using up-to-date information and methods consistent with CCME protocols. Advice and input received from Government of Yukon and other rightsholders and stakeholders were used to confirm which WQG types are most relevant to the South McQuesten River, based on designated water uses (e.g., drinking water, aquatic life, agriculture, wildlife, irrigation).

5.2 Results

As indicated previously, relatively few data were available prior to 2004 (i.e., stations were not sampled or a number of analytes were not analyzed; see Table 2.2 and Appendix A) and, as a result, summary statistics were calculated using data from 2004 to 2020. Additionally, the use of a data set spanning more than three years was expected to help capture some of the variability in water quality conditions that would have otherwise been accounted for, had five samples over a 30-day period of high variability been collected, as per The Guide. Summary statistics were calculated for all stations, not just the long-term monitoring station (YT09DD0008), to provide a weight-of-evidence for the identification of candidate COPCs (Table 5.1). Specifically, if a parameter was measured at elevated concentrations at multiple stations, it might be considered a higher priority for WQO relative to a COPC that was measured at elevated concentrations at the long-term station only.

Three types of WQG were used to screen the summary statistics and identify parameters requiring further evaluation as part of the COPC identification procedure. These WQG were selected based on relevant water uses for the South McQuesten River, and included the following:

- WQG for the protection of freshwater aquatic life;
- WQG for the protection of wildlife consumers; and
- WQG for livestock watering, which were used as surrogate WQG for the protection of wildlife consumers in the event that no wildlife WQG were available for the parameter of interest (Table 5.2).

Drinking water and irrigation were not considered relevant water uses for the South McQuesten River; additionally, drinking water and recreational WQG were not, in general, the most conservative (i.e., protective) WQG available. As such, WQG of these types were excluded from the data screening and COPC identification procedure. No water licenses for withdrawal of drinking water exist for the South McQuesten River, consumption of the river water without treatment is not recommended, and drinking WQG are not generally applied to natural waters that are only occasionally used for drinking (e.g., during relatively short periods of hunting or recreational activities; Janin 2020b, pers. comm.). For example, the Health Canada (2020) WQG for antimony in drinking water is based on a Tolerable Daily Intake concentration and consideration of the fact that antimony can be leached from plumbing. Similar to the case for drinking water, there are no known water licenses for irrigation along the South McQuesten River, nor are there any agricultural projects registered with the YESAB (Bouvier 2020, pers. comm.). Livestock production in the area is limited to a single grazing agreement. Therefore, WQG for livestock watering were retained in the screening specifically to act as surrogates for wildlife WQG, given that few wildlife-specific guidelines were available. This approach for wildlife is considered conservative because the WQG assumes all of the water used by the consumer comes from the same source (i.e., the South McQuesten River only).

Some total metals measured at the long-term monitoring station (YT09DD0008) on the South McQuesten River main stem had maximum concentrations that exceeded the 95th percentile baseline concentration by a factor of two or more in any given sample. These included total arsenic, chromium, iron, lead, manganese, silver, thallium, and vanadium (Table 5.1). Following the recommendations in The Guide, these parameters were carried forward as

Table 5.2: Water Quality Guidelines Used to Identify Contaminants of Potential Concern (COPCs) for the South McQuesten River

Parameter	Selected Guideline	Source/ Type	Rationale/ Notes
Physicochemical Parameters			
Dissolved Oxygen	9.5 mg/L	CCME guideline for freshwater aquatic life	Most conservative CCME guideline for early life stages of cold water biota
pH	6.5 to 9.0	Long-term chronic CCME guideline for freshwater aquatic life	-
Total Dissolved Solids	1,000 mg/L	Working BC WQG for livestock [a]	Lowest CCME guideline is for irrigation; however, irrigation has not been identified as a relevant water use for the South McQuesten River No freshwater aquatic life guidelines
Anions and Nutrients			
Alkalinity (total as $CaCO_3$)	<10 mg/L (waterbody is highly sensitive to acid inputs [i.e., <4 mg/L dissolved calcium]) 10 to 20 mg/L (waterbody is moderately sensitive to acid inputs [i.e., 4 to 8 mg/L dissolved calcium]) >20 mg/L (waterbody has low sensitivity to acid inputs [i.e., >8 mg/L dissolved calcium])	Working BC WQG for freshwater aquatic life	No CCME guideline available
Un-ionized Ammonia, as N [b]	19 µg/L	Long-term chronic CCME guideline for freshwater aquatic life	No other guidelines identified
Chloride	120 mg/L	Long-term chronic CCME guideline for freshwater aquatic life	Lowest CCME guideline is for irrigation; however, irrigation has not been identified as a relevant water use for the South McQuesten River
Fluoride	120 µg/L	Long-term chronic CCME guideline for freshwater aquatic life	-
Nitrate (as N) [c]	3.0 mg/L	Long-term chronic CCME guideline for freshwater aquatic life	-
Nitrite (as N) [c]	0.02 mg/L (chloride <2 mg/L) 0.04 mg/L (chloride 2 to 4 mg/L) 0.06 mg/L (chloride 4 to 6 mg/L) 0.08 mg/L (chloride 6 to 8 mg/L) 0.10 mg/L (chloride 8 to 10 mg/L) 0.20 mg/L (chloride >10 mg/L)	Approved long-term chronic BC WQG for freshwater aquatic life	Newer (2001) than the CCME (1987) guideline and more stringent
Dissolved Sulphate	128 mg/L (hardness 0 to 30 mg/L) 31 to 75 = 218 mg/L (hardness 31 to 75 mg/L) 76 to 180 = 309 mg/L (hardness 76 to 180 to 30 mg/L) 181 to 250 = 429 mg/L (hardness 181 to 250 mg/L) Determine on site-specific basis (hardness >250 mg/L)	Approved long-term chronic BC WQG for freshwater aquatic life	Newer (2013 versus 1987) and more stringent than the only CCME guideline available (1,000 mg/L livestock guideline) [a]
Cyanide			
Total Cyanide	5 µg/L	Long-term chronic CCME guideline for freshwater aquatic life	Lowest CCME guideline is equivalent to lowest approved BC WQG
Total Metals			
Aluminum	5 µg/L (pH <6.5) 100 µg/L (pH ≥6.5)	Long-term chronic CCME guideline for freshwater aquatic life	-
Arsenic	5 µg/L	Long-term chronic CCME guideline for freshwater aquatic life	-
Barium	1 mg/L	Working BC WQG for freshwater aquatic life	No CCME guideline available
Beryllium	0.13 µg/L	Working BC WQG for freshwater aquatic life	More stringent than the lowest CCME guidelines (100 µg/L for livestock) [a] No CCME freshwater aquatic life guidelines
Boron	1,500 µg/L	Long-term chronic CCME guideline for freshwater aquatic life	Lowest CCME guideline is for irrigation; however, irrigation has not been identified as a relevant water use for the South McQuesten River
Cadmium	0.04 µg/L (hardness <17 mg/L) EQG (µg/L) = 10(0.83(log[hardness]) – 2.46) (hardness ≥17 to ≤280 mg/L) 0.37 µg/L (hardness >280 mg/L)	Long-term chronic CCME guideline for freshwater aquatic life	-
Calcium	1,000 mg/L	CCME guideline for livestock [a]	No other guidelines identified
Chromium (VI) [d]	1 µg/L	Long-term chronic CCME guideline for freshwater aquatic life	-
Cobalt	1 µg/L	Freshwater FEQG	Newer (2017) and more stringent than the lowest CCME guideline (1987; 50 µg/L for irrigation, which is not a relevant water use for the South McQuesten River) and the lowest approved long-term chronic BC WQG for freshwater aquatic life (2004; 4 µg/L) Derivation followed CCME protocols No CCME freshwater aquatic life guidelines The MAC (BC WQG) for drinking water is equivalent (1 µg/L) but was adopted from US EPA screening levels and therefore may not be applicable to the South McQuesten River
Copper	2 µg/L (hardness <82 mg/L or unknown hardness) EQG (µg/L) = 0.2 * $e^{(0.8545[\ln(hardness)]-1.465)}$ (hardness ≥82 to ≤180 mg/L) 4 µg/L (hardness >180 mg/L)	Long-term chronic CCME guideline for freshwater aquatic life	-

Notes: mg/L = milligrams per litre; CCME = Canadian Council of Ministers of the Environment; - = no data/not applicable; BC WQG = British Columbia Water Quality Guideline; $CaCO_3$ = calcium carbonate; < = less than; > = greater than; µg/L = micrograms per litre; % = percent; ≥ = greater than or equal to; EQG = Environmental Quality Guideline; FEQG = Federal Environmental Quality Guideline; MAC = Maximum Allowable Concentration; US EPA = United States Environmental Protection Agency;≤ = less than or equal to; BC BLM = British Columbia Biotic Ligand Model; DOC = dissolved organic carbon.

[a] WQG for livestock watering were used as surrogate WQG for wildlife, given that few wildlife-specific WQG were available.

[b] The WQG for un-ionized ammonia was used because this fraction is the main driver of ammonia toxicity in freshwater (CCME 2010).

[c] The WQG for nitrate+nitrite was not included because the individual WQGs for nitrate and nitrite are far more conservative than the lowest combined nitrate+nitrite WQG (i.e., the 100 mg/L WQG for livestock).

[d] The WQG for chromium VI was used because this is the most toxic form of chromium (CCME 1999, with updates).

[e] In Table 5.1, the strontium WQG was used to screen total strontium, rather than dissolved, concentrations because dissolved strontium data were unavailable for the long-term monitoring station (YT09DD0008), which is the primary station of interest.

Table 5.2: Water Quality Guidelines used to Identify Contaminants of Potential Concern (COPCs) for the South McQuesten River

Parameter	Selected Guideline	Source/ Type	Rationale/ Notes
Total Metals			
Iron	300 µg/L	Long-term chronic CCME guideline for freshwater aquatic life	-
Lead	1 µg/L (hardness ≤ 60 mg/L or unknown hardness) EQG (µg/L)= $e^{\{1.273[\ln(\text{hardness})]-4.705\}}$ (hardness >60 to ≤ 180 mg/L) 7 µg/L (hardness >180 mg/L)	Long-term chronic CCME guideline for freshwater aquatic life	-
Manganese	EQG is determined using the CCME calculator	Long-term chronic CCME guideline for freshwater aquatic life	-
Mercury	0.026 µg/L	Long-term chronic CCME guideline for freshwater aquatic life	-
Molybdenum	50 µg/L	Approved short-term acute BC WQG for wildlife	Lowest CCME guideline is for irrigation; however, irrigation has not been identified as a relevant water use for the South McQuesten River Lowest CCME guideline for freshwater aquatic life is 73 µg/L
Nickel	25 µg/L (hardness ≤60 mg/L or unknown hardness) EQG (µg/L) = $e^{\{0.76[\ln(\text{hardness})]+1.06\}}$ (hardness >60 to ≤180 mg/L) 150 µg/L (hardness >180 mg/L)	Long-term chronic CCME guideline for freshwater aquatic life	-
Selenium	1 µg/L	Long-term chronic CCME guideline for freshwater aquatic life	-
Silver	0.25 µg/L	Long-term chronic CCME guideline for freshwater aquatic life	Higher than the lowest approved BC WQG (0.5 µg/L for the protection of aquatic life) but is newer (2015 versus 1996) and based on 33 years of research using standard protocols
Strontium [e]	2.5 mg/L	Freshwater FEQG	The freshwater FEQG is for dissolved strontium, but can be applied to total concentrations if dissolved strontium data are unavailable
Thallium	0.8 µg/L	Long-term chronic CCME guideline for freshwater aquatic life	-
Tin	0.008 µg/L	Working BC WQG for freshwater aquatic life	No CCME guideline available
Uranium	8.5 µg/L	Working BC WQG for freshwater aquatic life	Lower than the CCME guidelines for freshwater aquatic life and livestock [a] Is based on the CCME guideline for freshwater aquatic life, but has an assessment factor applied due to the limited data available in deriving the CCME guideline (secondary data sources only)
Vanadium	100 µg/L	CCME guideline for livestock [a]	No CCME or BC WQG for freshwater aquatic life The freshwater FEQG is 120 µg/L
Zinc	7.5 µg/L (hardness ≤90 mg/L) WQG (µg/L) = 7.5 + 0.75 (hardness - 90) (hardness 90 to 330 mg/L)	Approved long-term chronic BC WQG for freshwater aquatic life	Lower than the CCME guideline for livestock [a] No CCME freshwater aquatic life guidelines
Dissolved Metals			
Aluminum	0.05 mg/L (pH ≥ 6.5) WQG = $e^{[1.6-3.327(\text{median pH})+0.402(\text{median pH})2]}$ (pH < 6.5)	Approved long-term chronic BC WQG for freshwater aquatic life	No CCME guideline available
Cadmium	WQG = $e^{[0.736 \times \ln(\text{hardness*}) - 4.943]}$ (hardness 3.4 to 285 mg/L)	Approved long-term chronic BC WQG for freshwater aquatic life	No CCME guideline available
Calcium	1,000 mg/L	Working BC WQG for livestock [a]	No other guidelines identified
Copper	Calculated using BC BLM	Approved long-term chronic BC WQG for freshwater aquatic life	No CCME guideline available
Iron	0.35 mg/L	Approved short-term acute BC WQG for freshwater aquatic life	No other guidelines identified
Manganese	EQG (µg/L) = $e^{(0.878[\ln(\text{hardness})] + 4.76)}$	Short-term acute CCME guideline for freshwater aquatic life	No other guidelines identified
Strontium [e]	2.5 mg/L	Freshwater FEQG	No other guidelines identified
Zinc	EQG (µg/L) = $e^{(0.947[\ln(\text{hardness mg}\cdot\text{L-1})] - 0.815[\text{pH}] + 0.398[\ln(\text{DOC mg}\cdot\text{L-1})] + 4.625)}$ (hardness 23.4 to 399 mg/L, pH 6.5 to 8.13, and DOC 0.3 to 22.9 mg/L)	Long-term chronic CCME guideline for freshwater aquatic life	-

Notes: mg/L = milligrams per litre; CCME = Canadian Council of Ministers of the Environment; - = no data/not applicable; BC WQG = British Columbia Water Quality Guideline; CaCC$_3$ = calcium carbonate; < = less than; > = greater than; µg/L = micrograms per litre; % = percent; ≥ = greater than or equal to; EQG = Environmental Quality Guideline; FEQG = Federal Environmental Quality Guideline; MAC = Maximum Allowable Concentration; US EPA = United States Environmental Protection Agency;≤ = less than or equal to; BC BLM = British Columbia Biotic Ligand Model; DOC = dissolved organic carbon.

[a] WQG for livestock watering were used as surrogate WQG for wildlife, given that few wildlife-specific WQG were available.

[b] The WQG for un-ionized ammonia was used because this fraction is the main driver of ammonia toxicity in freshwater (CCME 2010).

[c] The WQG for nitrate+nitrite was not included because the individual WQGs for nitrate and nitrite are far more conservative than the lowest combined nitrate+nitrite WQG (i.e., the 100 mg/L WQG for livestock).

[d] The WQG for chromium VI was used because this is the most toxic form of chromium (CCME 1999, with updates).

[e] In Table 5.1, the strontium WQG was used to screen total strontium, rather than dissolved, concentrations because dissolved strontium data were unavailable for the long-term monitoring station (YT09DD0008), which is the primary station of interest.

candidate COPCs for WQO derivation. This is supported by elevated (i.e., more than two times the 95th percentile concentration) concentrations of these parameters at other stations along the main stem and tributaries (Table 5.1). Examples include total arsenic, chromium, manganese, and silver at (KNO)KV-1 and (KNO)KV-9 (Flat Creek) and total thallium and vanadium at (KNO)KV-1 and (KNO)KV-8.

Ninety-fifth percentile and maximum concentrations for fluoride, cyanide, and total aluminum, cadmium, cobalt, copper, iron, lead, and zinc exceeded relevant WQG, based on the data set for the long-term monitoring station (YT09DD0008; Table 5.1).[18] Maximum concentrations of total arsenic, chromium, manganese, silver and tin at YT09DD0008 also exceeded the relevant WQG. Therefore, fluoride, cyanide, and total aluminum, arsenic, cadmium, chromium, cobalt, copper, iron, lead, manganese, silver, tin, and zinc were evaluated further to identify whether the WQG exceedances occurred in two or more months within a three-year period, or for any period greater than 30 days (Government of Yukon 2021). The parameters that met one or both of these criteria included:

- fluoride (mean concentration exceeded the WQG);
- total aluminum (mean concentration exceeded the WQG);
- total arsenic (WQG exceedances occurred once per annum [May] from 2016 to 2018);
- total cadmium (mean concentration exceeded the WQG);
- total cobalt (mean concentration exceeded the WQG);
- total copper (WQG exceedances lasting more than 30 days occurred multiple times per year);
- total iron (mean concentration exceeded the WQG);
- total lead (WQG exceedances occurred once per annum [May] from 2014 to 2019);
- total silver (WQG exceedances occurred once per annum [May] from 2016 to 2018); and
- total zinc (mean concentration exceeded the WQG).

These parameters, in addition to total chromium, manganese, thallium, and vanadium, are therefore considered candidate COPCs for WQO derivation. Despite being identified as candidate COPCs based on measured concentrations greater than two times the 95th percentile concentration, total chromium and manganese did not meet the criteria for inclusion based on WQG exceedances. Only two WQG exceedances were identified for total chromium: one in

[18] Ninety-fifth percentile and maximum concentrations for dissolved aluminum, cadmium, copper, iron, and zinc also exceeded relevant WQG. However, because the dissolved metals data for the long-term monitoring station failed to meet the minimum requirements of The Guide (i.e., a minimum of three consecutive years of recent, continuous monthly monitoring data with more frequent sampling during periods of naturally high variability in water quality conditions), total metals were retained as the focus of the COPC selection procedure.

May 2017 and another in May 2019, and only one sample from June 2017 had a total manganese concentration in excess of the WQG (Appendix A). However, total chromium and manganese were still carried forward as COPCs based on concentrations that exceeded the 95th percentile baseline concentration by a factor of two or more in any given sample.

Cyanide was ruled out as a candidate COPC for inclusion in WQO derivation (Section 6) because the WQG exceedance identified in Table 5.1 is attributed to a single outlier (2.00 mg/L; see also Appendix Figure A.24) and only one year of data were available at the long-term station. Total cyanide was measured at few other stations; however, the decision to exclude total cyanide is supported by data for (EG)W39 (Haggart Creek) and (EG)W49, where total cyanide concentrations were consistently less than the LRL (Table 5.1).

Total tin was also excluded from subsequent WQO derivation steps, despite being initially identified as exceeding the WQG for periods lasting more than 30 days and at multiple times per year (Table 5.1). It was excluded because the LRLs for total tin were frequently greater than the relevant WQG (Appendix Figure A.85) and the estimated number of samples with concentrations exceeding the WQG was therefore biased high. Additionally, the number of samples with non-detect values (i.e., 82% of the total tin data set for the long-term monitoring station; Table 5.1) was sufficiently high (i.e., higher than 75%; see Section 6.1) that a 95th percentile concentration could not be reliably estimated.

6 CALCULATION OF NUMERICAL WATER QUALITY OBJECTIVES

6.1 Methods

Depending on seasonal cycles or other patterns in flow and water quality, it may be possible to derive a single WQO for each COPC, which would then be applied year-round, or it may be necessary to derive WQO that are applicable at different times of the year or only under certain conditions (Government of Yukon 2021a). For example, due to the relationship between suspended sediments and adsorbed metals, total metal concentrations tend to more variable over a range of clear versus turbid-flow conditions than corresponding dissolved concentrations. Clear-flow conditions refer to periods when suspended sediment concentrations are relatively low based on an assessment of background concentrations at the location of interest. Turbid-flow conditions represent temporary periods of elevated suspended sediment concentrations (e.g., during freshet or high-rainfall events) and adsorbed metals. In the case of total metals, it may be reasonable to derive WQO for clear-flow conditions or particular seasons only (e.g., outside of spring freshet). Derivation of WQO for the dissolved, rather than total, fraction may also be warranted, if the dissolved metals data set is of good quality and meets the requirements of The Guide.

Due to insufficient dissolved metals data for YT09DD0008 and the subsequent need to use total metals data for WQO derivation[19], the study team was required to evaluate whether the WQO would be applicable at different times of the year or only under certain conditions. Turbidity and TSS/non-filterable residue data for the long-term monitoring station were evaluated to identify samples representative of distinct “populations” of data (i.e., samples collected during clear versus turbid-flow periods). The temporal coverage of each data type was considered (e.g., was field turbidity consistently reported for samples collected from this location and is it a parameter that is or will be routinely reported in the future?) along with potential relationships between different measurement types (e.g., is turbidity correlated with non-filterable residue?). Potential relationships between COPC concentrations and indicators of clear versus turbid-flow conditions were also examined by correlation analysis. Significant correlations were assessed at an $\alpha = 0.05$ and the statistical analyses were completed in R (R Core Team 2021). Because flow data were not recorded at the long-term monitoring station, flow could not be factored into the evaluation.

[19] Government of Yukon began monitoring dissolved metal concentrations at YT09DD0008 following submission of the interim report for this study (Janin 2021a, pers. comm.; Slater and Minnow 2021).

Water quality objectives were derived for the COPCs identified in Section 5, specifically fluoride and total aluminum, arsenic, cadmium, chromium, cobalt, copper, iron, lead, manganese, silver, thallium, vanadium, and zinc. Because the non-degradation water management approach was selected for the long-term monitoring station on the South McQuesten River (Section 3), all preliminary WQO were calculated using the background concentration procedure and data collected from YT09DD0008 between 2005 and 2020. The 95th percentile concentration and the one-tailed 95% upper confidence limit of the mean (UCLM) were used to represent the preliminary maximum and average WQO, respectively, for each COPC (Government of Yukon 2021a). Calculations were completed using methods consistent with The Guide; however, because the data for most COPCs (i.e., except fluoride) were log-normally distributed, the measure of central tendency was calculated as the geometric, rather than arithmetic mean. All statistical analyses were completed in R (R Core Team 2021). As part of the WQO finalization process, the resulting preliminary WQO were compared to the WQG that were originally compiled, tabulated, and used to identify COPCs (Section 5). Comparisons focused on the WQG associated with the most sensitive water use for each COPC. Additionally, WQO derived as part of this study were compared to previously-derived WQO for the South McQuesten River. These were compiled from readily-available government reports and water use licenses.

6.2 Results

The data set for the long-term monitoring station (YT09DD0008) on the South McQuesten River was split into two “populations” of data (i.e., samples representing clear-flow versus turbid-flow conditions) based on laboratory measurements of turbidity. Laboratory measurements of turbidity in individual samples were used for the following reasons:

- laboratory turbidity data for the long-term station were available over the period of record and results continue to be reported for individual samples (Appendix Figure A.11);
- no field-measured turbidity data were available in the 2005 to 2020 data set for the long-term monitoring station (Appendix Figure A.10);
- TSS/non-filterable residue data were only reported from 2016 onward (Appendix Figure A.8);
- the paired laboratory turbidity and non-filterable residue results for samples collected after 2016 have a nearly 1:1 linear relationship, which suggests lab turbidity is suitable indicator of the suspended particle load in South McQuesten River water (Figure 6.1); and
- concentrations of most COPCs were at least weakly significantly correlated with the laboratory turbidity results and a number of strong correlations (i.e., for total aluminum, arsenic, chromium, iron, lead, silver, thallium, and vanadium) were identified (Table 6.1).

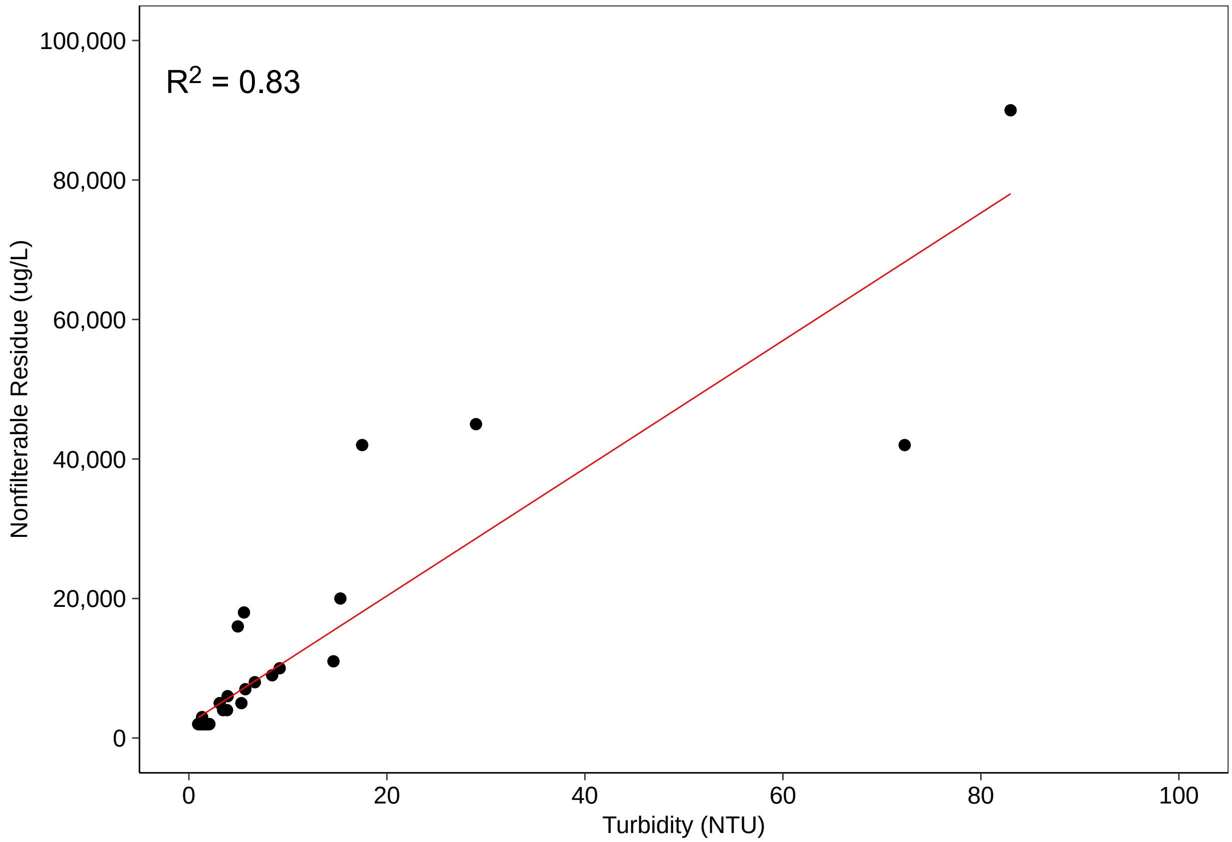


Figure 6.1: Non-filterable Residue and Turbidity Correlation at Station YT09DD0008 on the South McQuesten River Main Stem

Notes: Concentrations less than the laboratory reporting limit (LRL) were replaced with the LRL. The linear relationship was quantified using a Pearson correlation test (r = 0.91; p-value <0.001). Red line represents the line of best fit from a linear model.

Table 6.1: Pearson's Correlation Results for Concentrations of Contaminants of Potential Concern (COPCs) and Turbidity, Station YT09DD0008 on the South McQuesten River, 2005 to 2020

Parameter	Turbidity	
	P-value	R-value
Fluoride	0.235	-0.104
Total Aluminum	<0.001	0.701
Total Arsenic	<0.001	0.642
Total Cadmium	<0.001	0.361
Total Chromium	<0.001	0.964
Total Cobalt	0.005	0.247
Total Copper	<0.001	0.597
Total Iron	<0.001	0.948
Total Lead	<0.001	0.648
Total Manganese	<0.001	0.319
Total Silver	<0.001	0.707
Total Thallium	<0.001	0.885
Total Vanadium	<0.001	0.970
Total Zinc	0.001	0.283

P-value <0.05.

Strong Correlation (-0.6 < r < 0.6).

Notes: < = less than.

The delineation of clear versus turbid-flow conditions using a measurement that will continue to be reported over the long-term will be important for evaluating attainment (Section 8). As new water chemistry samples are collected from the long-term monitoring station on the South McQuesten River, it will be necessary to confirm whether they represent clear-flow versus turbid-flow conditions. Comparisons to the WQO and confirmation of attainment can only be completed for samples representing clear-flow conditions (see Section 8).

Based on a visual examination of the plot for lab turbidity, the 75th percentile concentration (i.e., 3.87 Nephelometric Turbidity Units [NTU], rounded to 4 NTU, for simplicity) was selected as the cutoff for clear-flow versus turbid-flow conditions (Figure 6.2). As a comparison, the CCME guideline for turbidity is a maximum average increase of 2 NTU relative to background levels for a long-term exposure (i.e., a 30-day period) under clear-flow conditions (CCME 2002). Because most of the turbidity results recorded between 2005 and 2020 were between 1 and 2 NTU, a maximum average increase of 2 NTU above background levels would result in measurements between 3 and 4 NTU.

The 95th percentile concentration and the one-tailed 95% UCLM were adopted as the 'preliminary maximum WQO' and 'preliminary average WQO', respectively, for each COPC (Table 6.2); again, the preliminary WQO are applicable to samples collected during clear-flow conditions only.[20] A visual examination of the data plots (Figure 6.3) for individual COPCs indicated that the 95th percentile statistic represented a good measure of the upper range of baseline water quality.

The preliminary maximum WQO derived for total arsenic, chromium, silver, thallium, and vanadium were less than the most conservative WQG that were used to screen the data for the long-term monitoring station and identify COPCs (Tables 5.2 and 6.2; Section 5). The results for these parameters make sense, given that concentrations in the baseline data set only rarely exceeded the most conservative WQG (if at all) (Figure 6.3; Tables 5.2 and 6.2) but were occasionally elevated well above (i.e., by a factor of two or more) the 95th percentile concentrations of the baseline data set (Section 5). The preliminary maximum WQO derived for total lead (3.0 micrograms per litre [µg/L]), manganese (304 µg/L), and zinc (144 µg/L; Table 6.2) were within the range of hardness-dependent long-term chronic WQG that were used to identify COPCs (Table 5.2; Section 5). They were also lower than or comparable to each of the short-term/maximum WQG compiled from the sources listed in Section 5.1. For iron, the preliminary maximum WQO (308 µg/L; Table 6.2), was only slightly above its

[20] No WQO were derived for turbid-flow conditions.

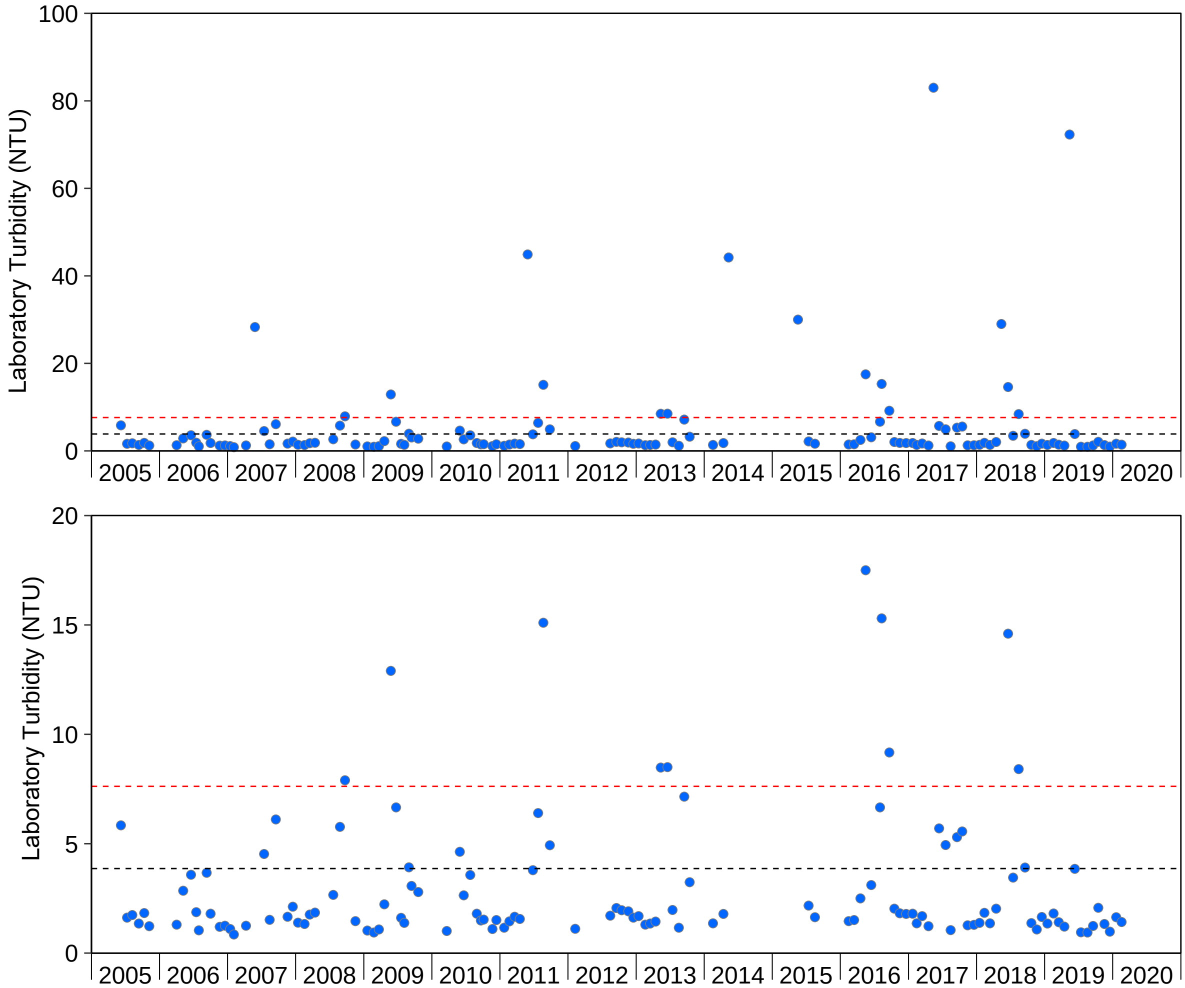


Figure 6.2: Measurements of Laboratory Turbidity Relative to the Mean of the Data Set and the Proposed Cut-off (<4 NTU) for Clear-flow Conditions, Station YT09DD0008, 2005 to 2020

Notes: NTU = Nephelometric Turbidity Units; < = less than. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL. Red line = mean; black line = 4 NTU cut-off for clear versus turbid-flow conditions at the long-term monitoring station on the South McQuesten River.

Table 6.2: Water Quality Objectives Derived for Contaminants of Potential Concern in the South McQuesten River (YT09DD0008, 2005 to 2020) Relative to Water Quality Guidelines

Parameter	Units	Preliminary Water Quality Objectives				Water Quality Guidelines [a]	
		Transformation	MCT [b]	Average WQO (95% UCLM) [c]	Maximum WQO (Upper 95th Percentile) [d]	WQG	WQG Type [e]
Fluoride	µg/L	Untransformed	126	132	180	120	CCME freshwater aquatic life
Total Aluminum	µg/L	Log_{10}	87	107	629	100	CCME freshwater aquatic life
Total Arsenic	µg/L	Log_{10}	1.8	1.8	2.3	5.0	CCME freshwater aquatic life
Total Cadmium	µg/L	Log_{10}	0.47	0.50	0.84	0.13 to 0.37	CCME freshwater aquatic life
Total Chromium	µg/L	Log_{10}	0.057	0.063	0.14	1.0	CCME freshwater aquatic life
Total Cobalt	µg/L	Log_{10}	1.2	1.4	5.0	1.0	Freshwater FEQG
Total Copper	µg/L	Log_{10}	1.9	2.1	6.2	2.0	CCME freshwater aquatic life
Total Iron	µg/L	Log_{10}	224	231	308	300	CCME freshwater aquatic life
Total Lead	µg/L	Log_{10}	1.2	1.3	3.0	2.4 to 7.0	CCME freshwater aquatic life
Total Manganese	µg/L	Log_{10}	162	174	304	180 to 790	CCME freshwater aquatic life
Total Silver	µg/L	Log_{10}	0.011	0.012	0.046	0.25	CCME freshwater aquatic life
Total Thallium	µg/L	Log_{10}	0.0017	0.0018	0.0040	0.80	CCME freshwater aquatic life
Total Vanadium	µg/L	Log_{10}	0.088	0.095	0.19	100	CCME livestock
Total Zinc	µg/L	Log_{10}	75	80	144	7.5 to 190	BC WQG freshwater aquatic life

Preliminary WQO is greater than the most conservative WQG used to identify COPCs and is not recommended as a "final" WQO.
Preliminary WQO is within the range of hardness-dependent WQG used to identify COPCs and is not recommended as a "final" WQO.
Notes: Unhighlighted preliminary WQO are less than the most conservative WQGs that were used to identify COPCs and are recommended as "final" WQO.
MCT = measure of central tendency; UCLM = upper confidence limit of the mean; WQG = Water Quality Guideline; µg/L = micrograms per litre; CCME = Canadian Council of Ministers of the Environment; FEQG = Federal Environmental Quality Guideline; BC WQG = British Columbia Water Quality Guideline; WQO = Water Quality Objective; COPC = Contaminant of Potential Concern; % = percent; BC = British Columbia.

[a] The WQO derived in this study were compared to the most conservative WQG used to identify COPCs in Section 5 of the report.

[b] The MCT was calculated as the mean (untransformed) or geometric mean (log_{10} transformed).

[c] Back-transformed one-tailed 95% UCLM.

[d] Calculated using the Kaplan-Meier method.

[e] The WQG from the CCME (1999, with updates) and BC (BCMOECCS 2021a) are long-term chronic WQG.

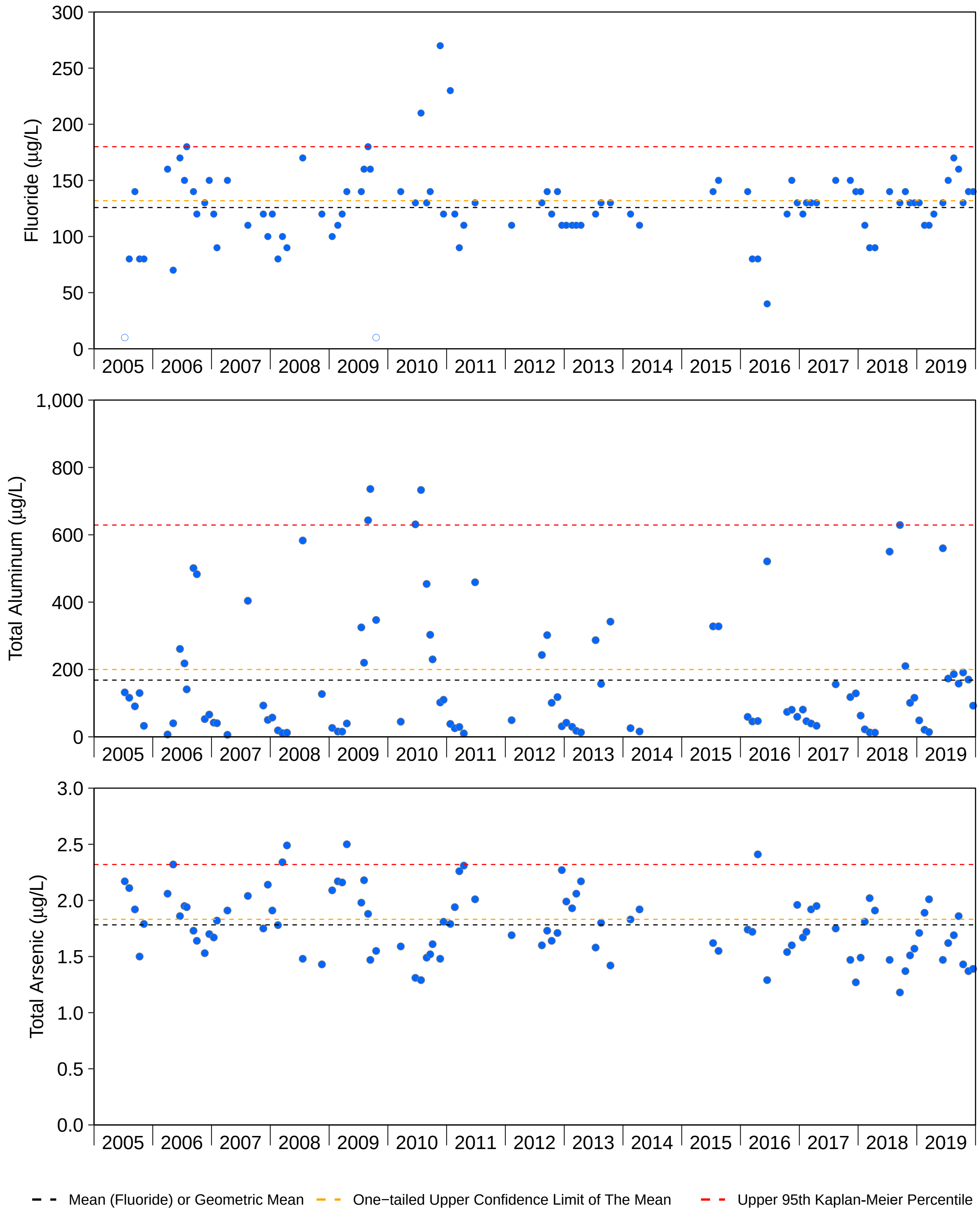


Figure 6.3: Concentrations of Contaminants of Potential Concern Relative to Water Quality Objectives, Station YT09DD0008 on the South McQuesten River

Note: Concentrations less than the laboratory reporting limit (LRL) are plotted as open symbols at the LRL. Only data for clear-flow samples (i.e., laboratory turbidity < 4 Nephelometric Turbidity Units [NTU]) are shown.

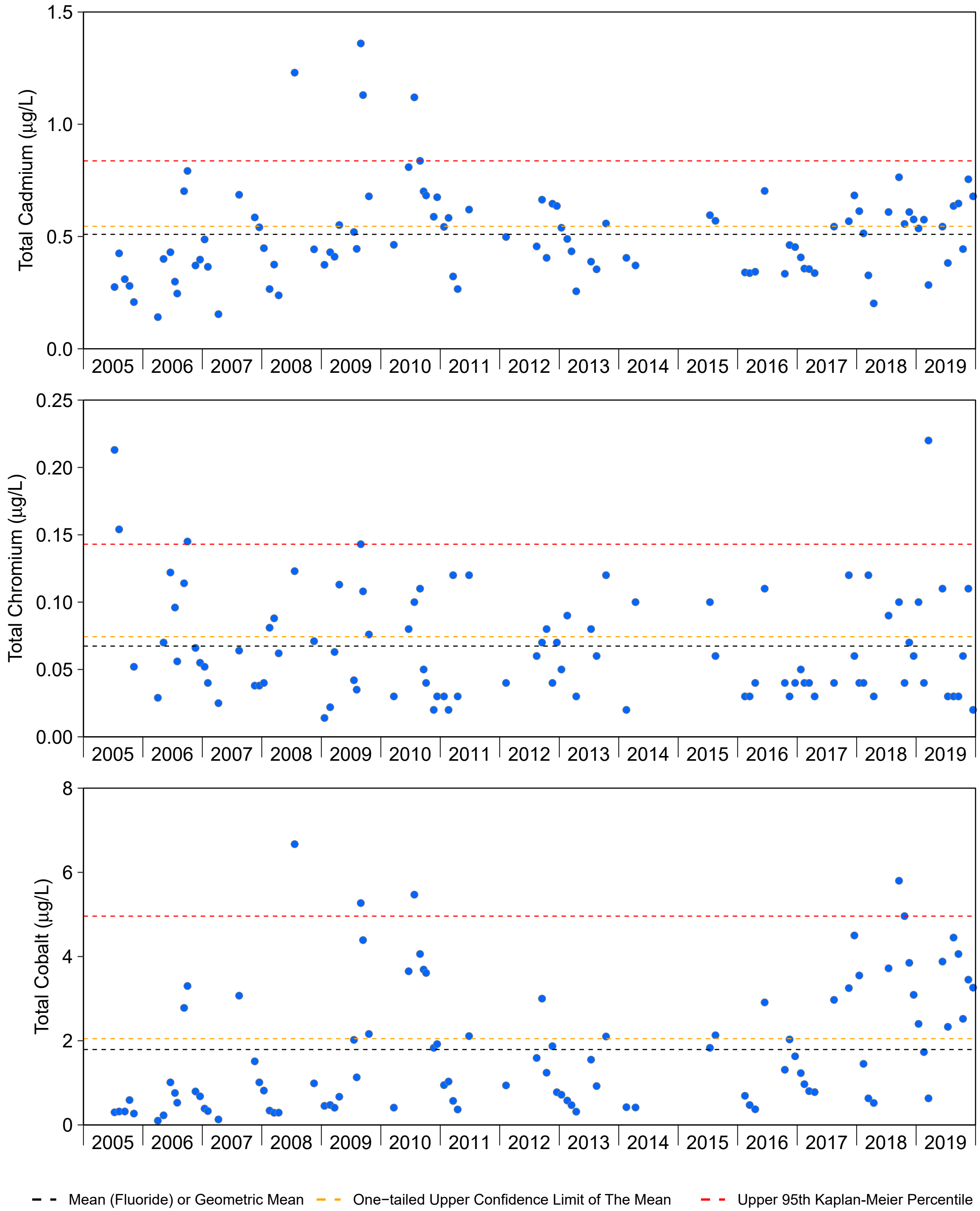


Figure 6.3: Concentrations of Contaminants of Potential Concern Relative to Water Quality Objectives, Station YT09DD0008 on the South McQuesten River

Note: Concentrations less than the laboratory reporting limit (LRL) are plotted as open symbols at the LRL. Only data for clear-flow samples (i.e., laboratory turbidity < 4 Nephelometric Turbidity Units [NTU]) are shown.

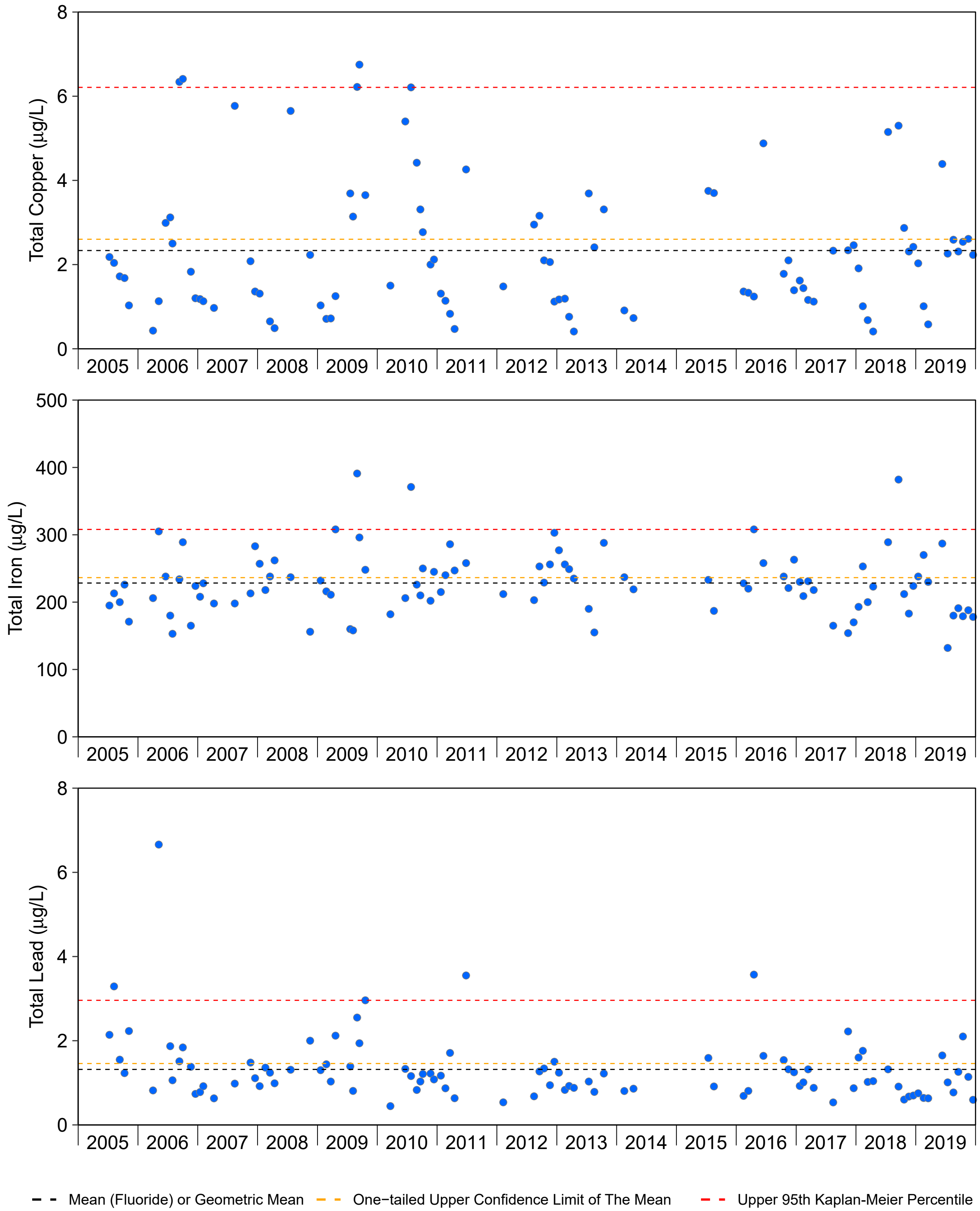


Figure 6.3: Concentrations of Contaminants of Potential Concern Relative to Water Quality Objectives, Station YT09DD0008 on the South McQuesten River

Note: Concentrations less than the laboratory reporting limit (LRL) are plotted as open symbols at the LRL. Only data for clear-flow samples (i.e., laboratory turbidity < 4 Nephelometric Turbidity Units [NTU]) are shown.

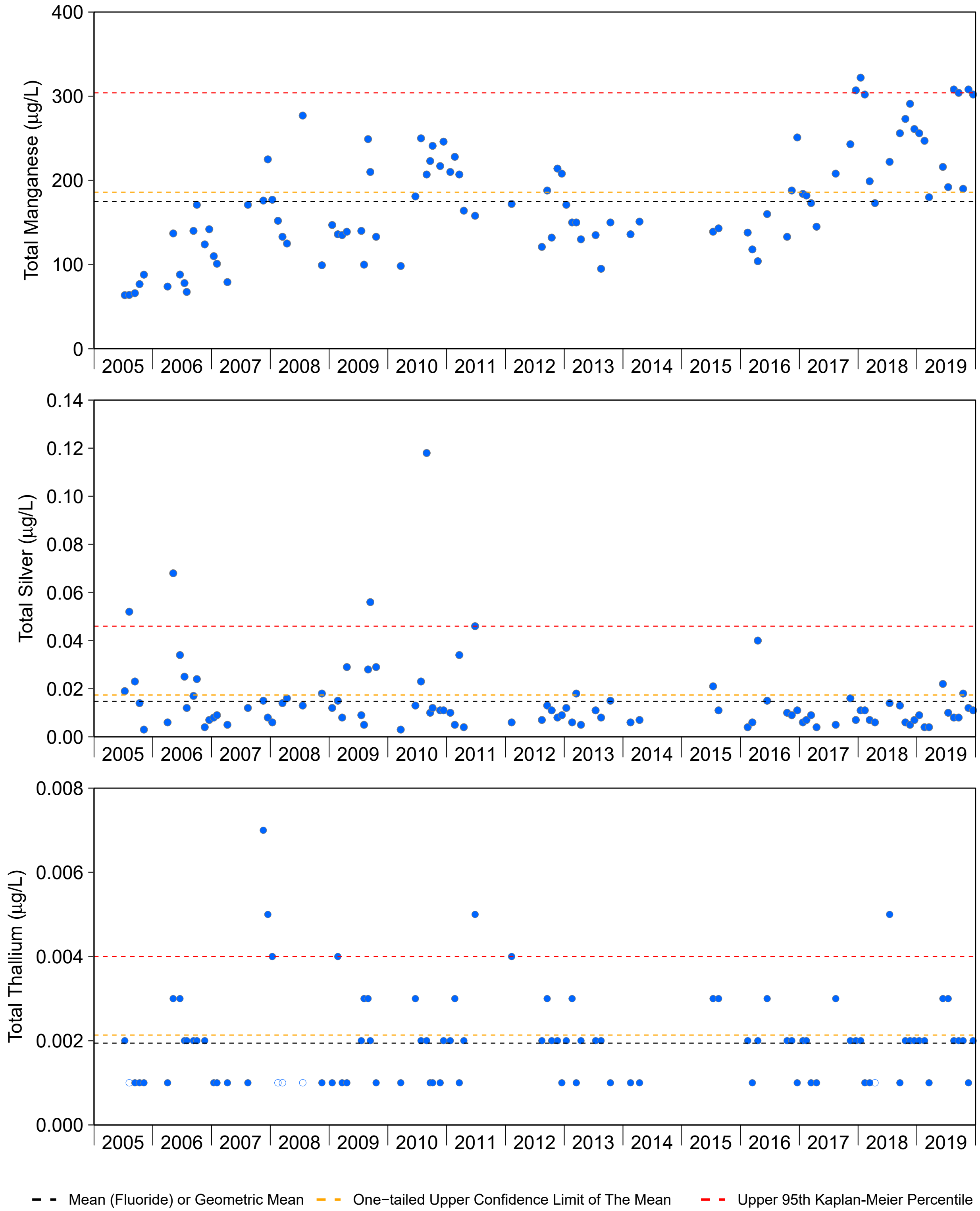


Figure 6.3: Concentrations of Contaminants of Potential Concern Relative to Water Quality Objectives, Station YT09DD0008 on the South McQuesten River

Note: Concentrations less than the laboratory reporting limit (LRL) are plotted as open symbols at the LRL. Only data for clear-flow samples (i.e., laboratory turbidity < 4 Nephelometric Turbidity Units [NTU]) are shown.

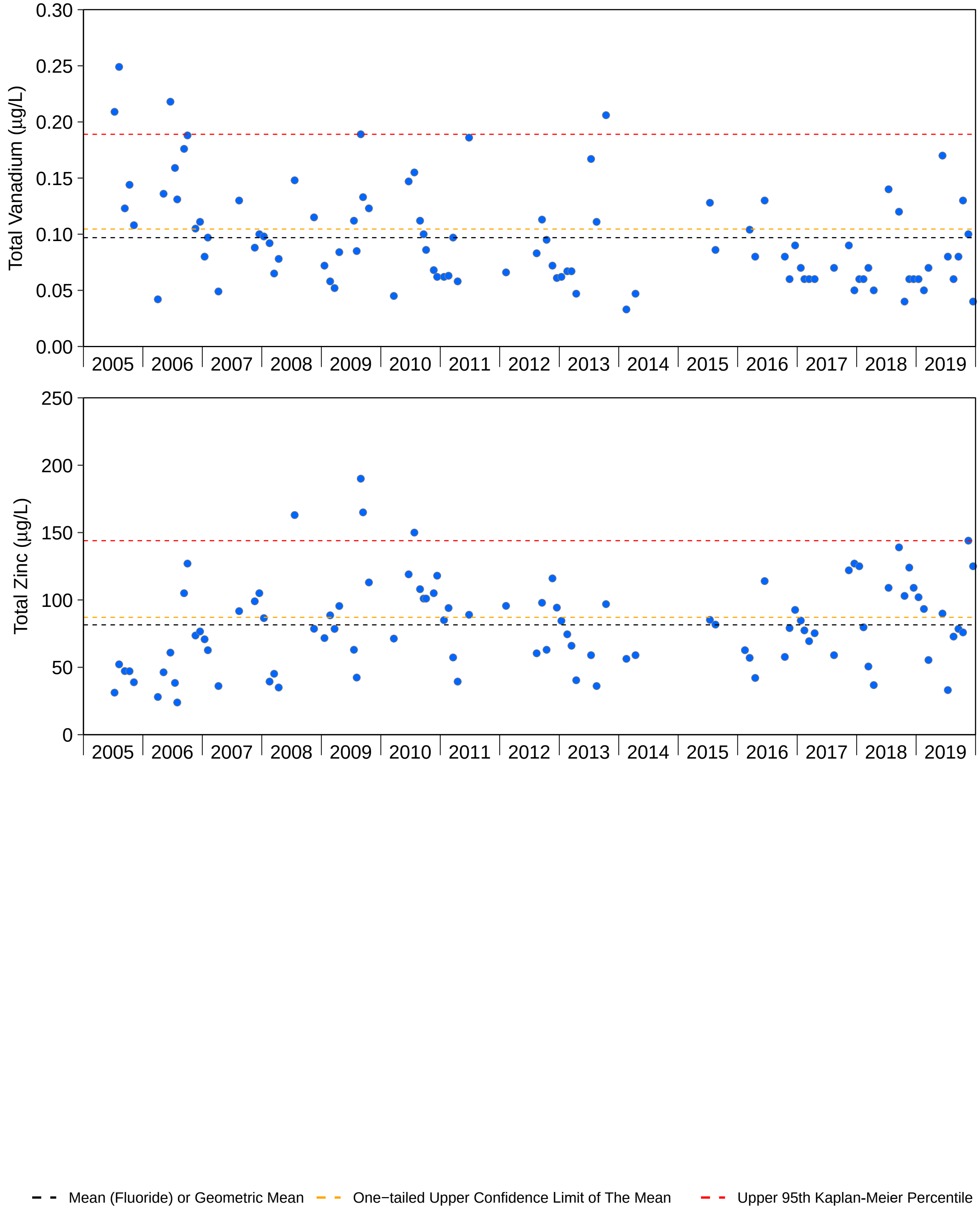


Figure 6.3: Concentrations of Contaminants of Potential Concern Relative to Water Quality Objectives, Station YT09DD0008 on the South McQuesten River

Note: Concentrations less than the laboratory reporting limit (LRL) are plotted as open symbols at the LRL. Only data for clear-flow samples (i.e., laboratory turbidity < 4 Nephelometric Turbidity Units [NTU]) are shown.

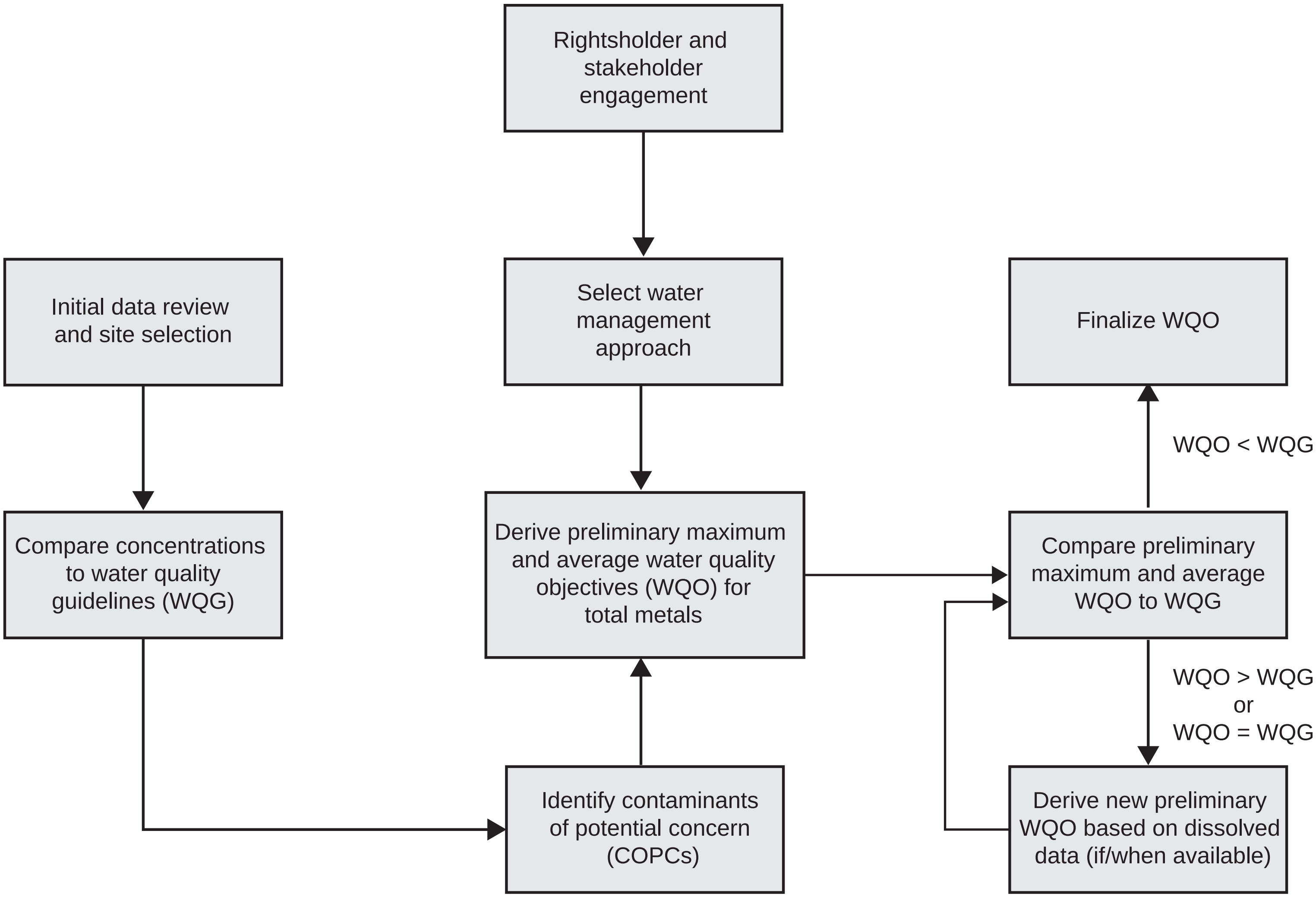
respective long-term chronic CCME guideline for freshwater aquatic life (300 µg/L; Table 5.2; CCME 1999, with updates) and well below the short-term acute WQG (1,000 µg/L) from BCMOECCS (2021a).

The preliminary maximum WQO for fluoride and total aluminum, cadmium, and copper were greater than the long-term chronic CCME freshwater life WQG that were used in the COPC identification steps in Section 5; the preliminary maximum WQO for cobalt was also well above the freshwater FEQG (Tables 5.2 and 6.2). However, the preliminary maximum WQO for fluoride and total aluminum, cadmium, and copper were still lower than the most conservative short-term or acute WQG compiled from the sources listed in Section 5.1. Additionally, despite being greater than the freshwater FEQG, the preliminary maximum WQO for cobalt was lower than the other freshwater aquatic life and wildlife/livestock guidelines compiled during the COPC identification step (Section 5.1).

The preliminary average WQO for most COPCs other than cadmium were lower than or only slightly greater than the most conservative WQG that were used to screen the data and identify COPCs (Tables 5.2 and 6.2; Section 5). Specifically, the preliminary average WQO for total arsenic, chromium, iron, lead, manganese, silver, thallium, and vanadium were lower than the most conservative WQG (Tables 5.2 and 6.2; Section 5). The preliminary average WQO for zinc (80 µg/L; Table 6.2) was within the range of the hardness-dependent long-term British Columbia WQG for the protection of freshwater aquatic life (Table 5.2; BCMOECCS 2021a). For fluoride and copper, the preliminary average WQO (132 and 2.1 µg/L, respectively; Table 6.2), were only slightly above their respective long-term chronic CCME guidelines for freshwater aquatic life (120 and 2 µg/L[21], respectively; Table 5.2; CCME 1999, with updates). The same was also true for aluminum (107 µg/L versus the 100 µg/L long-term chronic WQG for freshwater environments with pH greater than or equal to [≥] 6.5) and cobalt (1.4 µg/L versus the 1 µg/L freshwater FEQG; Tables 5.2 and 6.2; Government of Canada 2020). The preliminary average (0.50 µg/L) WQO for total cadmium was above the range of long-term chronic CCME guidelines (maximum = 0.37 µg/L; CCME 1999, with updates) that were used to identify COPCs (Section 5).

Based on the comparison to relevant WQG, the preliminary average and maximum WQO for total arsenic, chromium, silver, thallium, and vanadium and the preliminary average WQO for iron, lead, and manganese (Table 6.2) are recommended as final WQO (Figure 6.4). The Guide

[21] This is the most conservative long-term chronic CCME guideline for total copper and applies to waters with hardness <82 mg/L or unknown hardness; Table 5.2; CCME 1999, with updates).



Process Diagram for Deriving Water Quality Objectives for YT09DD0008 on the South McQuesten River

Date: November 2022
Project 227202.0049

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Figure 6.4

Trinity Consultants, Inc\Slater Environmental - 227202.0049 - WQO Engagement and Reporting\D - GIS\Report\Graphics\22-49 Figure 6.4 Process Diagram for Deriving Water Quality Objectives.pdf indicates that if preliminary WQO calculated using the background concentration procedure are greater than relevant WQG, the final WQO should be revised such that is it based on the same form of the COPC that will be released by a proposed project (Government of Yukon 2021a). If this logic is applied to the long-term monitoring station on the South McQuesten River, despite the absence of a proposed mining project, then the study team would recommend using dissolved concentration data (once available) to derive WQO for aluminum, cadmium, cobalt, copper, and iron[22] and potentially for lead, manganese, and zinc. This is because the dissolved forms of these metals are the forms most likely to be released by mining operations and are typically more representative of the bioavailable fraction (Adams et al. 2020).

Comparisons to existing WQO for the South McQuesten River main stem were possible for total arsenic, cadmium, copper, lead, silver, and zinc because AKHM previously derived WQO for these parameters at (KNO)KV-2 (Table 6.3). Station (KNO)KV-2 is on the South McQuesten River mainstem between Christal and Flat creeks (i.e., upstream from the long-term station; Figure 1.1; AKHM 2019; Ensero and AKHM 2020). The WQO derived herein were consistently lower than the WQO derived for (KNO)KV-2 (Table 6.3). For total arsenic and silver, this was because the WQO derived for (KNO)KV-2 were set equal to the CCME WQG (see WQG comparisons above). Similarly, the average and maximum WQO derived herein for lead were less than AKHM's average and maximum WQO, respectively, which were set to the BCMOECCS (2021a) WQG (AKHM 2019; Ensero and AKHM 2020). Differences in WQO that were derived using the background concentration procedure (i.e., the WQO for total cadmium, copper, and zinc) are expected to reflect differences in the inputs at the two stations. For example, Flat Creek, which is downstream from (KNO)KV-2, would not have influenced the baseline data set at (KNO)KV-2, but would have an effect on water quality conditions at the long-term monitoring station (YT09DD0008; Figure 1.1).

[22] This applies to the maximum WQO only since the preliminary average WQO met the criteria for a final average WQO (Government of Yukon 2021a).

Table 6.3: Comparison of Water Quality Objectives Derived for Contaminants of Potential Concern in the South McQuesten River

Parameter	Units	This Case Study		AKHM 2019		Ensero and AKHM 2020	
		YT09DD0008		KV-2 [c]			
		Average WQO [a]	Maximum WQO [b]	Average WQO	Maximum WQO	Average WQO	Maximum WQO
Total Arsenic	µg/L	1.8	2.3	CCME		CCME	
Total Cadmium	µg/L	0.50	0.84	0.67	1.0	0.69	0.94
Total Copper	µg/L	2.1	6.2	BCMOECCS		4.9	8.9
Total Lead	µg/L	1.3	3.0	BCMOECCS		BCMOECCS	
Total Silver	µg/L	0.012	0.046	CCME		CCME	
Total Zinc	µg/L	80	144	100	160	115	161

Notes: WQO = water quality objective; AKHM = Alexco Keno Hill Mining Corporation; µg/L = micrograms per litre; CCME = Canadian Council of Ministers of the Environment; BCMOECCS = British Columbia Ministry of Environment and Climate Change Strategy; % = percent; UCLM = upper confidence limit of the mean; WQG = water quality guidelines.

[a] Back-transformed one-tailed 95% UCLM.

[b] The 95th percentile concentration calculated using the Kaplan-Meier method.

[c] The WQO were either set equal to existing WQG from the CCME or BCMOECCS or calculated using methods comparable to the background concentration procedure (AKHM 2019; Ensero and AKHM 2020).

7 VALIDATION

7.1 Overview

As described in The Guide (Government of Yukon 2021a), the numerical WQO "provide precise estimates of the concentrations of COPCs…needed to meet the narrative WQO". Uncertainties arising from data sets (e.g., how well the data represent baseline conditions or bioavailable concentrations of COPCs), and the process for development of numerical WQO have potential to influence the validity of the numerical estimates. To address these uncertainties, The Guide recommends that application of numerical WQO be accompanied by "processes to confirm that the numerical WQO are effective for achieving the defined narrative outcome".

The selection of the non-degradation approach (Section 3.2) for the South McQuesten River leads to the following narrative WQO:

Baseline water quality must be maintained at all times. Any permitted discharges shall be regulated in a manner that prevents degradation of the quality of receiving waters (Government of Yukon 2021a).

In the context of non-degradation, there are two important aspects of validation for numerical WQO:

1. The greatest uncertainty in development of numerical WQO relates to whether the data set used to characterize baseline conditions, including central-tendency and upper-limit conditions, accurately represents the actual water quality conditions in the South McQuesten River. Validation of the numerical WQO needs to address this uncertainty.

2. An underlying assumption for the non-degradation approach is that baseline water quality is protective of the existing uses in the watercourse (i.e., existing uses will not be adversely affected provided that water quality is maintained, as required by the narrative WQO). Validation needs to confirm that the numerical WQO are, in fact, protective of these uses.

The study team reviewed potential approaches for validating the numerical WQO that would address the two key aspects described above. Proposed approaches for validation of the numerical WQO for the South McQuesten River are described below.

7.2 Uncertainties About Baseline Conditions

Although the data set used to establish the numerical WQO for the South McQuesten River was considered acceptable (Section 2), the monitoring results have not likely captured the full range of natural variability in concentrations of COPCs. This may be because the long-term monitoring station did not meet the requirement for more frequent sampling (i.e., five samples over a

30-day period) during known periods of high variability (e.g., freshet; see Section 2). Additional data collection will improve our understanding of water quality conditions and variability. As our South McQuesten River data set and understanding of water quality characteristics improve, it is important to confirm that the statistics used as numerical WQO remain valid.

Validation in this context requires periodic recalculation of numerical WQO statistics using the entire data set for the long-term station (YT09DD0008) on the South McQuesten River, including both the data used to initially calculate the numerical WQO and new data collected during the implementation period. It is recommended that Government of Yukon recalculate the numerical WQO at least once, when three new consecutive years of data that meet the requirements of The Guide are available for use. In addition to recalculation for the identified COPCs, the validation process should also include reconsideration of the list of COPCs. This would involve subjecting the data initially used to calculate the numerical WQO and the new data collected during the implementation period to the same COPC identification steps described in Section 5.1. For periods where attainment analysis (Section 8) confirms that South McQuesten River water quality meets the attainment requirements, validation can be accomplished by direct comparison of updated statistics with the WQO. Update of WQO should be considered if the validation shows meaningful differences in the statistics.

For periods where attainment analysis (Section 8) indicates that the South McQuesten River may not be meeting WQO, validation is more complicated because the attainment analysis results may indicate true non-attainment or may indicate that the South McQuesten River data used to calculate the WQO are not necessarily representative of baseline conditions. In these cases, validation and any need to update numerical WQO should be considered in combination with evaluation of attainment using appropriate statistical methods. Consideration of reference and/or regional data and conditions will provide important context in these circumstances (i.e., to support understanding of whether attainment failures are specific to the South McQuesten River or occurring at a larger scale).

7.3 Uncertainties About Protection of Existing Uses

Methods for validating that non-degradation numerical WQO are, in fact, protective of existing uses in the South McQuesten River should follow the validation methods described in The Guide for use-protection WQO. The scoping phase for development of the South McQuesten River numerical WQO confirmed that the freshwater ecosystem is the most sensitive existing use for the South McQuesten River. For freshwater ecosystem use, surface water toxicity testing is an appropriate tool to validate the underlying assumption that non-degradation WQO are protective of existing uses. If water quality conditions fail to achieve the narrative WQO, despite meeting the numerical WQO, then the WQO would be deemed invalid and should be revisited (Government of Yukon 2021a).

Toxicity testing should be conducted using water from the South McQuesten River and should include appropriate testing for chronic effects on sensitive life stages of species present in the South McQuesten River or representative species. Testing should include at least one species of fish, invertebrate, and algae or vascular plant. For example, the following types of chronic tests should be considered:

- 30-day early-life stage toxicity test with rainbow trout (e.g., Environment Canada 1998);
- 30-day early-life stage toxicity test with fathead minnows (*Pimephales promelas*; e.g., ASTM International 2016a; Environment Canada 2011);
- 28-day to 42-day toxicity test with amphipods (*Hyalella azteca*; e.g., ASTM International 2016b; USEPA 2000);
- 28-day surface water toxicity tests with mussels (*Lampsilis siliquoidea*; e.g., ASTM International 2016c; USEPA 2000);
- 7-day toxicity test with cladocerans (*Ceriodaphnia dubia*; e.g., ASTM International 2016d; Environment Canada 2007a);
- 72-hour toxicity test with algae (*Pseudokirchneriella subcapitata*; e.g., ASTM International 2016e; Environment Canada 2007b); and
- 7-day toxicity test with a freshwater macrophyte (*Lemna minor*; e.g., Environment Canada 2007c).

Validation toxicity testing should be completed as part of the initial implementation/application of the WQO. The acceptability of toxicity testing results (i.e., whether or not the results indicate the narrative WQO is achieved) is open to interpretation; however, acceptability criteria should be established before tests are initiated.

8 ATTAINMENT

8.1 Overview

Because achievement of the narrative WQO relies, in theory, on COPC concentrations at the location of interest achieving their respective numerical WQO, the most direct method of evaluating attainment is by monitoring water quality conditions (Government of Yukon 2021a). This type of water quality monitoring can be completed in conjunction with other studies (e.g., EEM) or through the development and implementation of an Aquatic Effects Monitoring Program (AEMP) (Government of Yukon 2021a). The AEMP can be developed to address other aspects of water quality (e.g., are there any trends in parameter concentrations?) and monitoring related to validation (see Section 7). The frequency of monitoring required to evaluate attainment is an important component of the AEMP (or similar).

The criteria for evaluating attainment of numerical WQO derived using the non-degradation approach (Section 3) and background concentration procedure (Section 5) are clearly laid out in The Guide (Government of Yukon 2021a). The guidance indicates that water chemistry data collected from the long-term station (YT09DD0008) on the South McQuesten River should be compared to the numerical WQO (Table 6.1). However, these comparisons should only be made for samples that were collected during periods of clear-flow (i.e., when laboratory turbidity results are less than 4 NTU; Section 5.2). The threshold or trigger for non-attainment is exceedance of the average or maximum non-degradation WQO. The WQO are exceeded and non-attainment occurs if more than 5% of concentrations in the most recent 20 samples exceed the maximum WQO or if the mean of those 20 samples exceeds the average WQO (Government of Yukon 2021a).

Uncertainty around attainment of WQO is typically addressed through an AMP that is tied to the AEMP (Government of Yukon 2021). An AMP describes actions that will be carried out in response to triggers or non-attainment, as well as the timelines associated with those actions. Because the non-degradation approach to water management was selected for the South McQuesten River (see Section 3), the threshold or trigger for non-attainment is exceedance of the non-degradation WQO. In the event that the threshold for non-compliance or non-attainment is exceeded, a Management Response Plan describing the mitigation and management actions to regain compliance would need to be prepared. Government of Yukon is not proposing to prepare an AMP and Management Response Plan as part of this case study; however, relevant aspects of watershed-wide AMPs were discussed in the August 25, 2022 engagement meeting with rightsholders and stakeholders (Section 4).

8.2 Initial Evaluation of Attainment

Site-specific water chemistry data collected from the South McQuesten River in 2020 and 2021 (i.e., from YT09DD0008) were used to confirm whether the numerical WQO derived for clear-flow conditions at YT09DD0008 attain the narrative objectives. These data were collected after the data set used to derive the WQO was finalized (i.e., after the end of 2019). Unfortunately, there are fewer than 20 samples in the 2020 to 2021 data set because sampling efforts and laboratory submissions/analyses were partially suspended or not completed in full in response to the COVID-19 pandemic (de Jong 2021, pers. comm.). The size of the 2020 to 2021 data set was further reduced through exclusion of samples representing turbid-flow conditions. Specifically, laboratory turbidity results for individual samples were used to identify samples representing clear-flow (i.e., laboratory turbidity <4 NTU) conditions, consistent with WQO derivation (Section 6), and only these samples were included in the evaluation of attainment.

Concentrations of COPCs from 2020 and 2021 were plotted and compared to the maximum numerical WQO (i.e., the 95th percentile baseline concentration; Table 6.1). Data from clear-flow samples used to calculate the WQO were included in the plots to support the evaluation. The frequency of WQO exceedances was then calculated as the number of exceedances in the most recent 20 samples. This step was completed for each COPC. According to The Guide, an exceedance rate of greater than 5% (i.e., two or more samples out of 20) would signal that the maximum WQO was exceeded.

Attainment of the maximum WQO (i.e., the 95th percentile baseline concentration) was achieved for most COPCs measured in the samples collected in 2020 and 2021 (Figure 8.1). However, two of the seven clear-flow samples collected between early 2020 and mid 2021 had concentrations of total manganese that exceeded the maximum WQO.[23] Because these exceedances represent more than 5% of the most recently-collected 20 clear-flow samples, they are considered indicative of non-attainment according to The Guide (see also Section 8.1, above). The two samples with elevated manganese concentrations were collected in early 2020 and may be attributable to the Shanghai Creek Fire that occurred in 2019 and burned along parts of the South McQuesten River (Government of Yukon 2022). This is because forest fires are known to result in elevated manganese concentrations in affected surface waters (HealthLinkBC 2021). Total cadmium and total chromium concentrations in one sample each were greater than the maximum WQO in 2020

[23] Dissolved manganese data were not available for the samples collected in 2020, including the two samples with concentrations greater than the maximum WQO.

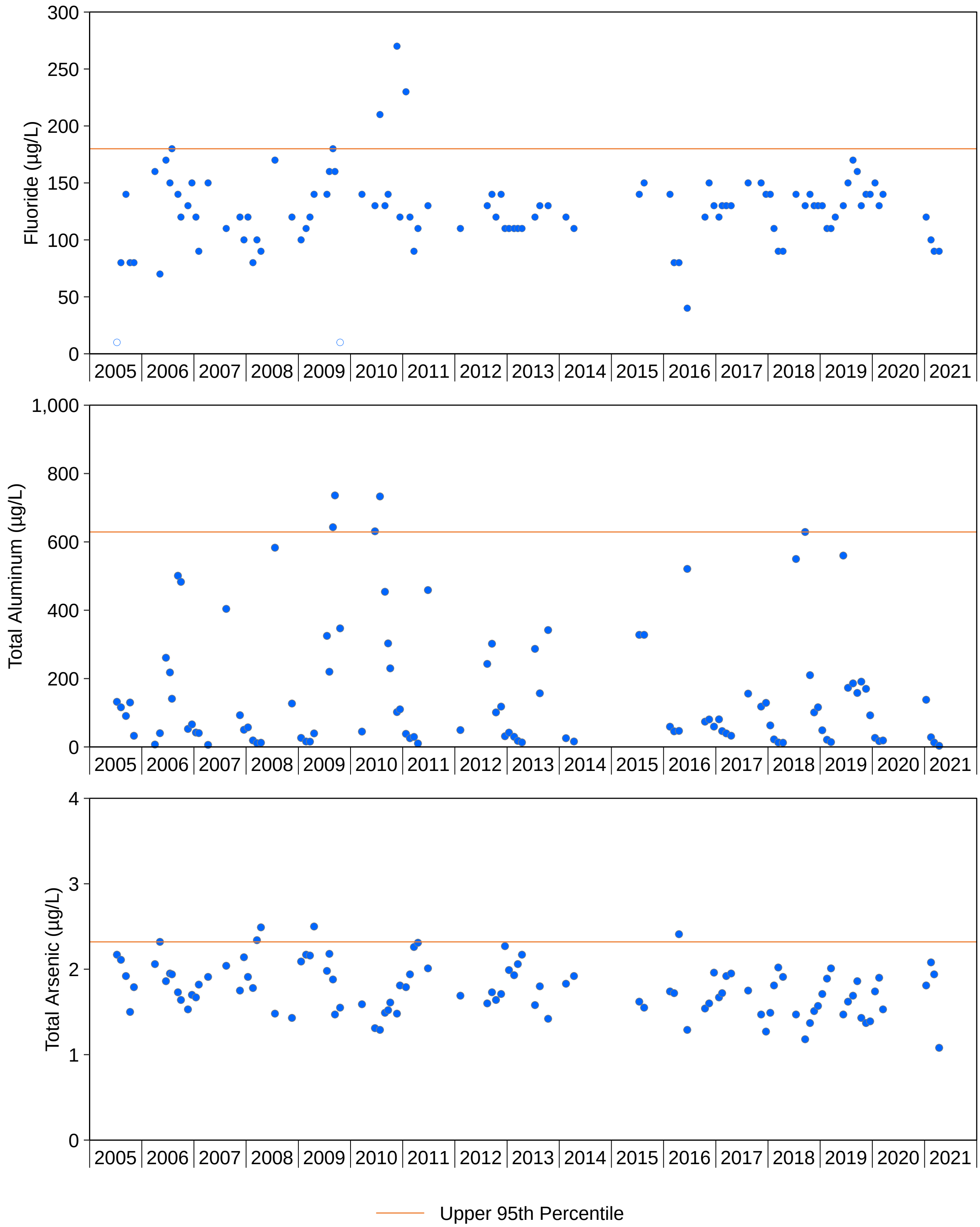
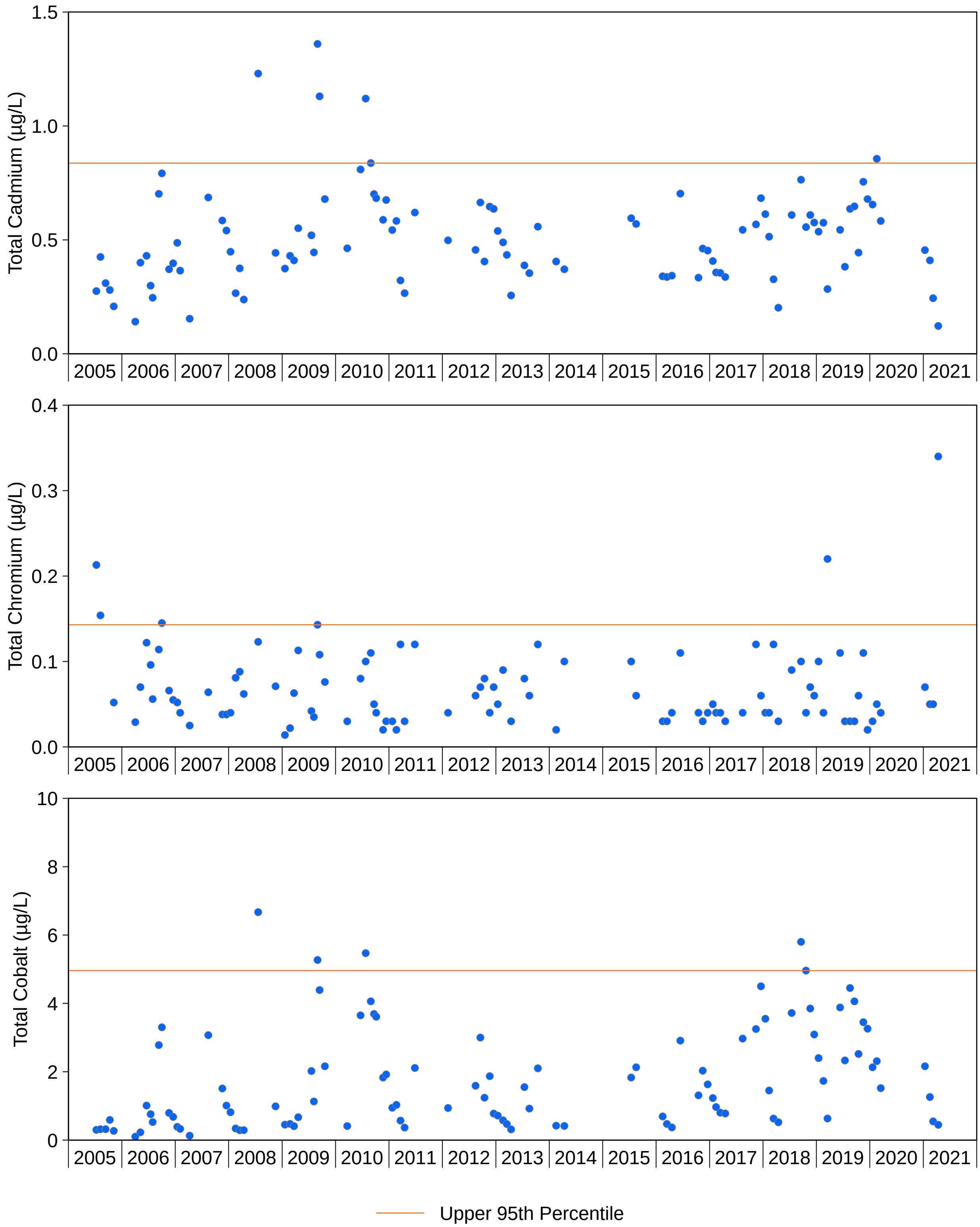


Figure 8.1: Attainment of the Maximum Water Quality Objectives for Concentrations of Contaminants of Potential Concern, Station YT09DD0008 on the South McQuesten River

Notes: Concentrations less than the laboratory reporting limit (LRL) are plotted as open symbols at the LRL. Only data for clear-flow samples (i.e., laboratory turbidity < 4 Nephelometric Turbidity Units [NTU]) are shown. Concentrations above the red lines are considered "non-compliant".



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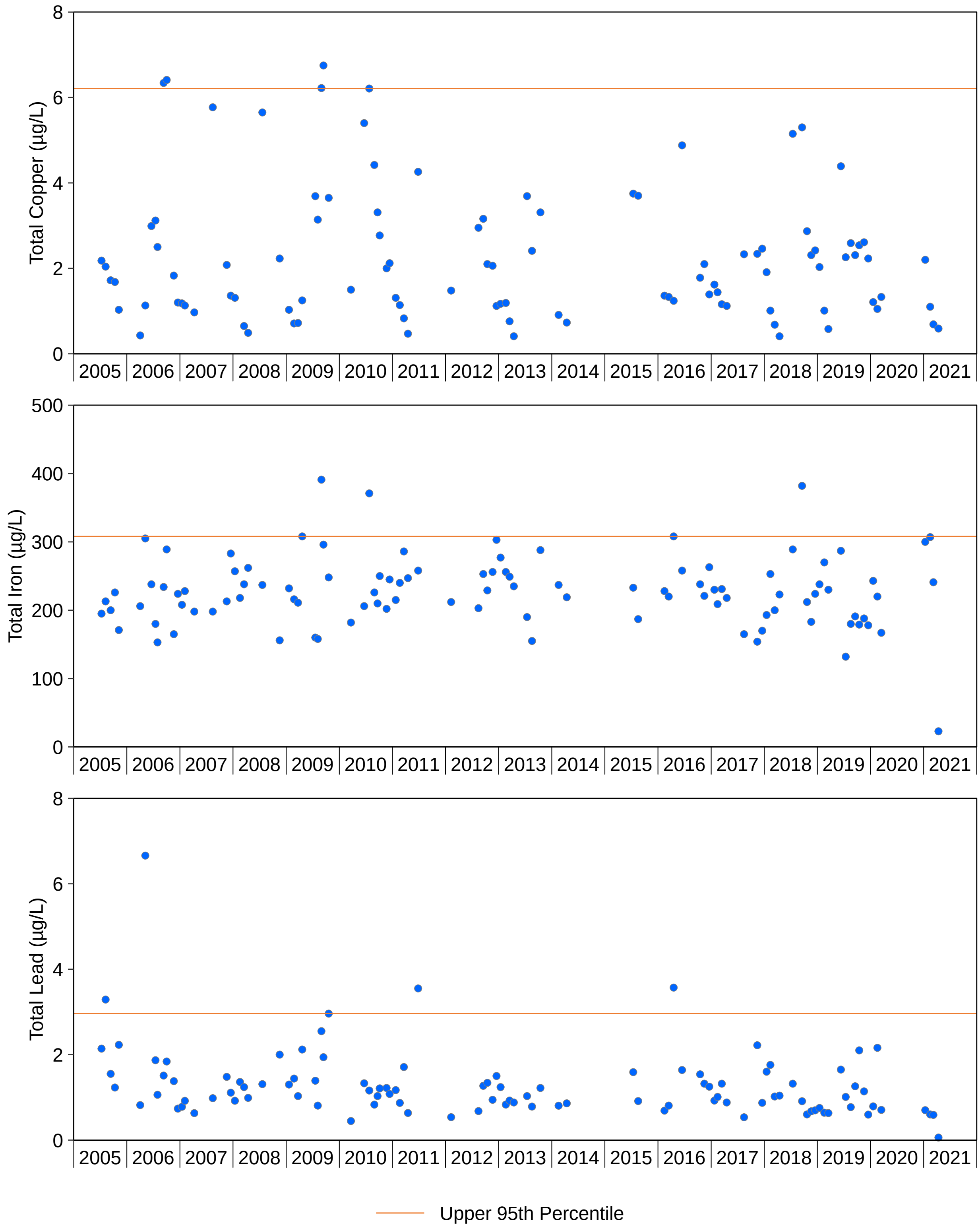

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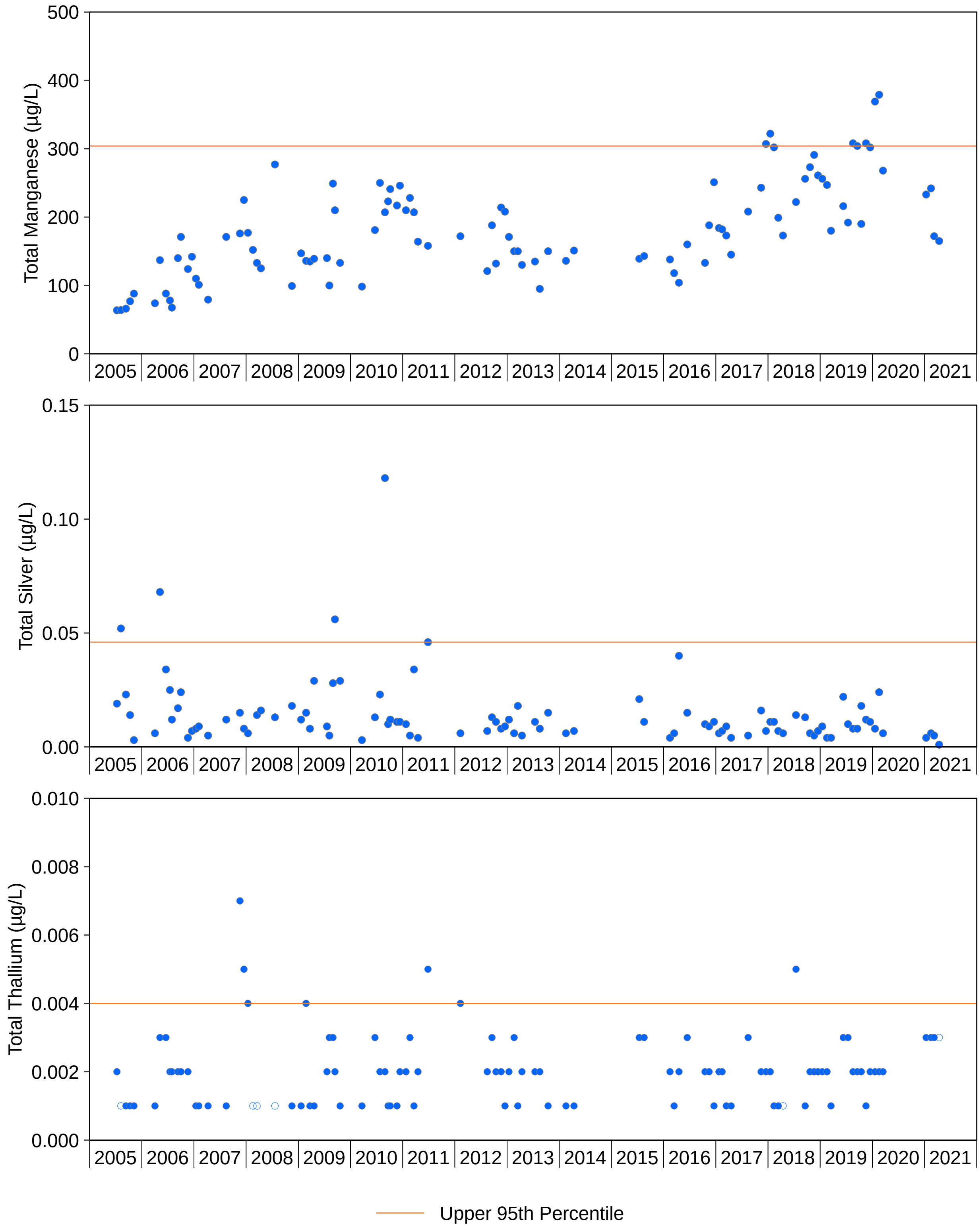

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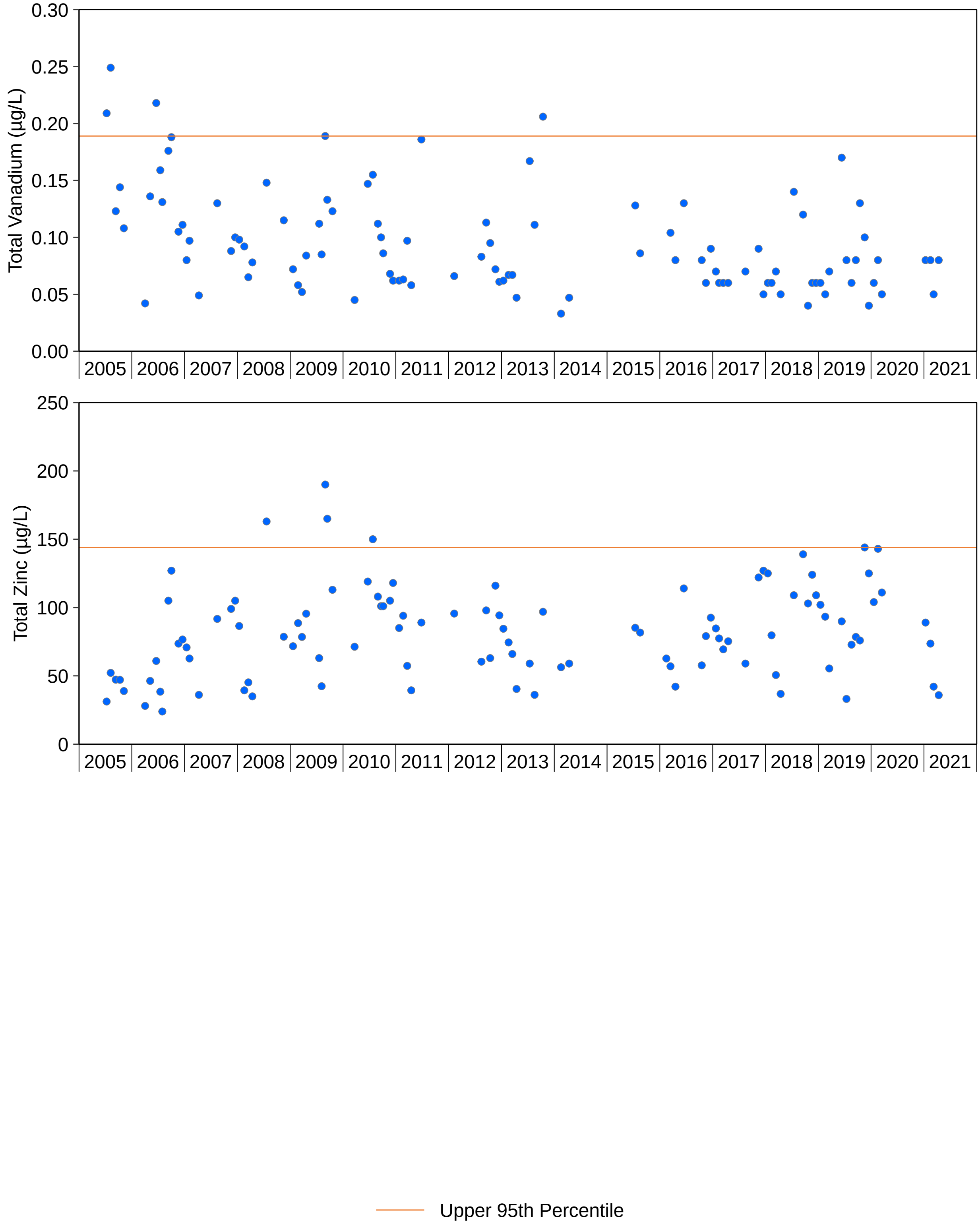

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and 2021, respectively (Figure 8.1). There were no dissolved cadmium data for the 2020 sample with a total cadmium concentration that was elevated relative to the maximum WQO. For the 2021 sample that had a total chromium concentration greater than the maximum WQO, the dissolved concentration (0.35 µg/L) was roughly equal to the total concentration (0.34 µg/L).[24] Again, a visual examination of the data plots (Figure 8.1) for individual COPCs indicated that the 95th percentile statistic represented a good measure of the upper range of baseline water quality.

To support comparisons to the average numerical WQO (i.e., the one-tailed 95% UCLM concentration for the baseline data set; Table 6.1), a rolling geometric mean[25] capturing 20 consecutive, clear-flow samples was calculated and plotted along with the WQO. Again, the years of data used to derive the WQO were included in the plots to support the evaluation. According to The Guide, if the mean for the 20 consecutive samples exceeds the WQO based on the one-tailed 95% UCLM, this signals that the WQO are exceeded.

In completing this exercise, the study team recognized that the prescribed method for confirming attainment is not compatible with the method for deriving the average numerical WQO for the South McQuesten River. Specifically, the average WQO for each COPC was calculated for approximately 100 individual samples spread over a period of 15 years. If data were collected for another 15 years and there were no trends over time, then the study team would expect the mean of the new data set to be consistent with the average WQO 95% of the time, which is consistent with the attainment criterion outlined for the background concentration procedure in The Guide. However, when the means and 95% UCLMs are calculated using the most recent 20 samples, the sample size (i.e., 20 versus 100) and the number of years in the data set are much fewer. Therefore, it cannot be expected that the mean of these 20 samples (or a rolling 20-sample mean) will be lower than the average WQO 95% of the time. This issue is exacerbated by fluctuations or cycling of COPC concentrations, which were observed for some COPCs (e.g., cobalt) over the 15-year period of baseline data collection (see Appendix A).

The study team identified two approaches for addressing the issues identified in comparing the 20-sample sub-sets of data to WQO that were derived using approximately 100 samples collected over a 15-year period. The first involved calculating additional screening values that are representative of the upper limit of the mean of the baseline data set, yet more comparable to a 20-sample rolling mean. These screening values included:

[24] The dissolved chromium concentration being greater than the total concentration may be attributed to the concentrations being close to the LRL (Austin 2020) or to other factors associated with field data collection and laboratory analysis, the discussion of which is outside the scope of this report.

[25] The comparisons in The Guide are based on the arithmetic mean; however, because most of the data used to derive the WQO are log-normally distributed, the use of geometric means is considered appropriate in this case.

1. the 95th percentile of the 20-sample rolling means (i.e., 95% of the 20-sample rolling means would be lower than this value if there were no trends over time); and

2. the mean of the 95% UCLMs that were calculated for each of the 20-sample rolling averages, which represent the 15-year period associated with the baseline data set.

These screening values were plotted along with the rolling 20-sample means and examined visually.

The second approach for addressing issues related to incompatible sample sizes involved identifying a larger number of samples (e.g., 30 or 50 samples, rather than 20) that would be more appropriate for confirming attainment (i.e., to better align the sample sizes used to confirm attainment with those used to derive WQO). Rolling geometric means calculated using sample sizes of n = 30 and n = 50 were plotted relative to the average WQO (i.e., the 95% UCLM).

When attainment was evaluated using the prescribed methods in The Guide (i.e., attainment was evaluated based on COPC concentrations in 20 consecutive clear-flow samples), the rolling geometric mean concentrations of fluoride and total aluminum, arsenic, chromium, copper, iron, lead, silver, and vanadium were below the average WQO (i.e., the 95% UCLM) in 2020 and 2021 (Figure 8.2). Rolling geometric mean concentrations of the remaining COPCs (i.e., total cadmium, cobalt, manganese, thallium, and zinc) had values in 2020 and 2021 that would be considered indicative of non-attainment, according to The Guide. However, the rolling 20-sample geometric mean concentrations over the period of record highlight the incompatibilities in sample sizes described above (i.e., the rolling average concentration exceeds the 95% UCLM more than 5% of the time despite previous "baseline" periods of higher concentrations; Figure 8.2).

The study team, upon reviewing the plots for individual COPCs, determined that comparisons to the 95th percentile of the 20-sample rolling means in the baseline data set is likely a more appropriate method of assessing attainment, rather than making comparisons to the 95% UCLM. This is because the rate of exceedance of the 95th percentile of the 20-sample rolling means in the baseline data set is only roughly 5% (Figure 8.2). Rates of exceedance were also less variable among COPCs compared to the mean of the 95% UCLMs. Based on screening values set equal to the 95th percentiles of the 20-sample rolling means, concentrations of all COPCs achieved attainment in 2020 and 2021, except total cobalt, manganese, and thallium (Figure 8.2).

When 30-sample rolling geometric means and the 95% UCLM were used to evaluate attainment in 2020 and 2021, total cadmium, cobalt, manganese, thallium, and zinc did not achieve attainment, consistent with the results for the 20-sample means; non-attainment only occurred for total cobalt and manganese when a sample size of 50 was used (Figures 8.2 to 8.4).

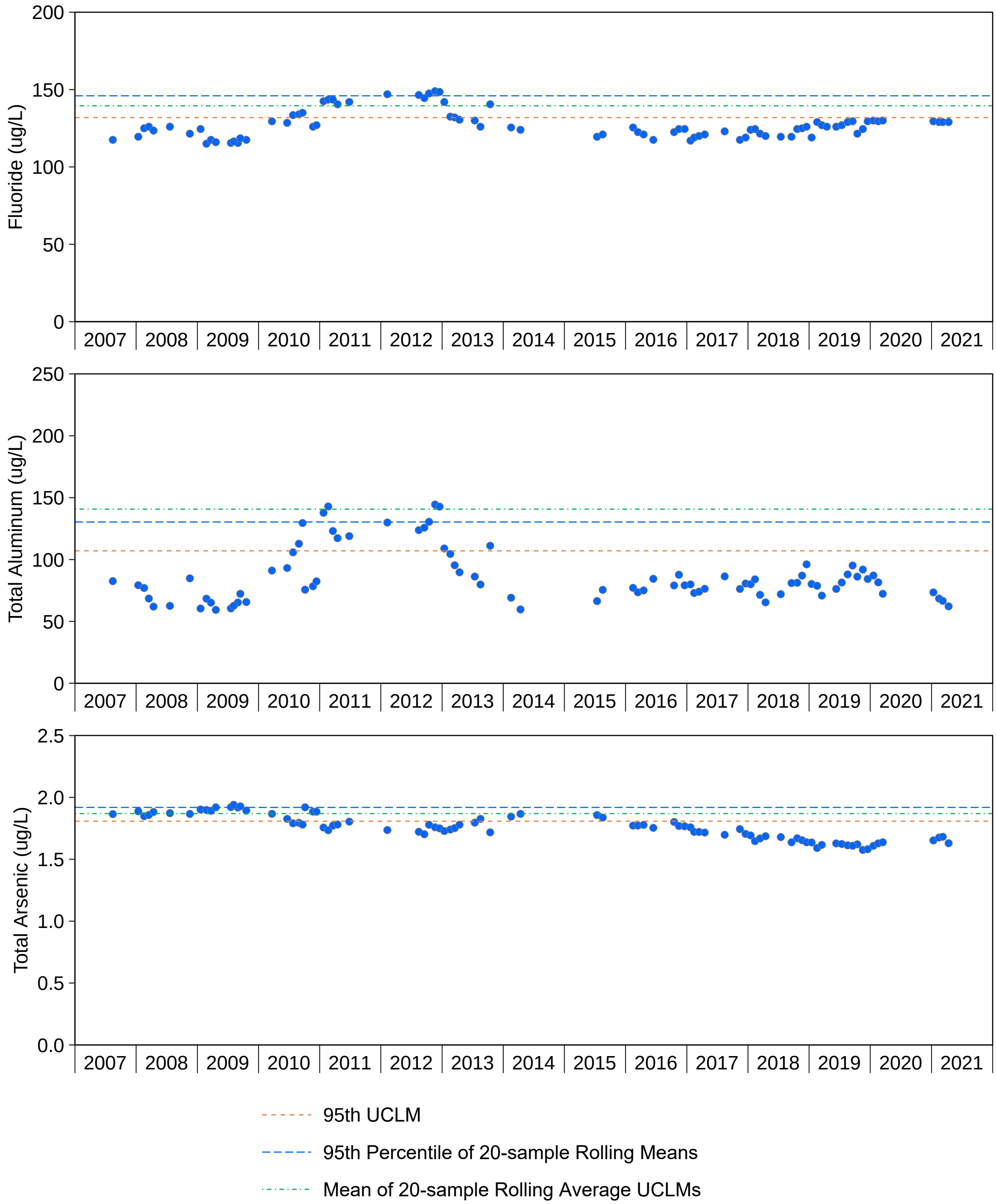
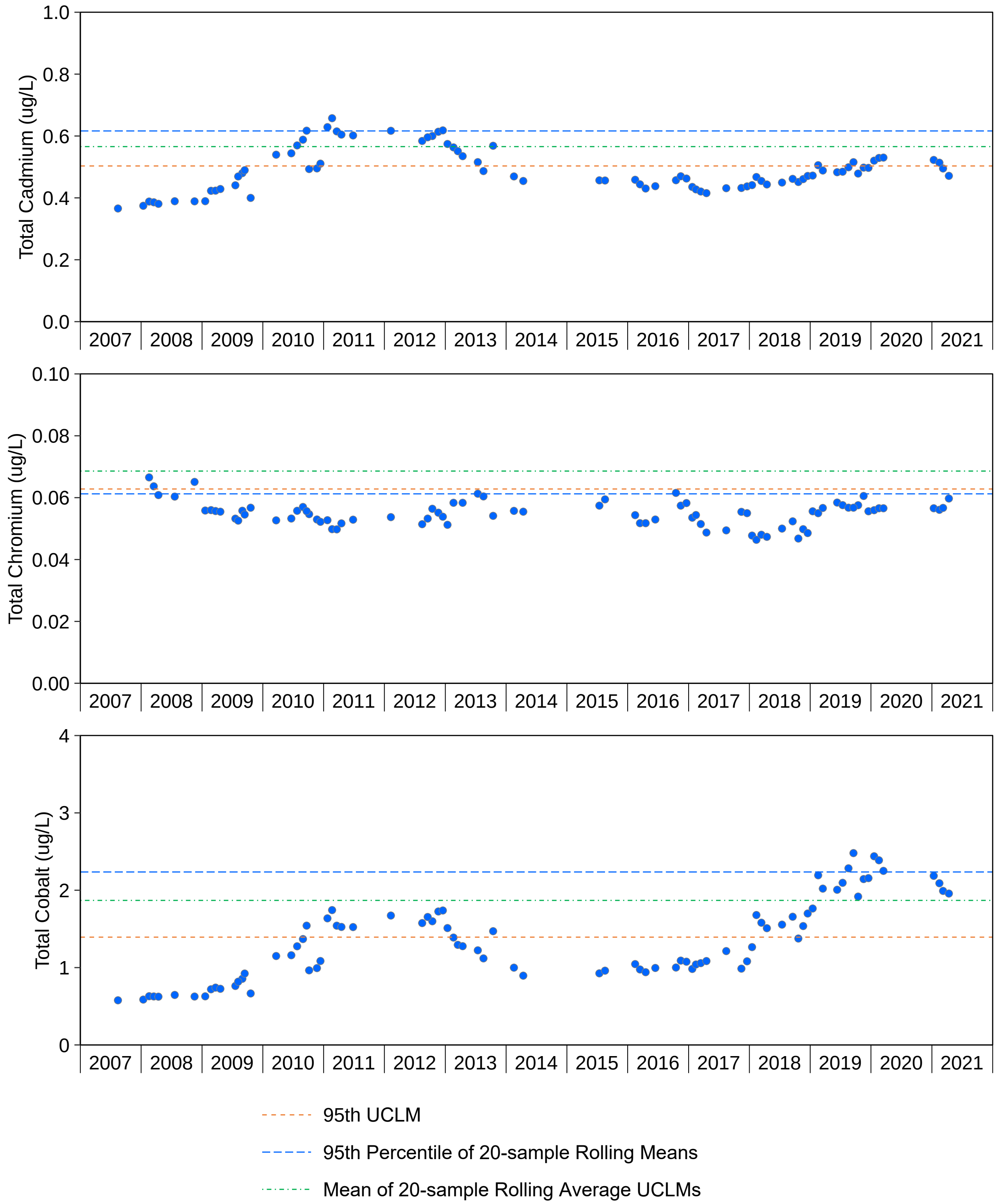


Figure 8.2: Comparisons of Rolling 20-Sample Mean Concentrations of Contaminants of Potential Concern to Average Water Quality Objectives and Possible Screening Values for Confirming Attainment, Station YT09DD0008 on the South McQuesten River

Notes: UCLM = Upper Confidence Limit of the Mean. Rolling mean concentrations were calculated for every 20 samples using an arithmetic or geometric mean depending on the distribution of the data (see Section 6 for more information). Only data for clear-flow samples (i.e., laboratory turbidity < 4 Nephelometric Turbidity Units [NTU]) are shown. Concentrations above the dashed lines are considered "non-compliant".



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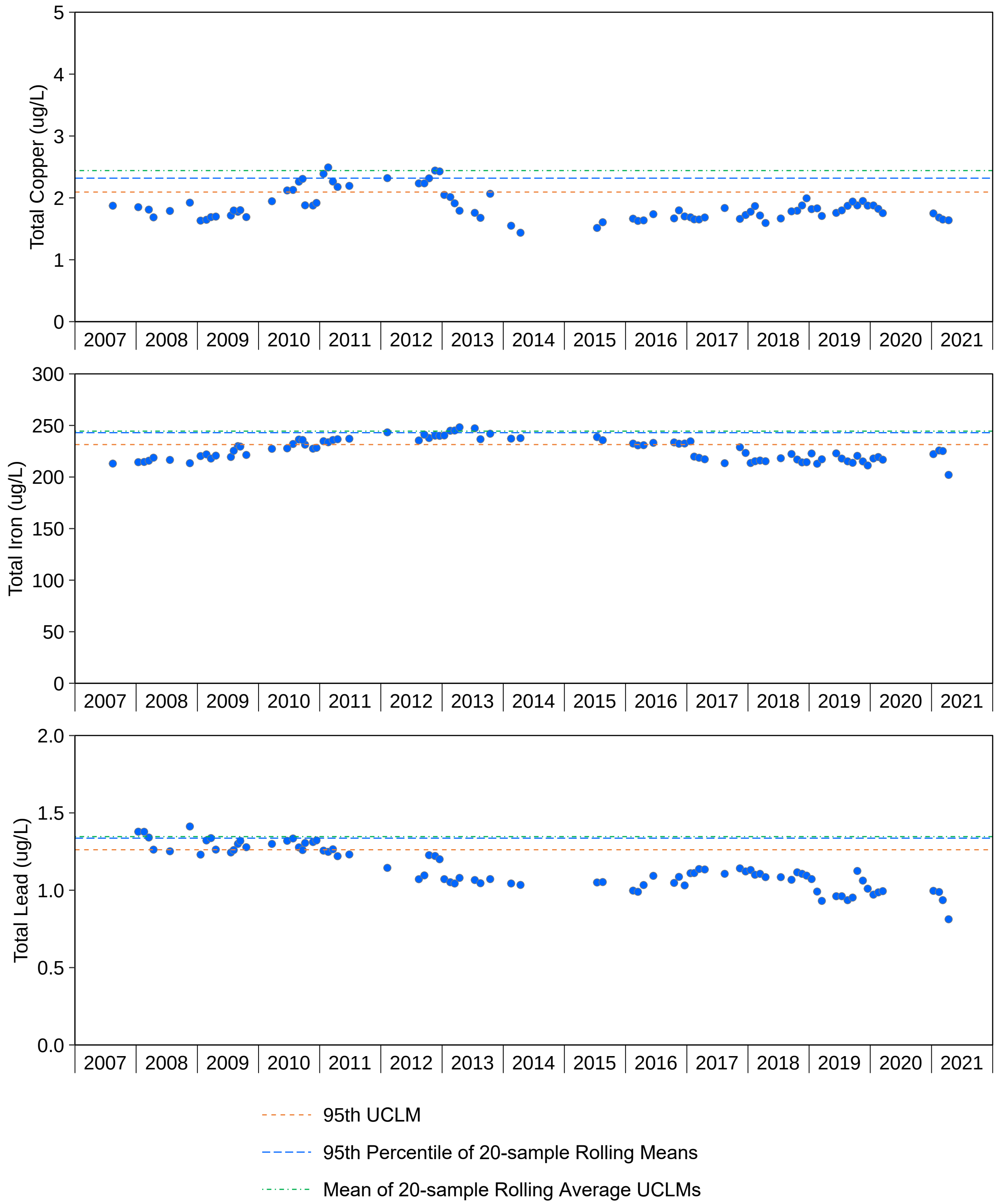

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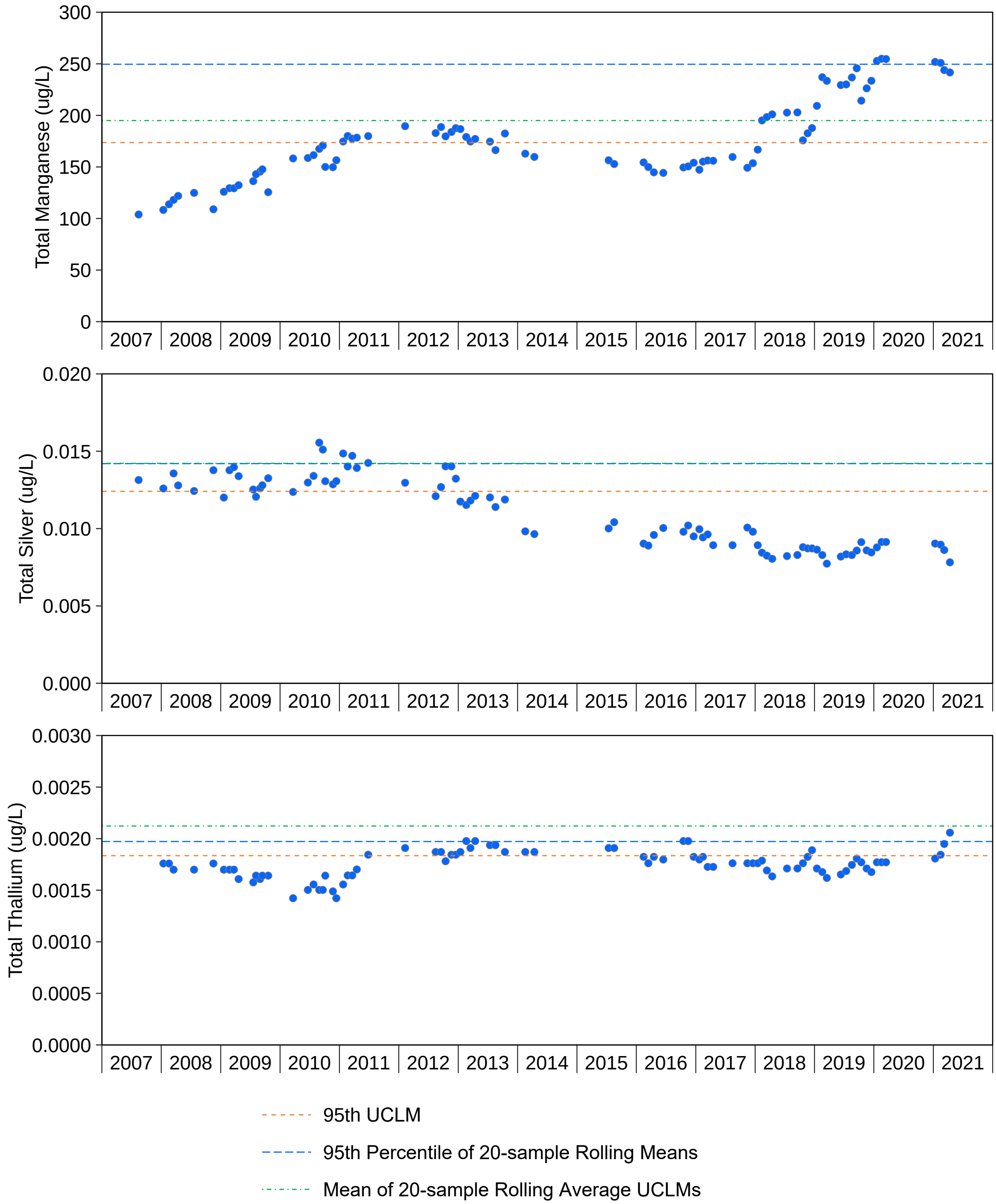

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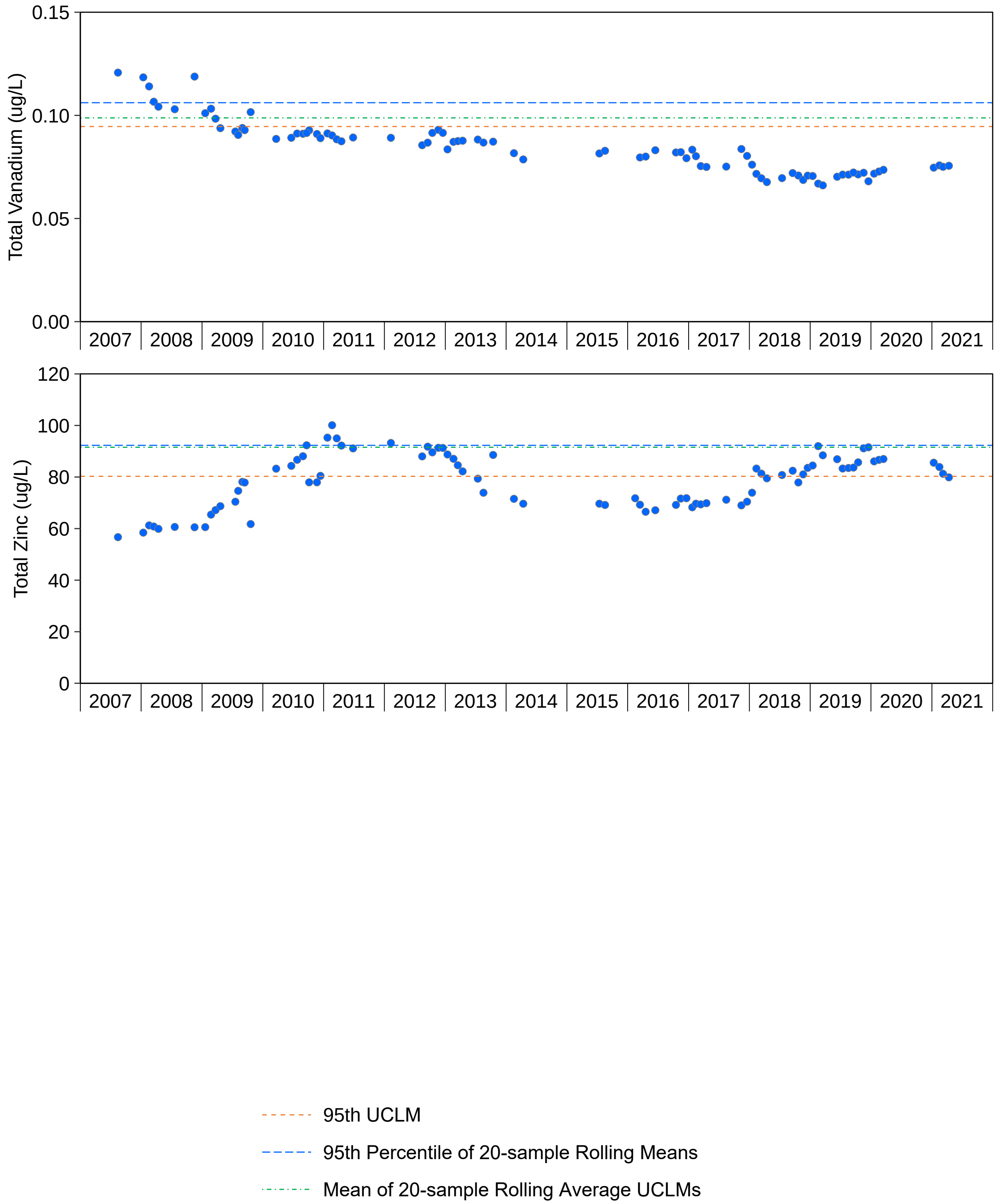

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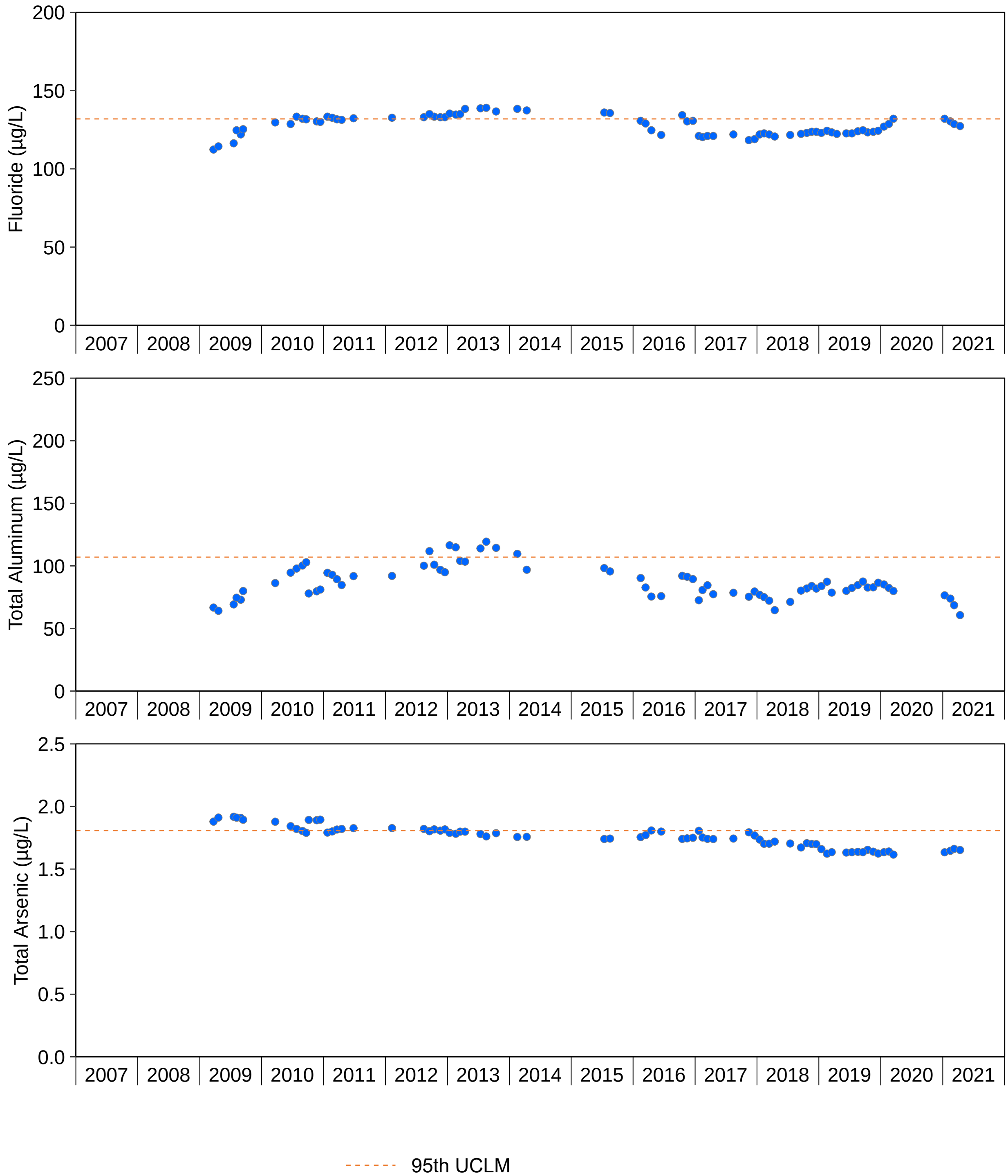

Figure 8.3: Comparisons of Rolling 30-Sample Mean Concentrations of Contaminants of Potential Concern to Average Water Quality Objectives for Confirming Attainment, Station YT09DD0008 on the South McQuesten River

Notes: UCLM = Upper Confidence Limit of the Mean. Rolling mean concentrations were calculated for every 30 samples using an arithmetic or geometric mean depending on the distribution of the data (see Section 6 for more information). Only data for clear-flow samples (i.e., laboratory turbidity < 4 Nephelometric Turbidity Units [NTU]) are shown. Concentrations above the dashed lines are considered "non-compliant".

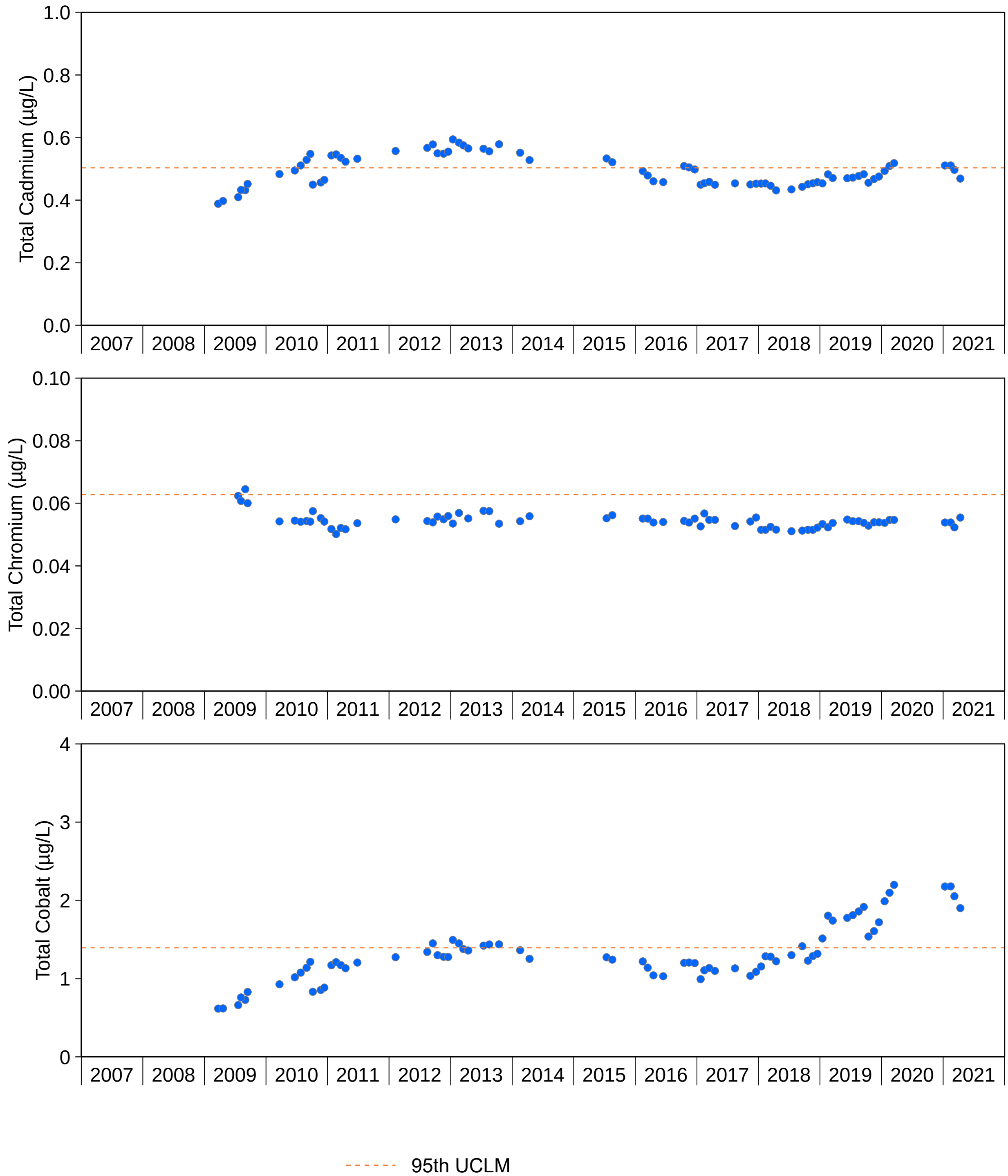

Figure 8.3: Comparisons of Rolling 30-Sample Mean Concentrations of Contaminants of Potential Concern to Average Water Quality Objectives for Confirming Attainment, Station YT09DD0008 on the South McQuesten River

Notes: UCLM = Upper Confidence Limit of the Mean. Rolling mean concentrations were calculated for every 30 samples using an arithmetic or geometric mean depending on the distribution of the data (see Section 6 for more information). Only data for clear-flow samples (i.e., laboratory turbidity < 4 Nephelometric Turbidity Units [NTU]) are shown. Concentrations above the dashed lines are considered "non-compliant".

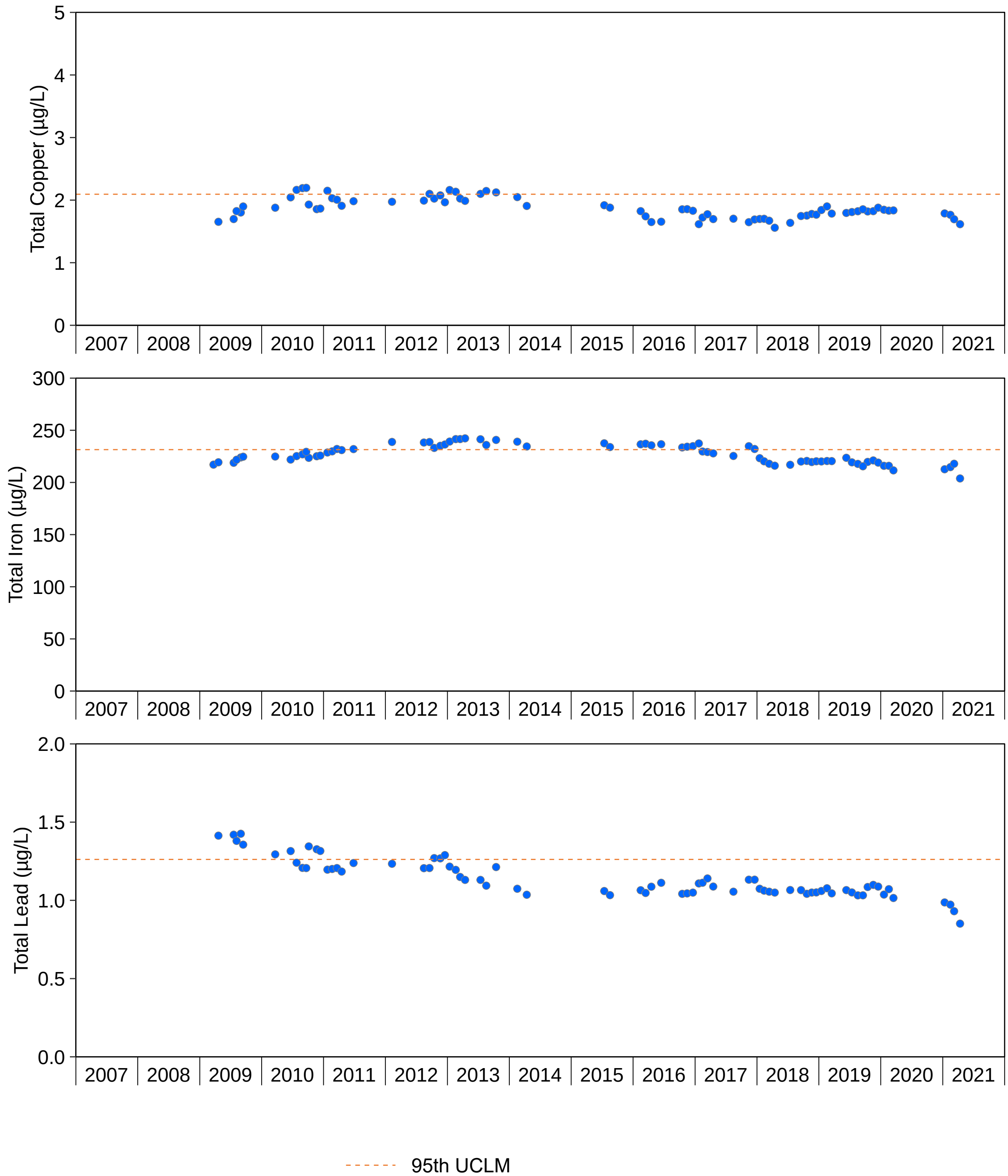

Figure 8.3: Comparisons of Rolling 30-Sample Mean Concentrations of Contaminants of Potential Concern to Average Water Quality Objectives for Confirming Attainment, Station YT09DD0008 on the South McQuesten River

Notes: UCLM = Upper Confidence Limit of the Mean. Rolling mean concentrations were calculated for every 30 samples using an arithmetic or geometric mean depending on the distribution of the data (see Section 6 for more information). Only data for clear-flow samples (i.e., laboratory turbidity < 4 Nephelometric Turbidity Units [NTU]) are shown. Concentrations above the dashed lines are considered "non-compliant".

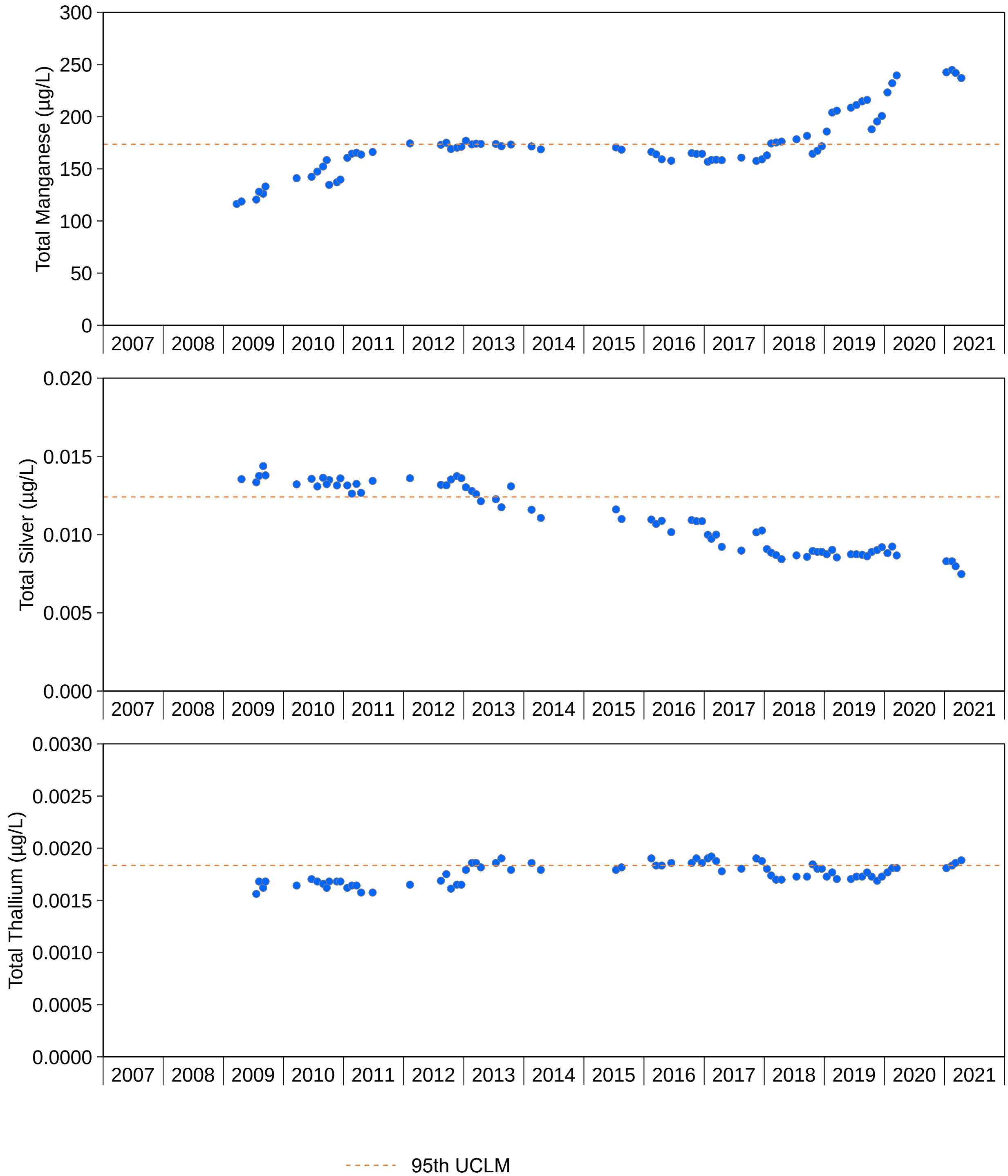

Figure 8.3: Comparisons of Rolling 30-Sample Mean Concentrations of Contaminants of Potential Concern to Average Water Quality Objectives for Confirming Attainment, Station YT09DD0008 on the South McQuesten River

Notes: UCLM = Upper Confidence Limit of the Mean. Rolling mean concentrations were calculated for every 30 samples using an arithmetic or geometric mean depending on the distribution of the data (see Section 6 for more information). Only data for clear-flow samples (i.e., laboratory turbidity < 4 Nephelometric Turbidity Units [NTU]) are shown. Concentrations above the dashed lines are considered "non-compliant".

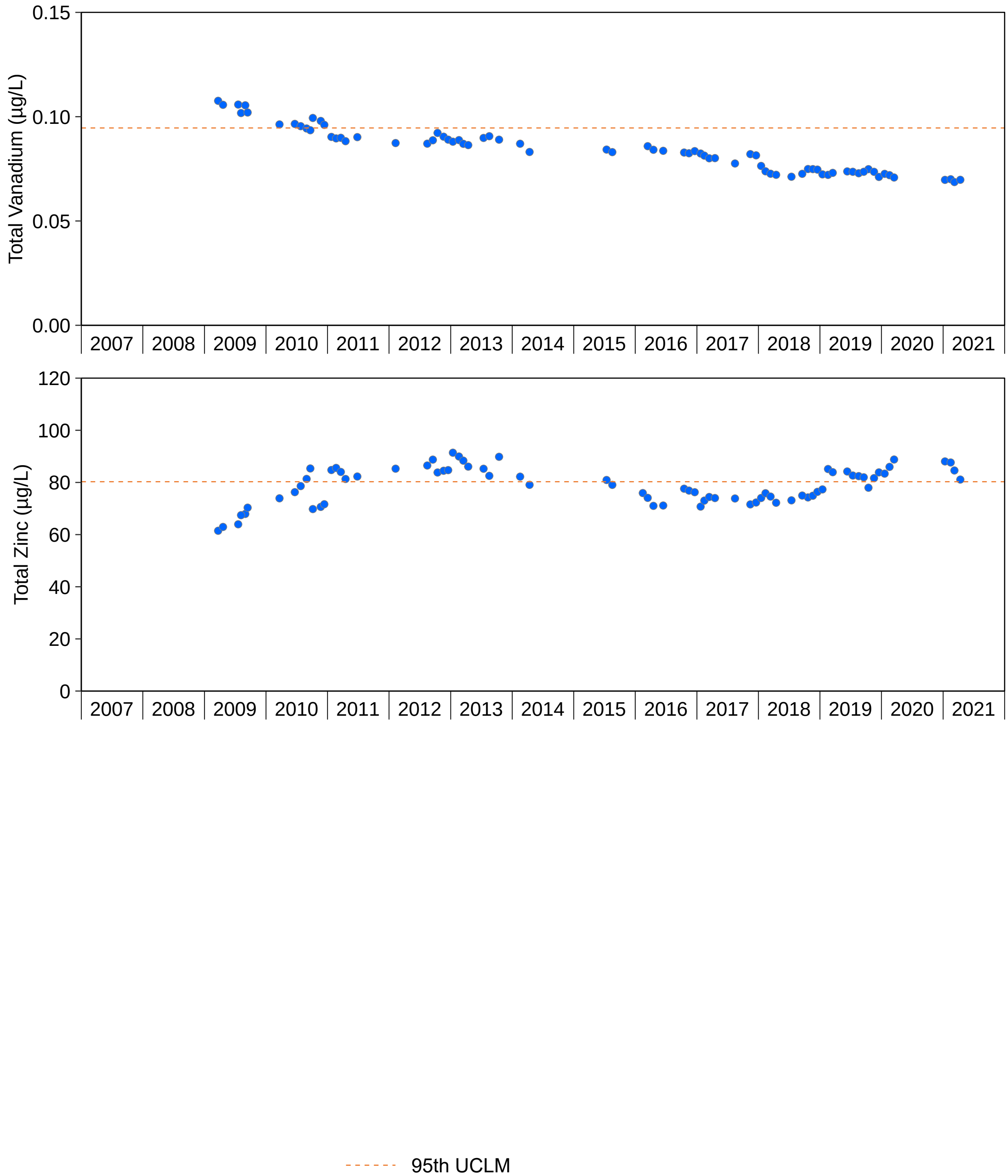

Figure 8.3: Comparisons of Rolling 30-Sample Mean Concentrations of Contaminants of Potential Concern to Average Water Quality Objectives for Confirming Attainment, Station YT09DD0008 on the South McQuesten River

Notes: UCLM = Upper Confidence Limit of the Mean. Rolling mean concentrations were calculated for every 30 samples using an arithmetic or geometric mean depending on the distribution of the data (see Section 6 for more information). Only data for clear-flow samples (i.e., laboratory turbidity < 4 Nephelometric Turbidity Units [NTU]) are shown. Concentrations above the dashed lines are considered "non-compliant".

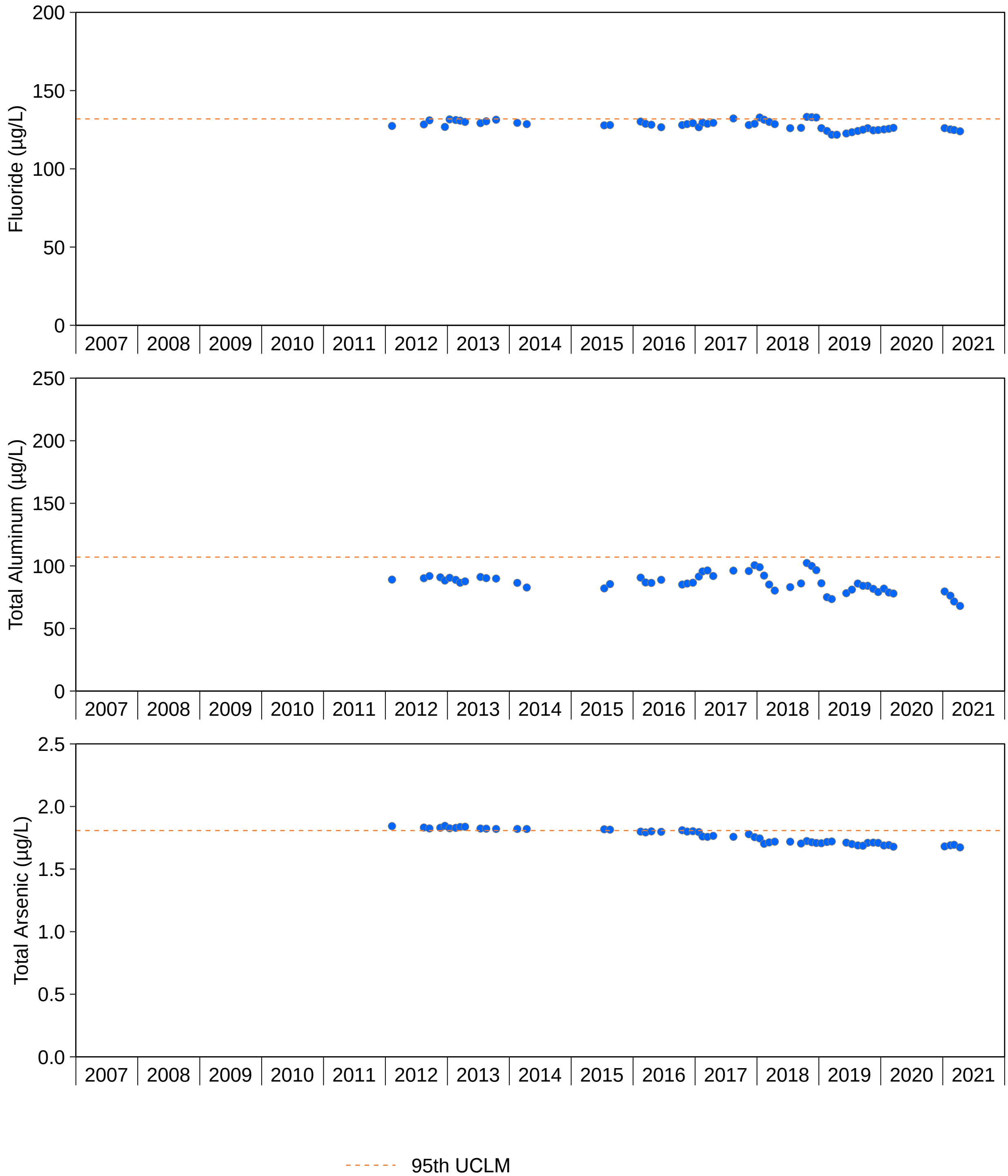

Figure 8.4: Comparisons of Rolling 50-Sample Mean Concentrations of Contaminants of Potential Concern to Average Water Quality Objectives for Confirming Attainment, Station YT09DD0008 on the South McQuesten River

Notes: UCLM = Upper Confidence Limit of the Mean. Rolling mean concentrations were calculated for every 50 samples using an arithmetic or geometric mean depending on the distribution of the data (see Section 6 for more information). Only data for clear-flow samples (i.e., laboratory turbidity < 4 Nephelometric Turbidity Units [NTU]) are shown. Concentrations above the dashed lines are considered "non-compliant".

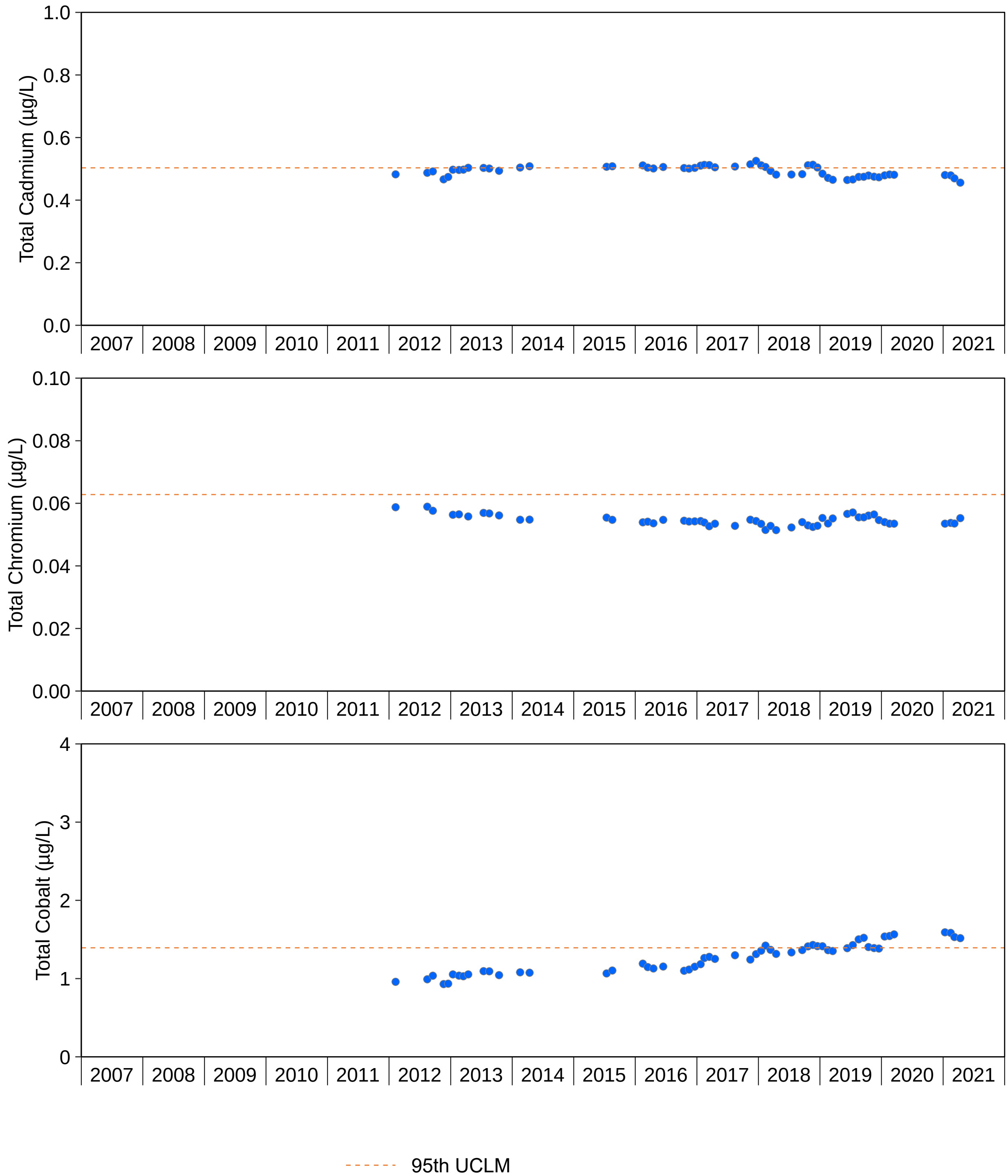

Figure 8.4: Comparisons of Rolling 50-Sample Mean Concentrations of Contaminants of Potential Concern to Average Water Quality Objectives for Confirming Attainment, Station YT09DD0008 on the South McQuesten River

Notes: UCLM = Upper Confidence Limit of the Mean. Rolling mean concentrations were calculated for every 50 samples using an arithmetic or geometric mean depending on the distribution of the data (see Section 6 for more information). Only data for clear-flow samples (i.e., laboratory turbidity < 4 Nephelometric Turbidity Units [NTU]) are shown. Concentrations above the dashed lines are considered "non-compliant".

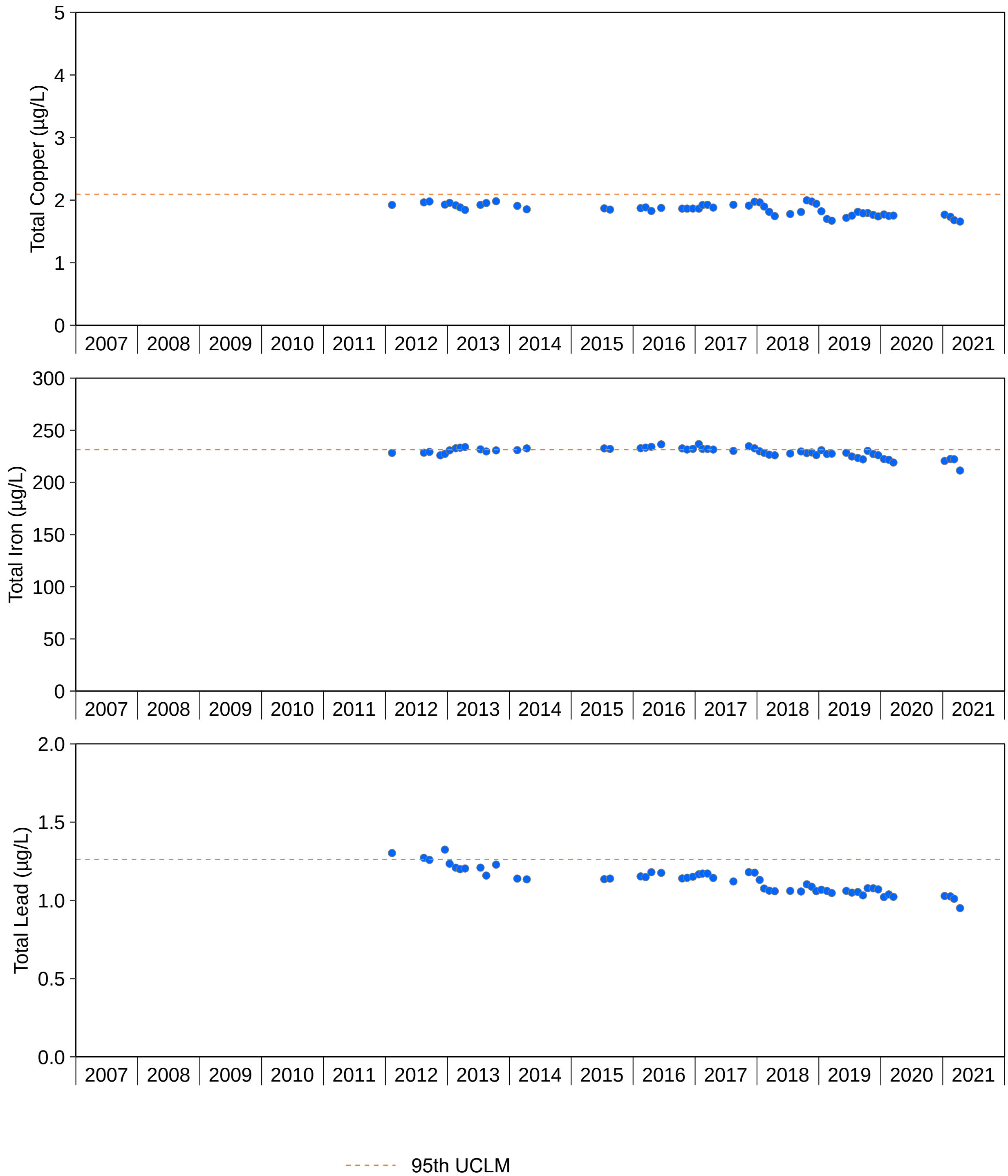

Figure 8.4: Comparisons of Rolling 50-Sample Mean Concentrations of Contaminants of Potential Concern to Average Water Quality Objectives for Confirming Attainment, Station YT09DD0008 on the South McQuesten River

Notes: UCLM = Upper Confidence Limit of the Mean. Rolling mean concentrations were calculated for every 50 samples using an arithmetic or geometric mean depending on the distribution of the data (see Section 6 for more information). Only data for clear-flow samples (i.e., laboratory turbidity < 4 Nephelometric Turbidity Units [NTU]) are shown. Concentrations above the dashed lines are considered "non-compliant".

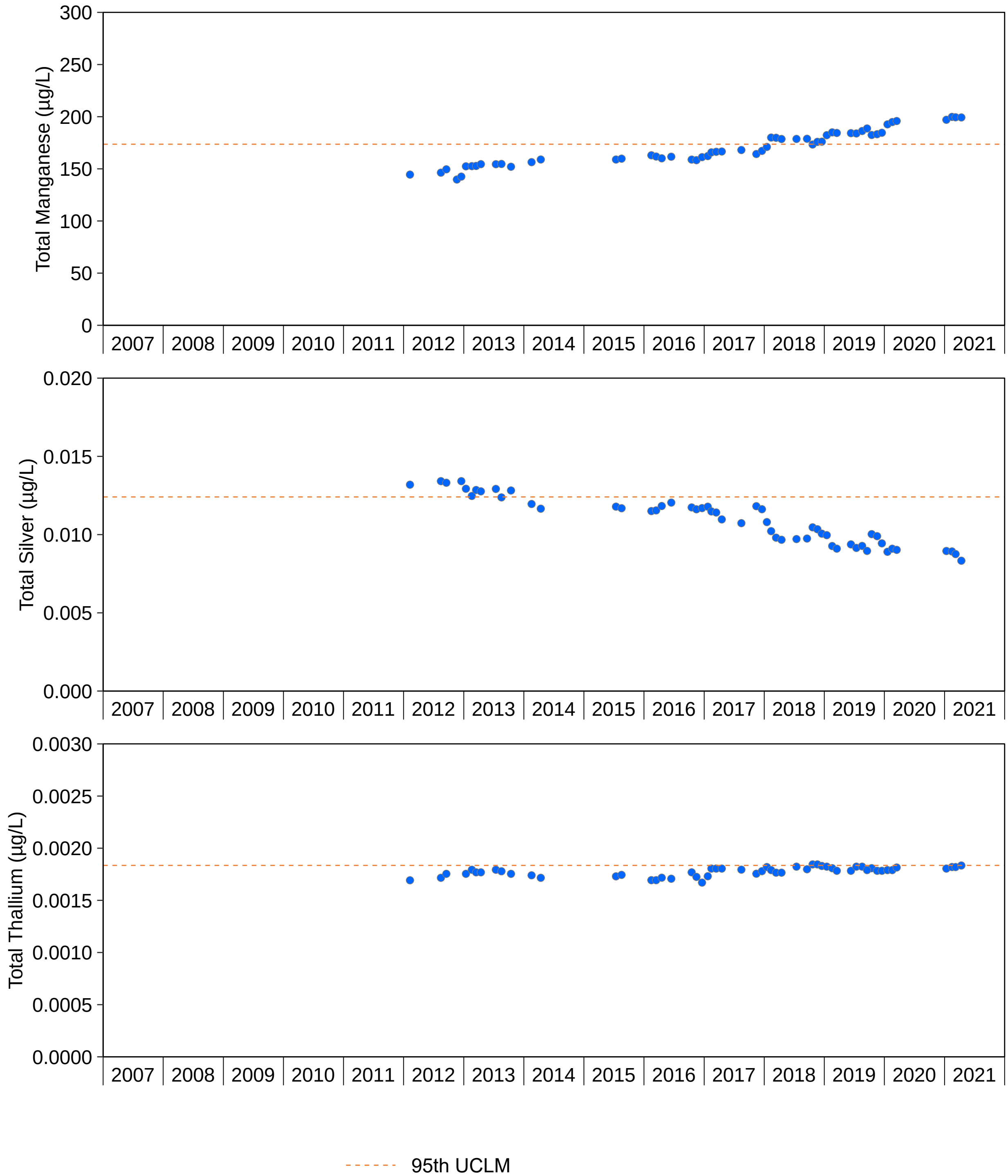

Figure 8.4: Comparisons of Rolling 50-Sample Mean Concentrations of Contaminants of Potential Concern to Average Water Quality Objectives for Confirming Attainment, Station YT09DD0008 on the South McQuesten River

Notes: UCLM = Upper Confidence Limit of the Mean. Rolling mean concentrations were calculated for every 50 samples using an arithmetic or geometric mean depending on the distribution of the data (see Section 6 for more information). Only data for clear-flow samples (i.e., laboratory turbidity < 4 Nephelometric Turbidity Units [NTU]) are shown. Concentrations above the dashed lines are considered "non-compliant".

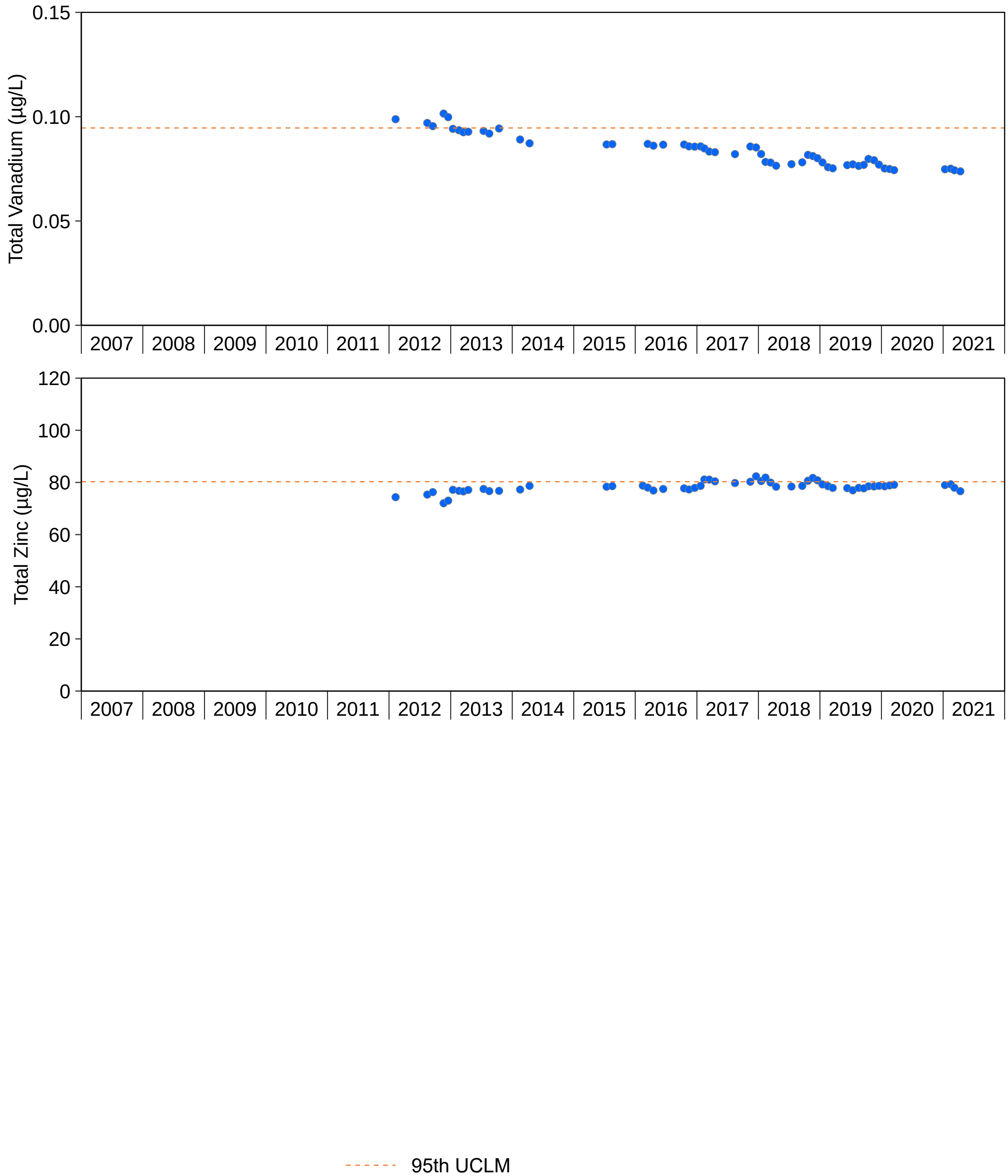

Figure 8.4: Comparisons of Rolling 50-Sample Mean Concentrations of Contaminants of Potential Concern to Average Water Quality Objectives for Confirming Attainment, Station YT09DD0008 on the South McQuesten River

Notes: UCLM = Upper Confidence Limit of the Mean. Rolling mean concentrations were calculated for every 50 samples using an arithmetic or geometric mean depending on the distribution of the data (see Section 6 for more information). Only data for clear-flow samples (i.e., laboratory turbidity < 4 Nephelometric Turbidity Units [NTU]) are shown. Concentrations above the dashed lines are considered "non-compliant".

Using 30-sample rolling means produced issues similar to the use of 20-sample rolling means, in that the means in the baseline data set exceeded the average WQO more than roughly 5% of the time (Figure 8.3). Therefore, a sample size of n = 30 samples is still insufficient for assessing attainment as part of this case study. A sample size of n = 50 samples is considered more appropriate for assessing attainment for most COPCs, given that exceedances of the average WQO in the baseline data set were on the order of approximately 5% for most COPCs (Figure 8.4). Total manganese and silver are the exceptions due to upward and downward trends, respectively, in the rolling geometric mean concentrations (Figure 8.4). The 50-sample rolling geometric means for total manganese and silver exceeded the 95% UCLM approximately 39 and 16% of the time over the period of baseline data collection and into 2021.

8.3 Recommendations for Evaluating Attainment

It is recommended that the approach to evaluating attainment for the South McQuesten River focus on surface water quality monitoring. This is because attainment of numerical objectives derived using the background concentration procedure can be confirmed based on water quality data alone. Additionally, because no bioaccumulative substances were identified as COPCs (Section 5), inclusion of benthic invertebrate and fish tissue chemistry sampling is not required to confirm attainment of South McQuesten River WQO (Government of Yukon 2021a). Benthic invertebrate community surveys or other types of biological monitoring or toxicity testing would be implemented under an AMP framework (Section 8.4) in the event of non-attainment.

Consistent with the recommendations laid out in The Guide for baseline water quality monitoring programs that are intended for use in WQO derivation, water quality monitoring to confirm attainment should include collection of the following:

- Monthly *in situ* water quality measurements (i.e., temperature, pH, specific conductance, dissolved oxygen, and turbidity) and chemistry samples (physicochemical parameters, nutrients, major ions, dissolved organic carbon, total and dissolved metals, and any other parameters identified as COPCs);
- Intensive (i.e., five samples in a period of 30 days) sampling events during periods of higher natural variability in water quality (e.g., freshet); and
- Flow measurements, which should be collected using standardized methods (e.g., BCMOE 2009) and should be co-located and collected concurrently with individual water samples.

Typically, establishment of a “reference” area with similar geology, topography, climate, and ecology is recommended to support interpretation of water chemistry data used to evaluate attainment. However, this is not practical in the case of the South McQuesten River because suitable reference areas are unlikely to exist, given the long history of mining activity in the watershed (see Section 1.2.2). Much of the watershed (and surrounding watersheds) is influenced by exploration and mining activities and these activities pre-date the available water quality data sets. However, these considerations are less critical in the event a reference location is established solely for the purposes of evaluating climate change influences on water quality (i.e., rather than evaluating the influence of Cache Creek[26] or mining activities).

The following triggers or thresholds for non-attainment are recommended for the WQO derived for the long-term monitoring station on the South McQuesten River[27]:

- Two or more of the 20 most-recent clear-flow samples with concentrations greater than the maximum WQO (i.e., the 95th percentile baseline concentration), consistent with The Guide;
- A rolling geometric mean concentration (which is continually updated to include the most recent 20 clear-flow samples) that exceeds the screening value (Table 8.1) equal to the 95th percentile of the 20-sample rolling means from the baseline data set by more than 5%; or
- A rolling geometric mean concentration (which is continually updated to include the most recent 50 clear-flow samples) that exceeds the average WQO (i.e., the 95% UCLM of the baseline data set) by more than 5%.

Additionally, if a reported concentration exceeds the maximum COPC concentration in the baseline data set or thresholds for toxic effects to biota (e.g., literature-based aquatic toxicity reference values [TRVs] and toxicity databases for relevant organisms), a prompt, detailed examination of the data is warranted. The same is also true if the WQO exceedance is thought to be linked to a specific cause (e.g., a newly established mine discharge upstream).

[26] Cache Creek is a known source of cadmium and zinc to the South McQuesten River and is also lowering pH (Government of Yukon 2022).

[27] The study team cautions that these triggers or thresholds for non-attainment are specific to this case study and the associated data set; they should not be transferred to other projects.

Table 8.1: Upper 95th Percentiles of 20-sample Rolling Means for Contaminants of Potential Concern in the South McQuesten River (YT09DD0008), 2005 to 2021

Parameter	Units	Upper 95th Percentile
Fluoride	µg/L	146
Total Aluminum	µg/L	130
Total Arsenic	µg/L	1.9
Total Cadmium	µg/L	0.62
Total Chromium	µg/L	0.061
Total Cobalt	µg/L	2.2
Total Copper	µg/L	2.3
Total Iron	µg/L	243
Total Lead	µg/L	1.3
Total Manganese	µg/L	250
Total Silver	µg/L	0.014
Total Thallium	µg/L	0.0020
Total Tin	µg/L	0.0070
Total Vanadium	µg/L	0.11
Total Zinc	µg/L	92

Notes: µg/L = micrograms per litre.

9 SPATIAL AND TEMPORAL APPLICABILITY

Based on discussions with Yukon Environment representatives (Janin 2021b, pers. comm.) in March 2021, additional consideration was given to the broader spatial and temporal application of the WQO derived at the long-term monitoring station. Specifically, the study team was asked to evaluate and determine whether the WQO are applicable at the derivation location only (i.e., at YT09DD0008) or if they may be applied further upstream. Because the non-degradation water management approach was applied at the long-term monitoring station (YT09DD0008), it is expected that achievement of the numerical and narrative WQO at all areas upstream of YT09DD0008 would support achievement of WQO at YT09DD0008. In other words, if the WQO derived for YT09DD0008 are often exceeded at upstream locations, then it is unlikely that water quality conditions downstream at YT09DD0008 would attain WQO. Therefore, the WQO are applicable to the South McQuesten River at and upstream from YT09DD0008. It is not recommended that the WQO be applied downstream of YT09DD0008, given that the WQO will not capture inputs from along the main stem downstream of YT09DD0008 or from Haggart Creek.

10 SUMMARY

Slater and Minnow completed a case study wherein The Guide (Government of Yukon 2021a) was used to identify COPCs and develop WQO for the South McQuesten River (Et'o Nyäk Tagé), YT. Data to support characterization of baseline water quality, identification of COPCs, and derivation of WQO were available from 1981 to 2020, depending on the sampling location. Data for individual water quality parameters and stations on the South McQuesten River main stem and its tributaries were evaluated to inform conclusions about data quality and quantity, as well as station selection.

Overall, the water quality data were considered to be of sufficient quality for use in calculating summary statistics to support identification of candidate COPCs. Because relatively few stations were sampled at least annually prior to 2004, data sets were truncated to 2004 through the end of 2019. Dissolved metal concentrations were not routinely reported at ECCC's long-term monitoring station (YT09DD0008) on the South McQuesten River downstream from Flat Creek. Depending on the station and year, concentrations of physicochemical parameters (e.g., pH), ions, and nutrients were not consistently reported and flow data were reported infrequently, if at all.

The long-term monitoring station (YT09DD0008) was identified as the most appropriate location for WQO derivation for the South McQuesten River based on the requirements of The Guide and the characteristics of the data sets for individual stations. The data set for YT09DD0008 was one of only two data sets that met the recommendation for three years of continuous monthly monitoring (2013 to 2018) and was far enough downstream to capture inputs from Cache, Christal, and Flat creeks. However, the data set did lack dissolved metals data, flow data, and more frequent sampling during periods of high variability (e.g., freshet). These short-comings, as well as the inability to capture inputs from Haggart Creek, were considered throughout subsequent steps of the case study.

Based on consideration of social, economic, and environmental values and watershed-specific factors, the non-degradation management approach was selected for use in deriving WQO at the long-term monitoring station (YT09DD0008) on the South McQuesten River. Specifically, the South McQuesten River is of significant cultural and ecological importance for the First Nation of Na-cho Nyäk Dun and other users. It is also identified as containing fisheries, aquatic resources, or linkages to fish habitat that are ecologically or culturally important.

Based on the criteria outlined in The Guide, fluoride and total aluminum, arsenic, cadmium, chromium, cobalt, copper, iron, lead, manganese, silver, thallium, vanadium, and zinc were identified as COPCs and carried forward for WQO derivation. Because WQO had to be derived using total, rather than dissolved, metal concentrations, the study team was required to identify samples representative of distinct “populations” of data (i.e., samples collected during clear versus turbid-flow periods). It was decided that laboratory turbidity would be used to identify samples representing clear-flow conditions and the WQO would not apply to turbid-flow conditions. Samples were considered representative of clear-flow conditions at a laboratory turbidity value <4 NTU.

The preliminary average and maximum WQO for total arsenic, chromium, silver, thallium, and vanadium and the preliminary average WQO for iron, lead, and manganese that were calculated using the background concentration procedure are recommended as final WQO for clear-flow conditions. These WQO were lower than the most conservative WQG that were used to identify COPCs. Preliminary maximum WQO for the remaining COPCs were greater than the WQG that were used to identify COPCs. However, they were lower than short-term or acute freshwater aquatic life and wildlife/livestock guidelines compiled during the COPC identification step. The preliminary average WQO for most COPCs other than cadmium were less than or only slightly greater than the most conservative WQO that were used to screen the data and identify COPCs. The WQO derived herein were consistently lower than the WQO derived for (KNO)KV-2, which is further upstream on the South McQuesten River main stem.

The study team recommends using dissolved concentration data (once available) to derive WQO for aluminum, cadmium, cobalt, copper, and iron and potentially lead and zinc because the dissolved forms of these metals are the forms most likely to be released by mining operations and are typically more representative of the bioavailable fraction. This recommendation is consistent with recommendations in The Guide for finalizing WQO. Additionally, development of dissolved WQO for all metal COPCs may be warranted, given that these WQO could potentially be applied to all seasons and conditions (i.e., during periods of turbid-flow).

In this study, there is uncertainty related to whether the data set accurately represents water quality conditions in the South McQuesten River and around the assumption that baseline water quality is protective of the existing uses in the watercourse. It is recommended that the numerical WQO are recalculated periodically using existing and newly-collected data to confirm their validity. The validation process should also include reconsideration of the list of COPCs (e.g., inclusion of new COPCs based on a review of newly-collected data). Methods for validating that non-degradation numerical WQO are protective of existing uses in the South McQuesten River should follow the validation methods for use-protection WQO. Specifically, surface water toxicity testing using sensitive life stages of species present in the river or representative species should be completed to confirm the most sensitive water use (i.e., freshwater aquatic life) is protected.

If water quality conditions fail to achieve the narrative WQO for use-protection, despite meeting the numerical WQO, then the WQO would be deemed invalid.

An initial assessment of whether the numerical WQO for clear-flow conditions attained the narrative WQO in 2020 and 2021 indicated that attainment of the maximum WQO (i.e., the 95th percentile baseline concentration) was achieved for most COPCs. However, two of the samples collected in early 2020 had concentrations of total manganese that exceeded the maximum WQO, which is indicative of non-attainment according to The Guide. Total cadmium and total cobalt concentrations in one sample each exceeded the maximum WQO in 2020 and 2021, respectively.

To support comparisons to the average numerical WQO (i.e., the one-tailed 95% UCLM of the baseline data set), 20-sample rolling geometric means were calculated and plotted along with the WQO. However, in completing this exercise, it was recognized that the methods used to derive the average numerical WQO for the South McQuesten River were statistically incompatible with the prescribed methods for confirming attainment. Specifically, the average WQO for each COPC was calculated for approximately 100 individual samples spread over a period of 15 years, whereas attainment was meant to be evaluated based on smaller sample size of 20 samples. To address the issues arising from differences in sample sizes, the study team calculated and evaluated additional screening values and considered whether it would be appropriate to assess attainment based on a larger sample size (e.g., 50 samples instead of 20). The study team determined that comparisons to the 95th percentile of the 20-sample rolling means in the baseline data set is likely a more appropriate method of assessing attainment, rather than making comparisons to the 95% UCLM. This is because the rate of exceedance of the 95th percentile of the 20-sample rolling means in the baseline data set is more consistently 5%. Alternatively, a 50-sample rolling geometric mean could potentially be used along with the 95% UCLM to confirm attainment at YT09DD0008 on the South McQuesten River. This is possible because exceedances of the average WQO in the baseline data set were on the order of approximately 5% for most COPCs when 50-sample rolling means were used. However, the study team recognizes that although confirmation of attainment based on a 50-sample rolling mean may be a feasible approach for YT09DD0008, it may not be suitable for use with other data sets.

Continued water quality sampling to confirm attainment should include collection of data as indicated in The Guide and the references cited therein. It is recommended that monitoring results be evaluated based on the following triggers or thresholds for non-attainment:

- Two or more of the 20 most-recent clear-flow samples with concentrations greater than the maximum WQO;

- A rolling geometric mean concentration (which is continually updated to include the most recent 20 clear-flow samples) that exceeds the 95th percentile of the 20-sample rolling means from the baseline data set by more than 5%;
- A rolling geometric mean concentration (which is continually updated to include the most recent 50 clear-flow samples) that exceeds the average WQO (i.e., the 95% UCLM of the baseline data set) by more than 5%; or
- A concentration that exceeds the maximum COPC concentration in the baseline data set or thresholds for toxic effects to biota (e.g., aquatic TRVs from the literature).

As part of this case study, consideration was given to the broader spatial and temporal application of the WQO derived at the long-term monitoring station. Because the non-degradation water management approach was used, it is expected that achievement of the numerical and narrative WQO at all areas upstream of YT09DD0008 would support achievement of WQO at YT09DD0008. Therefore, the WQO derived herein are applicable to the South McQuesten River at and upstream from YT09DD0008. It is not recommended that the WQO be applied downstream, given that inputs from along the main stem downstream of YT09DD0008 or from Haggart Creek will be captured.

11 UNCERTAINTIES

There uncertainties associated with the data sets and the processes used to identify COPCs and derive WQO. The key areas of uncertainty identified for this project are described below.

Concentrations of total metals may not be reliable indicators of the bioavailable fractions or the forms of COPCs released by quartz mining or other projects. Ideally, WQO for metals would be derived using dissolved concentrations, which are typically more representative of the bioavailable fraction (Adams et al. 2020). Total metal concentrations also tend to be more variable than dissolved concentrations due to the relationship between suspended sediments and adsorbed metals (Kerr and Cooke 2017; Sinclair et al. 2015). Due to the variability in the baseline data set for total metals, some allowances must be made for the expected natural average rate of exceedance. For most of the identified COPCs, an exceedance rate of more than 10 or 20% over the 95% UCLM is likely most useful in interpreting water quality data and identifying rates of elevated concentrations that would trigger a more detailed investigation.

The baseline data set may not adequately represent baseline conditions. The data set for the long-term monitoring station did not meet the requirement for more frequent sampling (i.e., five samples over a 30-day period) during known periods of high variability (e.g., freshet). However, the use of a data set spanning from 2004 to the end of 2019 was expected to help capture some of this variability in water quality conditions. Additionally, using a weight-of-evidence approach (i.e., considering the summary statistics for all stations, not just the long-term station) for identifying COPCs was expected to reduce uncertainties around which parameters occurred at elevated concentrations during the period over which baseline data were collected. Another source of uncertainty is how exactly the 2019 Shanghai Creek Fire, which burned along the section of the South McQuesten River that includes the long-term station, impacted the baseline surface water quality data set. Overall, collection and analysis of new data and validation of the numerical WQO is expected to reduce the uncertainties related to the baseline data set.

Some water quality parameters did not have WQG to support identification of COPCs. This is largely because water quality parameters are prioritized for WQG derivation based on rightsholder and stakeholder engagement and concerns, as well as the availability of data related to toxicity and toxicity modifying factors (CCME 2007). Therefore, the COPC identification process applied in this study (Section 5) assumes that parameters that have WQG accurately represent the list of parameters with the greatest potential to adversely affect relevant water uses (e.g., freshwater life, livestock). However, the evaluation of parameter concentrations relative to the 95th percentile concentrations of the baseline data set lends support to COPC selection.

A laboratory turbidity result of 4 NTU may not be the appropriate cutoff for identifying clear-flow conditions under which the WQO were derived or will be applied. To account for the greater variability in total (versus dissolved) metal concentrations with varying turbidity/TSS levels, it was necessary to identify an appropriate cutoff for delineating clear-flow versus turbid-flow conditions. Due to the paucity of field turbidity data and the temporal limitations of the TSS/non-filterable residue data set for the long-term station, it was necessary to use a laboratory, rather than field, measurement. Additionally, the 4 NTU laboratory turbidity cutoff was selected based on professional judgement and visual examination of the data plots and is therefore somewhat subjective.

Baseline water quality may not be adequately protective of existing uses in the South McQuesten River. This is an aspect of the non-degradation approach in general but applies to this study. Associated uncertainties should be addressed through toxicity testing with site water and subsequent validation of the WQO.

12 CONCLUSIONS AND RECOMMENDATIONS

Conclusions and recommendations based on the outcomes of this study are as follows:

- Overall, the data sets for physicochemical parameters, ions, and nutrients were limited (i.e., represented few stations, years, and sampling events).
- Additionally, there was a paucity of flow data to support interpretation of parameter concentrations reported for the South McQuesten River. Flow data are valuable for understanding contaminant loading and seasonal fluctuations in parameter concentrations. It is therefore recommended that Government of Yukon attempt to coordinate flow monitoring with any future water quality monitoring at locations where there is an intention to derive WQO.
- Of the data sets provided for the South McQuesten River and its tributaries, only two had three years of continuous monthly monitoring data, as per the recommendations set out in The Guide, and neither of these data sets met the recommendation for more frequent sampling annually during expected periods of high, short-term variability in water quality conditions (e.g., during freshet). It is therefore recommended that Yukon Government continues to monitor water quality at the station YT09DD0008. Yukon Government is committed to monitoring this location as part of its long-term water monitoring network operated in partnership with ECCC. In addition, for the long-term monitoring station (YT09DD0008) or any other location where WQO are meant to be derived, it is recommended that the frequency of water quality monitoring events be re--evaluated and aligned with the recommendations of The Guide.
- Given the completeness of the data sets and the requirements of The Guide, it was determined that the most appropriate location for deriving WQO was the long-term water quality monitoring station downstream from Flat Creek (YT09DD0008). However, because dissolved metal concentration data were not reported at the recommended frequency for this station, it was necessary to derive WQO for total metal concentrations and clear-flow conditions only. The WQO should not be applied to turbid flow conditions (e.g., during freshet or any other period when laboratory turbidity >4NTU).
- In response to the interim recommendations for this study, Government of Yukon and ECCC began analyzing dissolved, in addition to total, metal concentrations in water samples collected from YT09DD0008. Sampling and analyses should be completed at least monthly and more frequently during freshet, and other known periods of high variability, to align with the recommendations in The Guide. This would allow Government of Yukon to revisit the data for this station after a few years' time and update the WQO.

Until then, Government of Yukon can continue to use the analytical results for total metals to confirm attainment. Alternatively, Government of Yukon could investigate potential options for increasing the frequency of water quality sampling at (EG)W49 (Figure 1.1) to support derivation of WQO at this location. The rationale for this would be to develop WQO that reflect inputs from Haggart Creek, in addition to the inputs upstream.

- Maximum concentrations of total arsenic, chromium, iron, lead, manganese, silver, thallium, and vanadium exceeded the 95th percentile baseline concentration by a factor of two or more in one or more samples from the long-term monitoring station (YT09DD0008) on the South McQuesten River main stem.
- In addition to the parameters listed above, fluoride and total aluminum, cadmium, cobalt, copper, and zinc were identified as COPCs and were carried forward for WQO derivation. These parameters (in addition to total arsenic, iron, lead, and silver) had concentrations that exceeded WQG in two or more months within a three-year period, or for a period greater than 30 days.
- The non-degradation water management approach was identified as the most appropriate approach for WQO derivation that will apply at the long-term monitoring station (YT09DD0008). On this basis, the numerical WQO were derived using the background concentration procedure, as per the recommendations in The Guide.
- The data set for the long-term monitoring station (YT09DD0008) on the South McQuesten River was split into two "populations" of data (i.e., samples representing clear-flow versus turbid-flow conditions) based on laboratory measurements of turbidity. Samples with laboratory turbidity measurements <4 NTU were considered representative of clear-flow conditions. As new water chemistry samples are collected from the long-term monitoring station, it will be necessary to identify samples representative of clear-flow conditions. Comparisons to the WQO and confirmation of attainment can only be completed for these types of samples.
- The preliminary average and maximum WQO for total arsenic, chromium, silver, thallium, and vanadium and the preliminary average WQO for iron, lead, and manganese calculated using the background concentration procedure are recommended as final WQO. Consistent with The Guide, the study team recommends using dissolved concentration data (once available) to derive WQO for aluminum, cadmium, cobalt, copper, and iron and potentially lead and zinc because the dissolved forms of these metals are the forms most likely to be released by mining operations and are typically more representative of the bioavailable fraction. Derivation of dissolved WQO for all COPCs

may be warranted, given that the dissolved (versus total) WQO could apply to turbid and clear-flow conditions.

- To confirm their validity, the numerical WQO should be recalculated periodically using existing and newly-collected data; the list of COPCs should also be revisited concurrent with recalculation of the WQO. The approach to validation should be consistent with that of the use-protection water management approach and should include surface water toxicity testing with sensitive life stages of relevant aquatic species.
- The initial evaluation of attainment indicated that for most COPCs, an exceedance rate of more than 5% for comparisons to the 95th percentile of the 20-sample rolling means or the 95% UCLM WQO for 50-sample rolling means is likely most useful in interpreting water quality data and identifying rates of elevated concentrations that would signal the potential for non-attainment and trigger a more detailed investigation.
- It is recommended that monitoring results be evaluated based on the following triggers or thresholds to investigate and confirm non-attainment:
    - Two or more of the 20 most-recent clear-flow samples with concentrations greater than the maximum WQO;
    - A rolling geometric mean concentration (which is continually updated to include the most recent 20 clear-flow samples) that exceeds the 95th percentile of the 20-sample rolling means from the baseline data set by more than 5%;
    - A rolling geometric mean concentration (which is continually updated to include the most recent 50 clear-flow samples) that exceeds the average WQO (i.e., the 95% UCLM of the baseline data set) by more than 5%; or
    - A concentration that exceeds the maximum COPC concentration in the baseline data set or thresholds for toxic effects to biota.
- Because the non-degradation water management approach was applied at the long-term monitoring station (YT09DD0008), it is expected that achievement of the numerical and narrative WQO at all areas upstream of YT09DD0008 would support achievement of WQO at YT09DD0008. Therefore, the WQO are applicable to the South McQuesten River at and upstream from YT09DD0008. It is not recommended that the WQO be applied downstream of YT09DD0008, given that the WQO will not capture inputs from along the main stem downstream of YT09DD0008 or from Haggart Creek.
- The study team cautions that the WQO derived for YT09DD0008 are not transferable to other systems, even those within the Yukon River drainage. Additionally, the approaches

that were used here to derive WQO and evaluate attainment were selected based on the specific conditions of the YT09DD0008 data set (see Sections 2 and 8). Therefore, the methods and triggers for non-attainment described here are not considered transferable to other projects.

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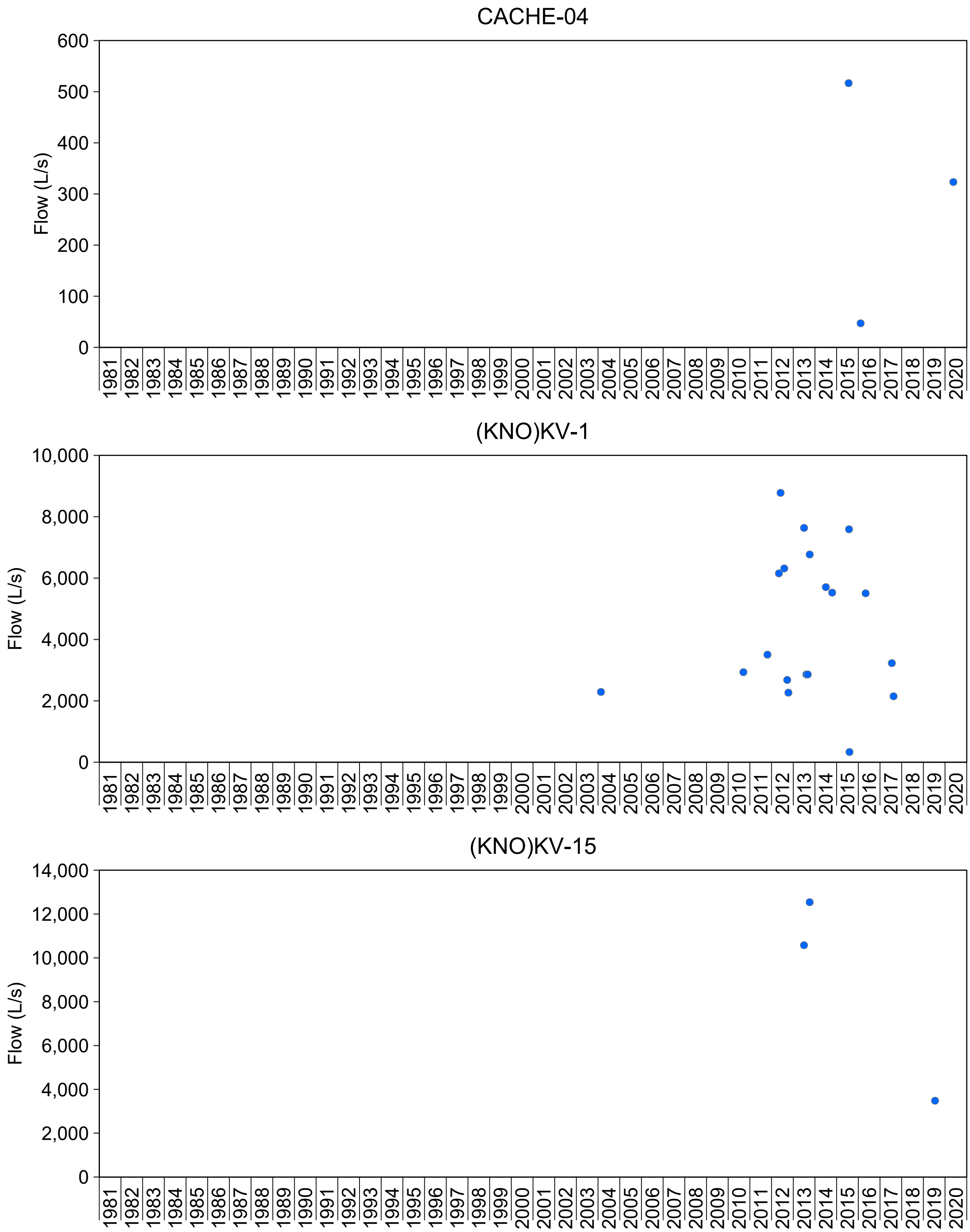
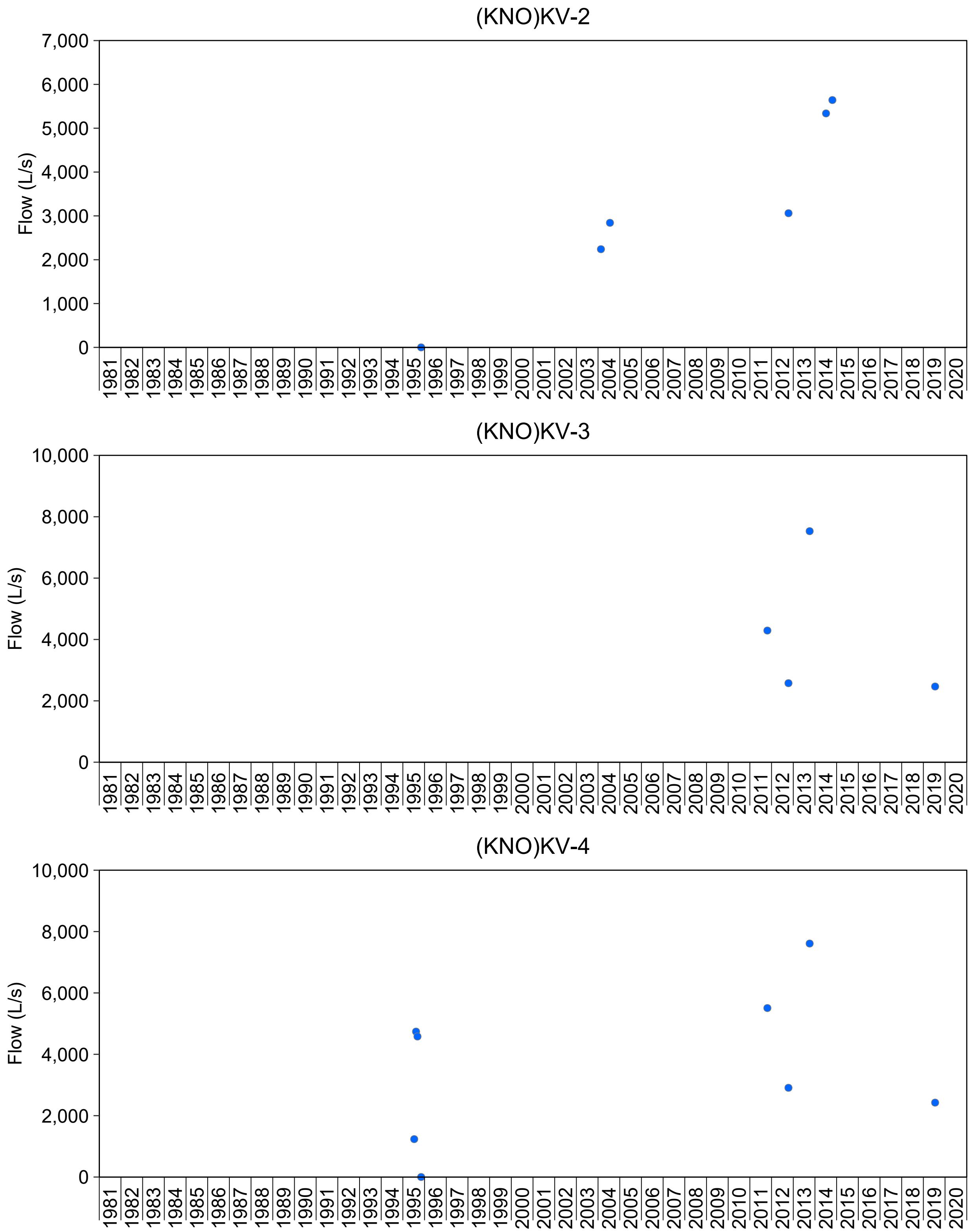


Figure A.1: Time Series Plots of Flows (L/s) in the South McQuesten River, 1981 to 2020

Notes: L/s = litres per second.



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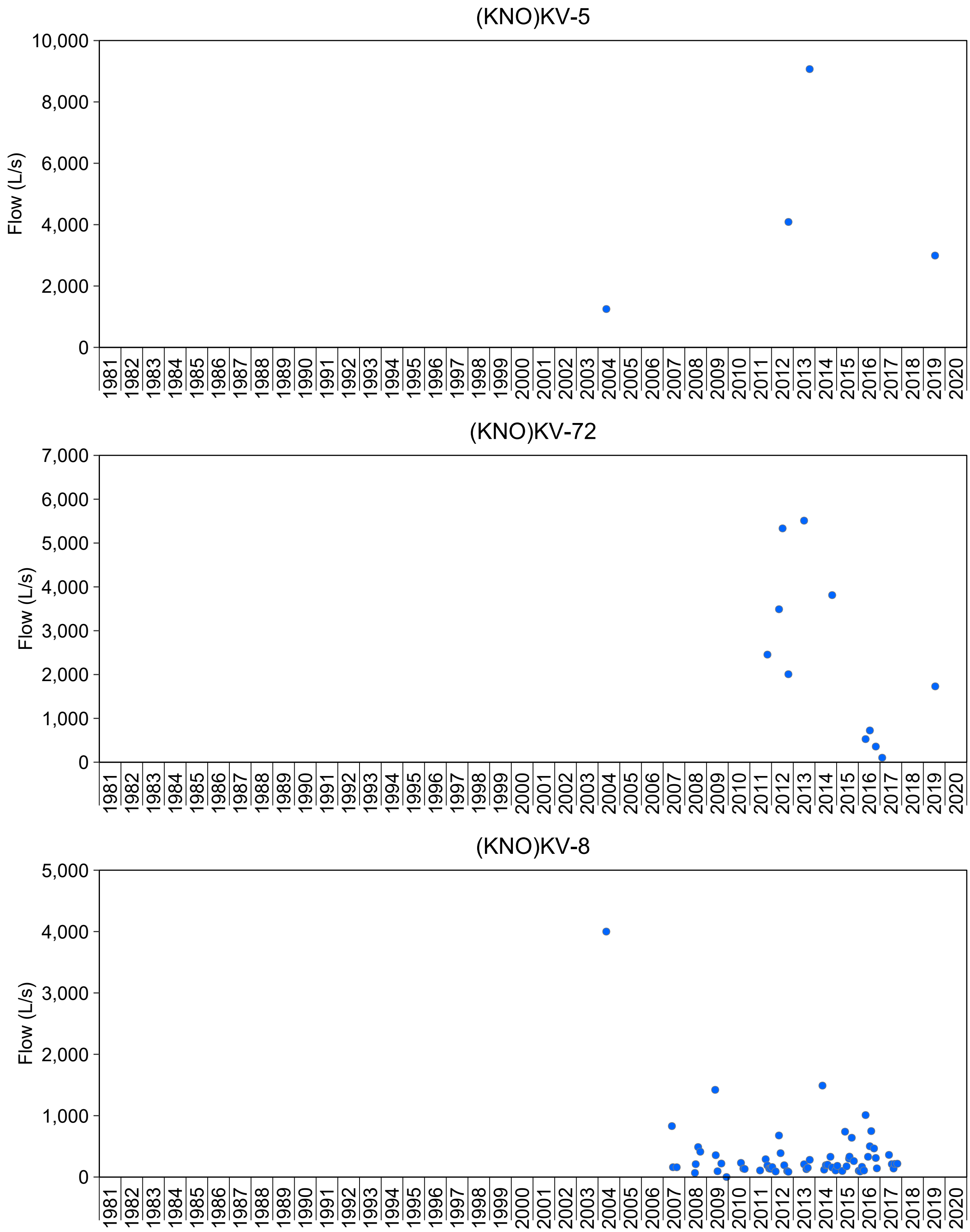

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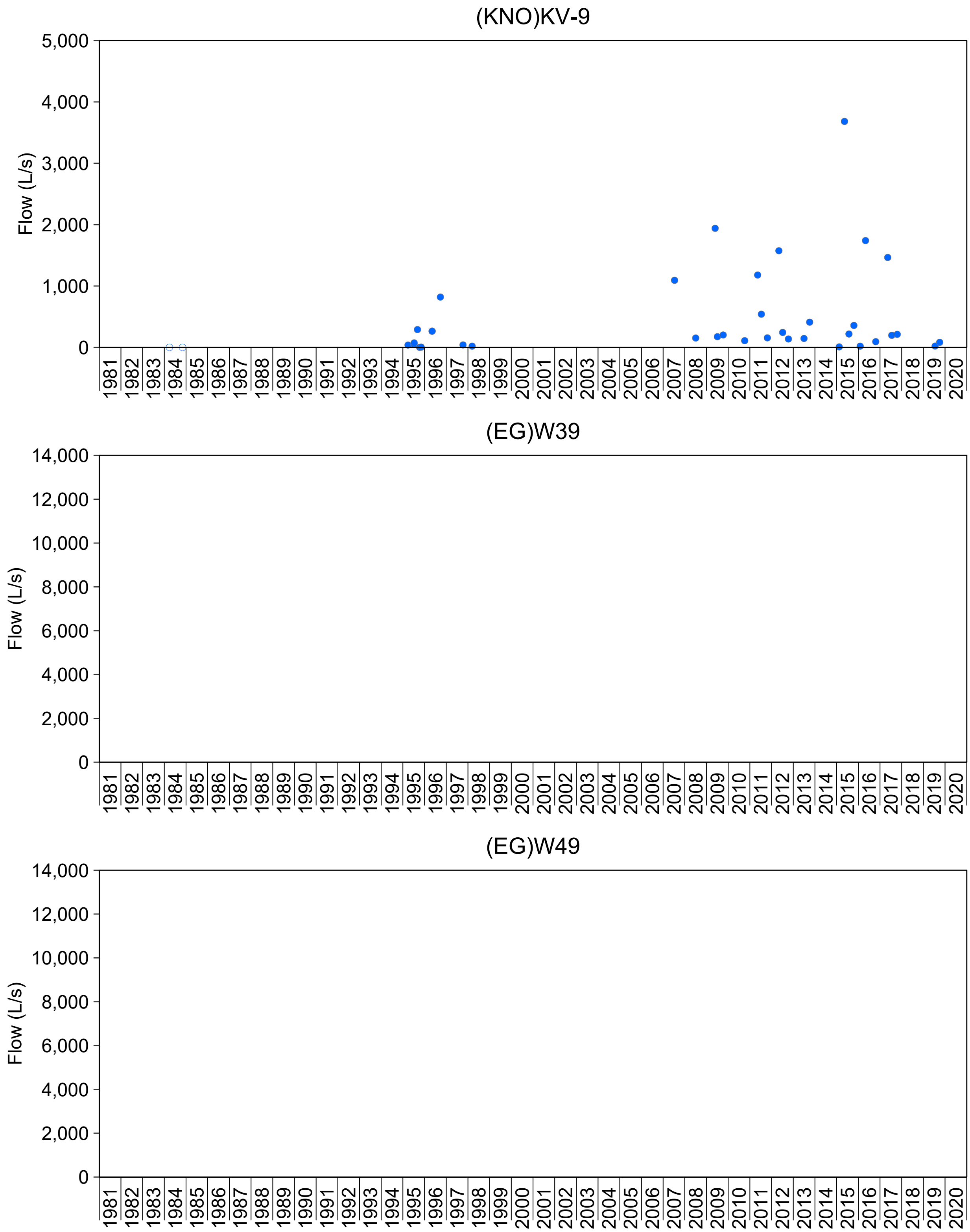

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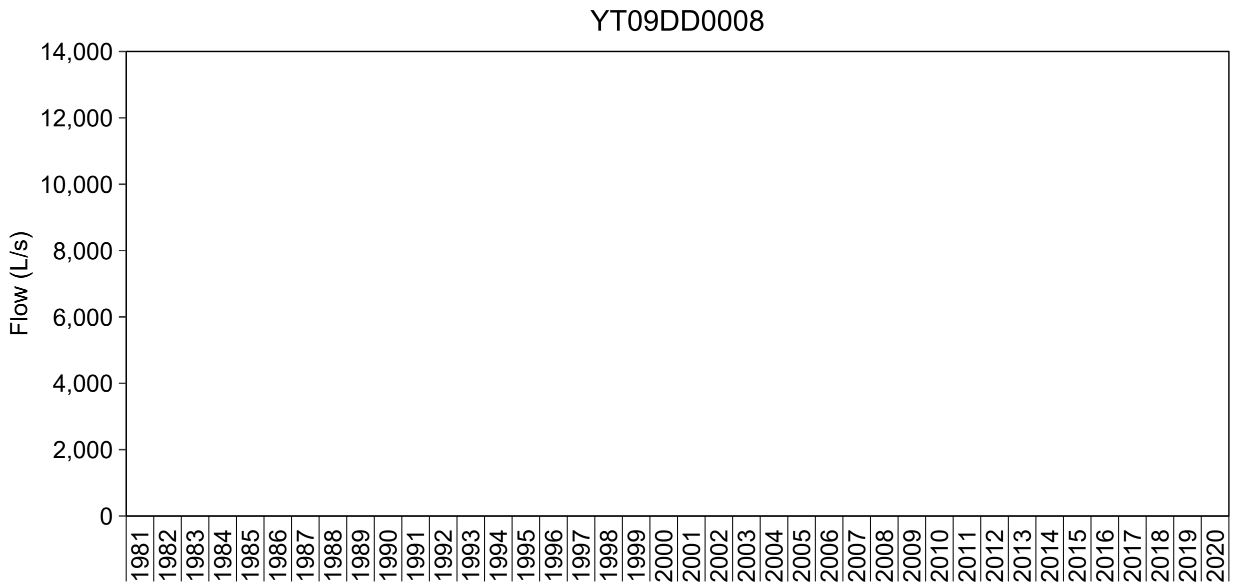

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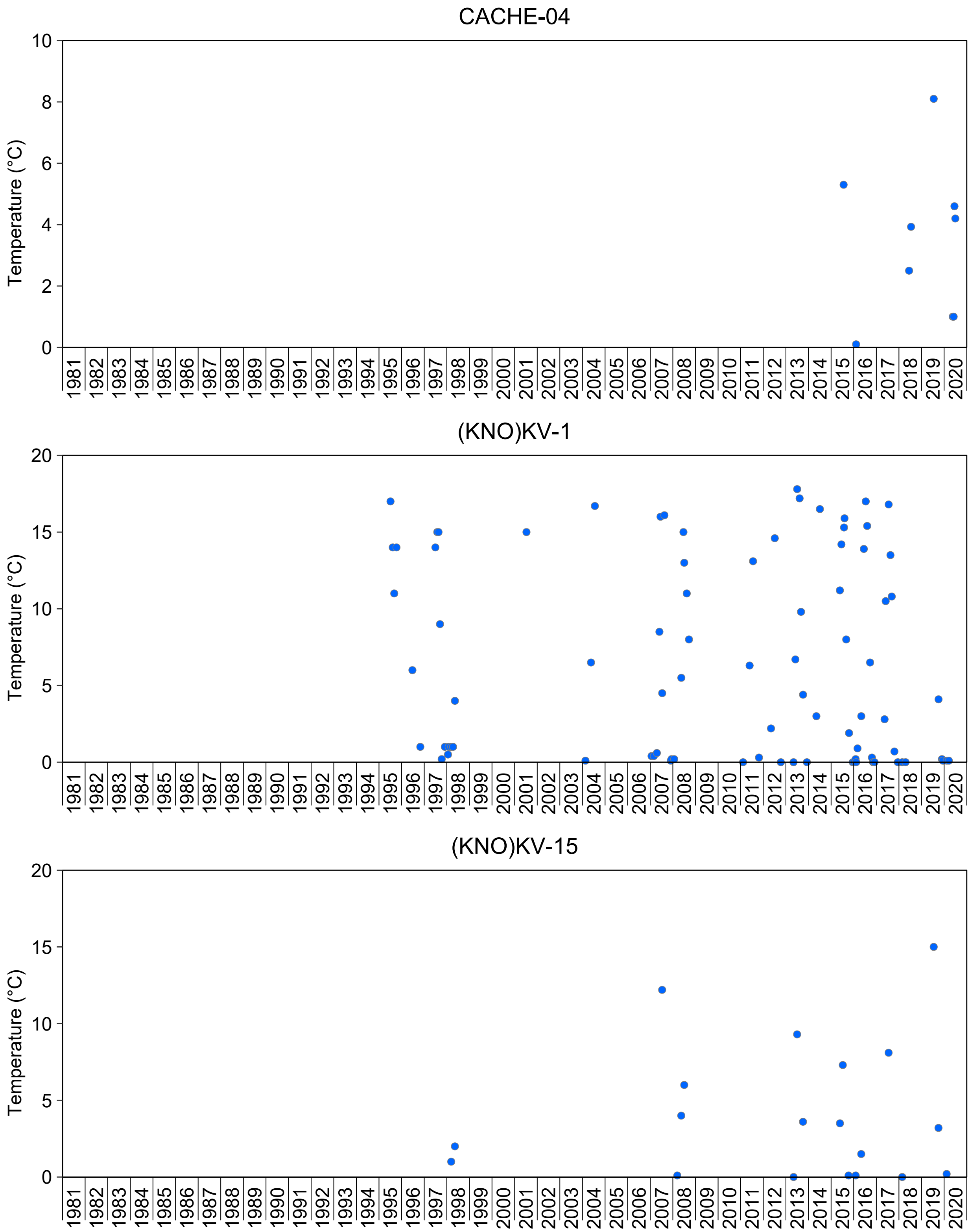
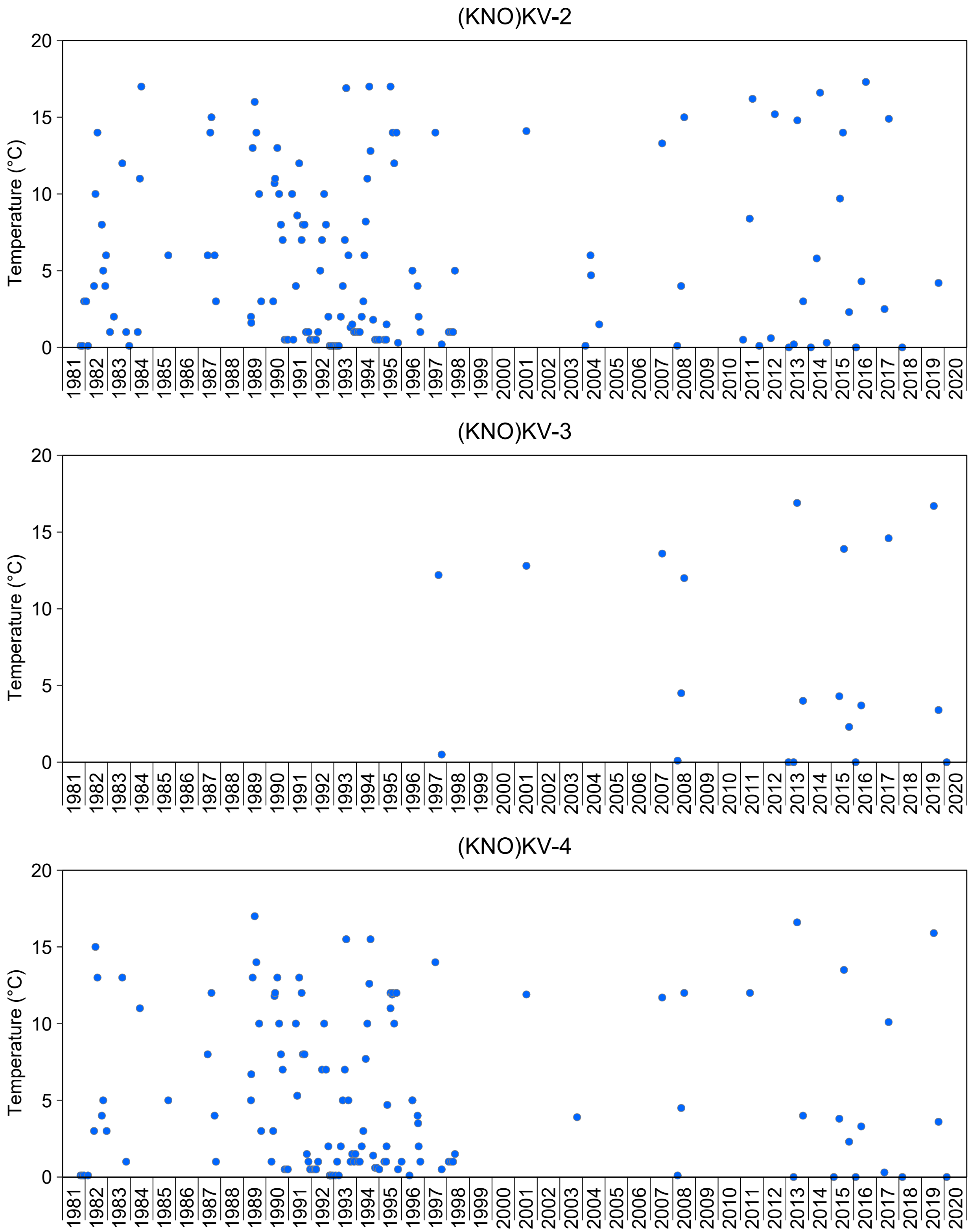


Figure A.2: Time Series Plots of Water Temperatures (°C) in the South McQuesten River, 1981 to 2020

Notes: °C = degrees Celsius.



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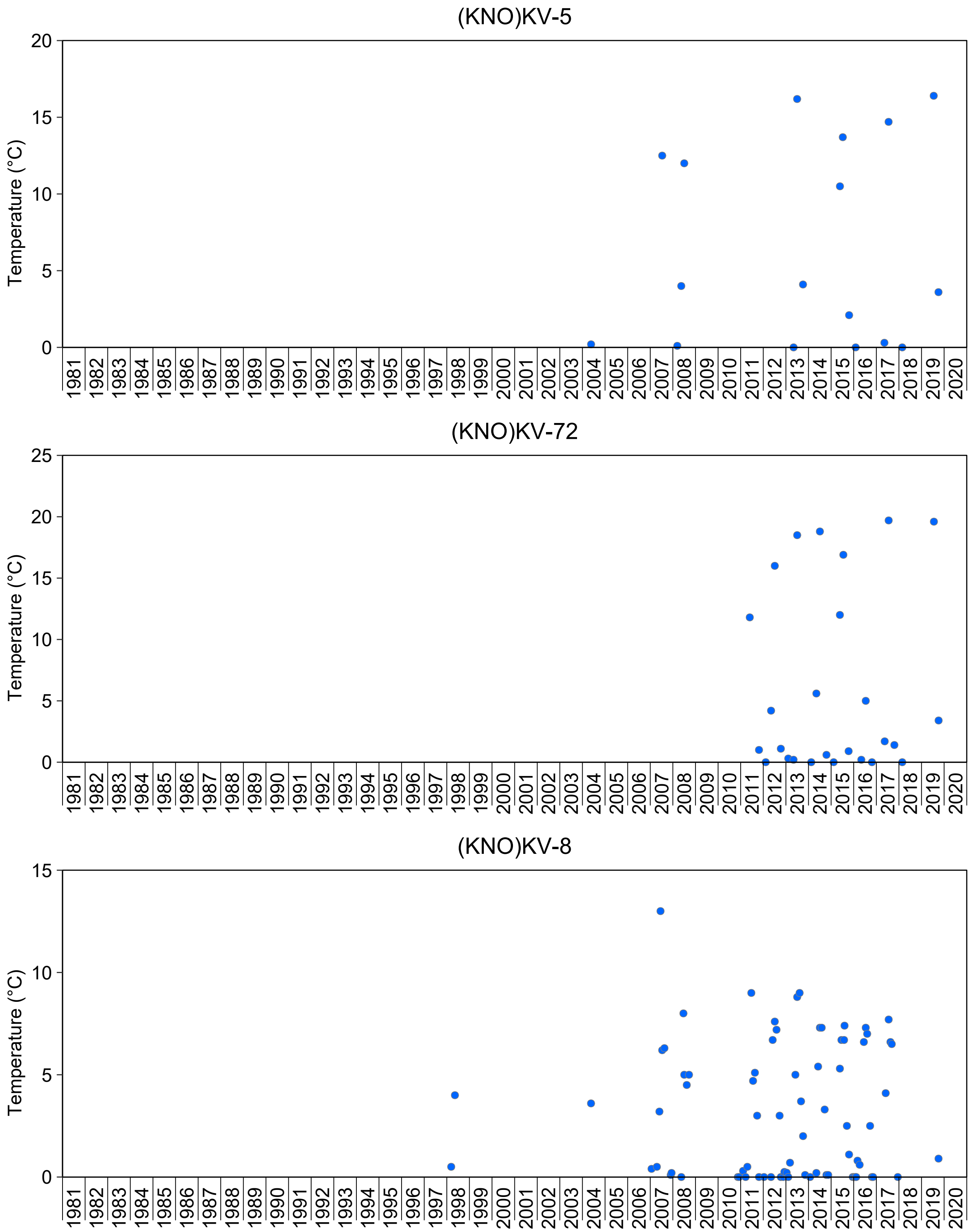

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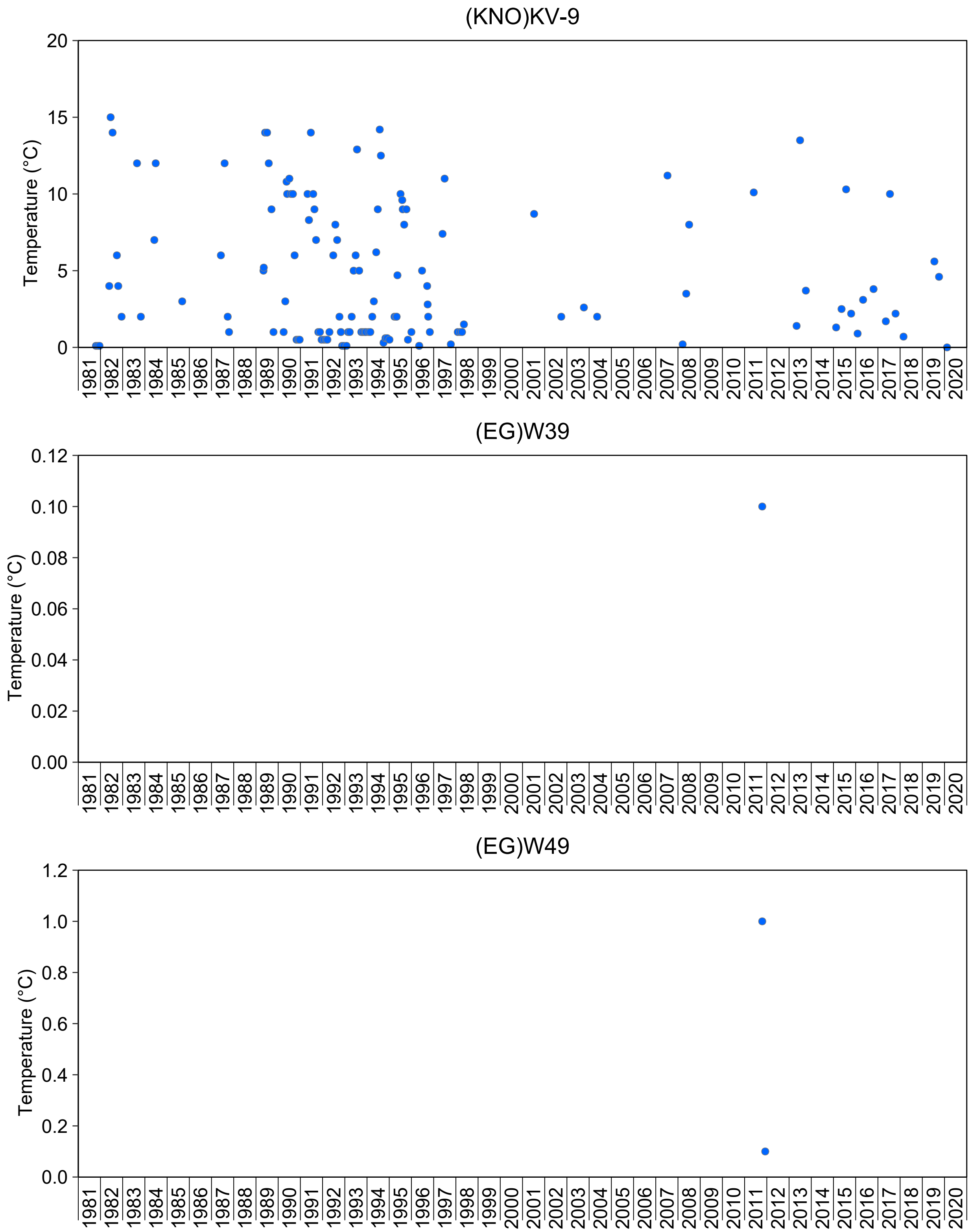

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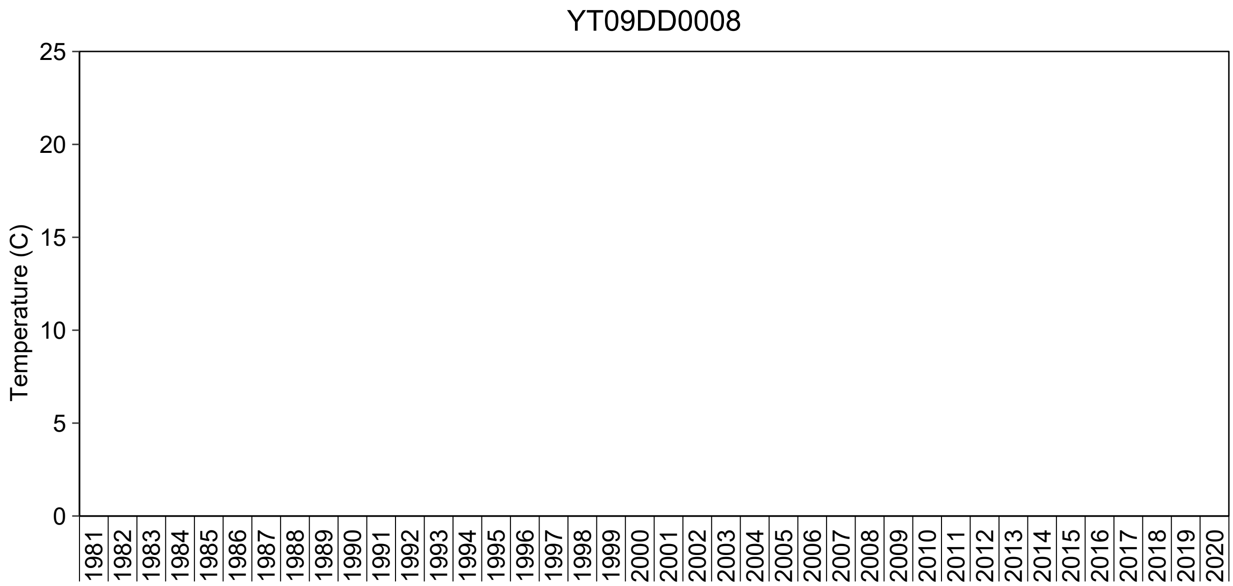

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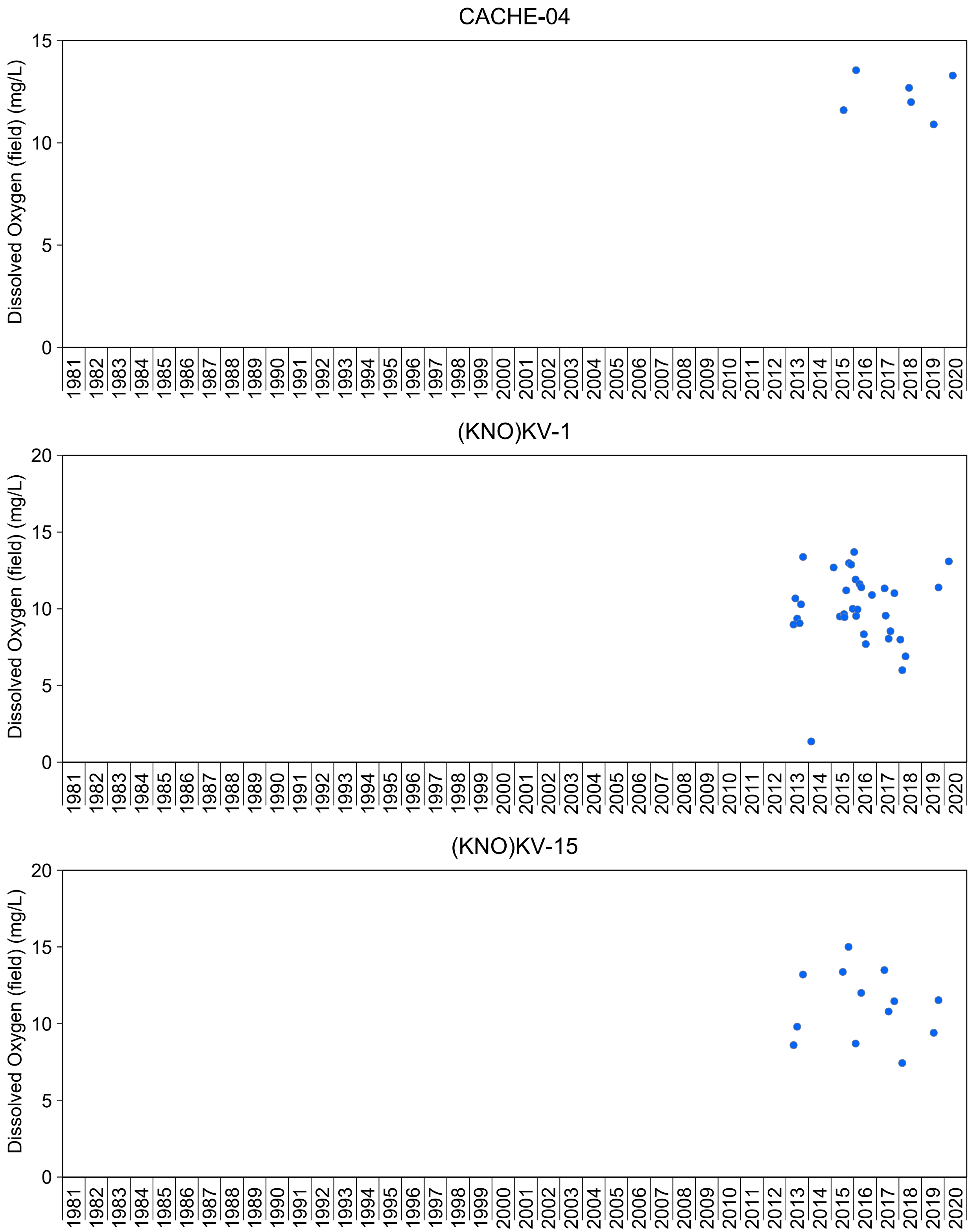
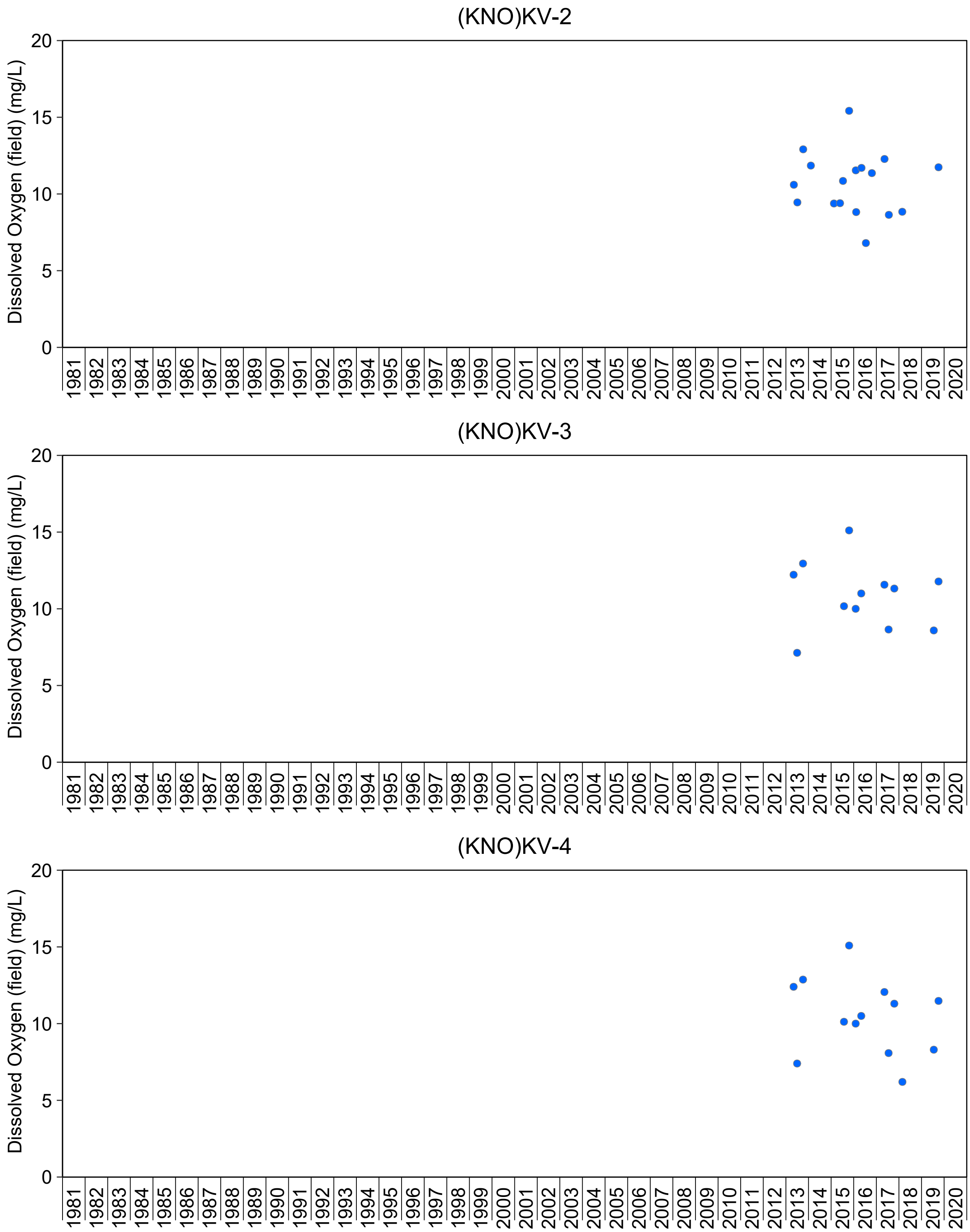


Figure A.3: Time Series Plots of Dissolved Oxygen (field) Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre.



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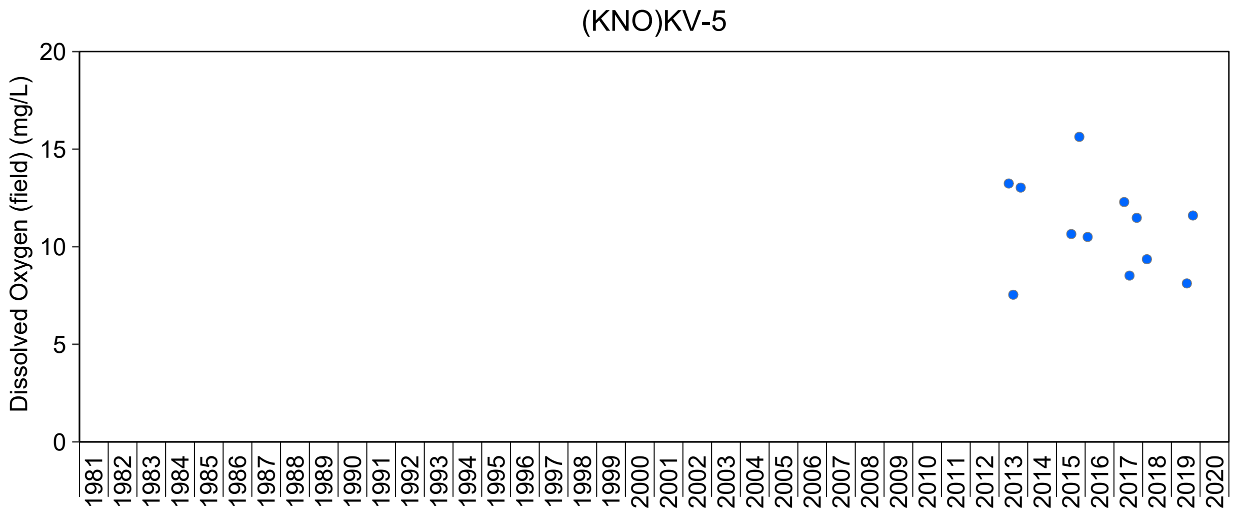

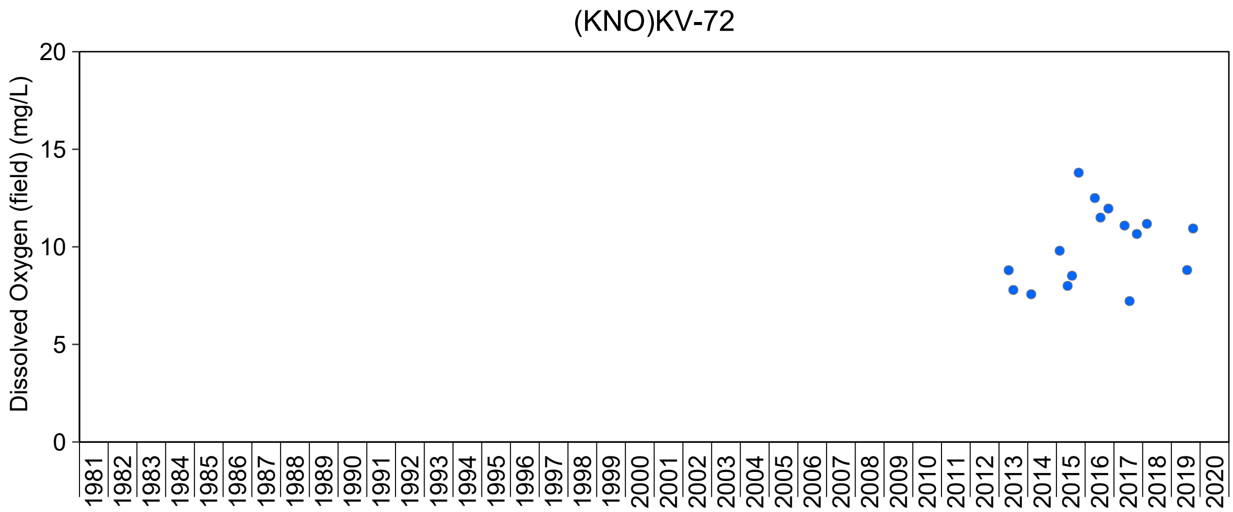

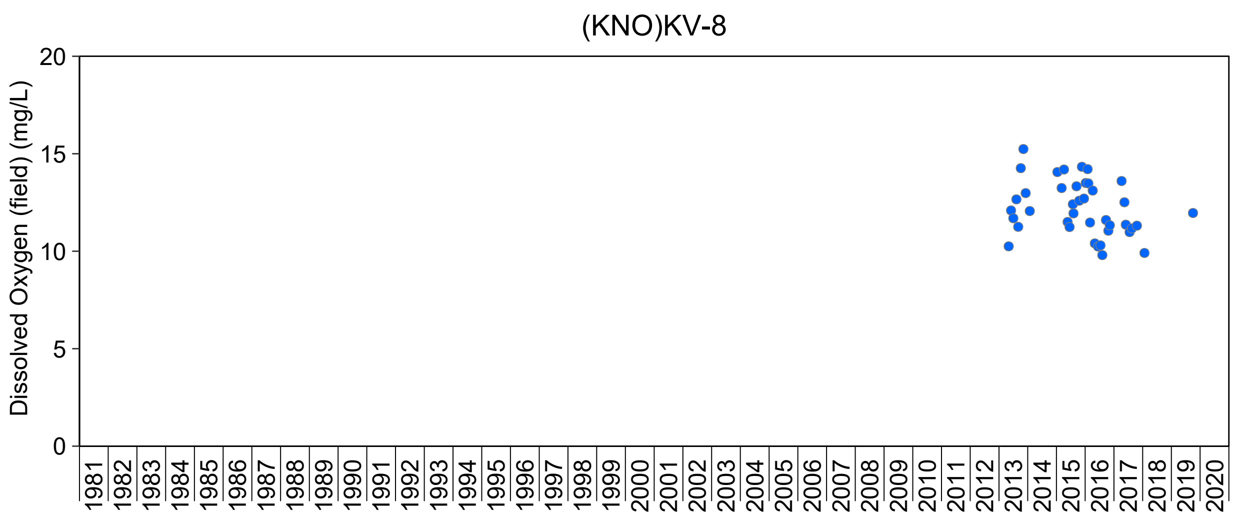

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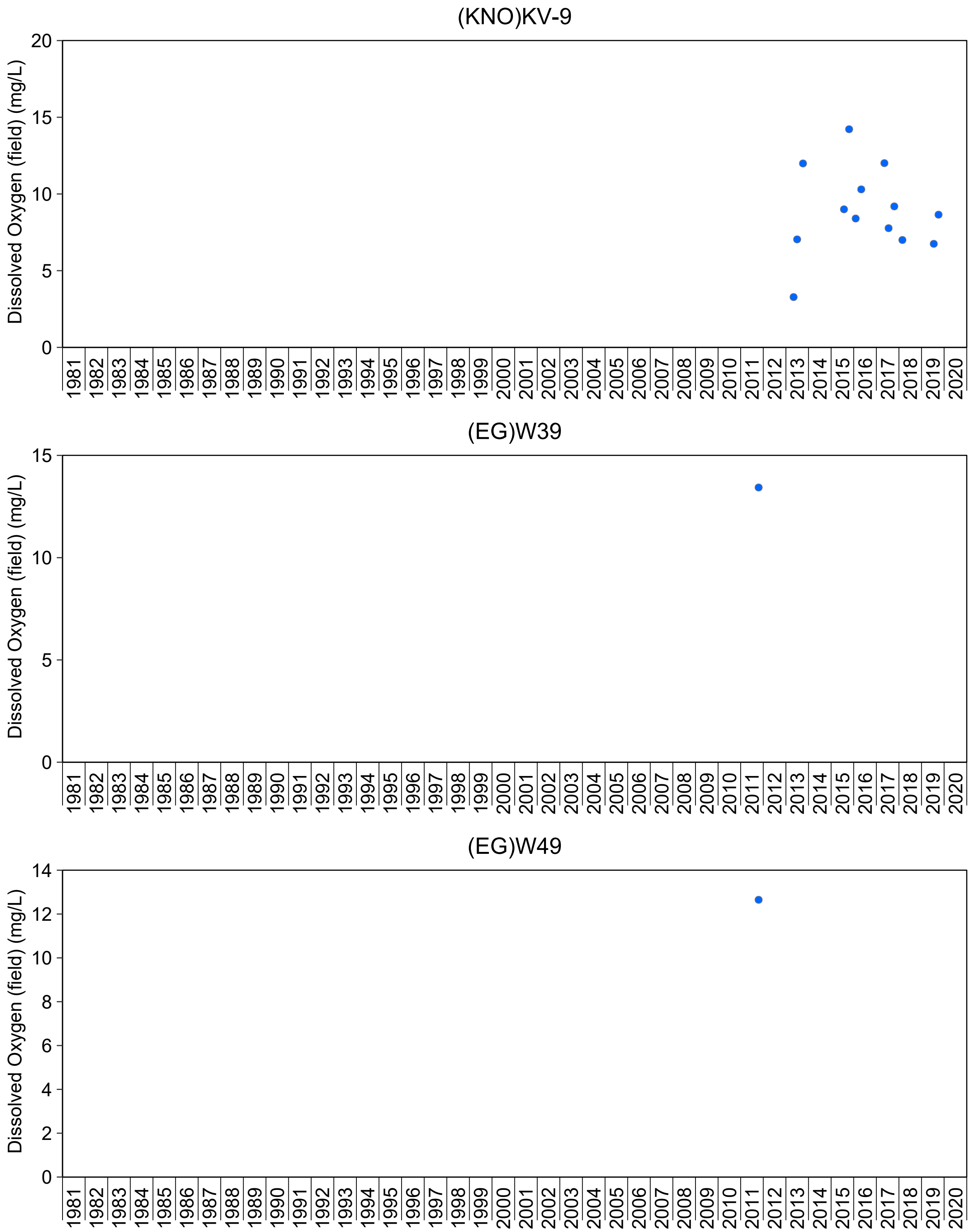

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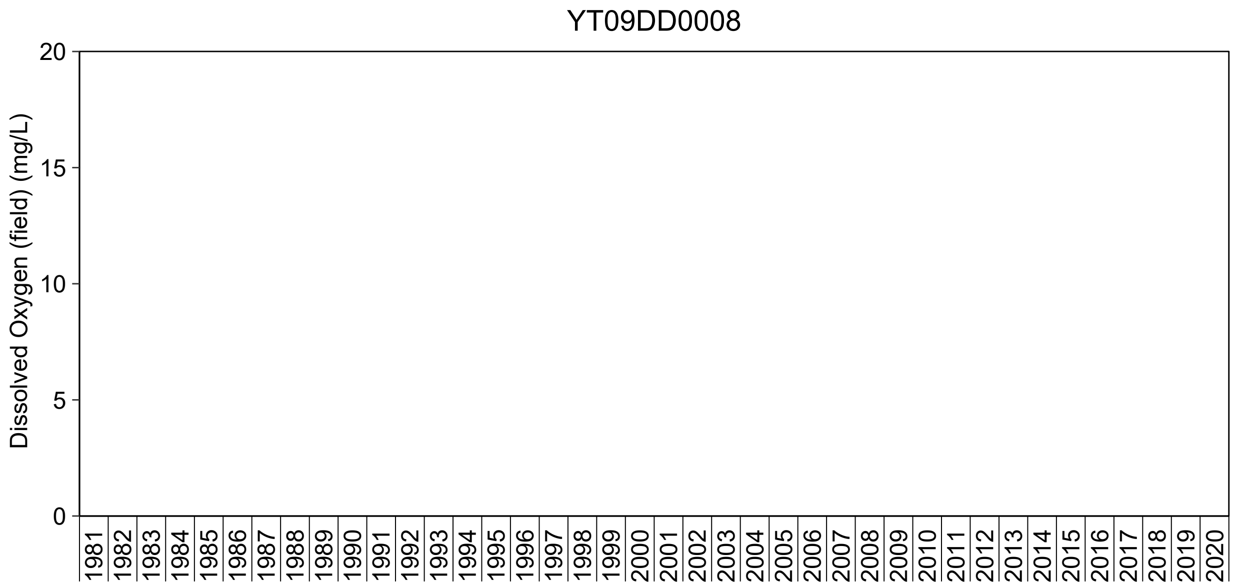

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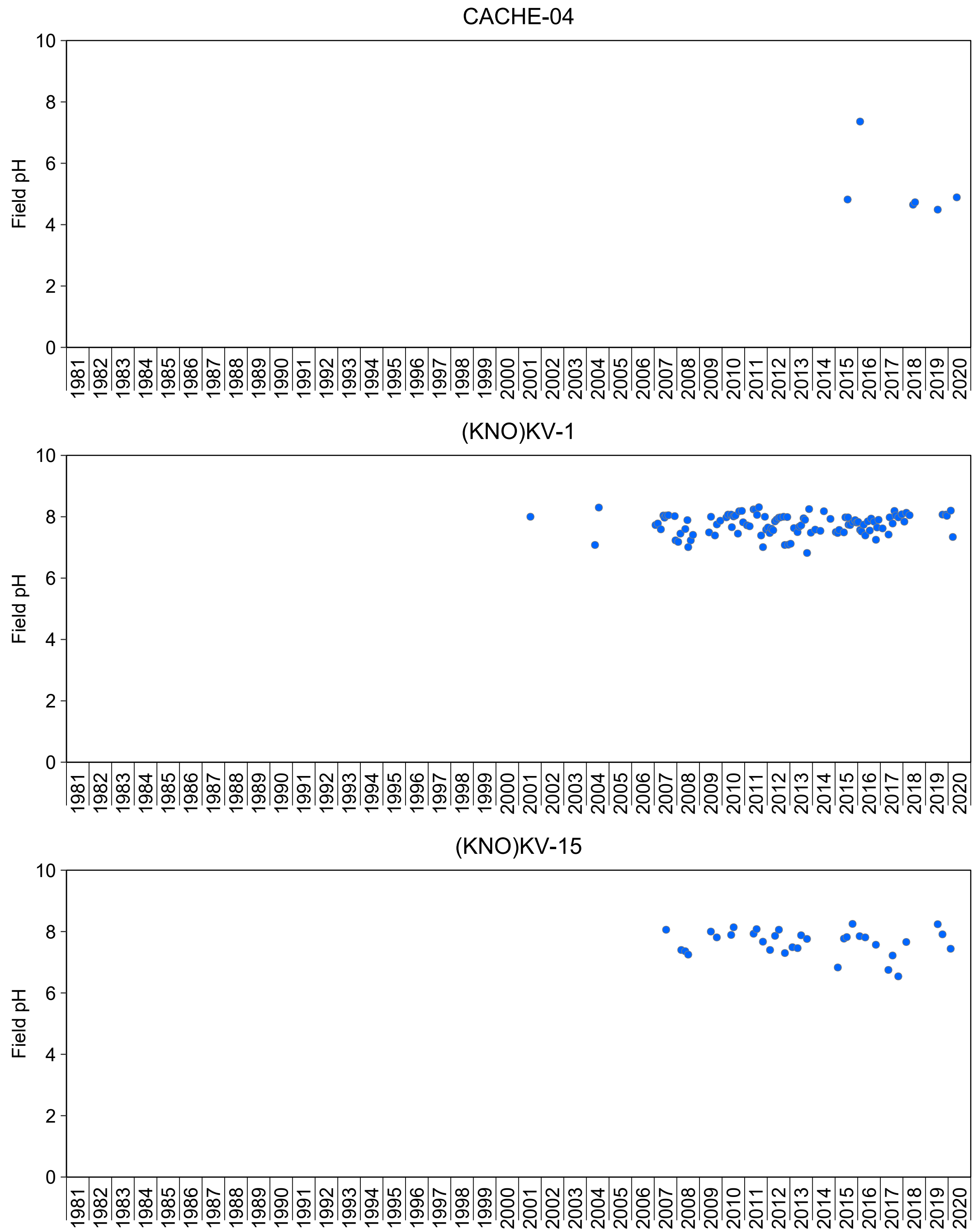
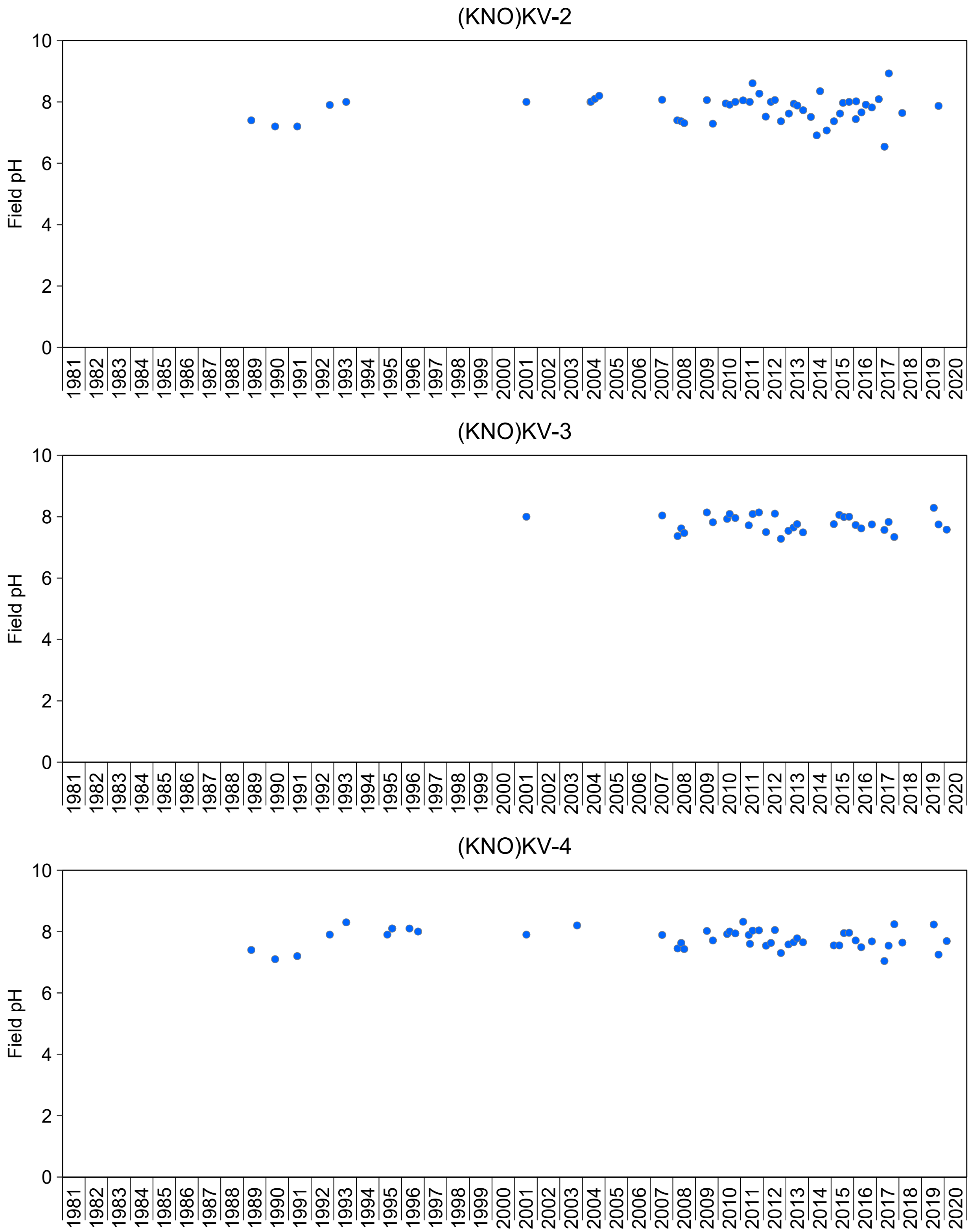


Figure A.4: Time Series Plots of pH (field) in the South McQuesten River, 1981 to 2020



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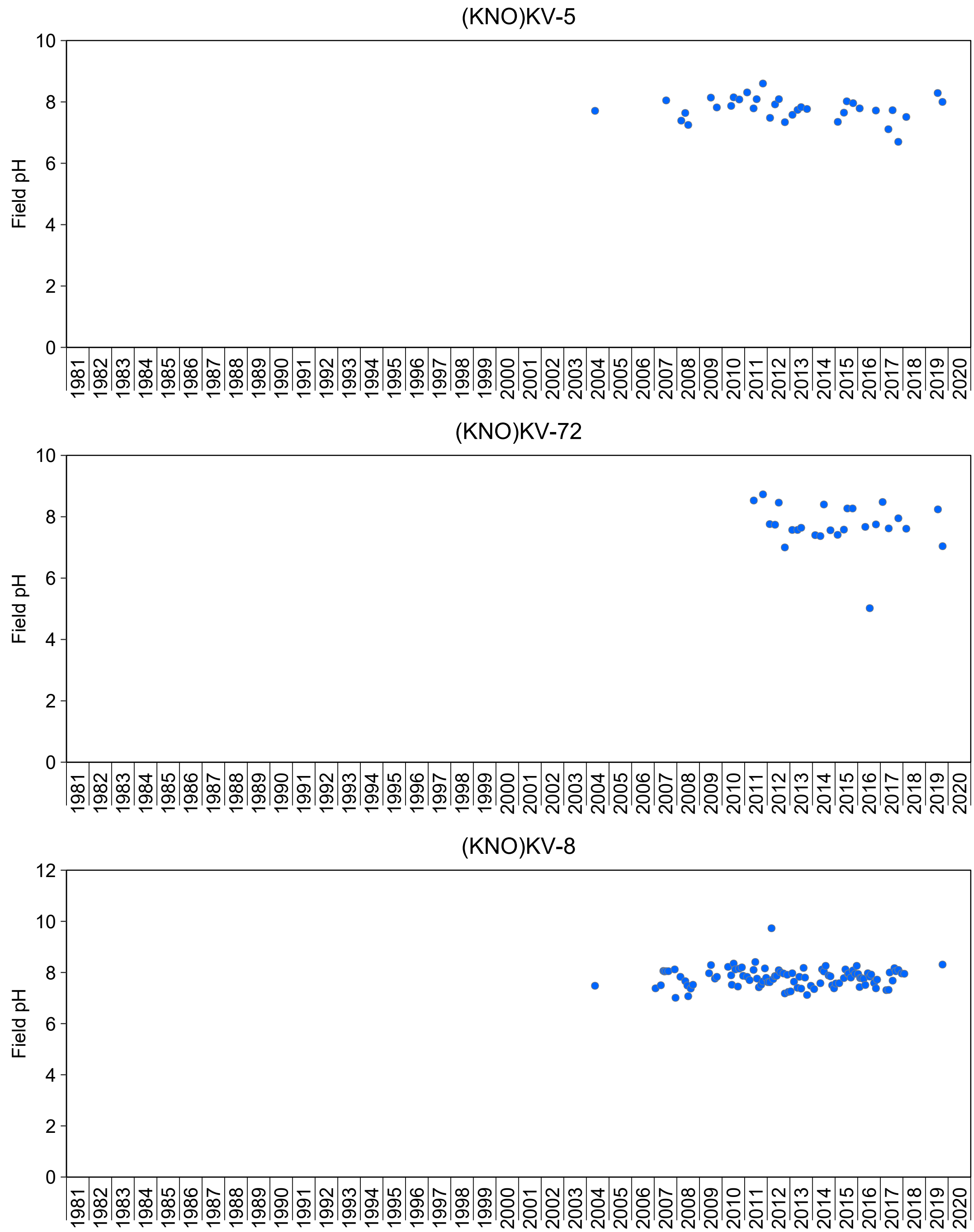

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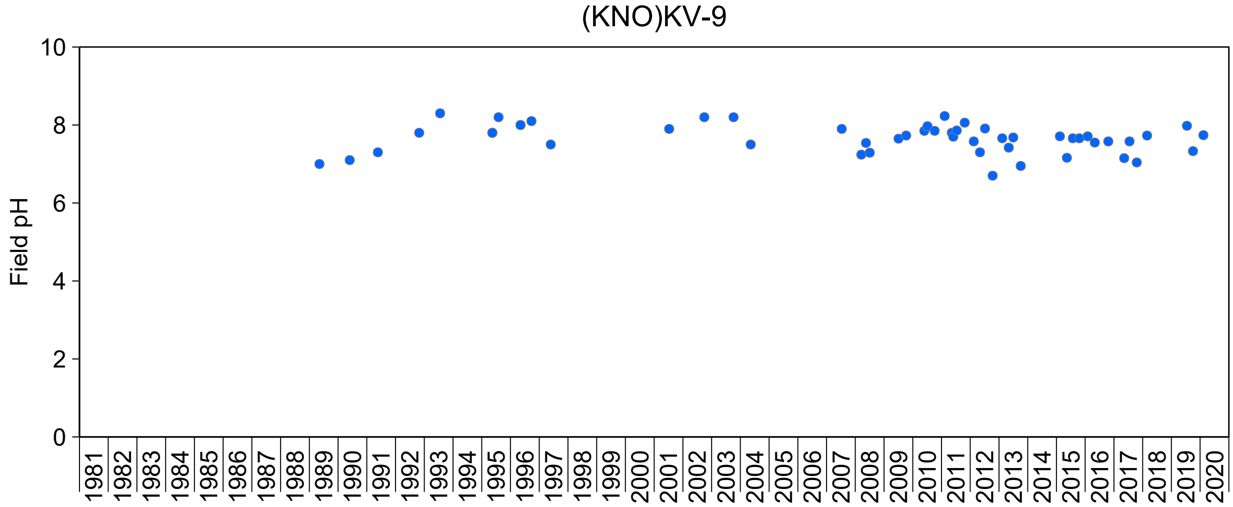

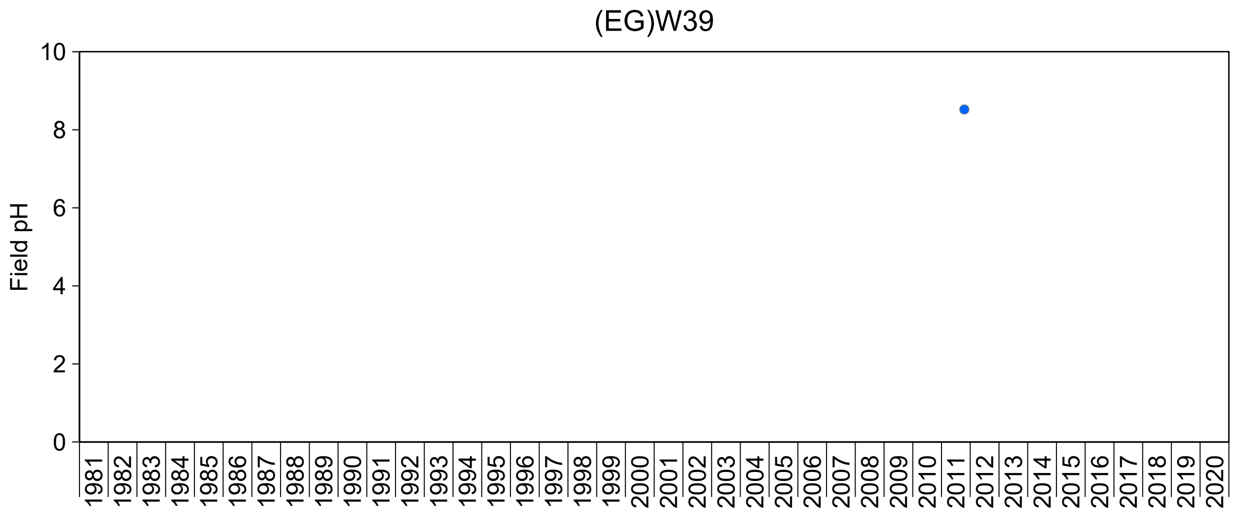

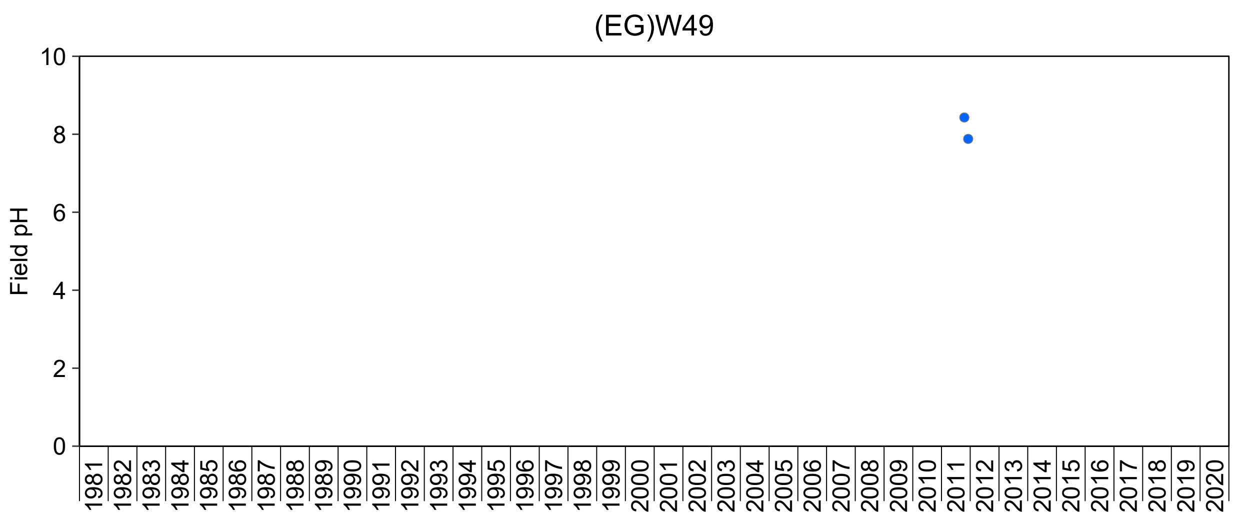

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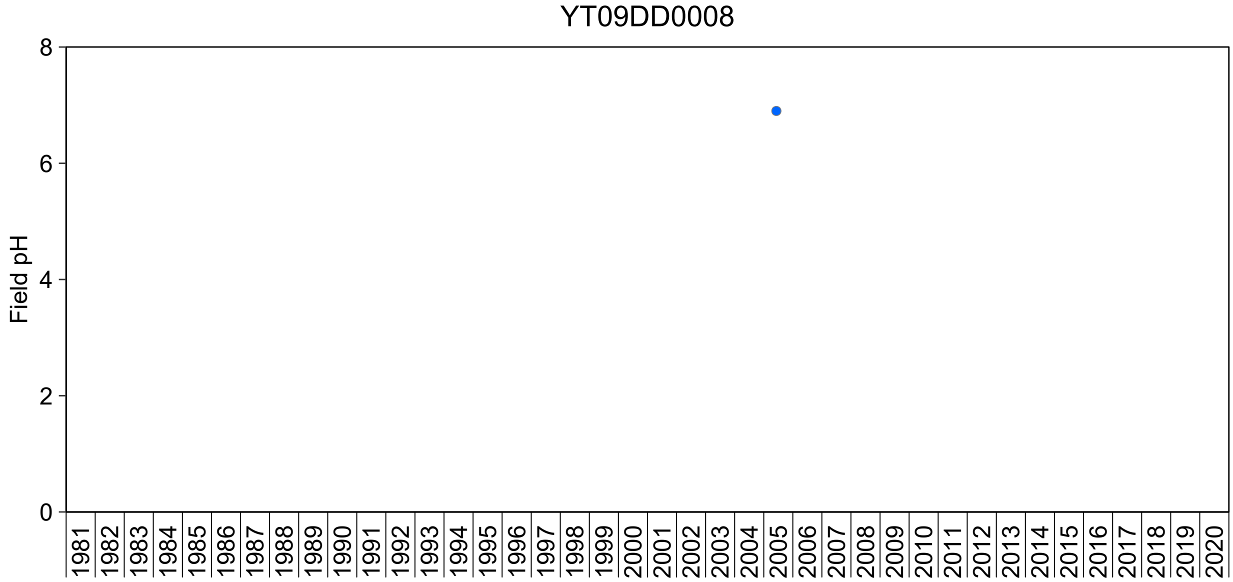

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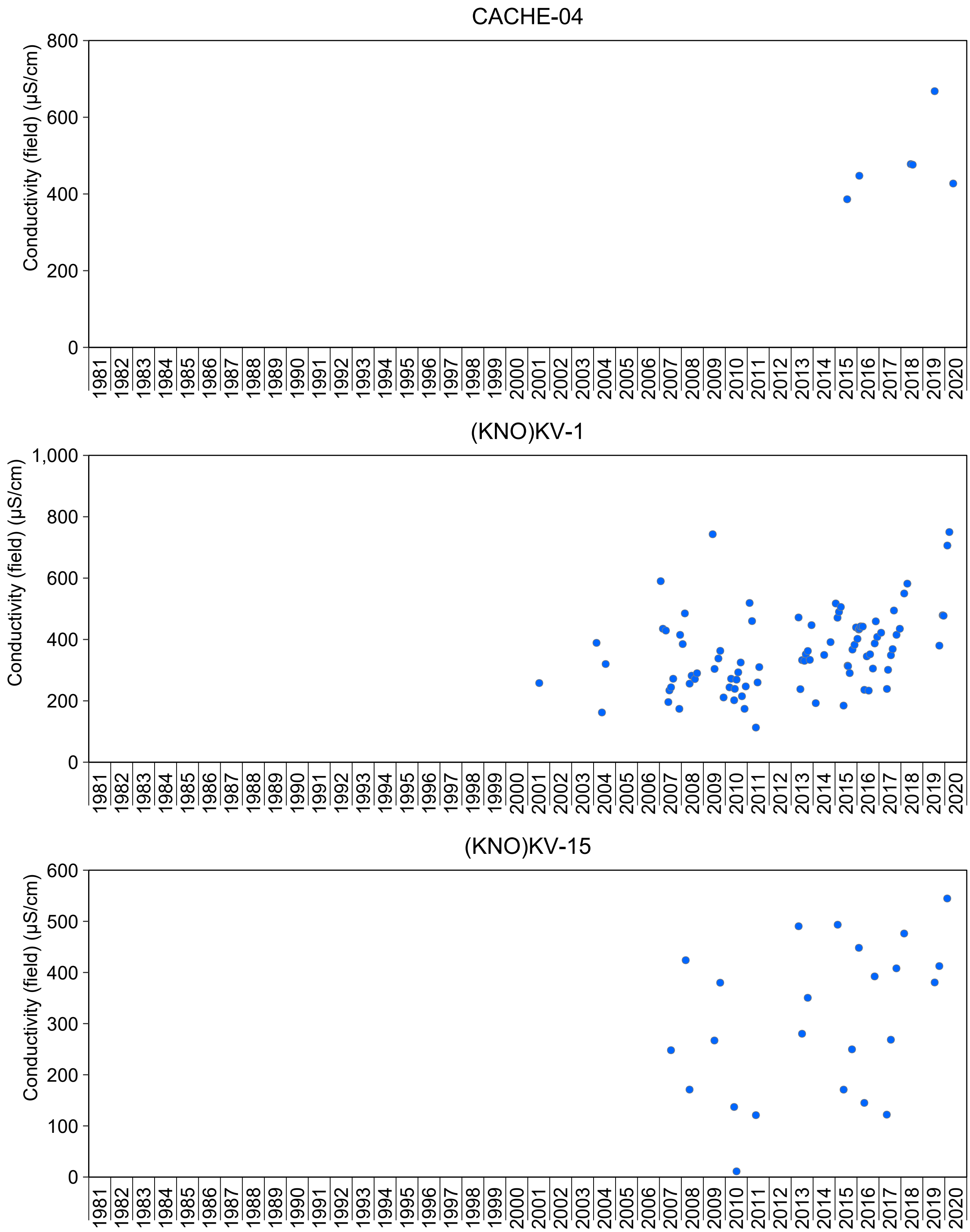
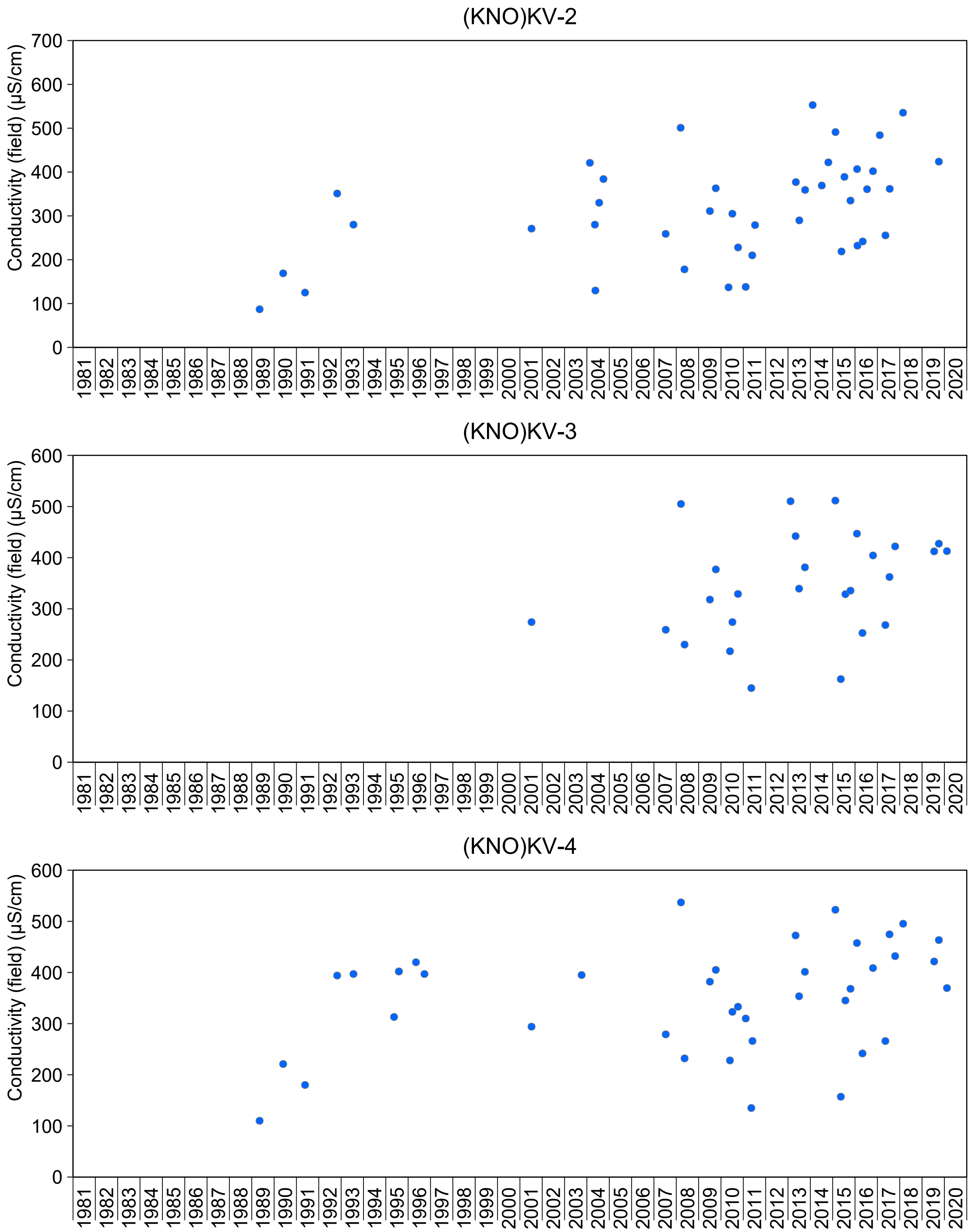


Figure A.5: Time Series Plots of Conductivity (field; µS/cm) in the South McQuesten River, 1981 to 2020

Notes: µS/cm = microSiemens per centimetre.



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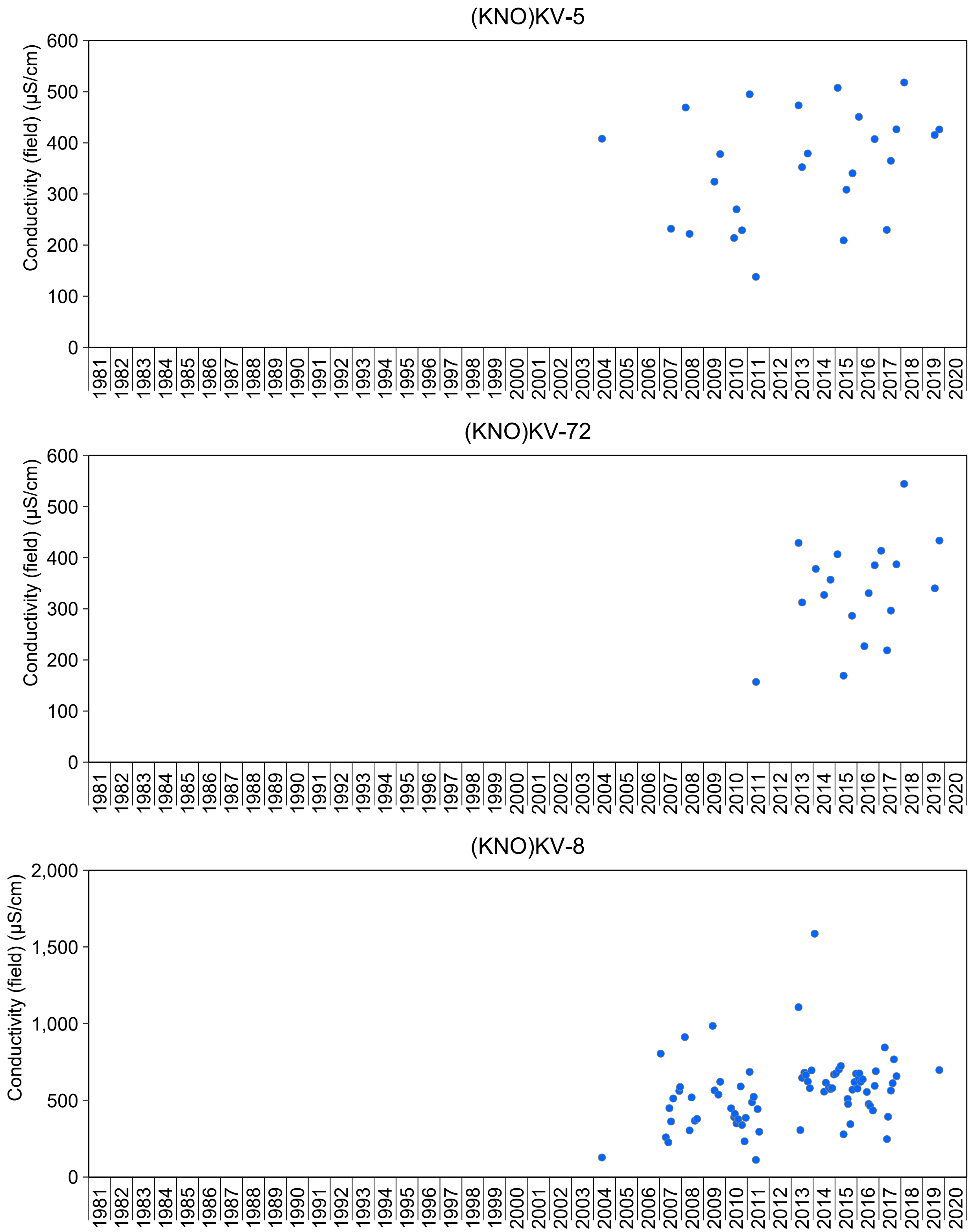

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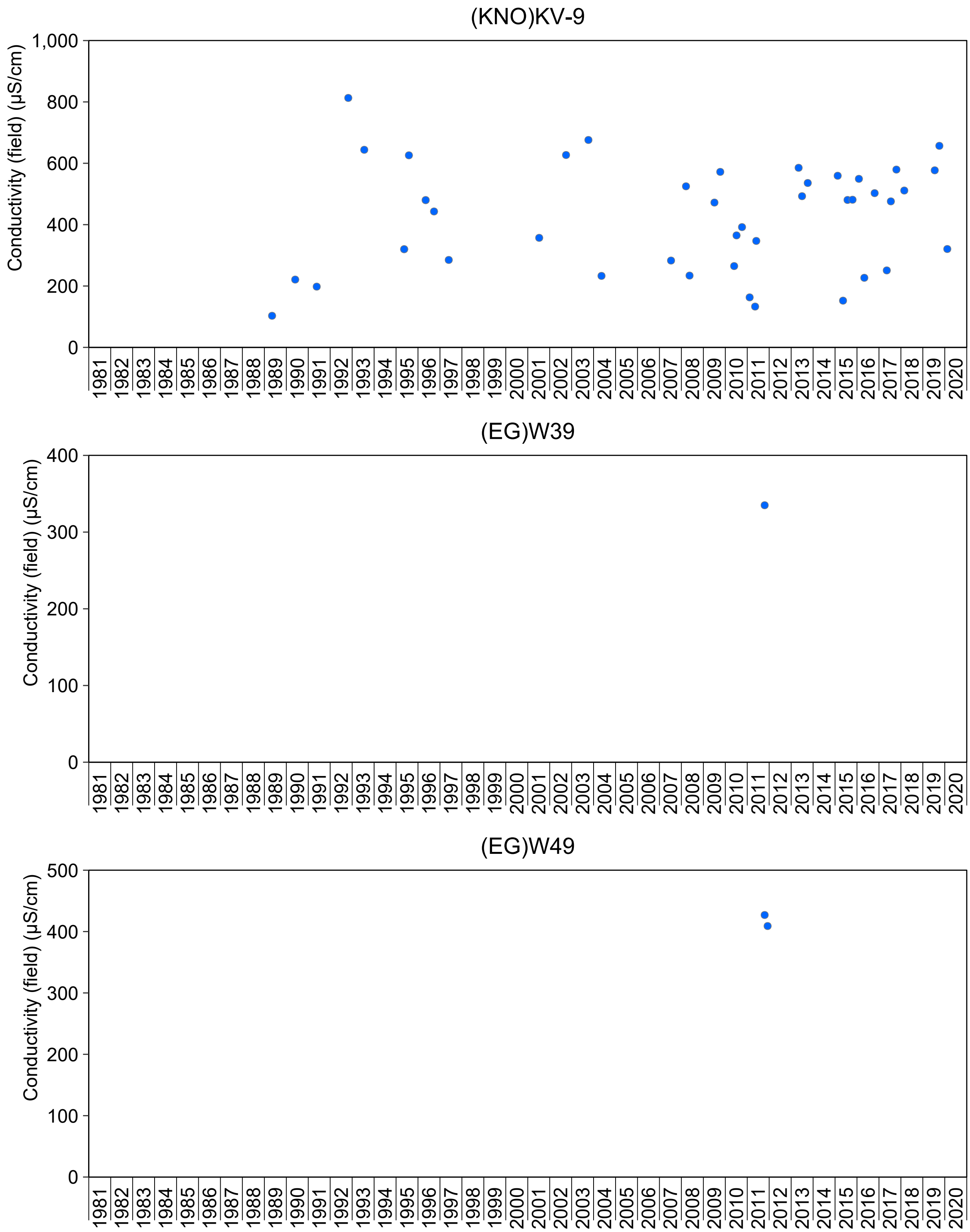

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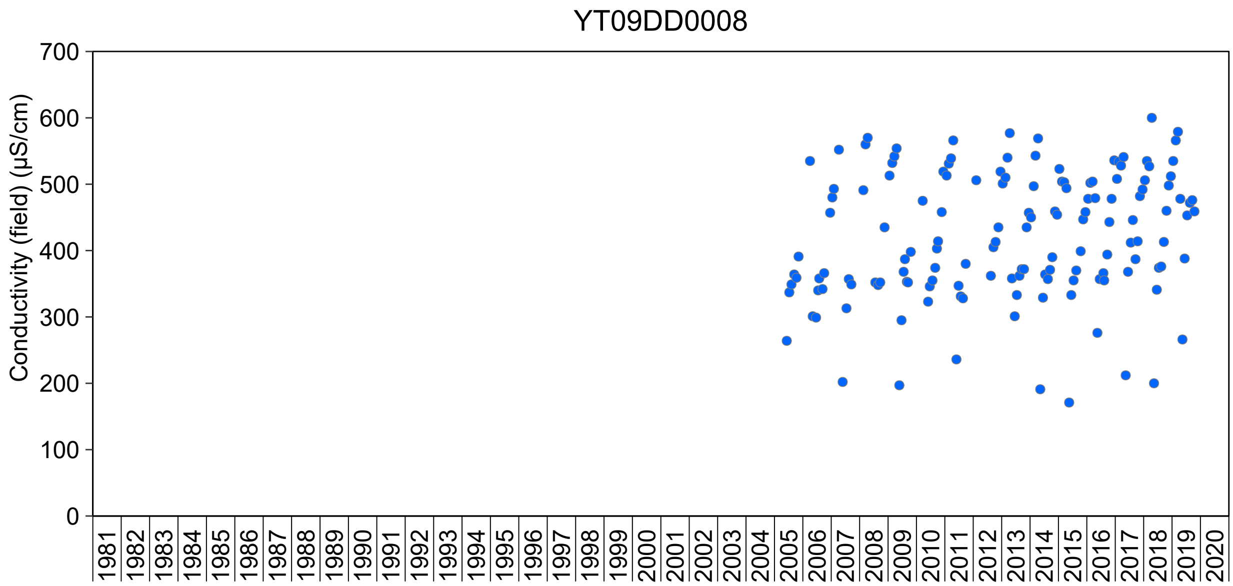

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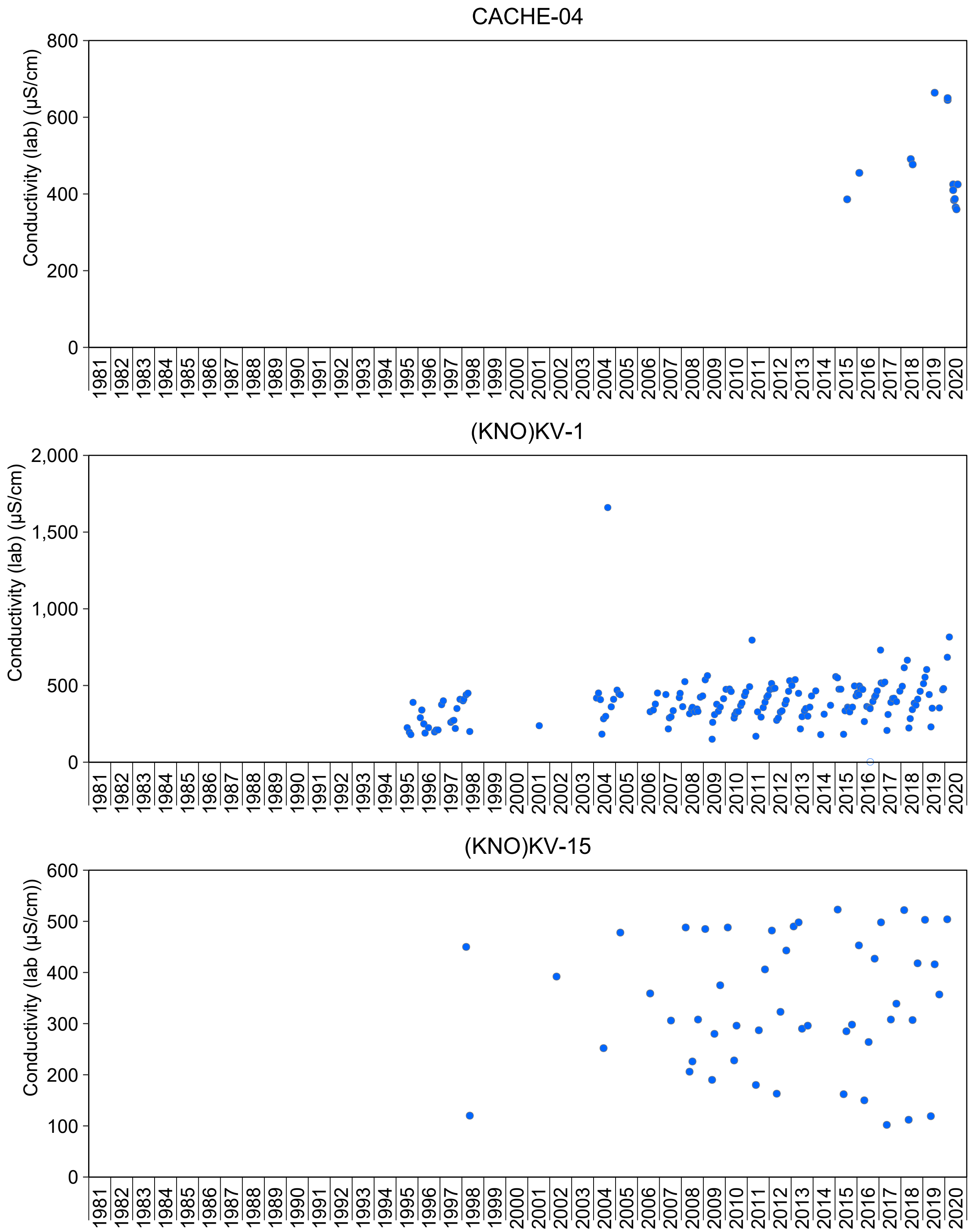

Figure A.6: Time Series Plots of Conductivity (lab; µS/cm) in the South McQuesten River, 1981 to 2020

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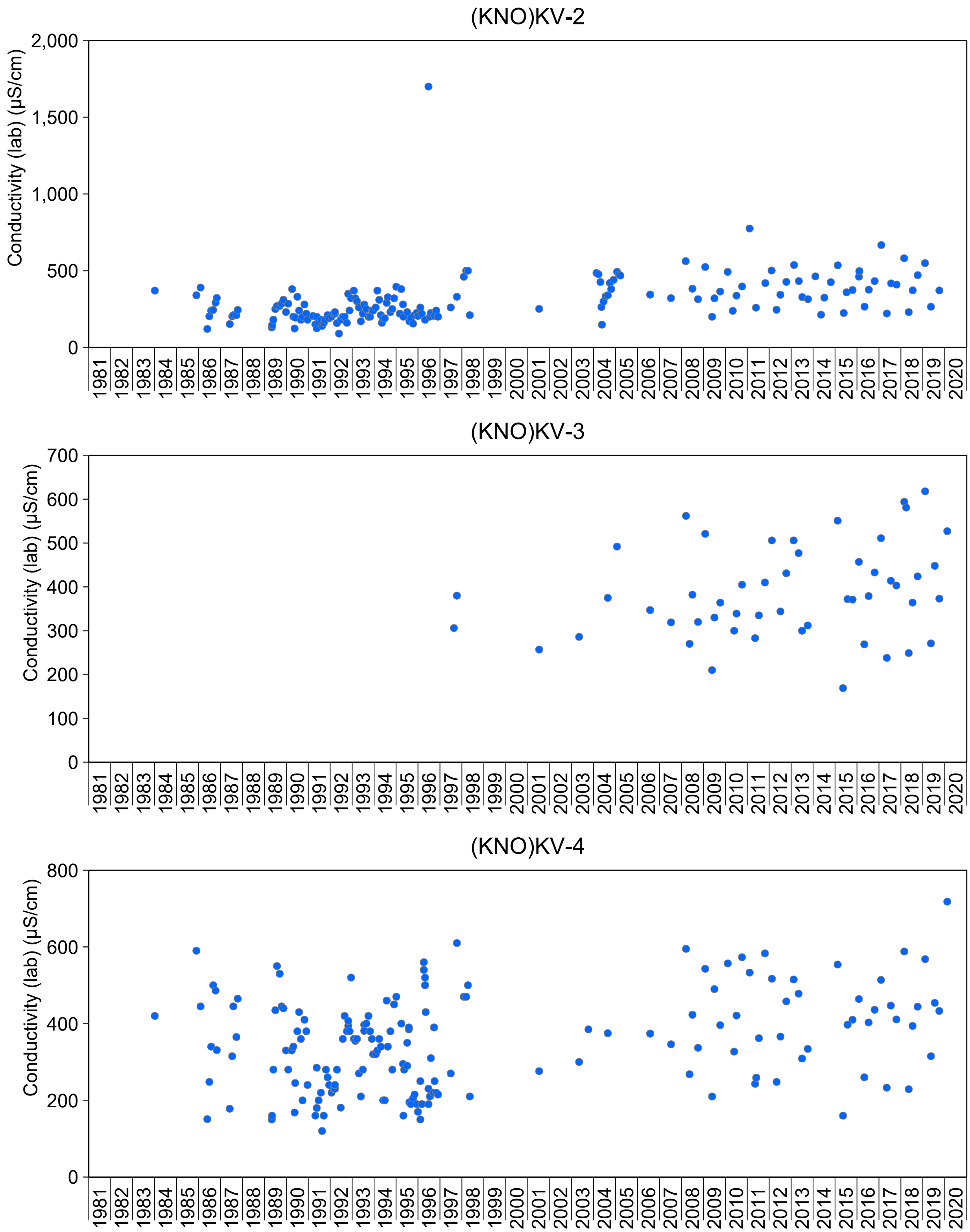

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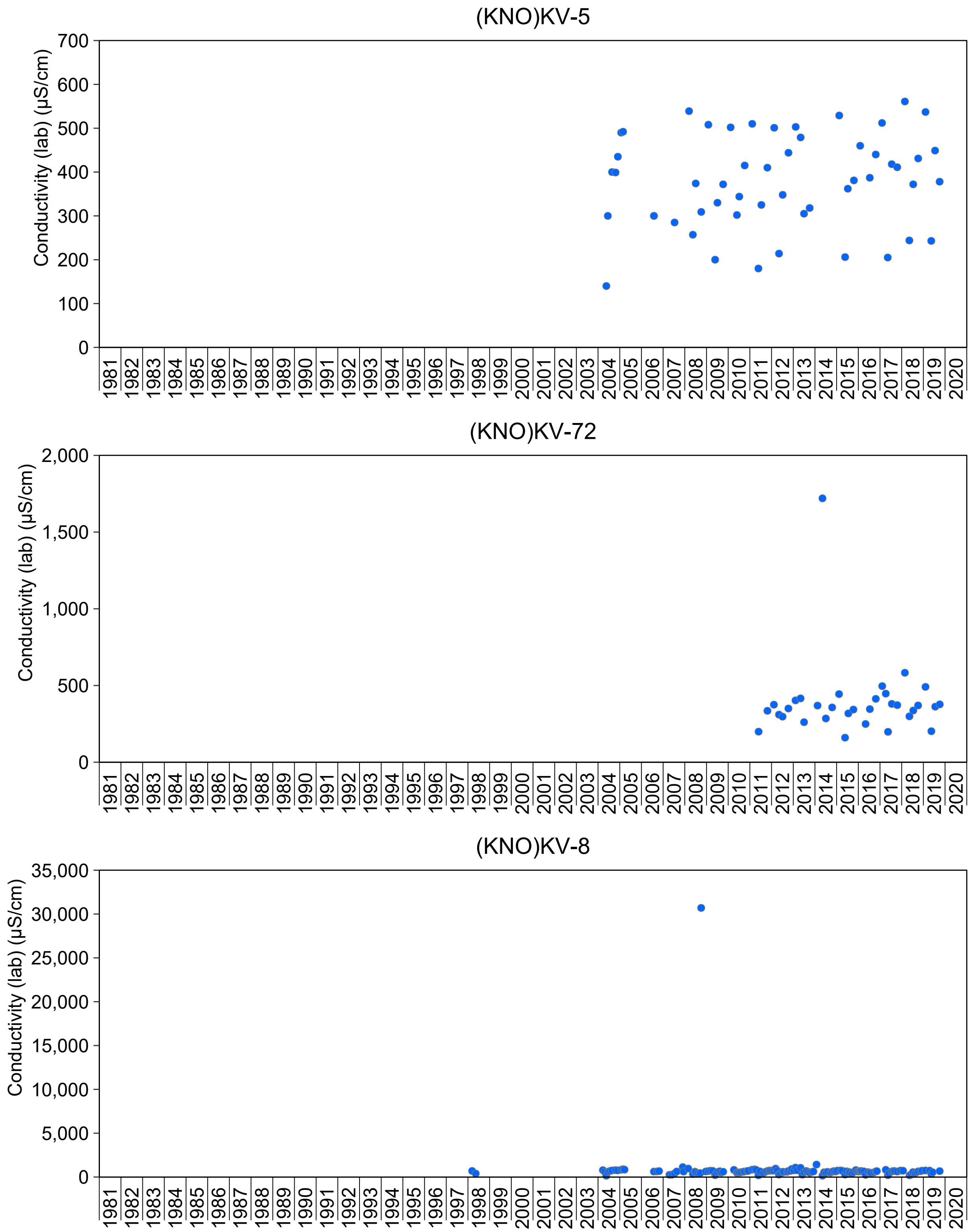

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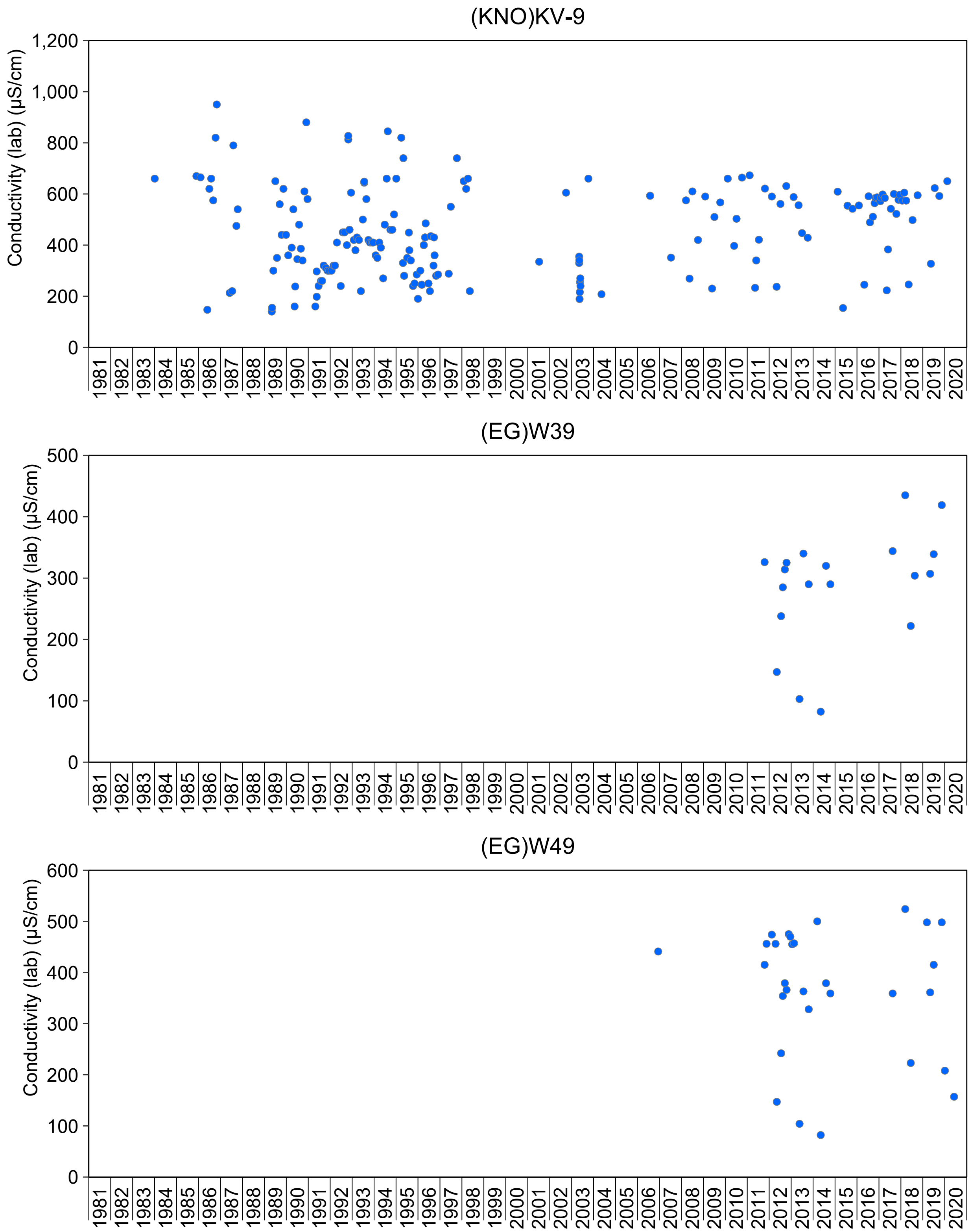

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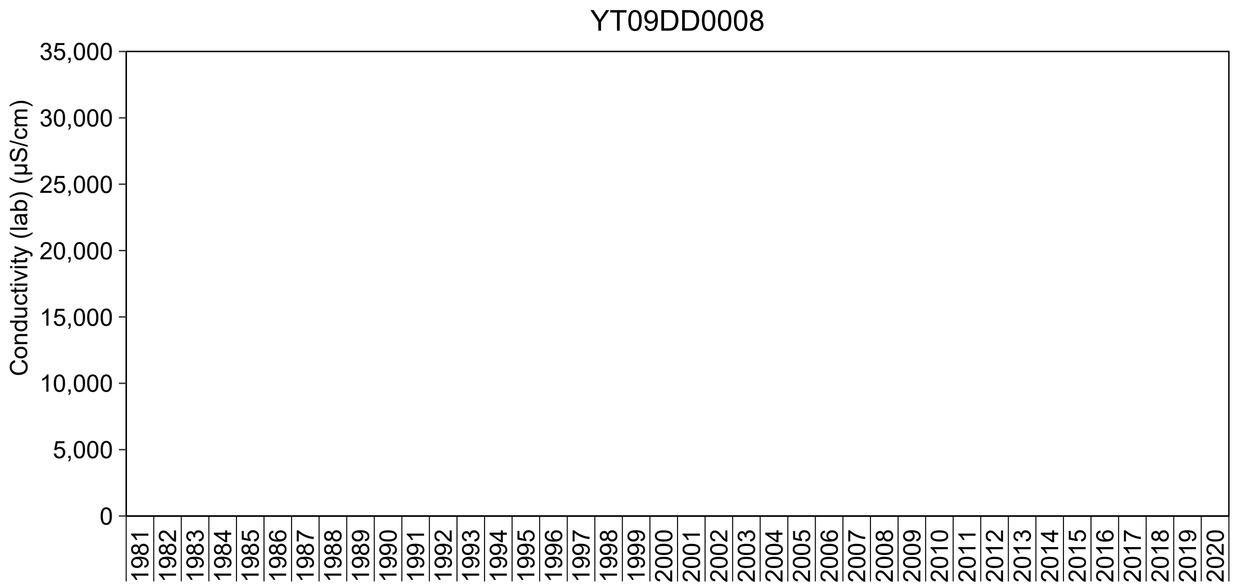


Figure A.6: Time Series Plots of Conductivity (lab; µS/cm) in the South McQuesten River, 1981 to 2020

Notes: µS/cm = microSiemens per centimetre.

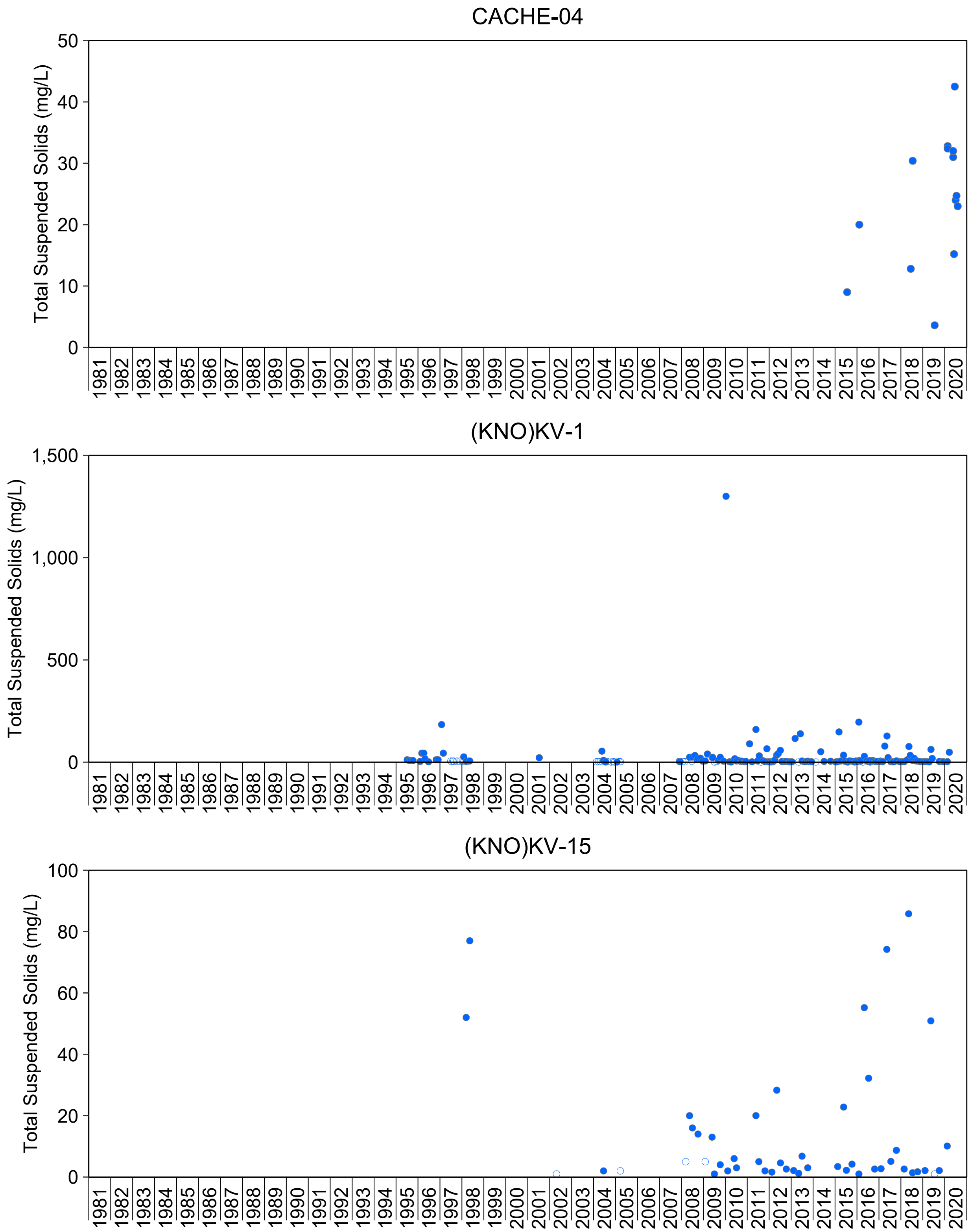


Figure A.7: Time Series Plots for Total Suspended Solids Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

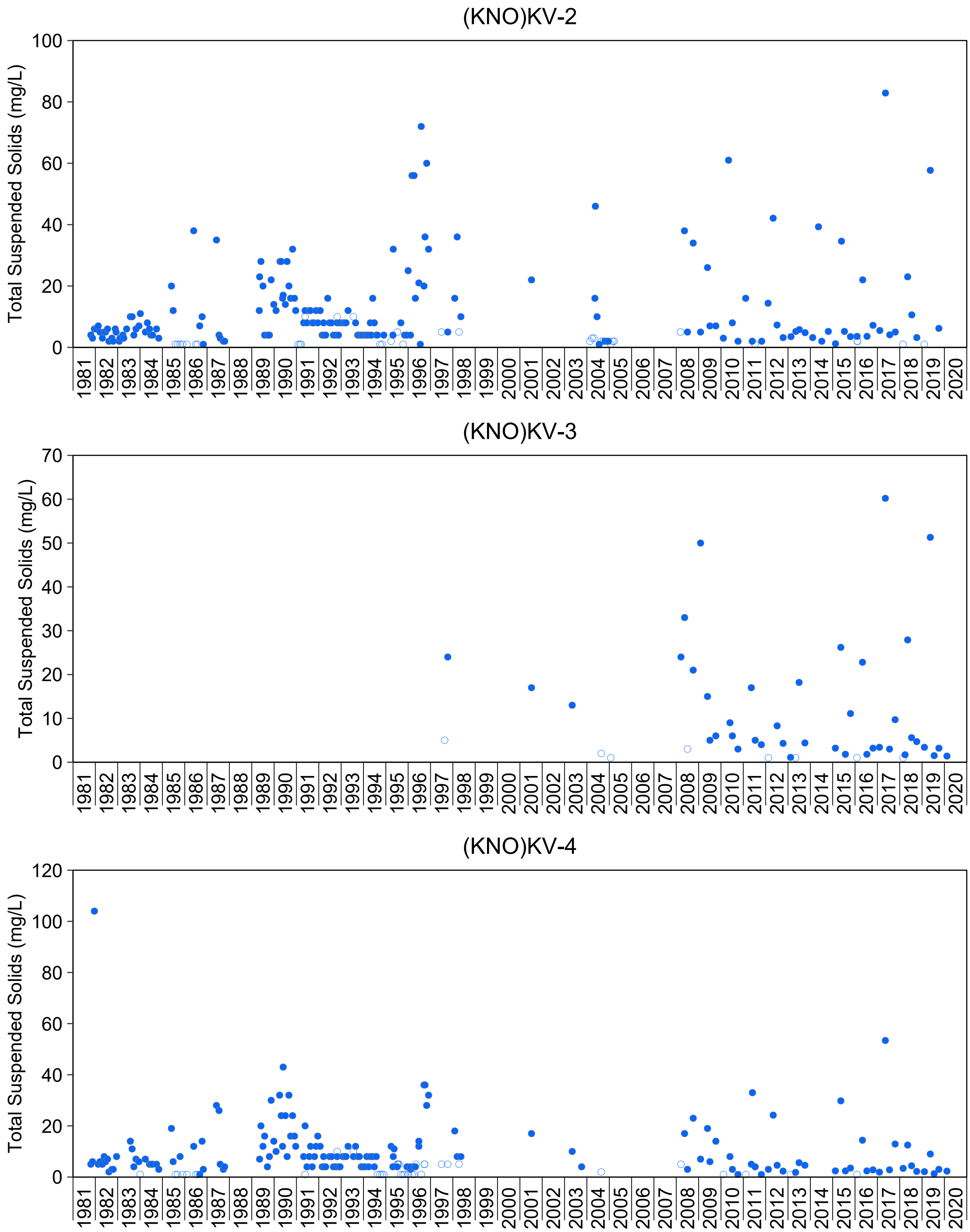


Figure A.7: Time Series Plots for Total Suspended Solids Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

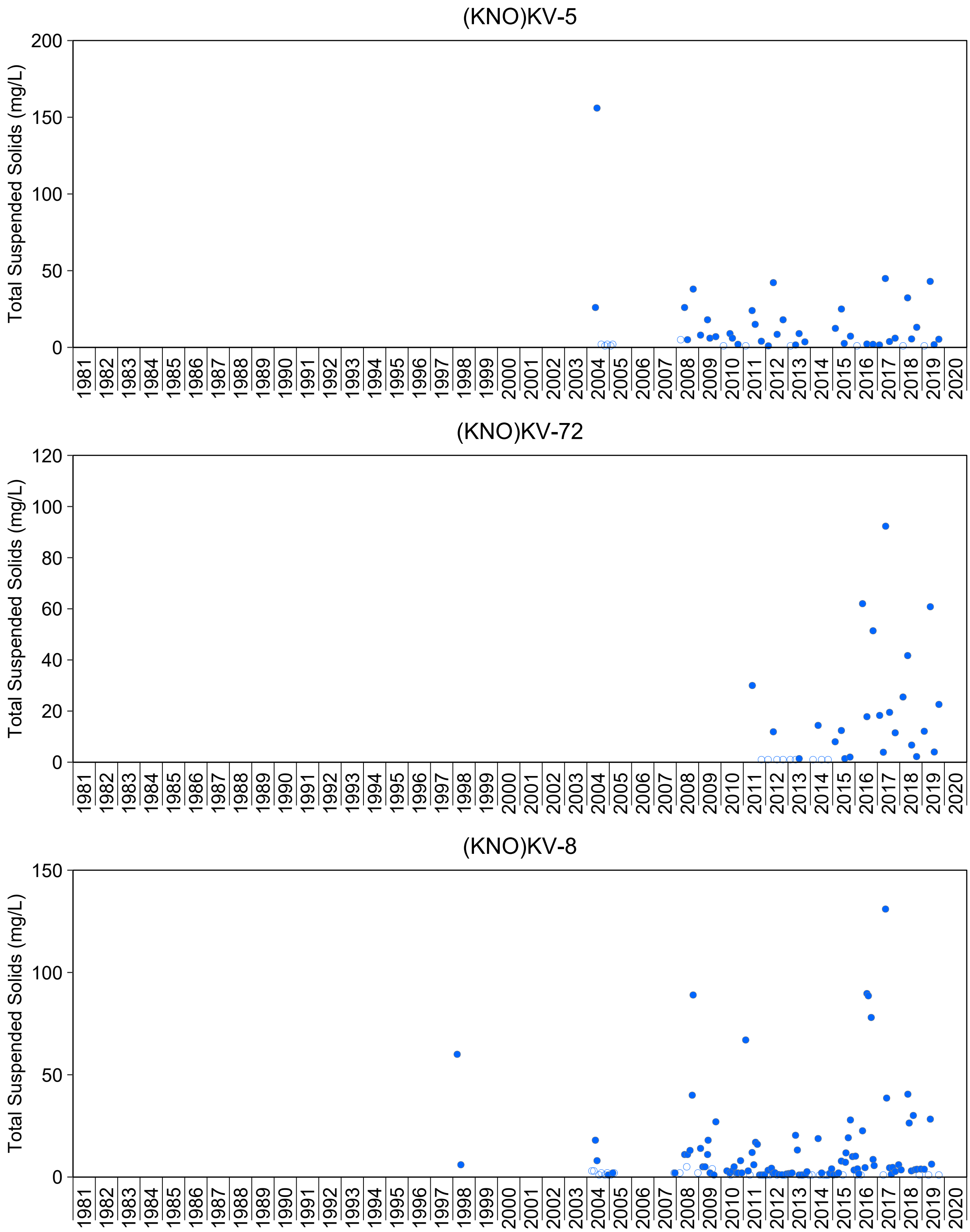


Figure A.7: Time Series Plots for Total Suspended Solids Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

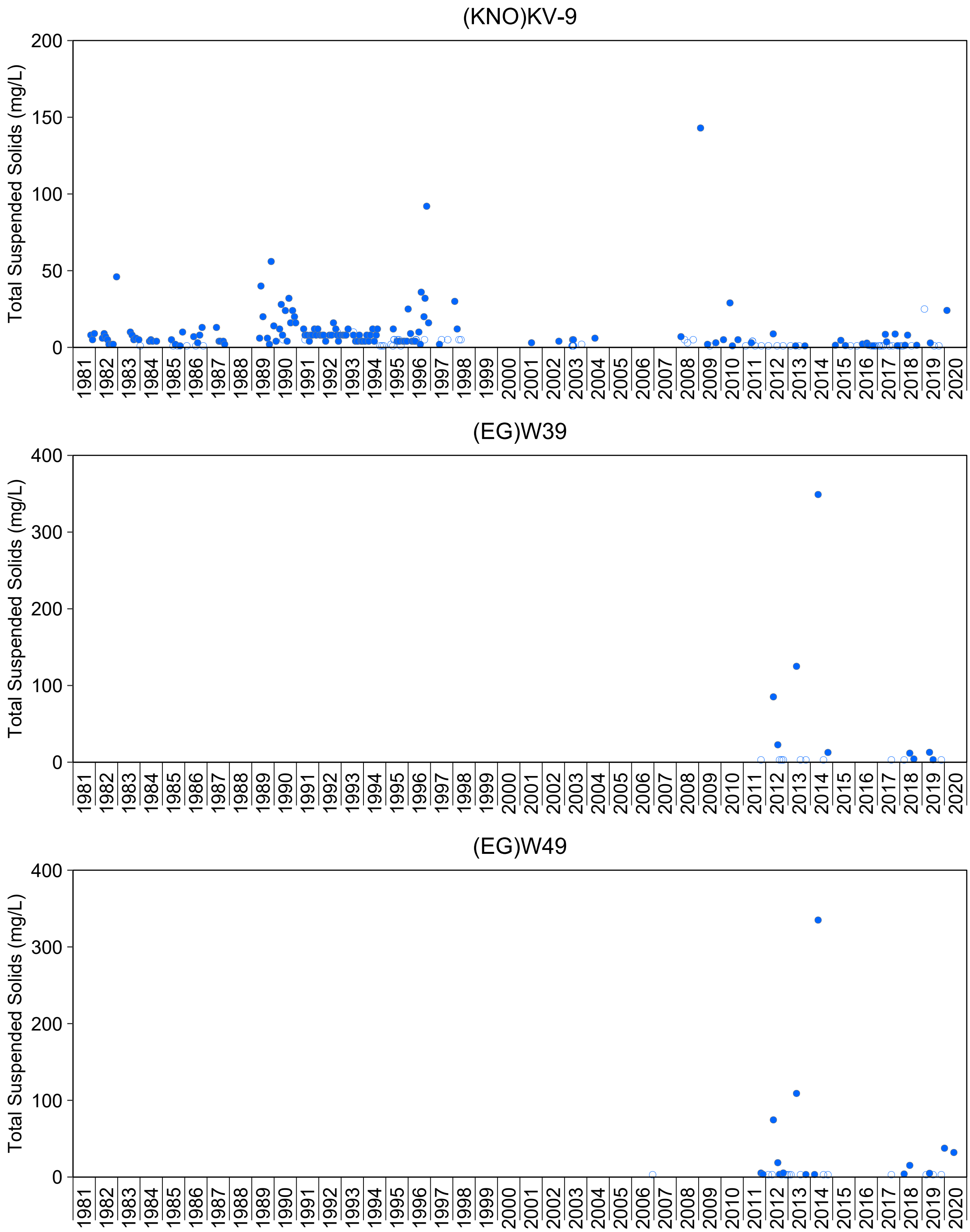


Figure A.7: Time Series Plots for Total Suspended Solids Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

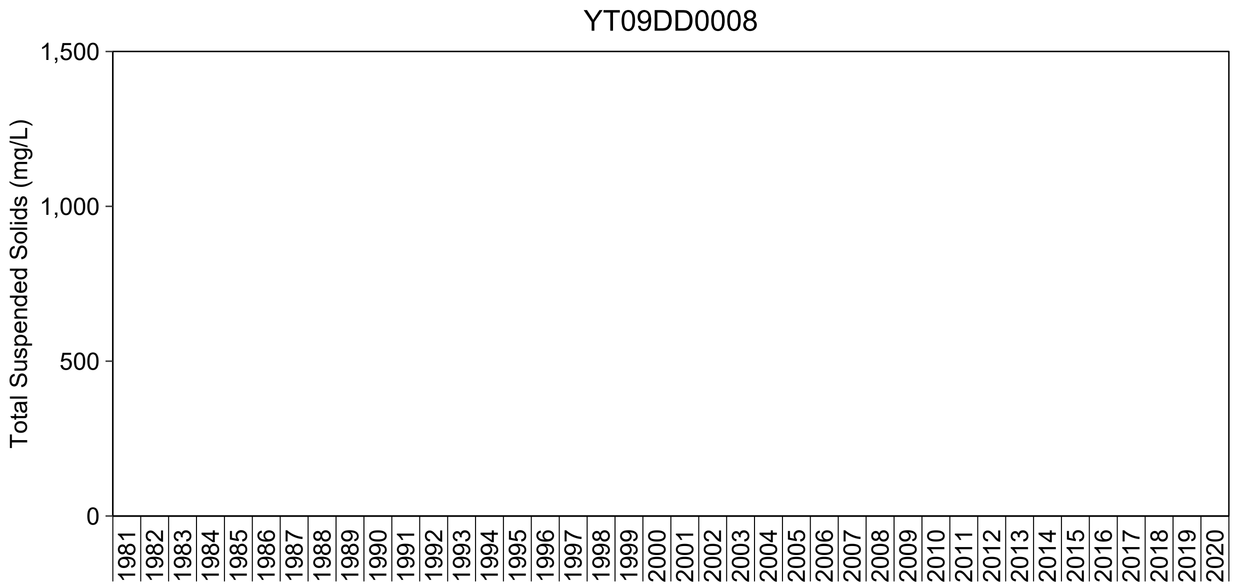
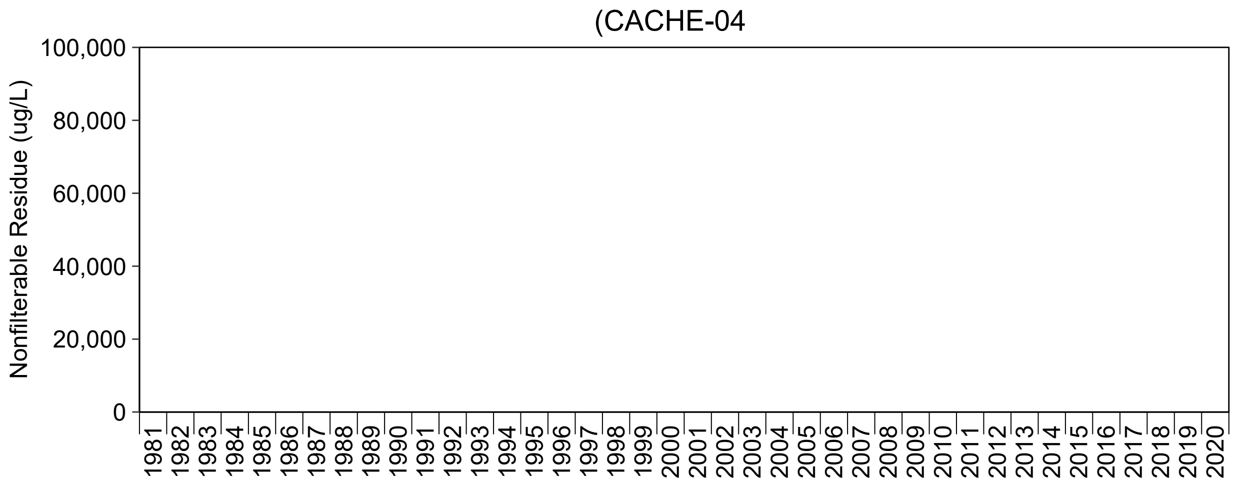
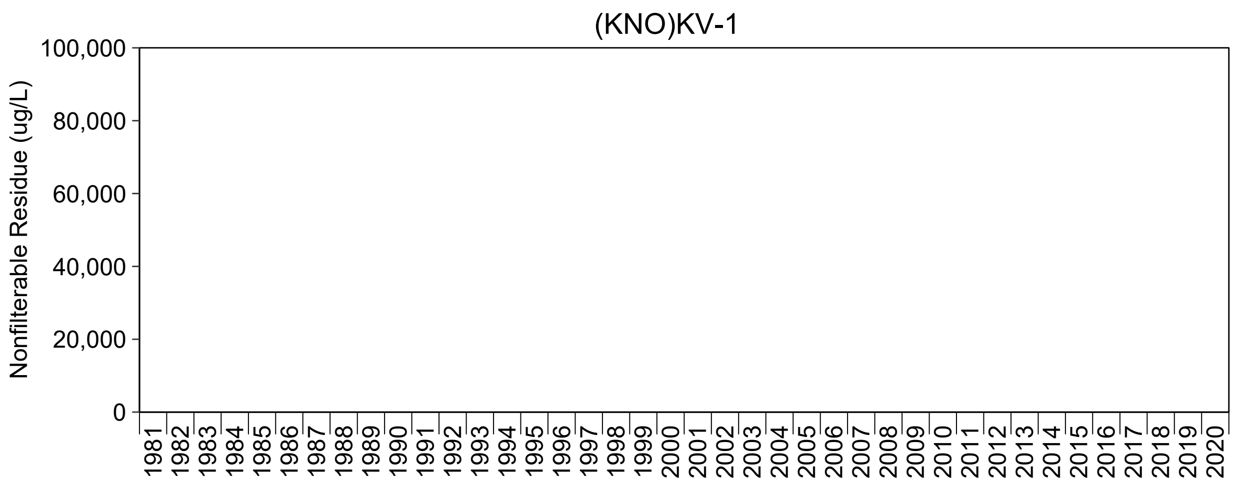


Figure A.7: Time Series Plots for Total Suspended Solids Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.





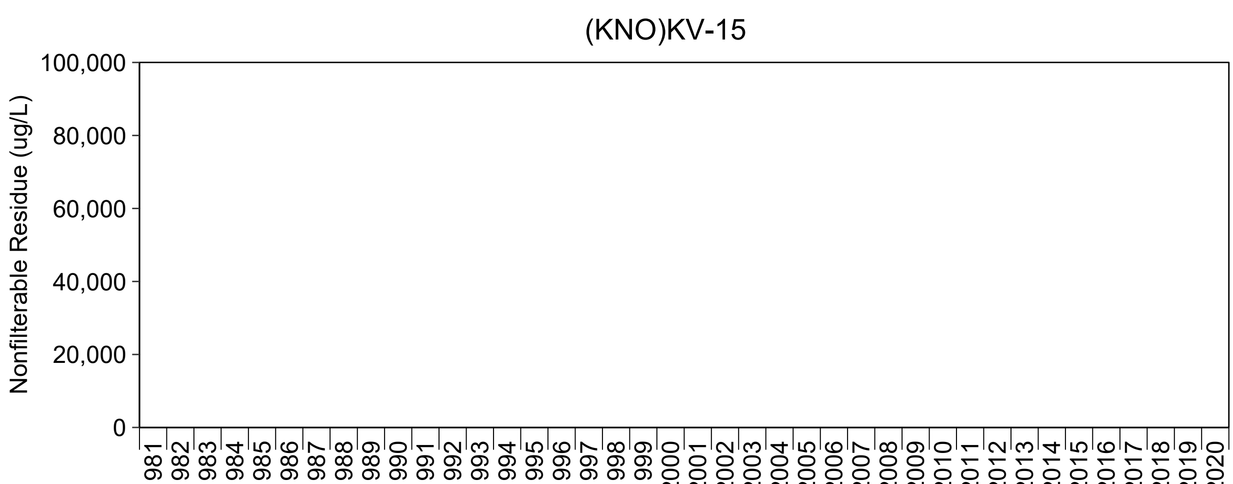
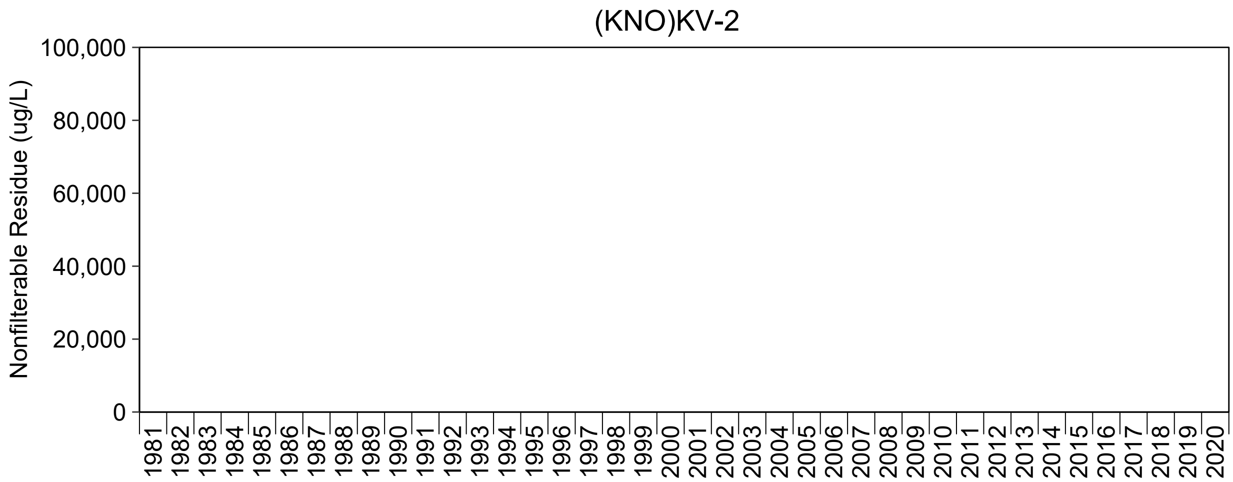
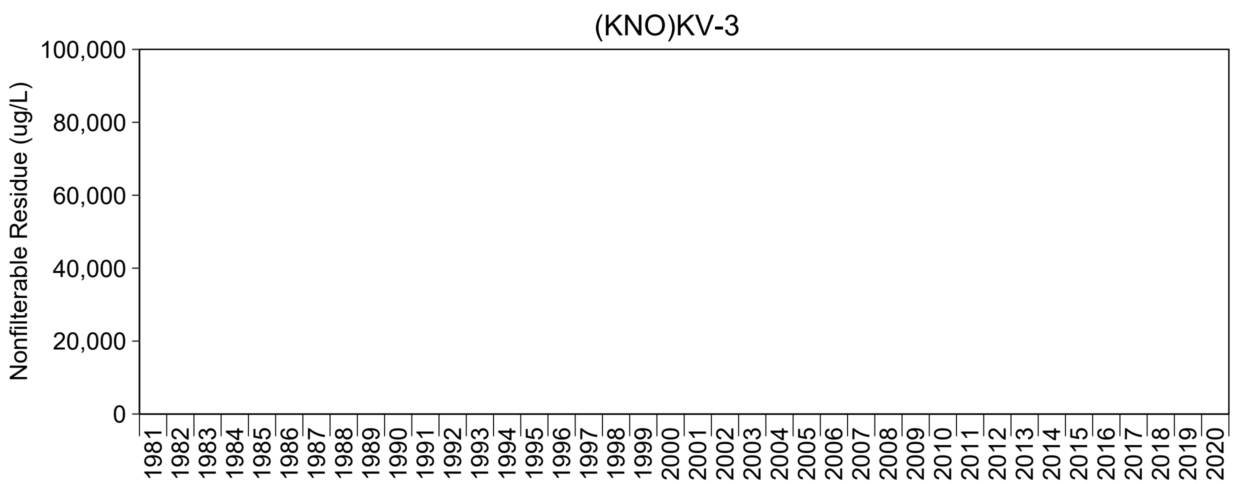


Figure A.8: Time Series Plots of Non-filterable Residue Concentrations (ug/L) in the South McQuesten River, 1981 to 2020

Notes: ug/L = micrograms per litre; Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.





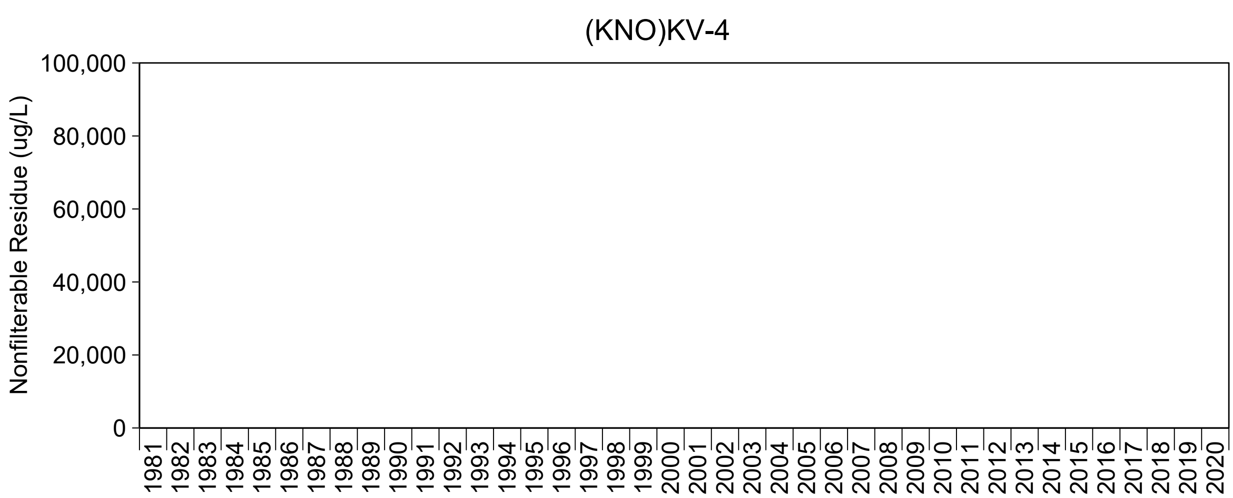
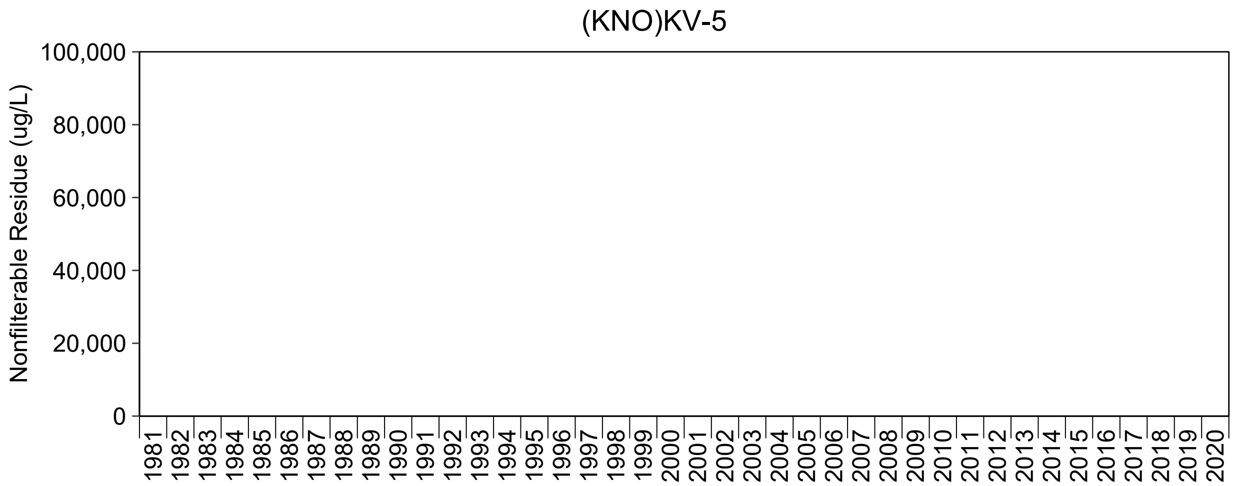
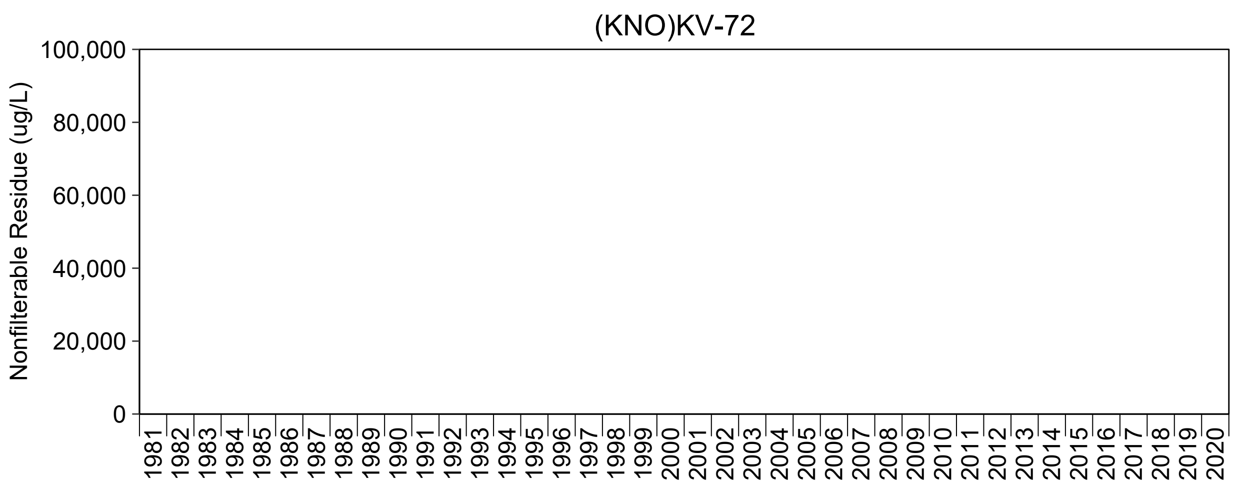


Figure A.8: Time Series Plots of Non-filterable Residue Concentrations (ug/L) in the South McQuesten River, 1981 to 2020

Notes: ug/L = micrograms per litre; Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.





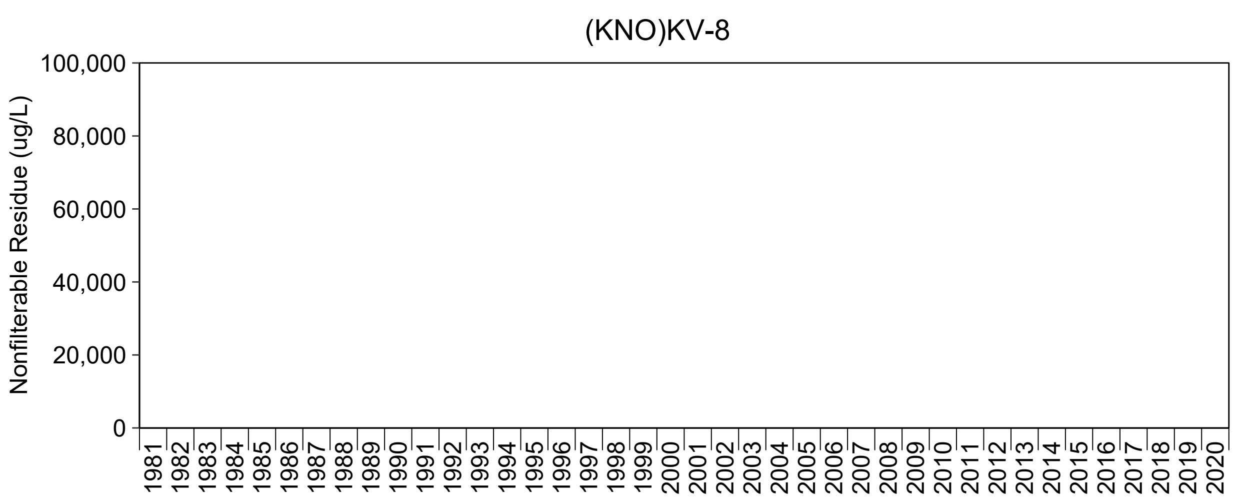
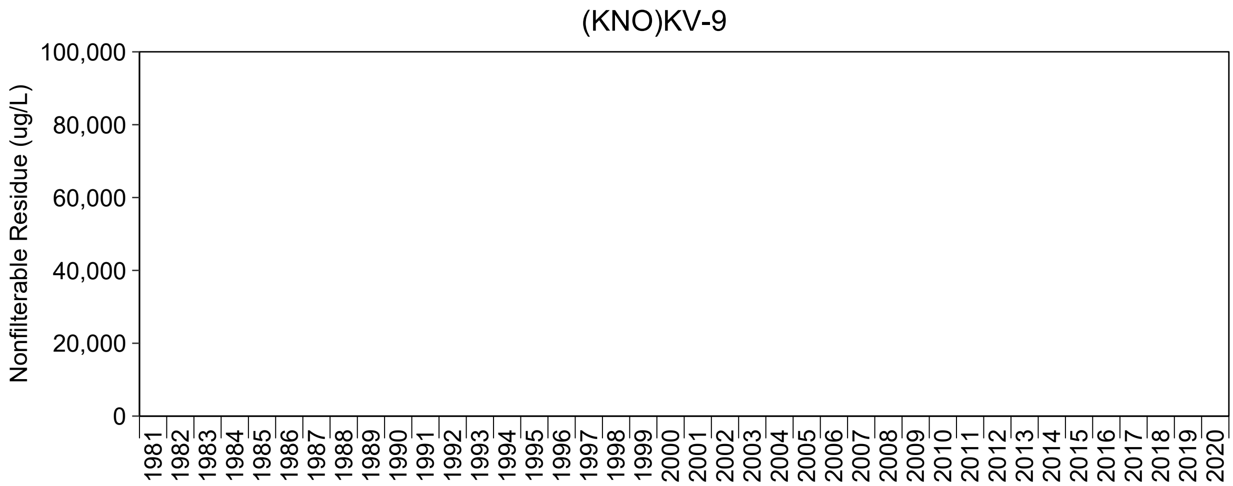
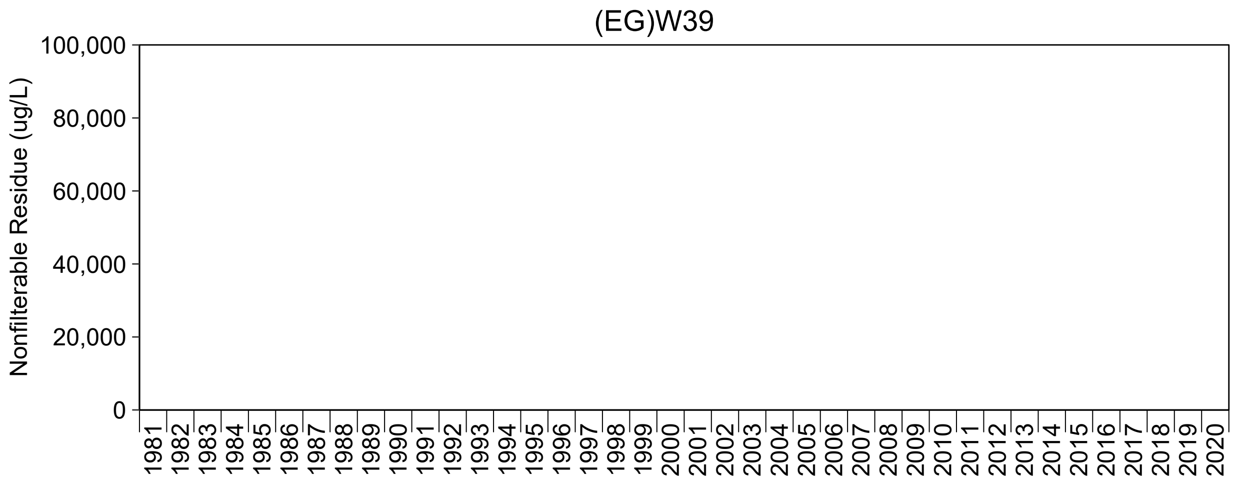


Figure A.8: Time Series Plots of Non-filterable Residue Concentrations (ug/L) in the South McQuesten River, 1981 to 2020

Notes: ug/L = micrograms per litre; Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.





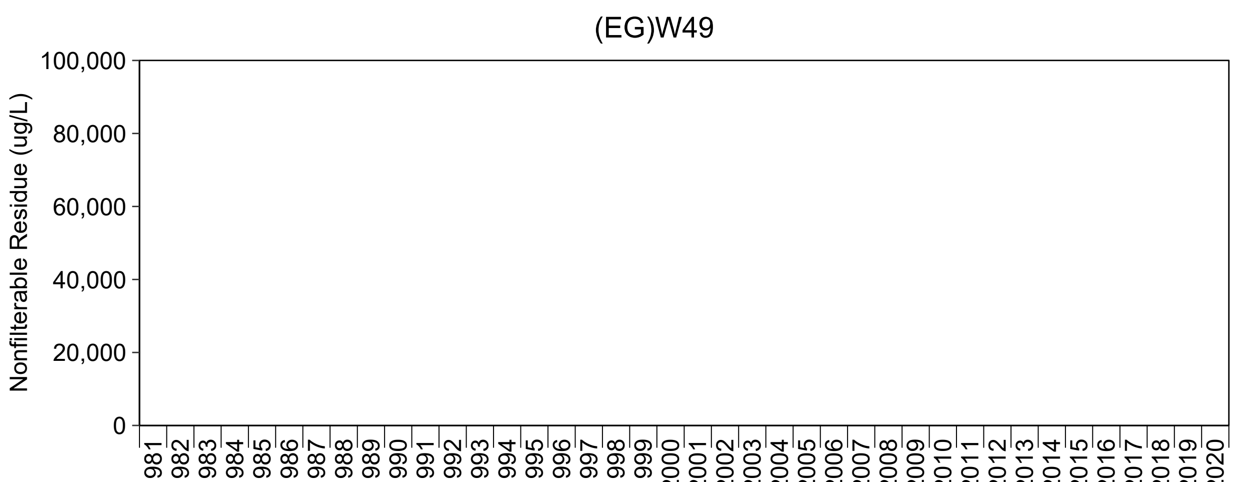


Figure A.8: Time Series Plots of Non-filterable Residue Concentrations (ug/L) in the South McQuesten River, 1981 to 2020

Notes: ug/L = micrograms per litre; Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

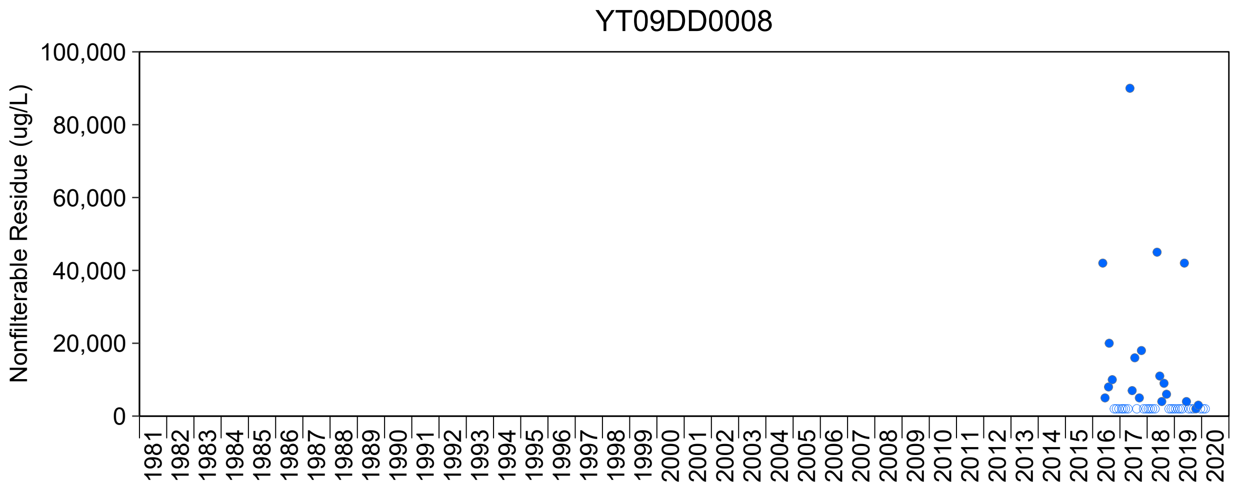
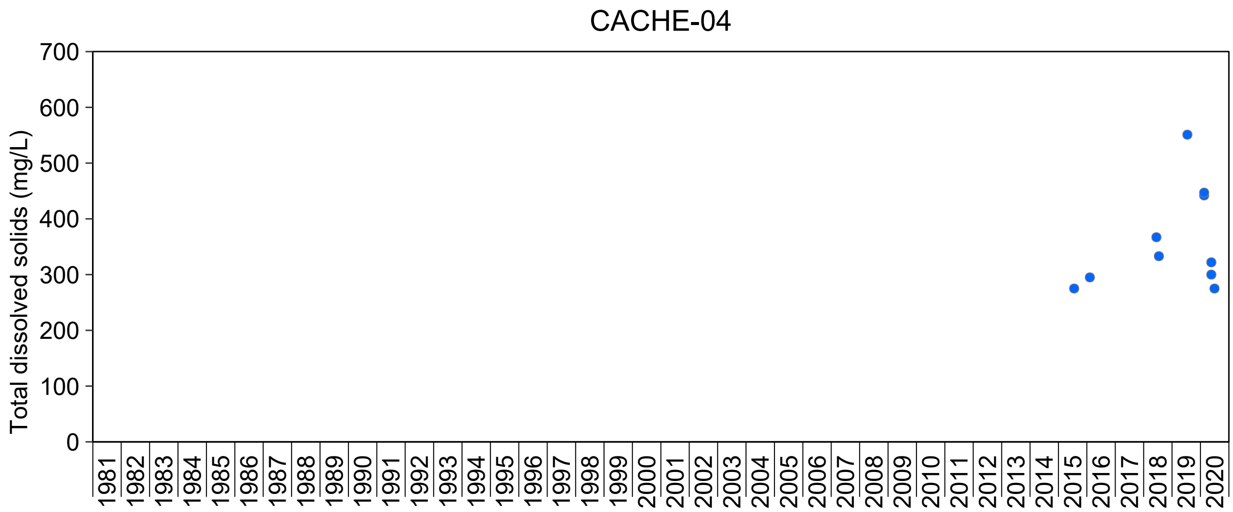
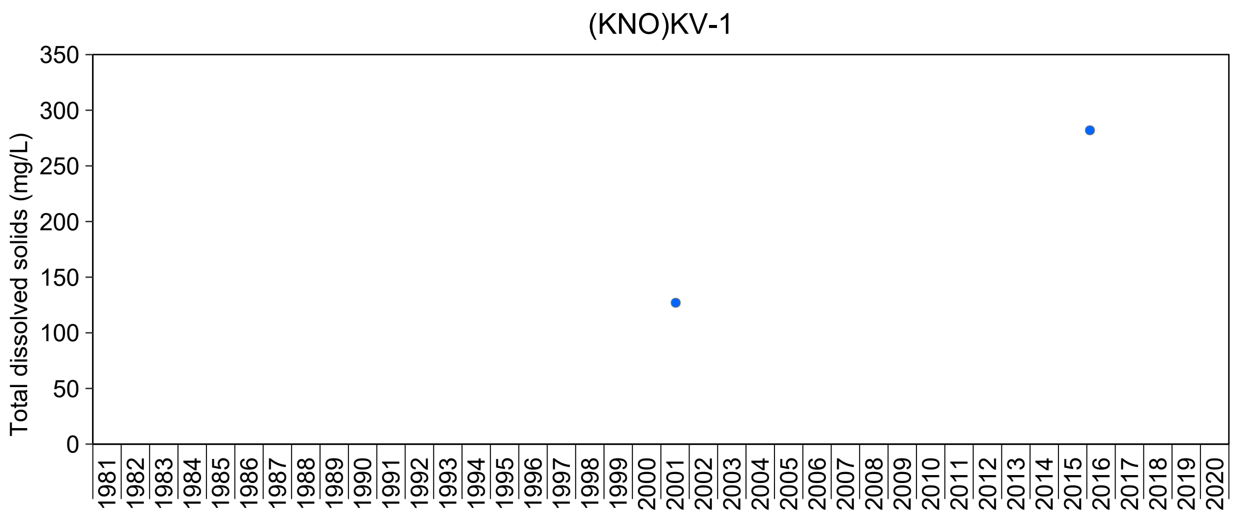


Figure A.8: Time Series Plots of Non-filterable Residue Concentrations (ug/L) in the South McQuesten River, 1981 to 2020

Notes: ug/L = micrograms per litre; Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.





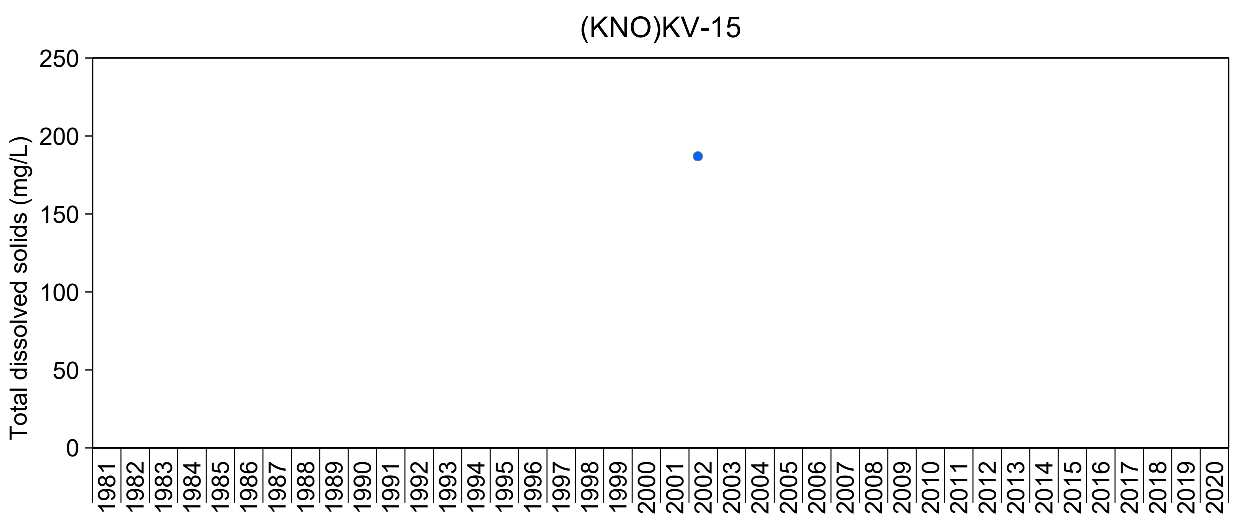


Figure A.9: Time Series Plots of Total Dissolved Solids Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

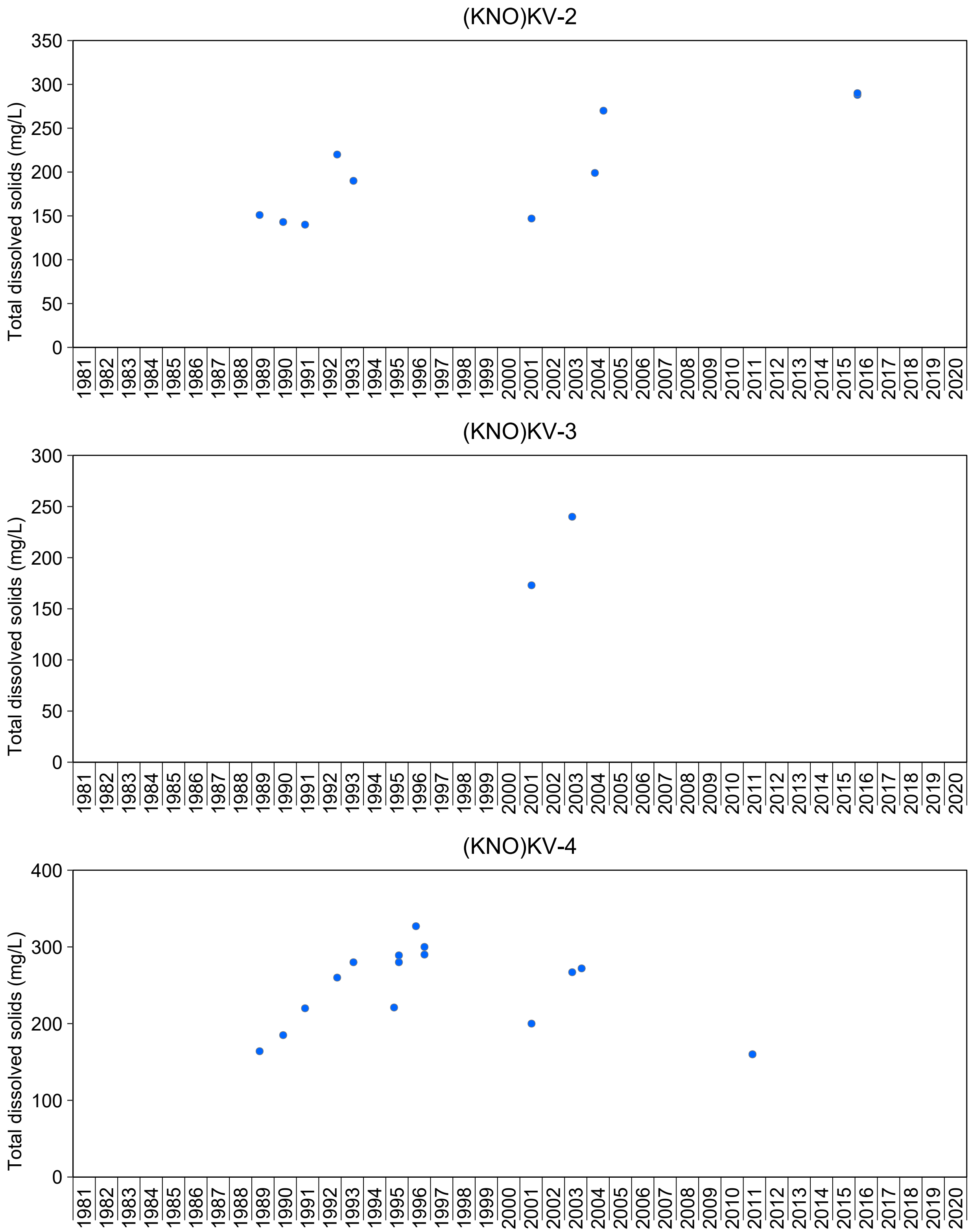
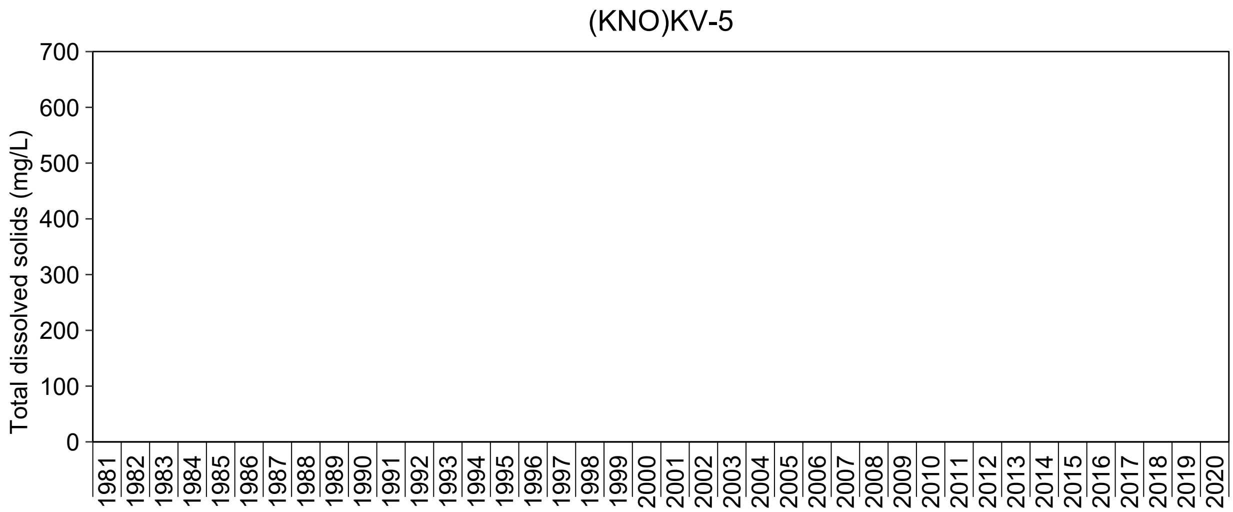
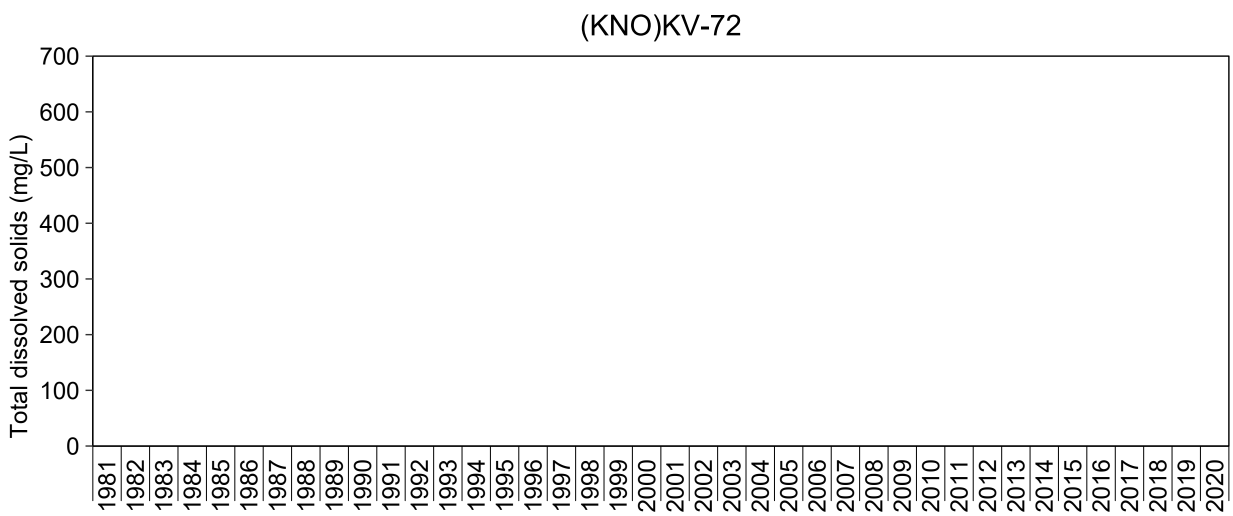


Figure A.9: Time Series Plots of Total Dissolved Solids Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.





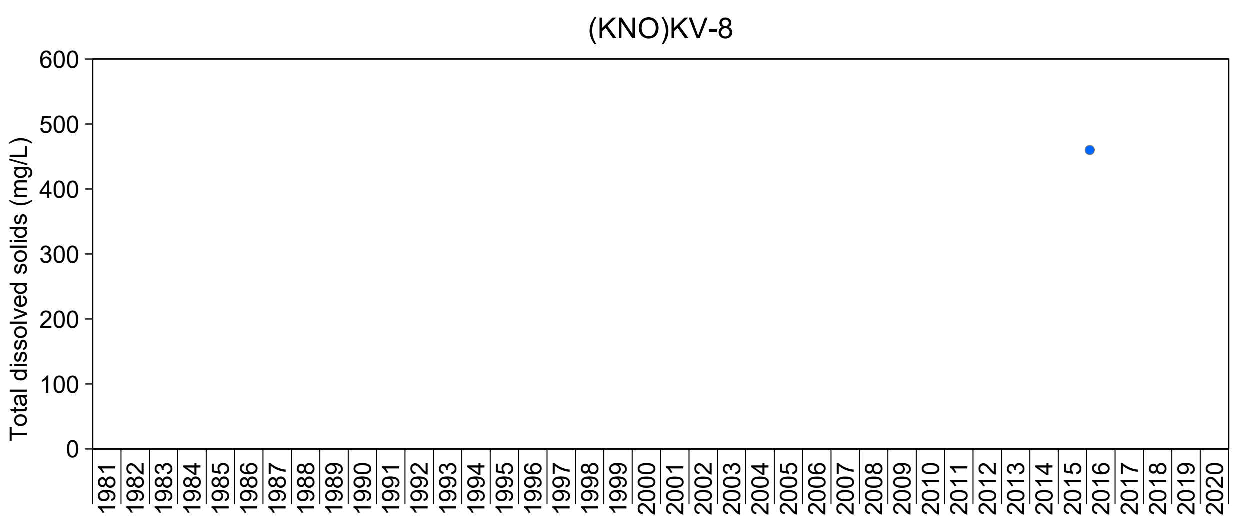


Figure A.9: Time Series Plots of Total Dissolved Solids Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

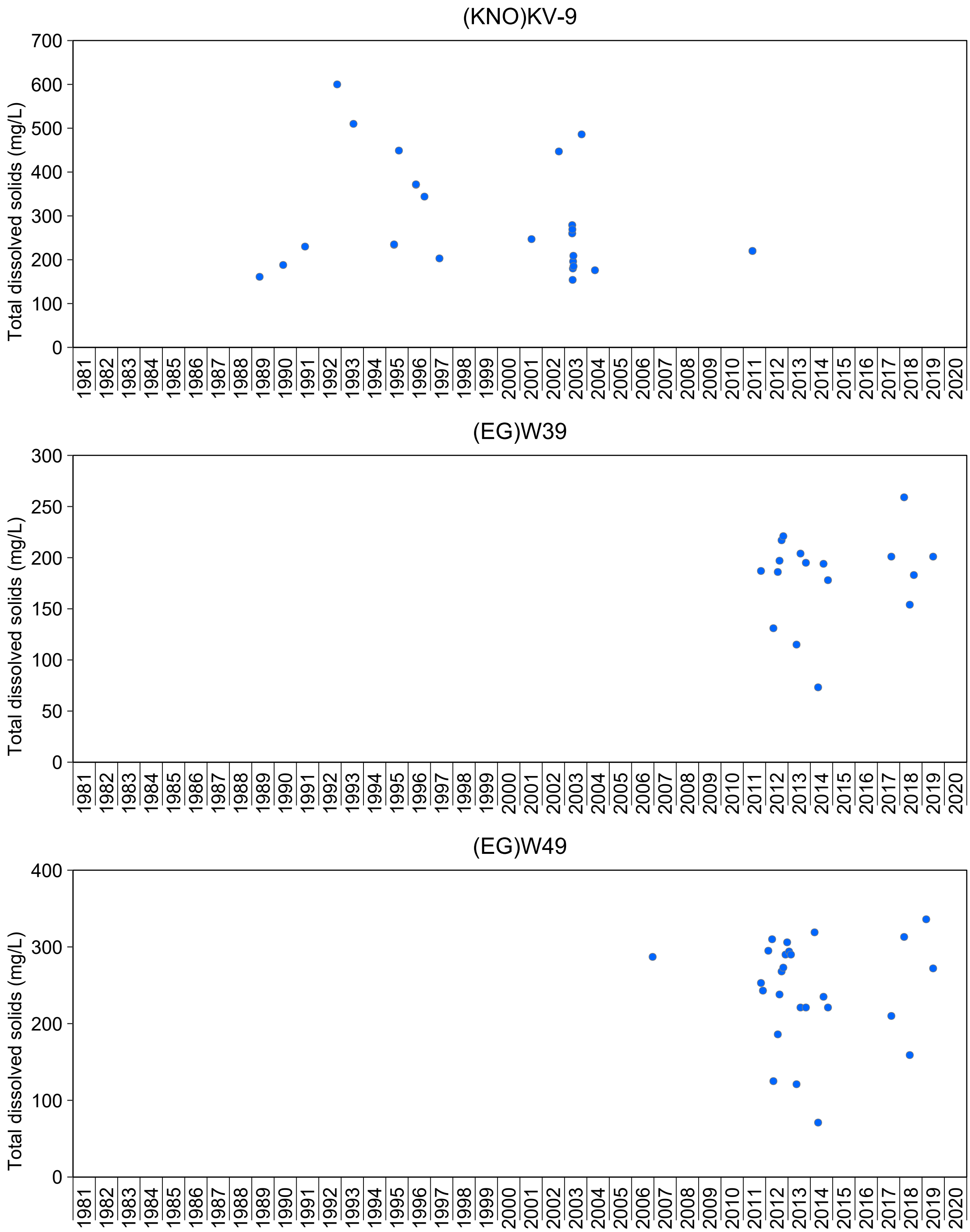
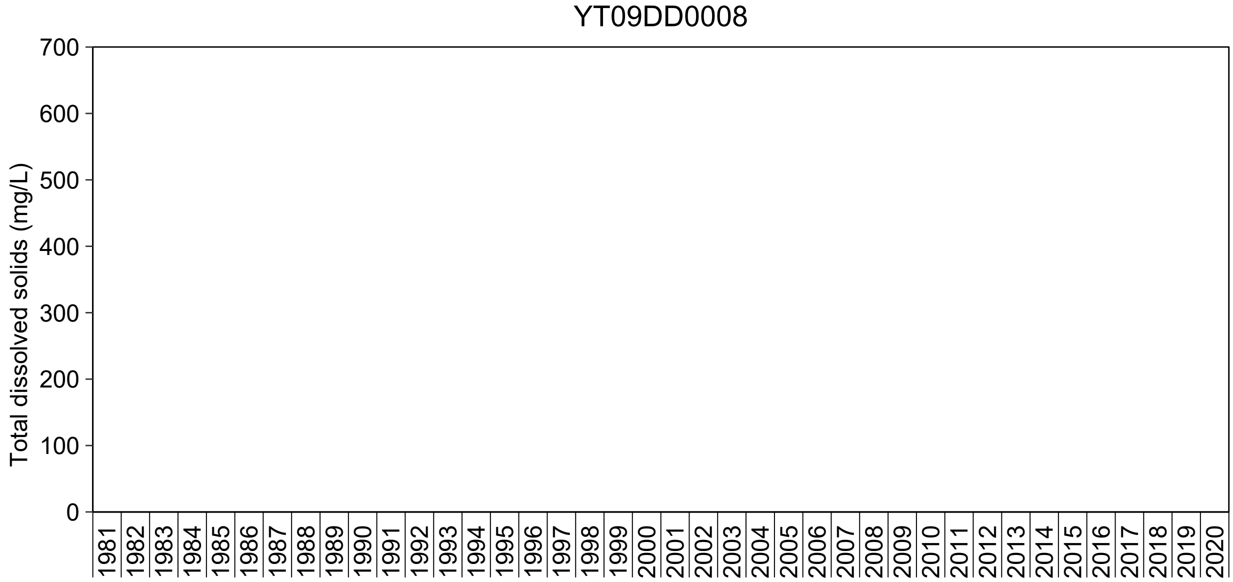


Figure A.9: Time Series Plots of Total Dissolved Solids Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.



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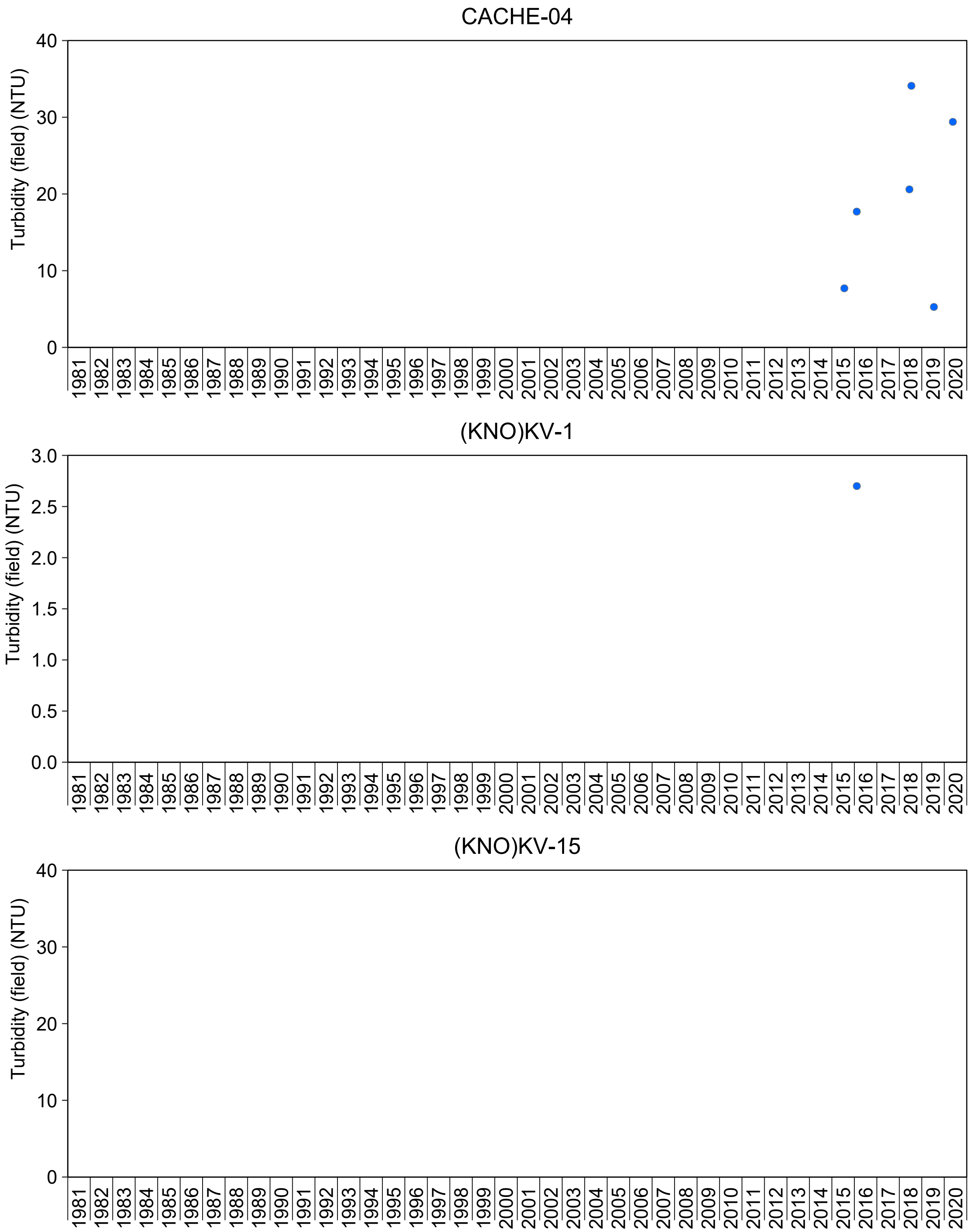


Figure A.10: Time Series Plots of Turbidity (field; NTU) in the South McQuesten River, 1981 to 2020

Notes: NTU = Nephelometric Turbidity Units.

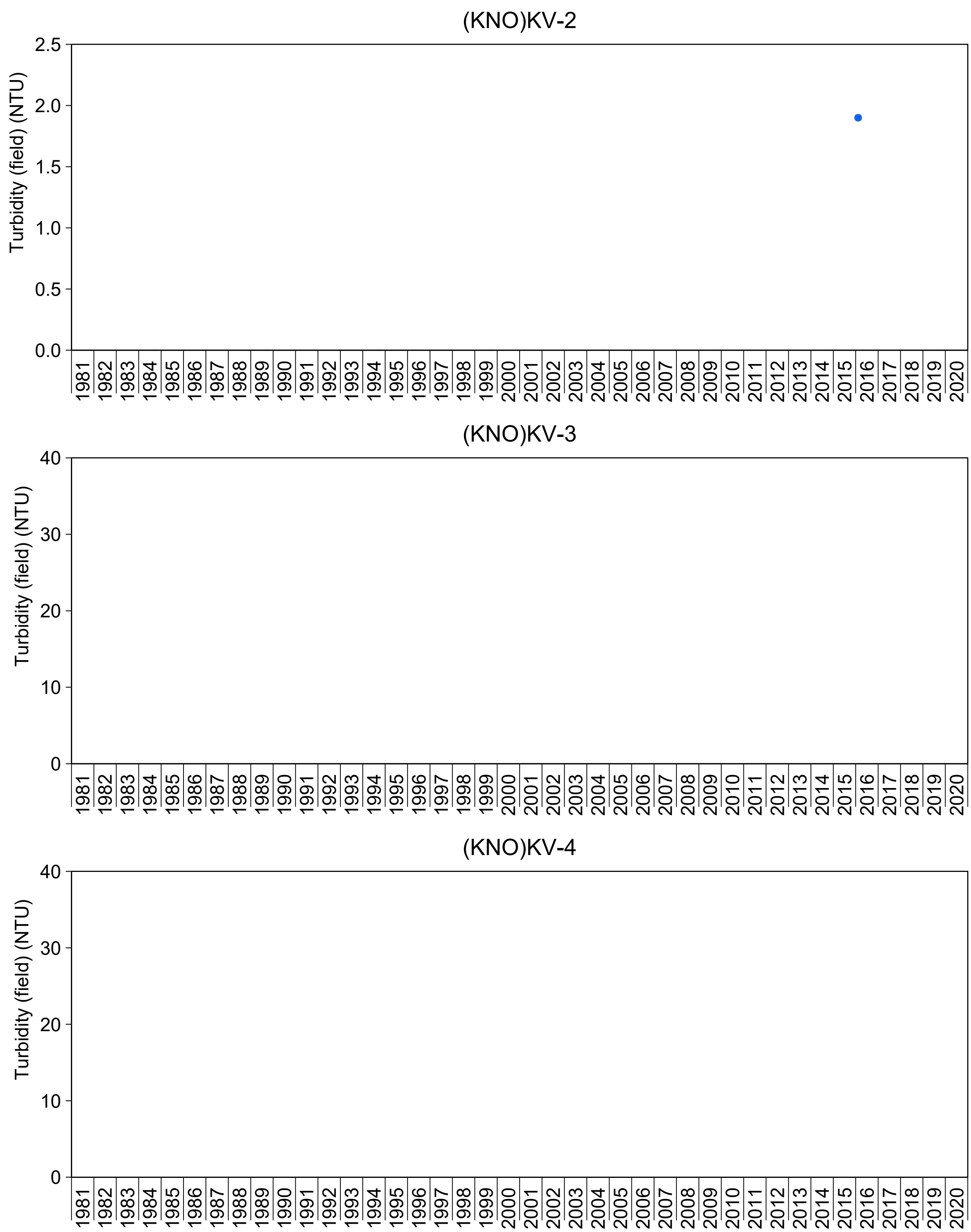


Figure A.10: Time Series Plots of Turbidity (field; NTU) in the South McQuesten River, 1981 to 2020

Notes: NTU = Nephelometric Turbidity Units.

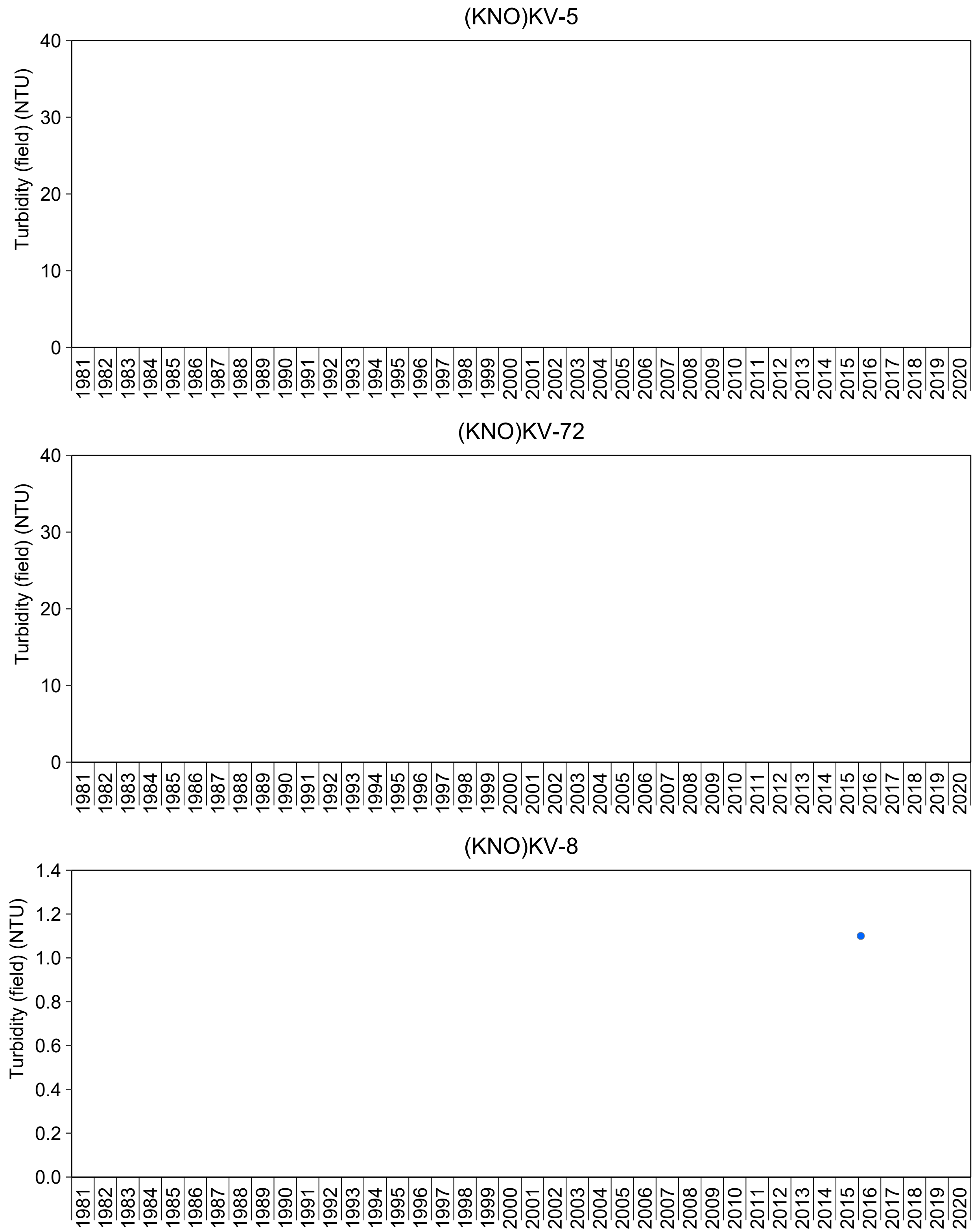


Figure A.10: Time Series Plots of Turbidity (field; NTU) in the South McQuesten River, 1981 to 2020

Notes: NTU = Nephelometric Turbidity Units.

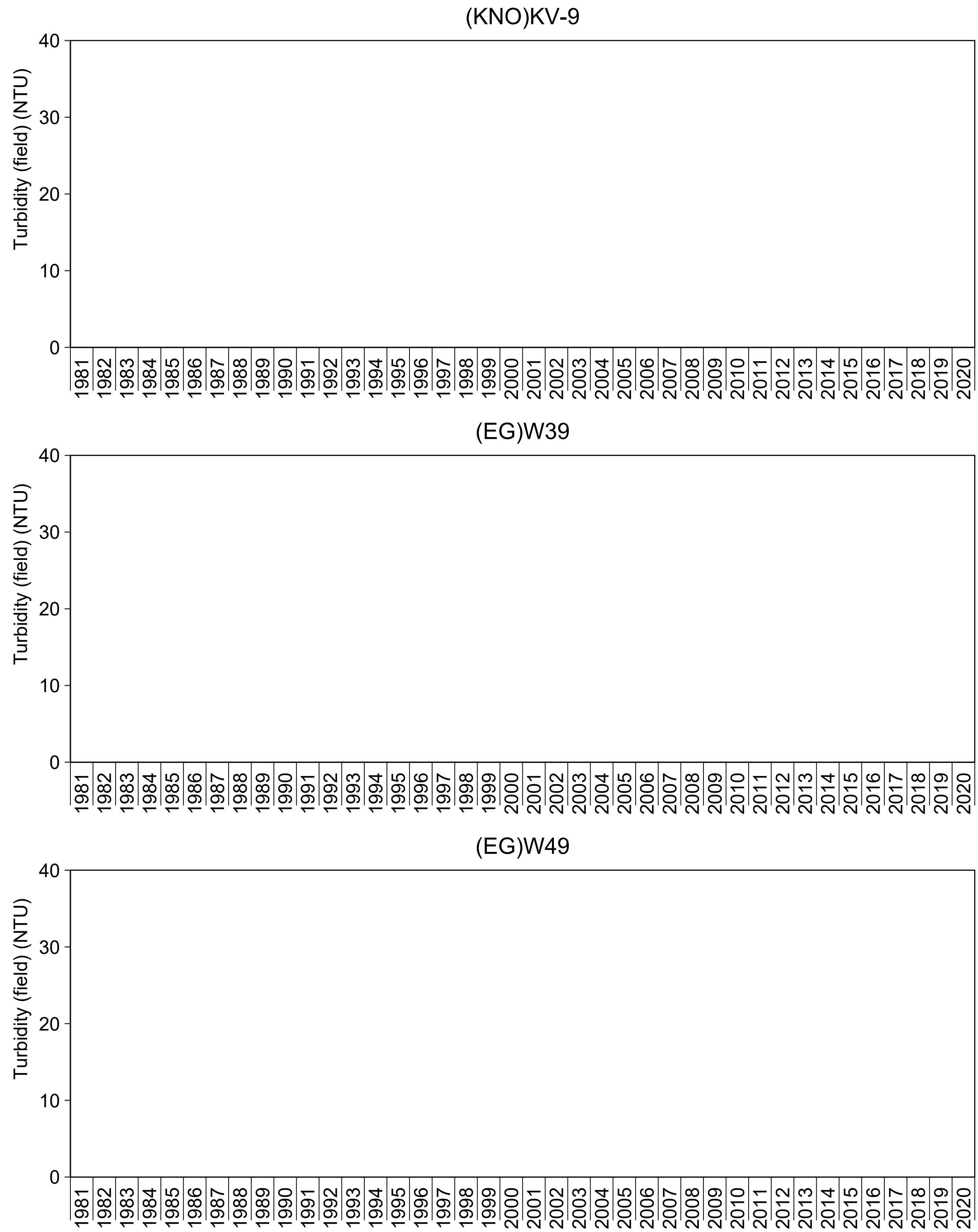


Figure A.10: Time Series Plots of Turbidity (field; NTU) in the South McQuesten River, 1981 to 2020

Notes: NTU = Nephelometric Turbidity Units.

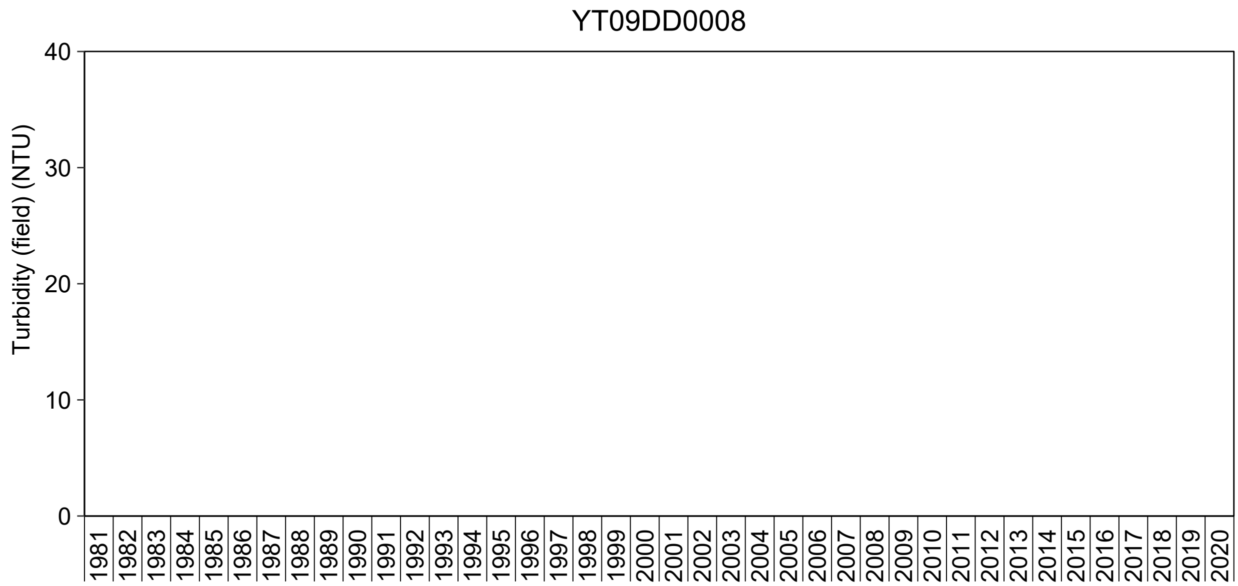


Figure A.10: Time Series Plots of Turbidity (field; NTU) in the South McQuesten River, 1981 to 2020

Notes: NTU = Nephelometric Turbidity Units.

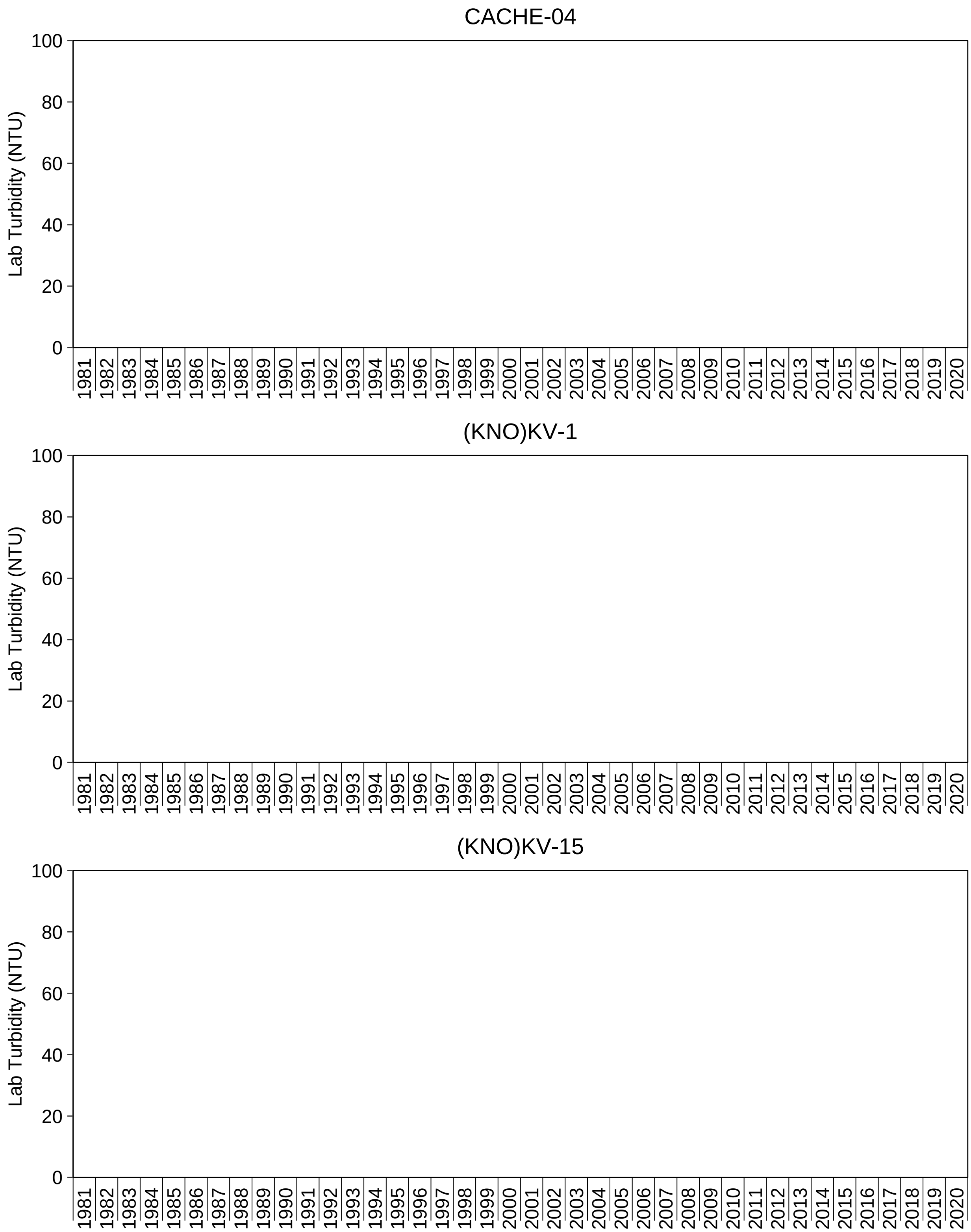


Figure A.11: Time Series Plots of Turbidity (lab; NTU) in the South McQuesten River, 1981 to 2020

Notes: NTU = Nephelometric Turbidity Units. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

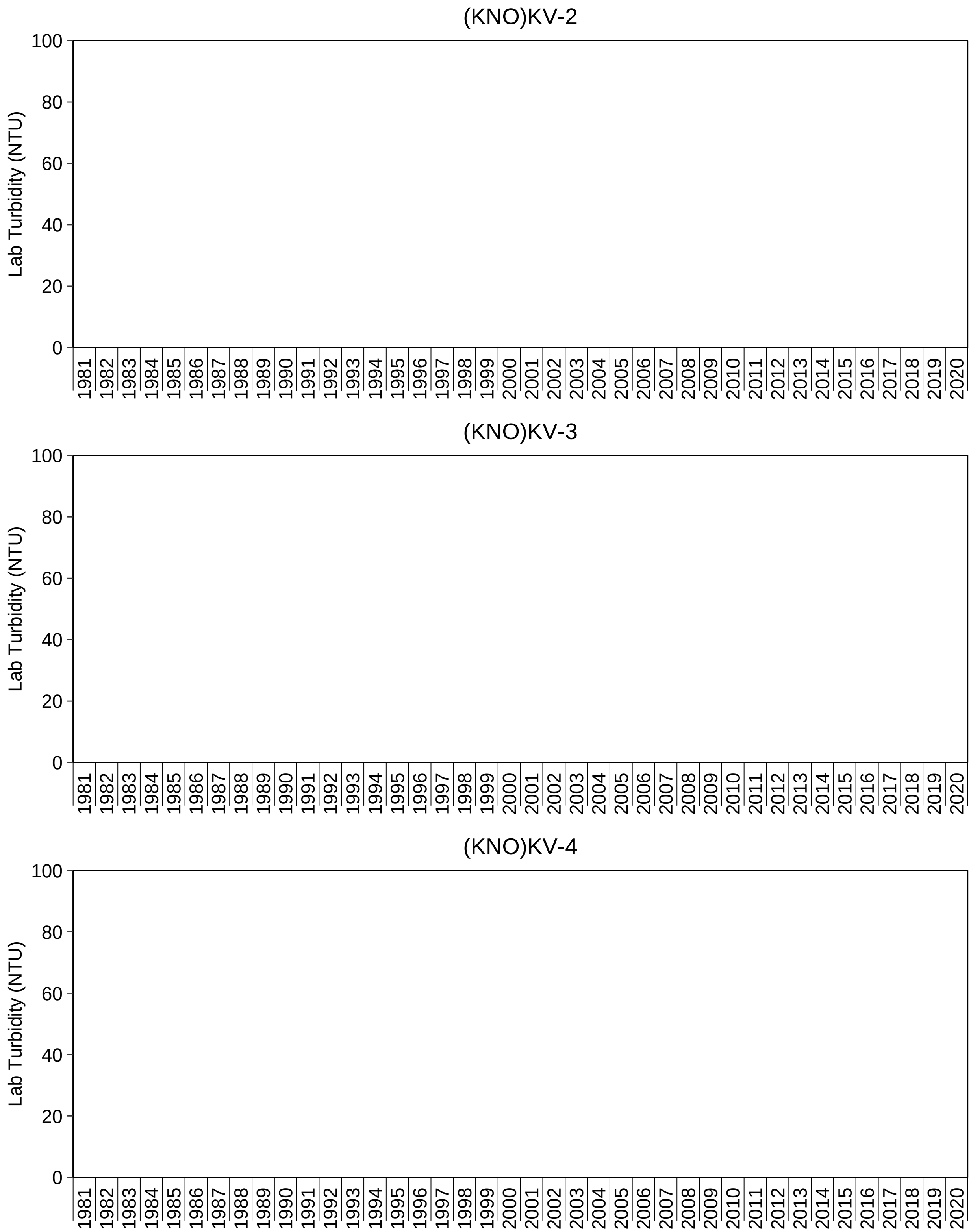


Figure A.11: Time Series Plots of Turbidity (lab; NTU) in the South McQuesten River, 1981 to 2020

Notes: NTU = Nephelometric Turbidity Units. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

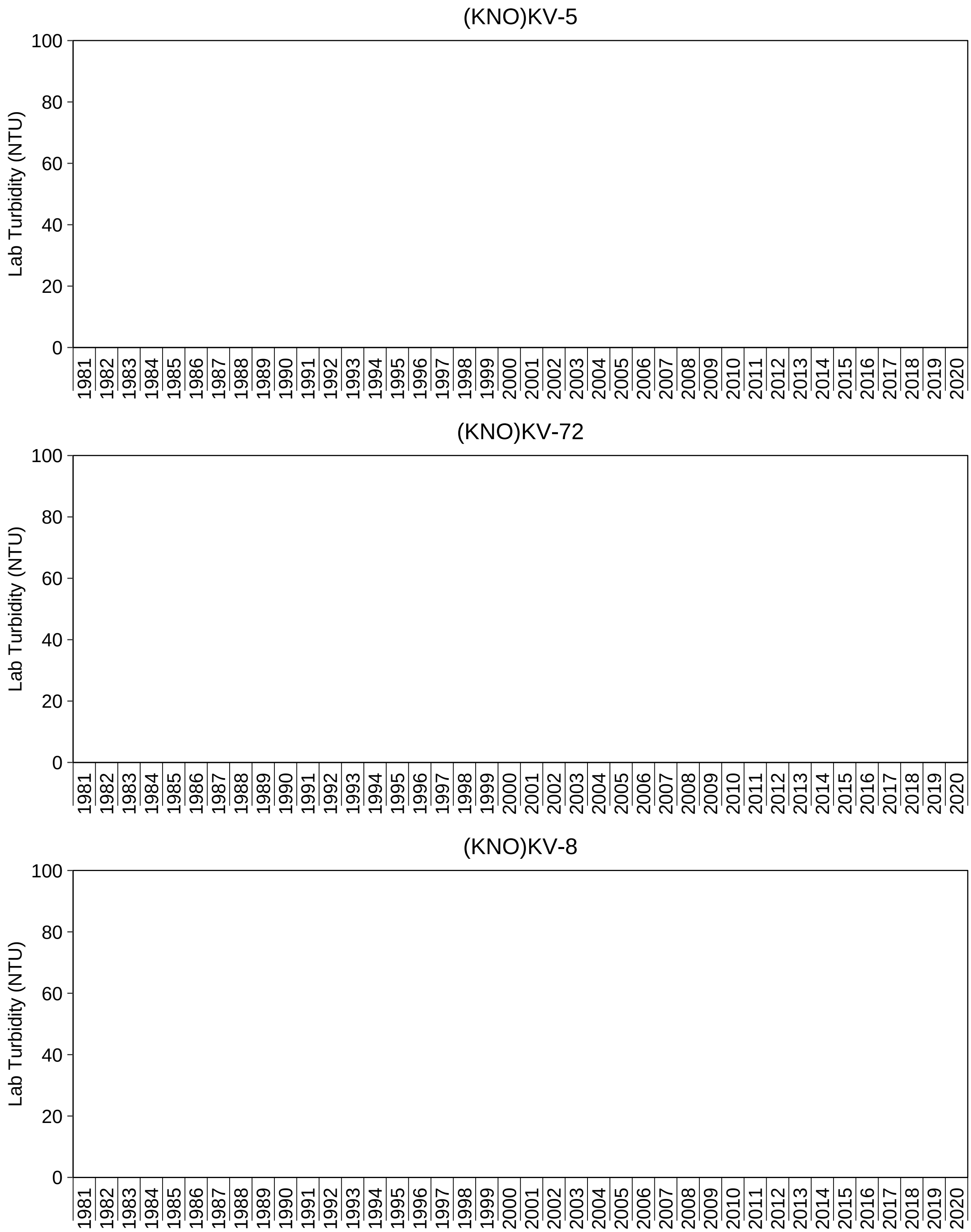
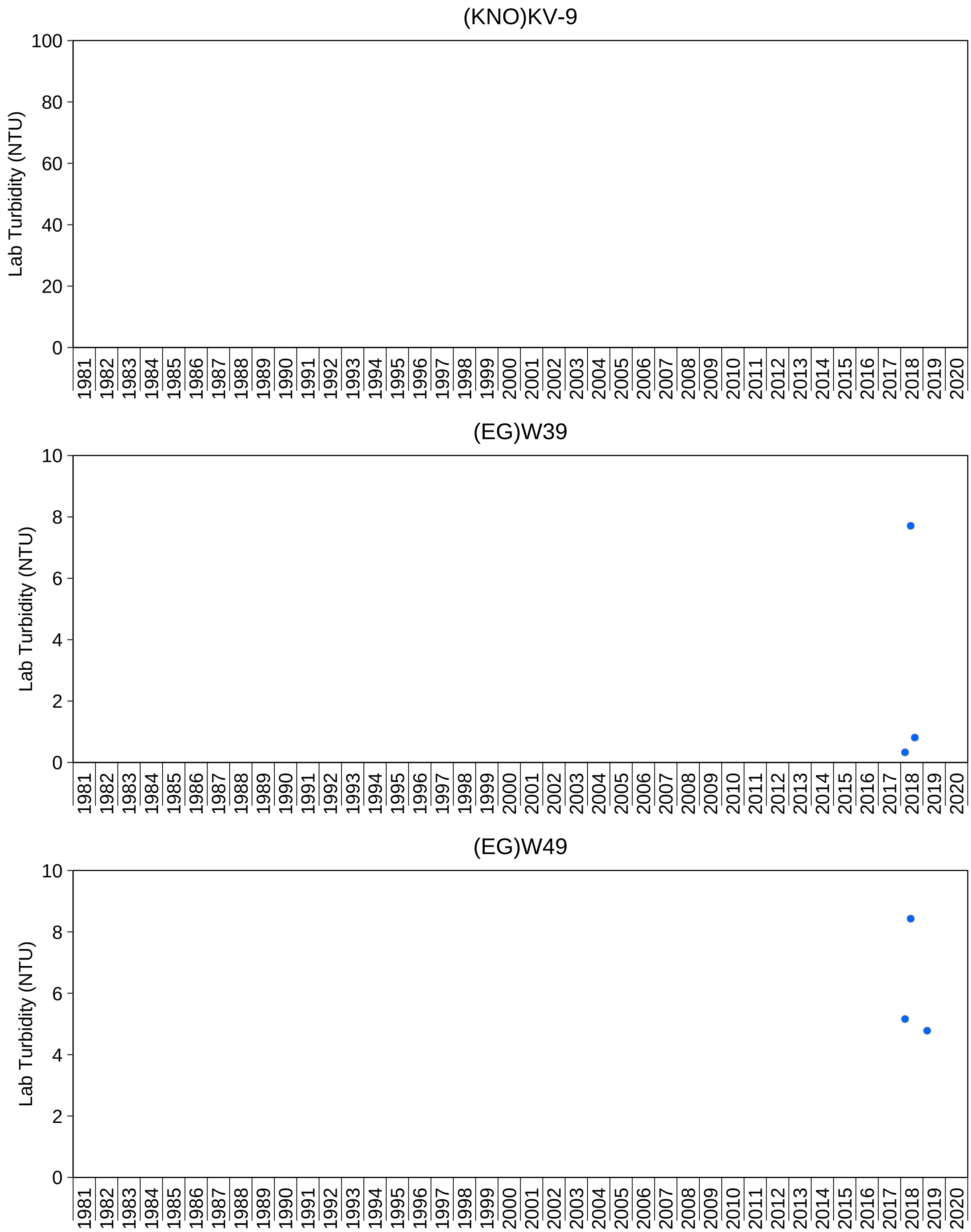


Figure A.11: Time Series Plots of Turbidity (lab; NTU) in the South McQuesten River, 1981 to 2020

Notes: NTU = Nephelometric Turbidity Units. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.



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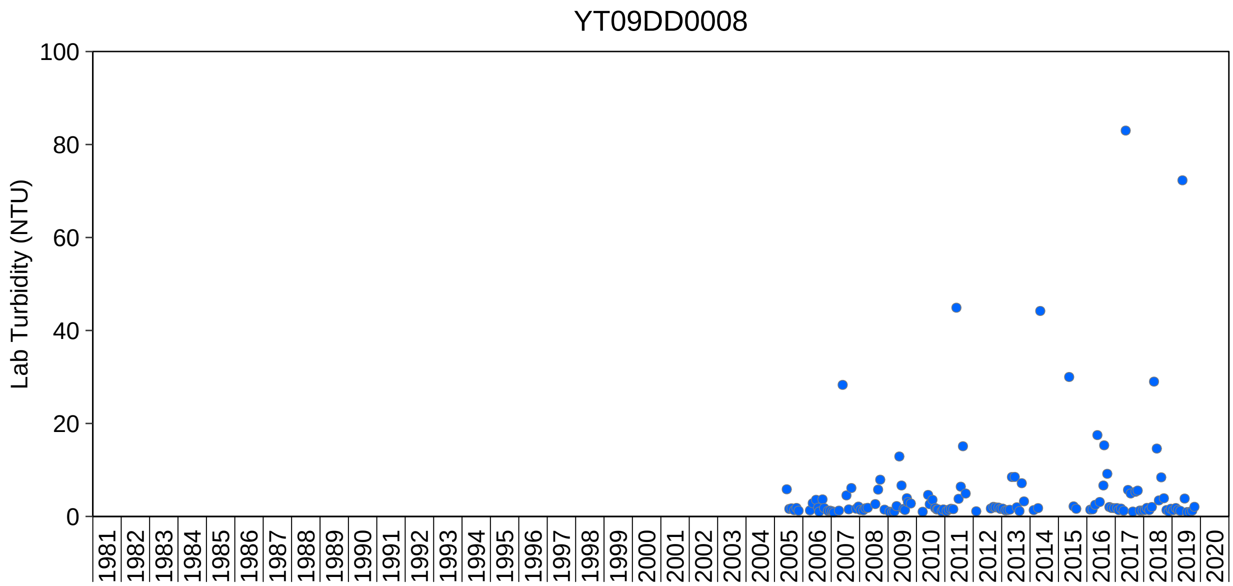

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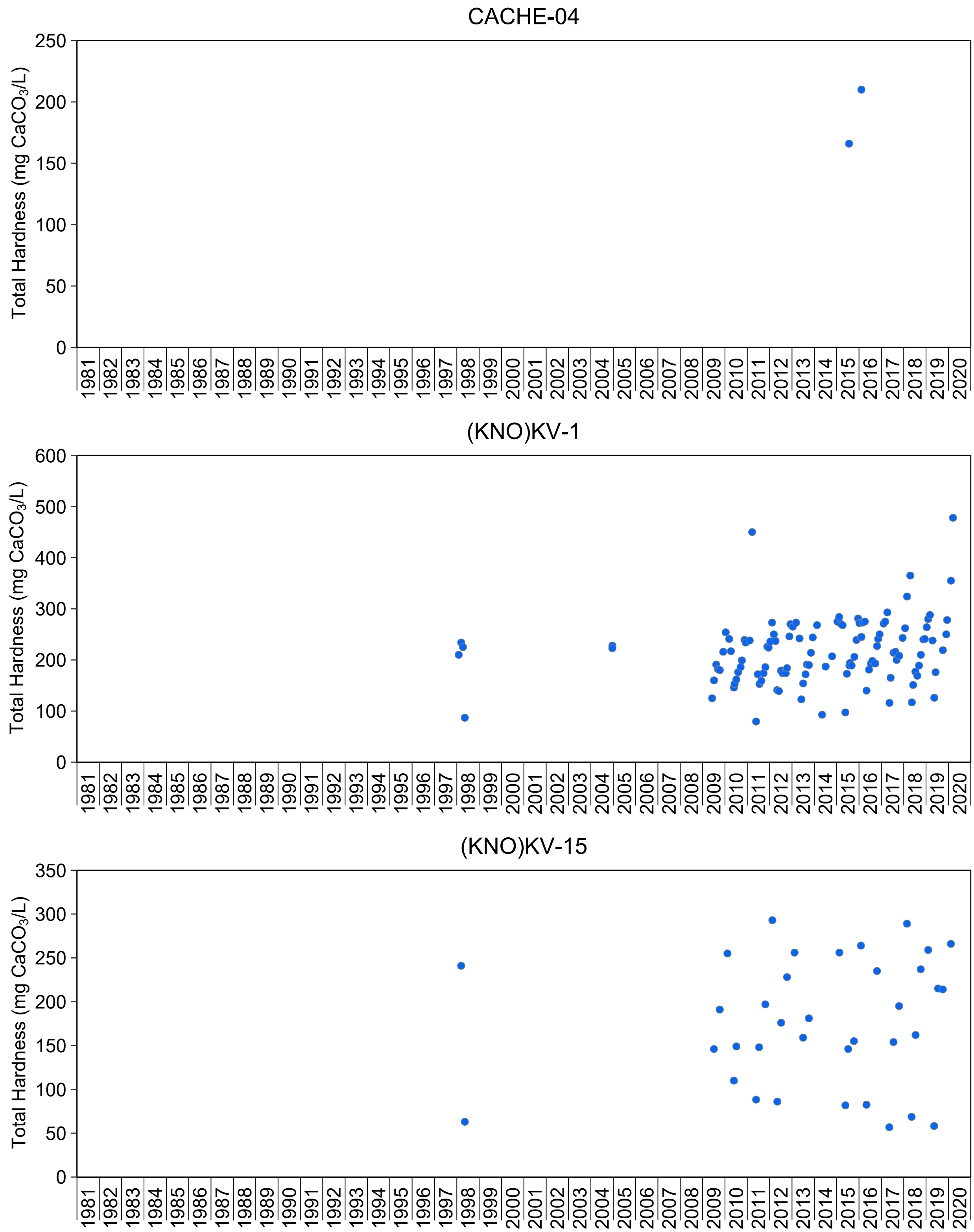
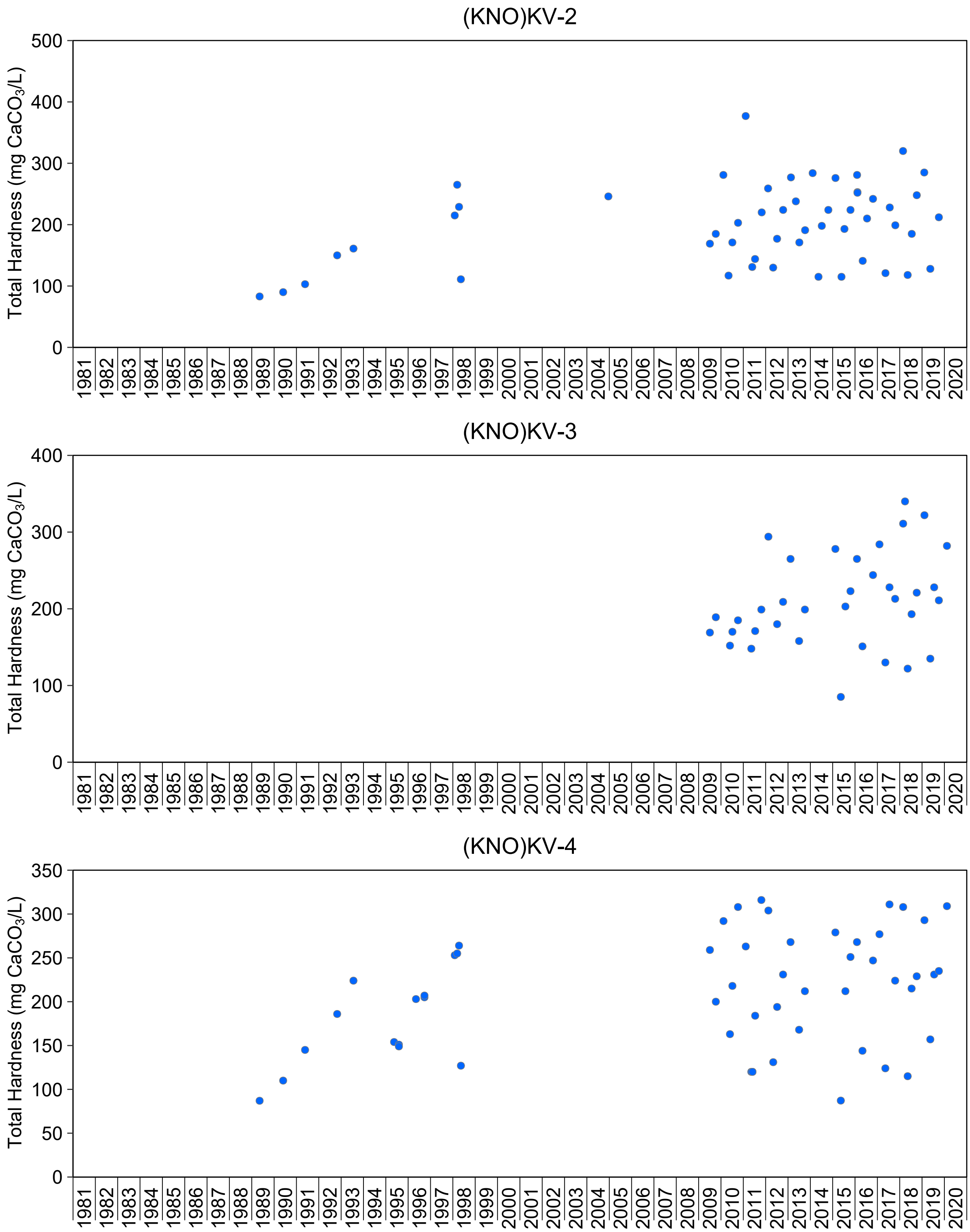


Figure A.12: Time Series Plots of Total Hardness Concentrations (mg $CaCO_3$/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L $CaCO_3$ /L = milligrams per litre as calcium carbonate. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.



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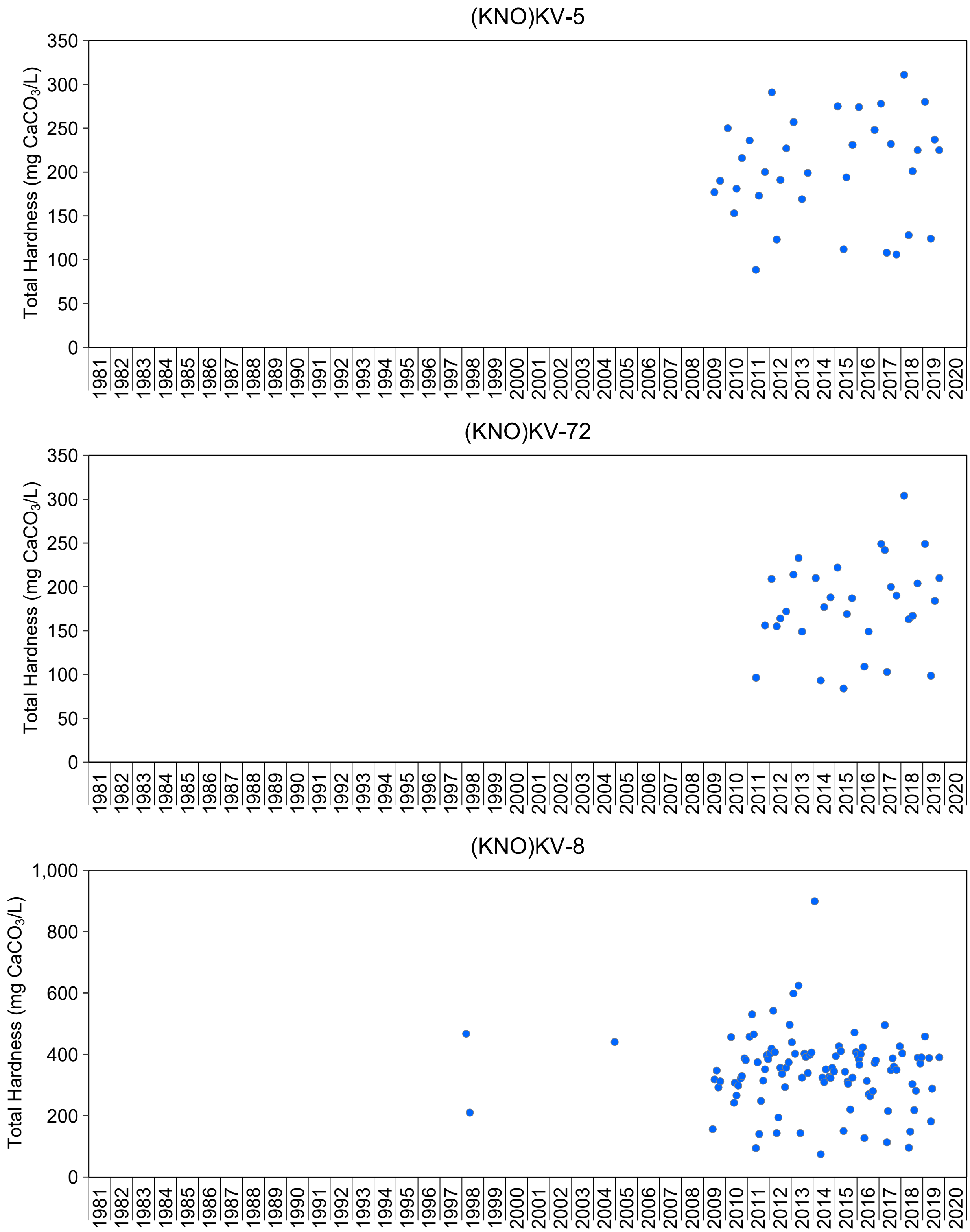
Notes: mg/L $CaCO_3$ /L = milligrams per litre as calcium carbonate. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.



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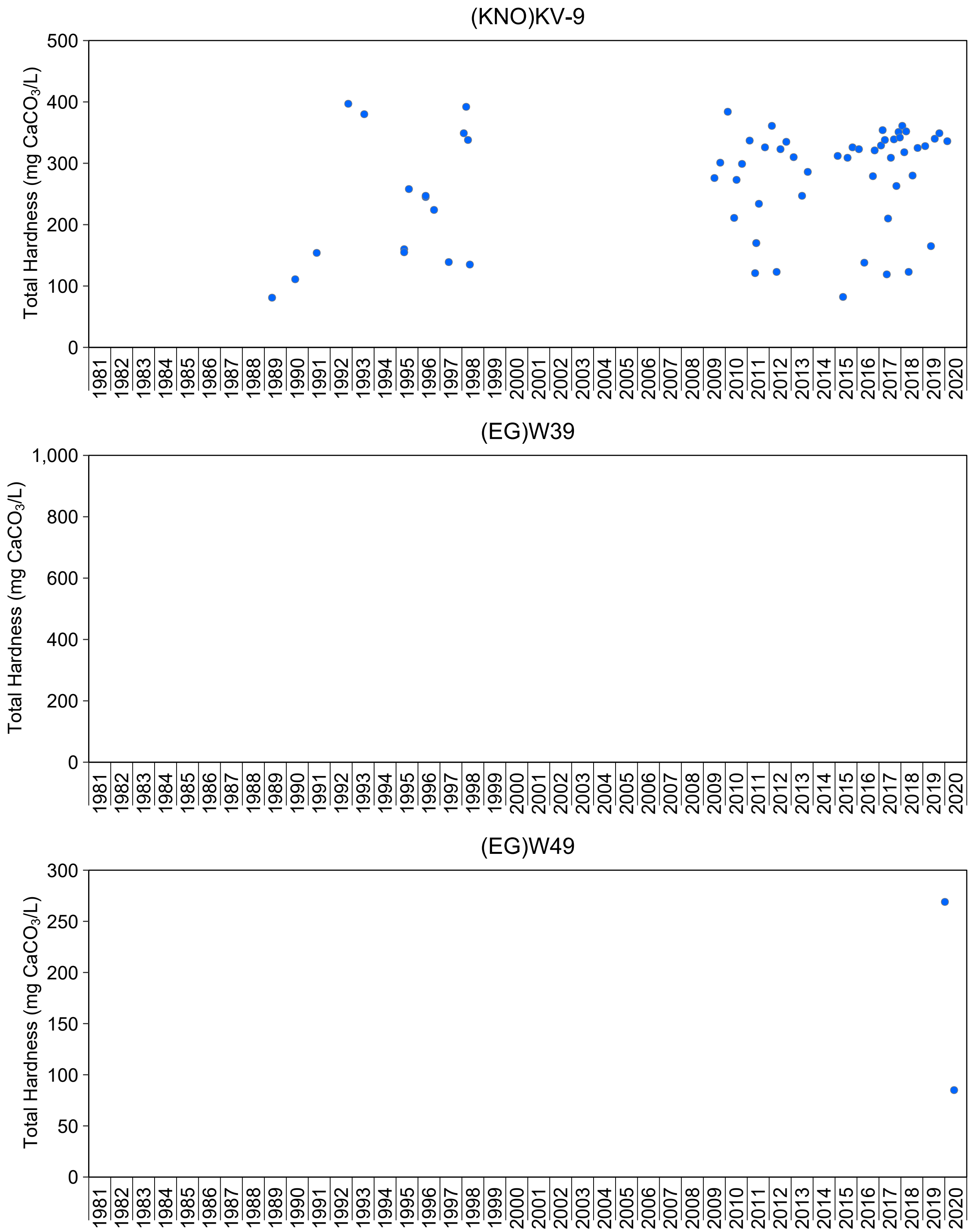

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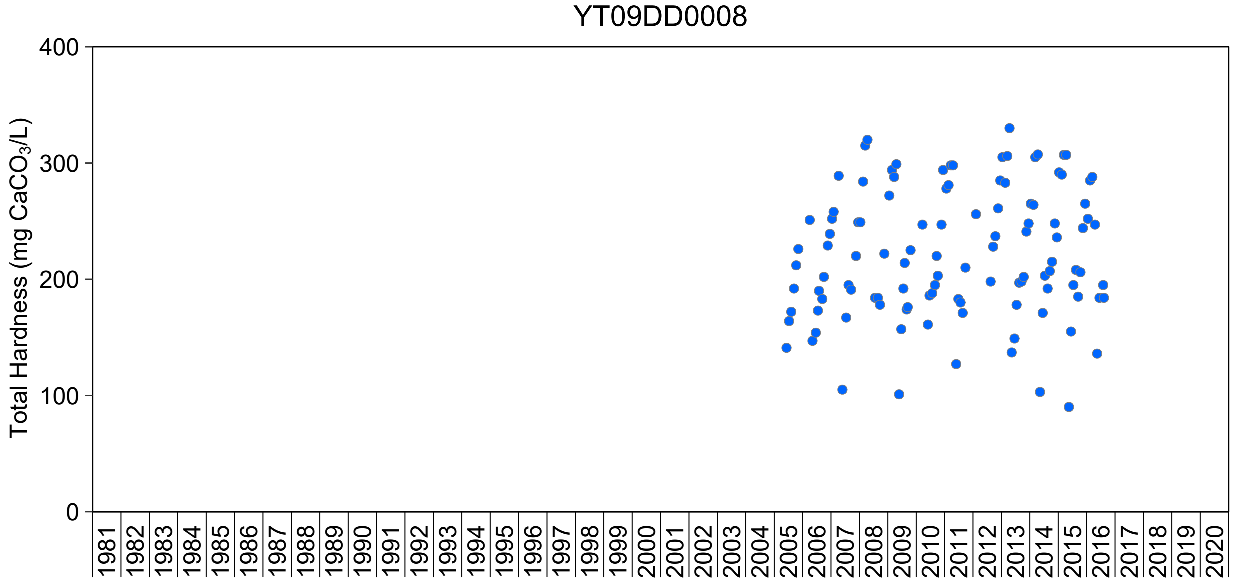

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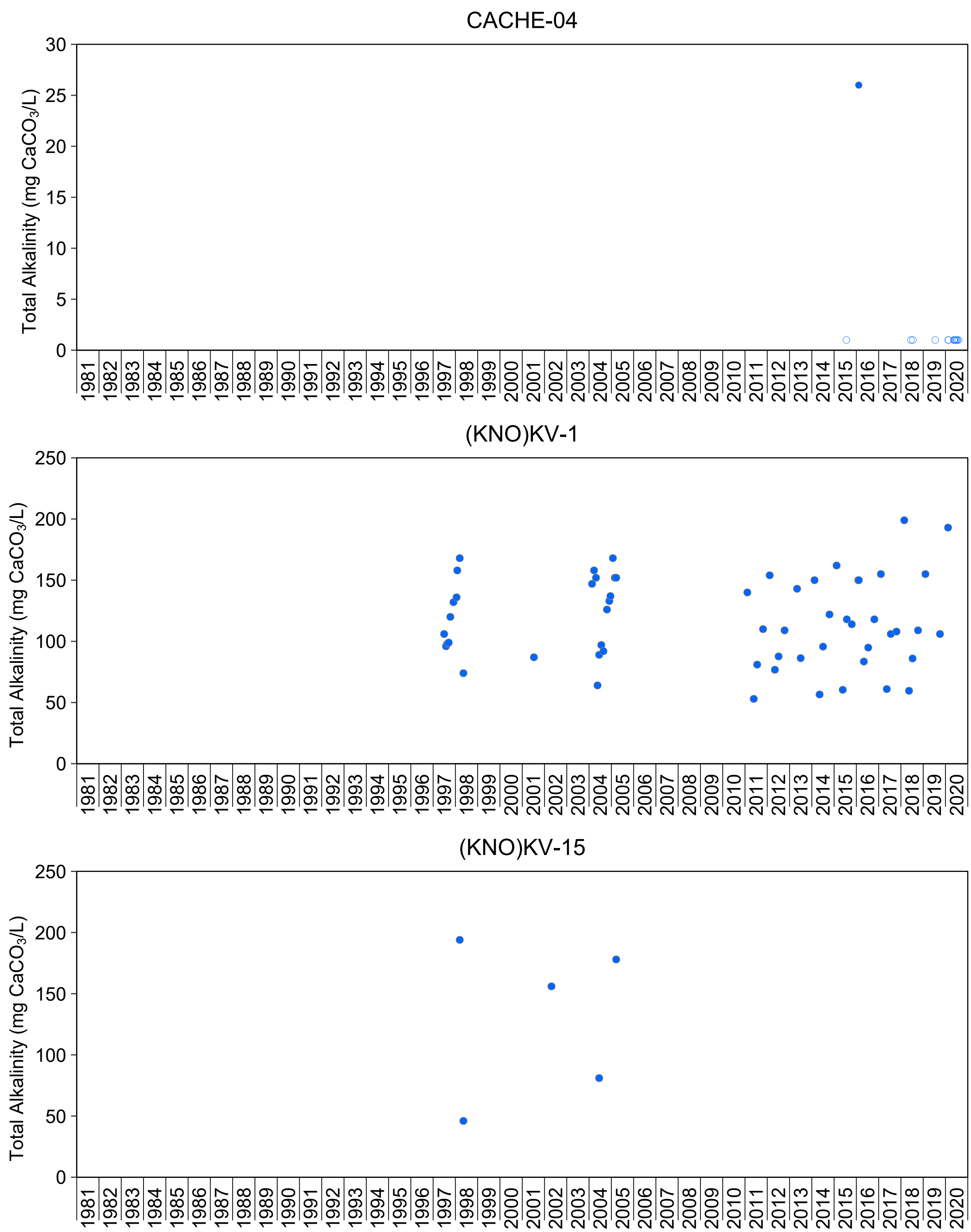


Figure A.13: Time Series Plots of Total Alkalinity Concentrations (mg $CaCO_3$/L) in the South McQuesten River, 1981 to 2020

Notes: mg $CaCO_3$/L = milligrams per litre as calcium carbonate. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

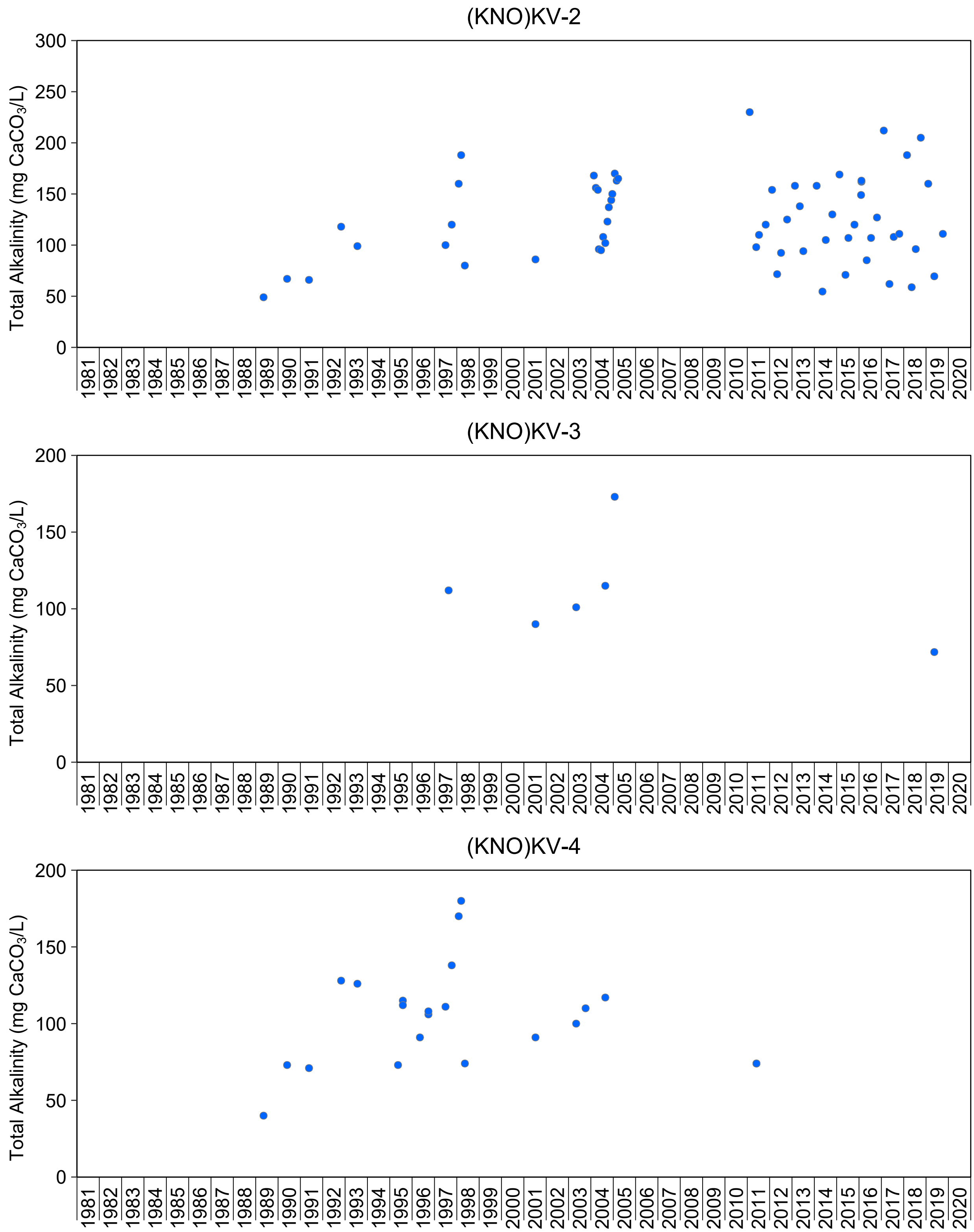
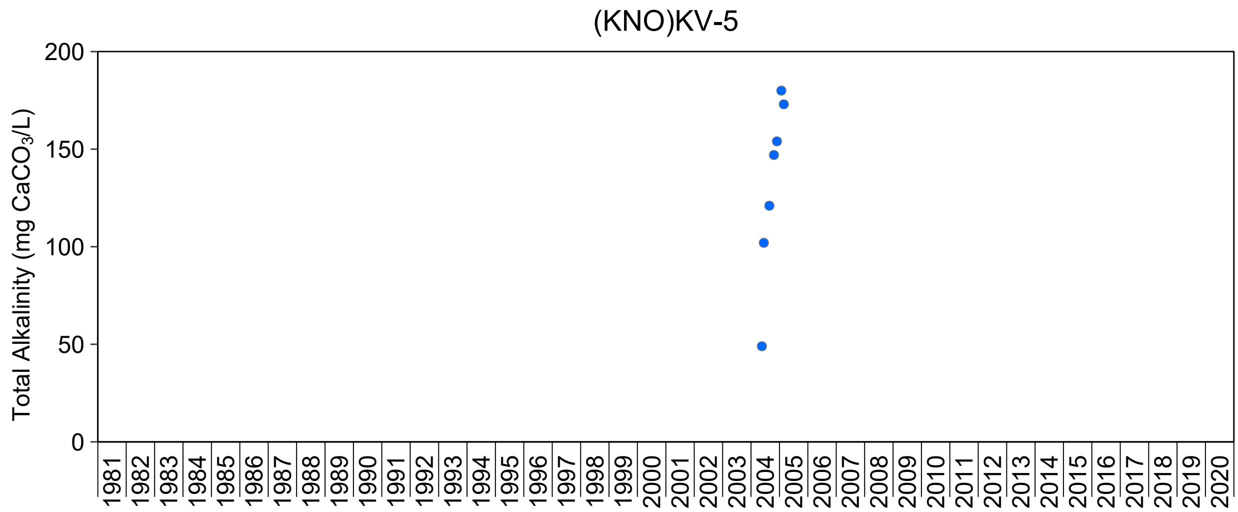
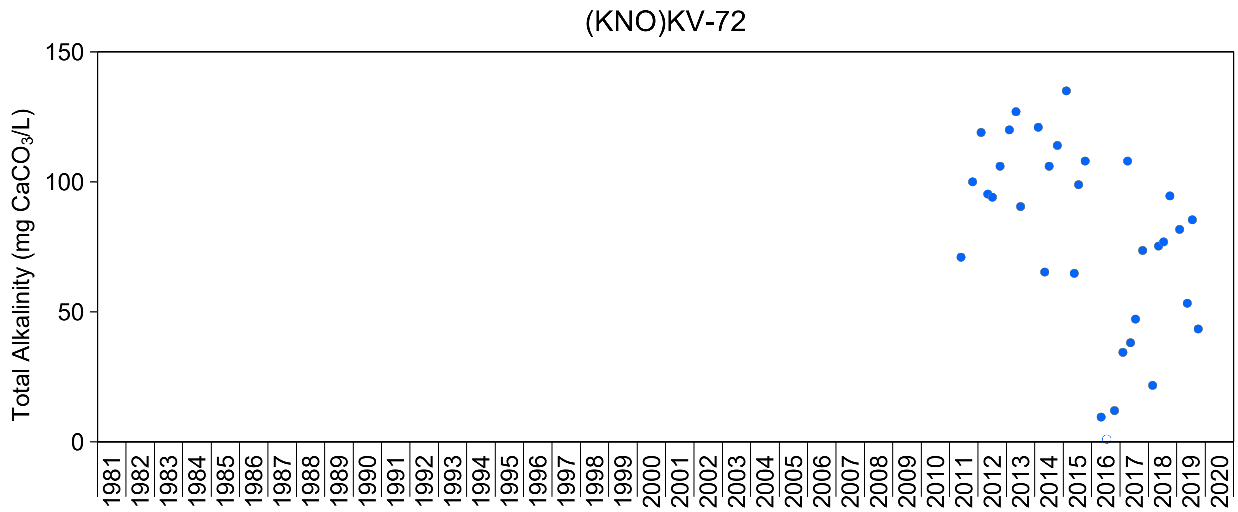


Figure A.13: Time Series Plots of Total Alkalinity Concentrations (mg $CaCO_3$/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L $CaCO_3$ /L = milligrams per litre as calcium carbonate. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.





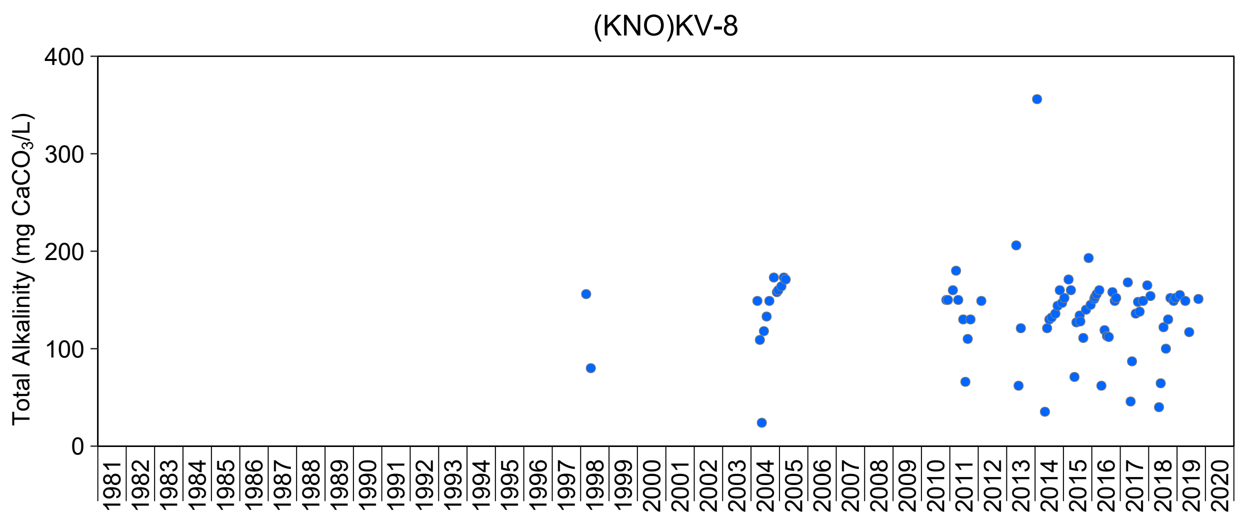


Figure A.13: Time Series Plots of Total Alkalinity Concentrations (mg $CaCO_3$/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L $CaCO_3$ /L = milligrams per litre as calcium carbonate. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

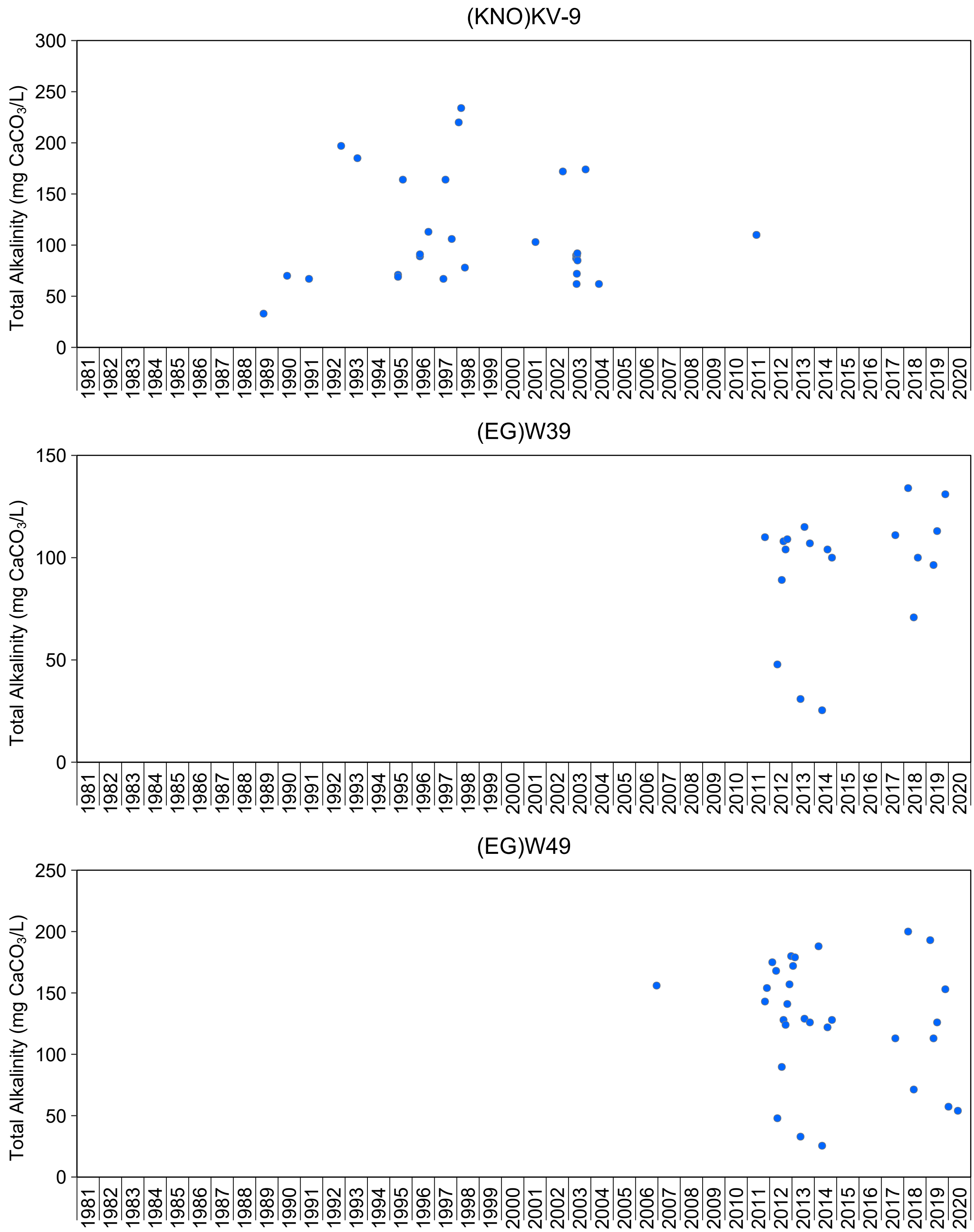


Figure A.13: Time Series Plots of Total Alkalinity Concentrations (mg $CaCO_3$/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L $CaCO_3$ /L = milligrams per litre as calcium carbonate. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

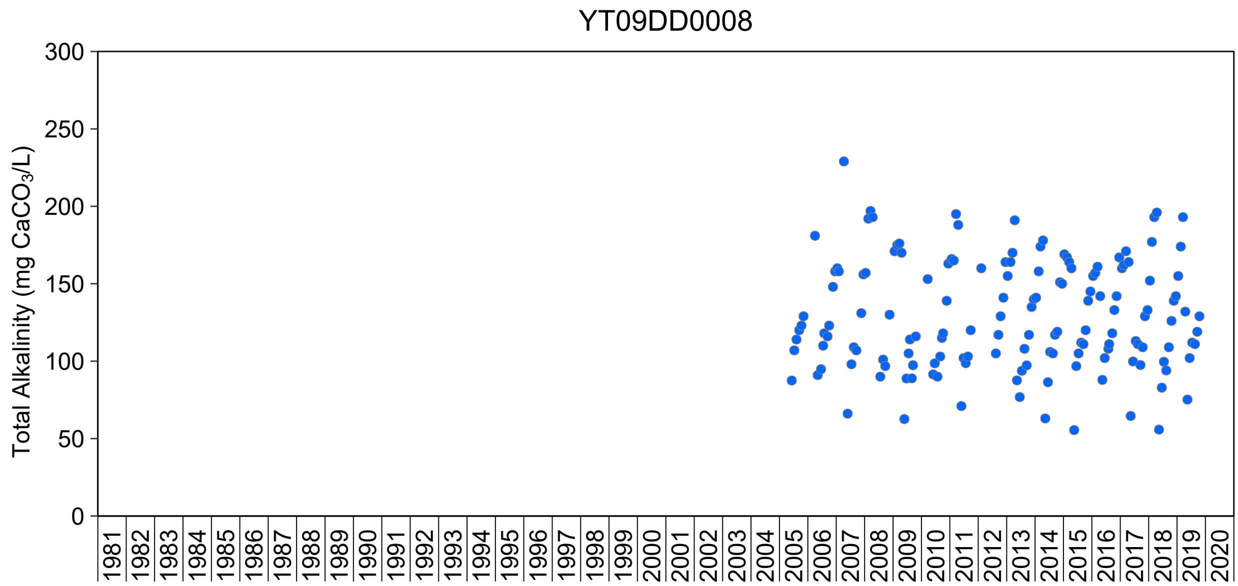


Figure A.13: Time Series Plots of Total Alkalinity Concentrations (mg $CaCO_3$/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L $CaCO_3$ /L = milligrams per litre as calcium carbonate. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

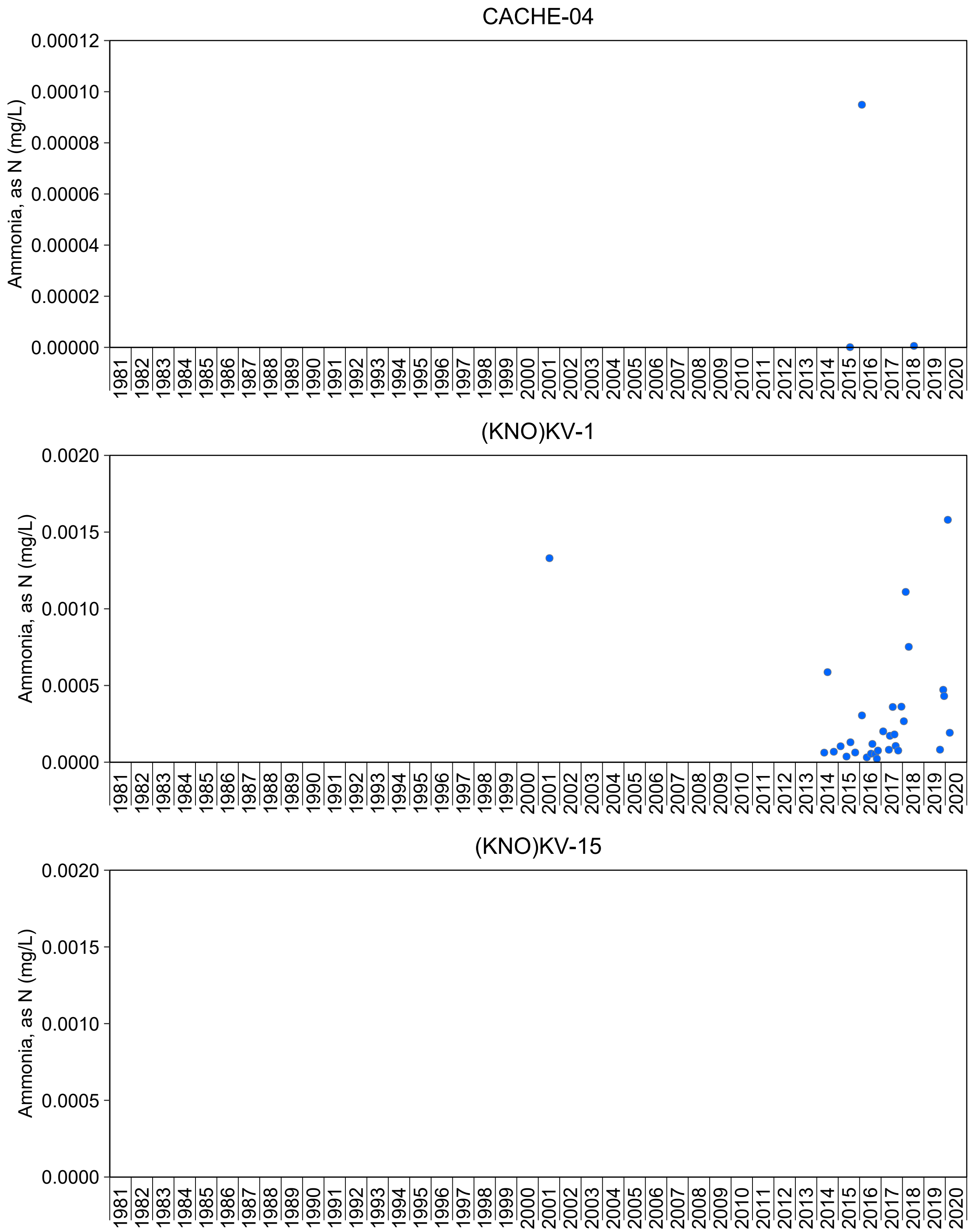


Figure A.14: Time Series Plots of Un-ionized Ammonia Concentrations (as N; mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

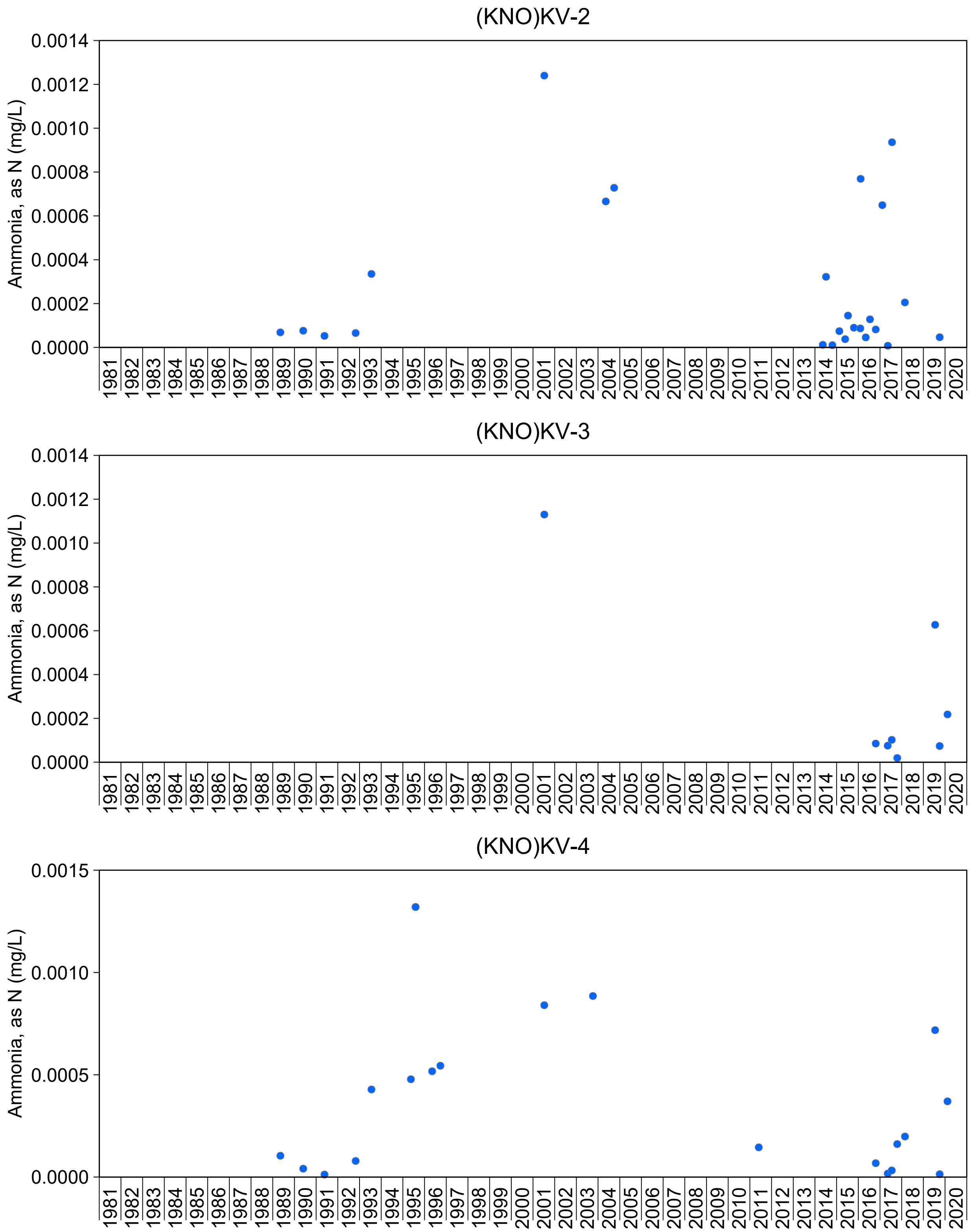


Figure A.14: Time Series Plots of Un-ionized Ammonia Concentrations (as N; mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

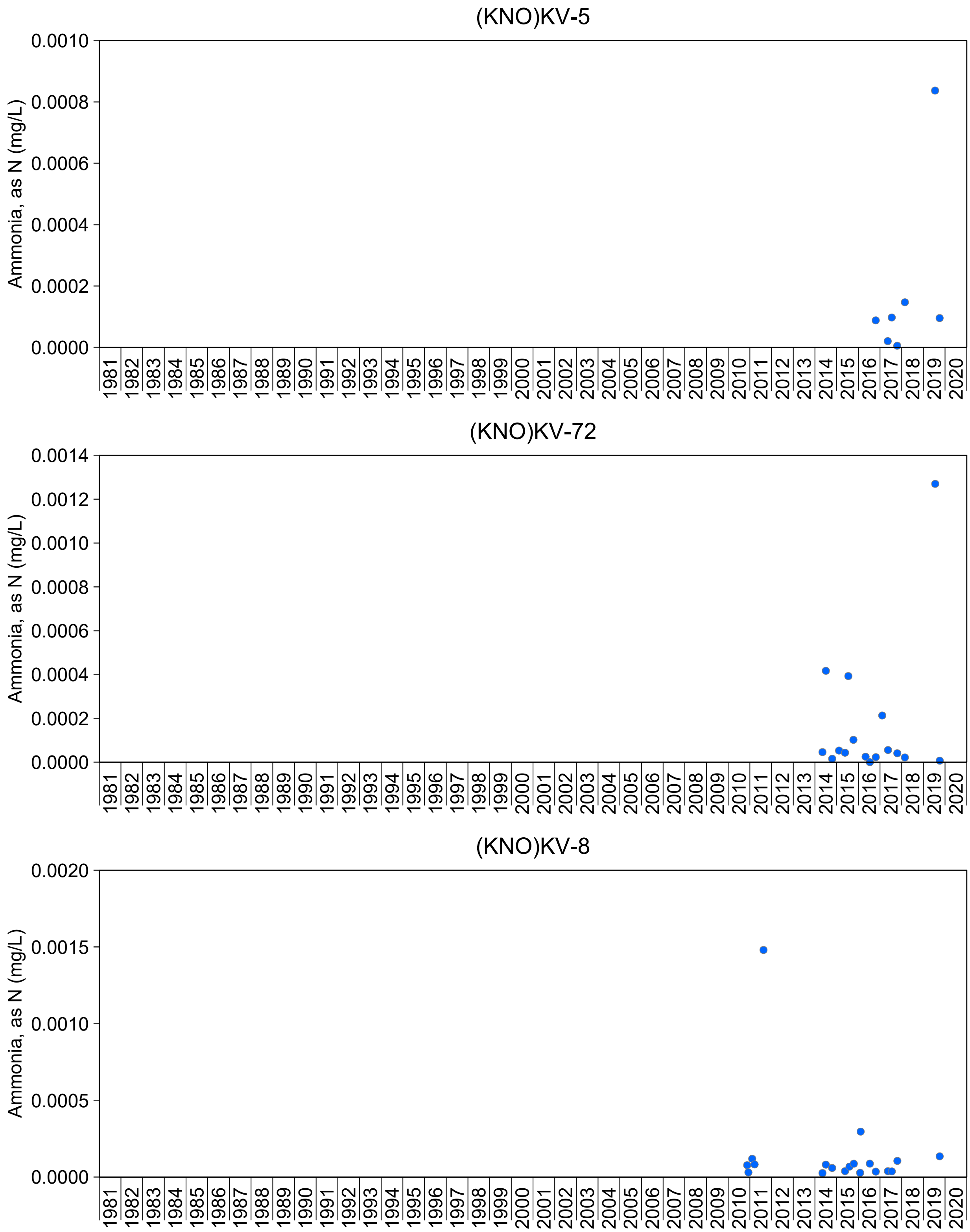


Figure A.14: Time Series Plots of Un-ionized Ammonia Concentrations (as N; mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

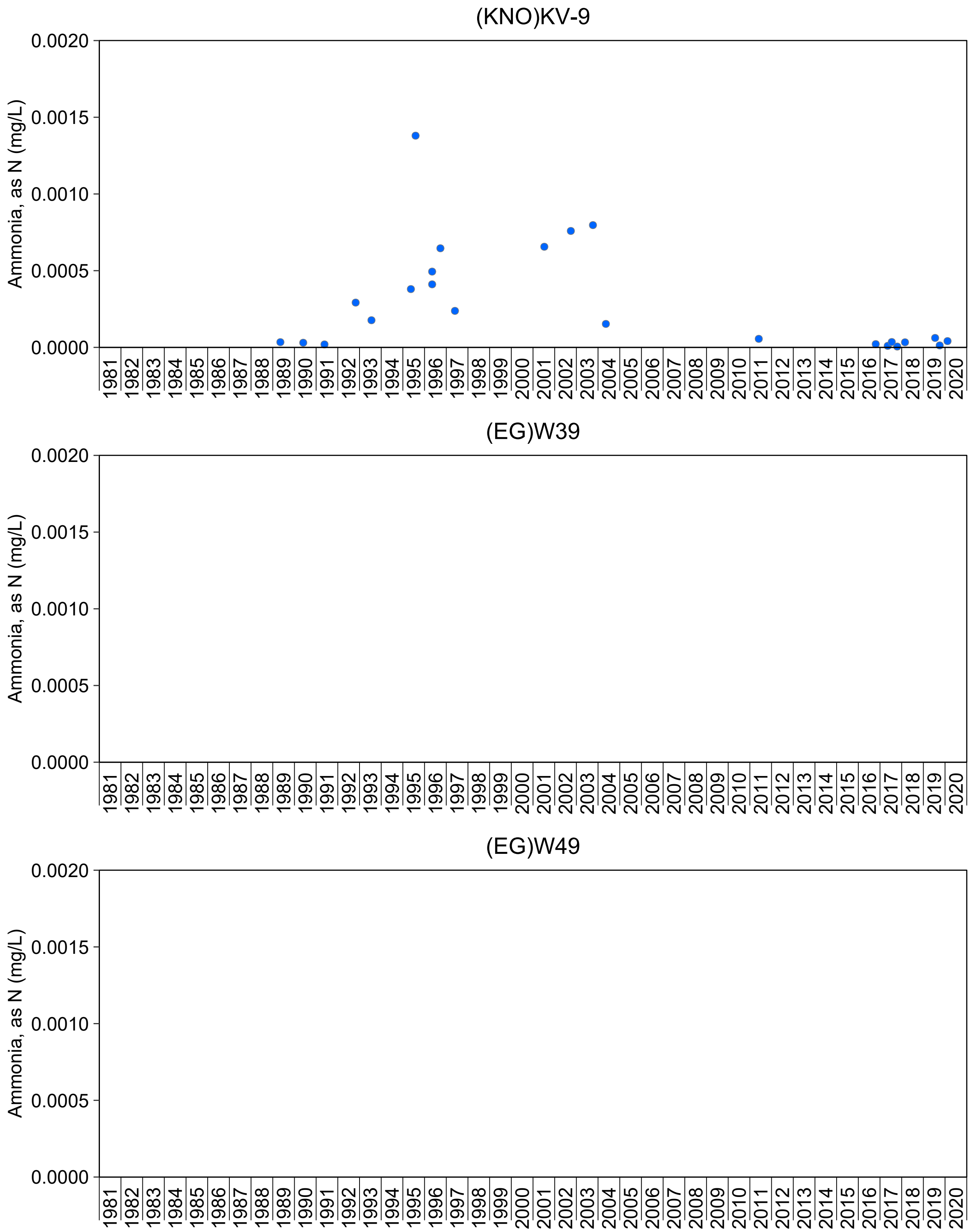


Figure A.14: Time Series Plots of Un-ionized Ammonia Concentrations (as N; mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

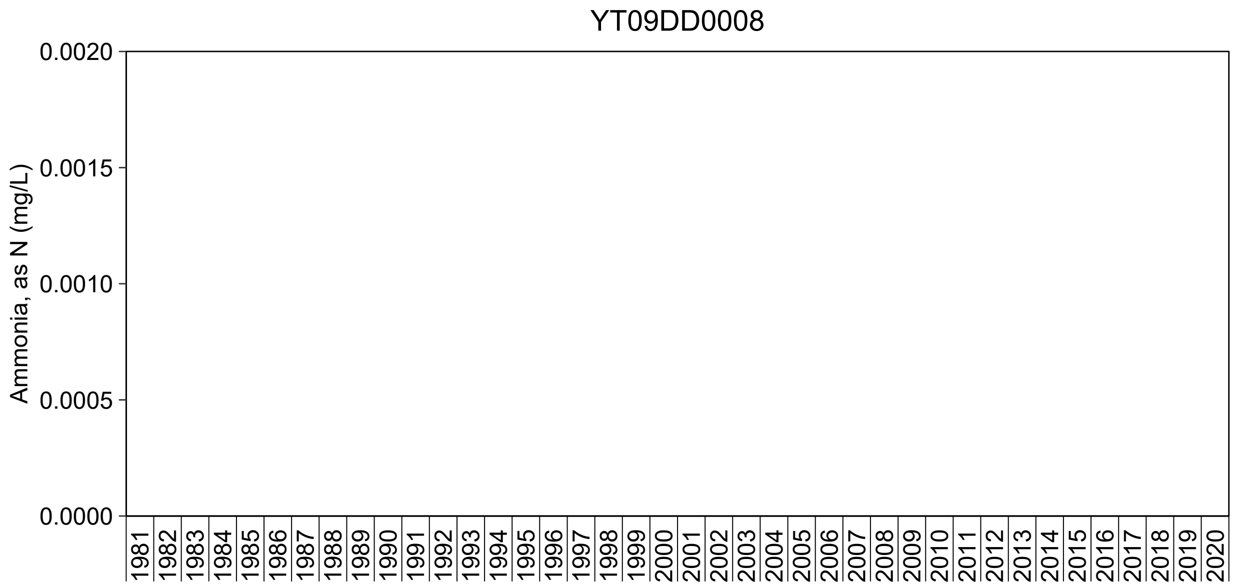


Figure A.14: Time Series Plots of Un-ionized Ammonia Concentrations (as N; mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

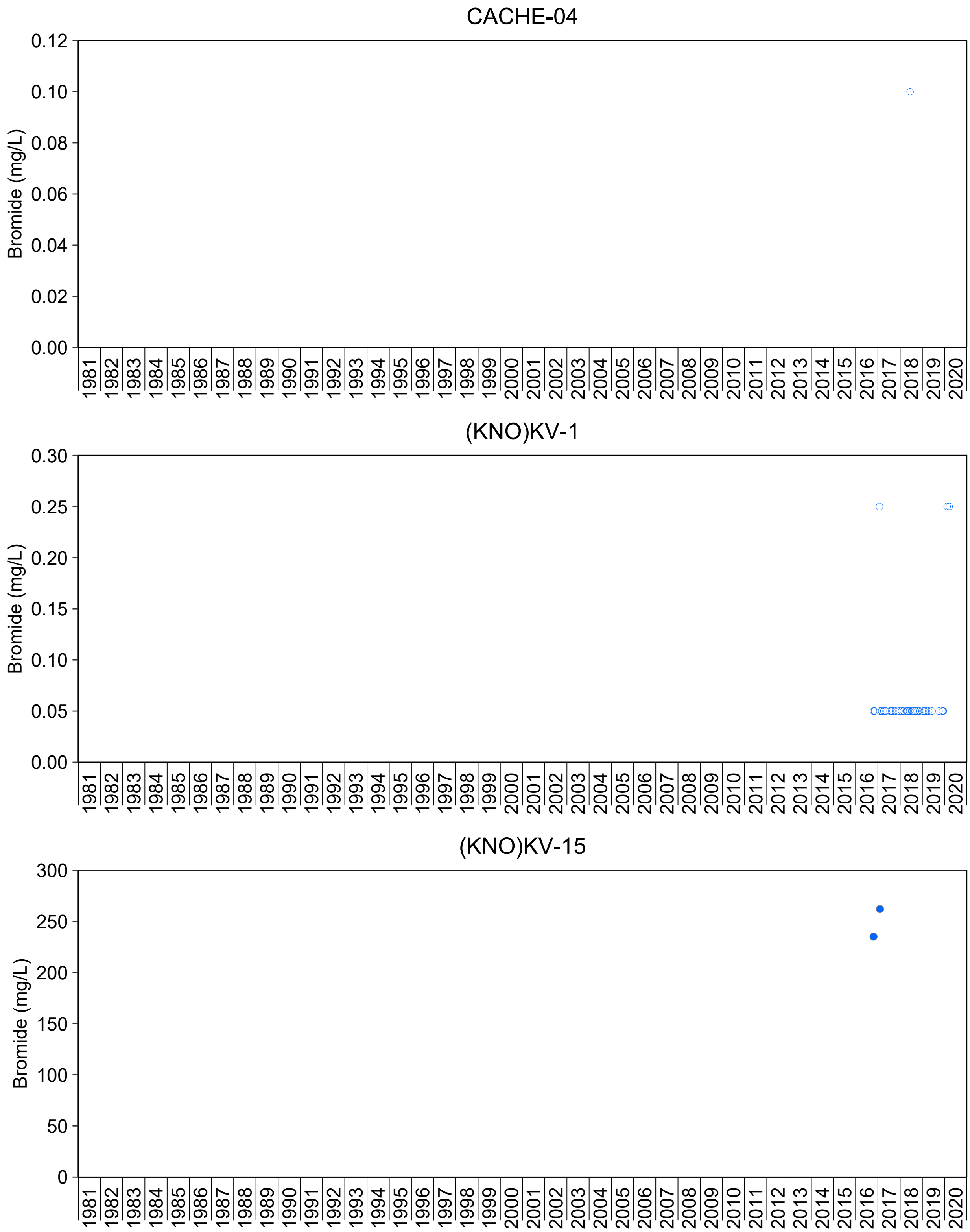


Figure A.15: Time Series Plots of Bromide Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

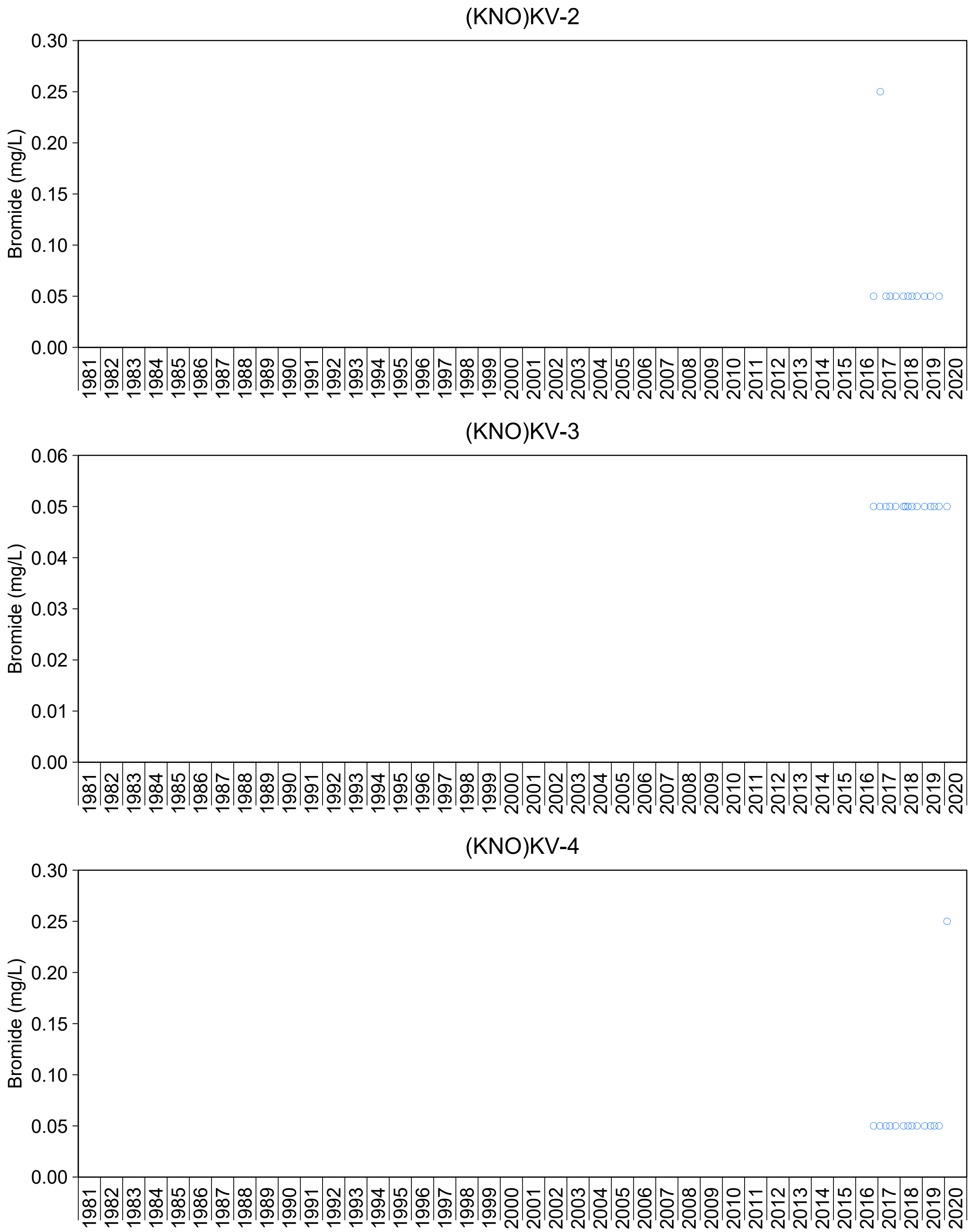


Figure A.15: Time Series Plots of Bromide Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

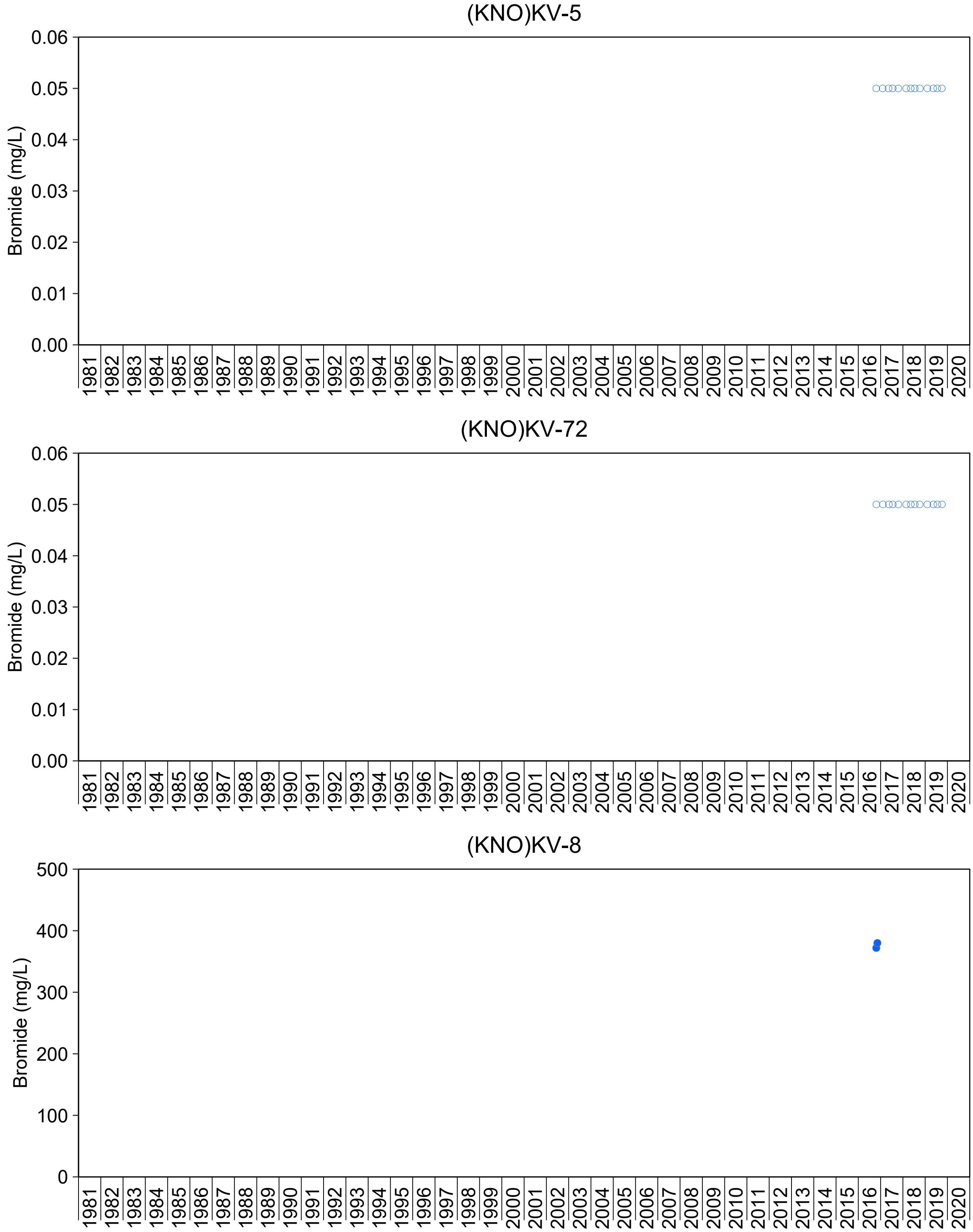


Figure A.15: Time Series Plots of Bromide Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

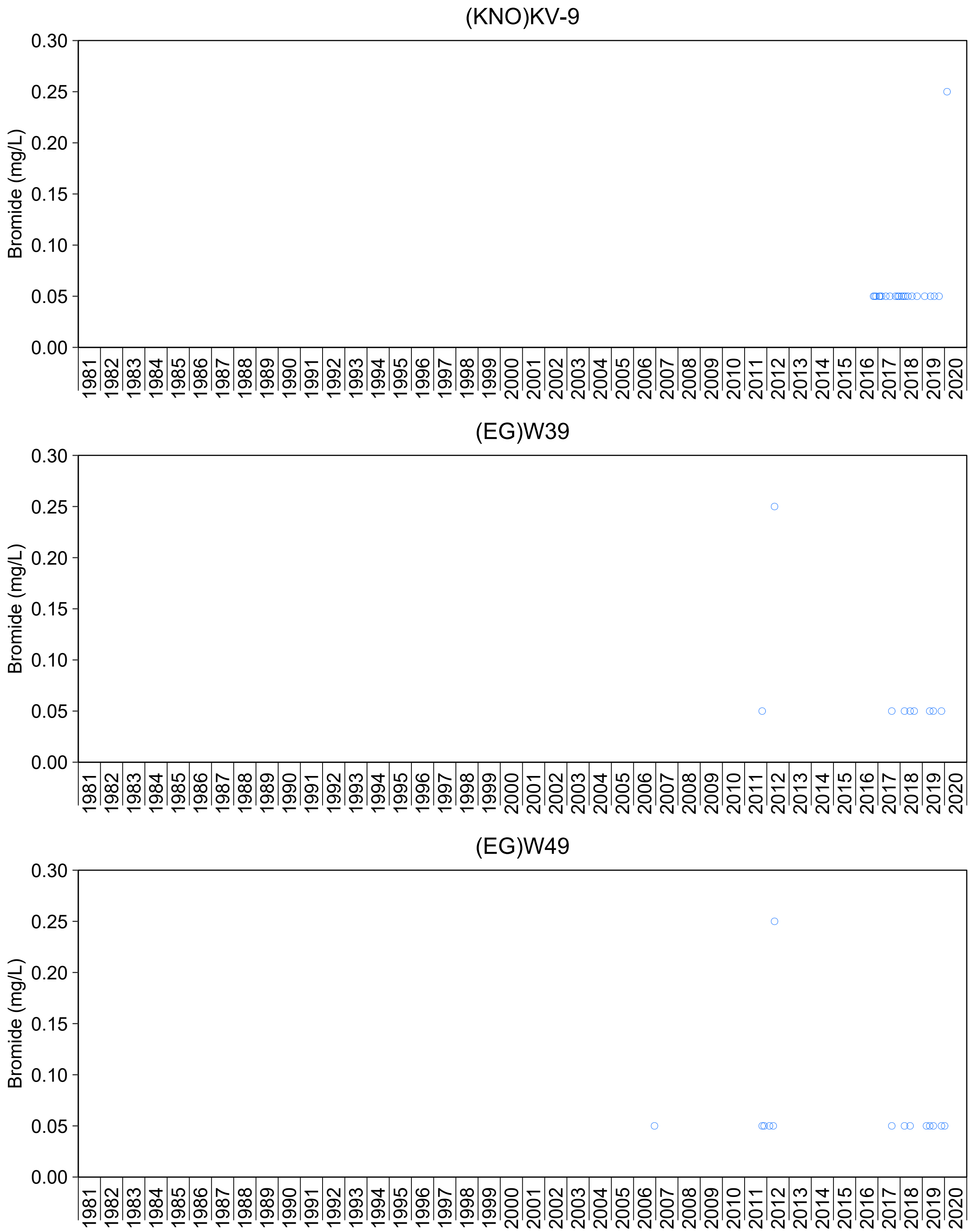


Figure A.15: Time Series Plots of Bromide Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

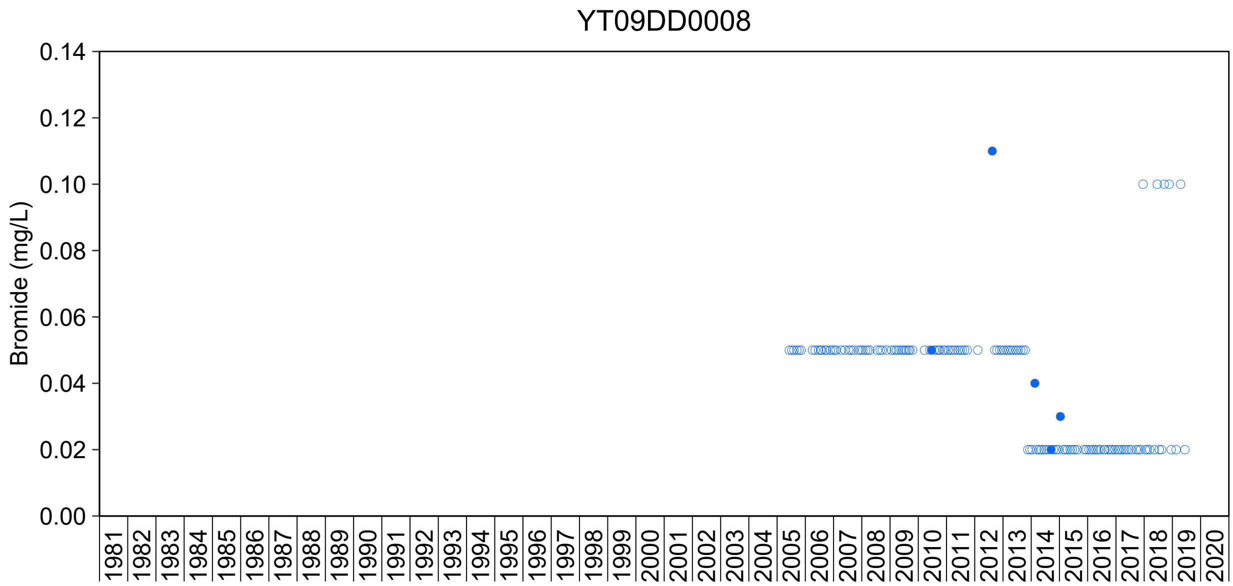


Figure A.15: Time Series Plots of Bromide Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

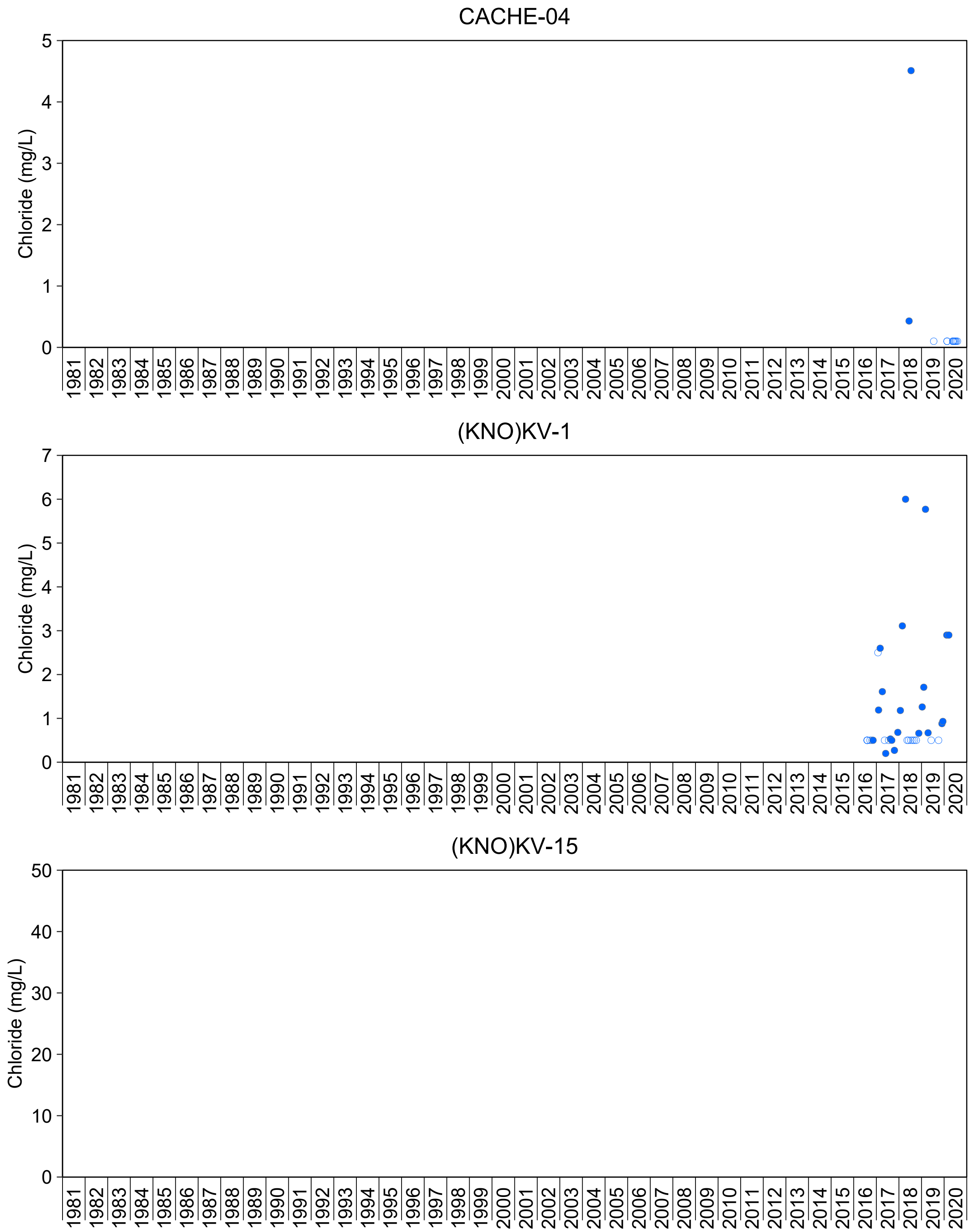


Figure A.16: Time Series Plots of Chloride Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

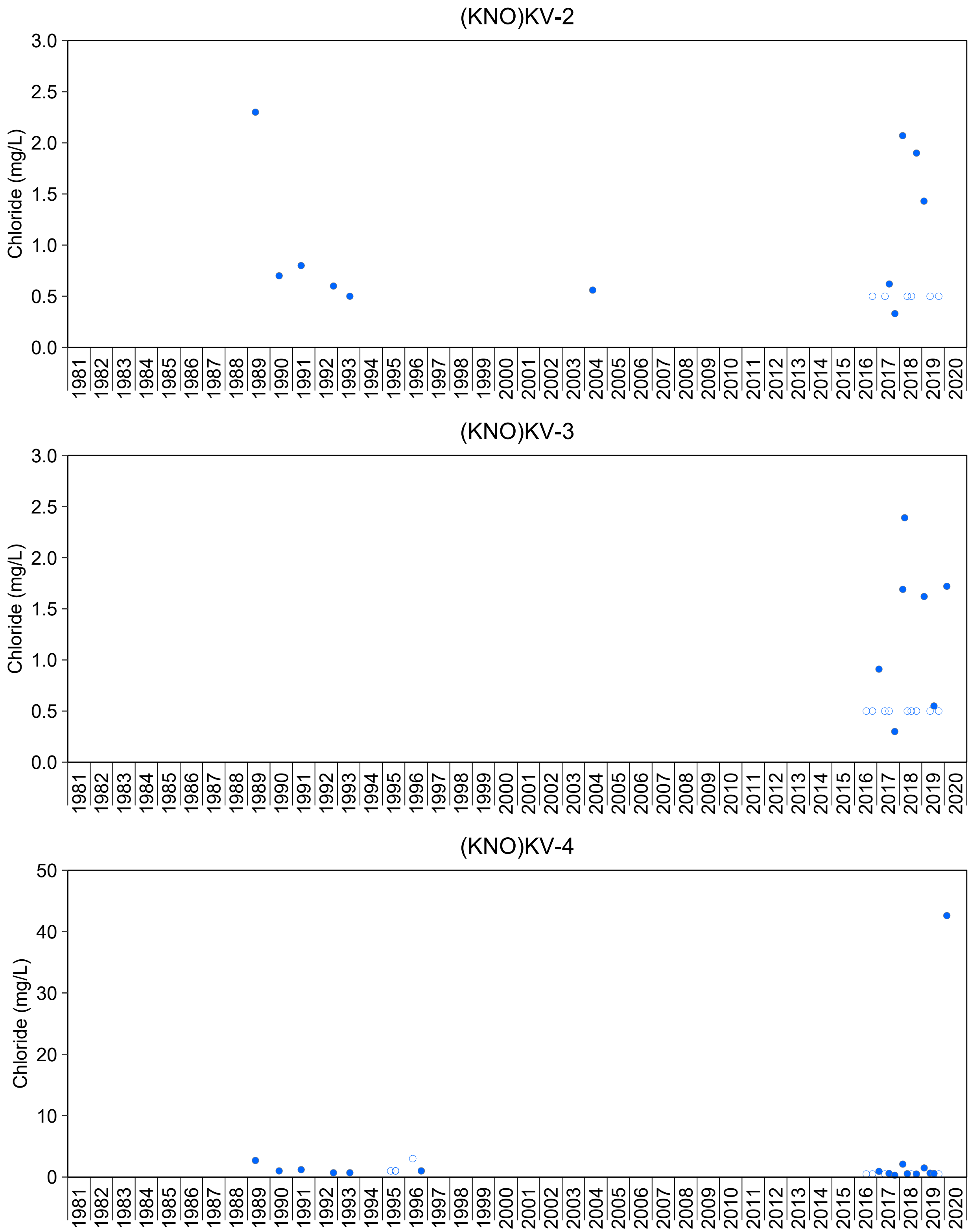


Figure A.16: **Time Series Plots of Chloride Concentrations (mg/L) in the South McQuesten River, 1981 to 2020**

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

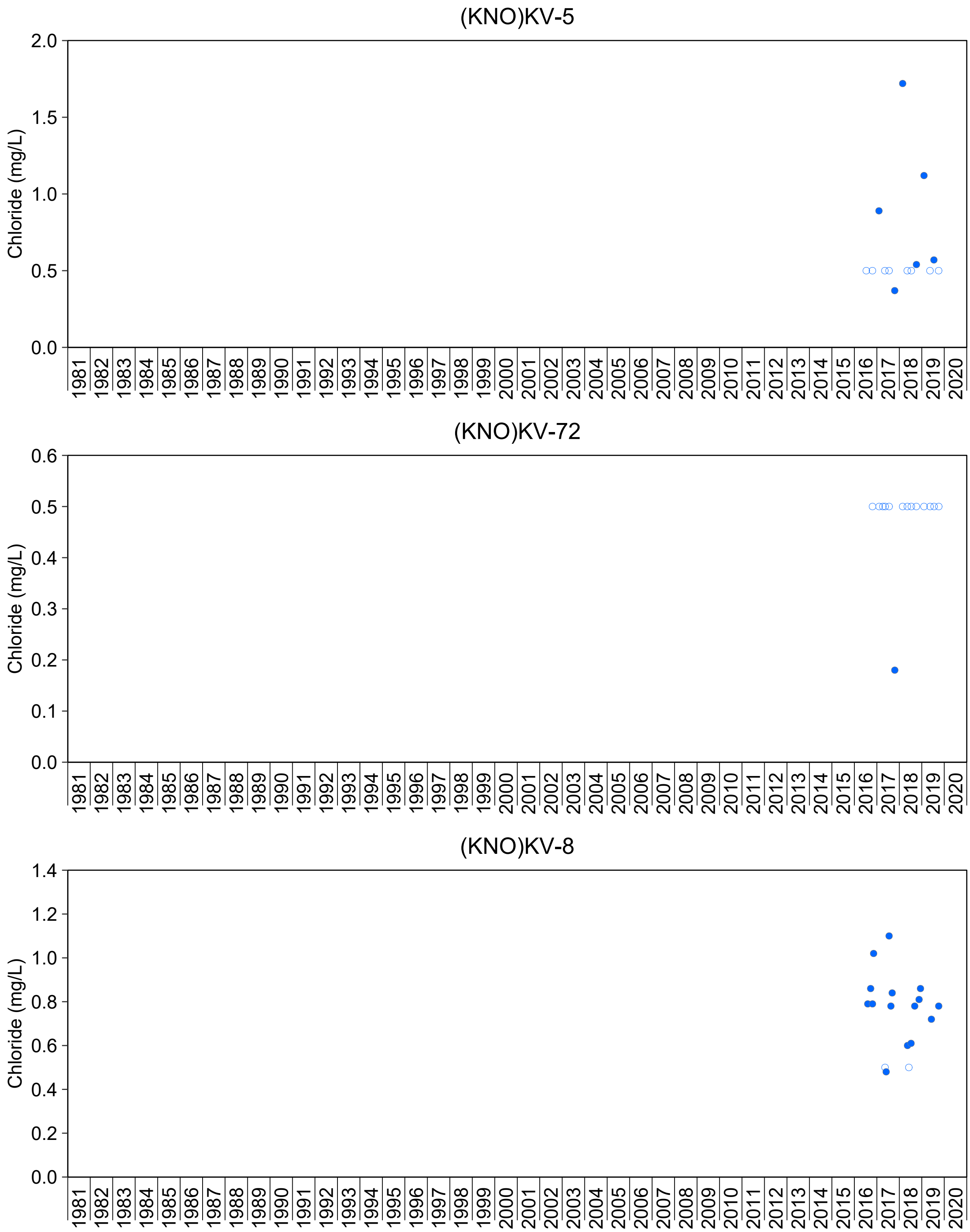


Figure A.16: Time Series Plots of Chloride Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

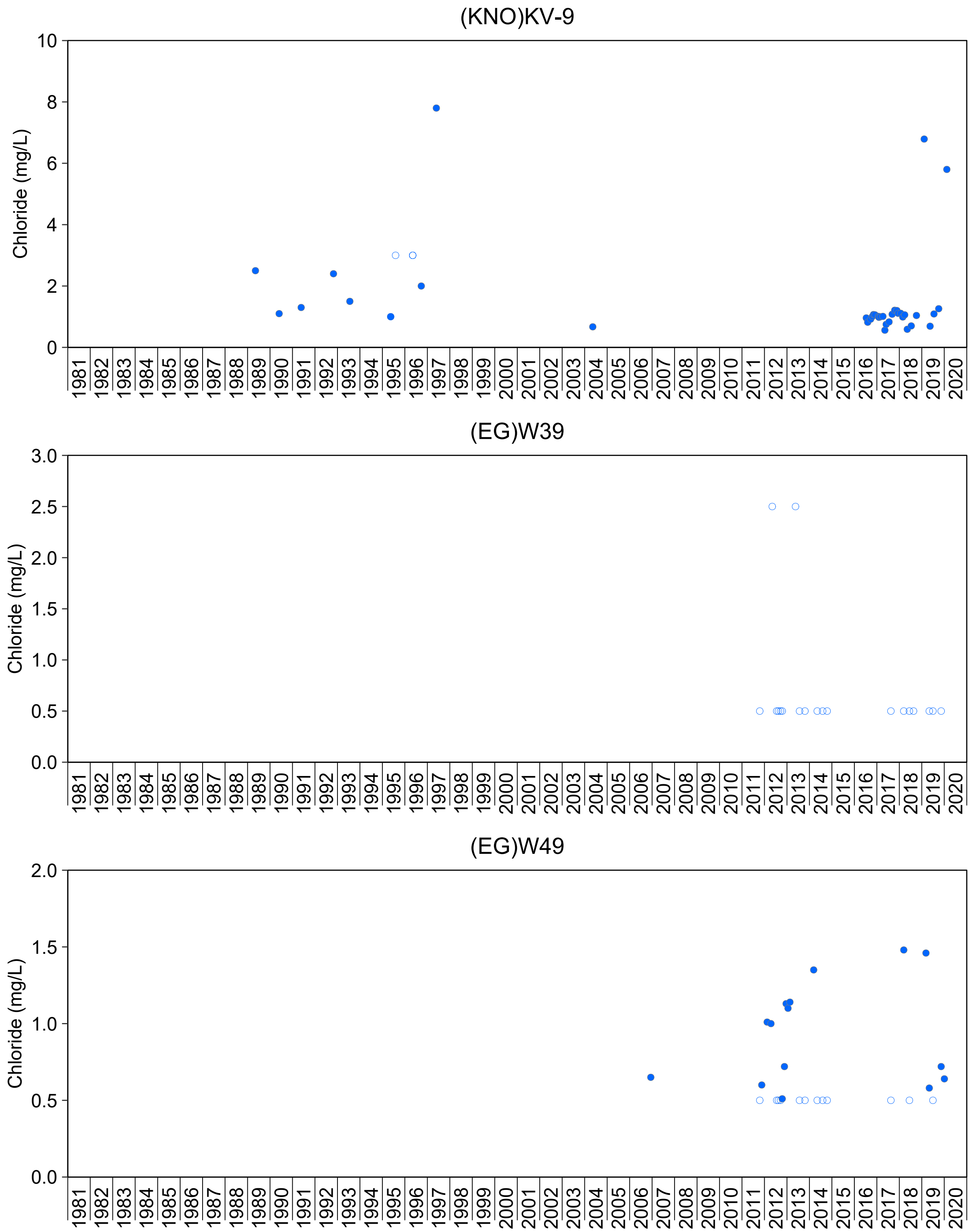


Figure A.16: Time Series Plots of Chloride Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

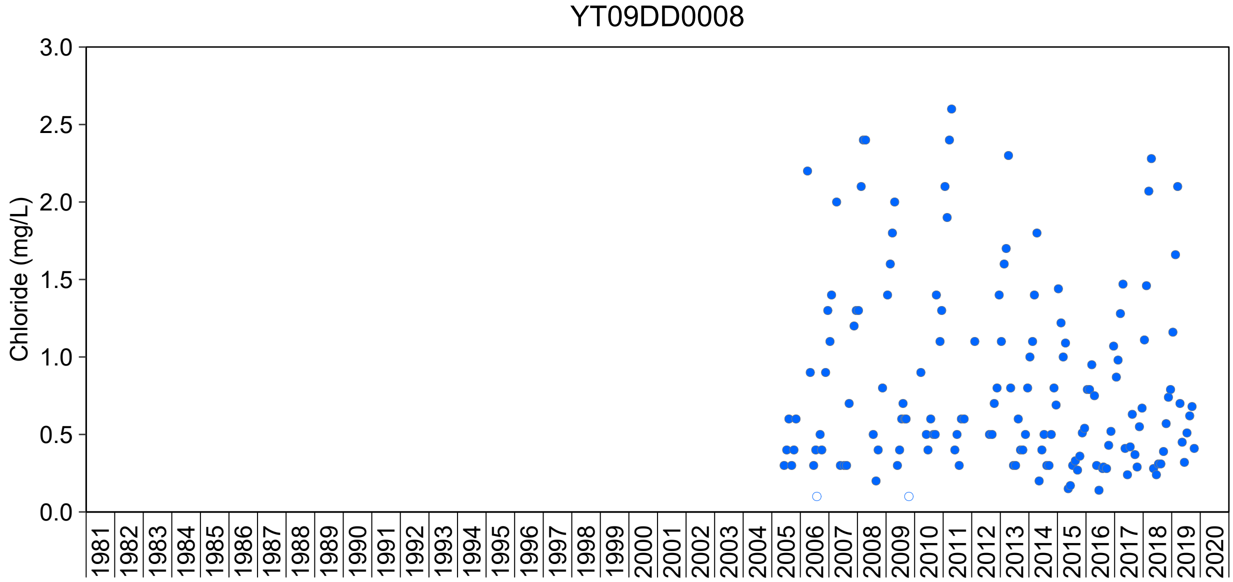


Figure A.16: Time Series Plots of Chloride Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

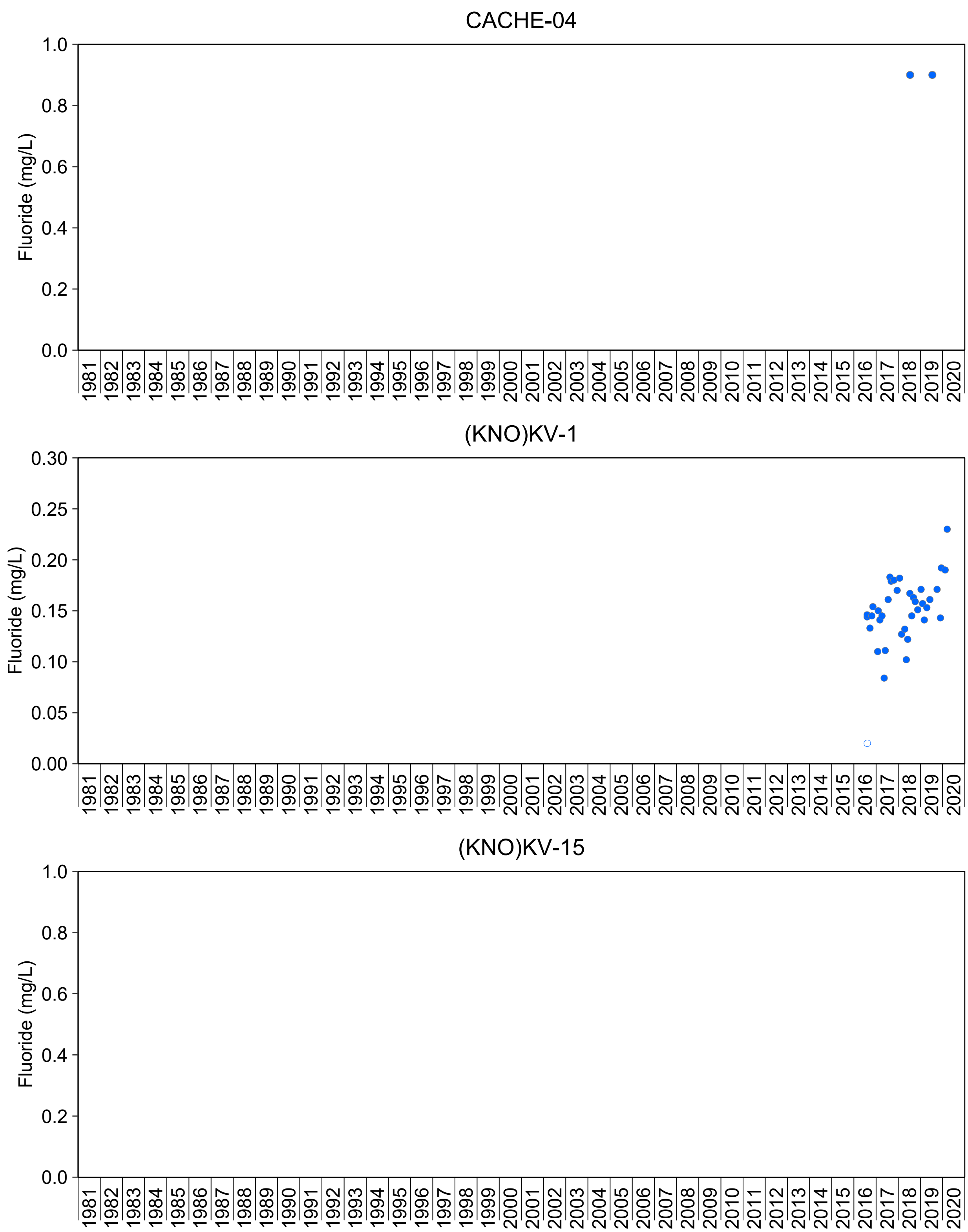


Figure A.17: Time Series Plots of Fluoride Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

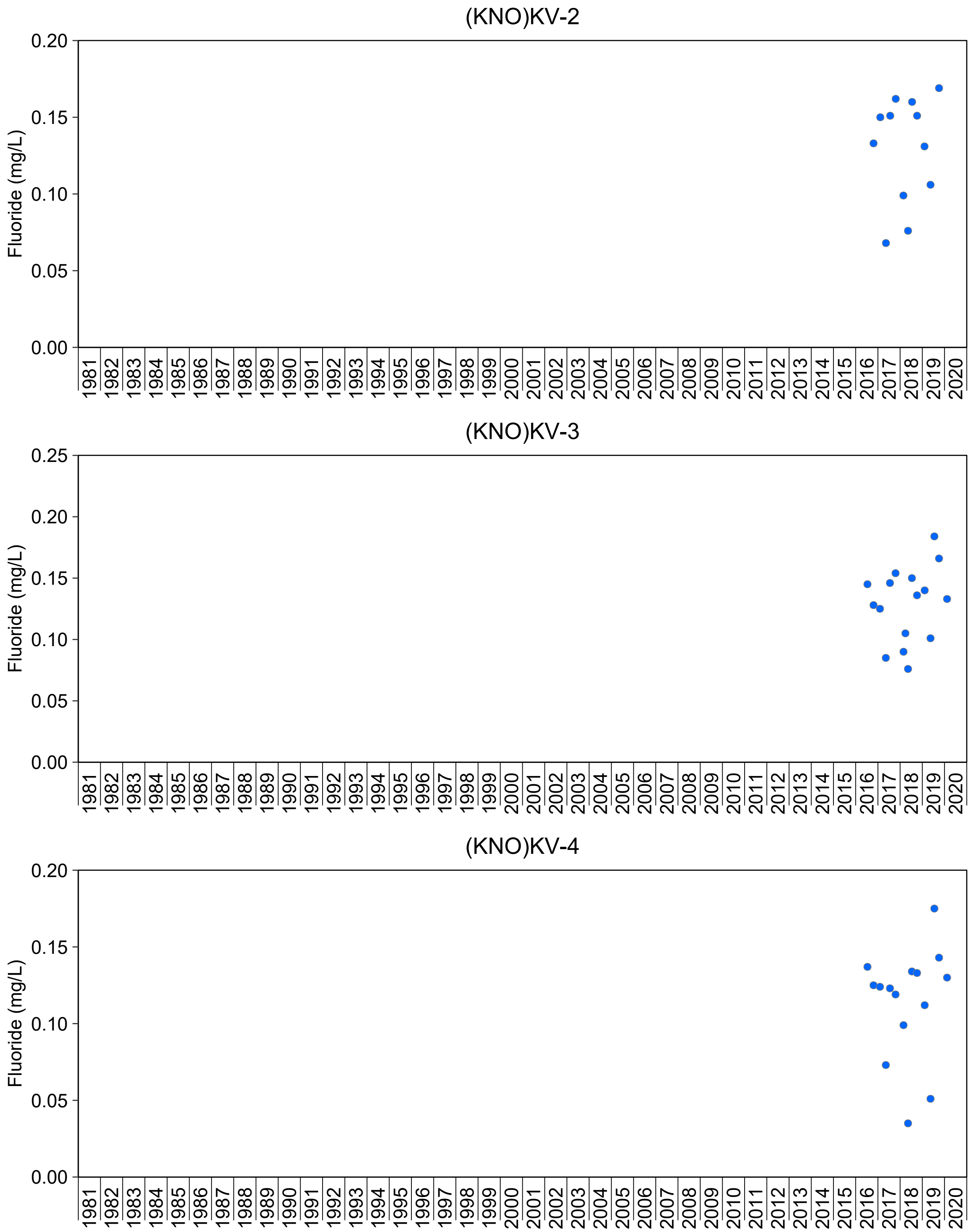


Figure A.17: Time Series Plots of Fluoride Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

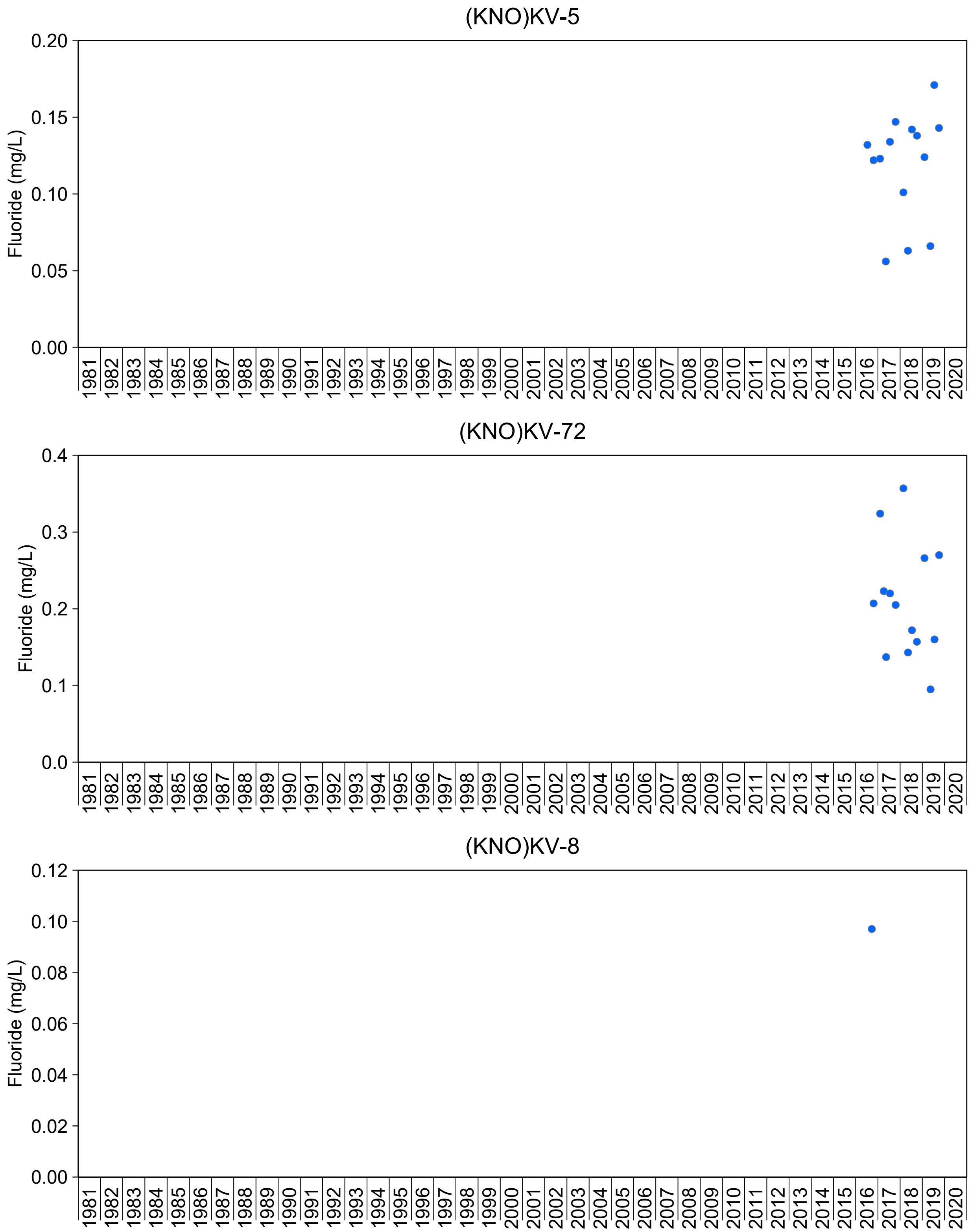


Figure A.17: Time Series Plots of Fluoride Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

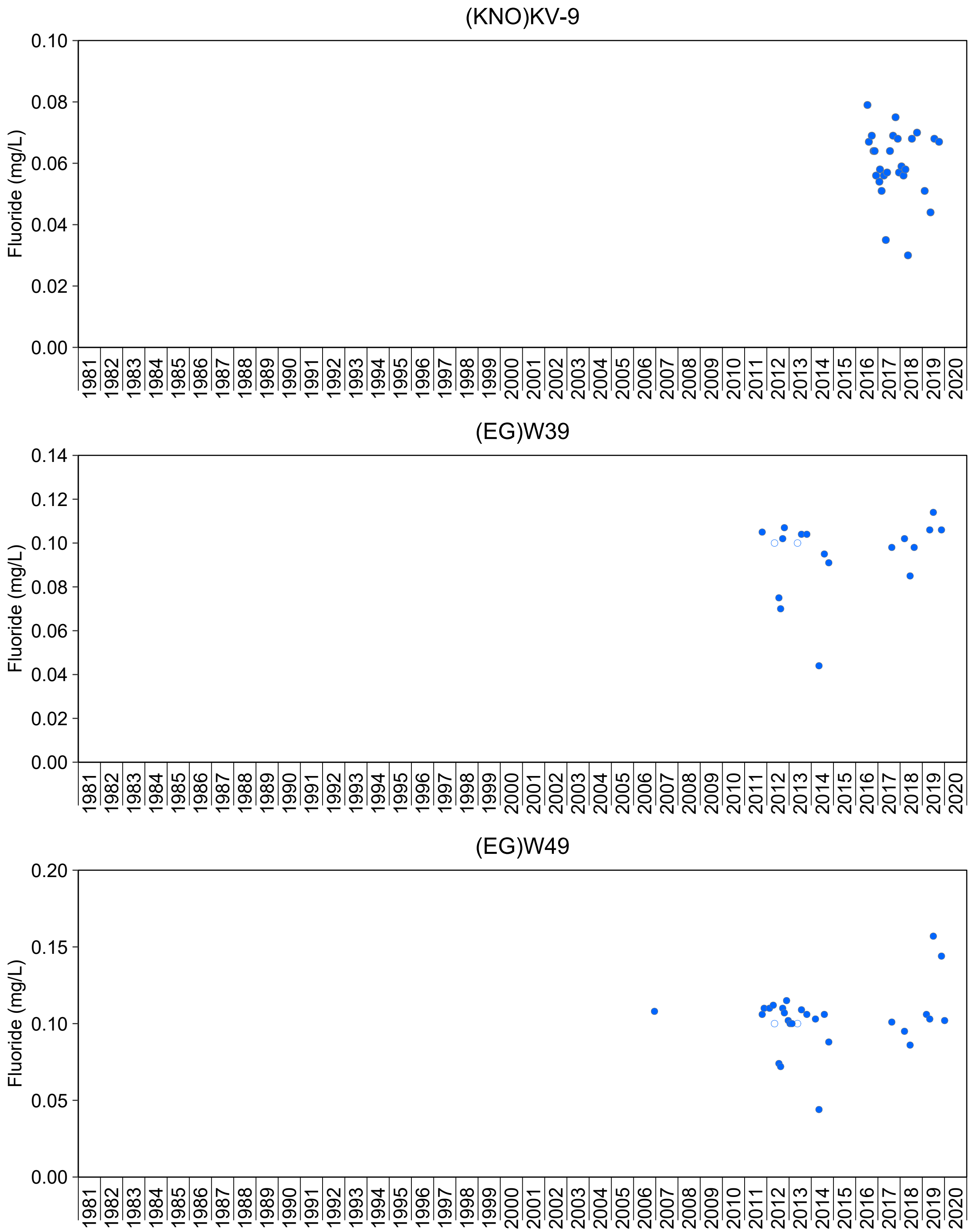


Figure A.17: Time Series Plots of Fluoride Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

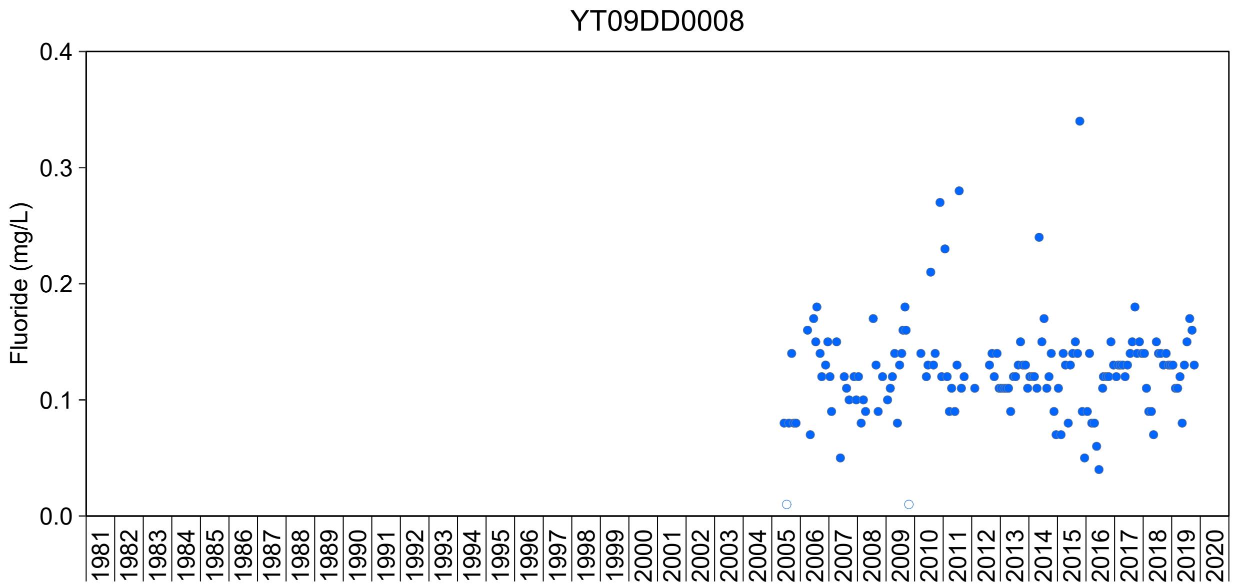


Figure A.17: Time Series Plots of Fluoride Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

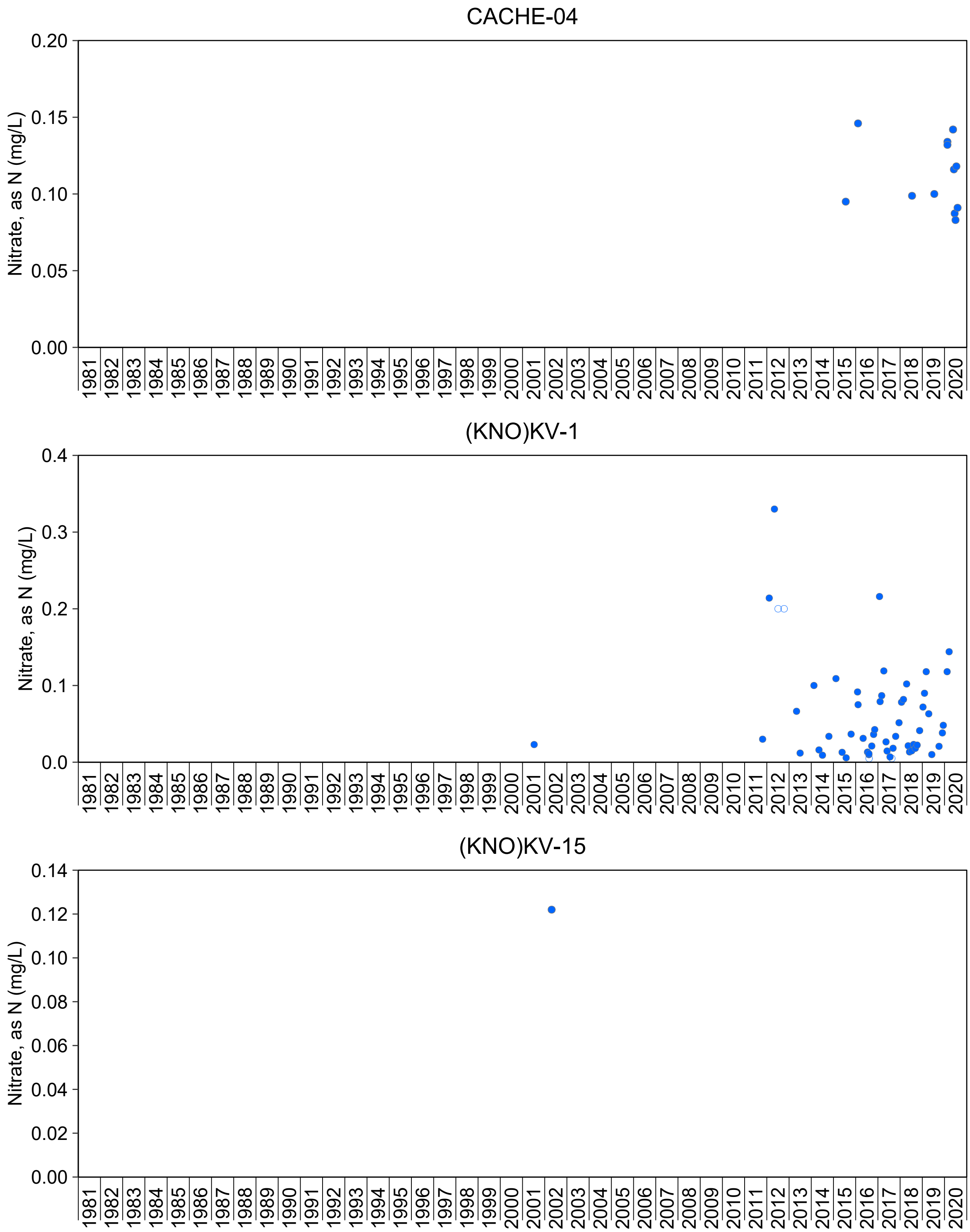


Figure A.18: Time Series Plots of Nitrate Concentrations (as N; mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

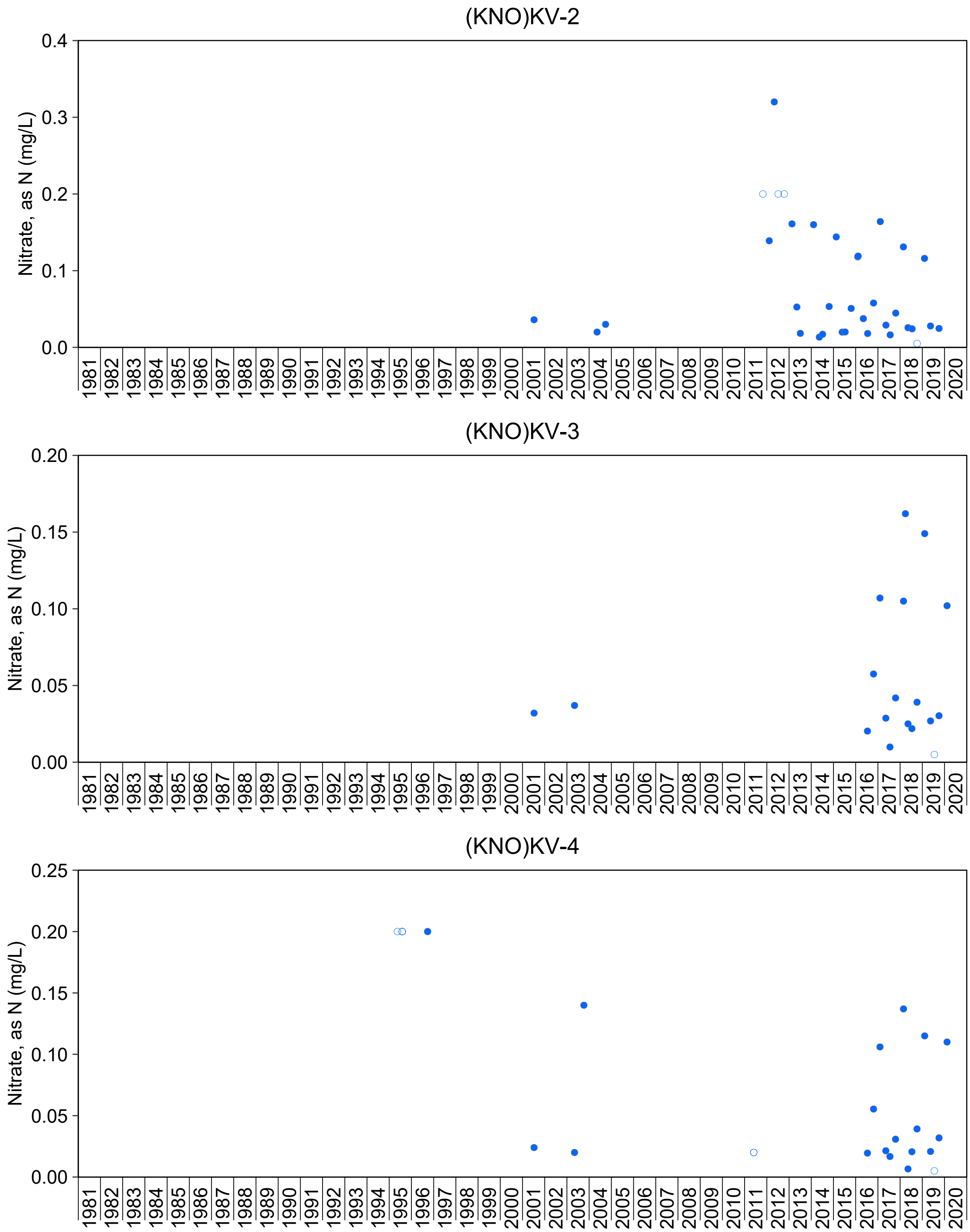


Figure A.18: Time Series Plots of Nitrate Concentrations (as N; mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

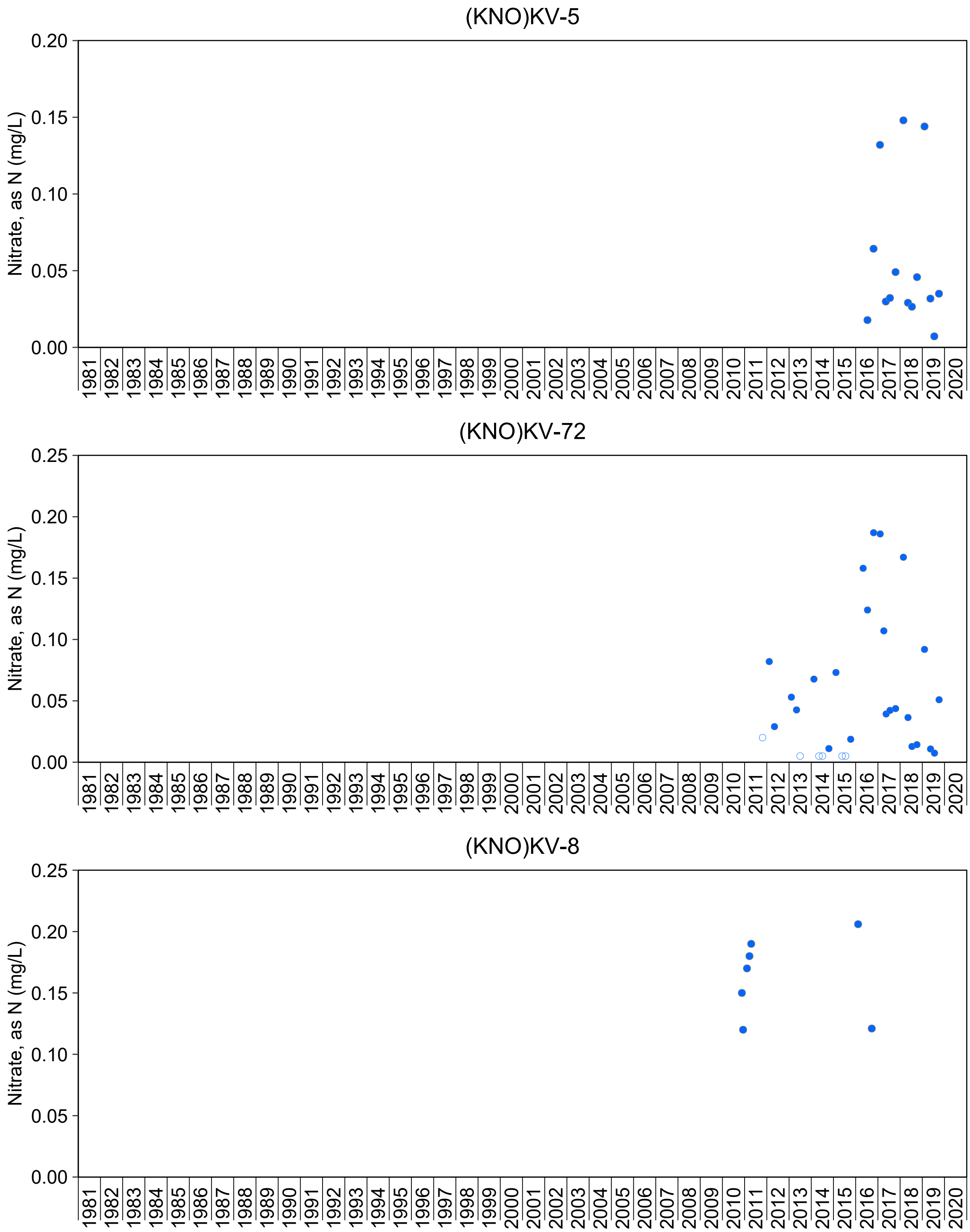


Figure A.18: Time Series Plots of Nitrate Concentrations (as N; mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

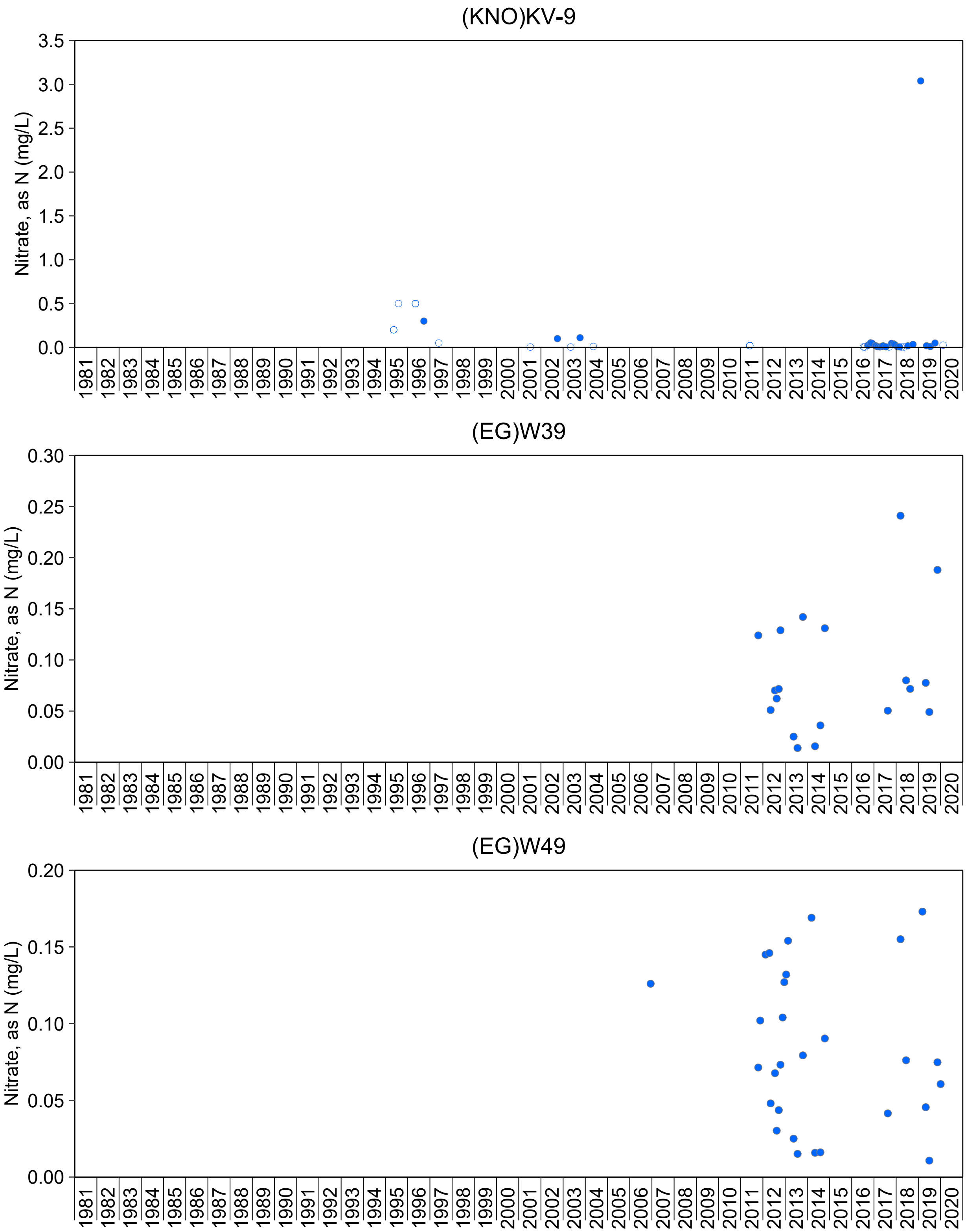


Figure A.18: **Time Series Plots of Nitrate Concentrations (as N; mg/L) in the South McQuesten River, 1981 to 2020**

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

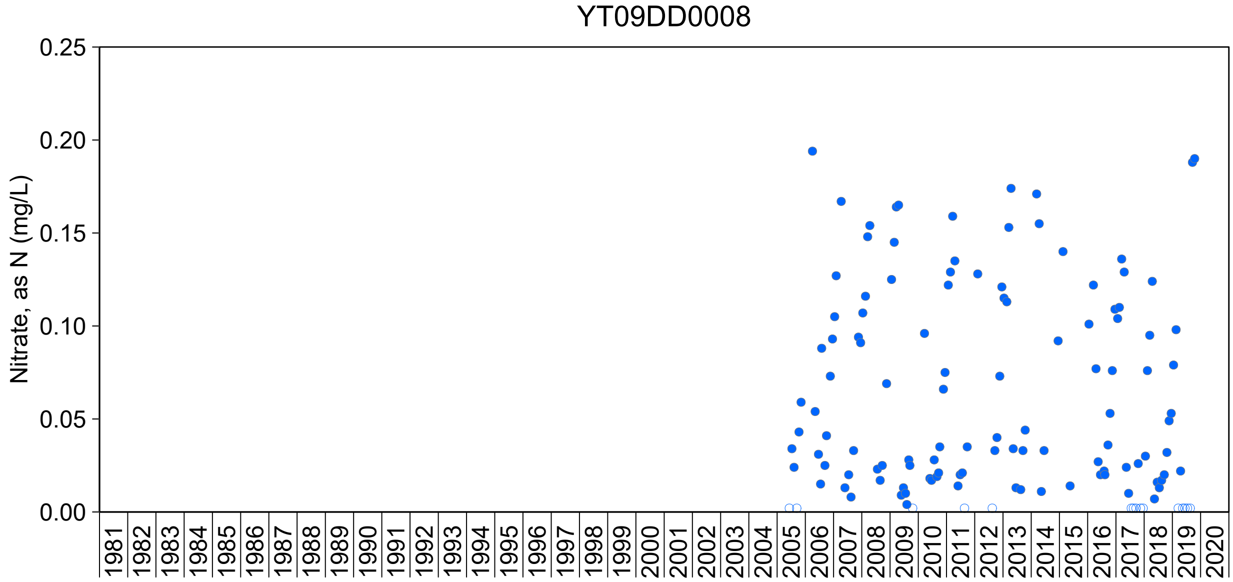


Figure A.18: Time Series Plots of Nitrate Concentrations (as N; mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

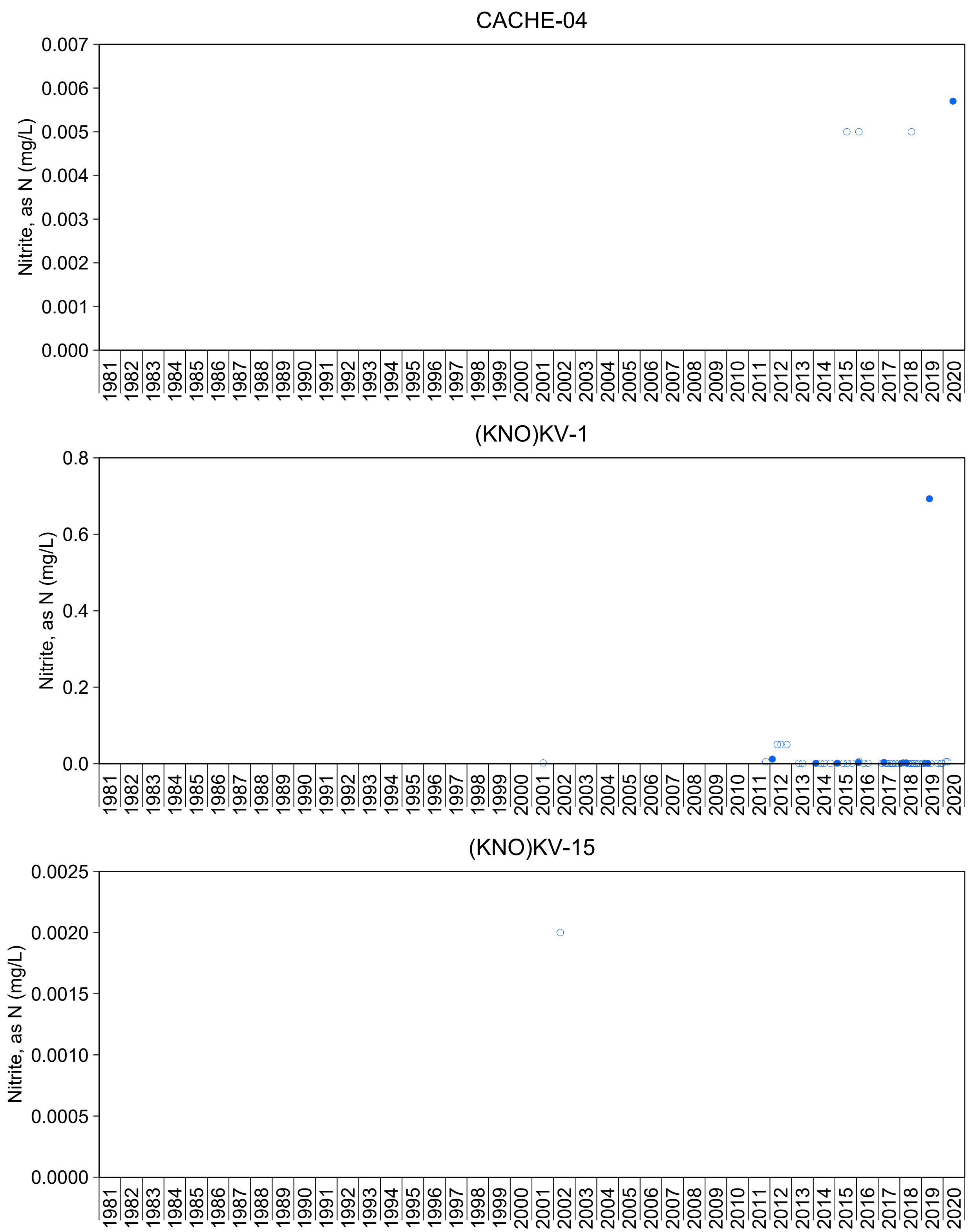


Figure A.19: Time Series Plots of Nitrite Concentrations (as N; mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

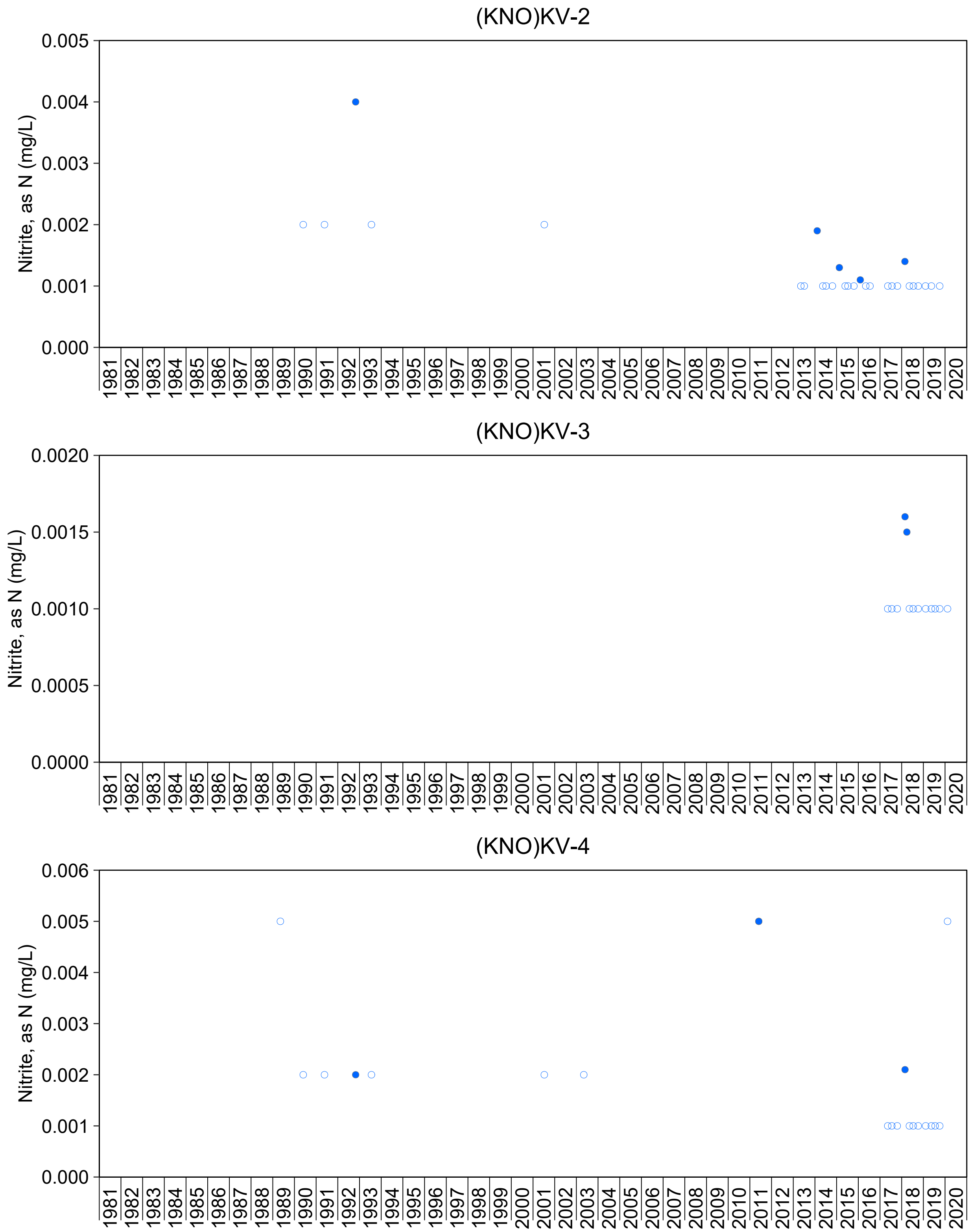


Figure A.19: Time Series Plots of Nitrite Concentrations (as N; mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

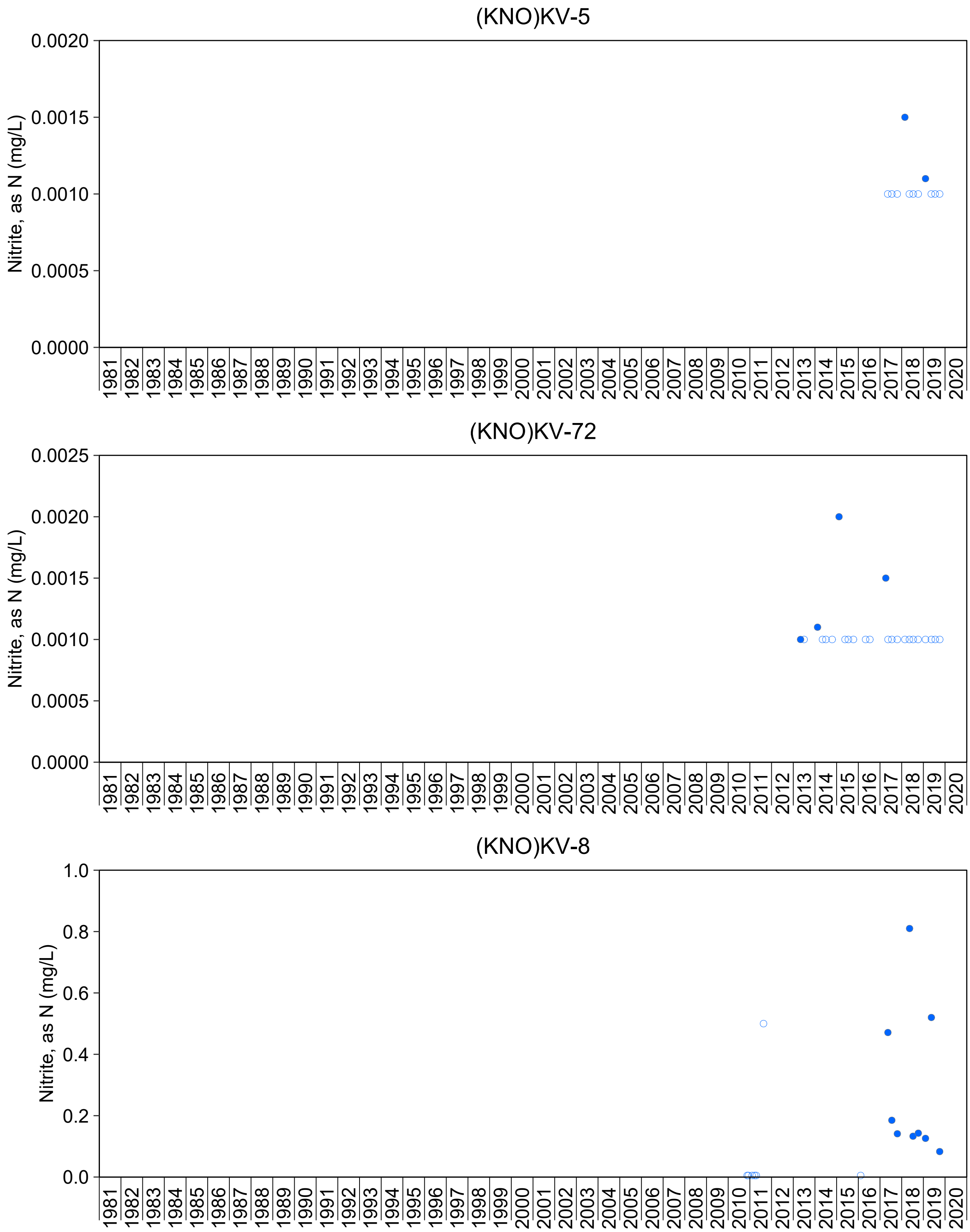


Figure A.19: Time Series Plots of Nitrite Concentrations (as N; mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

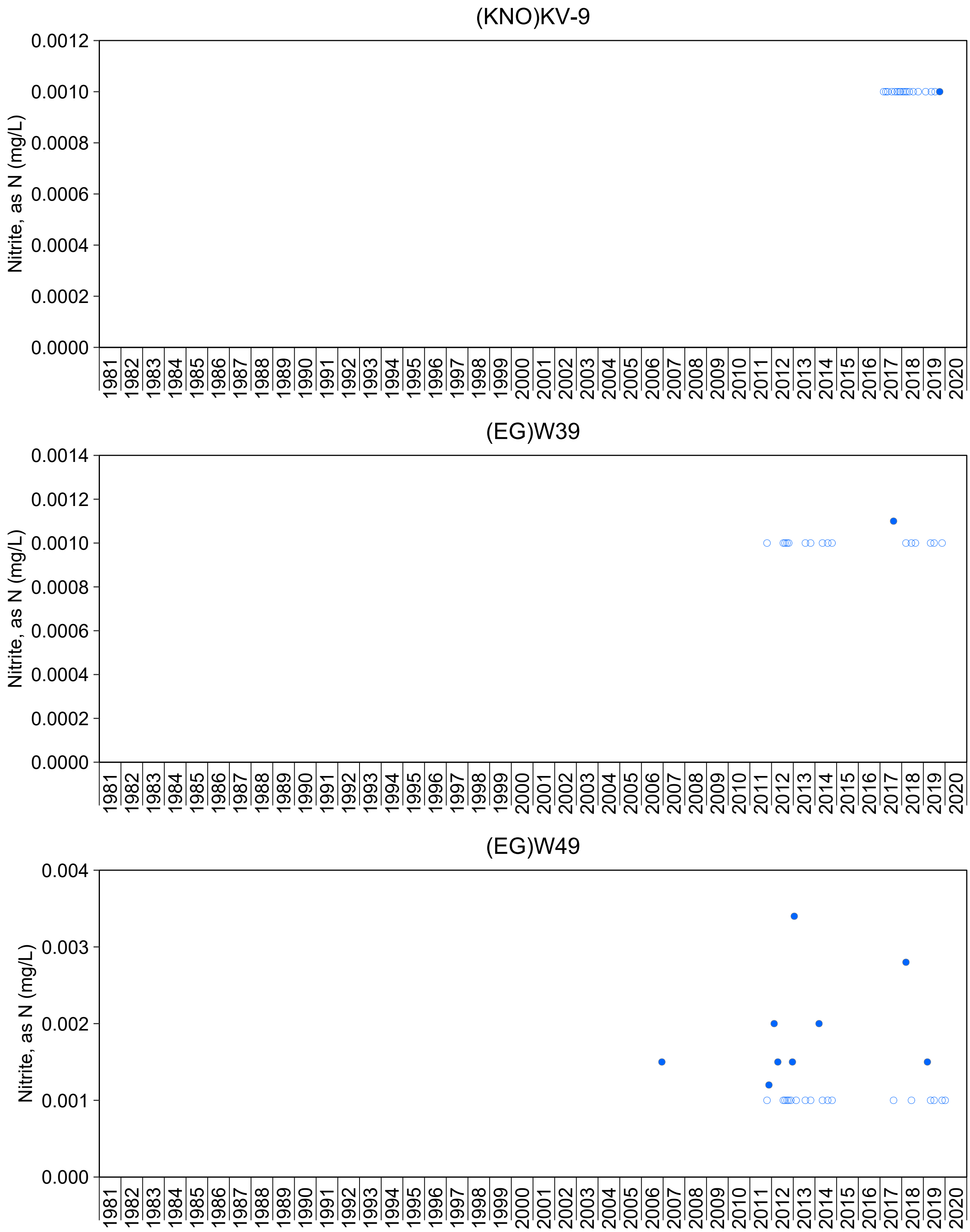


Figure A.19: Time Series Plots of Nitrite Concentrations (as N; mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

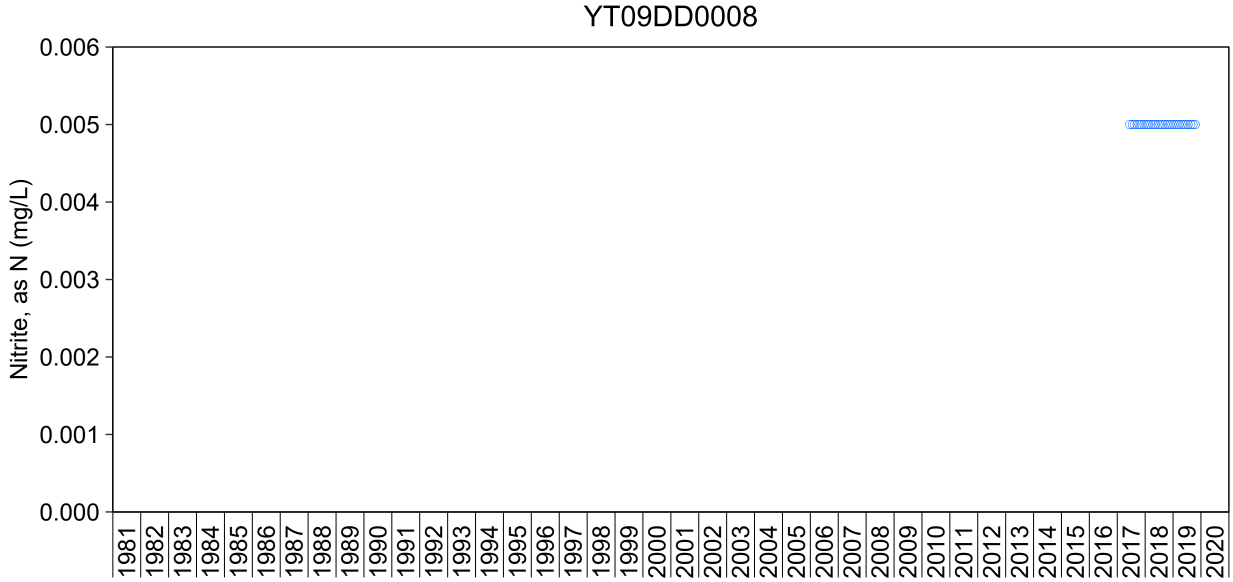


Figure A.19: Time Series Plots of Nitrite Concentrations (as N; mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

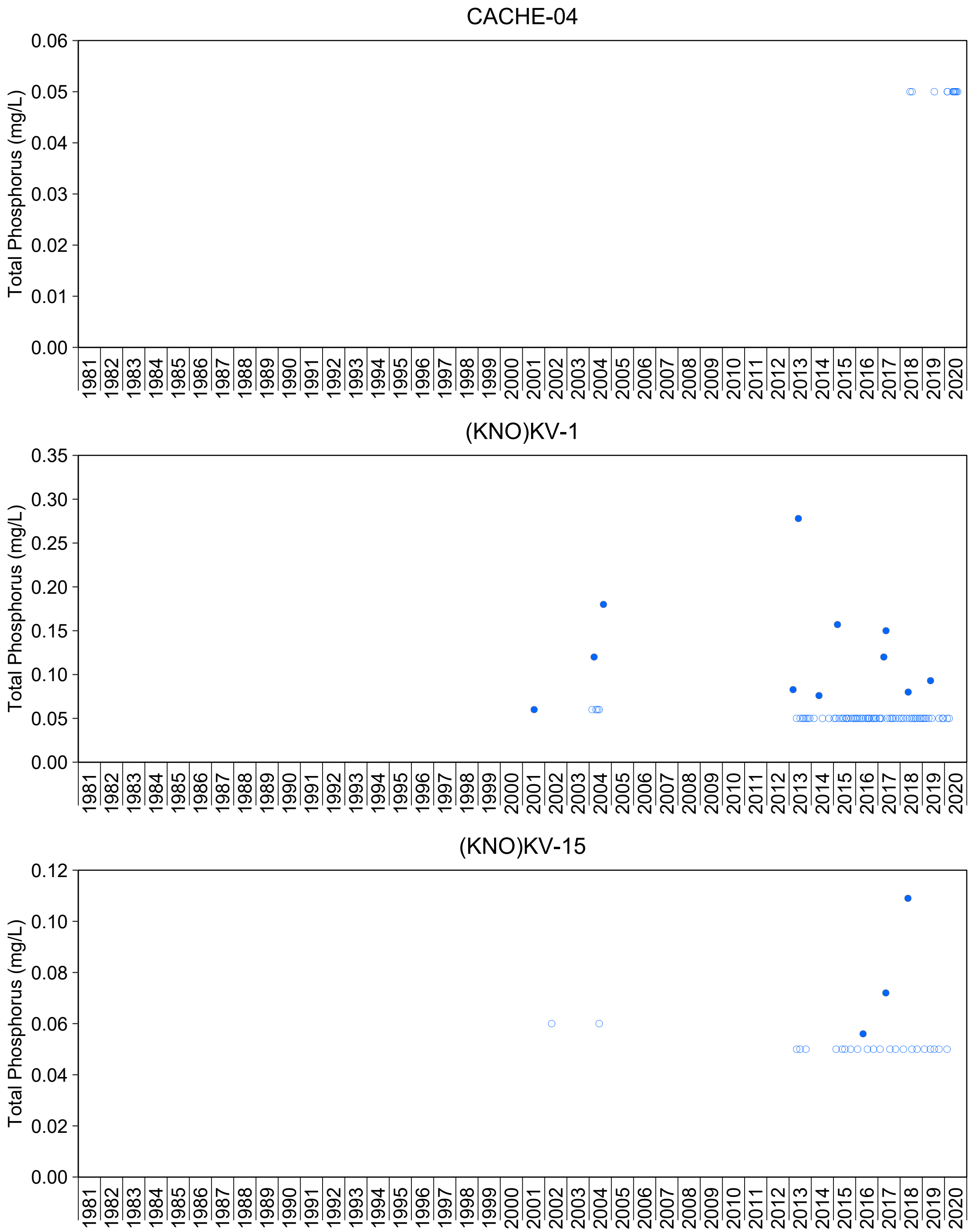


Figure A.20: Time Series Plots of Total Phosphorus Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

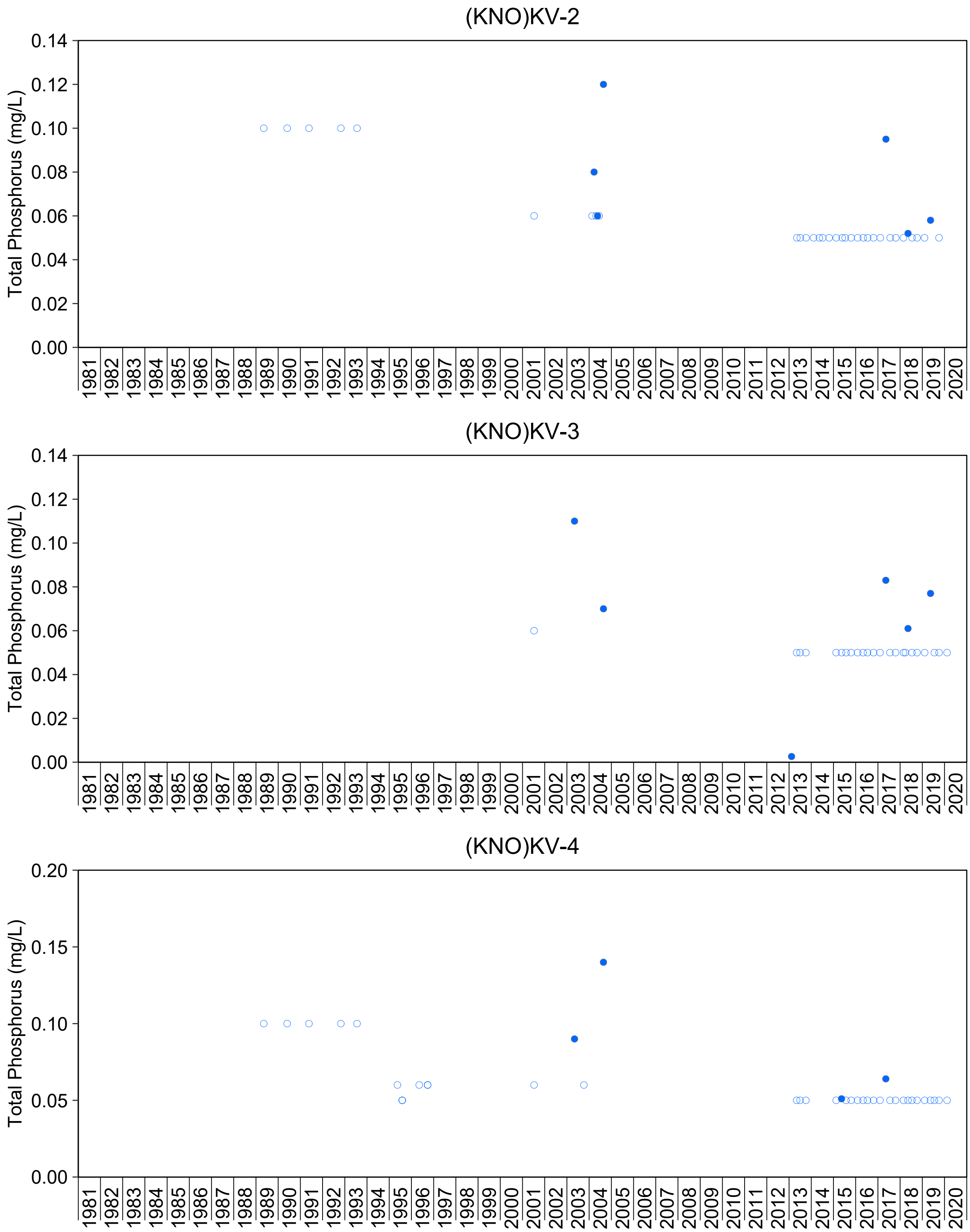


Figure A.20: Time Series Plots of Total Phosphorus Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

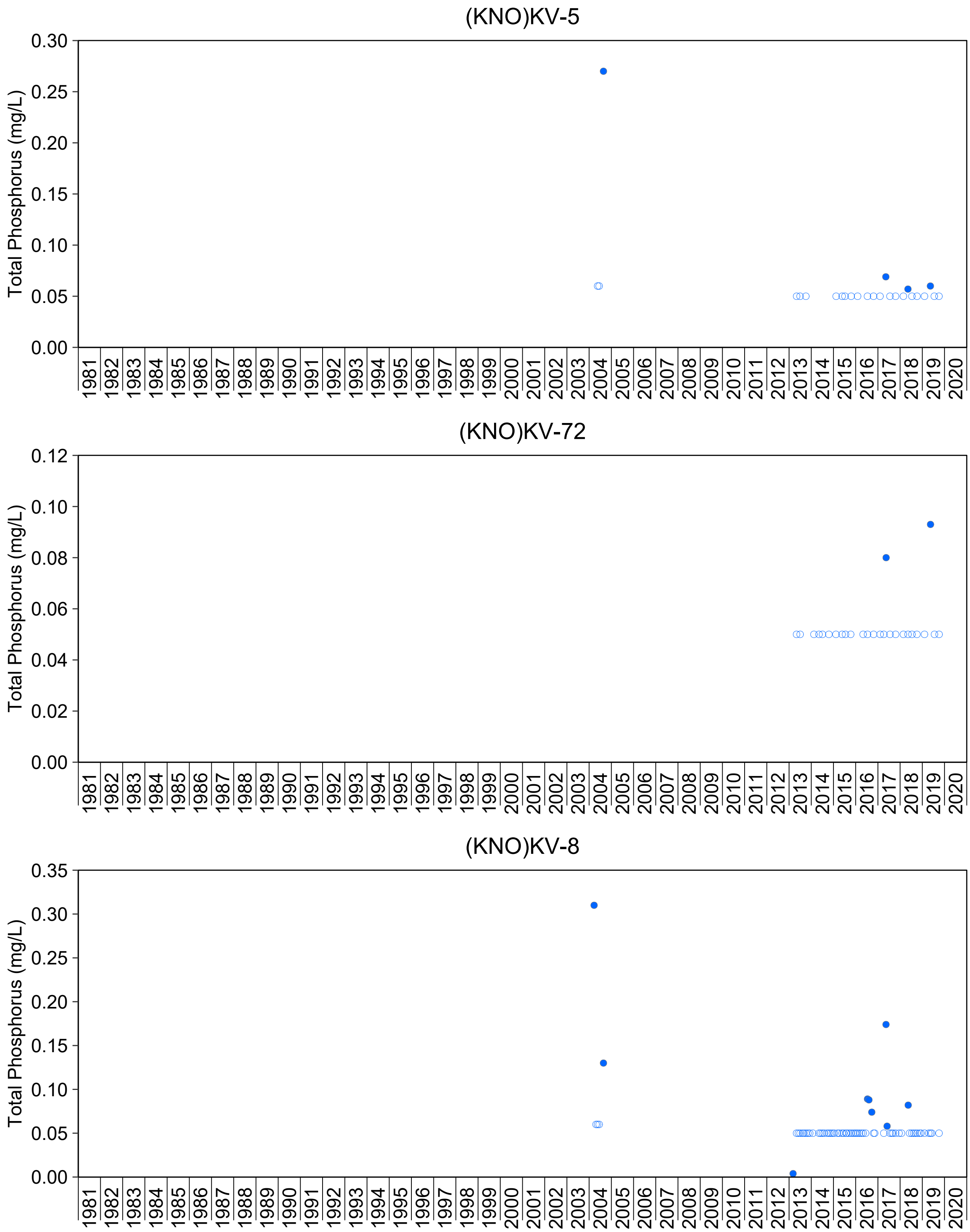


Figure A.20: Time Series Plots of Total Phosphorus Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

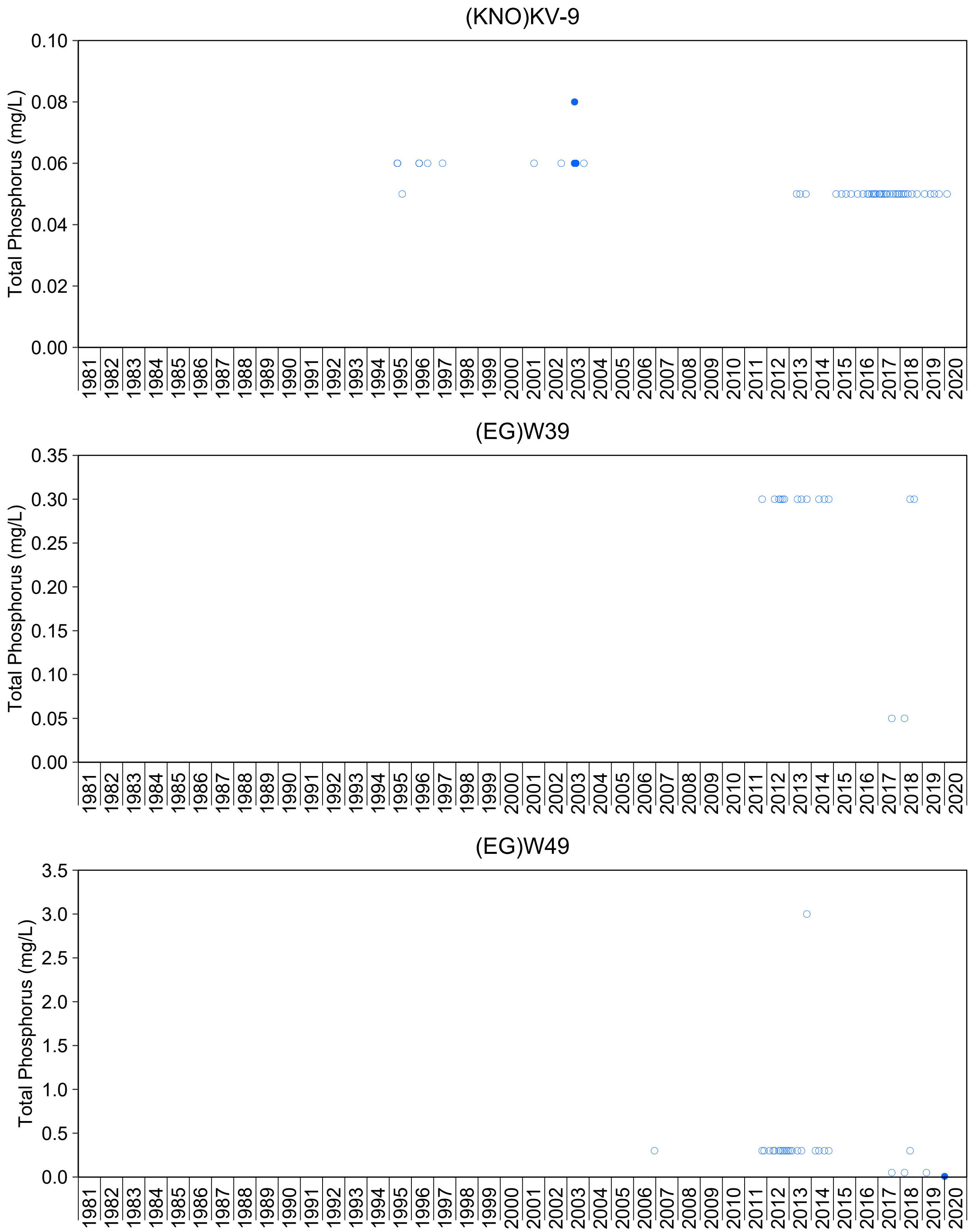


Figure A.20: Time Series Plots of Total Phosphorus Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

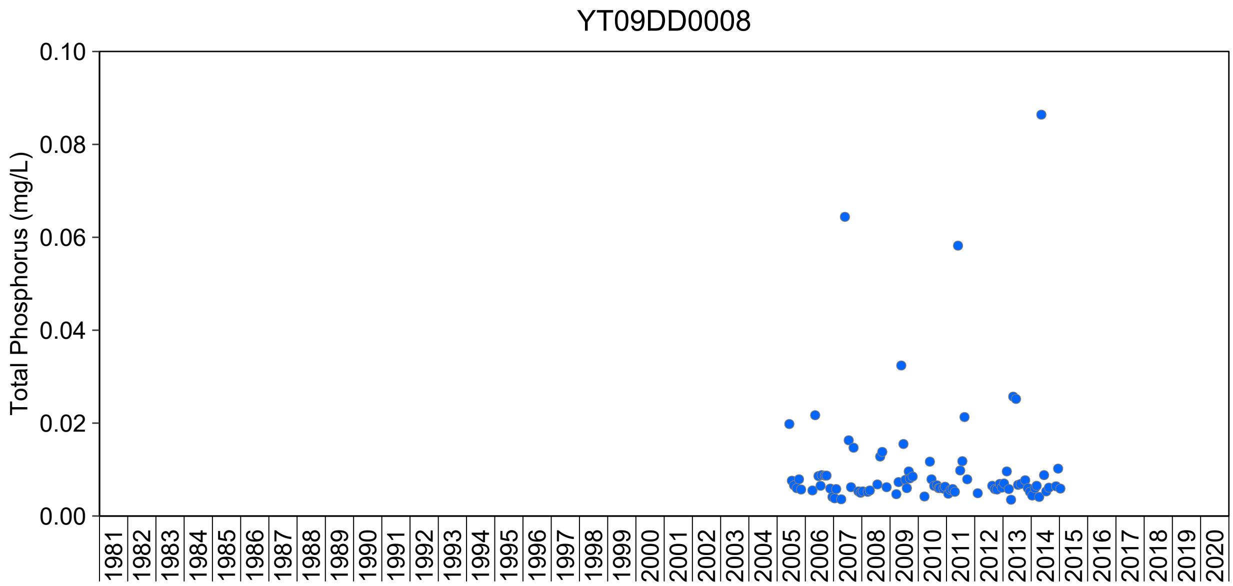


Figure A.20: Time Series Plots of Total Phosphorus Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

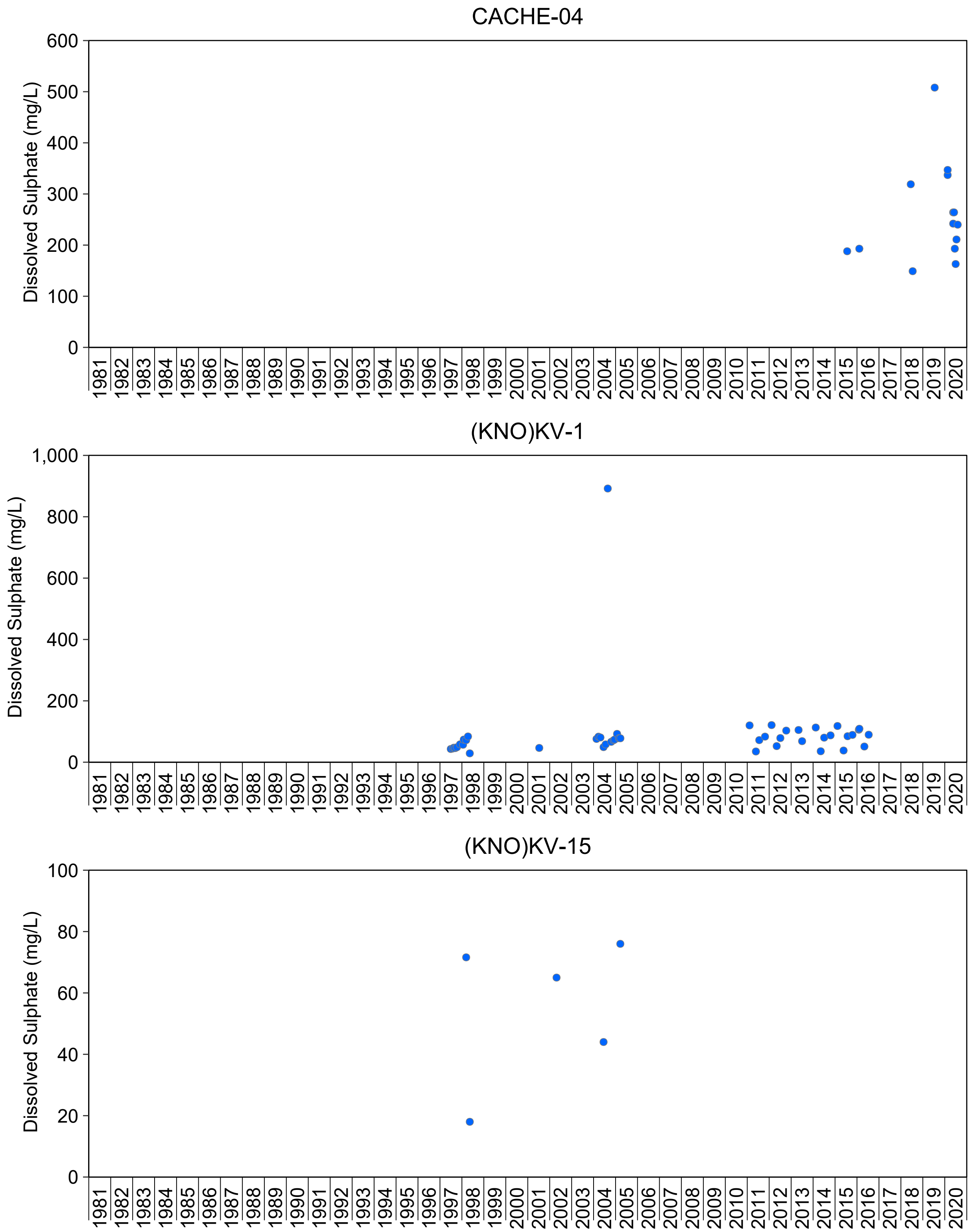


Figure A.19: Time Series Plots of Dissolved Sulphate Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

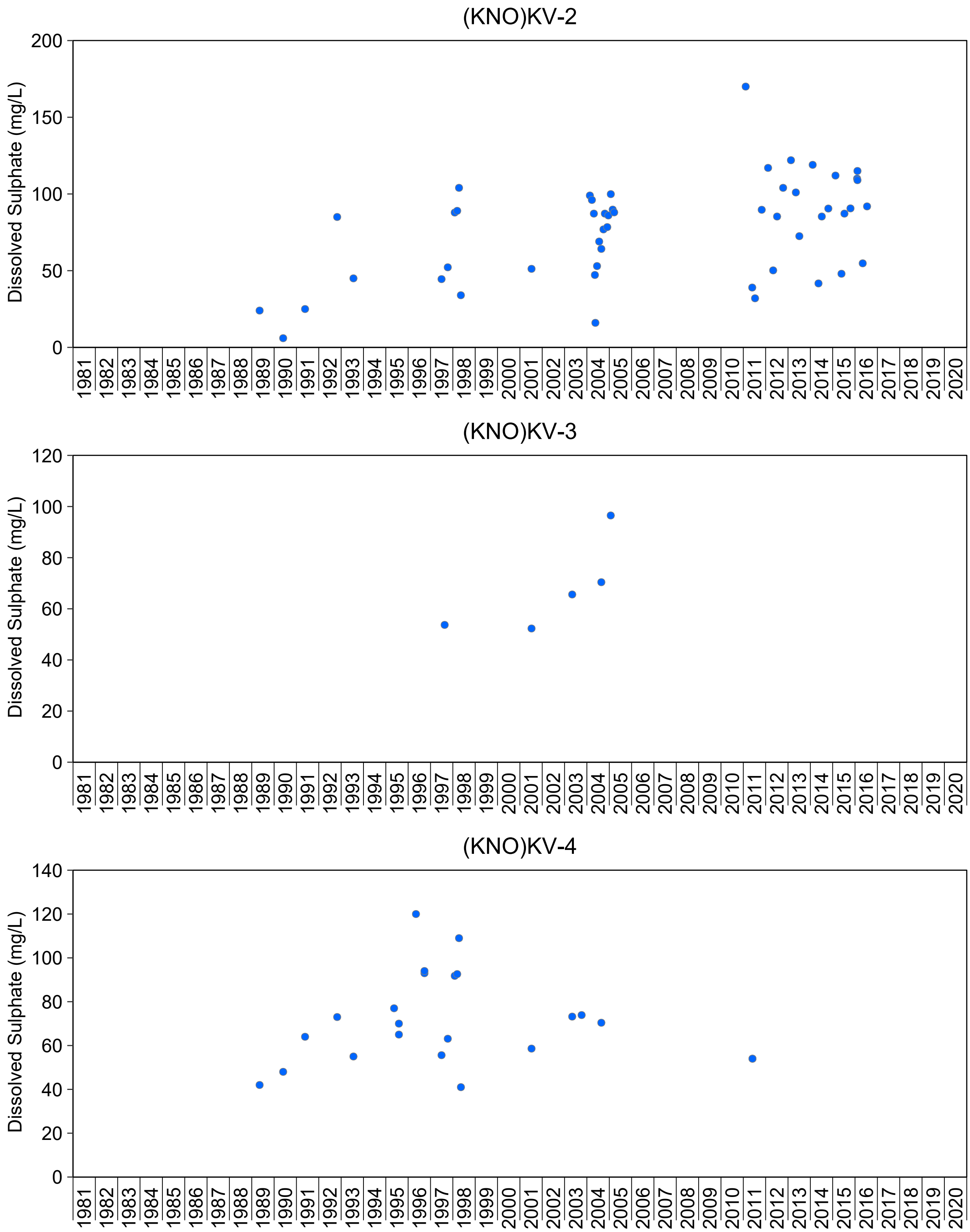


Figure A.21: Time Series Plots of Dissolved Sulphate Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

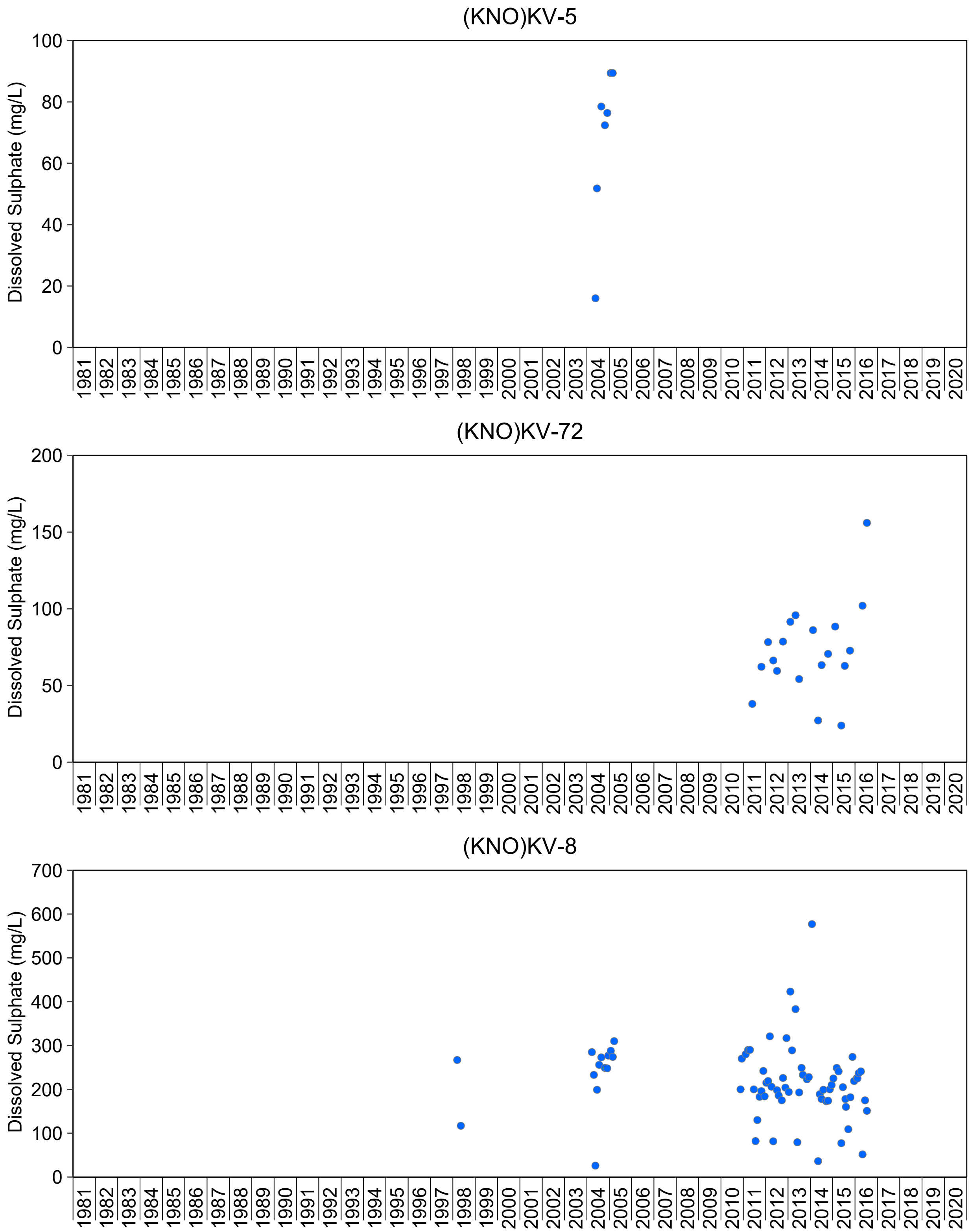


Figure A.21: Time Series Plots of Dissolved Sulphate Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

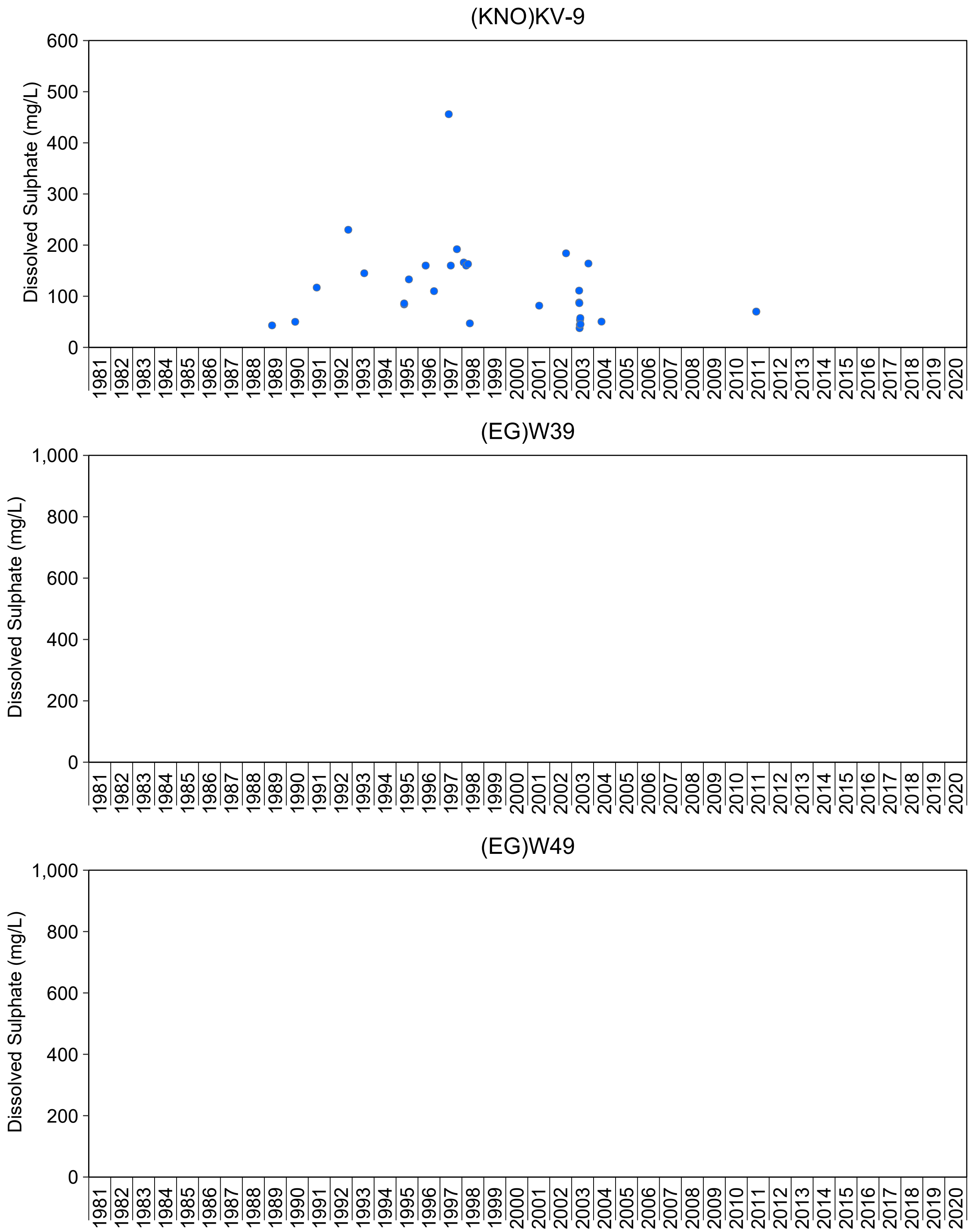


Figure A.21: Time Series Plots of Dissolved Sulphate Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

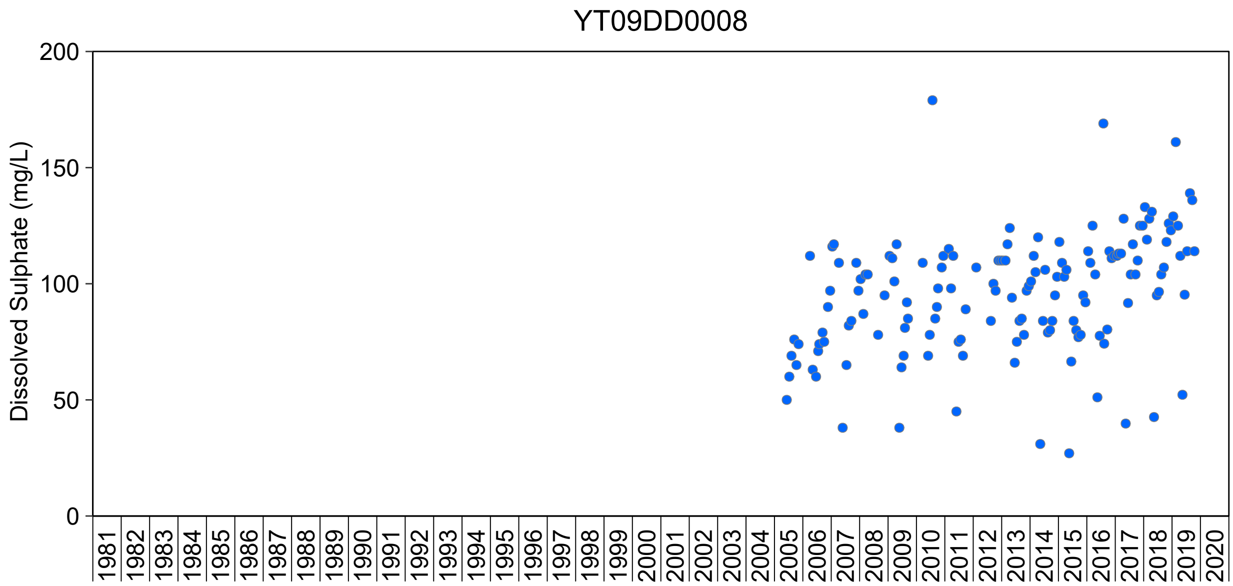


Figure A.21: Time Series Plots of Dissolved Sulphate Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

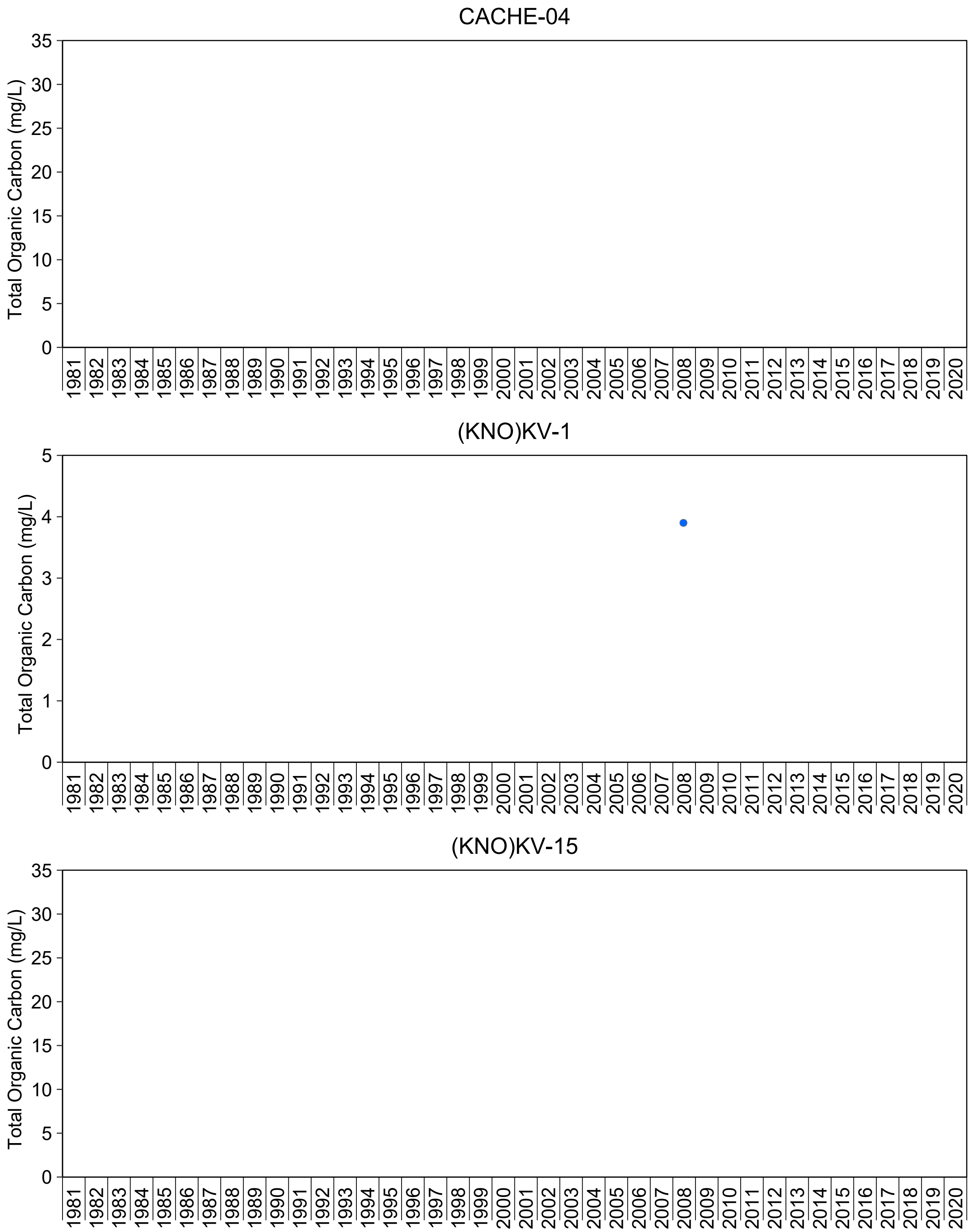
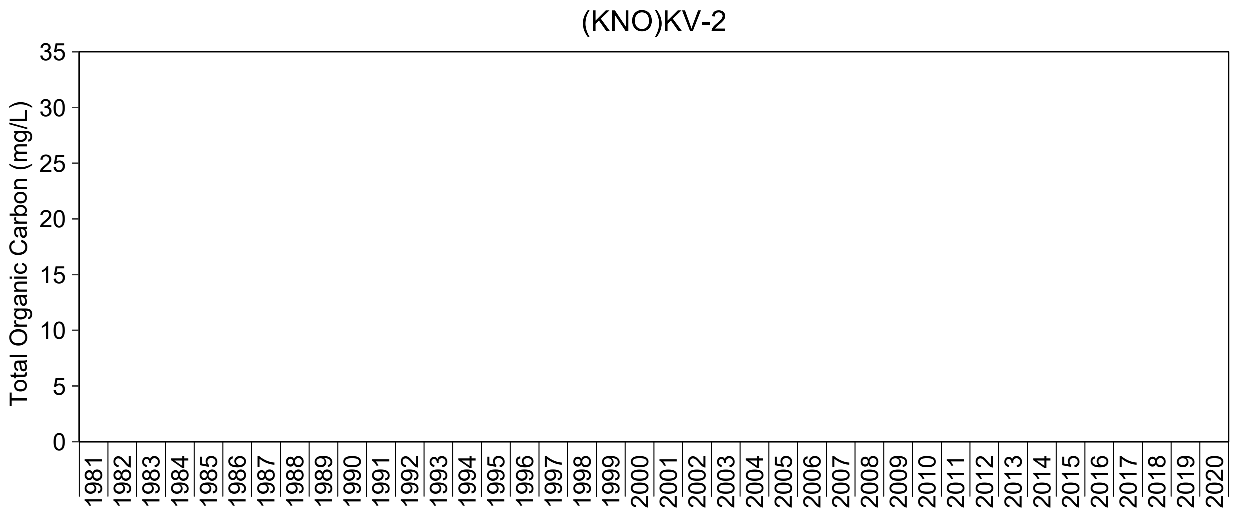
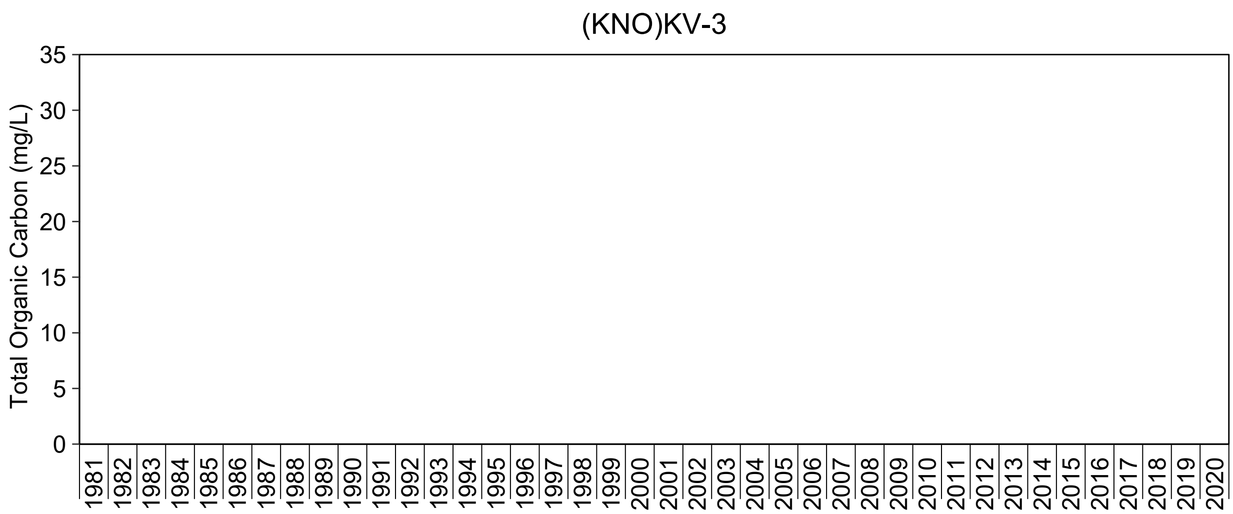


Figure A.22: Time Series Plots of Total Organic Carbon Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.





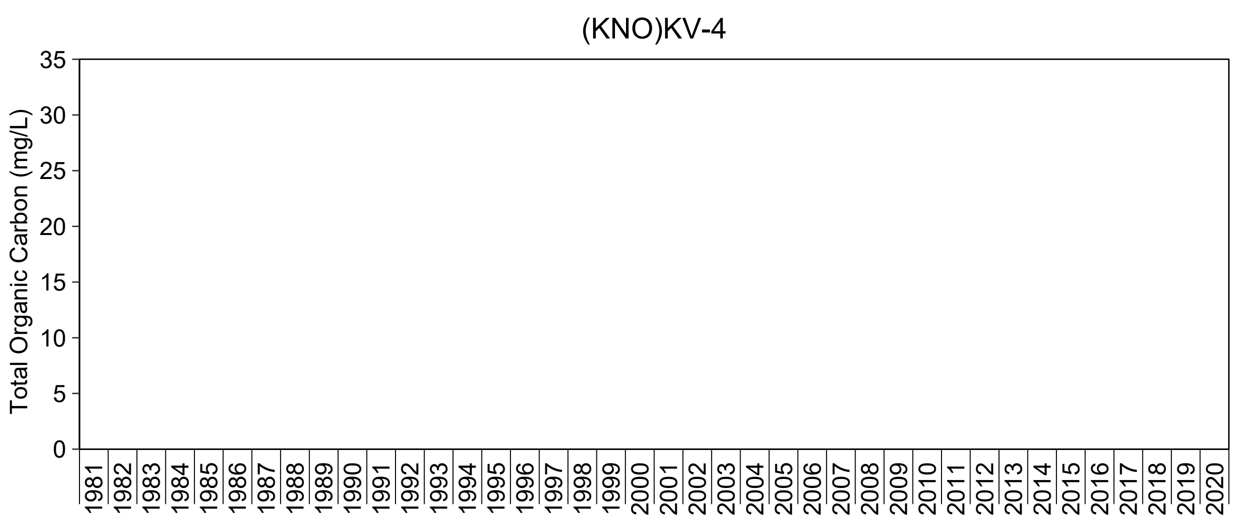
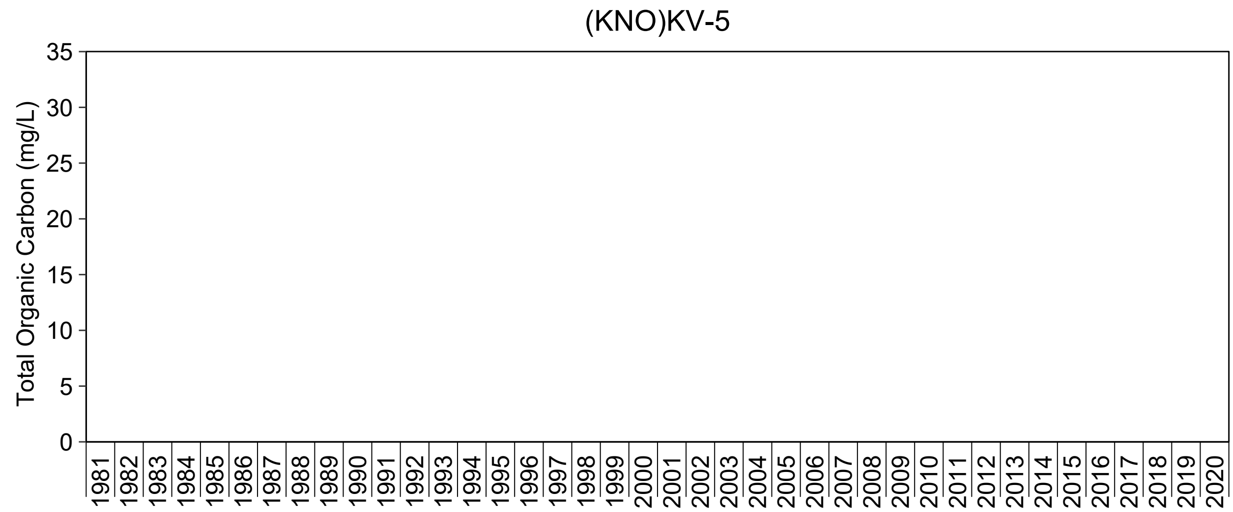
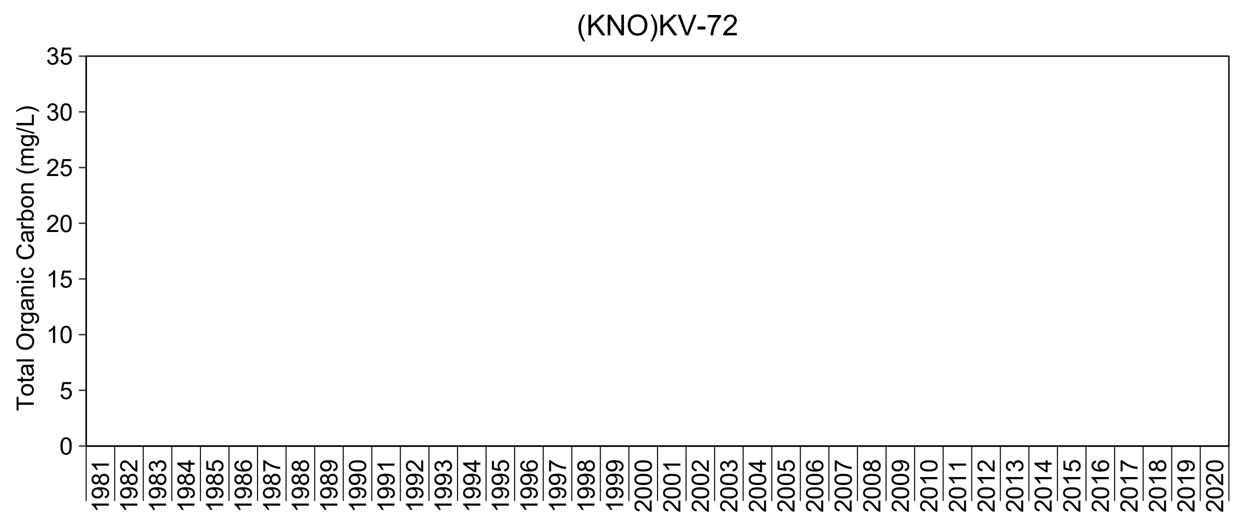


Figure A.22: Time Series Plots of Total Organic Carbon Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.





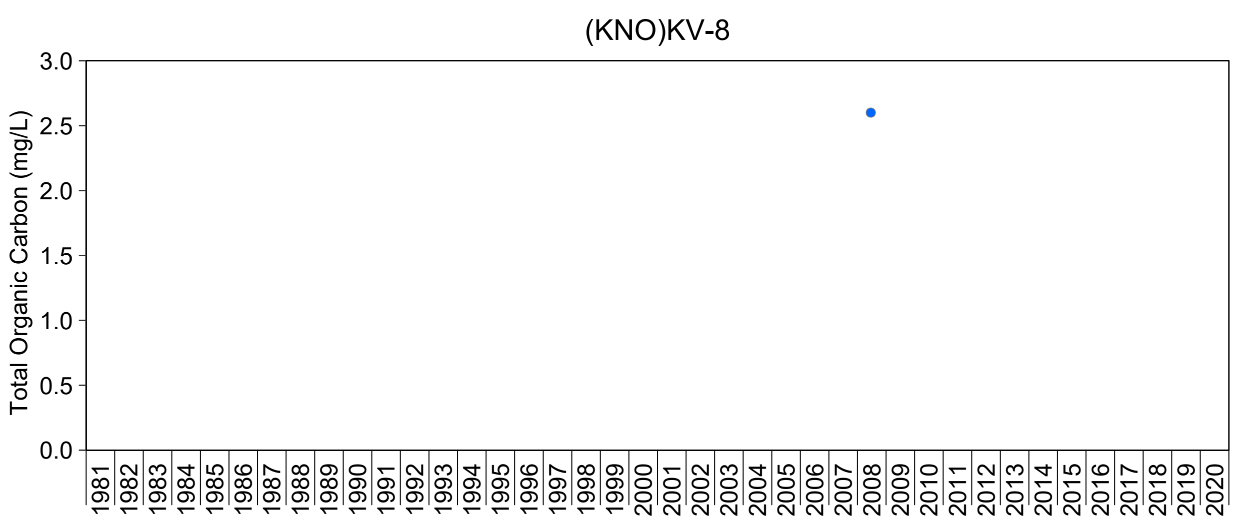


Figure A.22: Time Series Plots of Total Organic Carbon Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

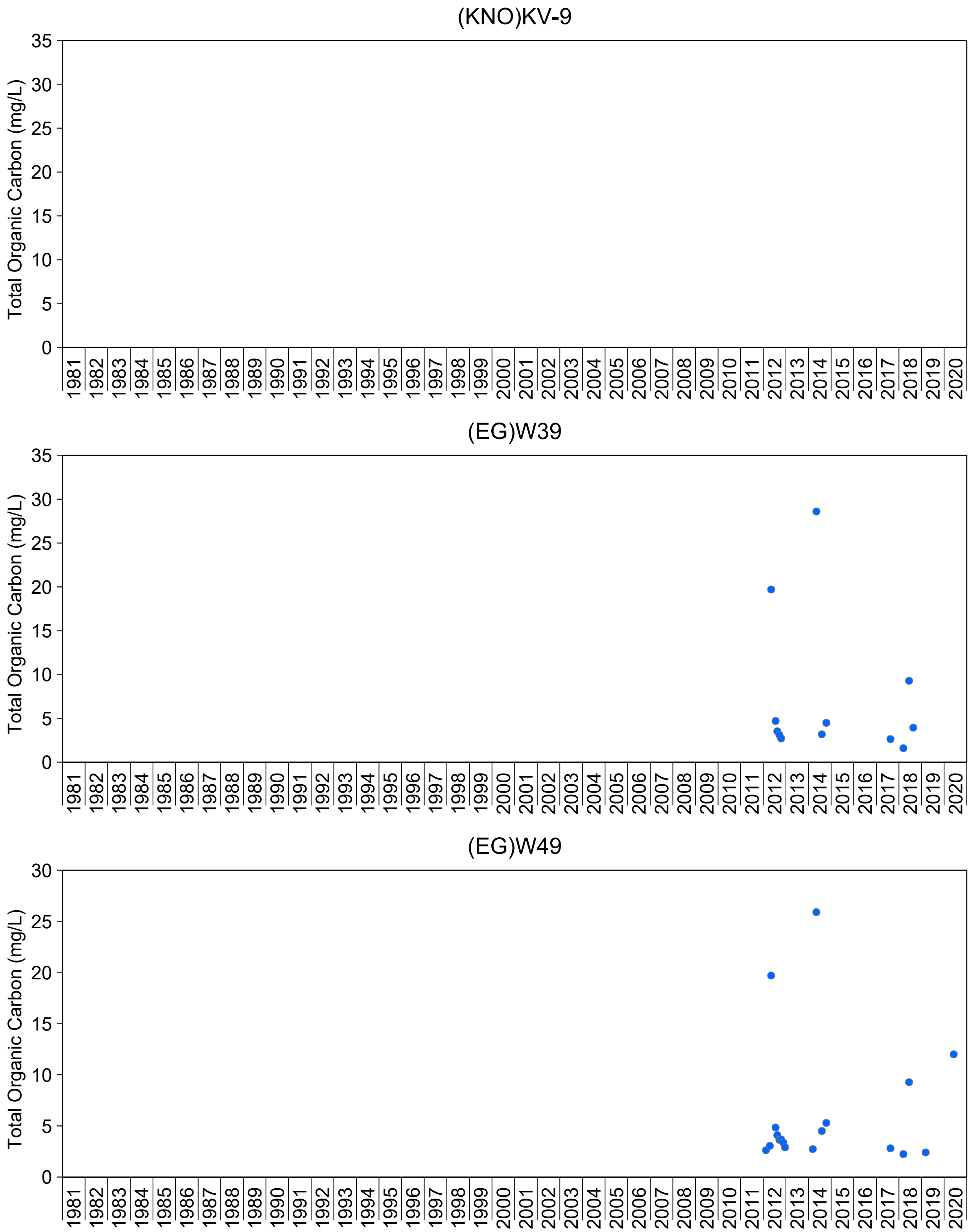


Figure A.22: Time Series Plots of Total Organic Carbon Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

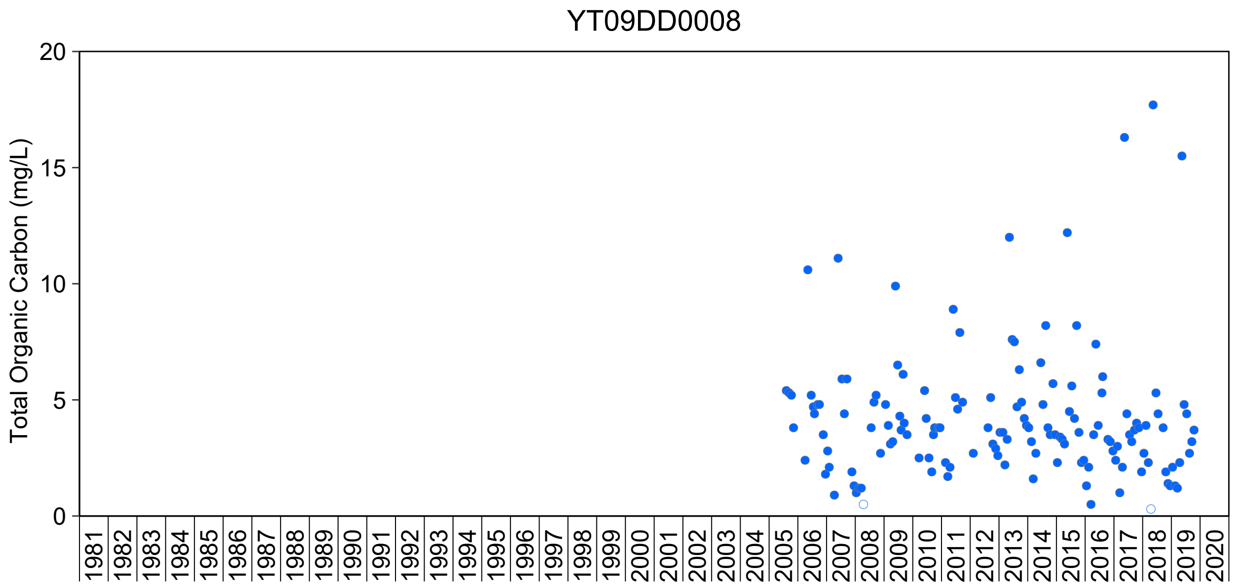


Figure A.22: Time Series Plots of Total Organic Carbon Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

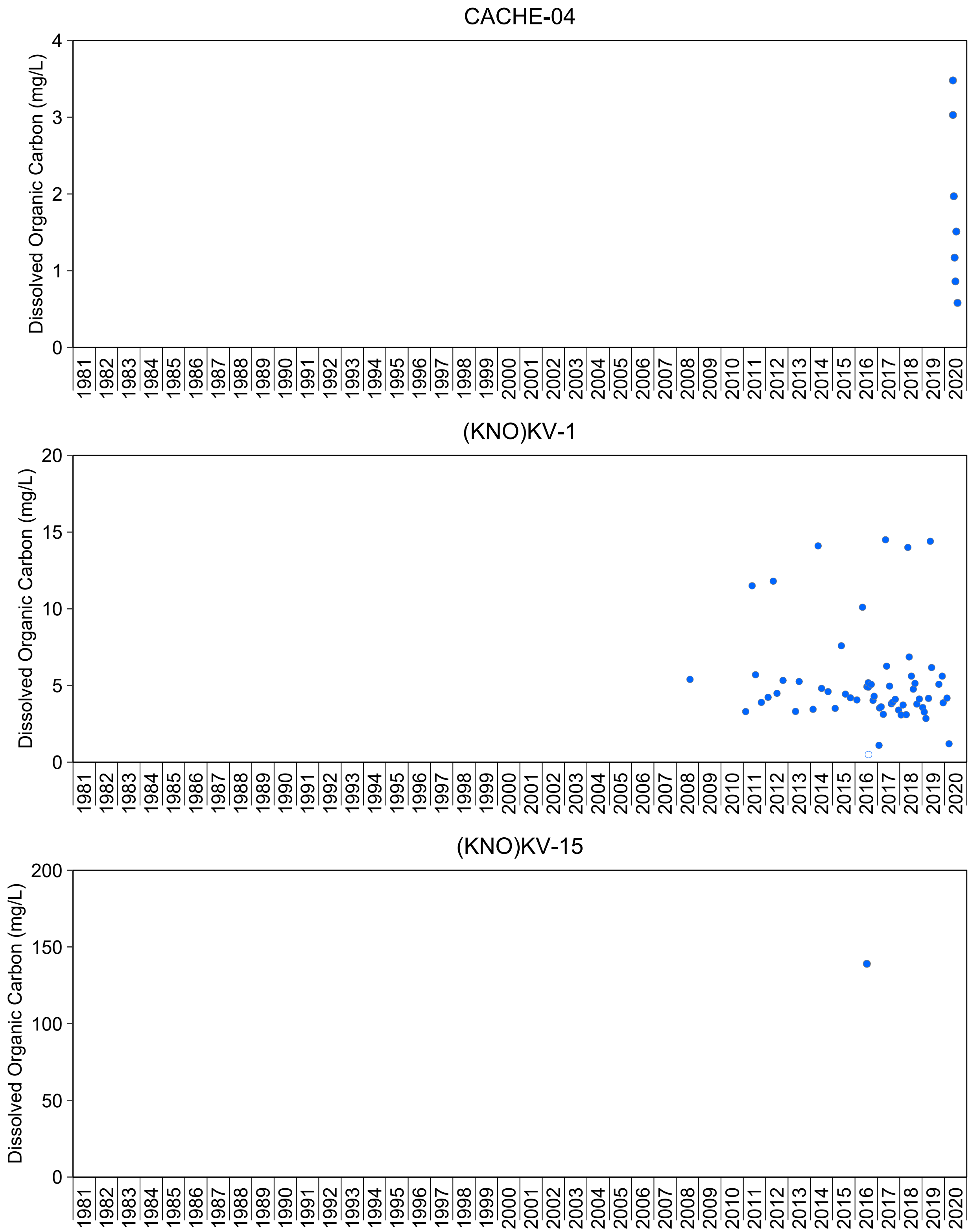


Figure A.23: Time Series Plots of Dissolved Organic Carbon Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

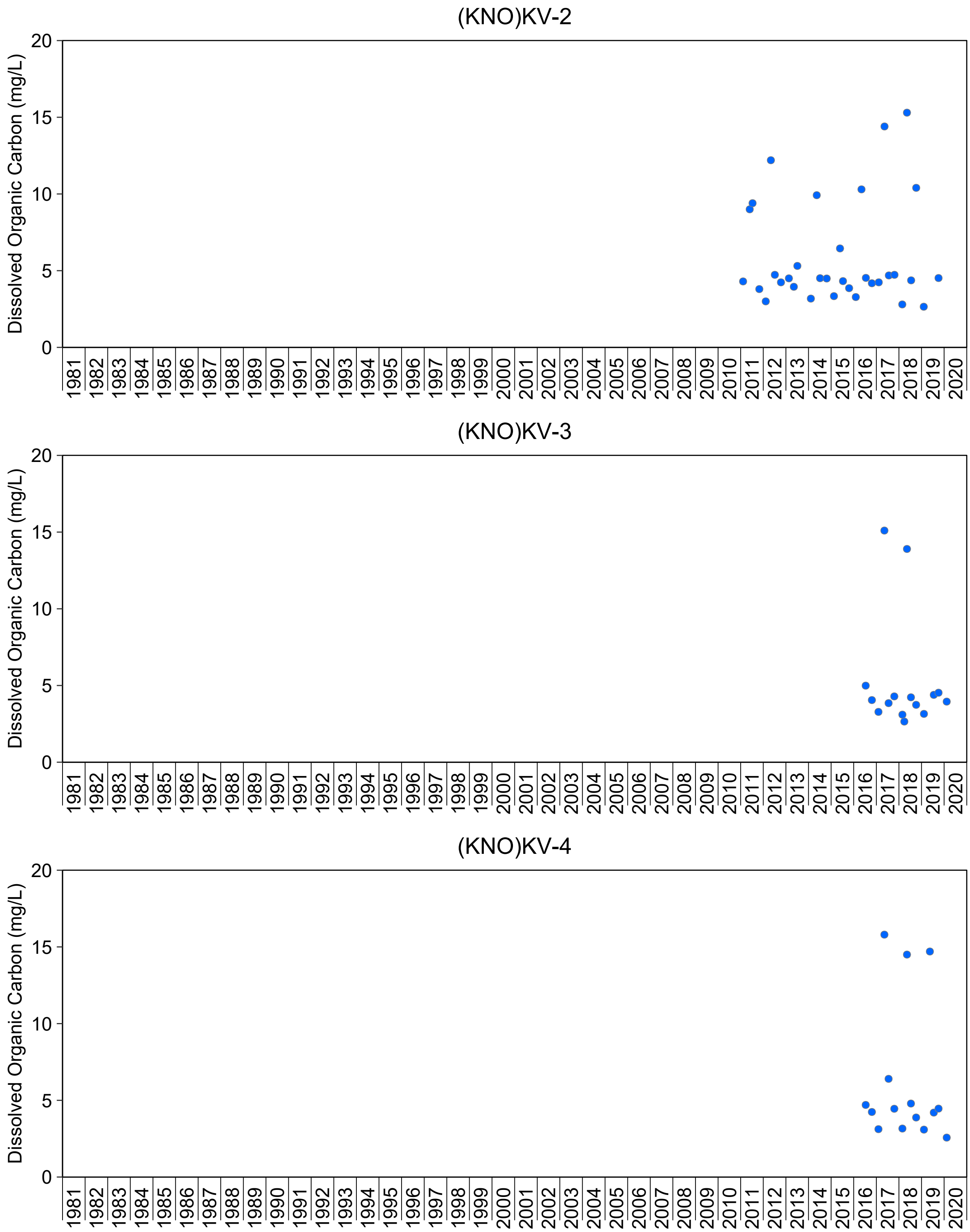


Figure A.23: Time Series Plots of Dissolved Organic Carbon Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

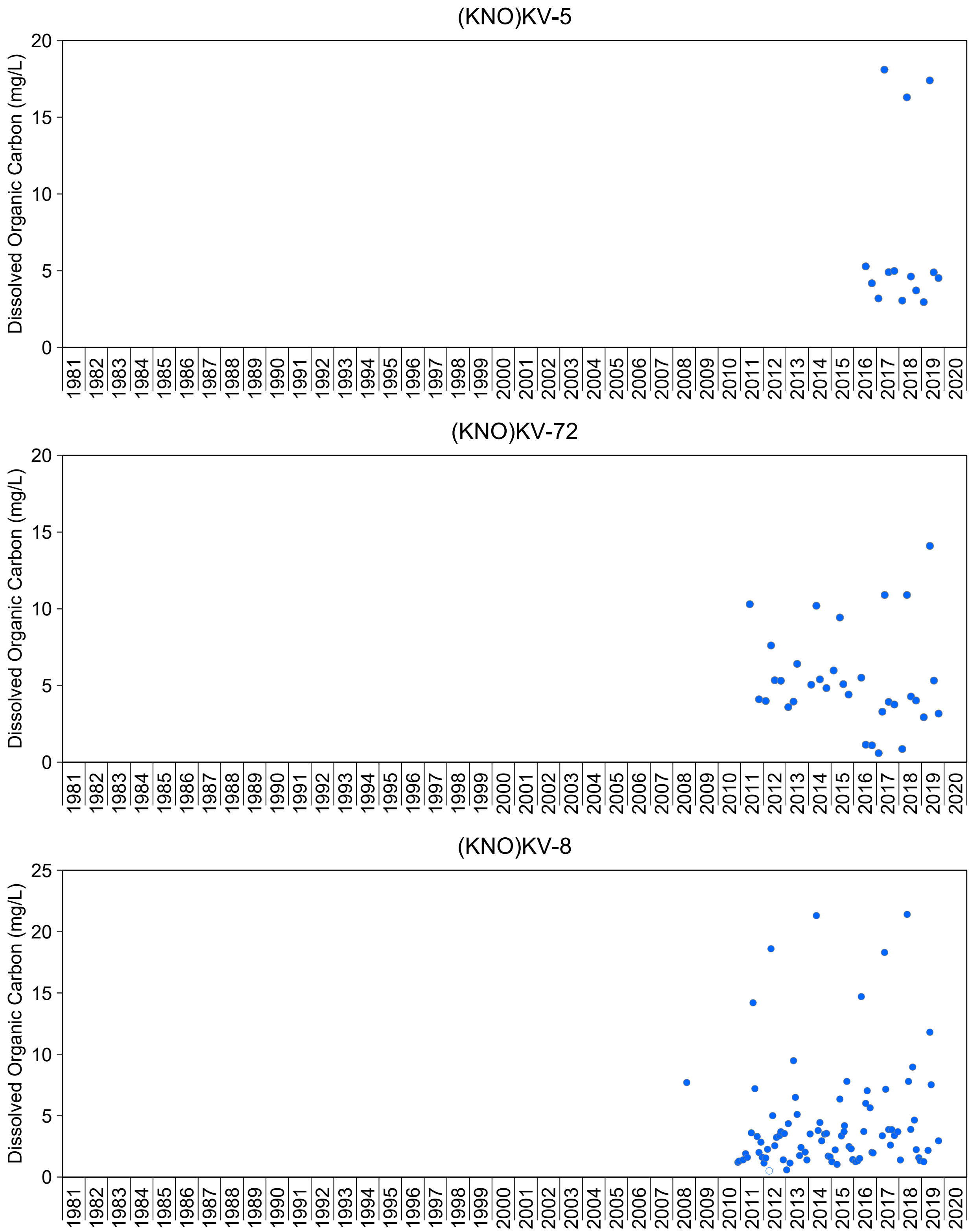


Figure A.23: Time Series Plots of Dissolved Organic Carbon Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

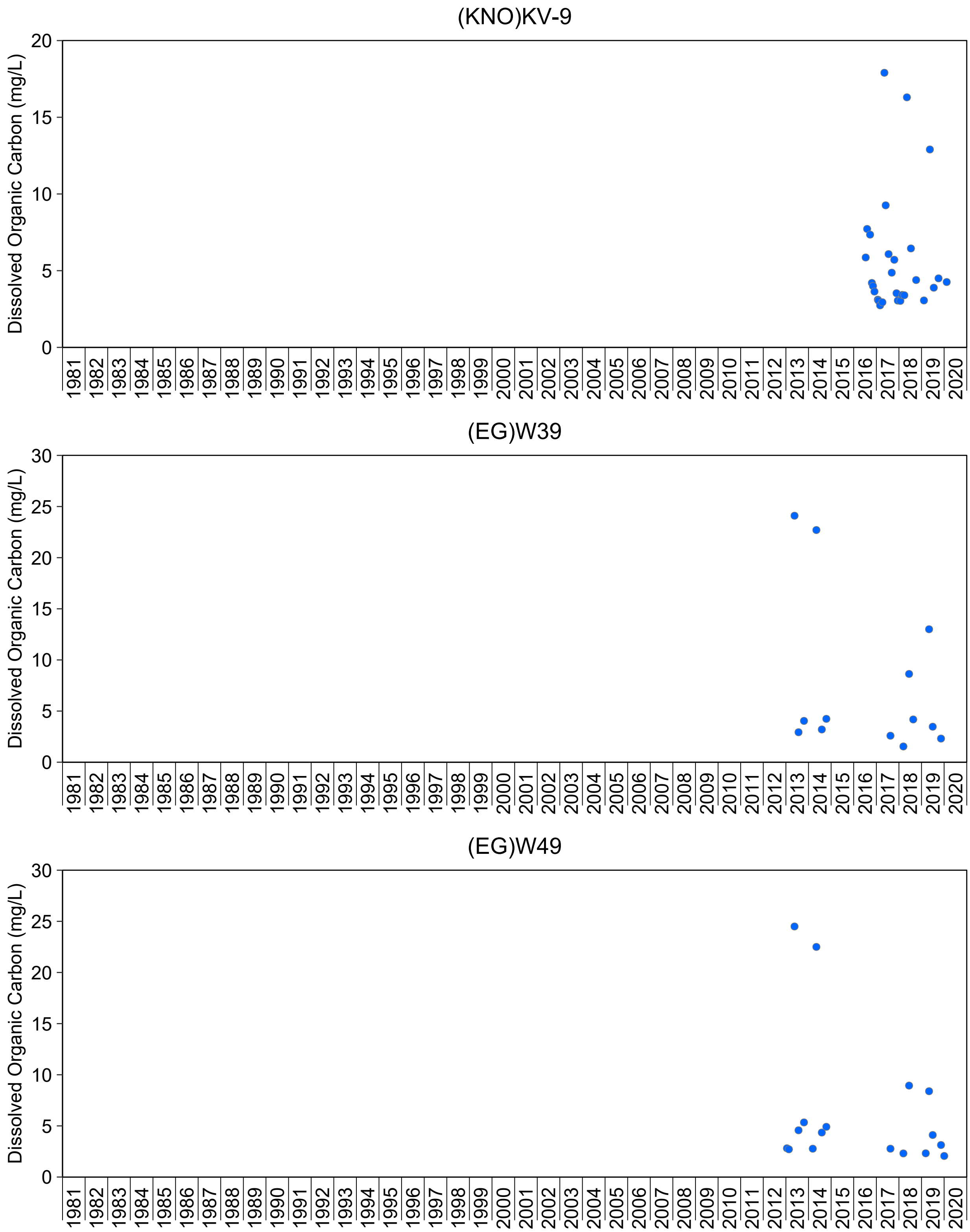


Figure A.23: Time Series Plots of Dissolved Organic Carbon Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

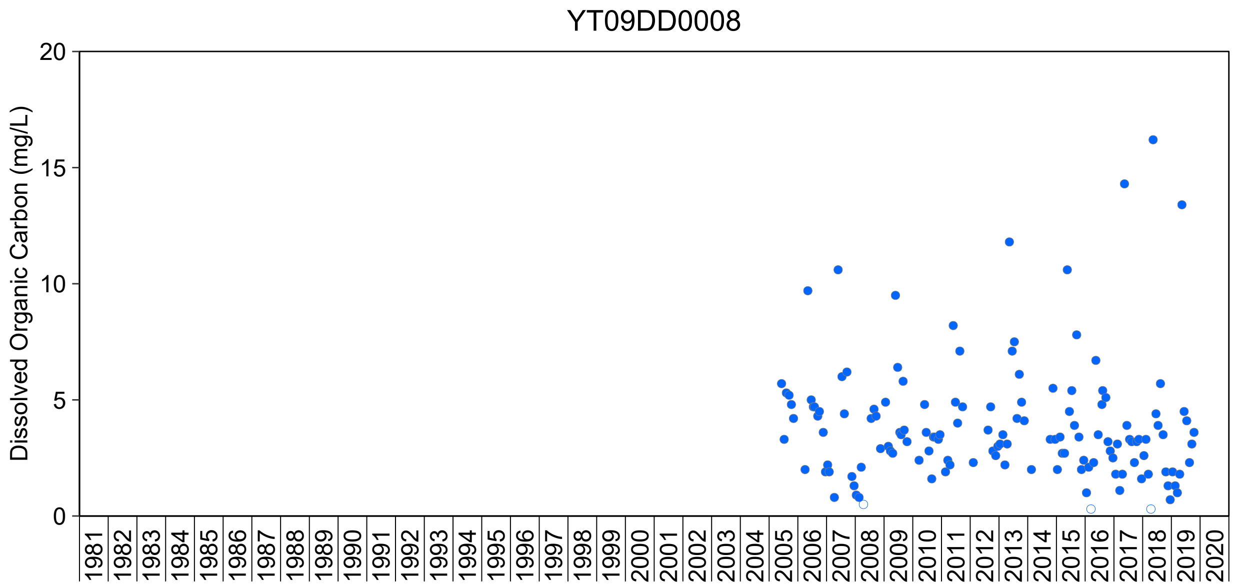


Figure A.23: Time Series Plots of Dissolved Organic Carbon Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

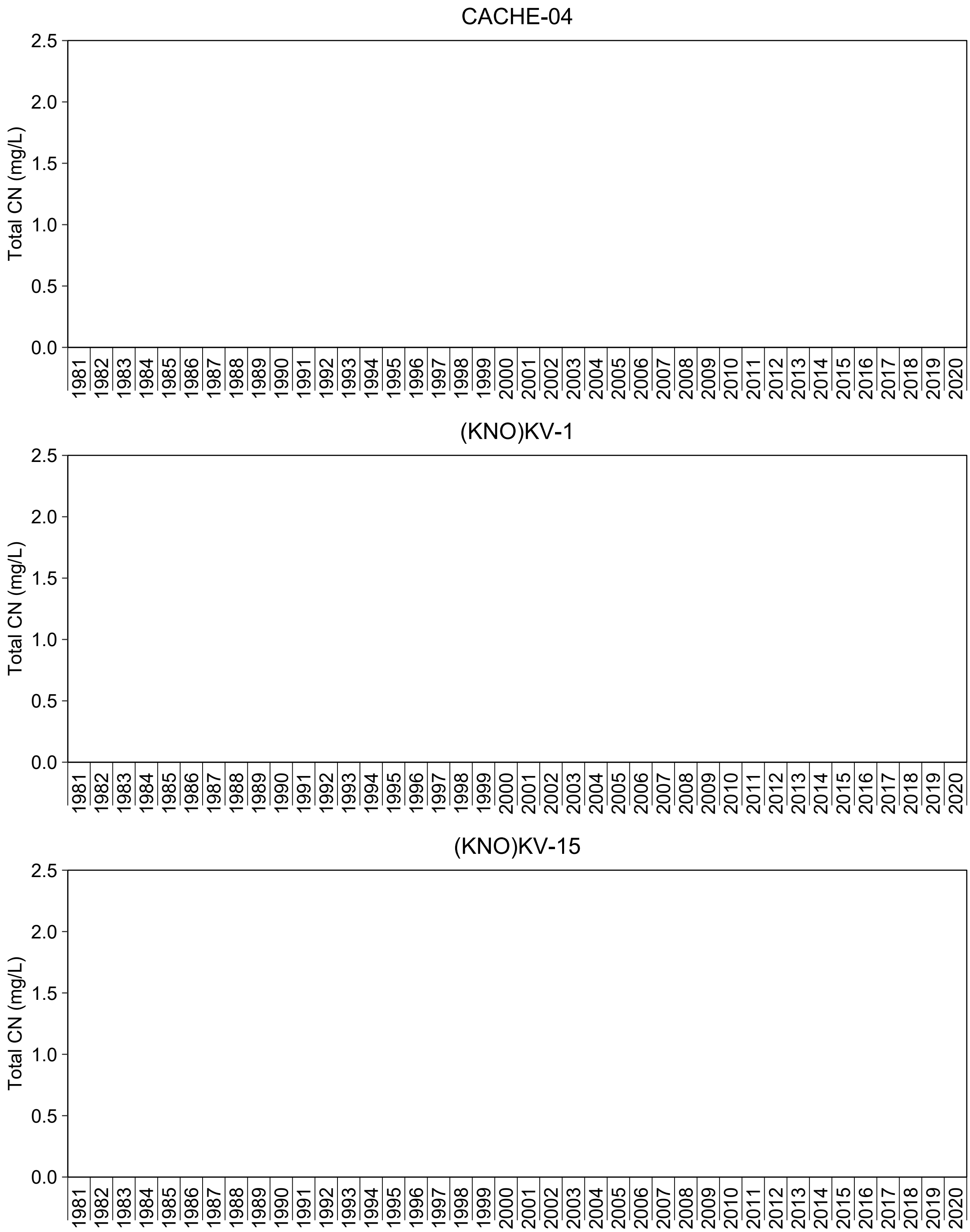


Figure A.24: Time Series Plots of Total Cyanide Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: CN = cyanide; mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

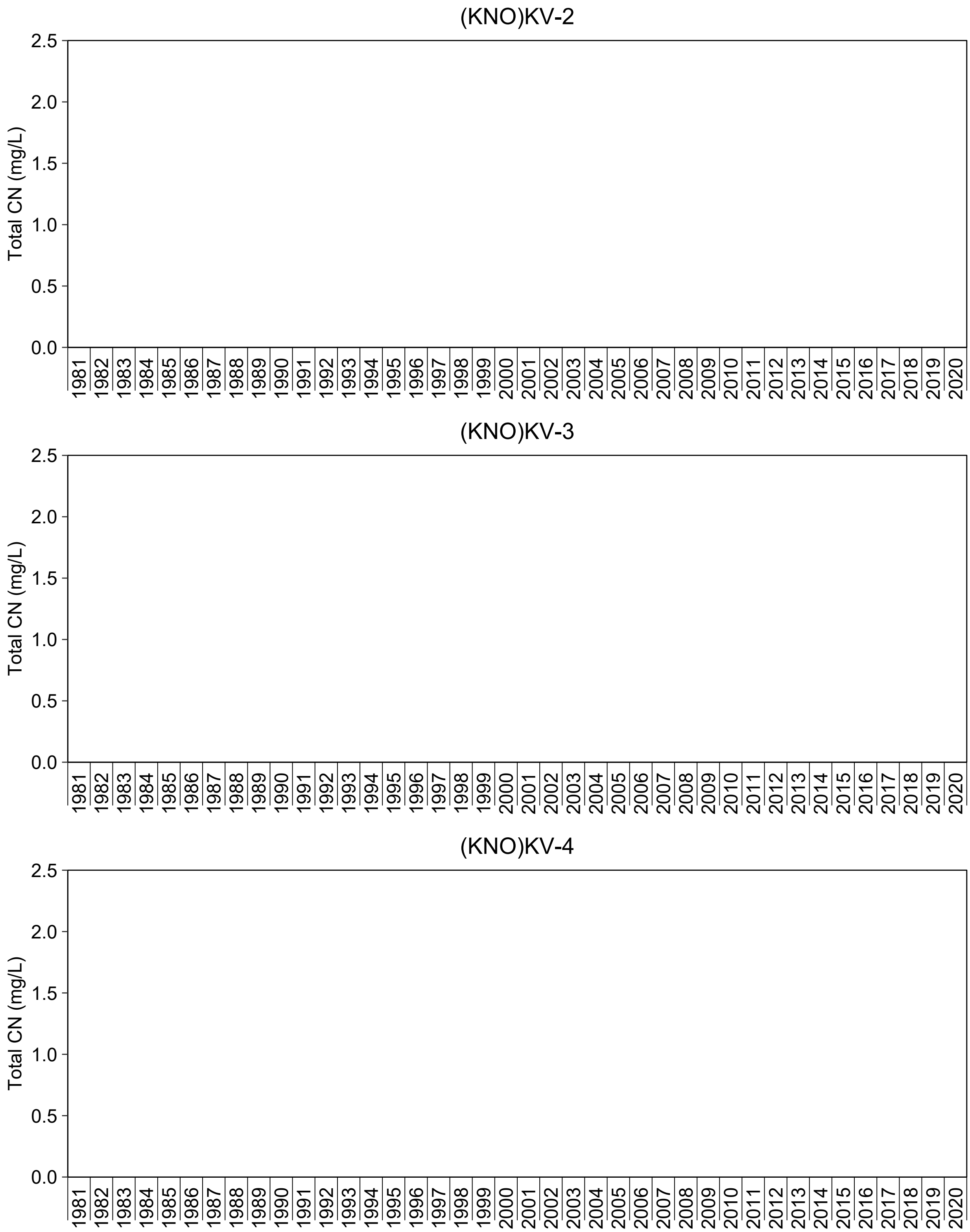


Figure A.24: Time Series Plots of Total Cyanide Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: CN = cyanide; mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

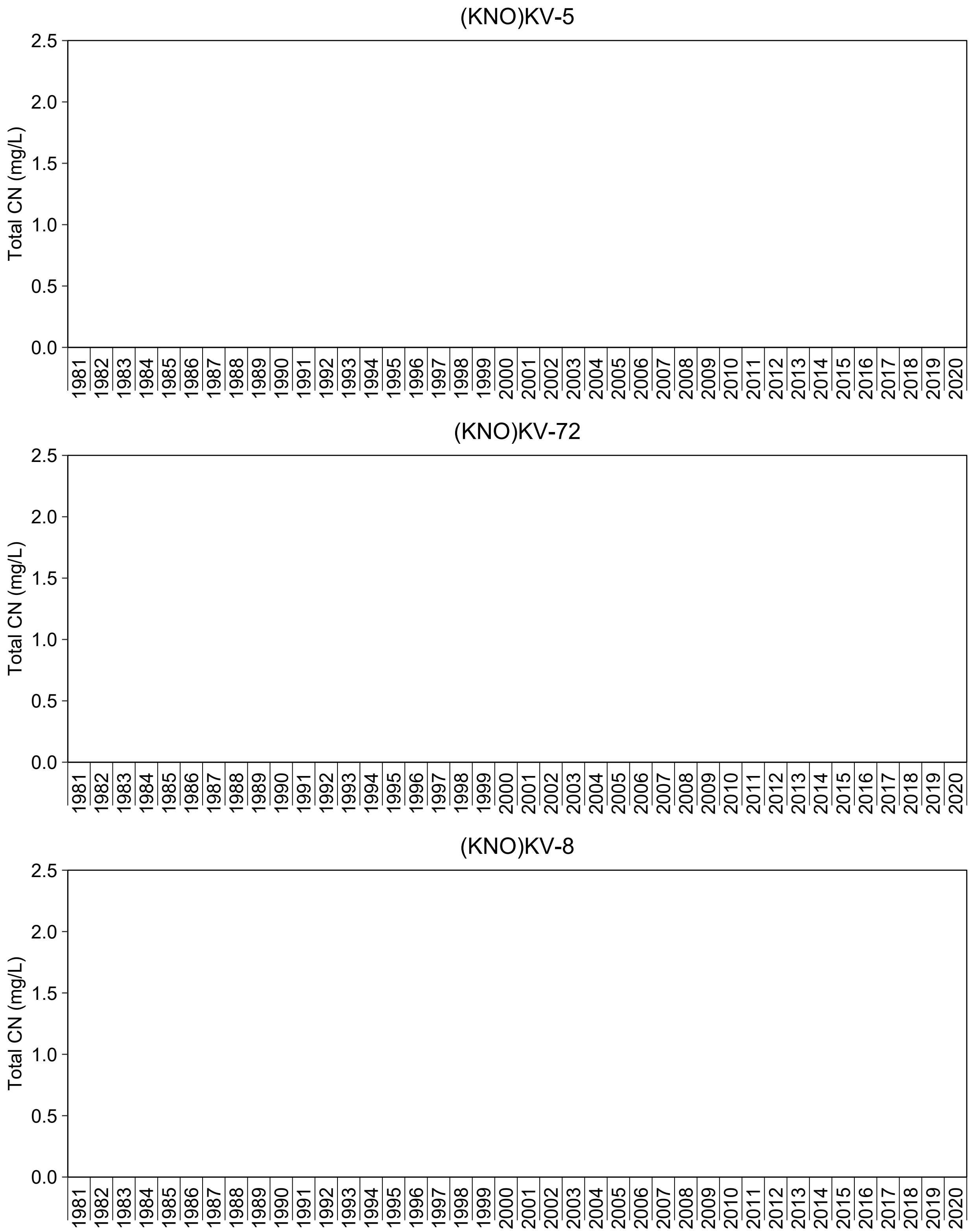


Figure A.24: Time Series Plots of Total Cyanide Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: CN = cyanide; mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

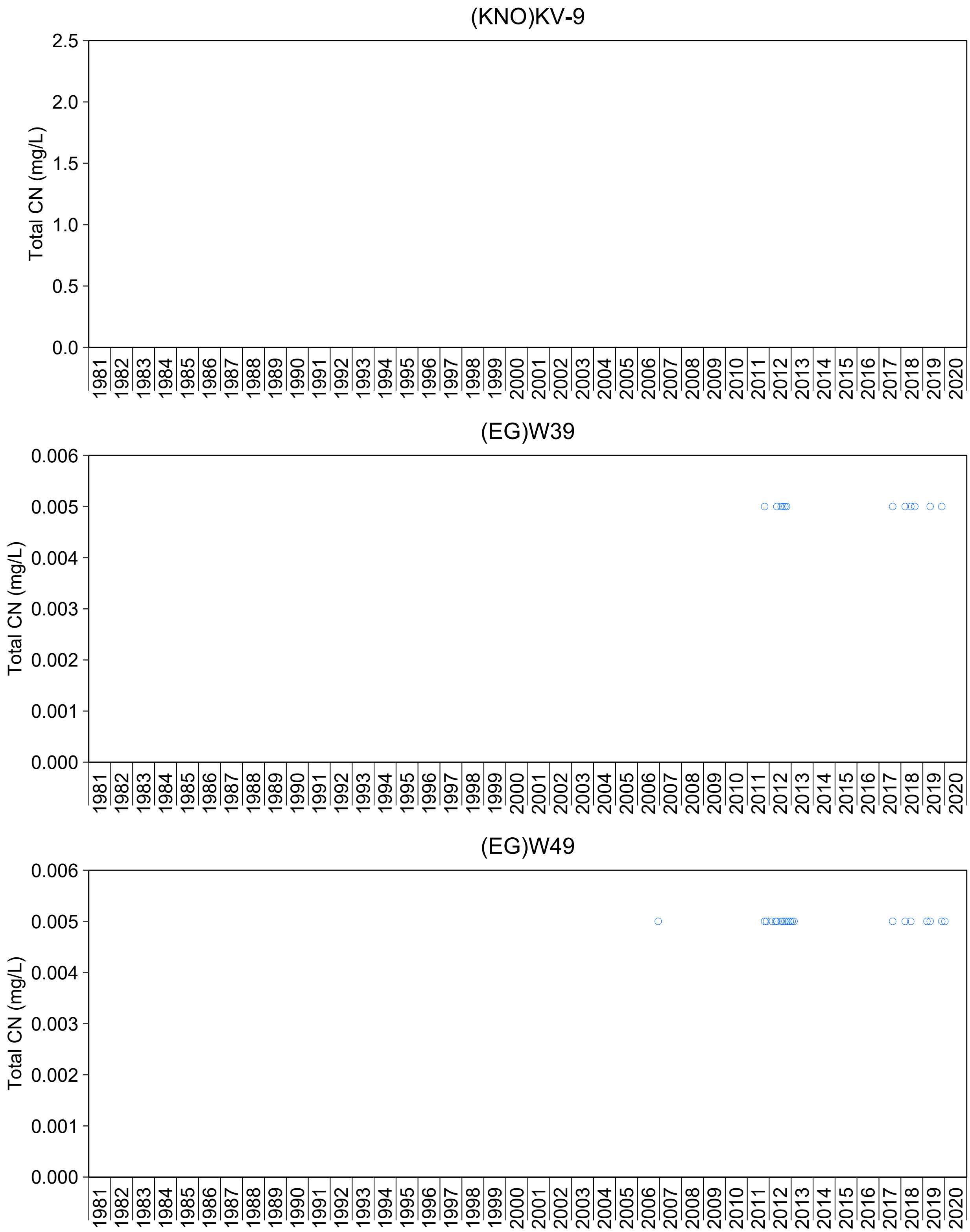


Figure A.24: Time Series Plots of Total Cyanide Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: CN = cyanide; mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

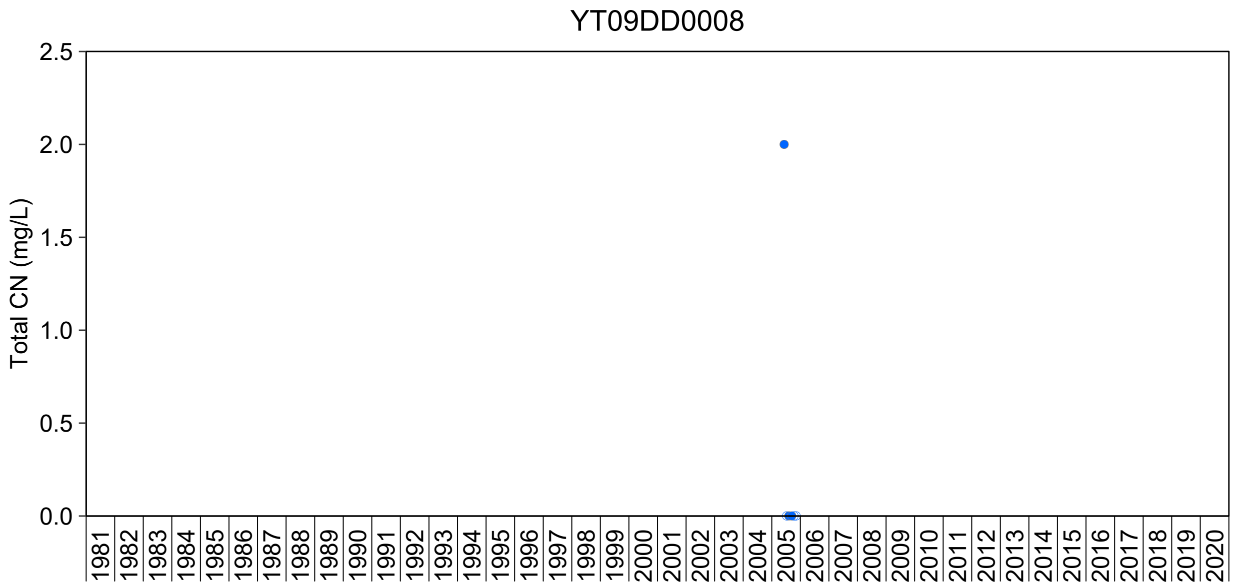
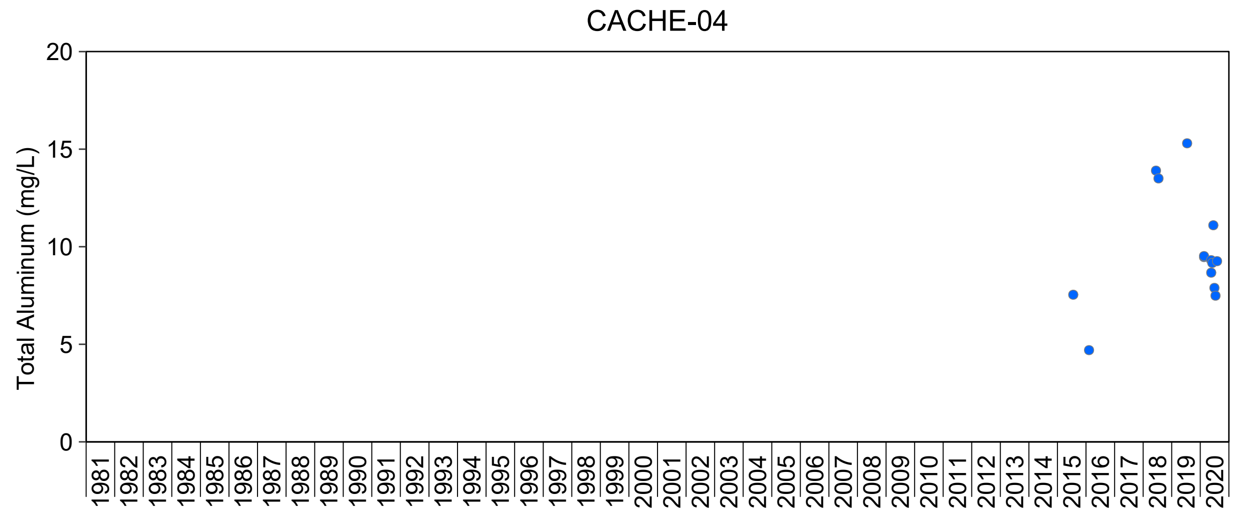
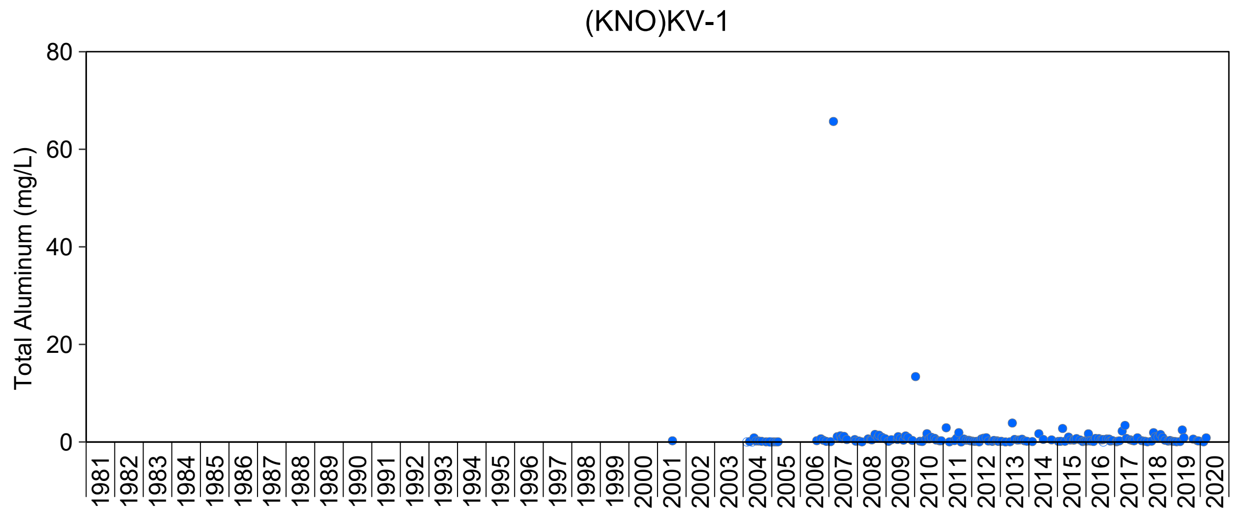


Figure A.24: Time Series Plots of Total Cyanide Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: CN = cyanide; mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.





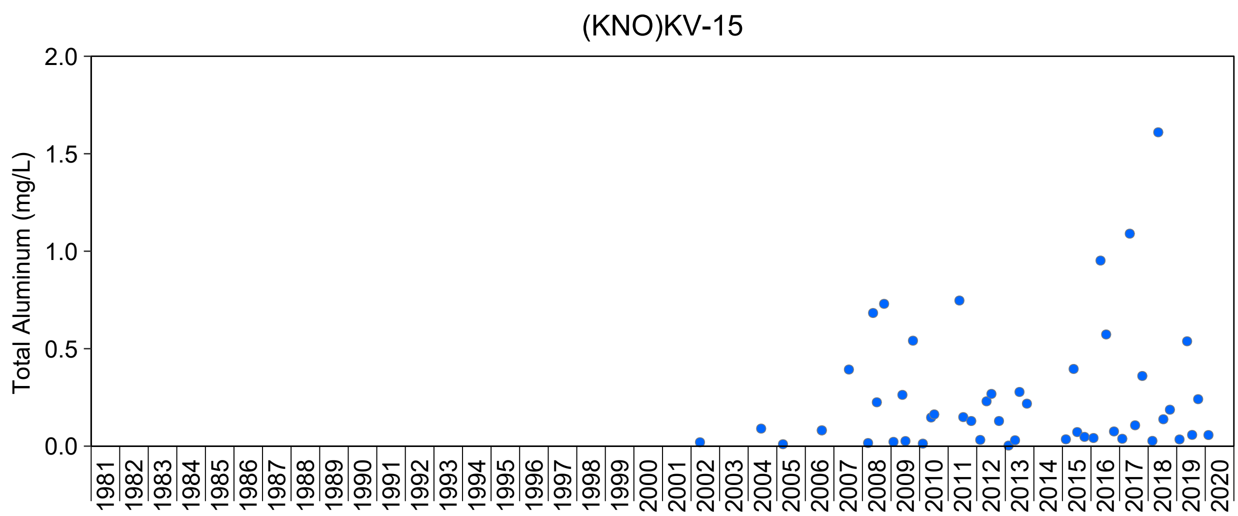


Figure A.25: Time Series Plots of Total Aluminum Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

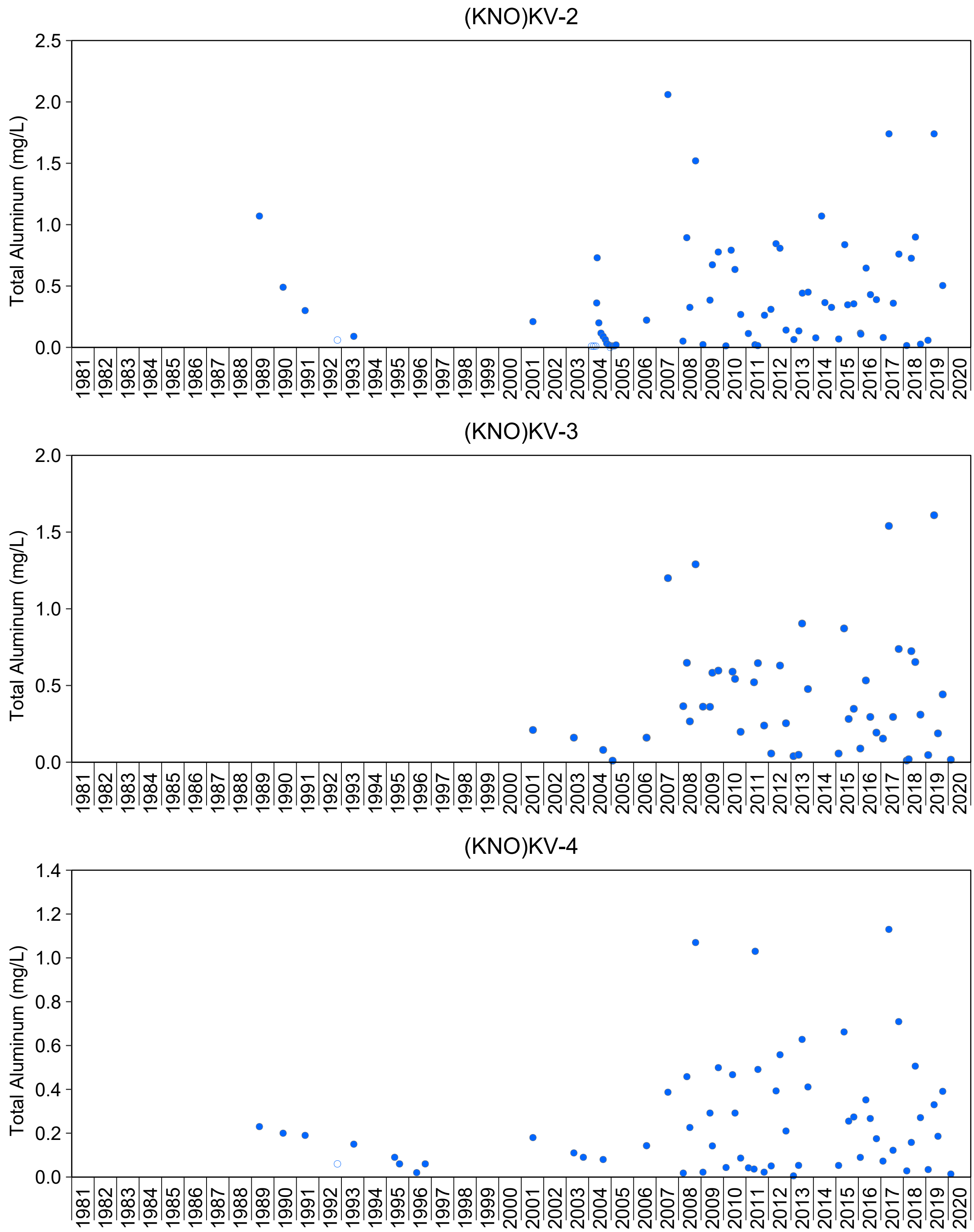
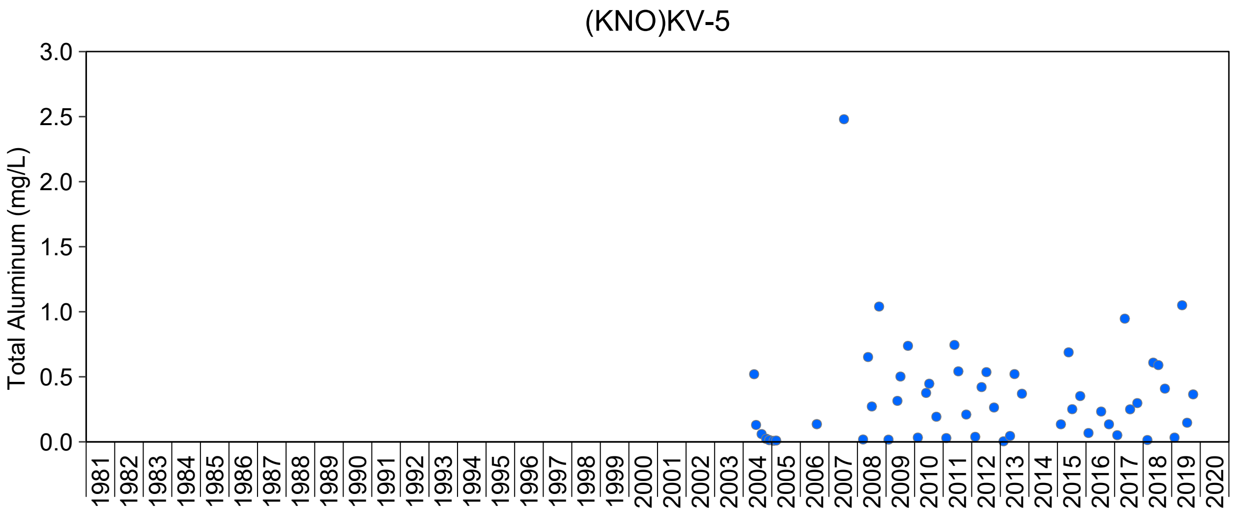
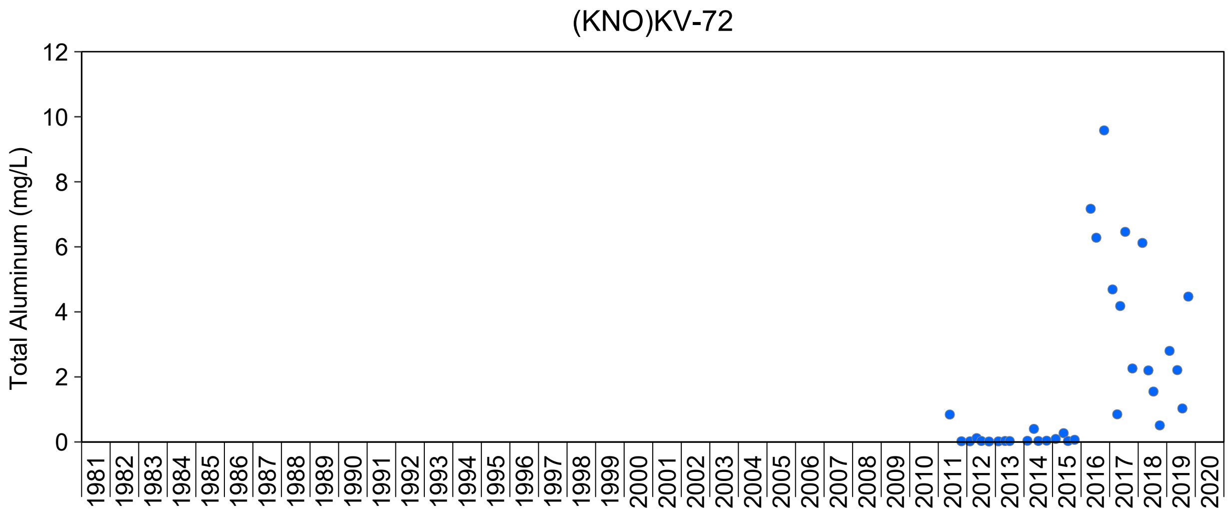


Figure A.25: Time Series Plots of Total Aluminum Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.





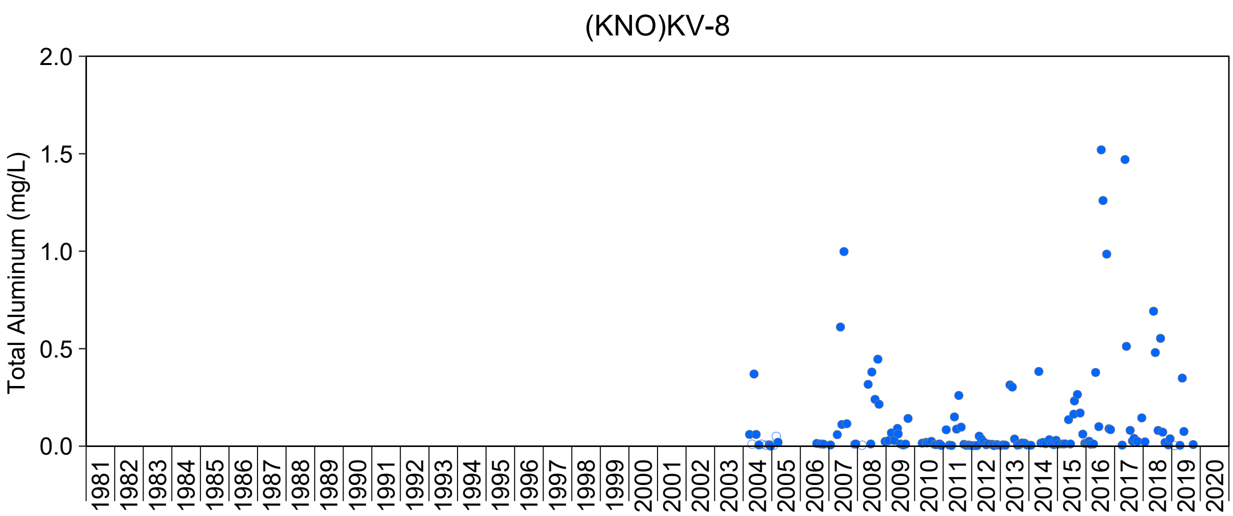


Figure A.25: Time Series Plots of Total Aluminum Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

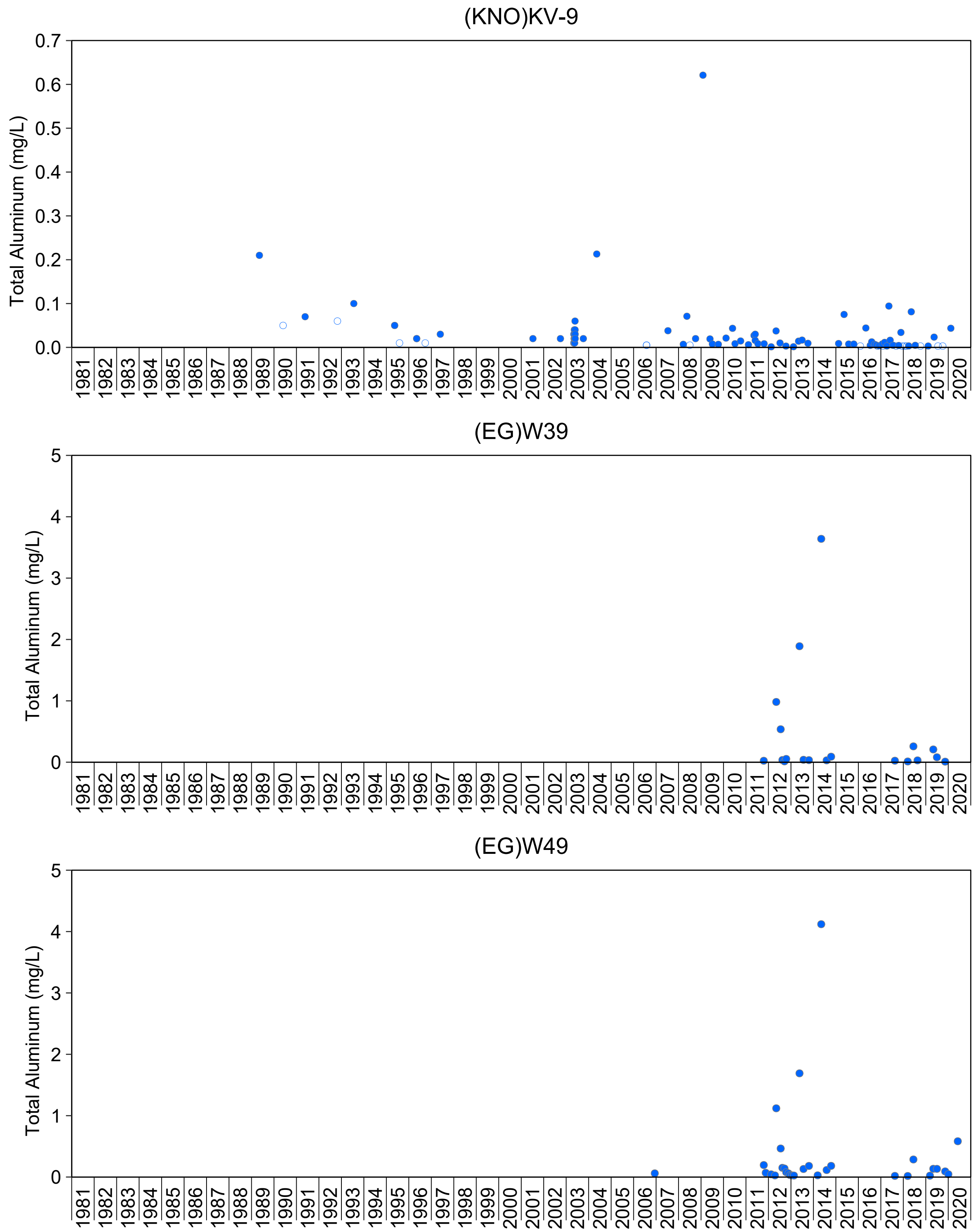


Figure A.25: Time Series Plots of Total Aluminum Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

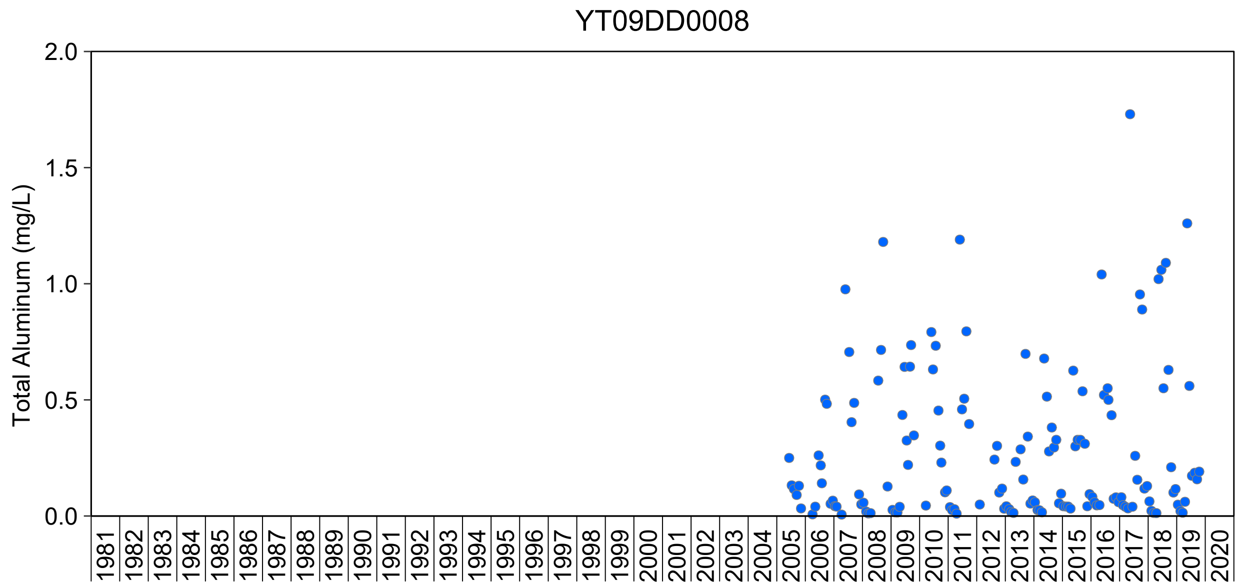


Figure A.25: Time Series Plots of Total Aluminum Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

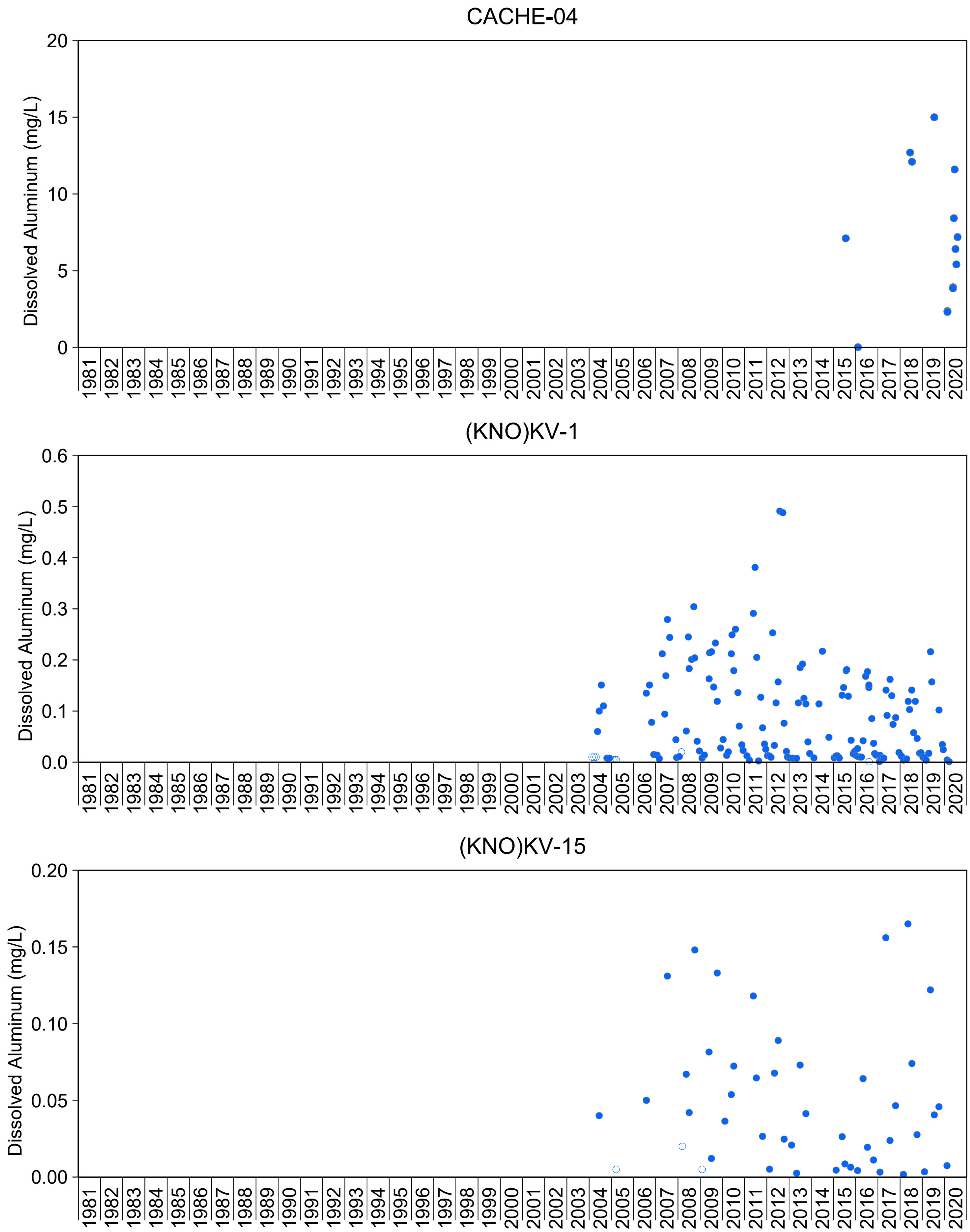


Figure A.26: Time Series Plots of Dissolved Aluminum Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

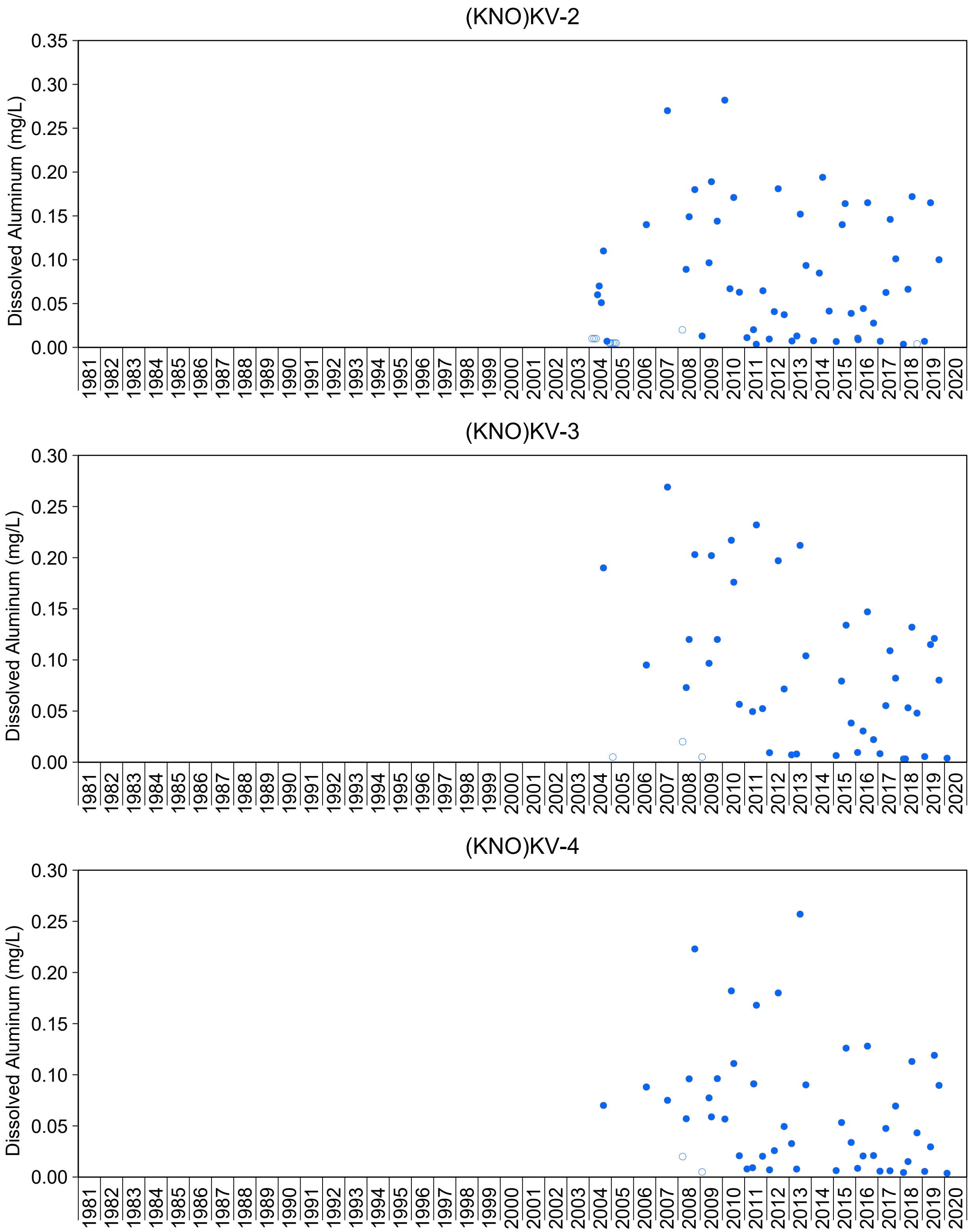


Figure A.24: Time Series Plots of Dissolved Aluminum Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

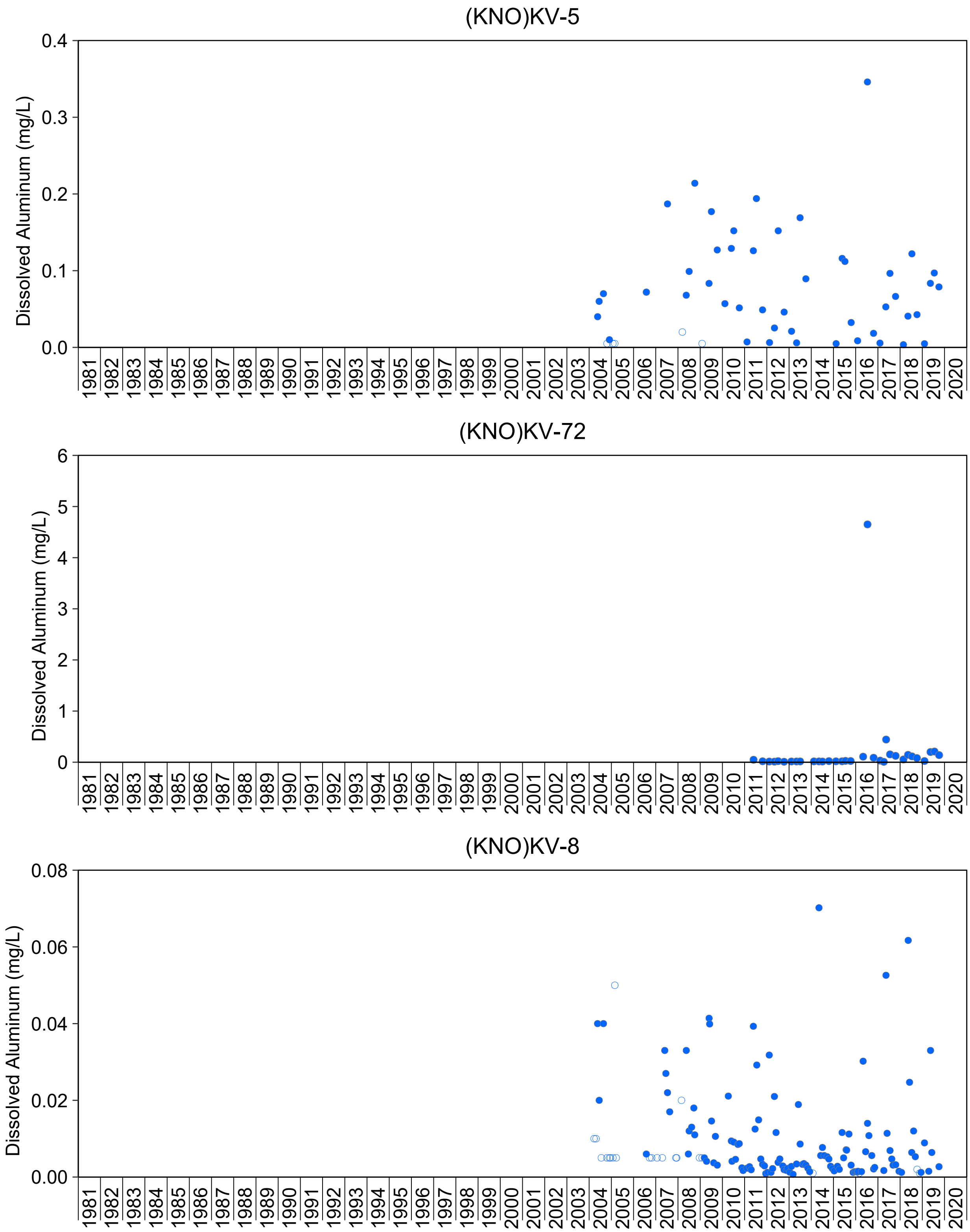


Figure A.26: Time Series Plots of Dissolved Aluminum Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

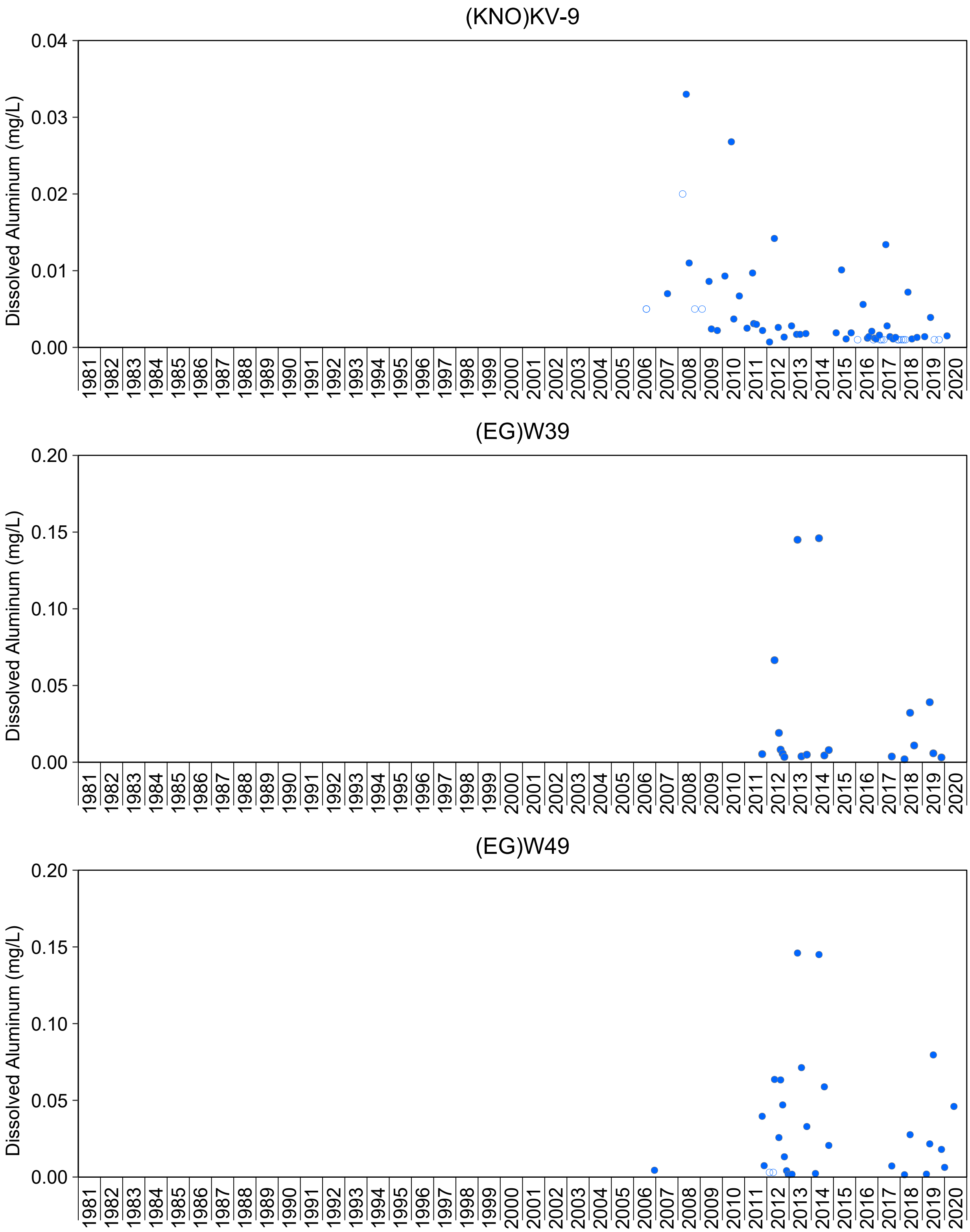


Figure A.26: Time Series Plots of Dissolved Aluminum Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

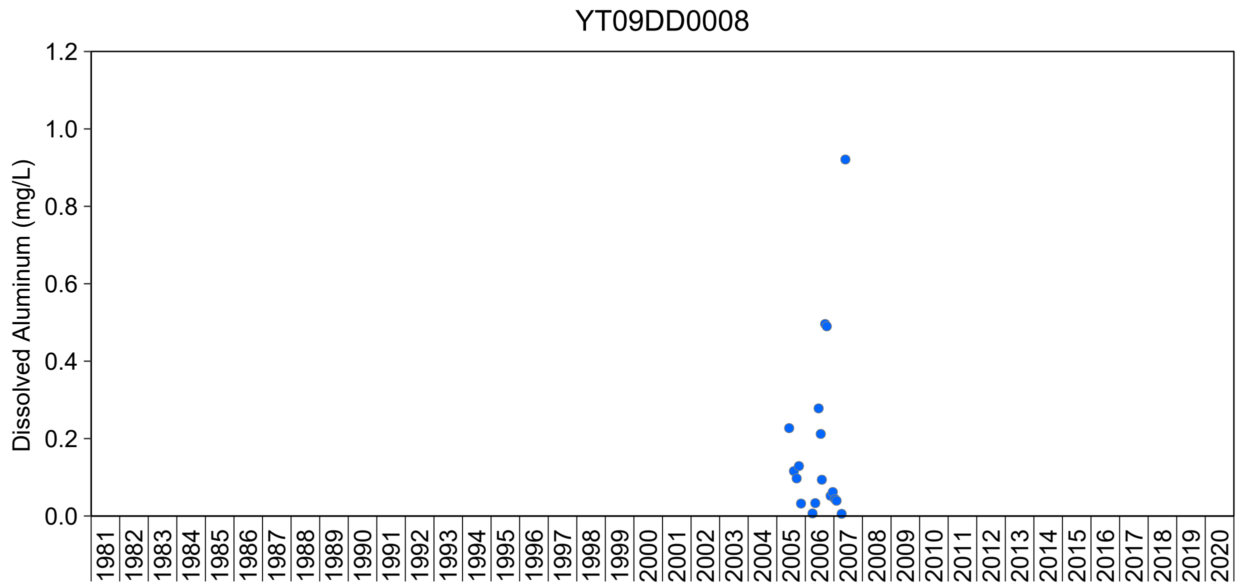


Figure A.26: Time Series Plots of Dissolved Aluminum Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

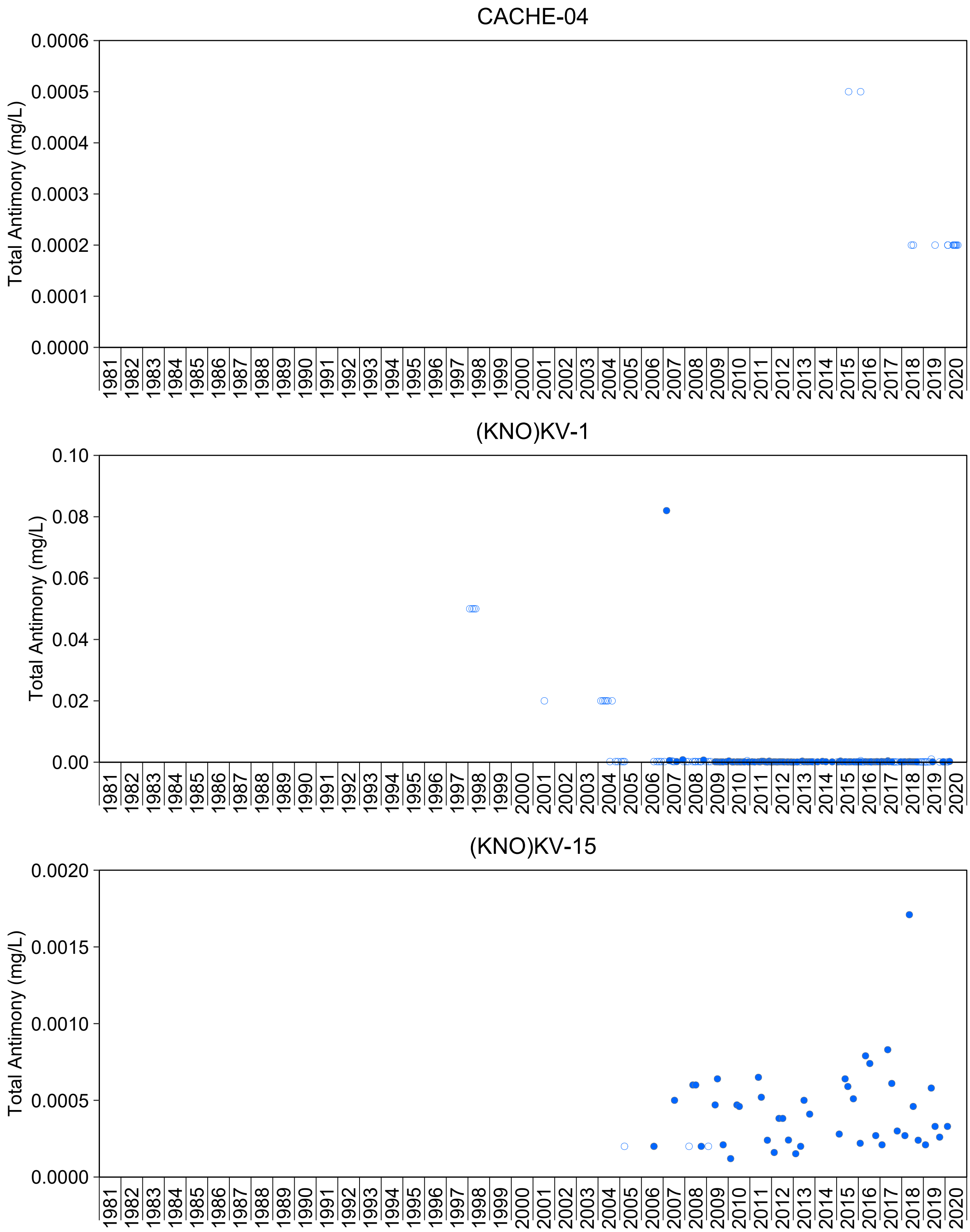


Figure A.27: Time Series Plots of Total Antimony Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

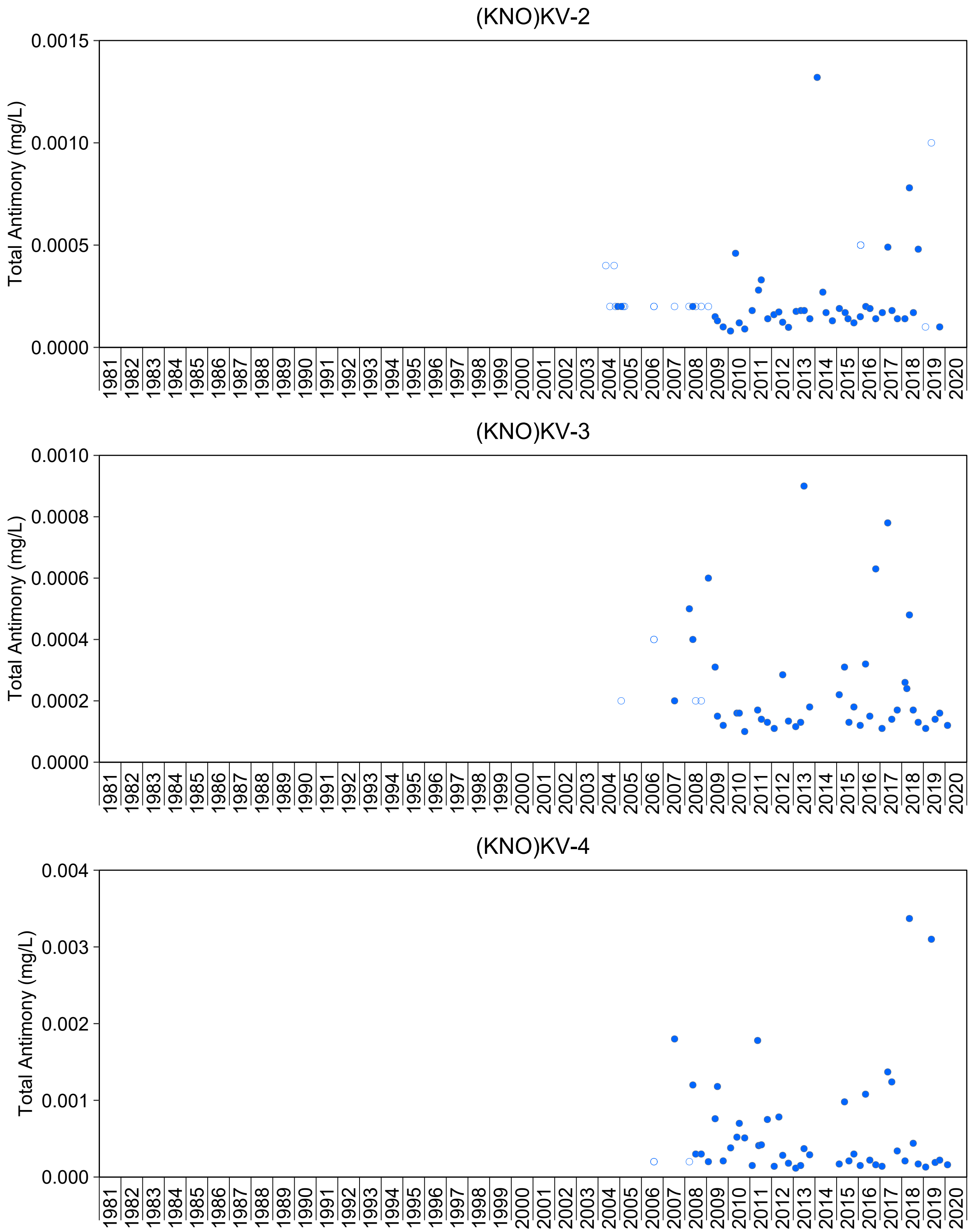


Figure A.27: Time Series Plots of Total Antimony Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

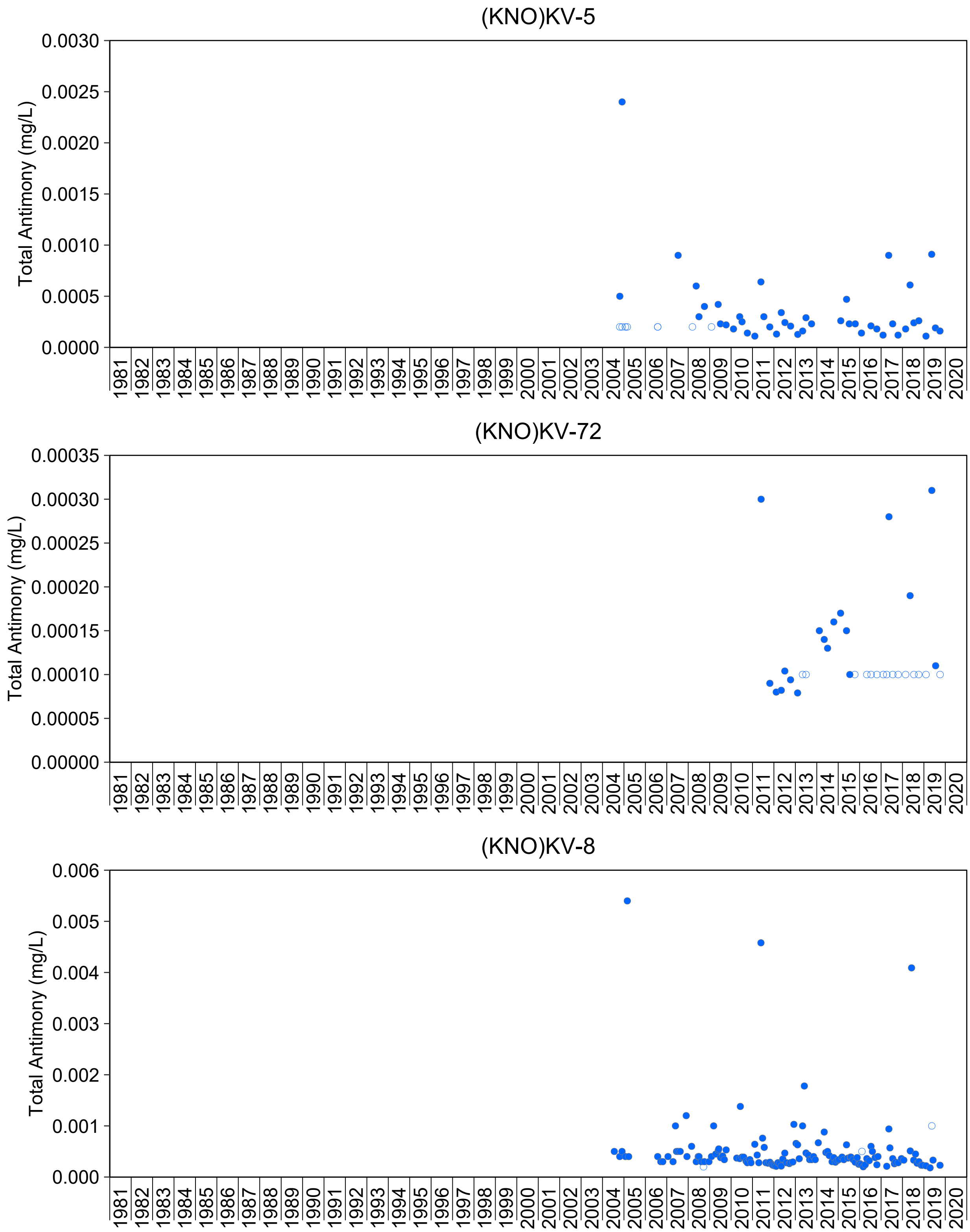


Figure A.27: Time Series Plots of Total Antimony Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

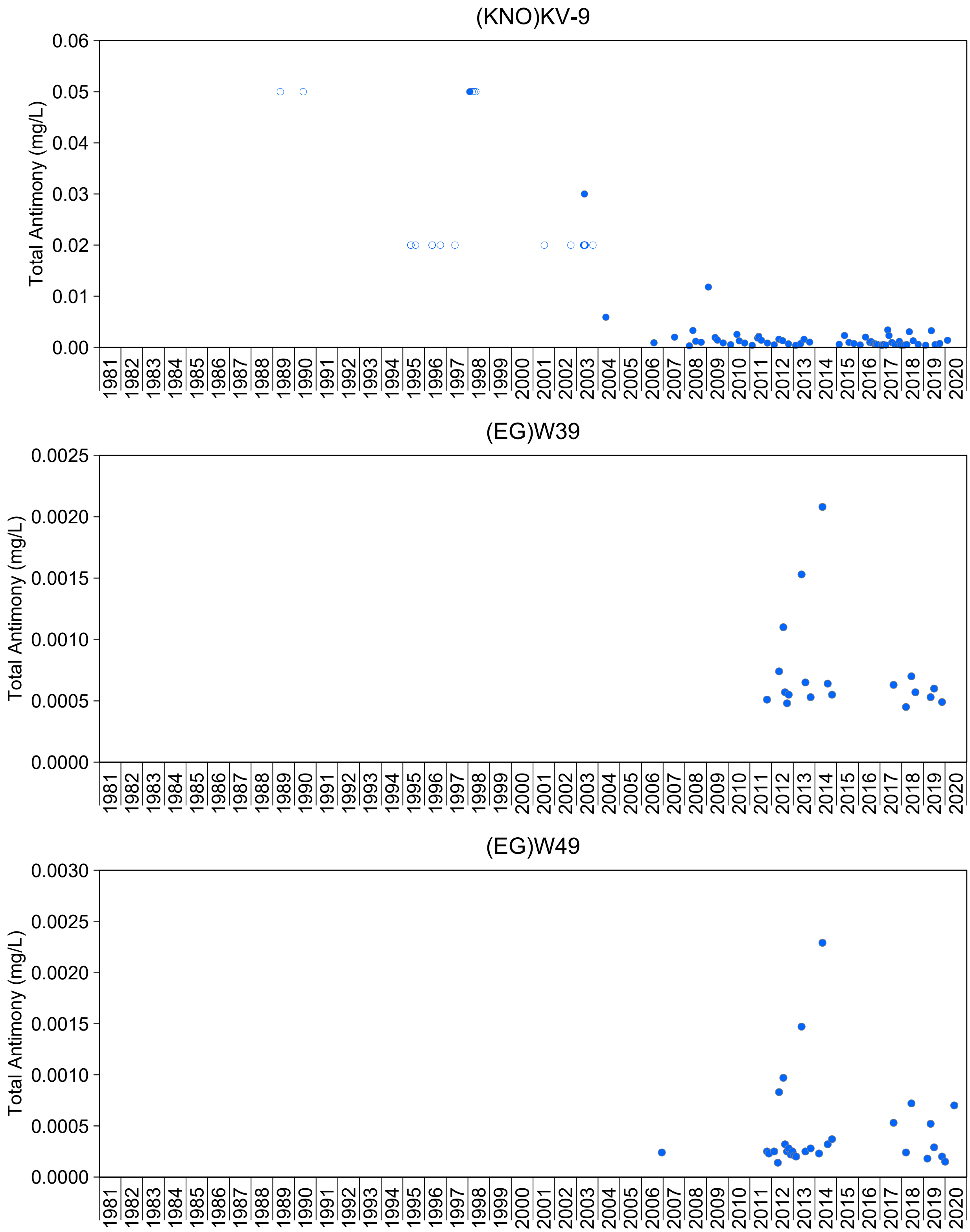


Figure A.27: Time Series Plots of Total Antimony Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

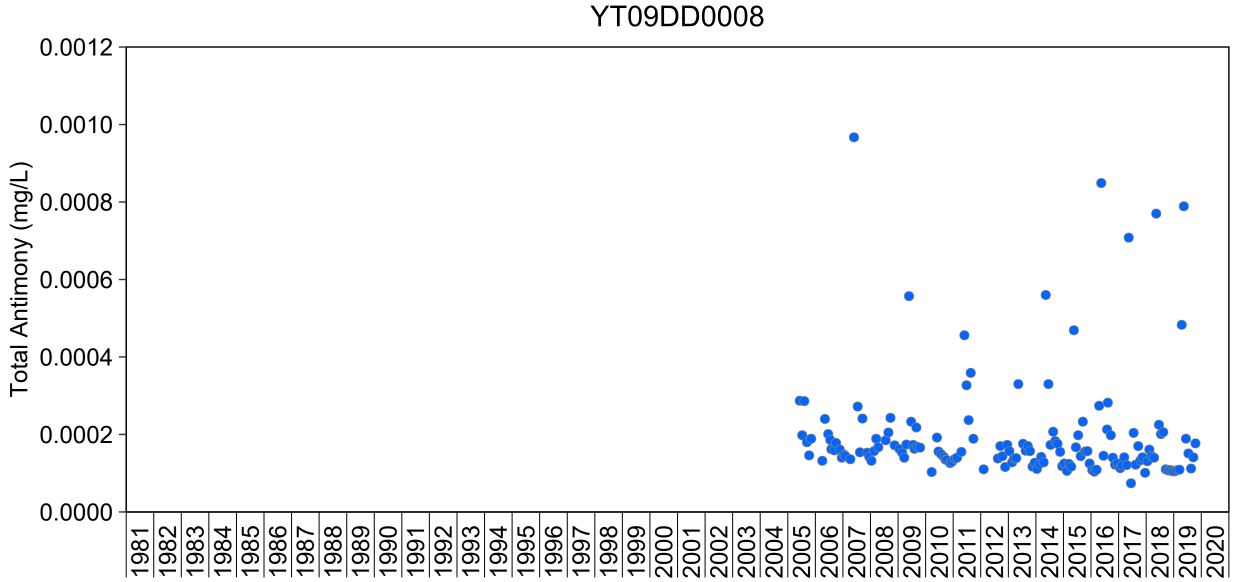


Figure A.27: Time Series Plots of Total Antimony Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

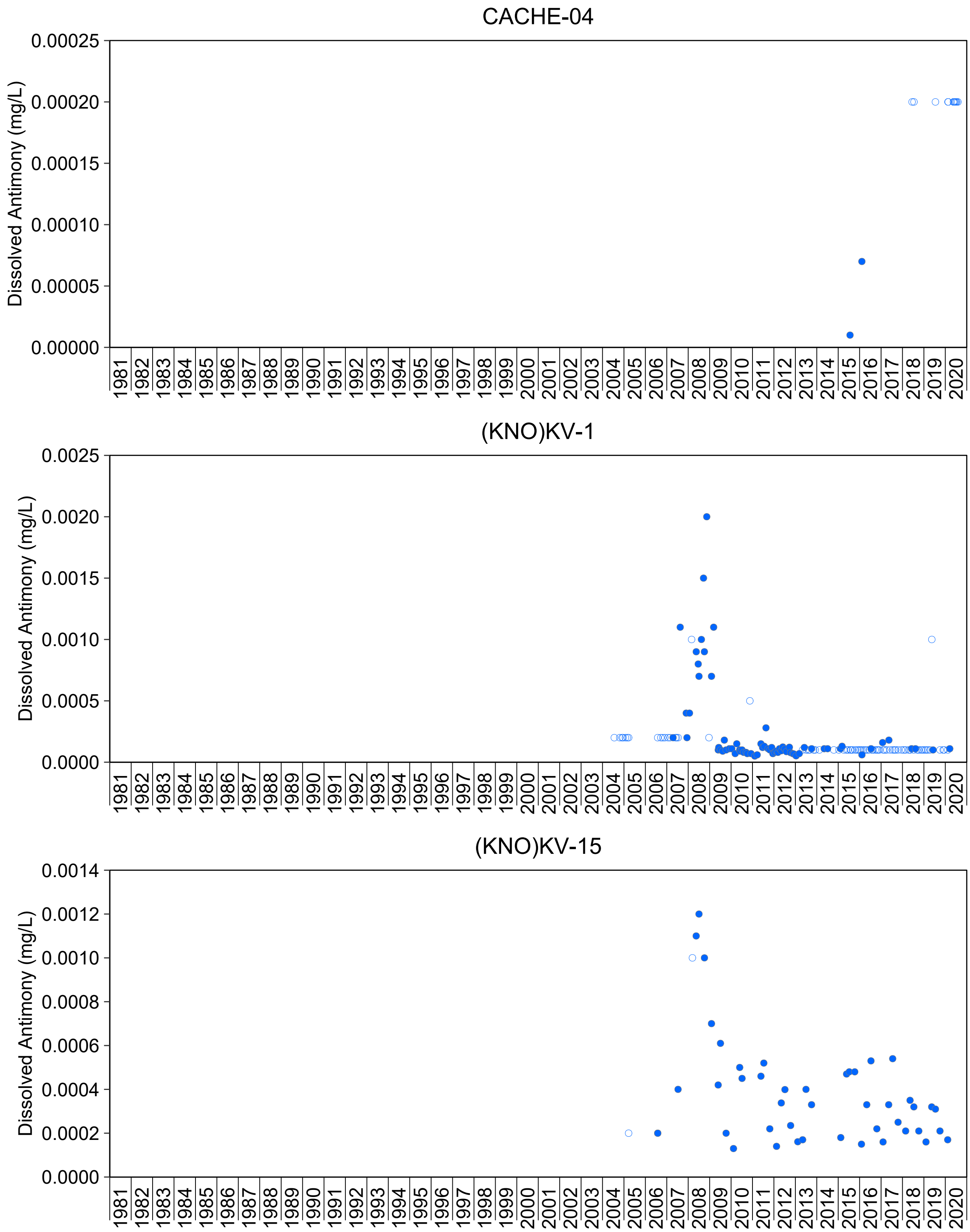


Figure A.28: Time Series Plots of Dissolved Antimony Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

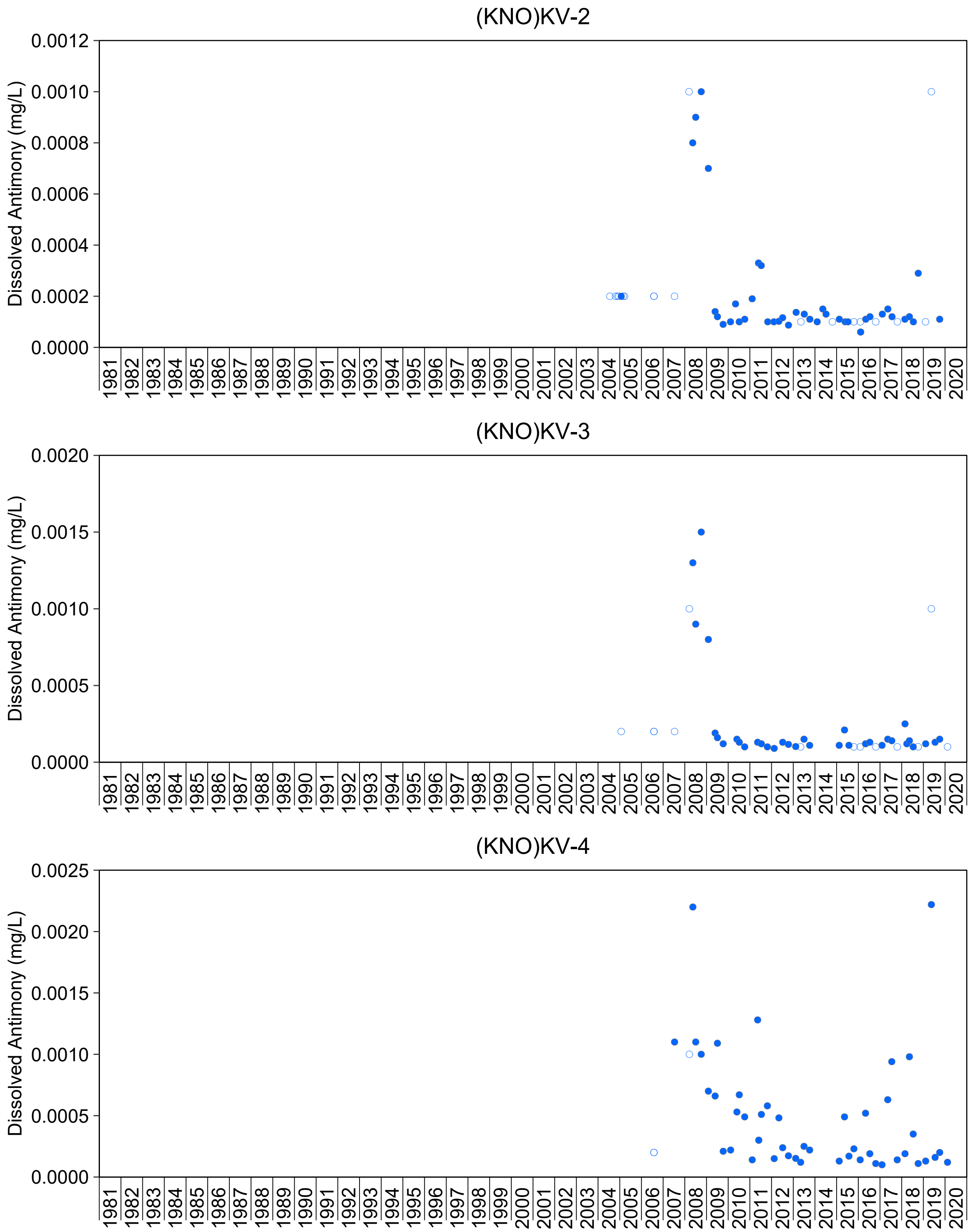


Figure A.28: Time Series Plots of Dissolved Antimony Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

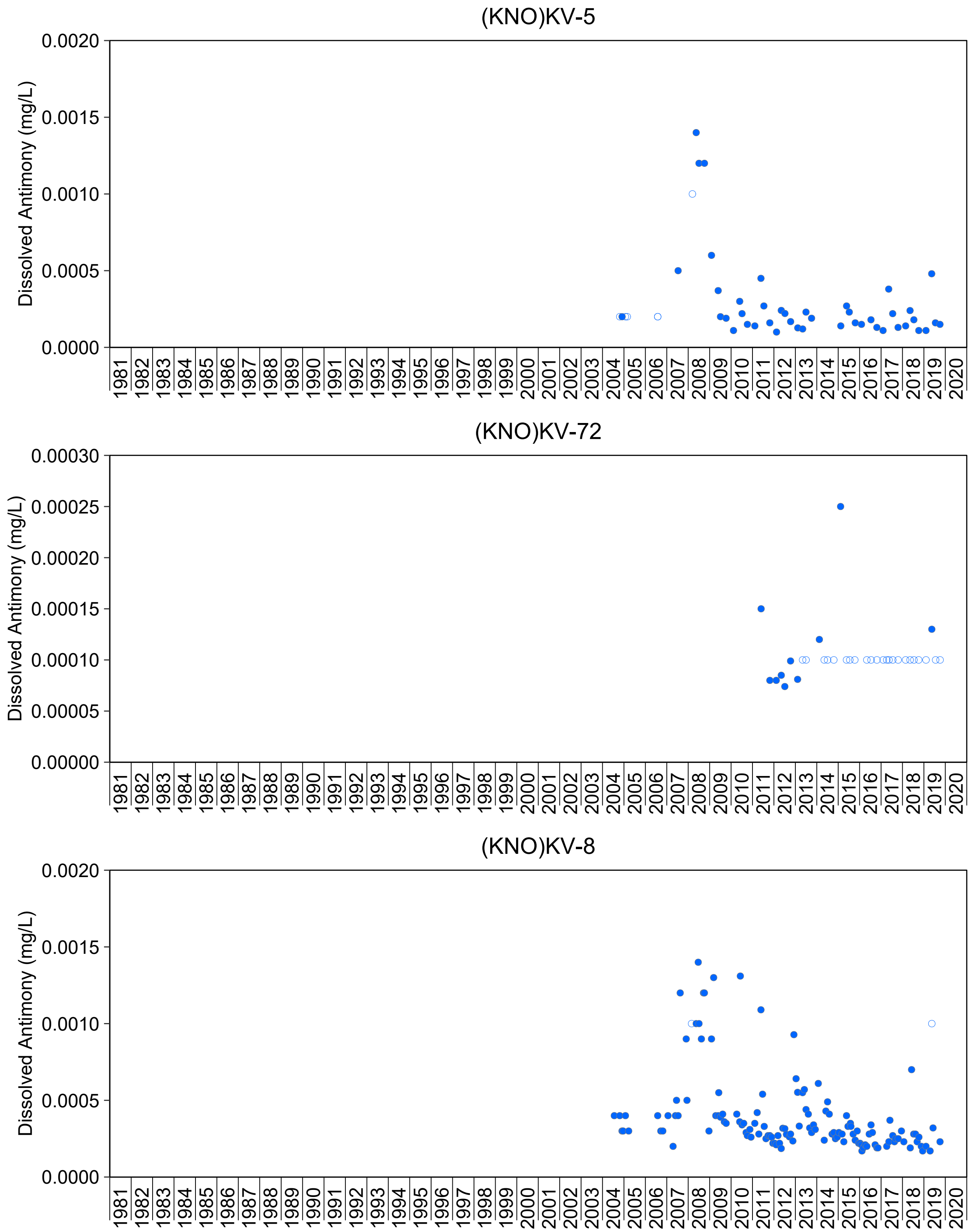


Figure A.28: Time Series Plots of Dissolved Antimony Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

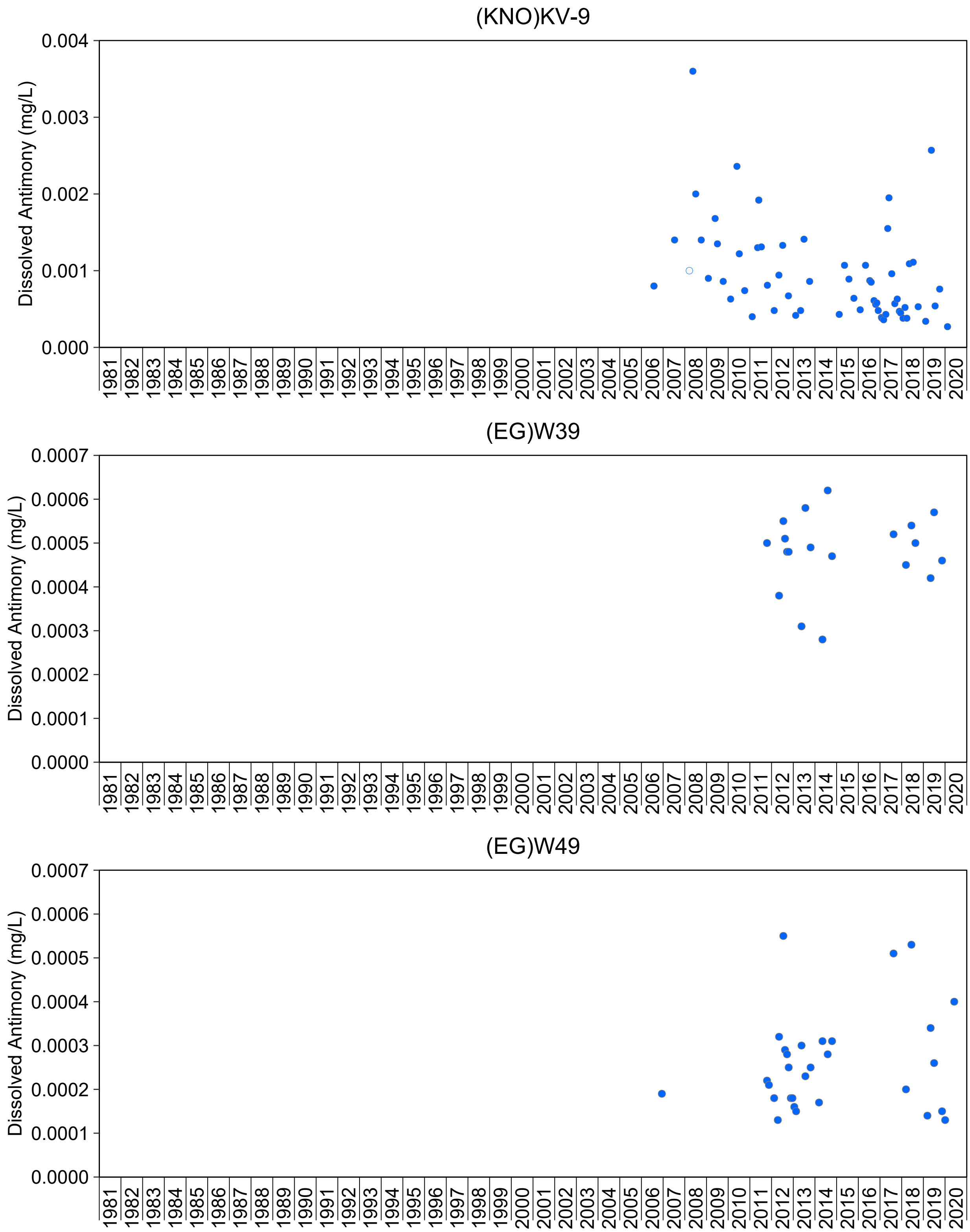


Figure A.28: Time Series Plots of Dissolved Antimony Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

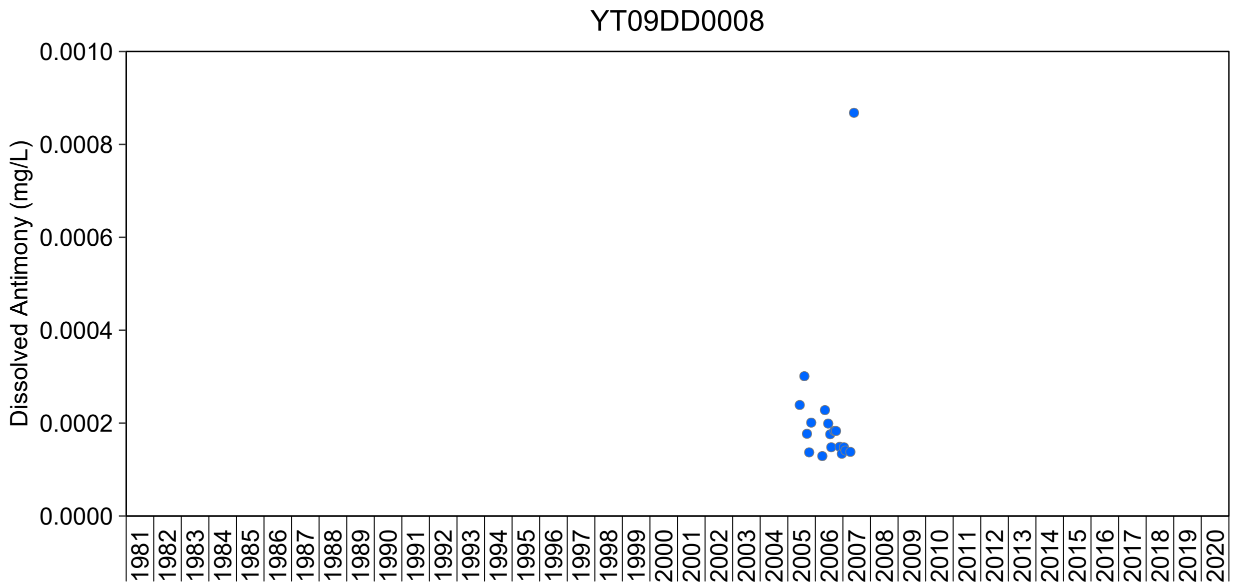


Figure A.28: Time Series Plots of Dissolved Antimony Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

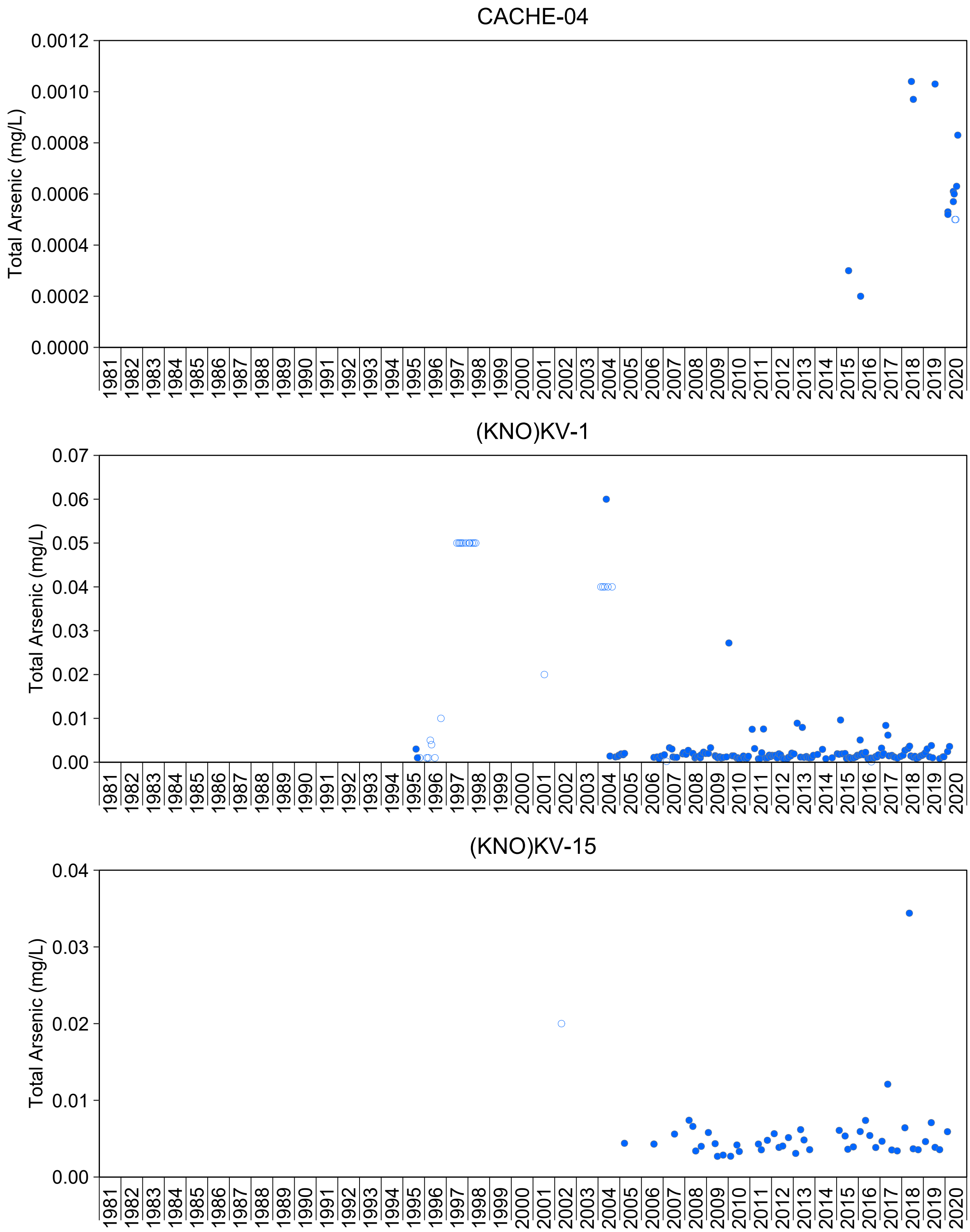


Figure A.29: Time Series Plots of Total Arsenic Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

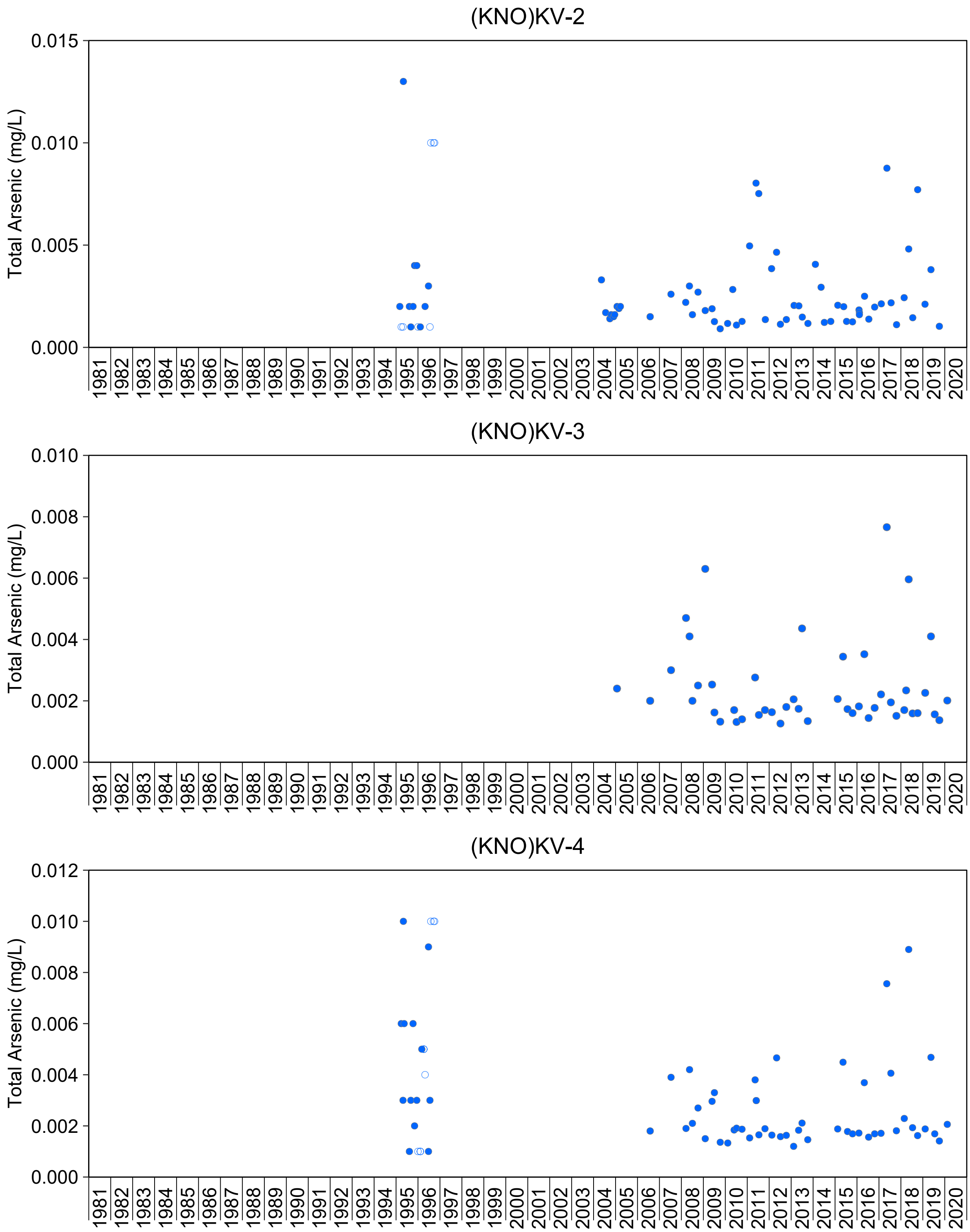


Figure A.29: Time Series Plots of Total Arsenic Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

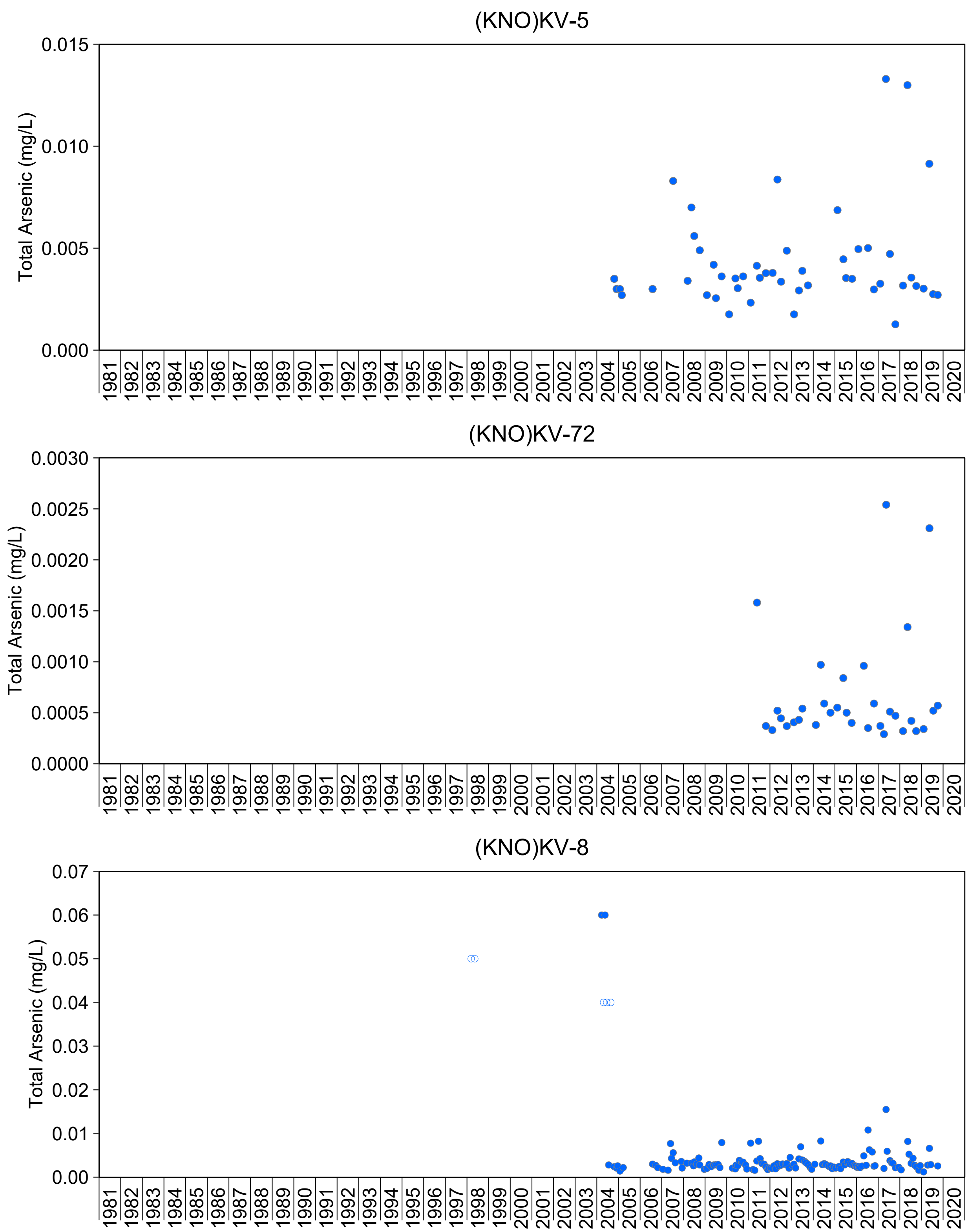


Figure A.29: Time Series Plots of Total Arsenic Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

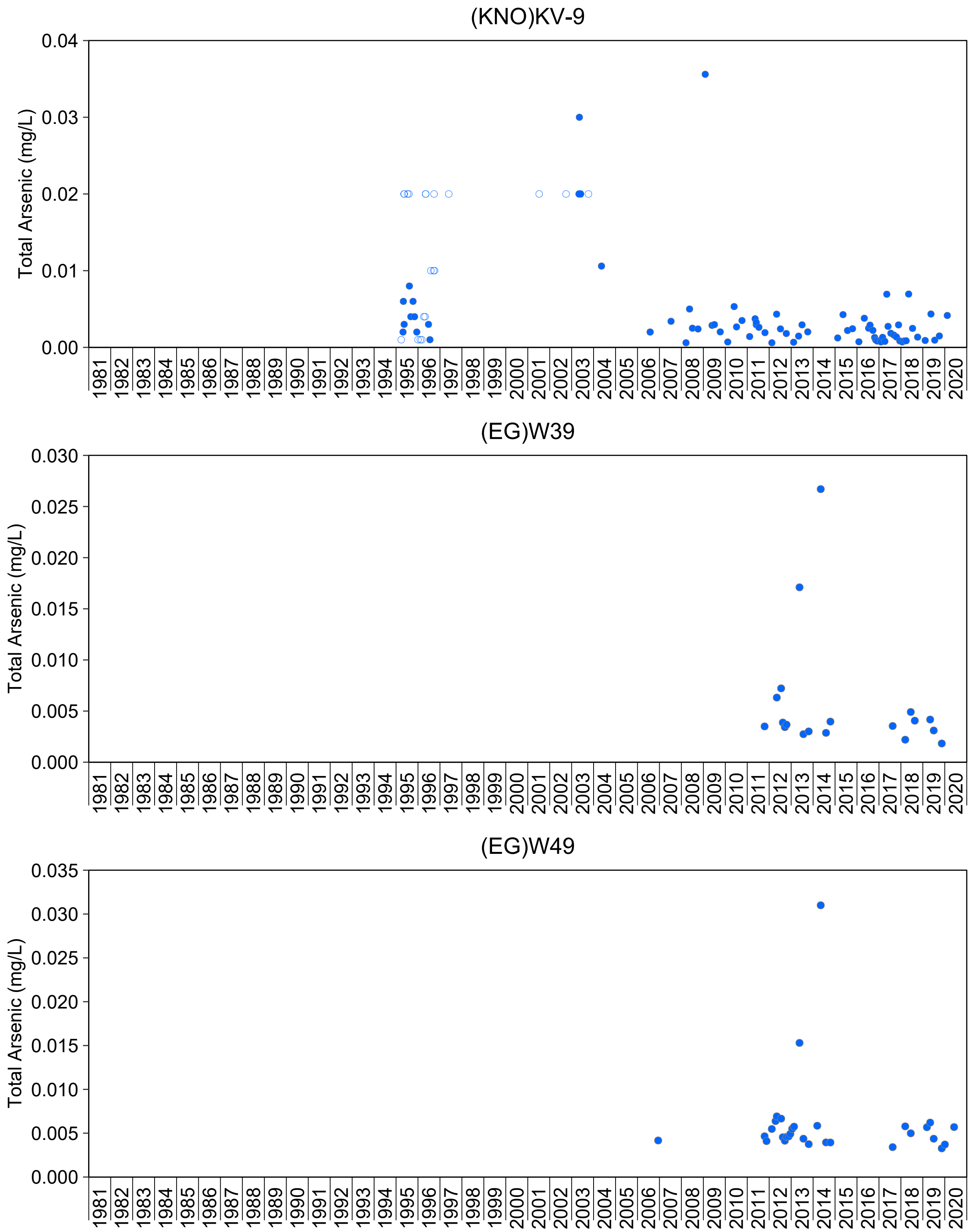


Figure A.29: Time Series Plots of Total Arsenic Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

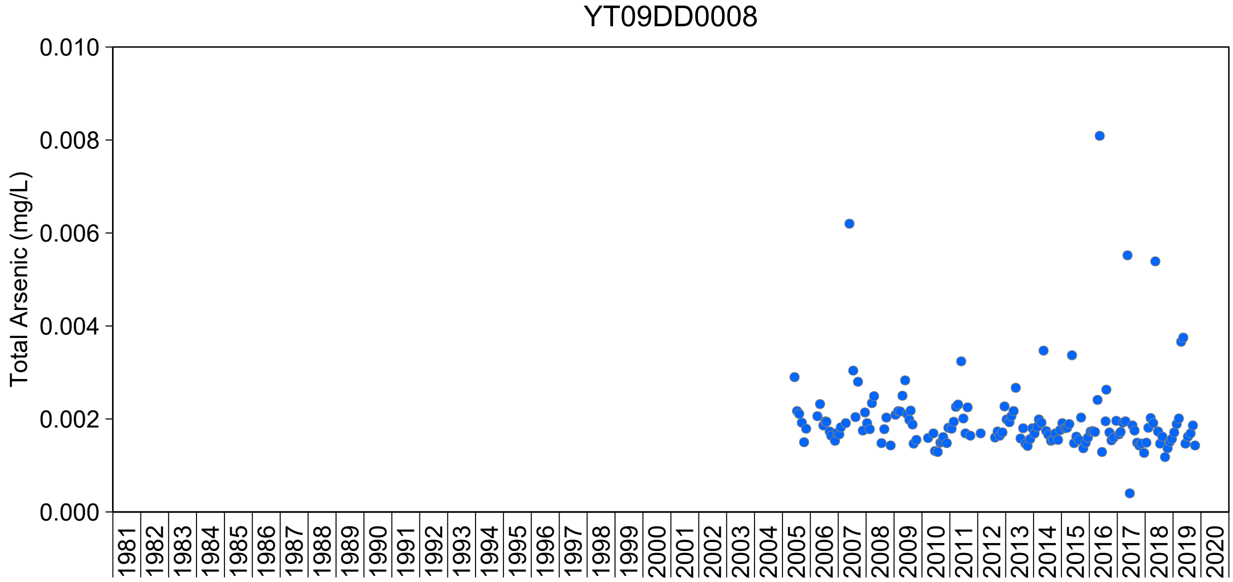


Figure A.29: Time Series Plots of Total Arsenic Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

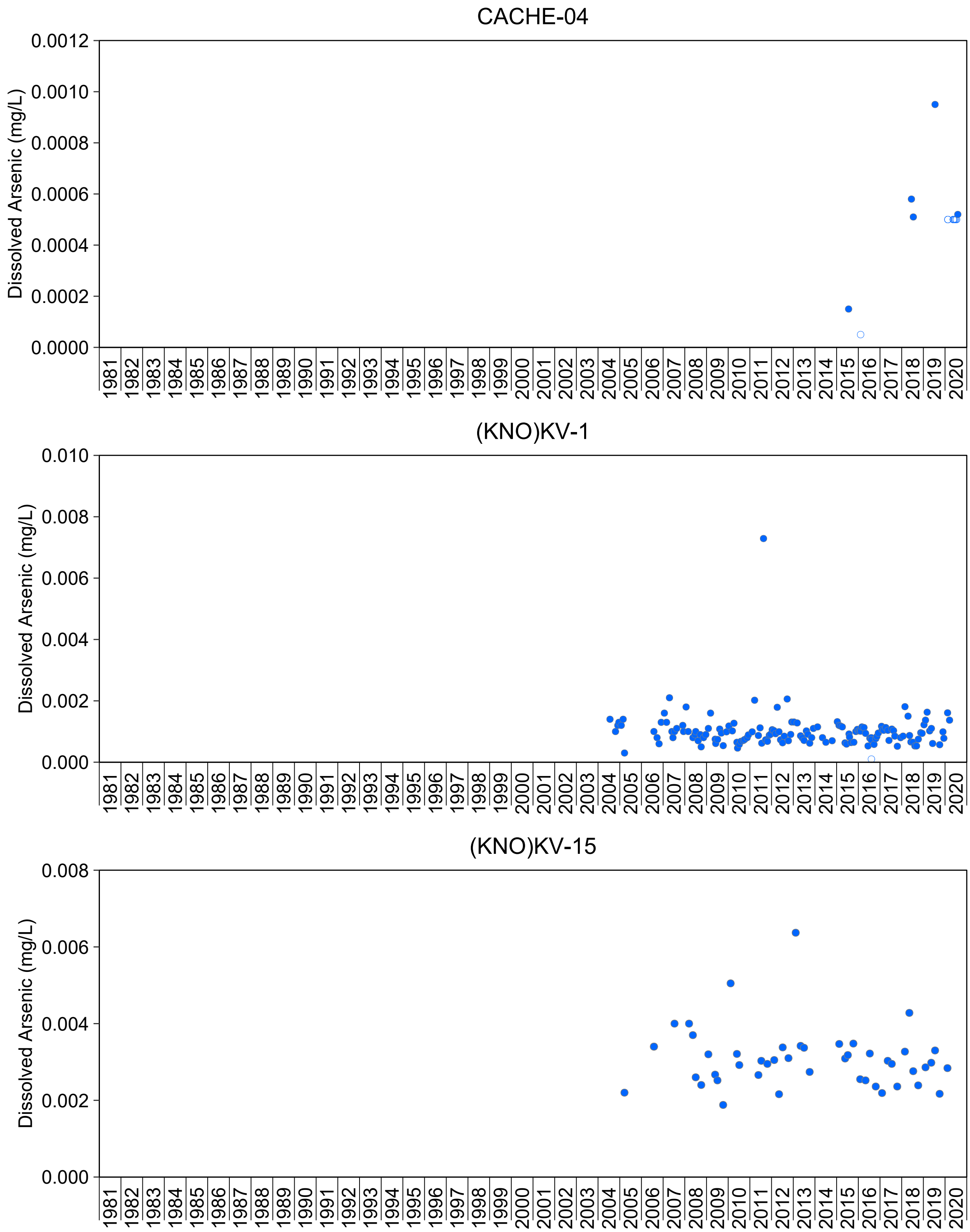


Figure A.30: Time Series Plots of Dissolved Arsenic Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

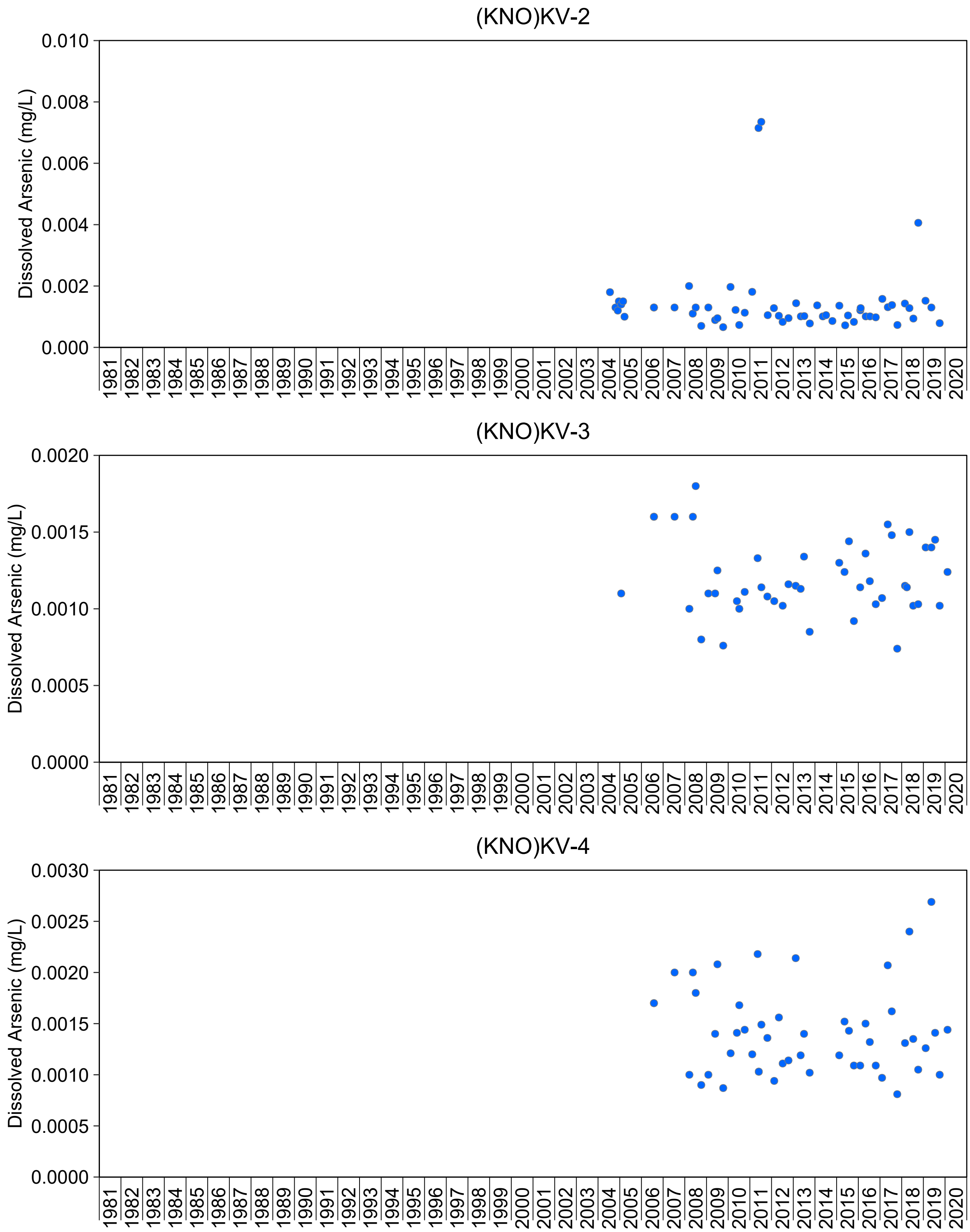


Figure A.30: **Time Series Plots of Dissolved Arsenic Concentrations (mg/L) in the South McQuesten River, 1981 to 2020**

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

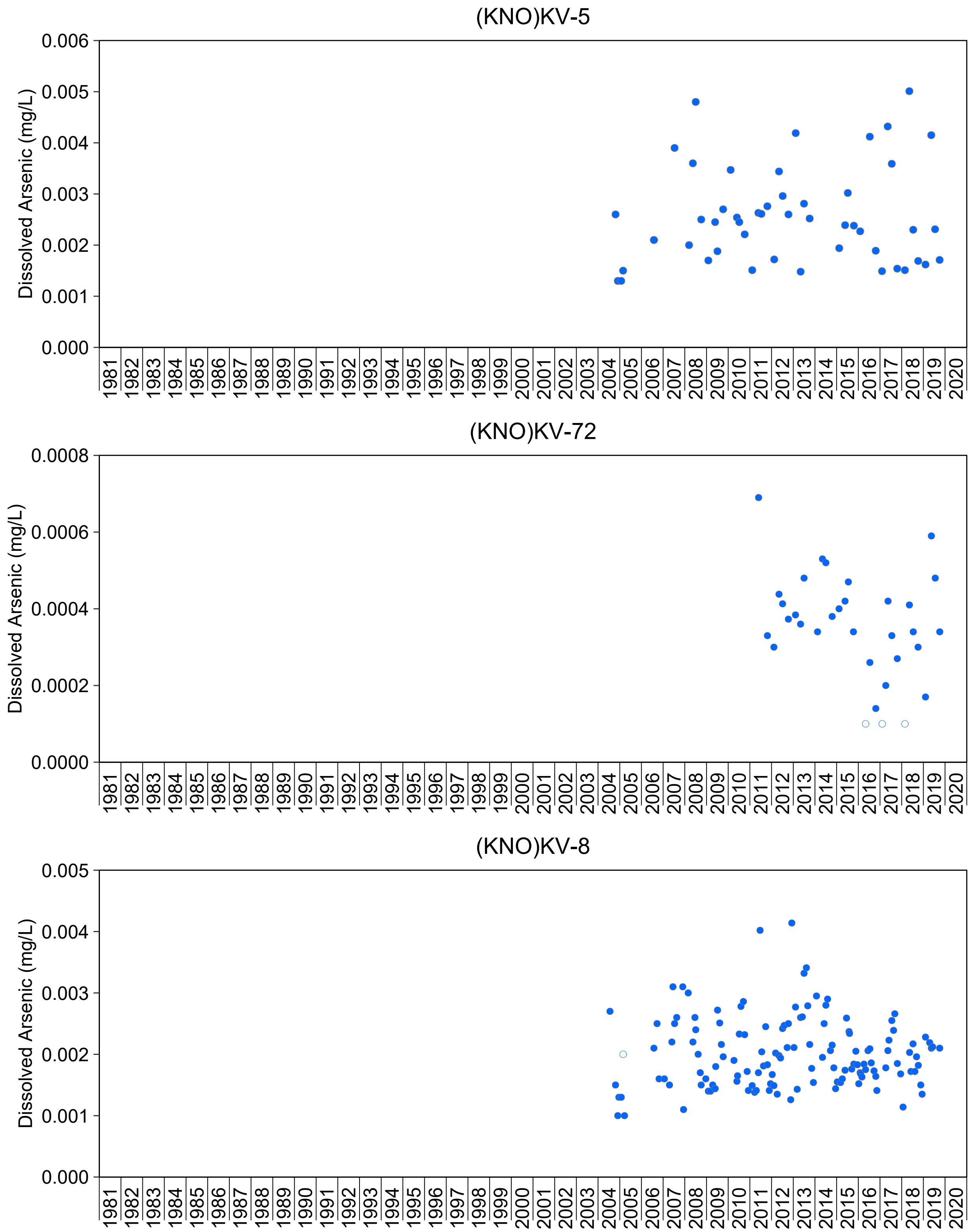


Figure A.30: Time Series Plots of Dissolved Arsenic Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

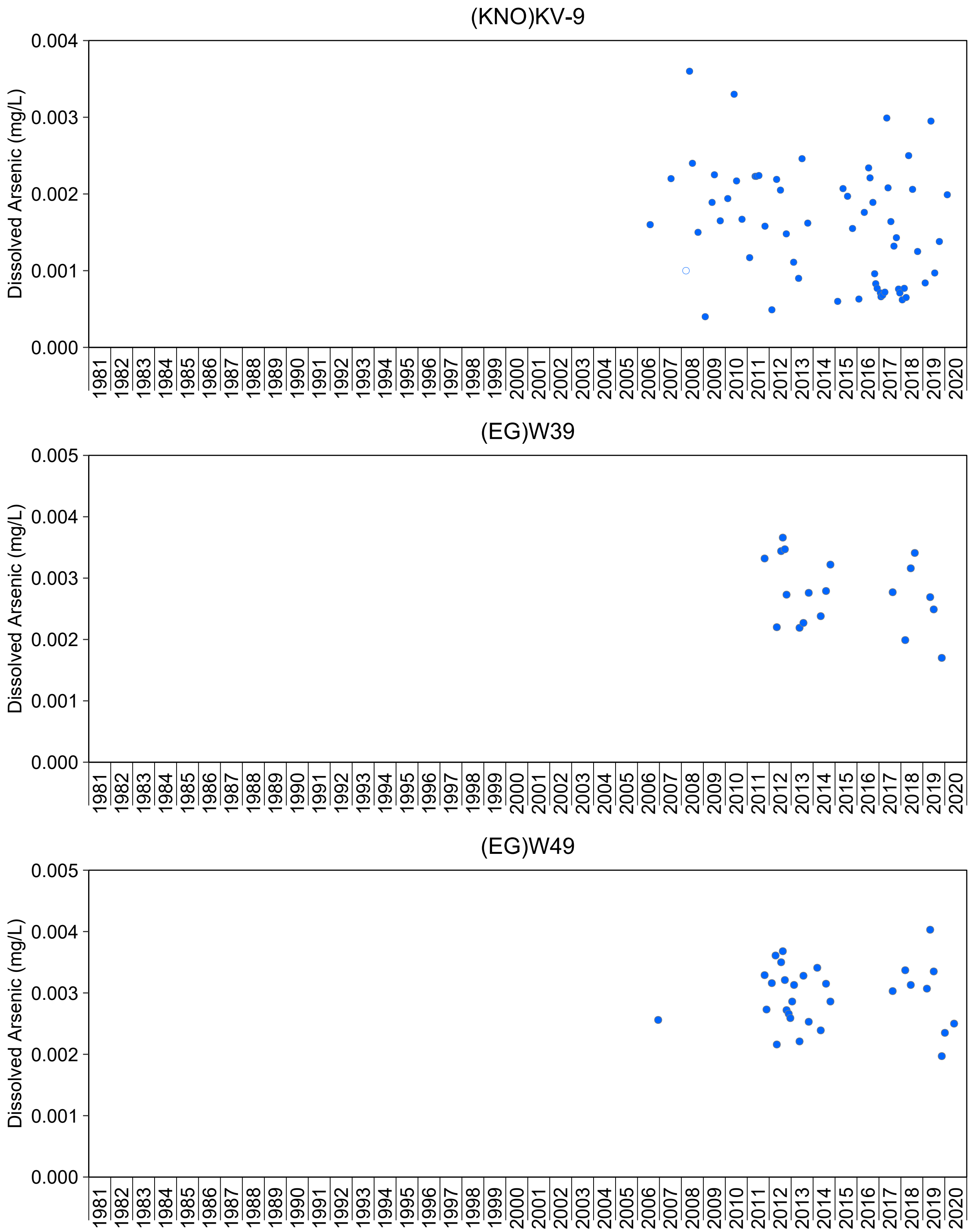


Figure A.30: Time Series Plots of Dissolved Arsenic Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

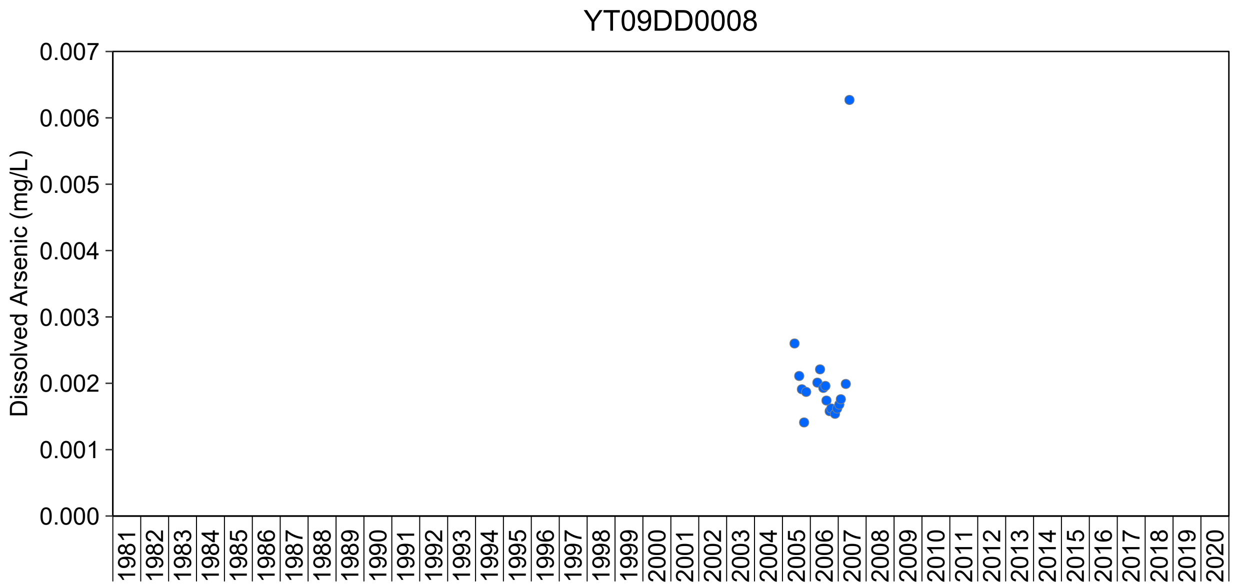


Figure A.30: Time Series Plots of Dissolved Arsenic Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

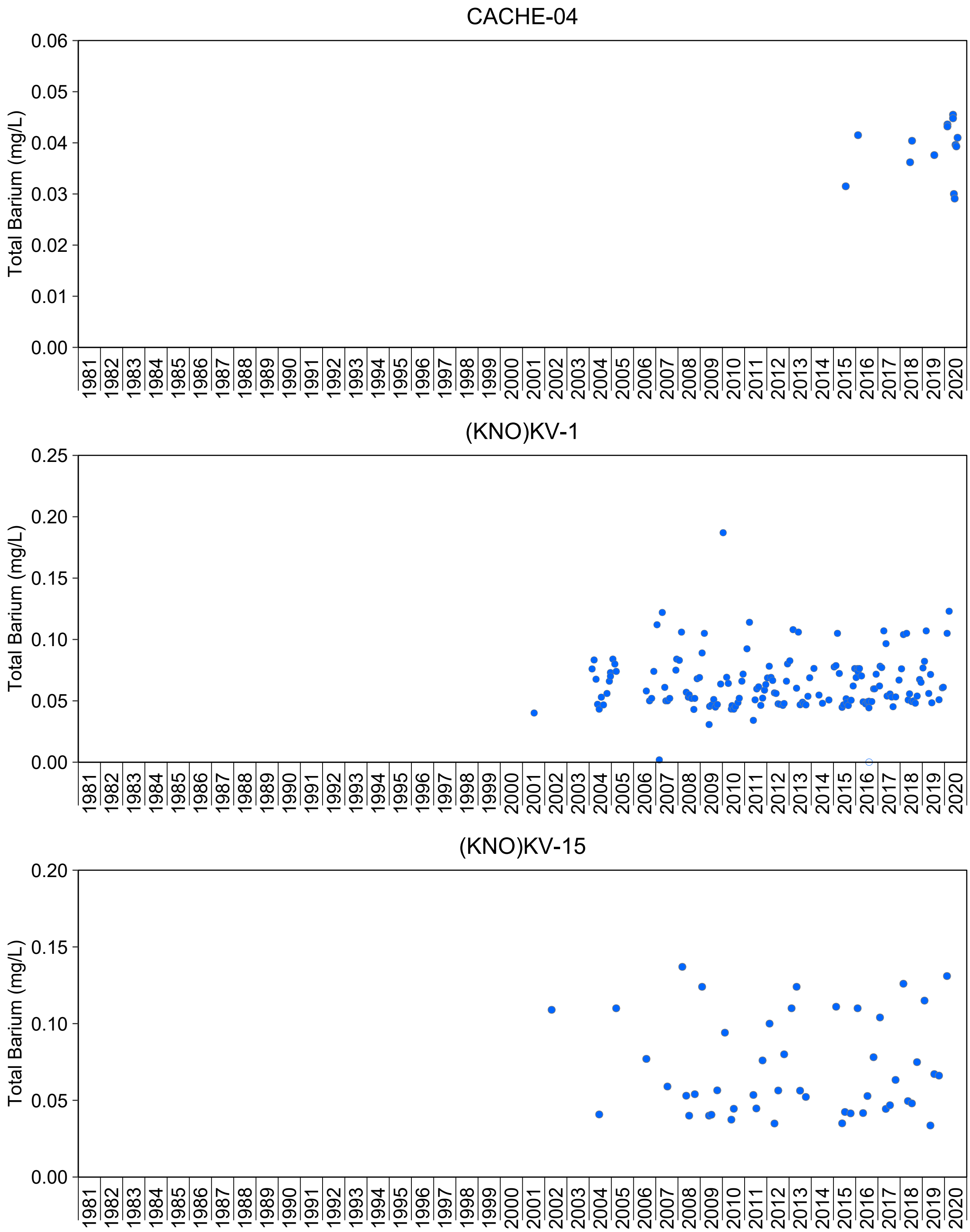


Figure A.31: Time Series Plots of Total Barium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

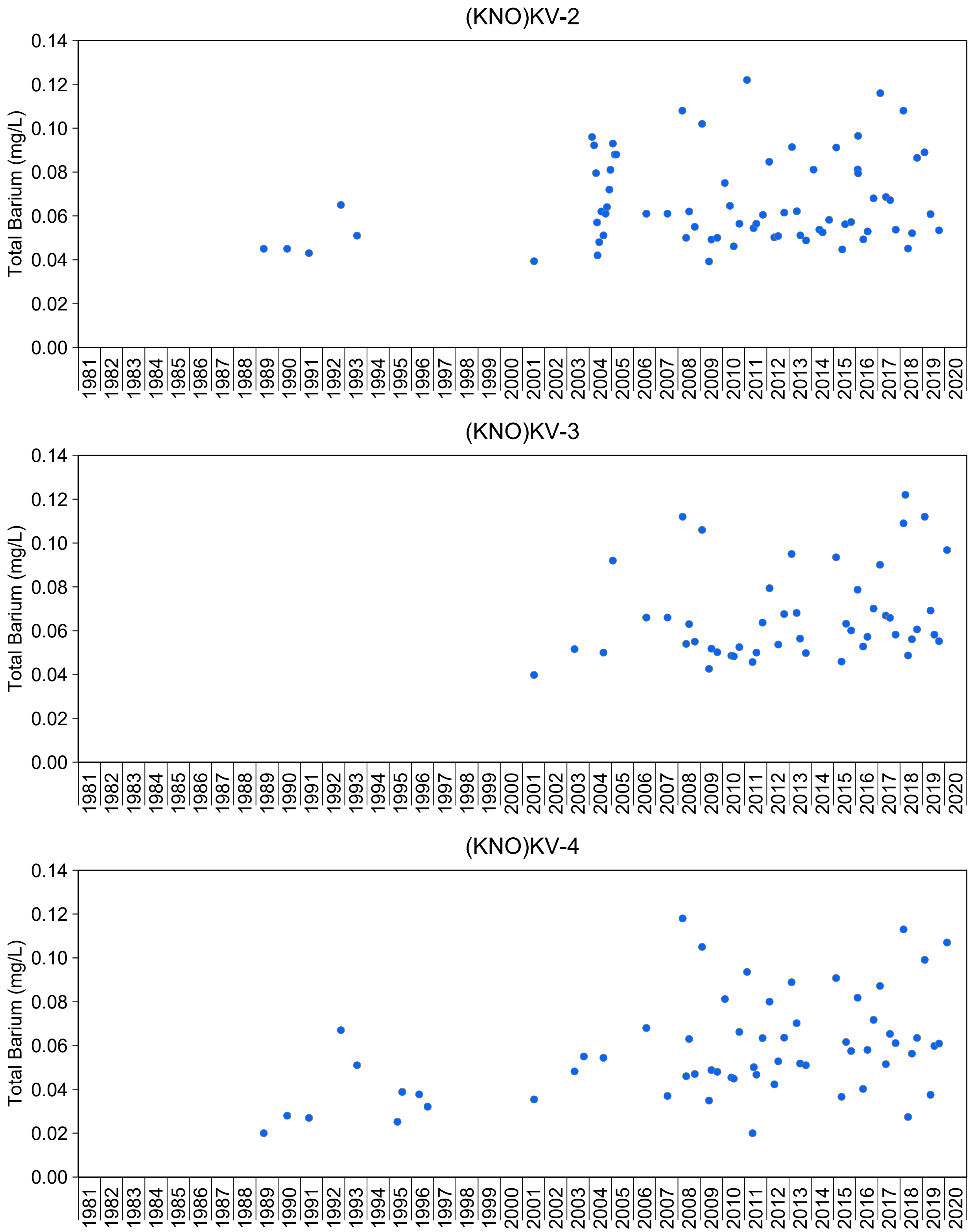


Figure A.31: Time Series Plots of Total Barium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

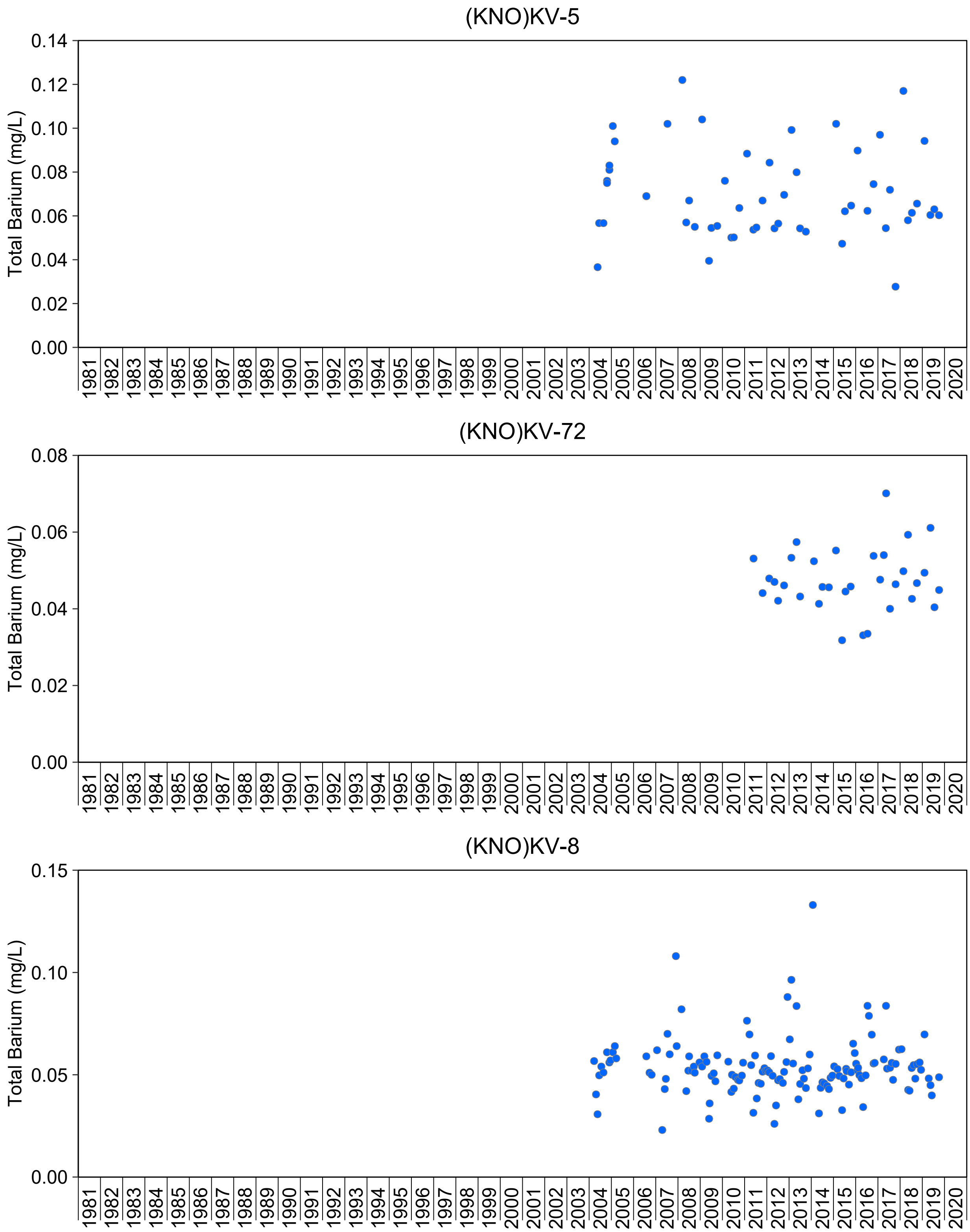


Figure A.31: Time Series Plots of Total Barium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

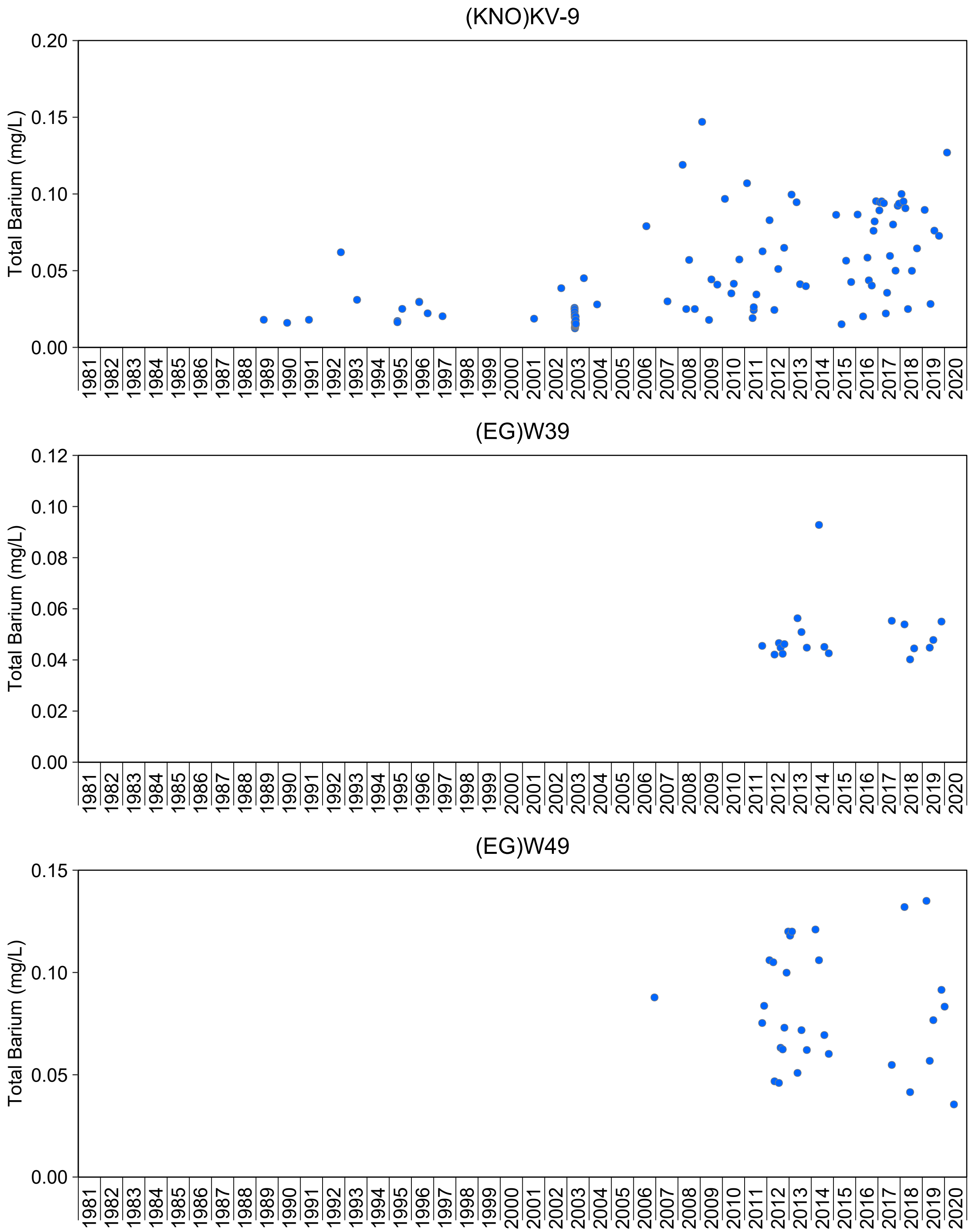


Figure A.31: Time Series Plots of Total Barium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

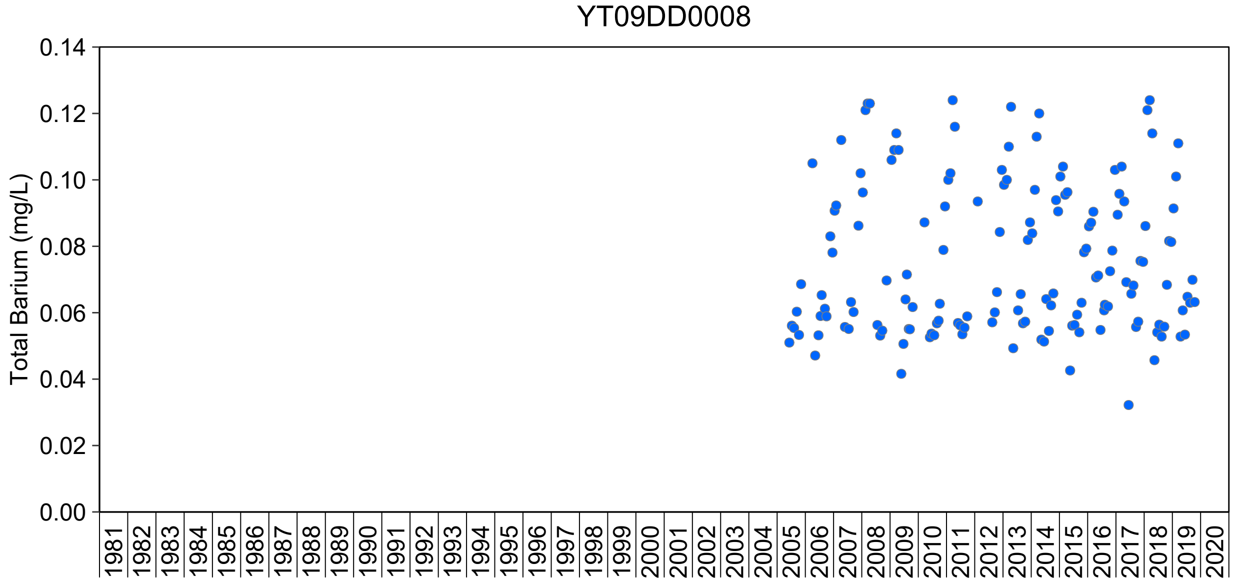


Figure A.31: **Time Series Plots of Total Barium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020**

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

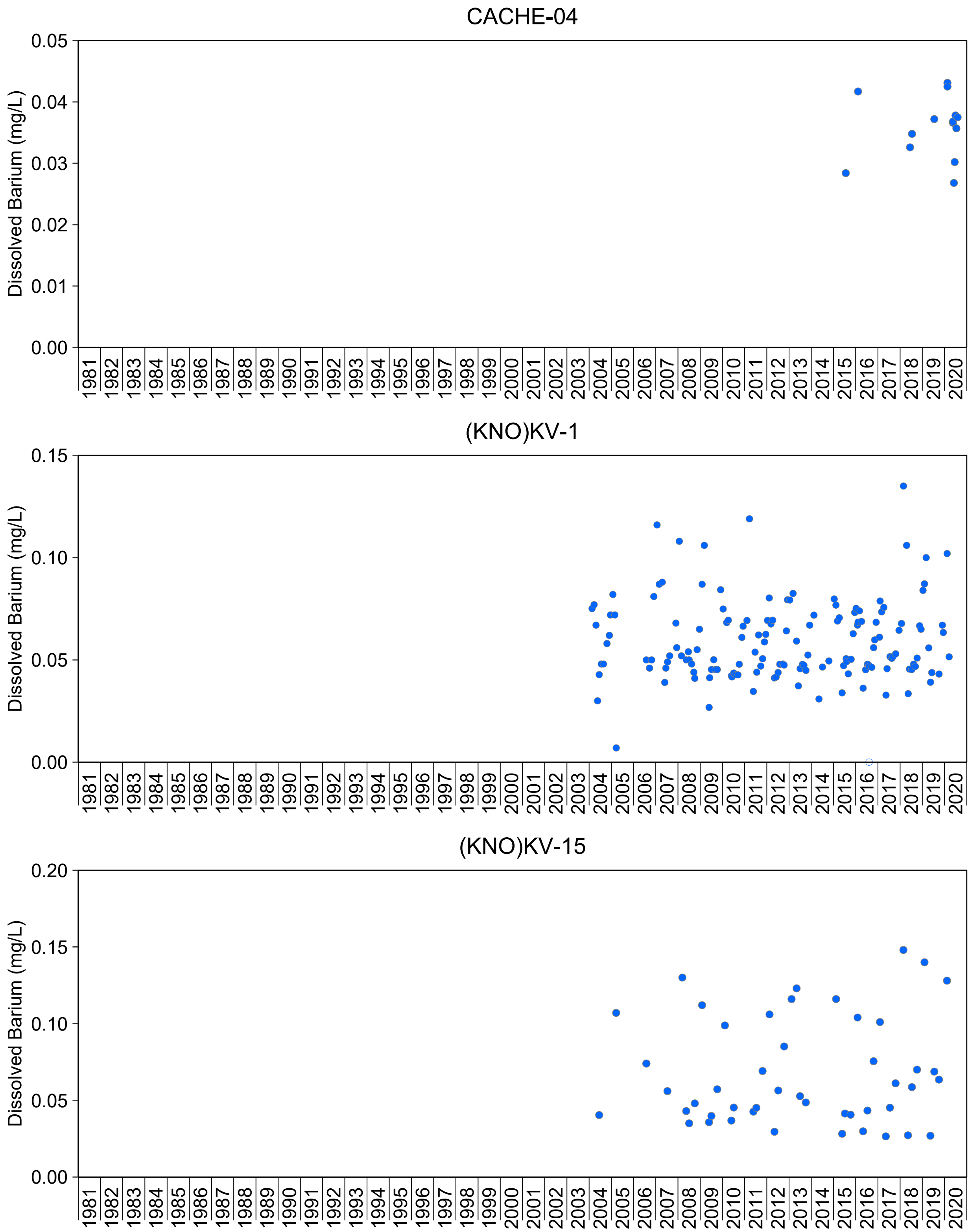


Figure A.32: Time Series Plots of Dissolved Barium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

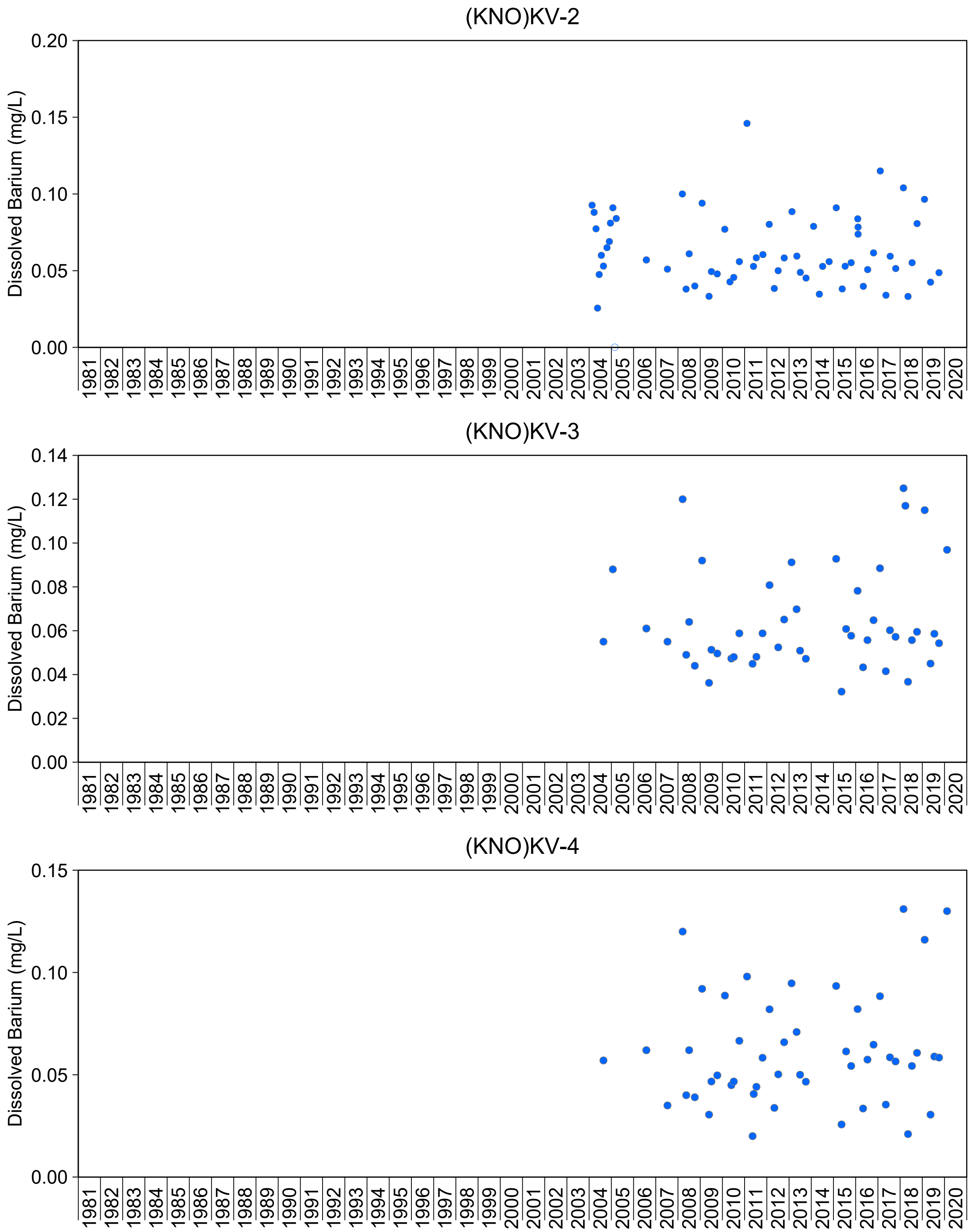


Figure A.32: Time Series Plots of Dissolved Barium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

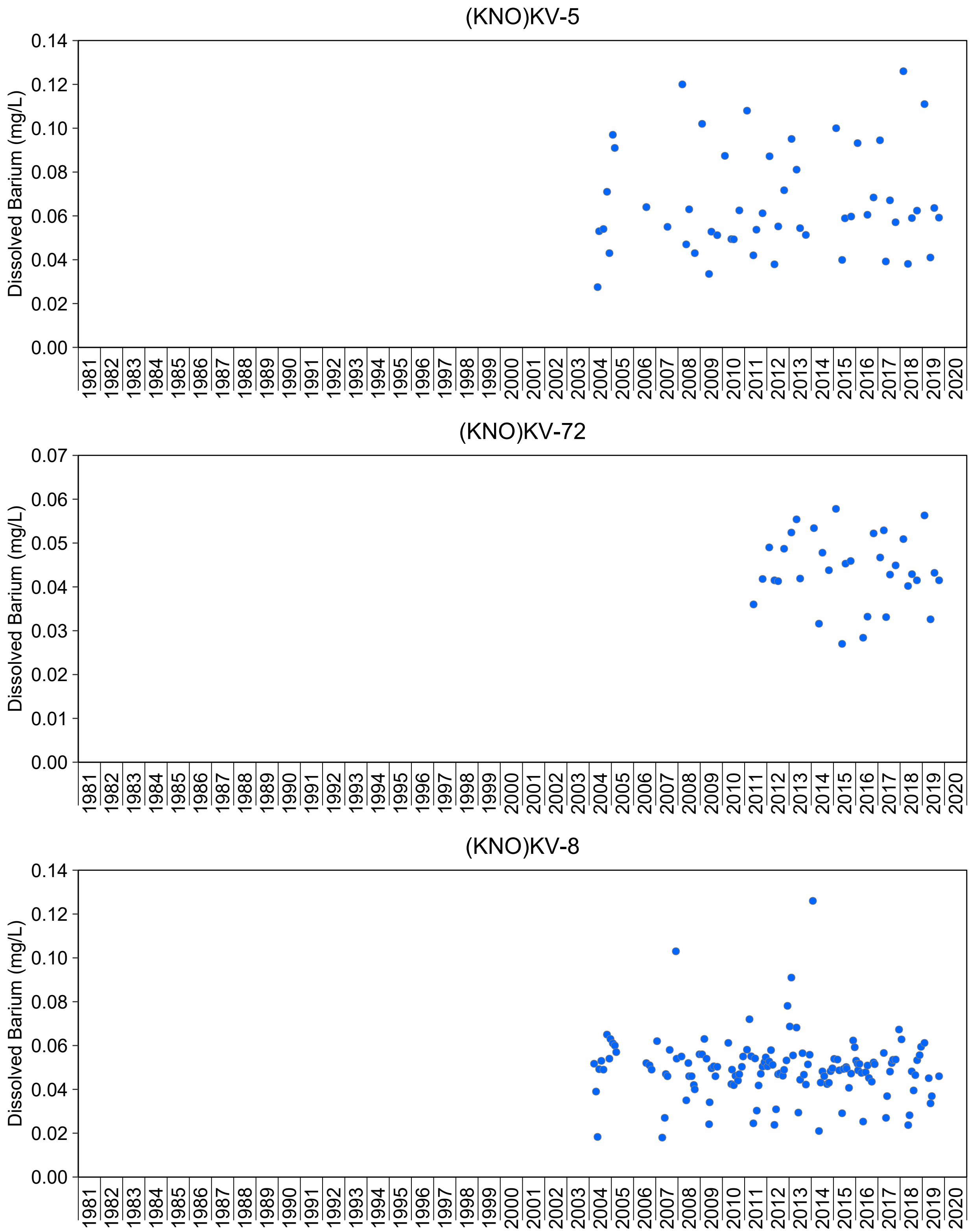


Figure A.32: Time Series Plots of Dissolved Barium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

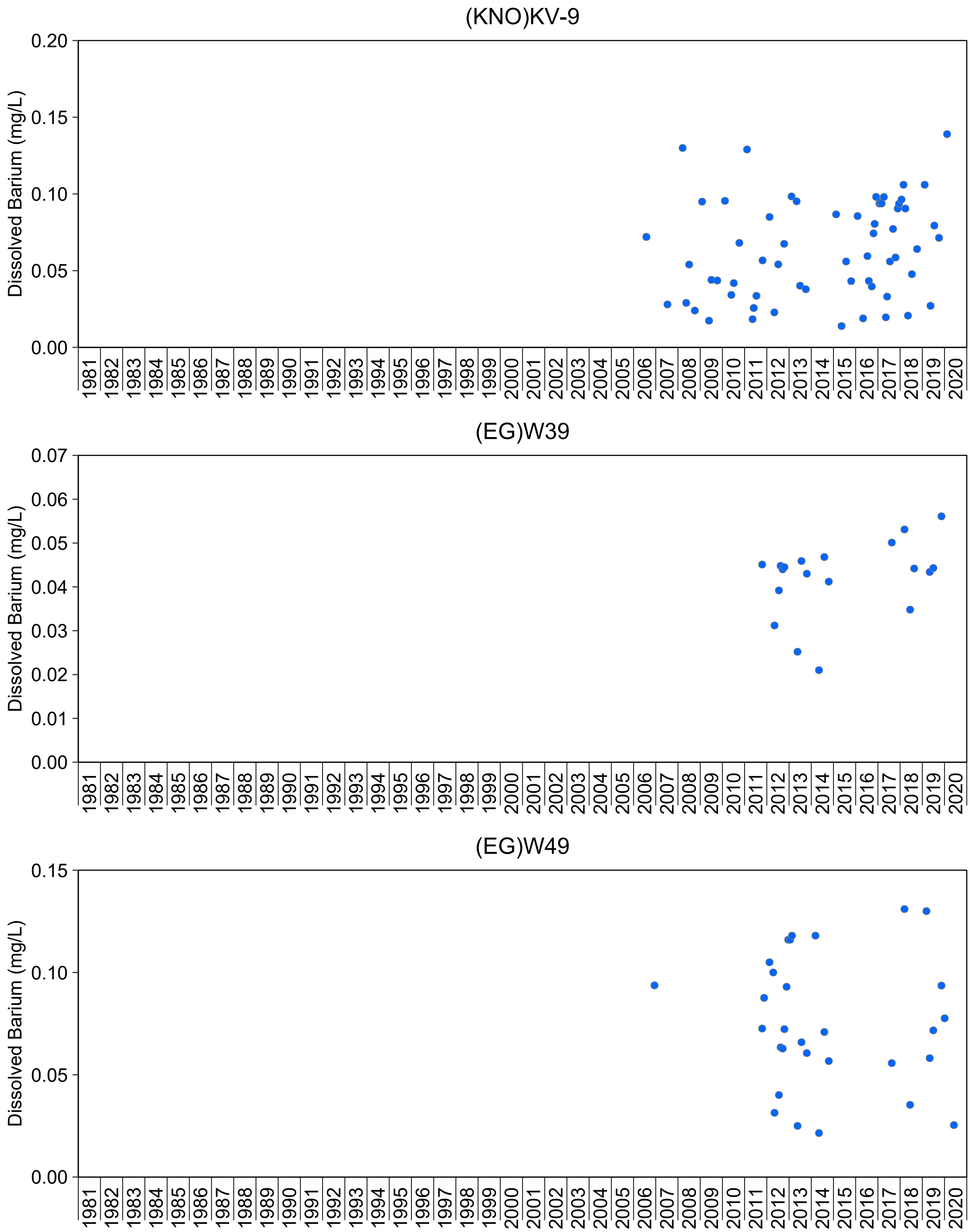


Figure A.32: Time Series Plots of Dissolved Barium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

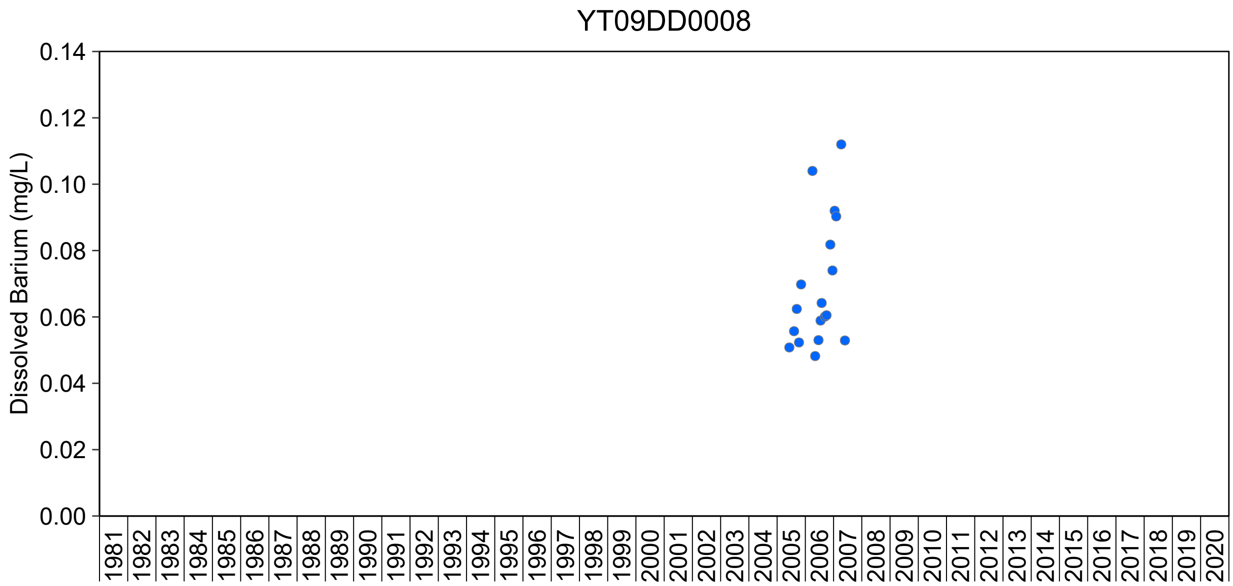


Figure A.32: **Time Series Plots of Dissolved Barium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020**

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

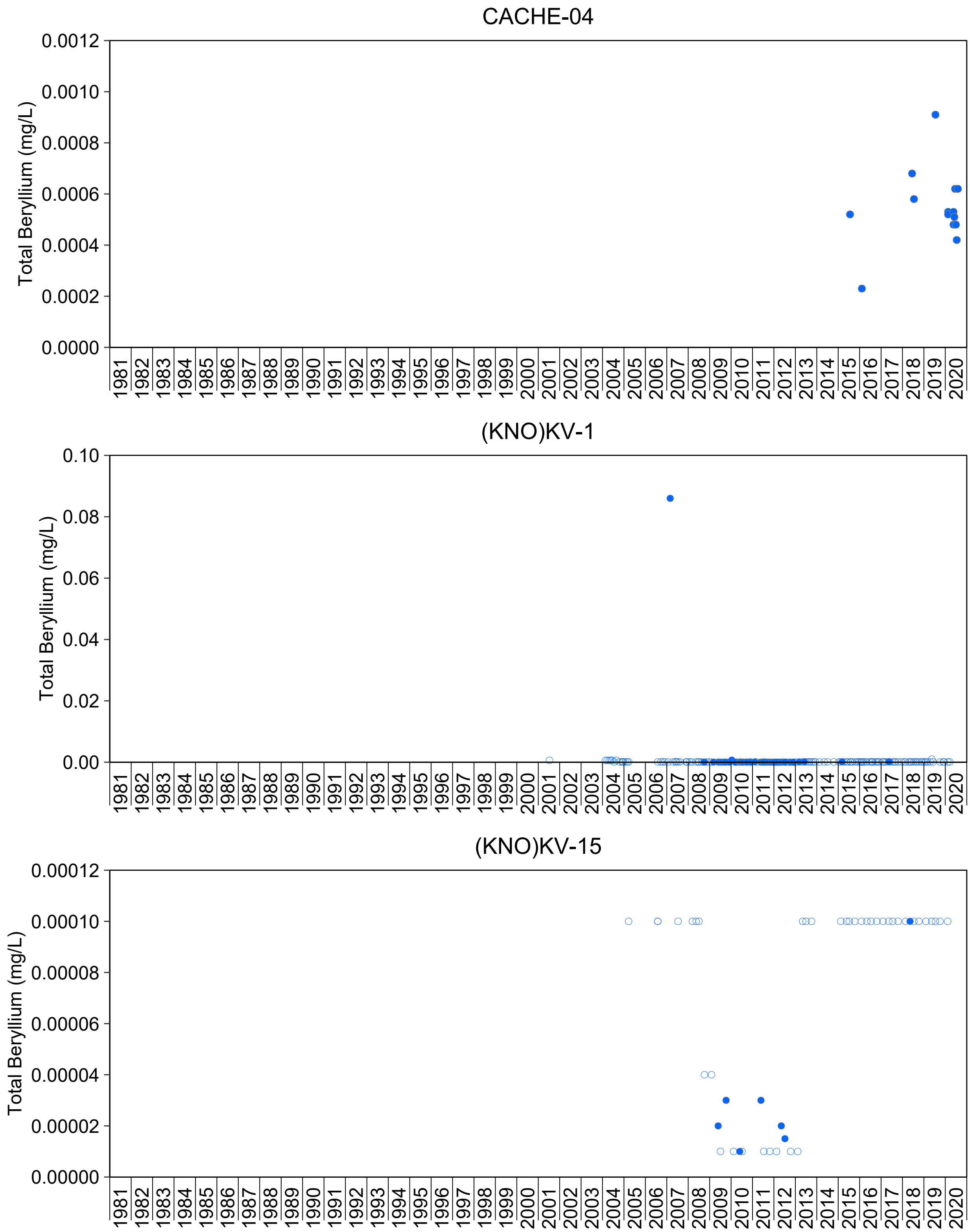


Figure A.33: Time Series Plots of Total Beryllium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

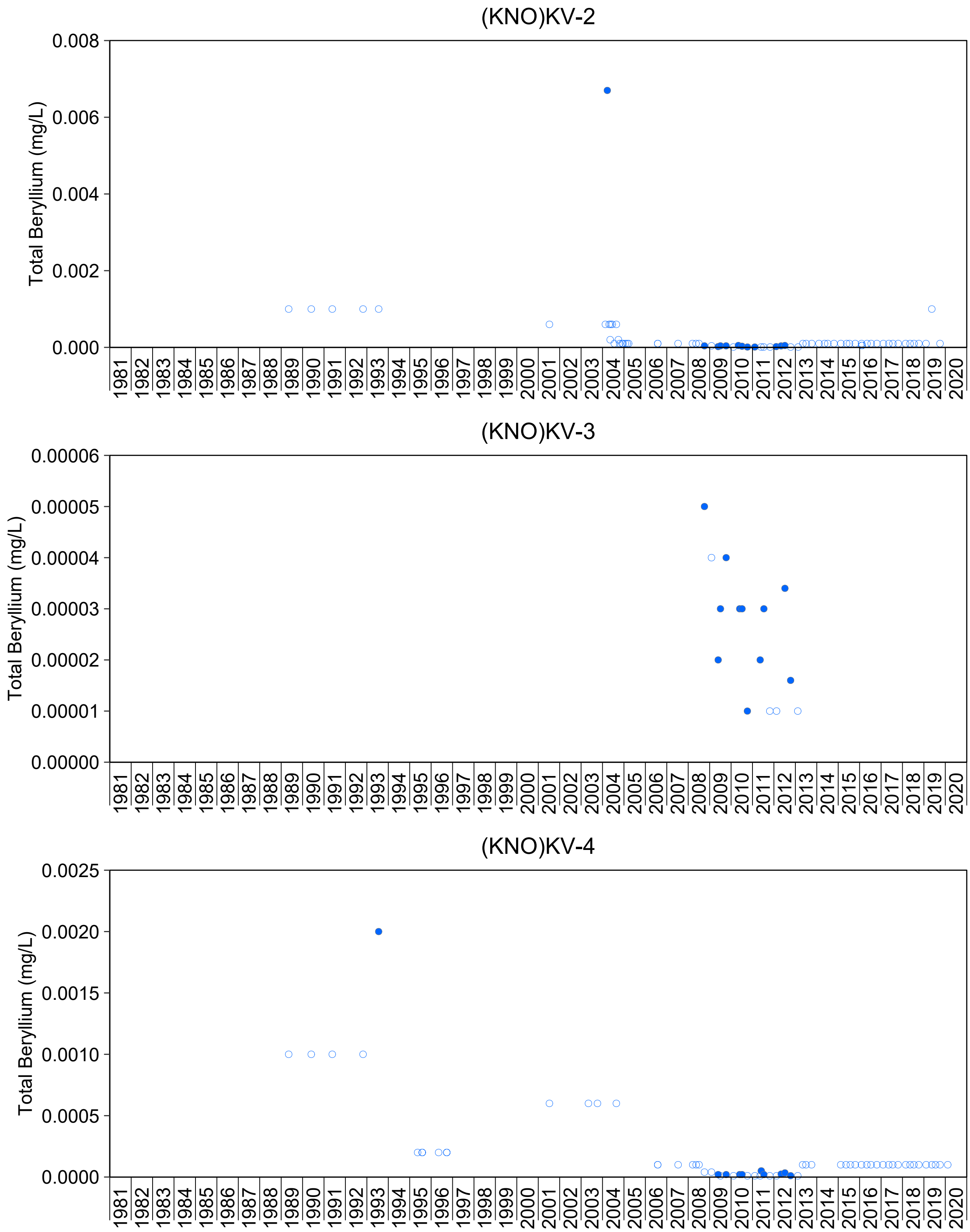


Figure A.33: **Time Series Plots of Total Beryllium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020**

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

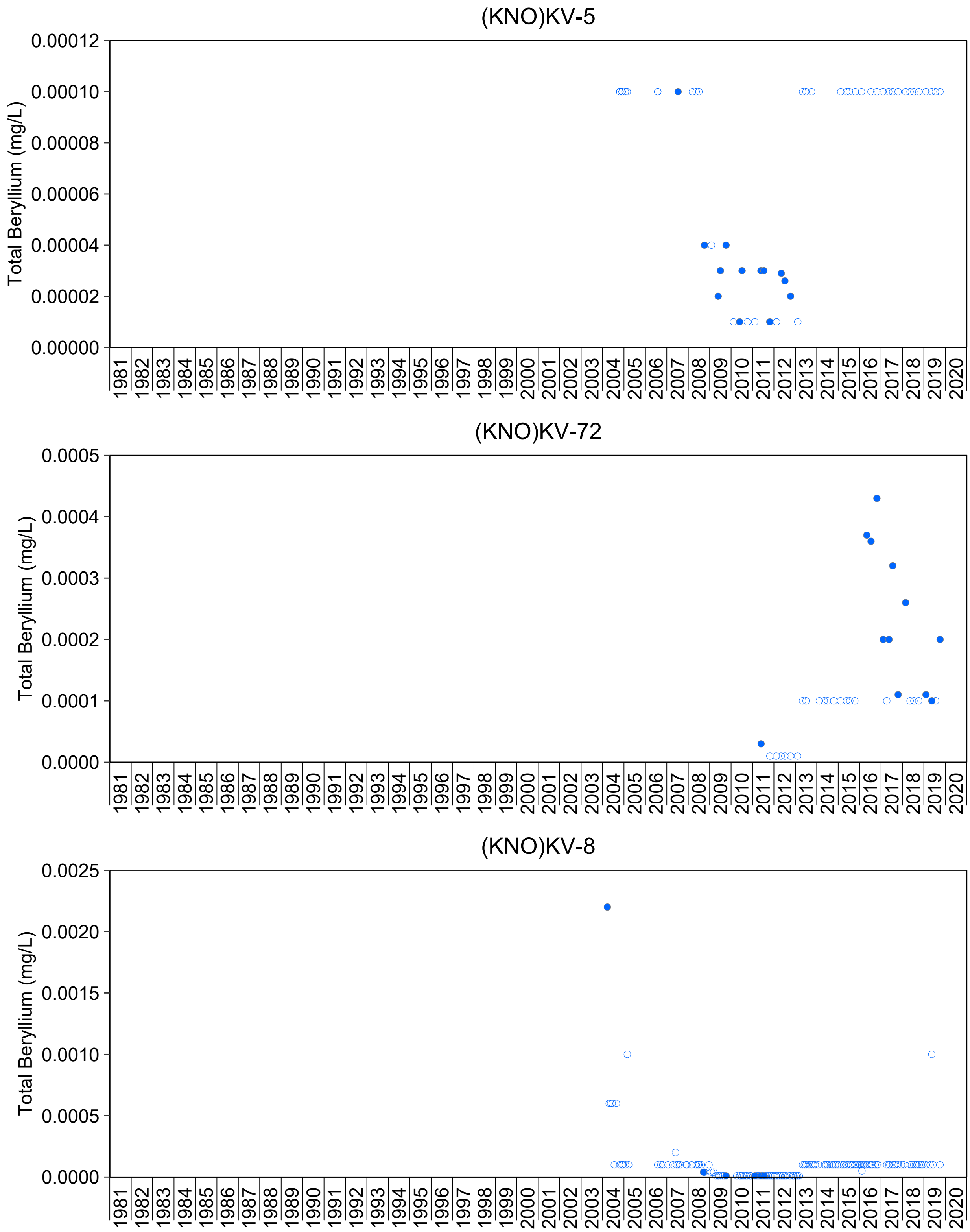
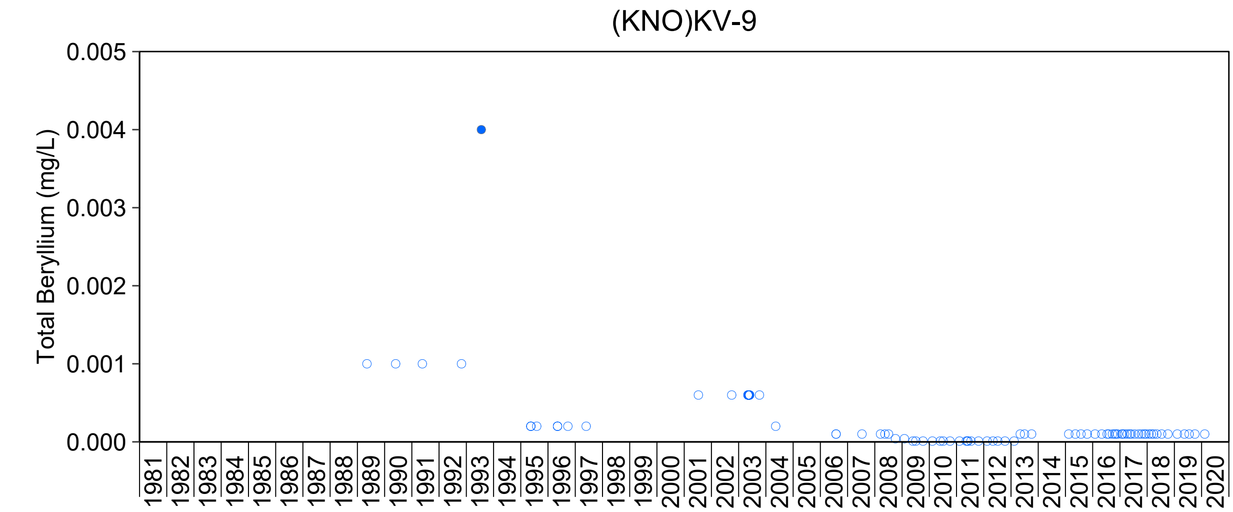
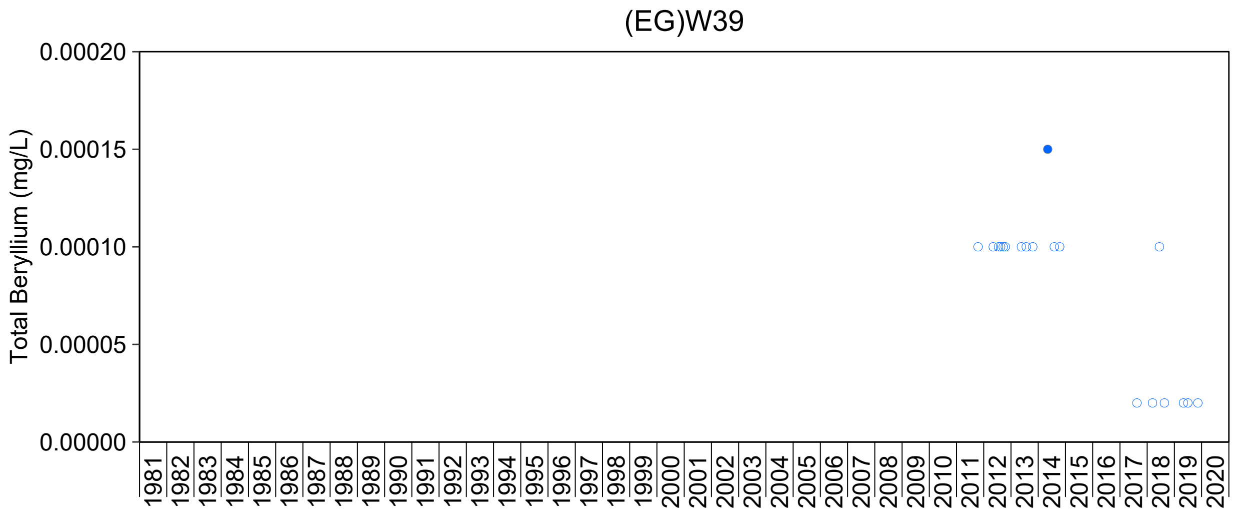


Figure A.33: Time Series Plots of Total Beryllium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.





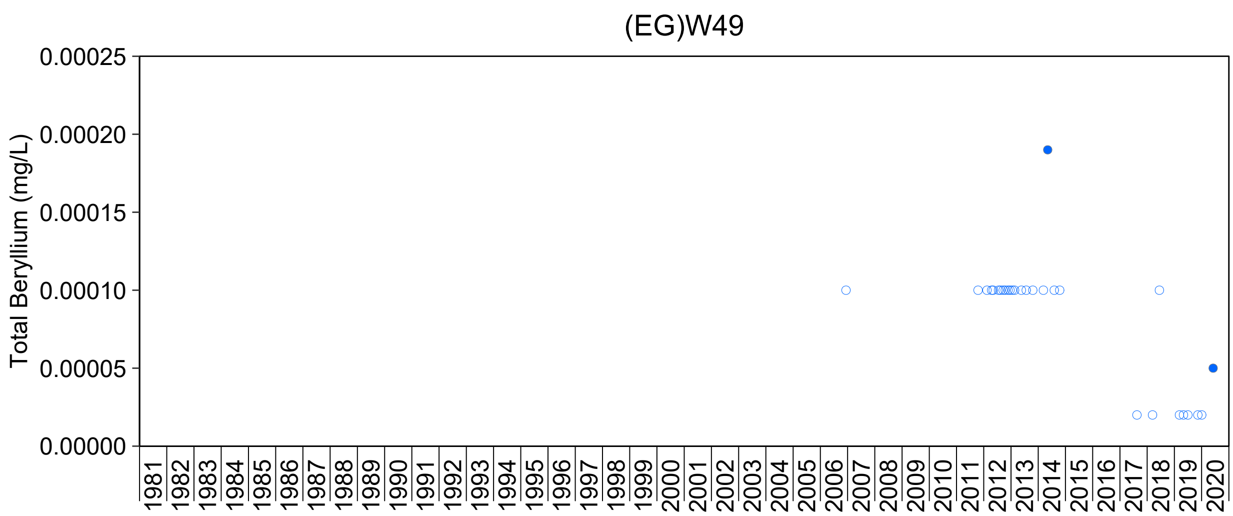


Figure A.33: Time Series Plots of Total Beryllium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

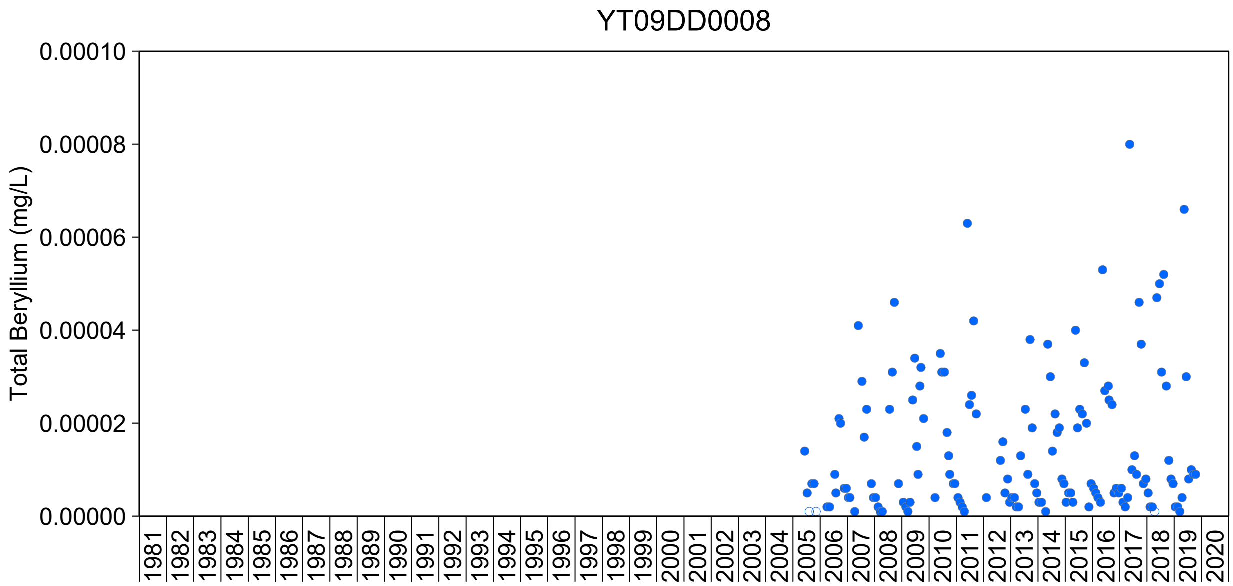


Figure A.33: Time Series Plots of Total Beryllium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

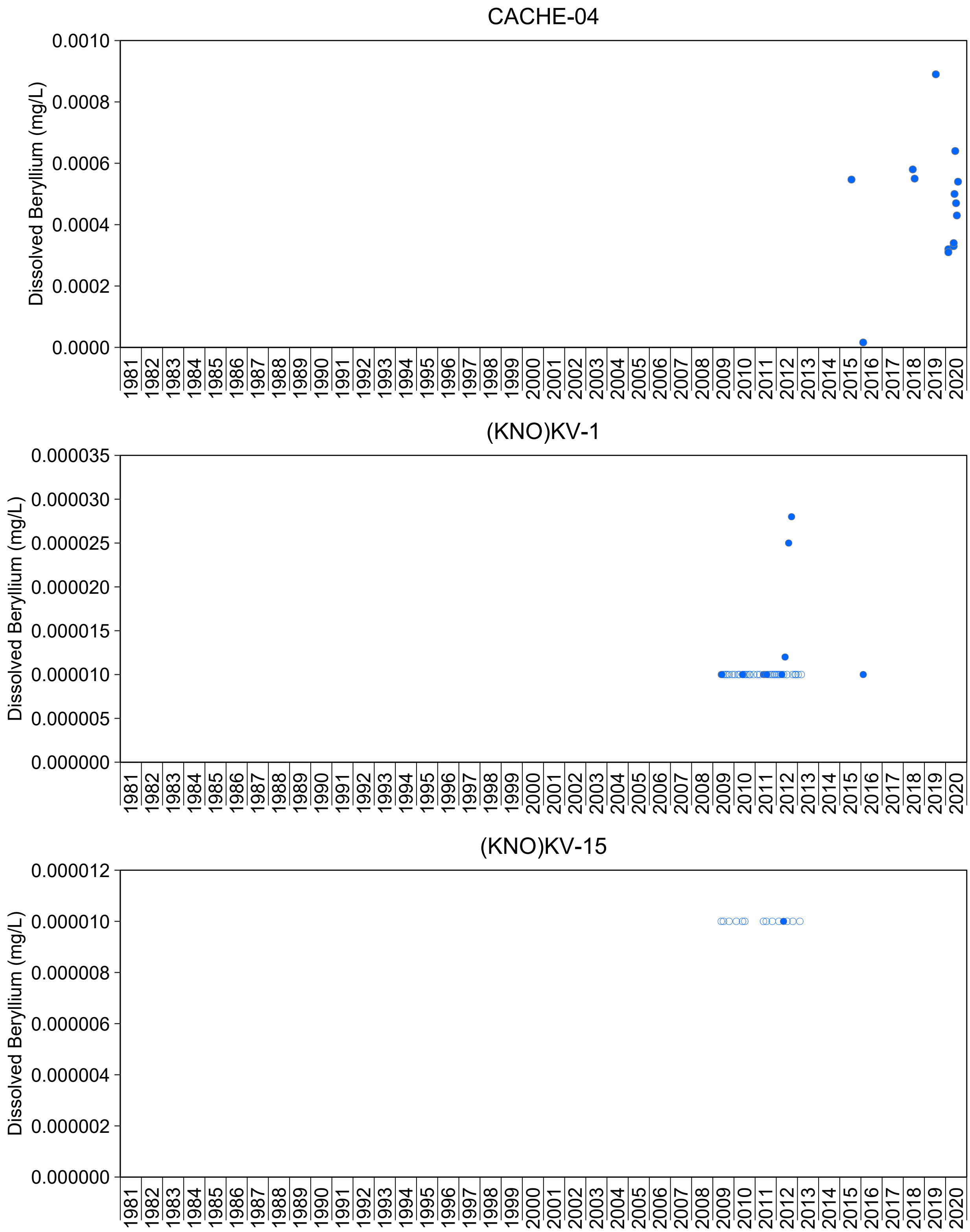


Figure A.34: Time Series Plots of Dissolved Beryllium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

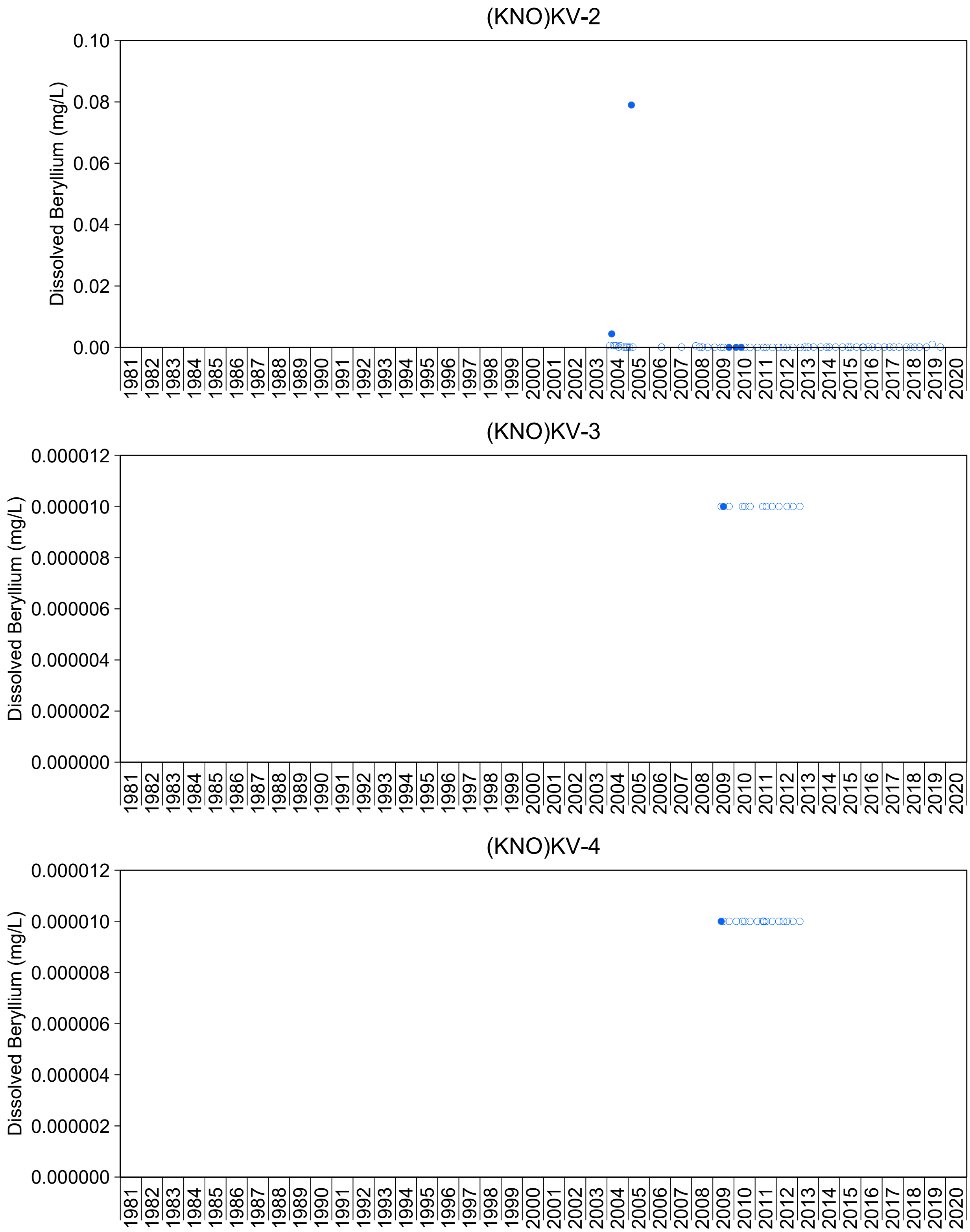


Figure A.34: Time Series Plots of Dissolved Beryllium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

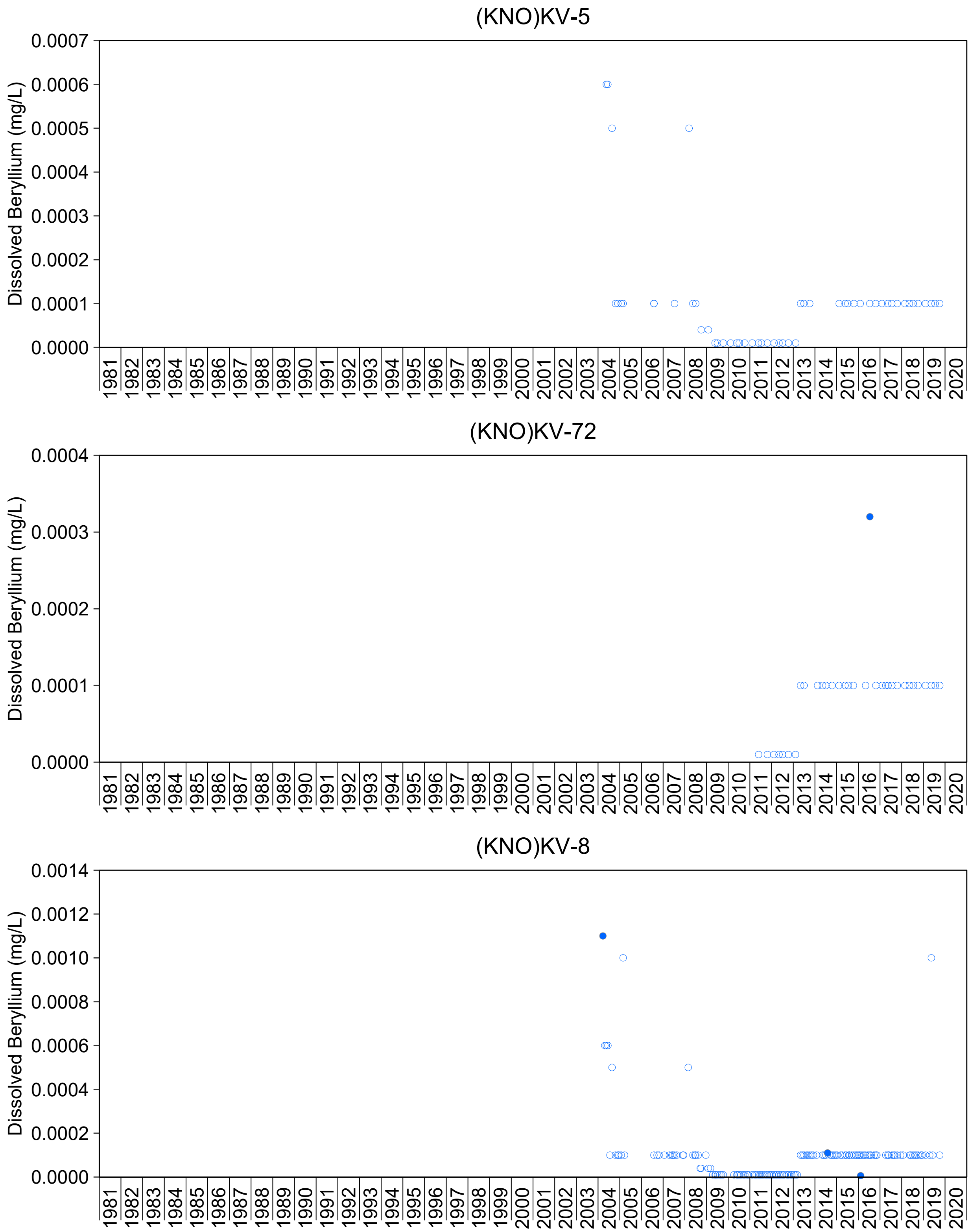


Figure A.34: Time Series Plots of Dissolved Beryllium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

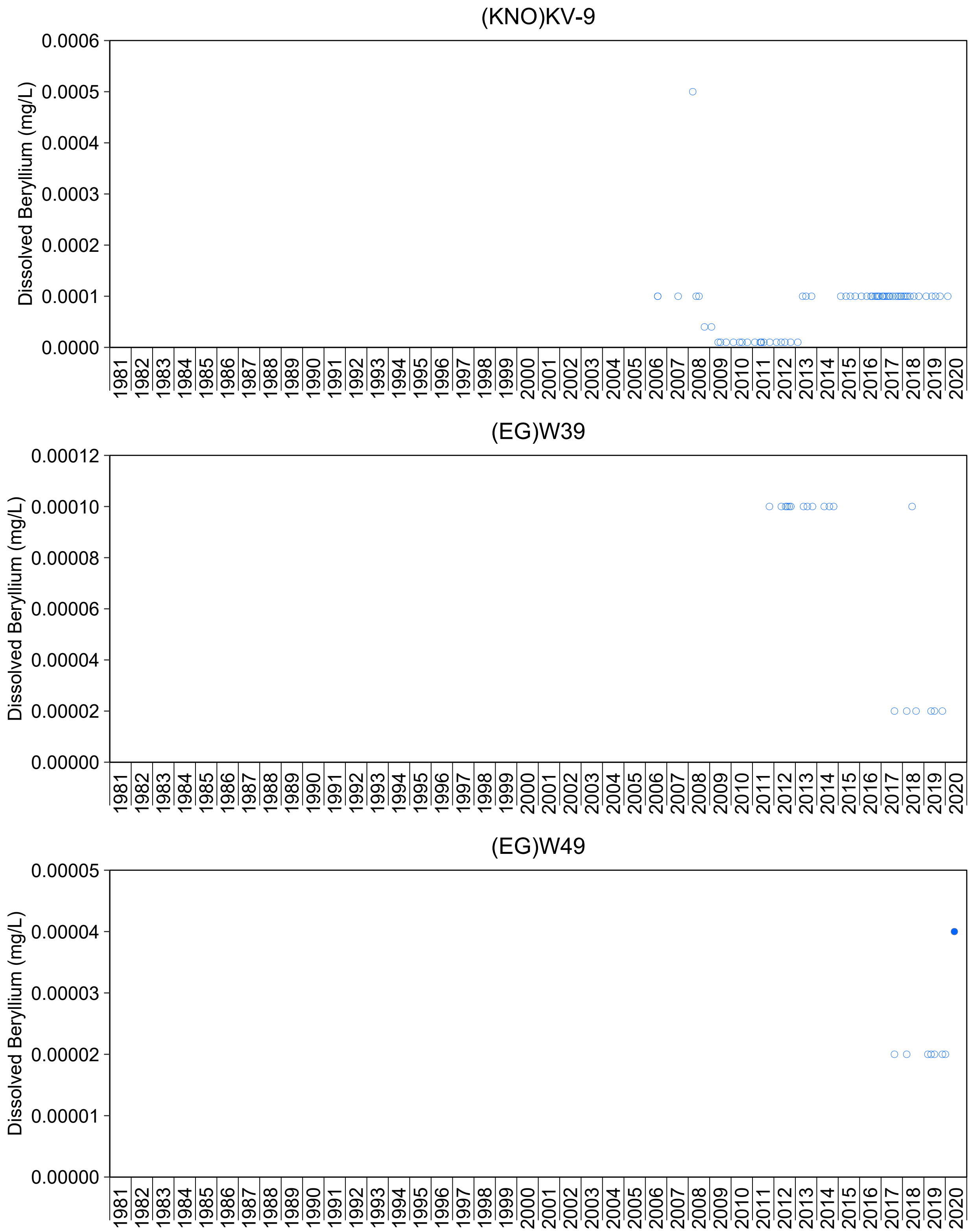


Figure A.34: Time Series Plots of Dissolved Beryllium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

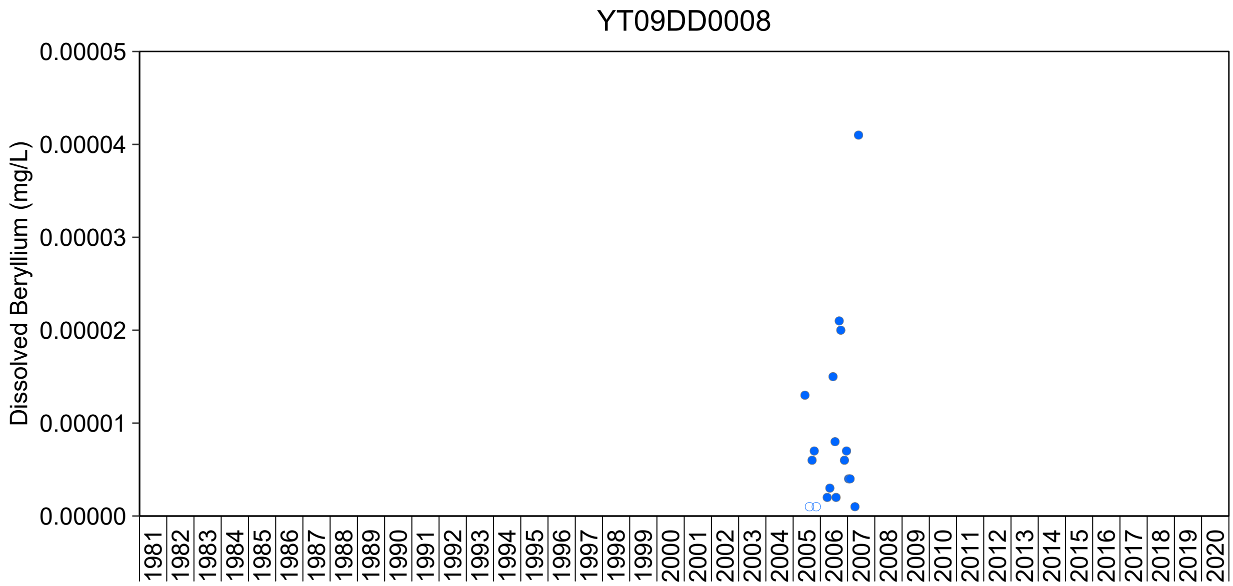


Figure A.34: Time Series Plots of Dissolved Beryllium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

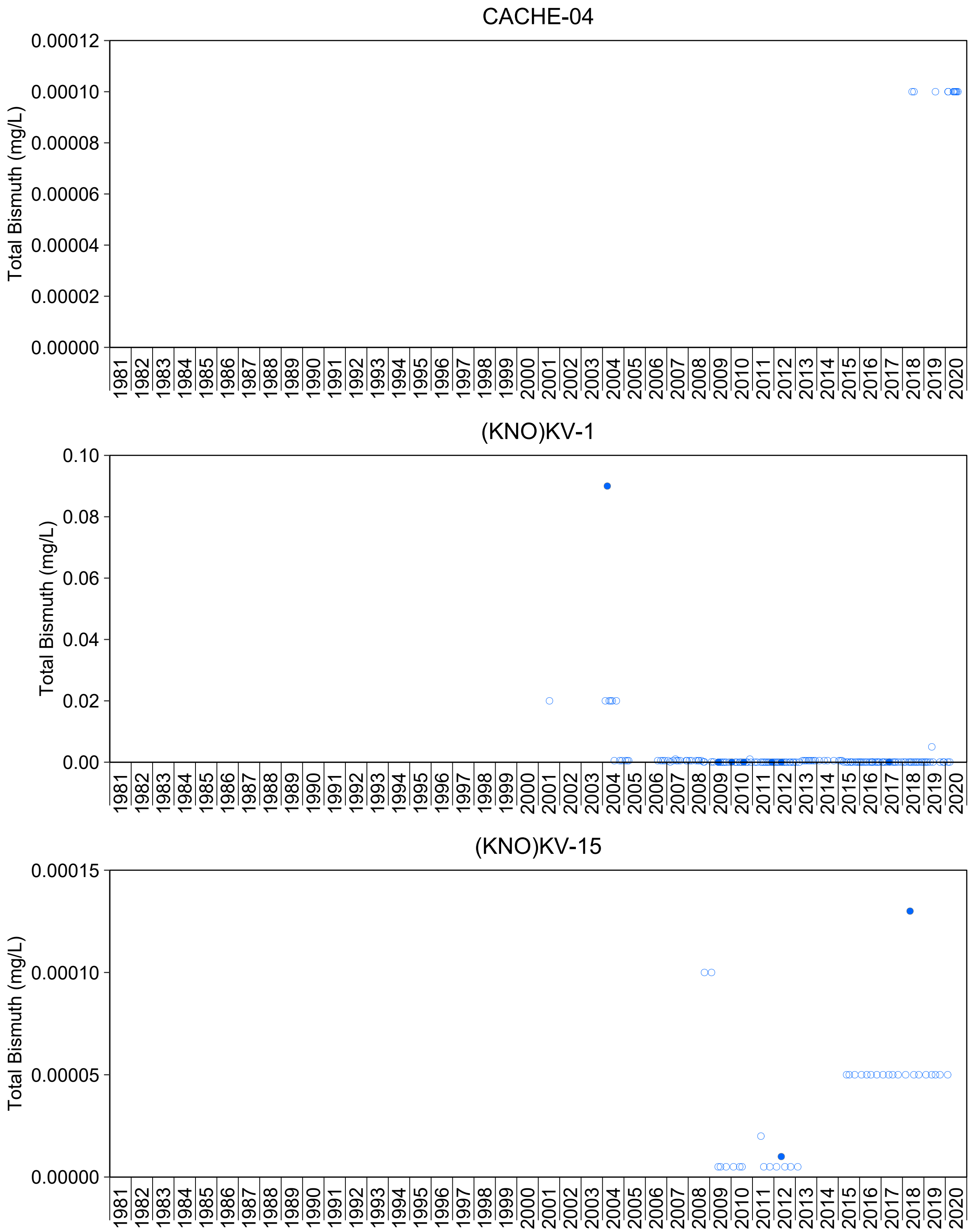


Figure A.35: Time Series Plots of Total Bismuth Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

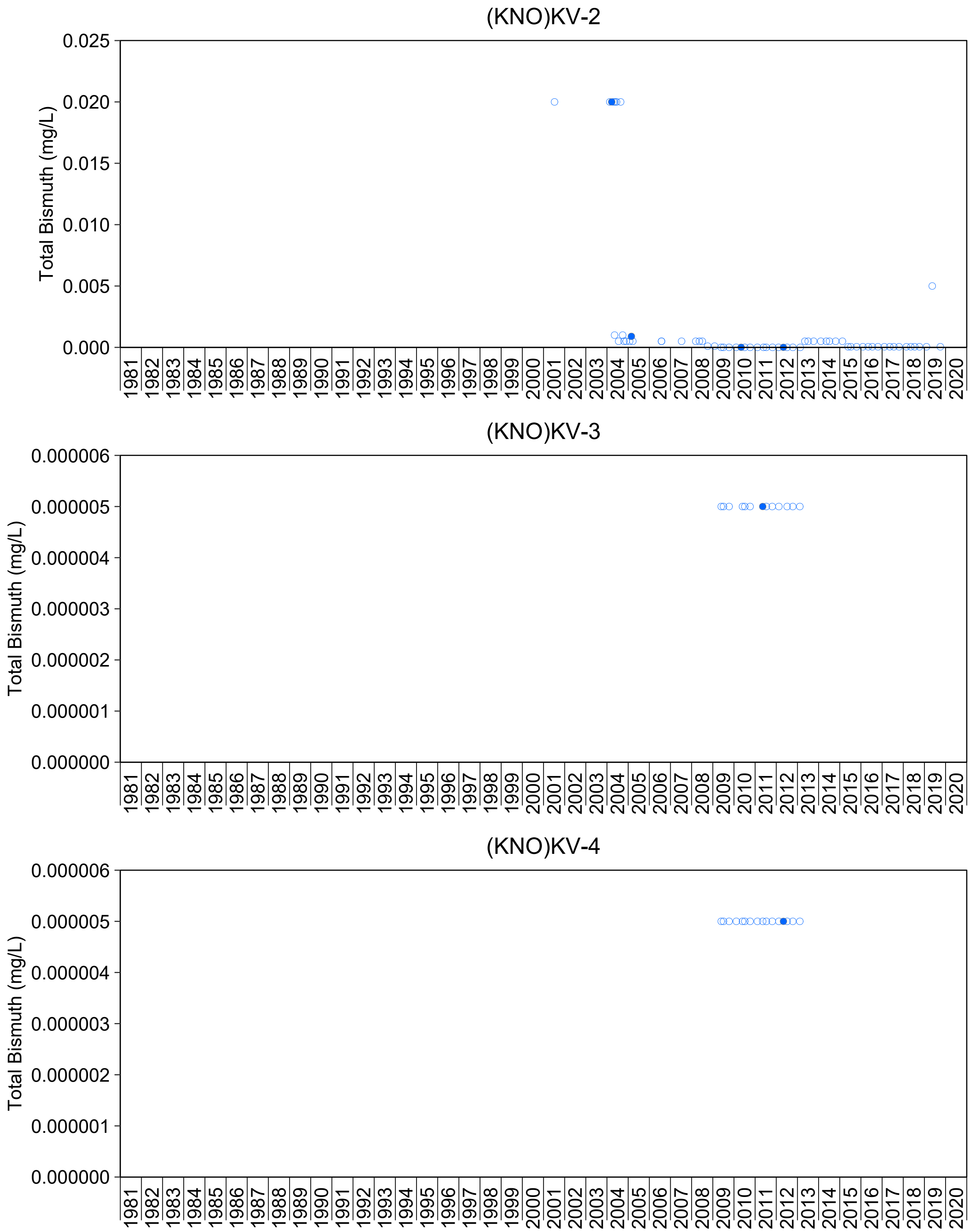


Figure A.35: Time Series Plots of Total Bismuth Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

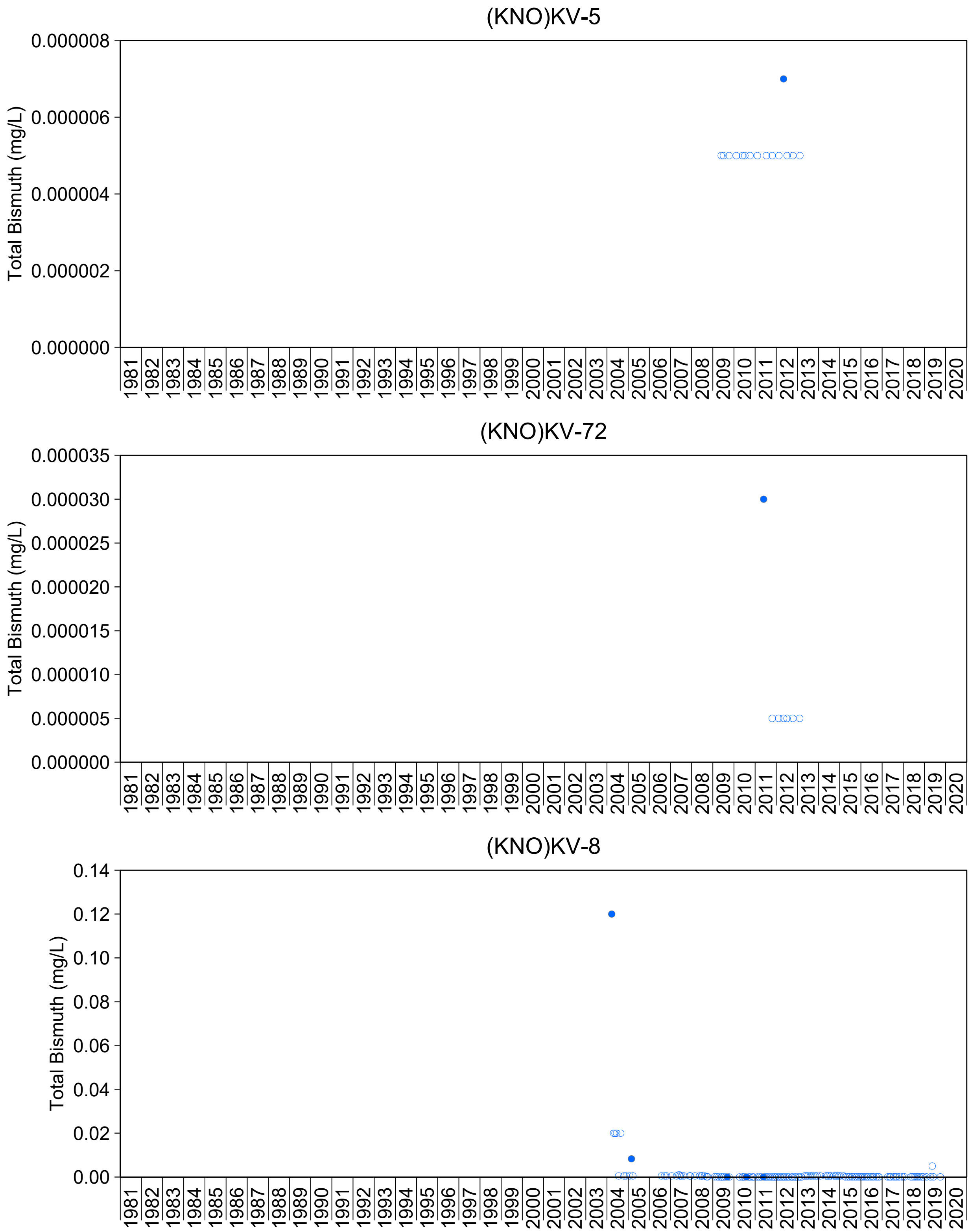


Figure A.35: Time Series Plots of Total Bismuth Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

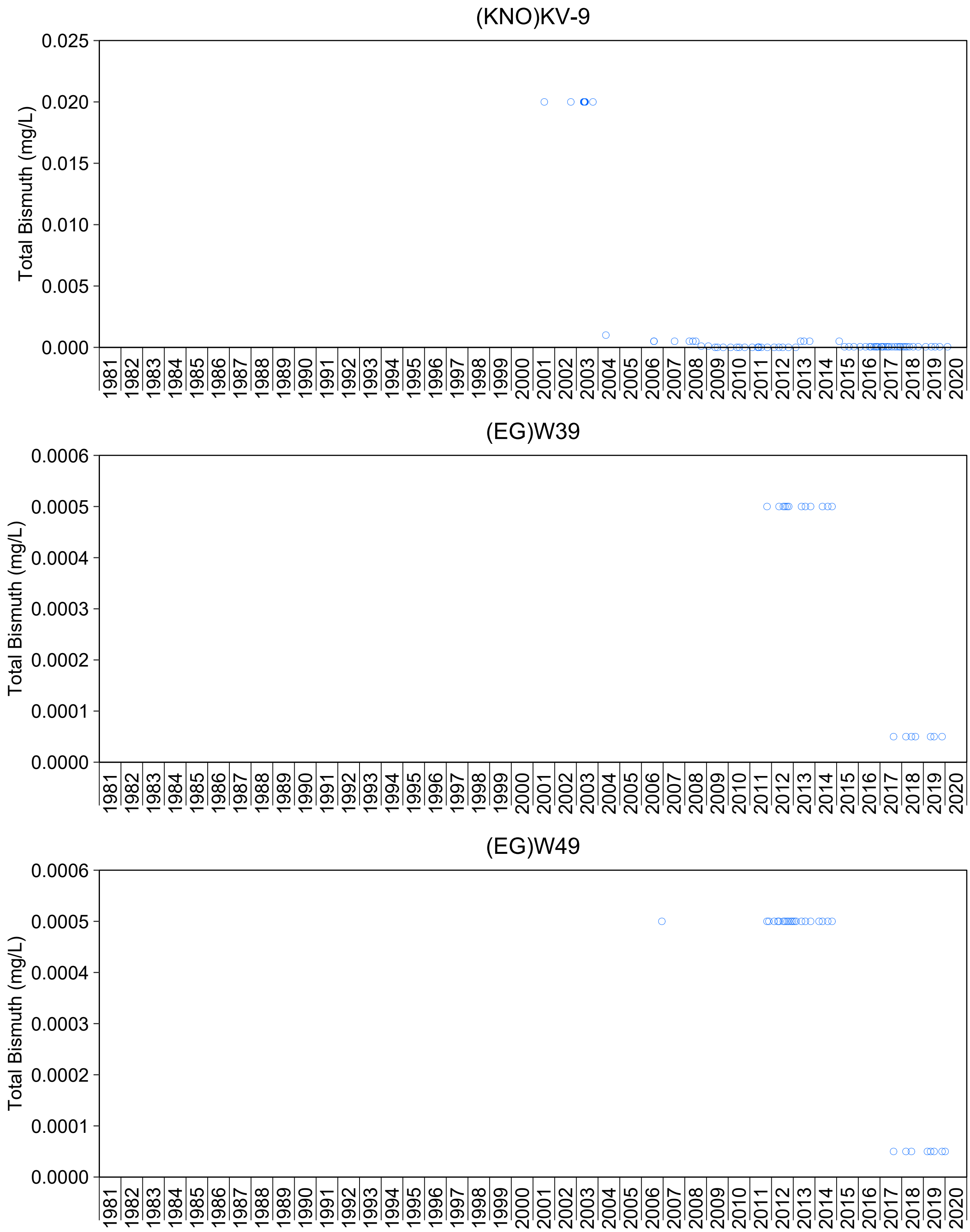


Figure A.35: Time Series Plots of Total Bismuth Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

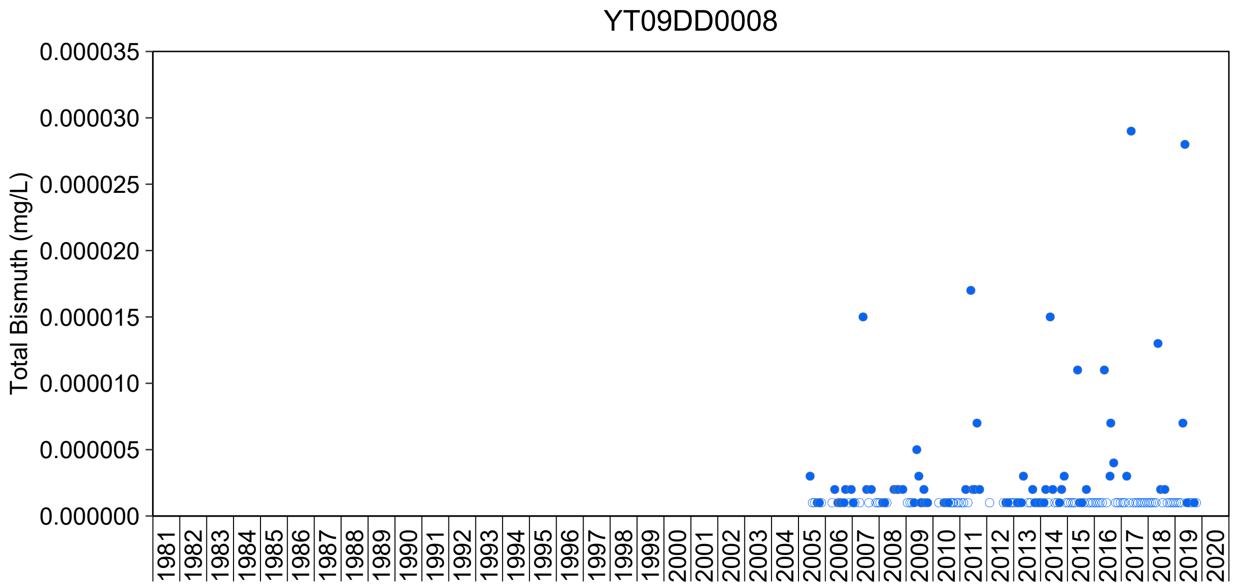


Figure A.35: Time Series Plots of Total Bismuth Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

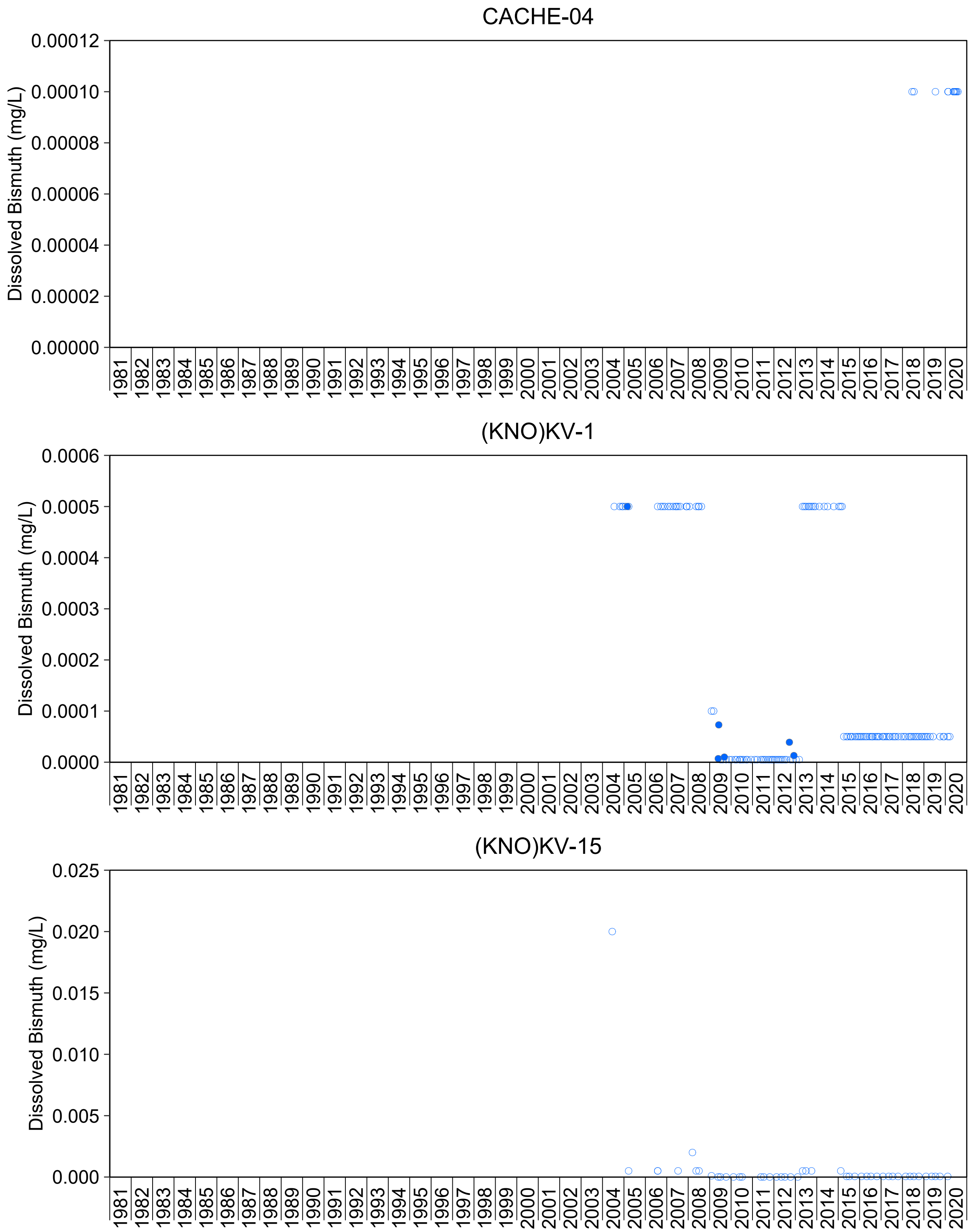


Figure A.36: Time Series Plots of Dissolved Bismuth Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

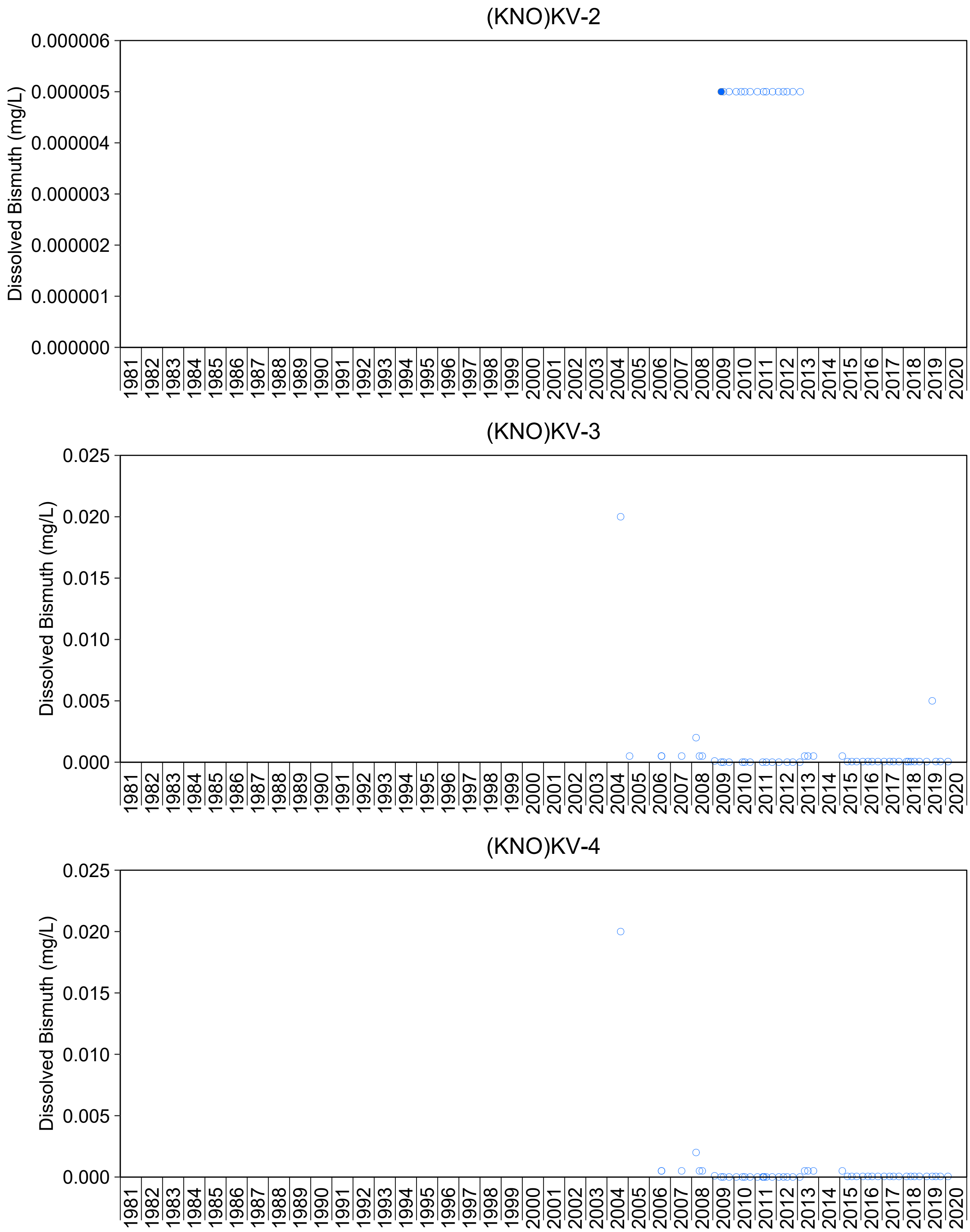


Figure A.36: Time Series Plots of Dissolved Bismuth Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

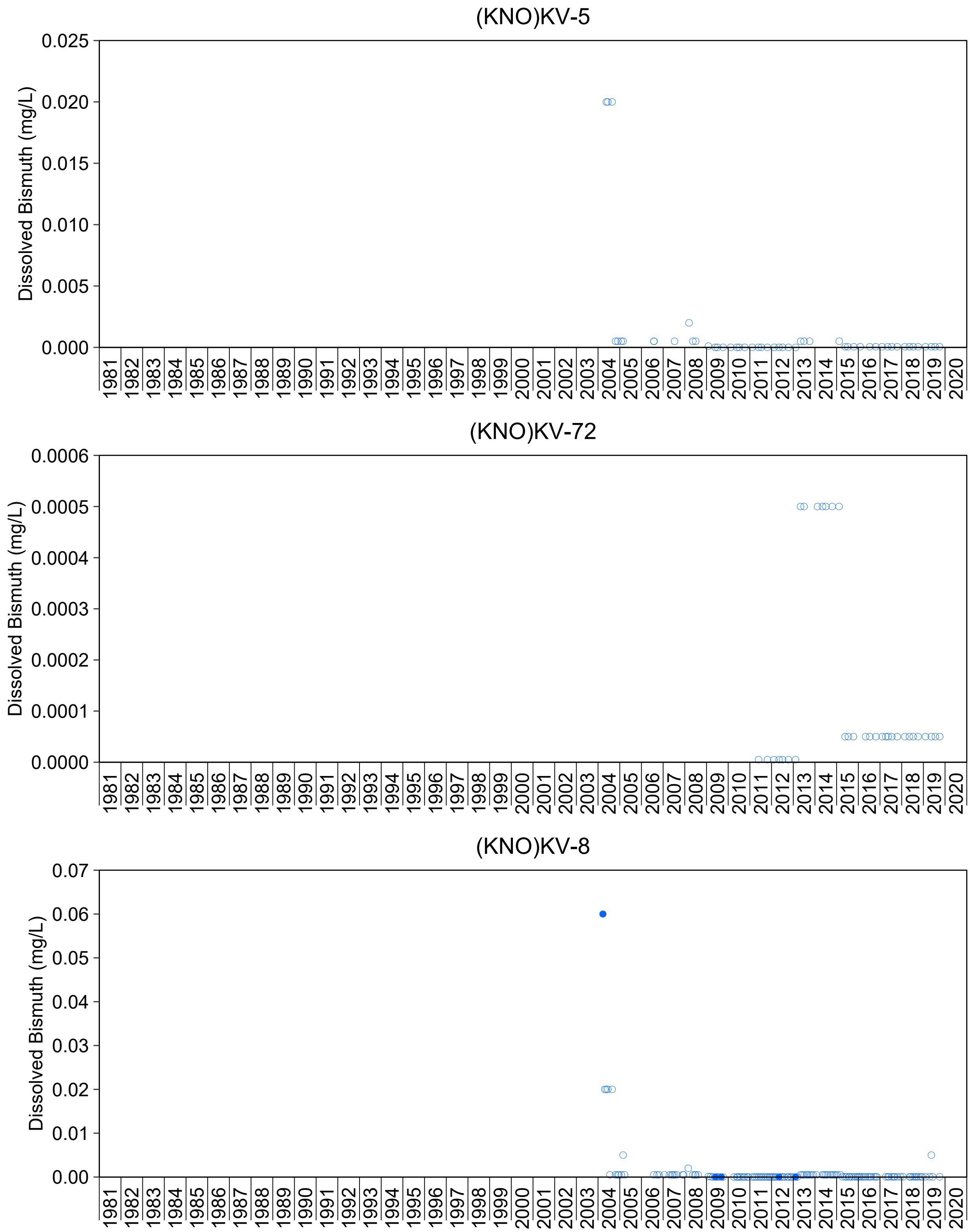


Figure A.36: Time Series Plots of Dissolved Bismuth Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

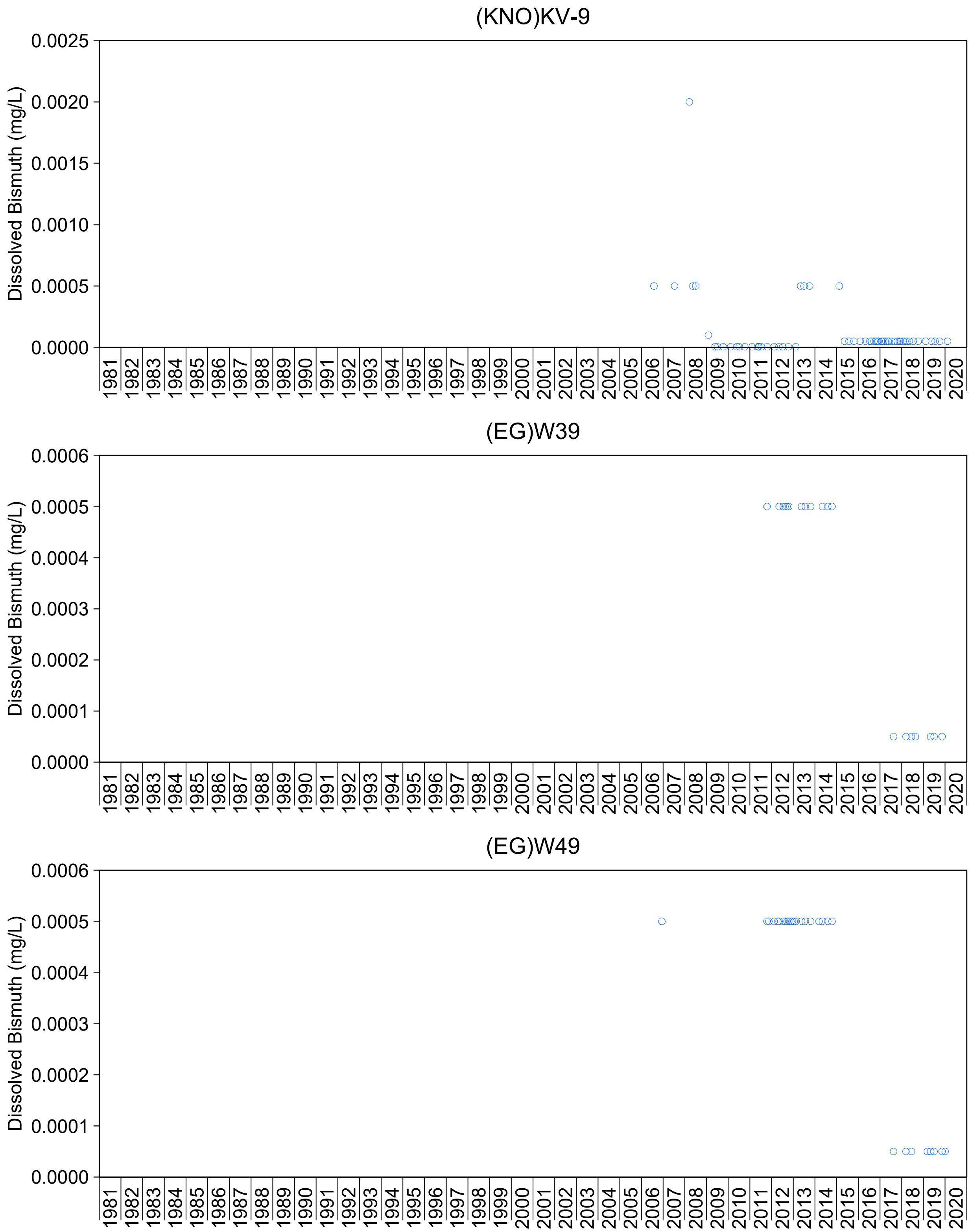


Figure A.36: Time Series Plots of Dissolved Bismuth Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

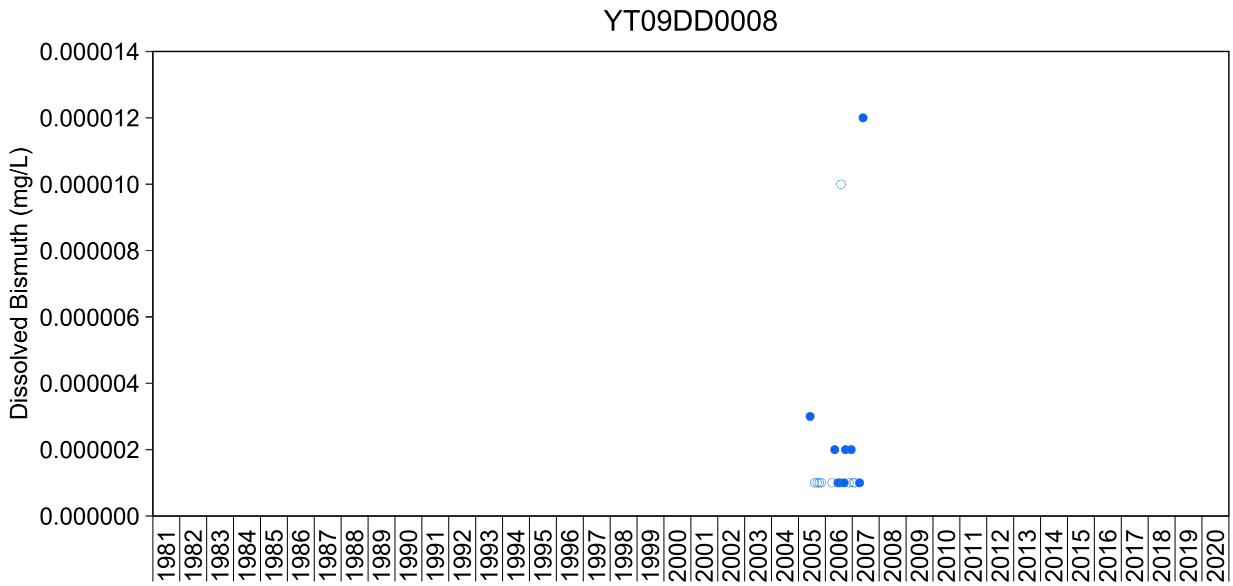


Figure A.36: Time Series Plots of Dissolved Bismuth Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

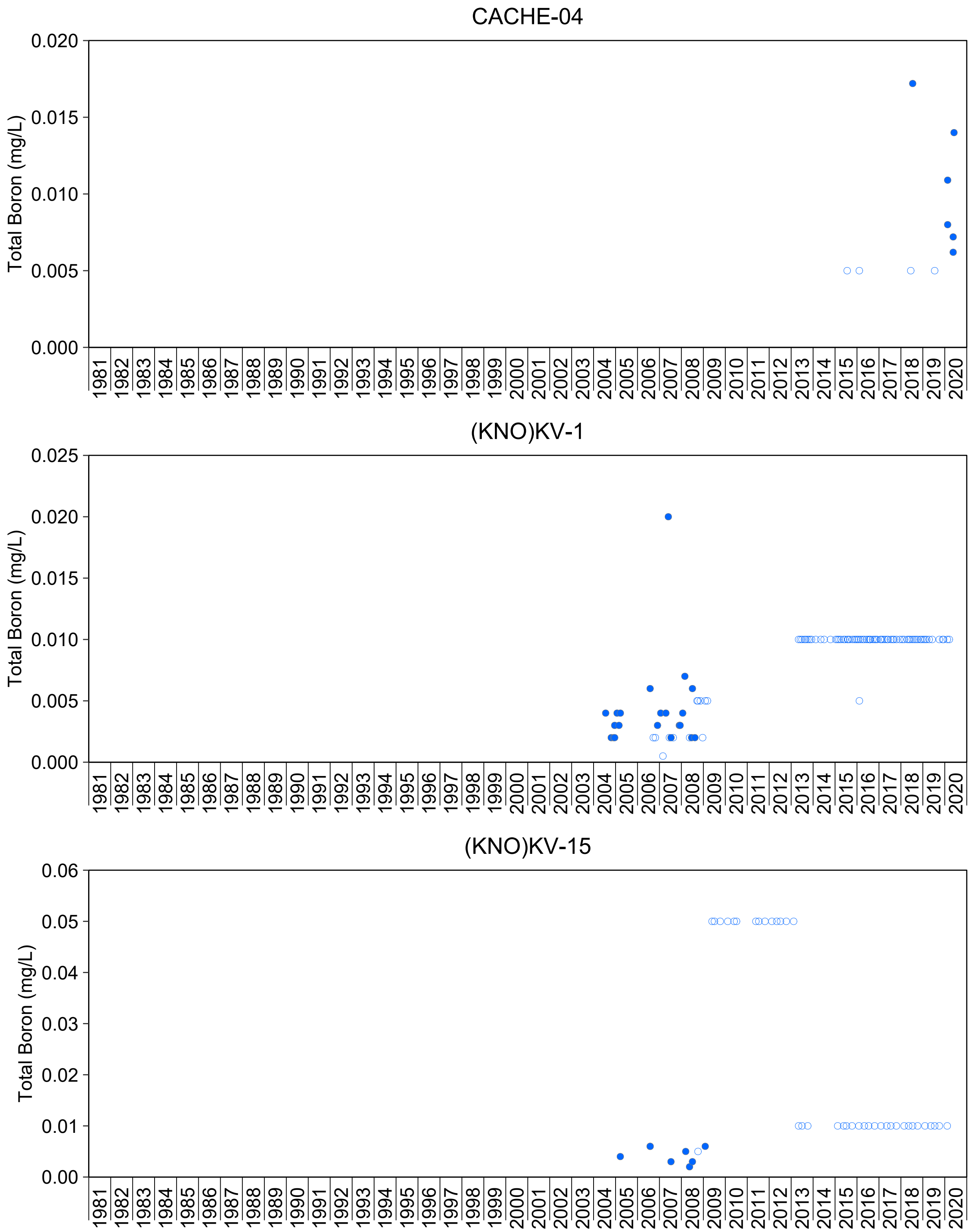


Figure A.37: Time Series Plots of Total Boron Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

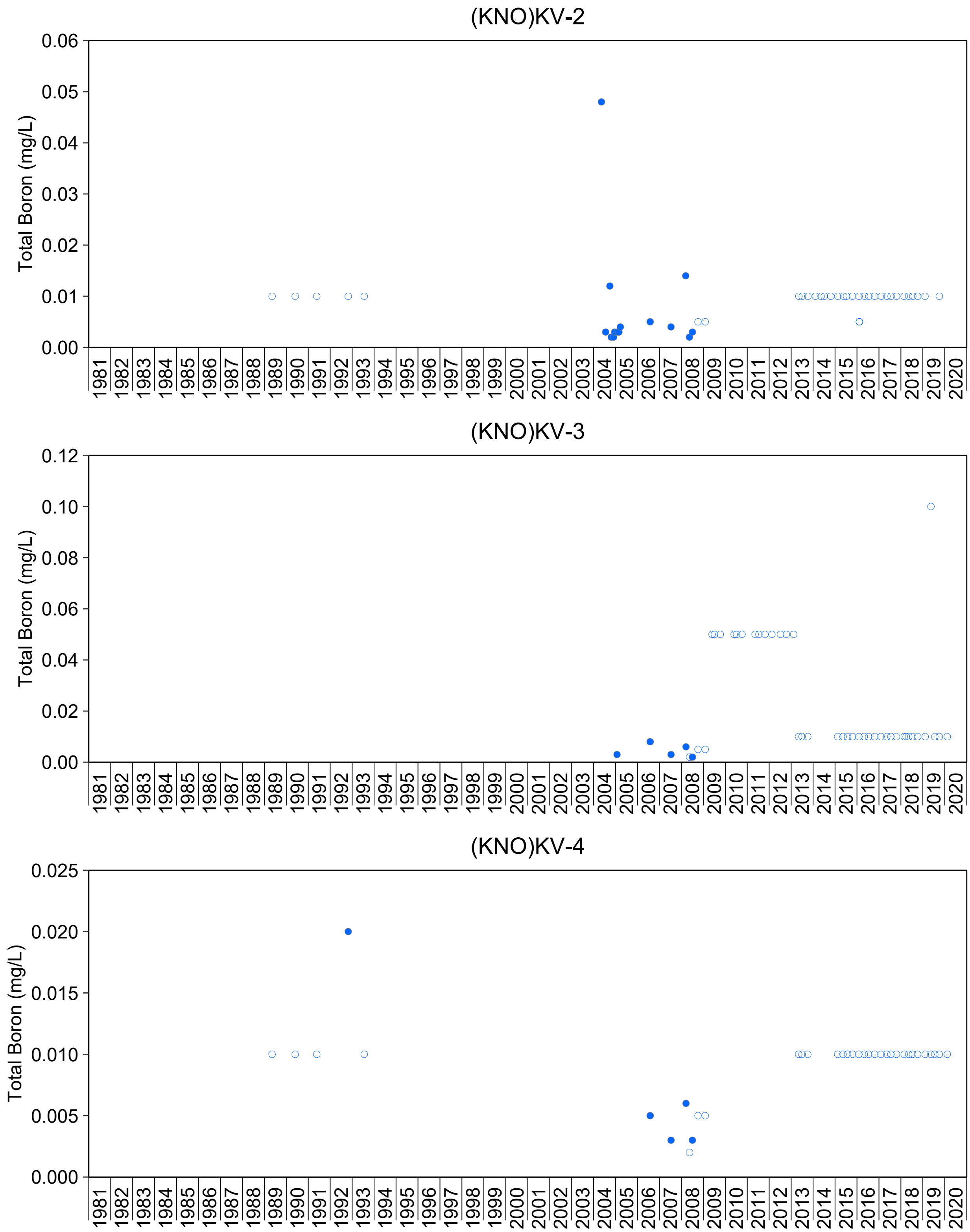


Figure A.37: Time Series Plots of Total Boron Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

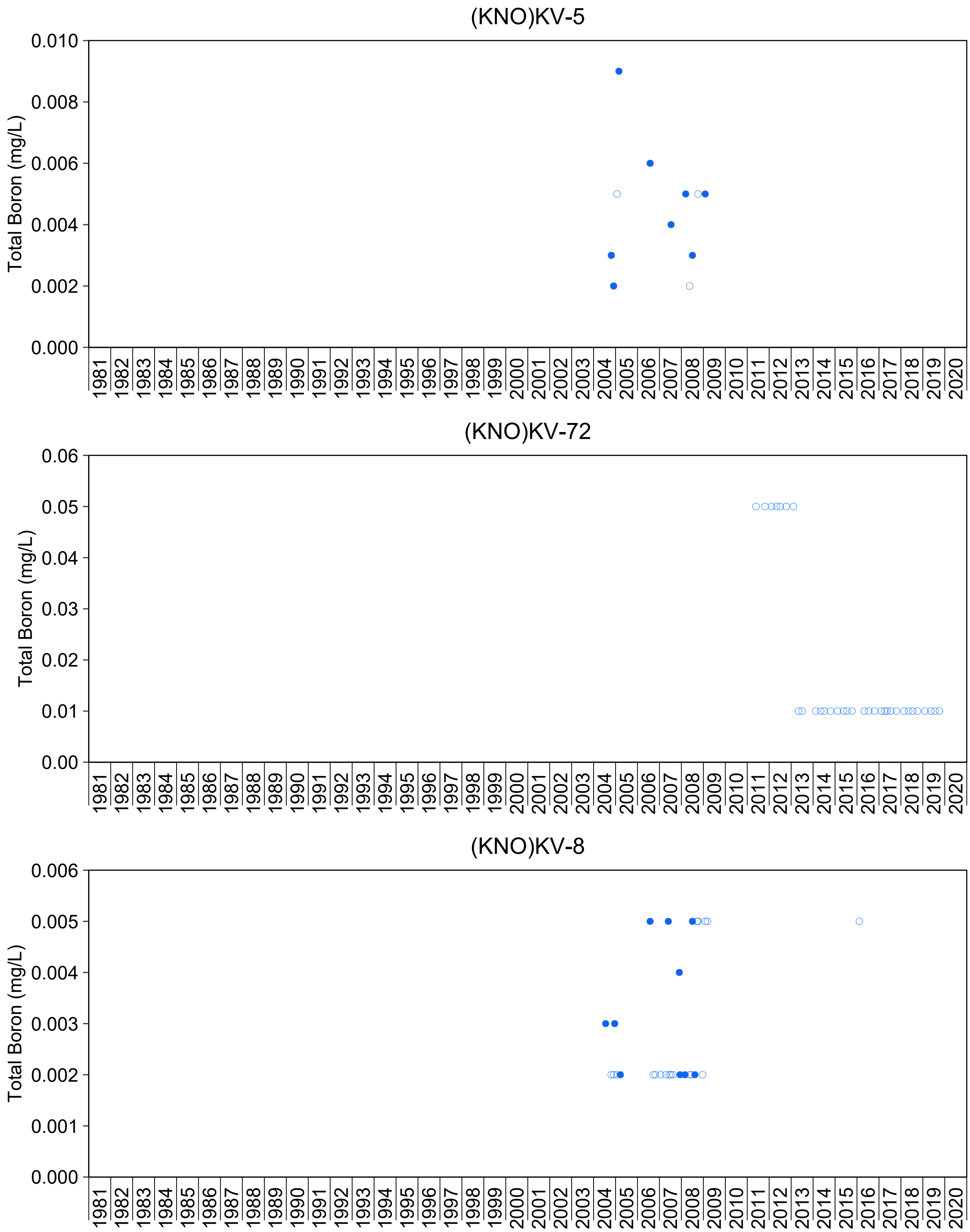


Figure A.37: Time Series Plots of Total Boron Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

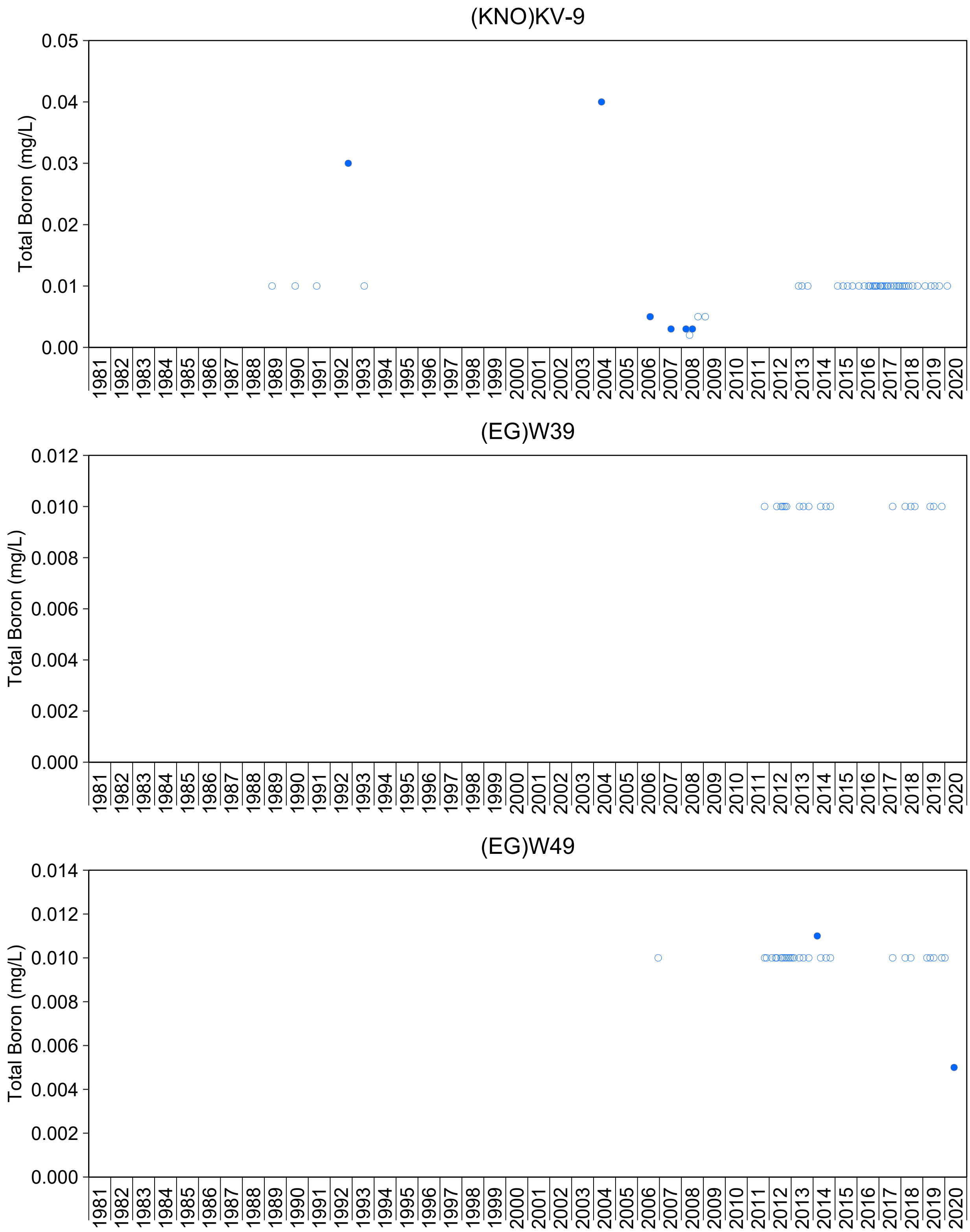


Figure A.37: Time Series Plots of Total Boron Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

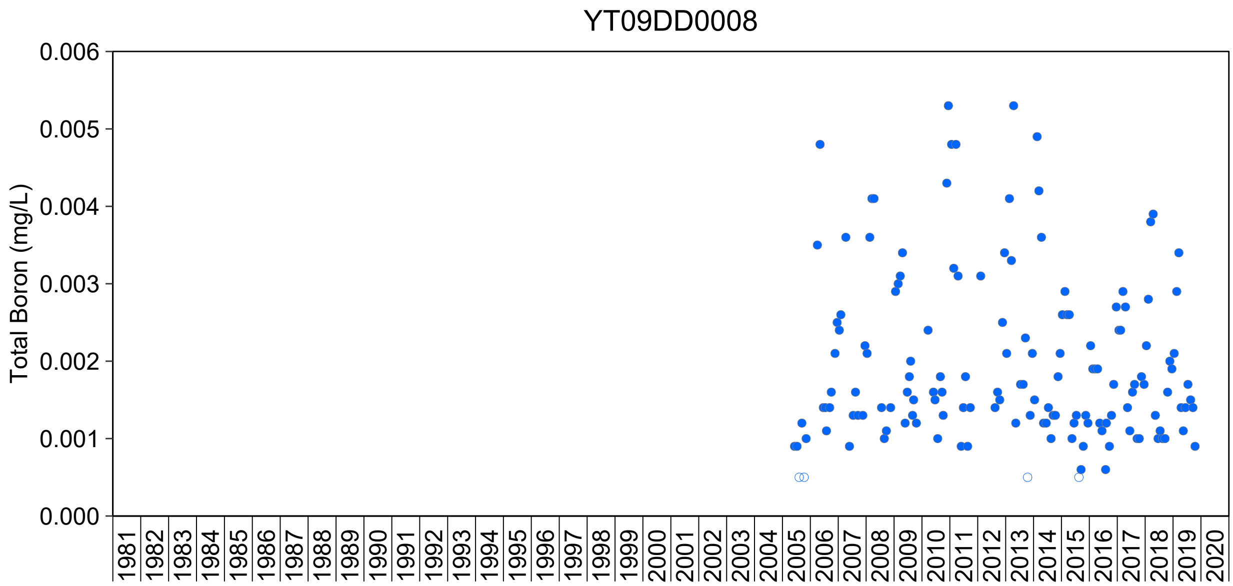


Figure A.37: Time Series Plots of Total Boron Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

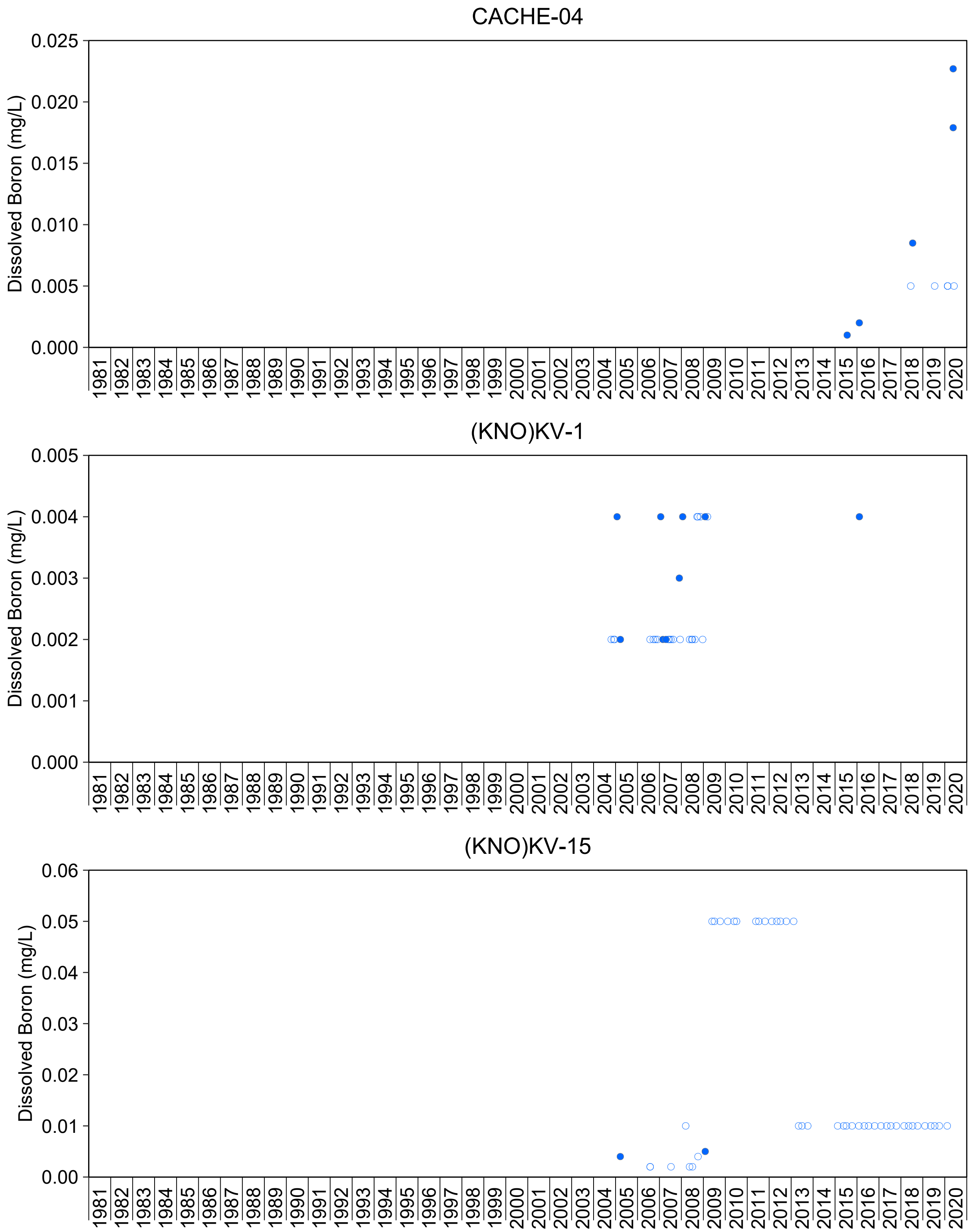


Figure A.38: Time Series Plots of Dissolved Boron Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

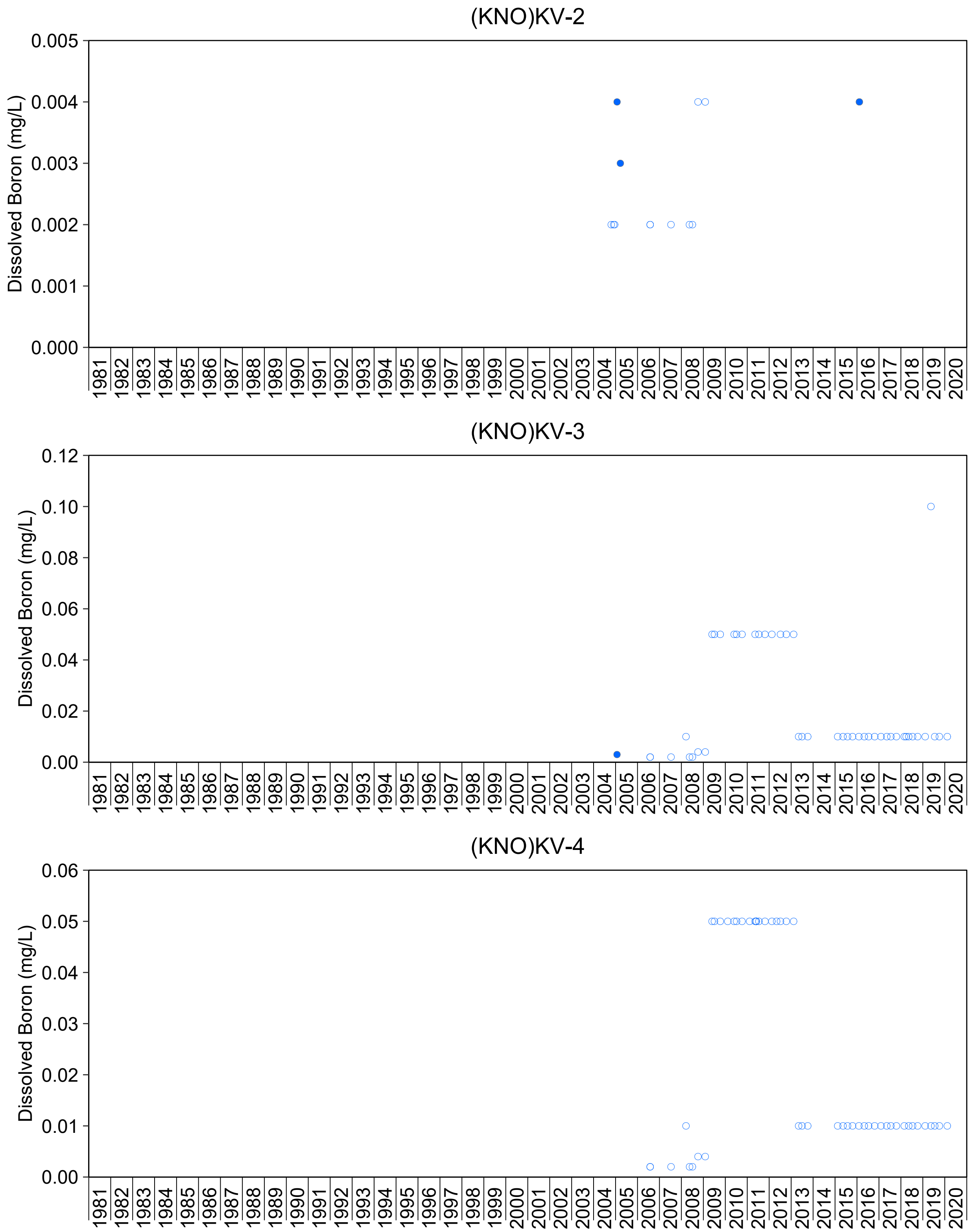


Figure A.38: Time Series Plots of Dissolved Boron Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

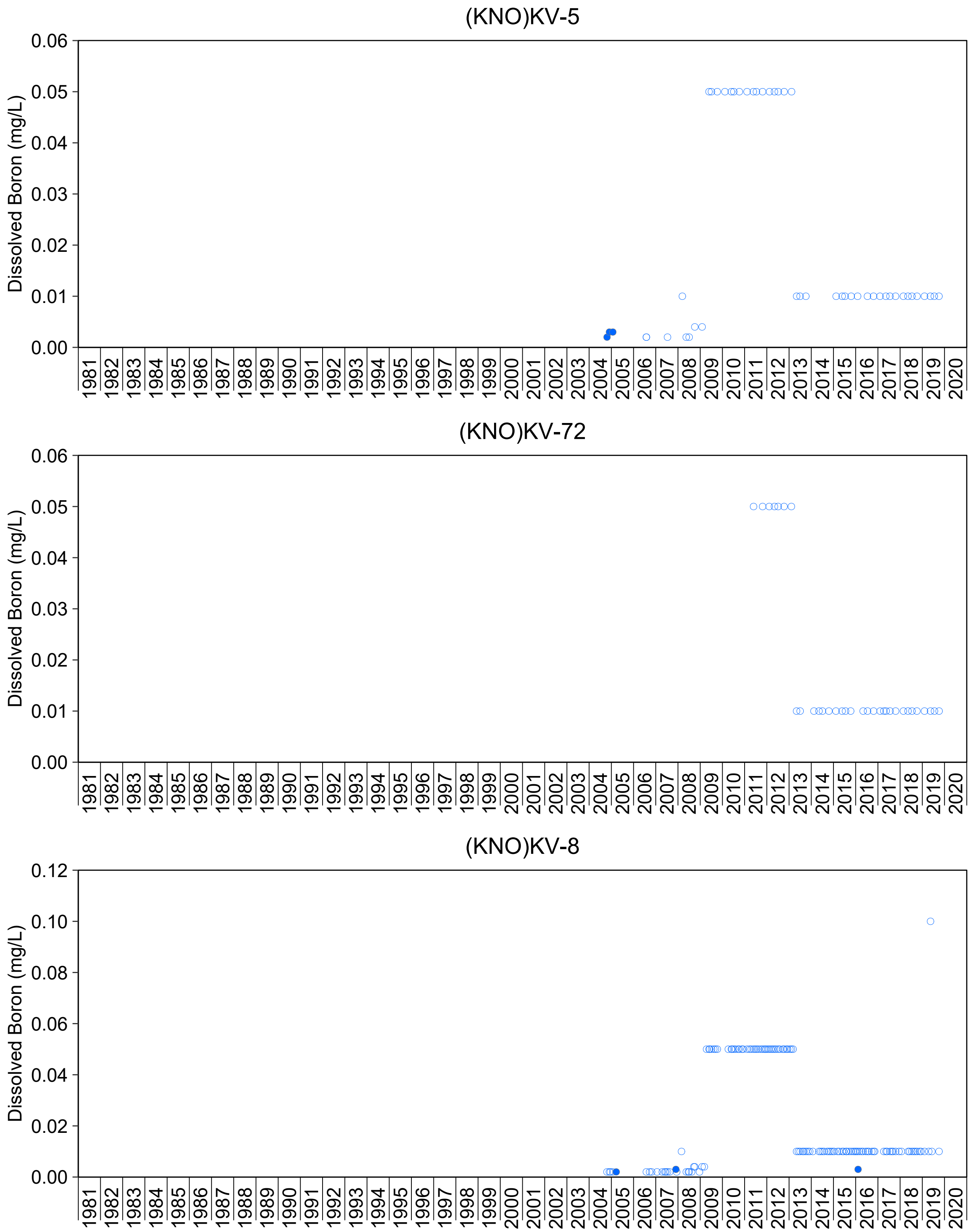


Figure A.38: Time Series Plots of Dissolved Boron Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

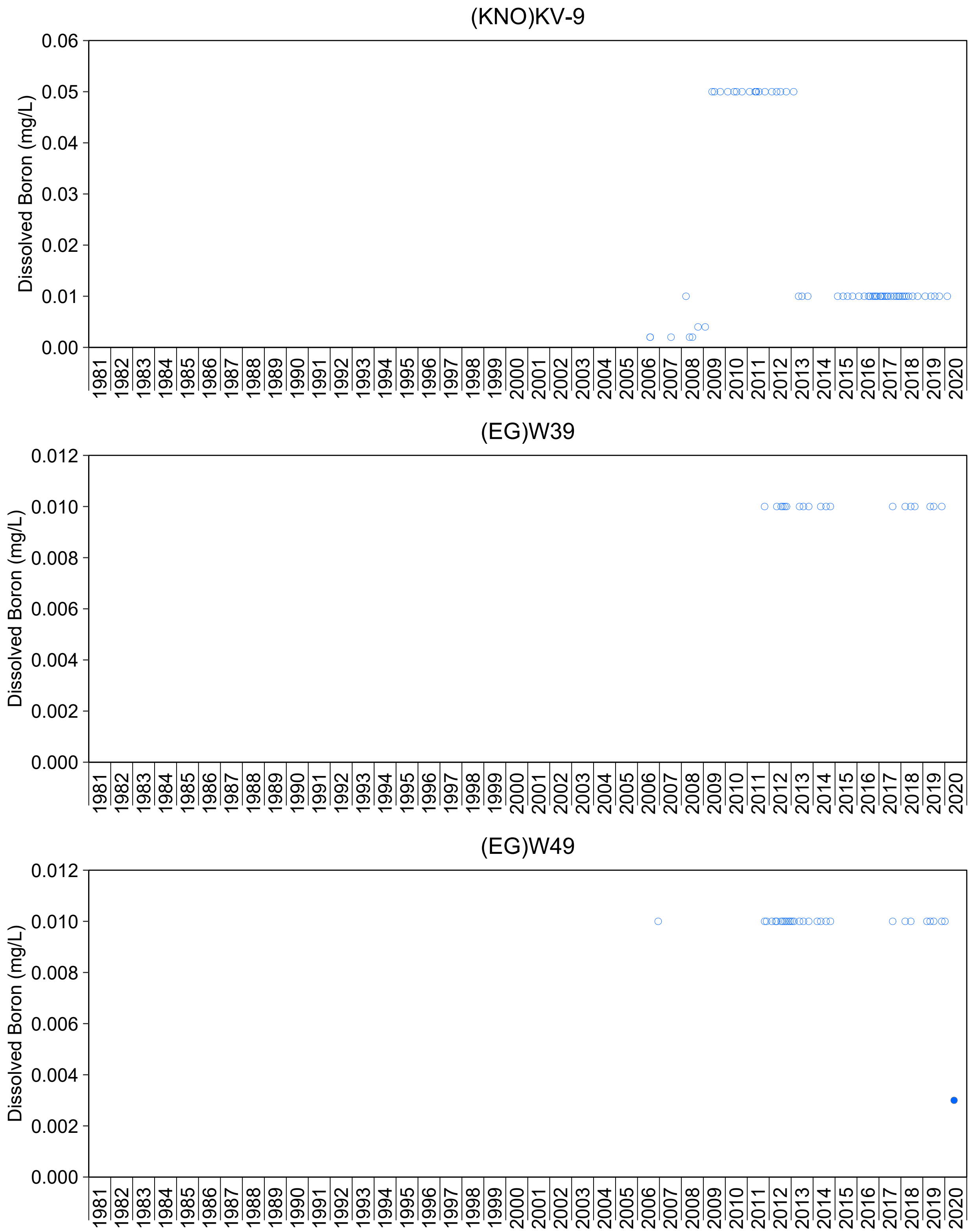


Figure A.38: Time Series Plots of Dissolved Boron Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

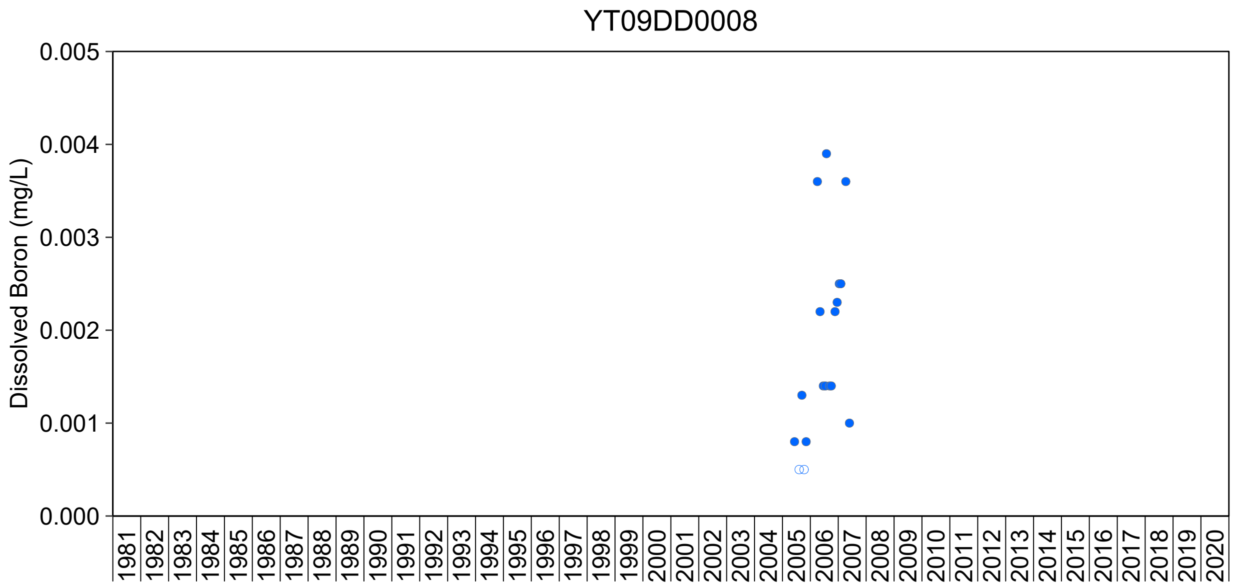


Figure A.38: Time Series Plots of Dissolved Boron Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

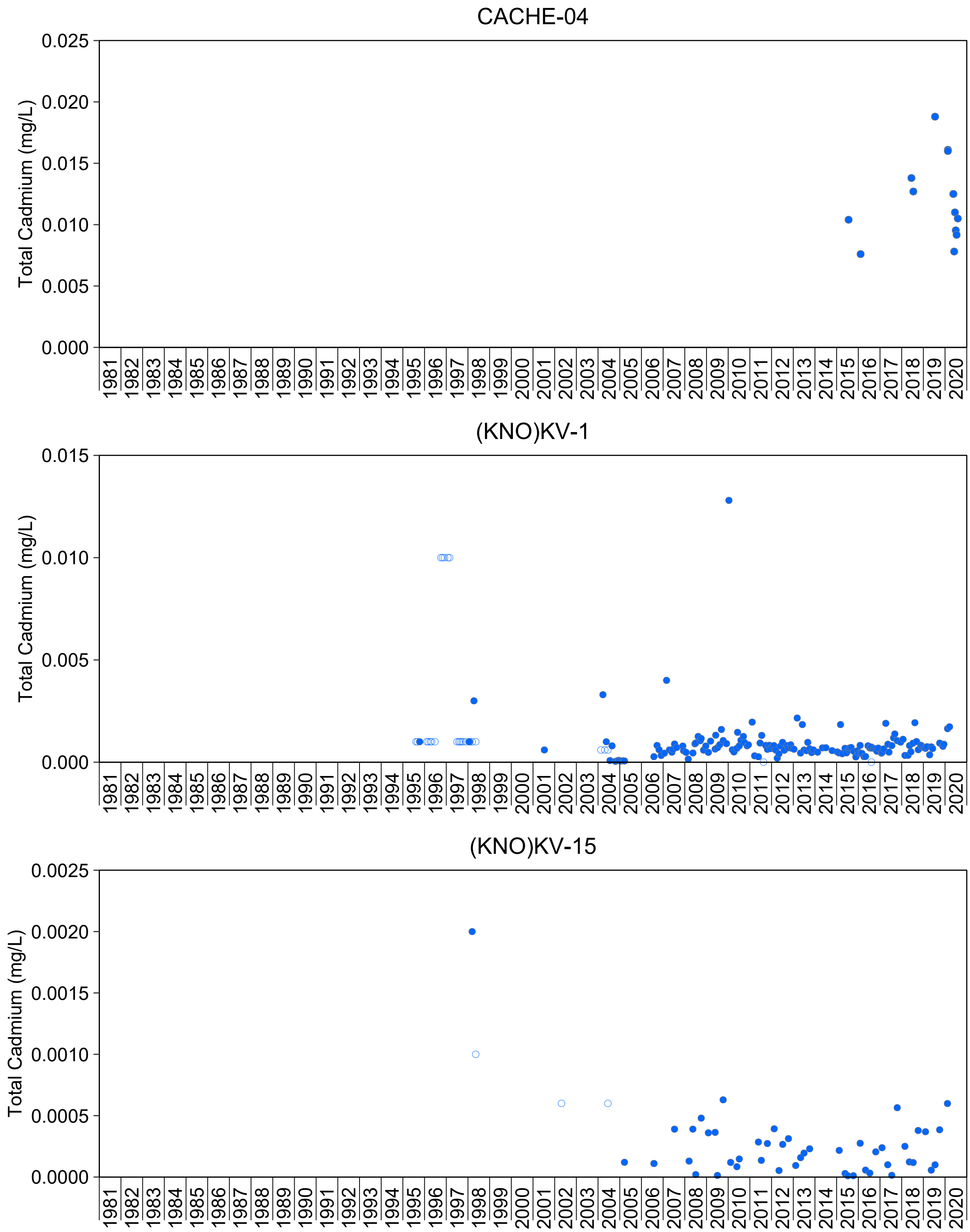


Figure A.39: **Time Series Plots of Total Cadmium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020**

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

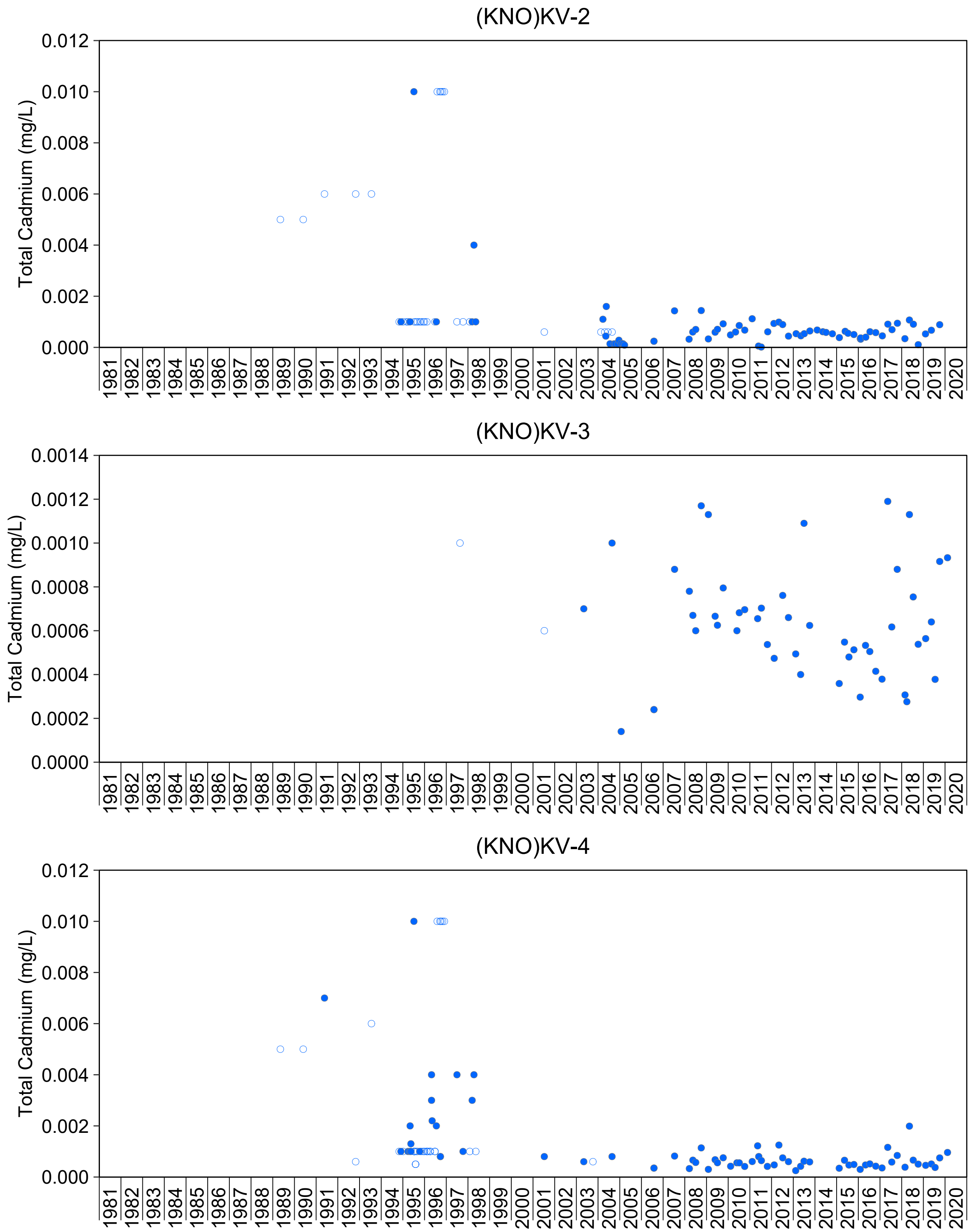


Figure A.39: **Time Series Plots of Total Cadmium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020**

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

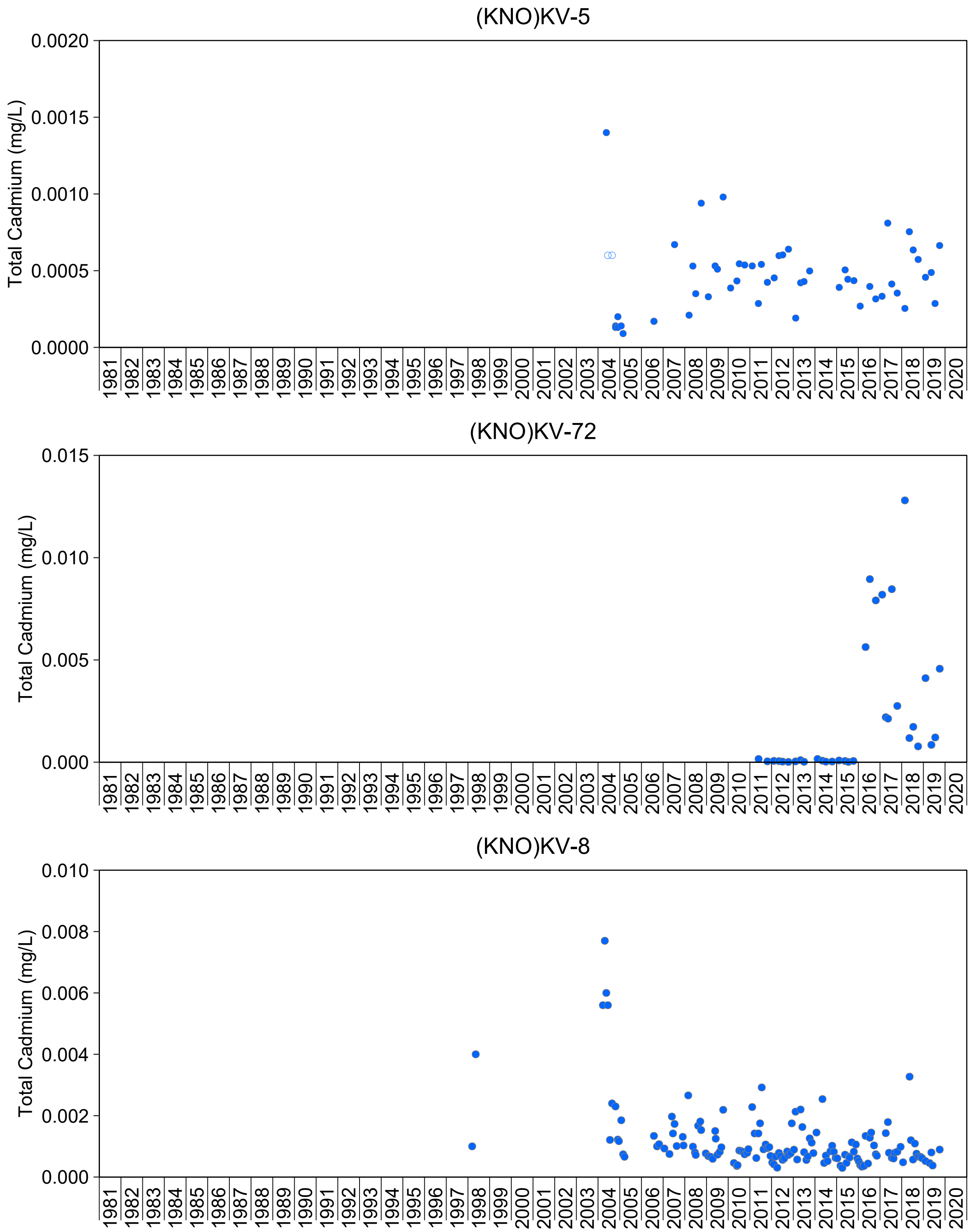


Figure A.39: Time Series Plots of Total Cadmium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

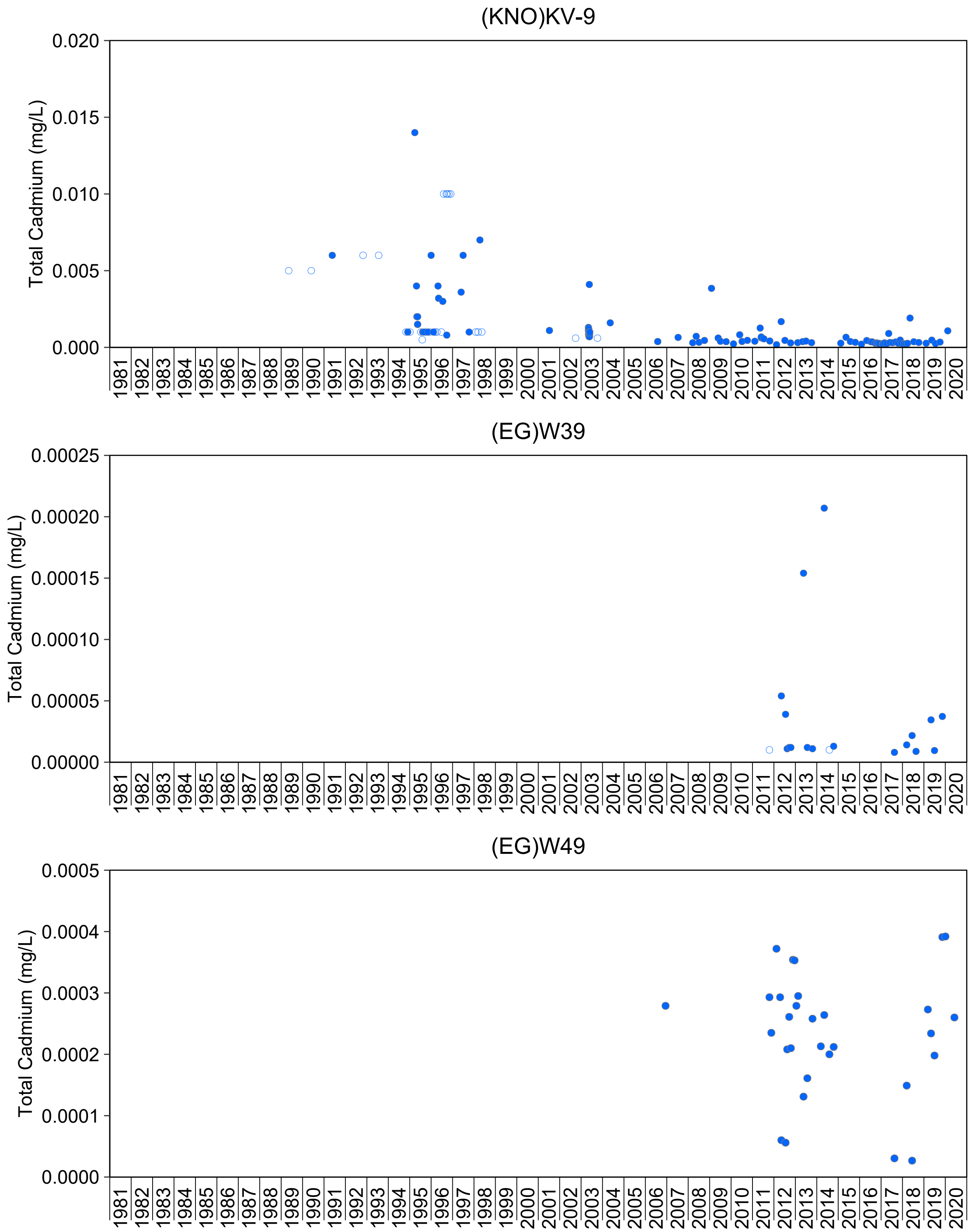


Figure A.39: Time Series Plots of Total Cadmium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

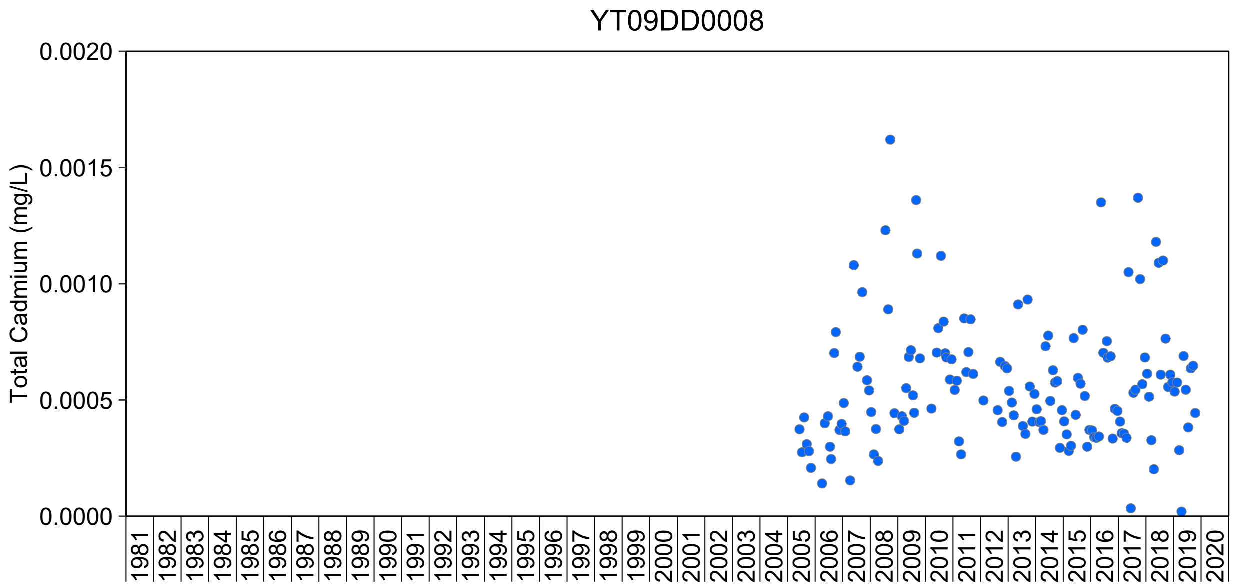


Figure A.39: Time Series Plots of Total Cadmium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

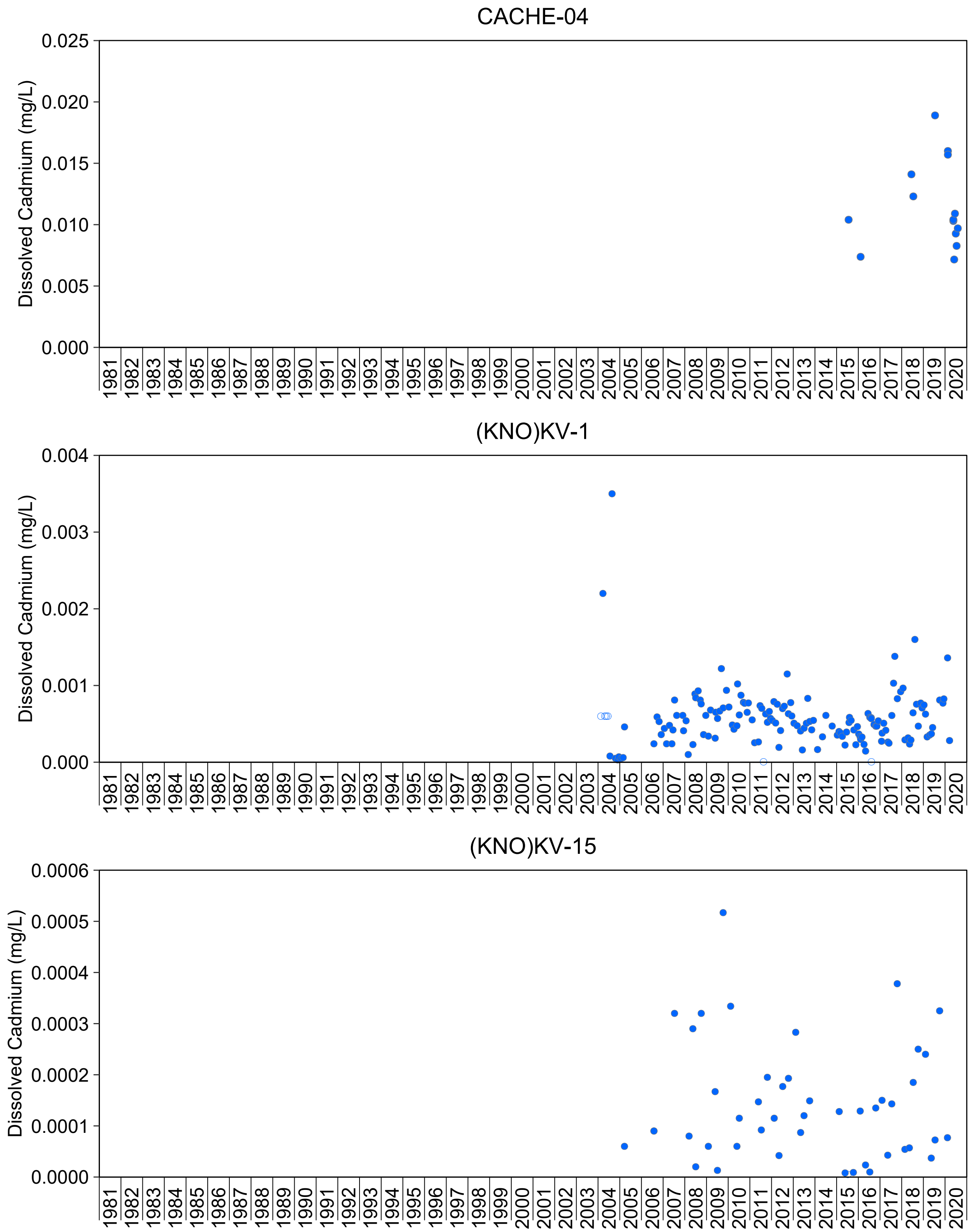


Figure A.40: Time Series Plots of Dissolved Cadmium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

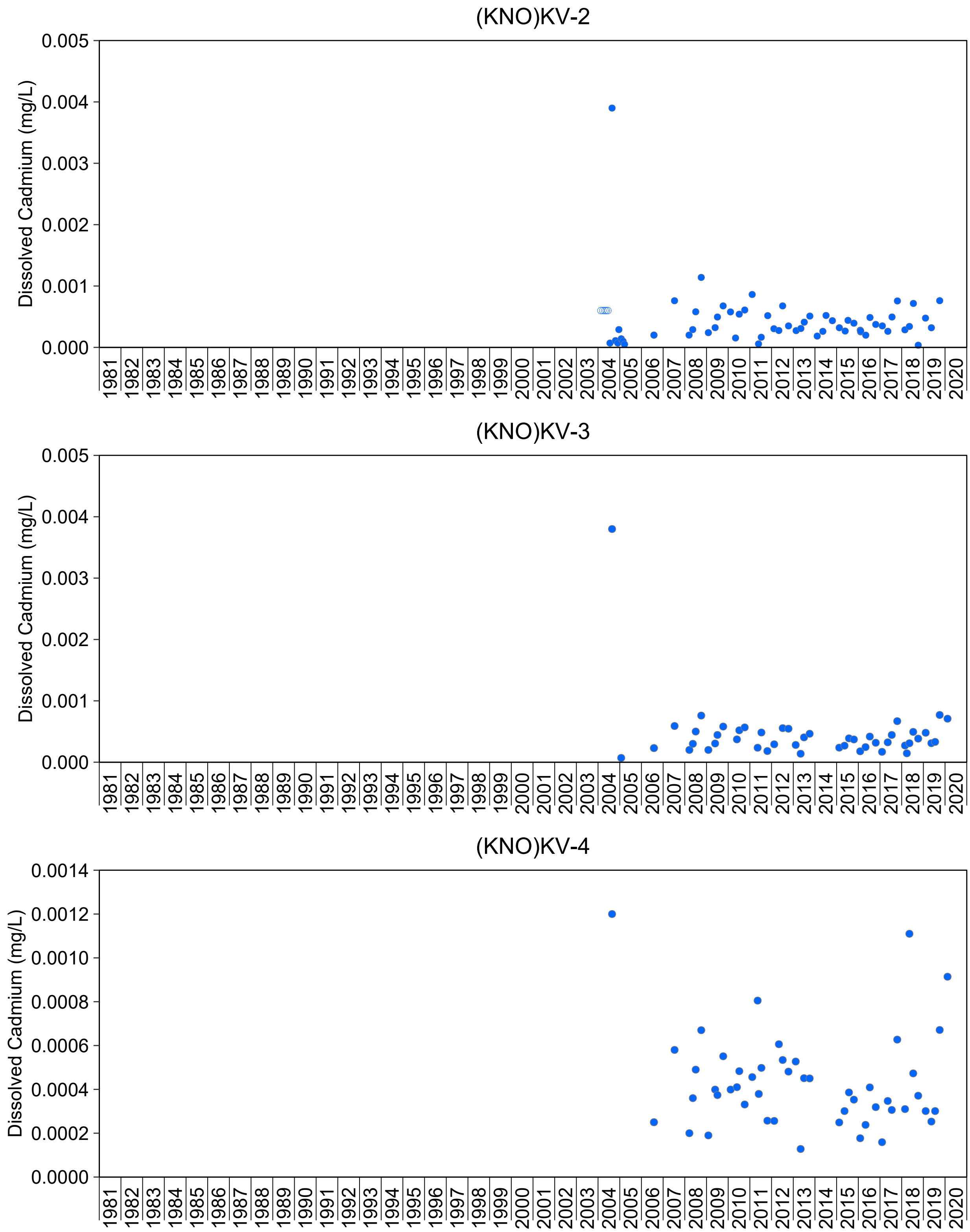


Figure A.40: Time Series Plots of Dissolved Cadmium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

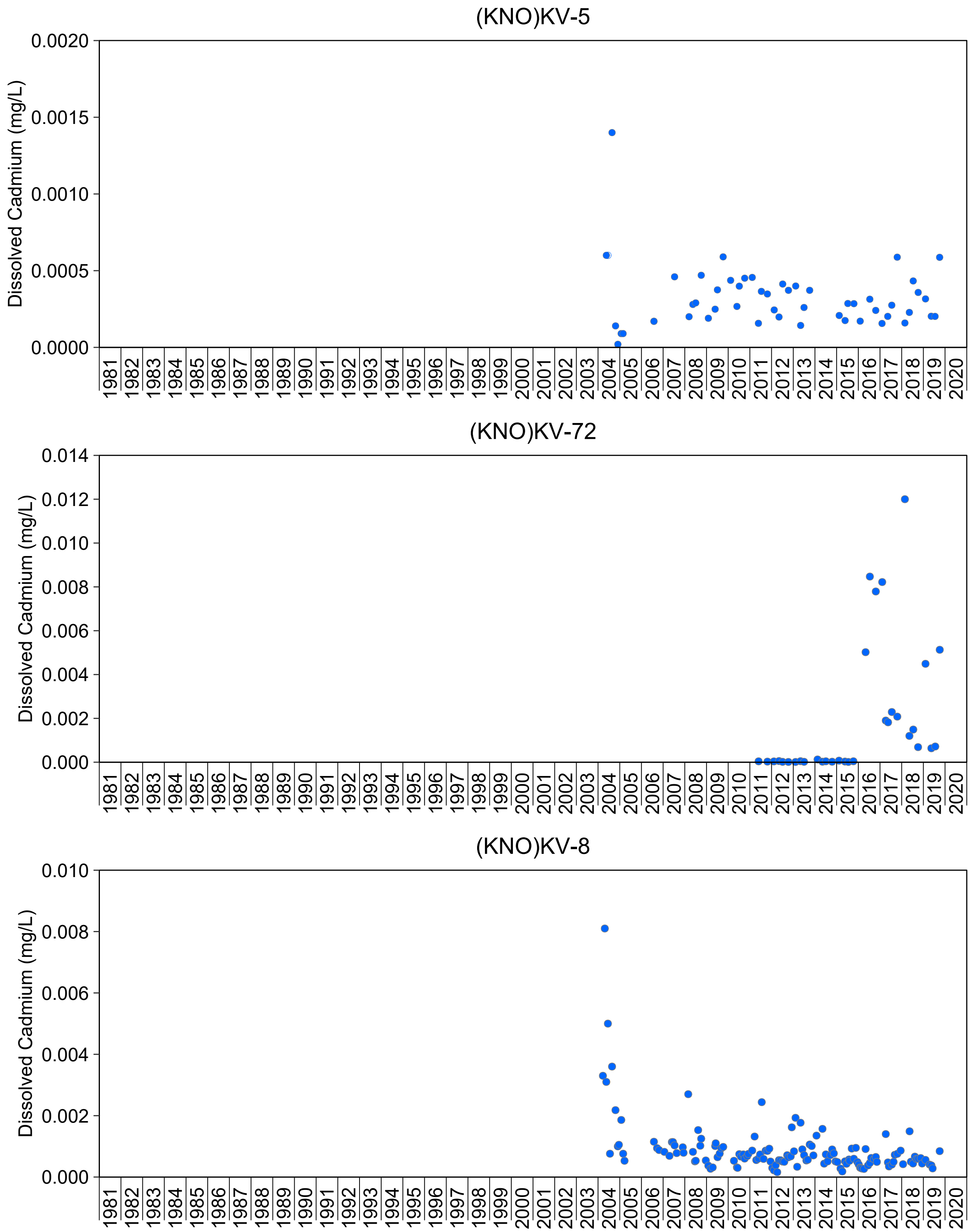


Figure A.40: Time Series Plots of Dissolved Cadmium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

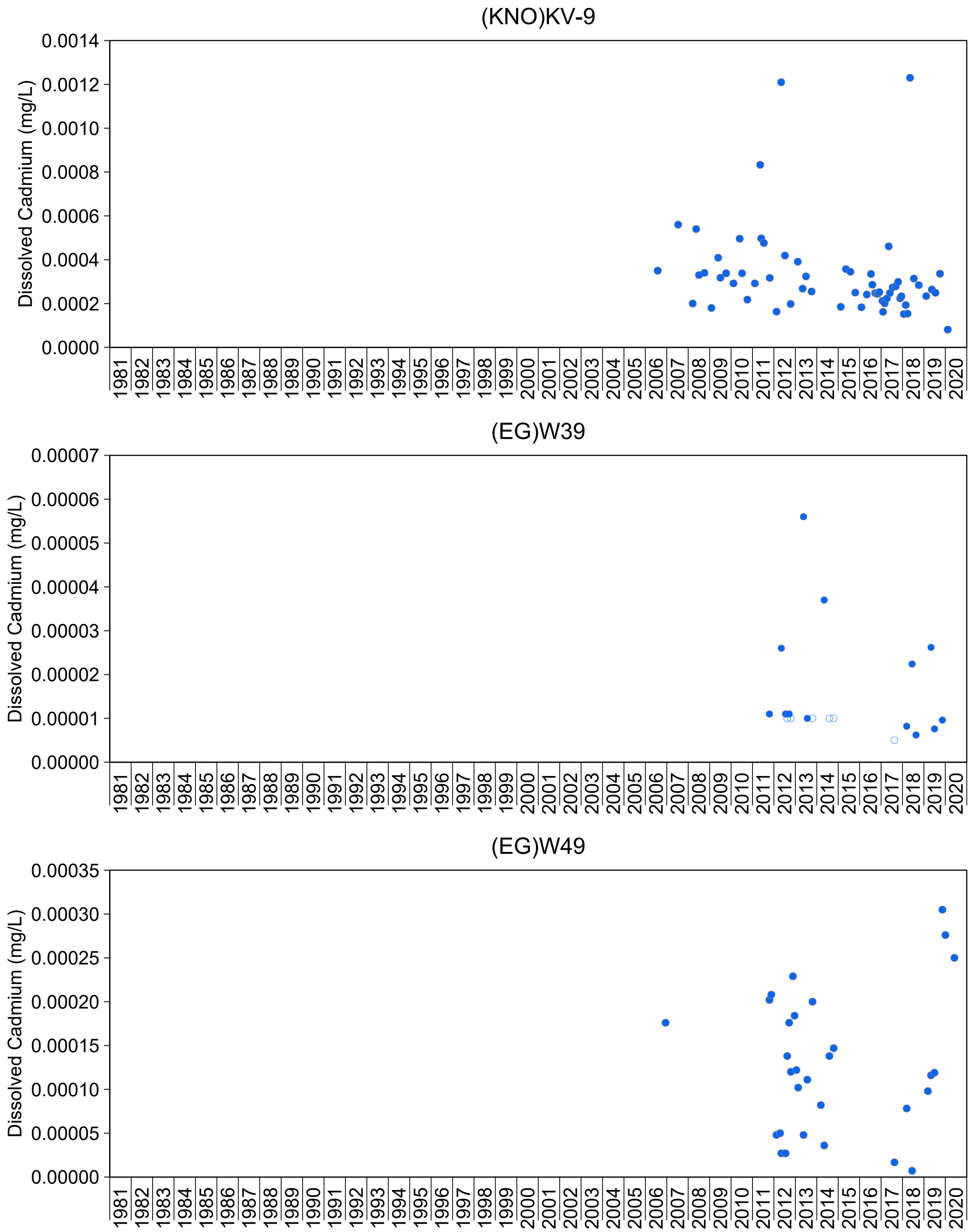


Figure A.40: Time Series Plots of Dissolved Cadmium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

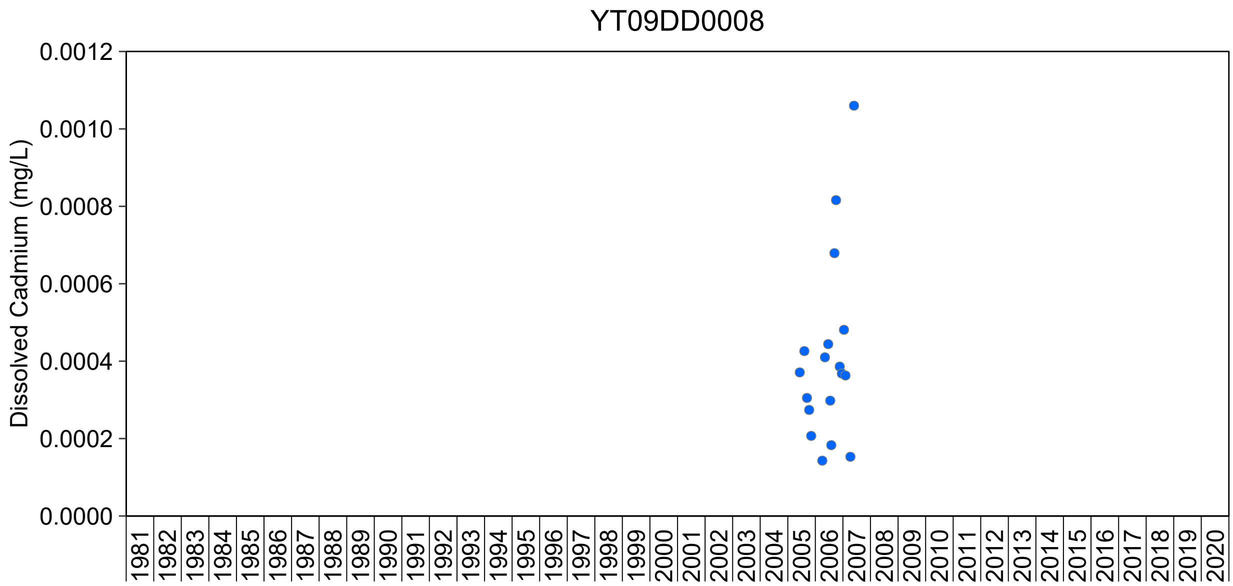


Figure A.40: Time Series Plots of Dissolved Cadmium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

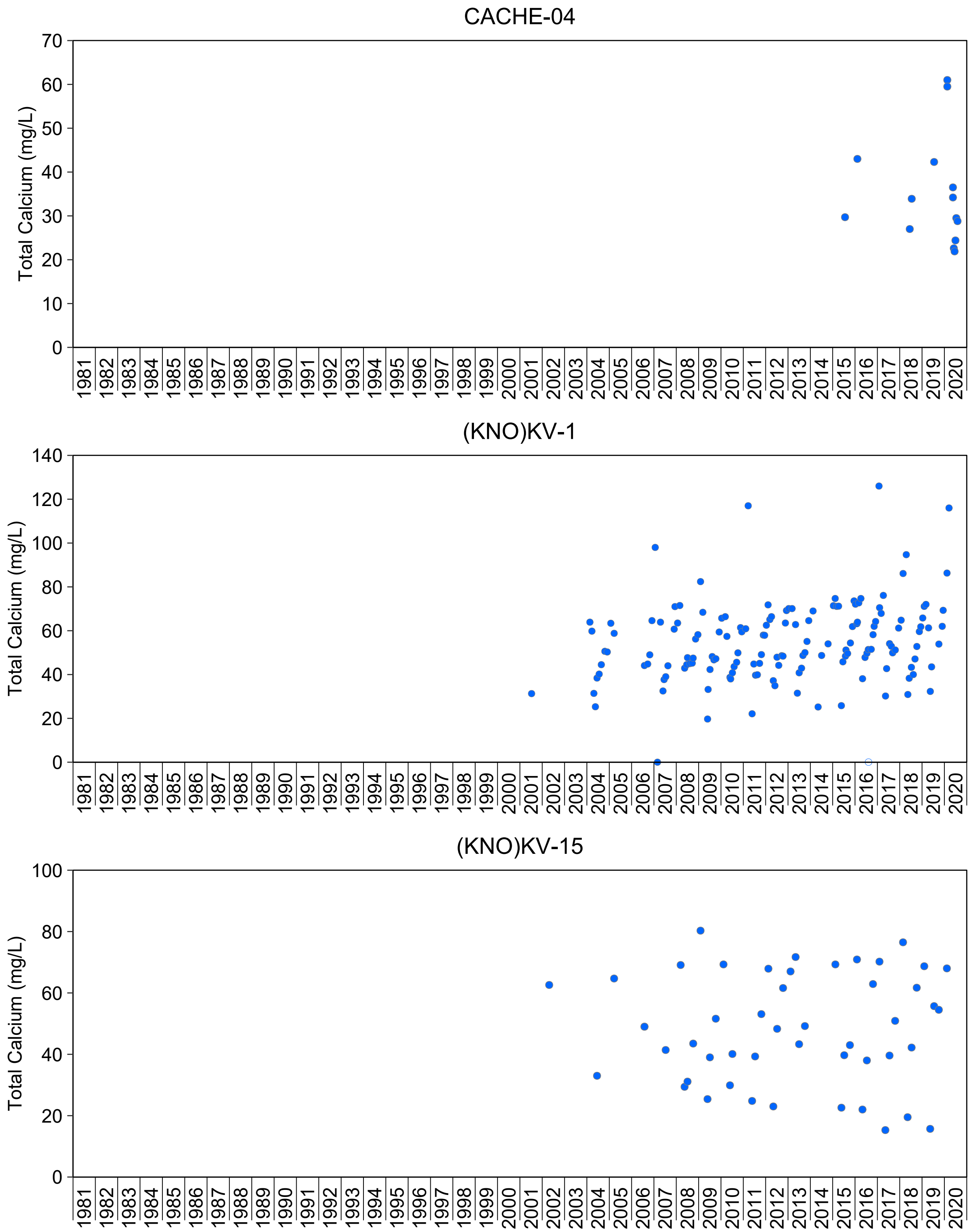


Figure A.41: Time Series Plots of Total Calcium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

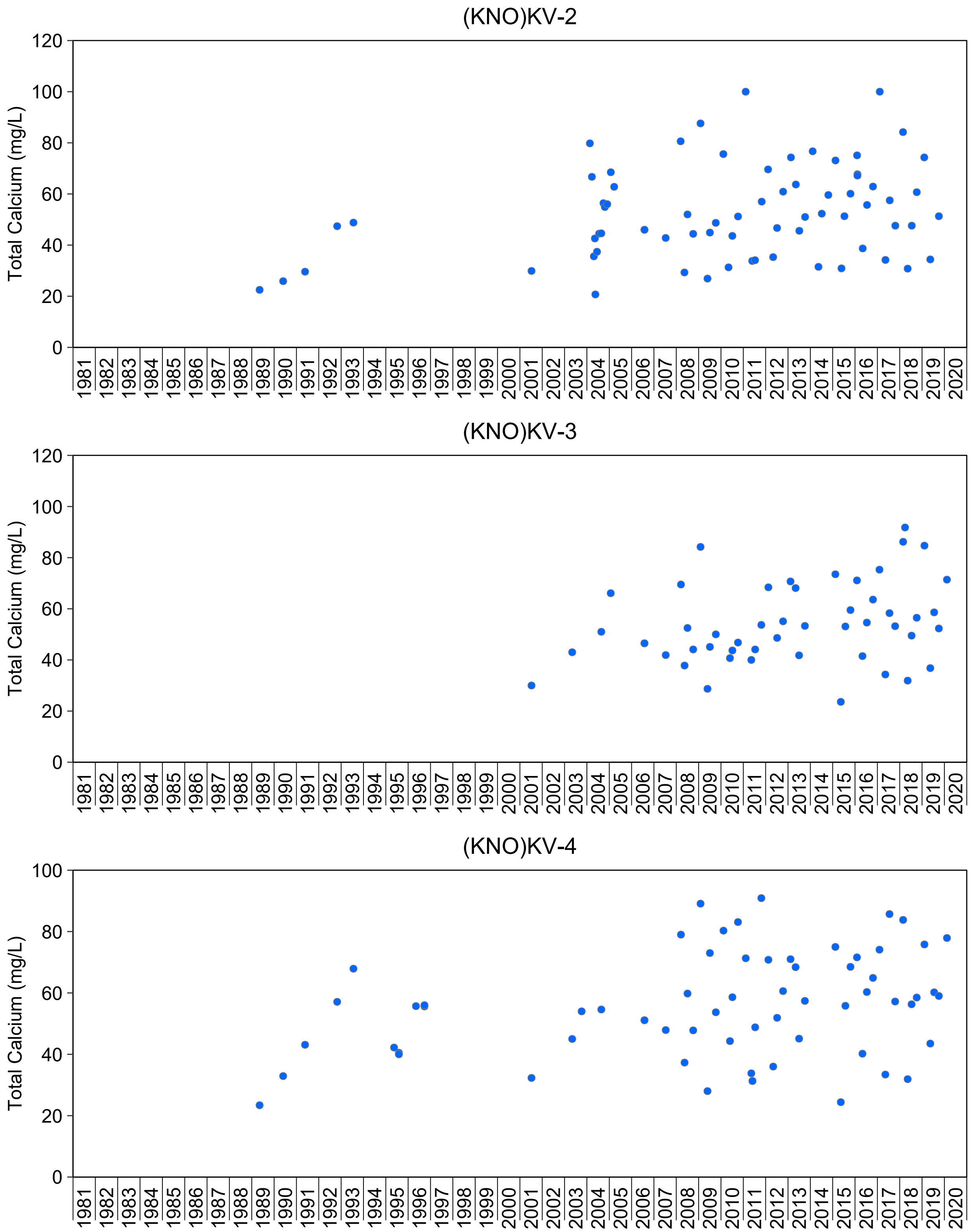


Figure A.41: Time Series Plots of Total Calcium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

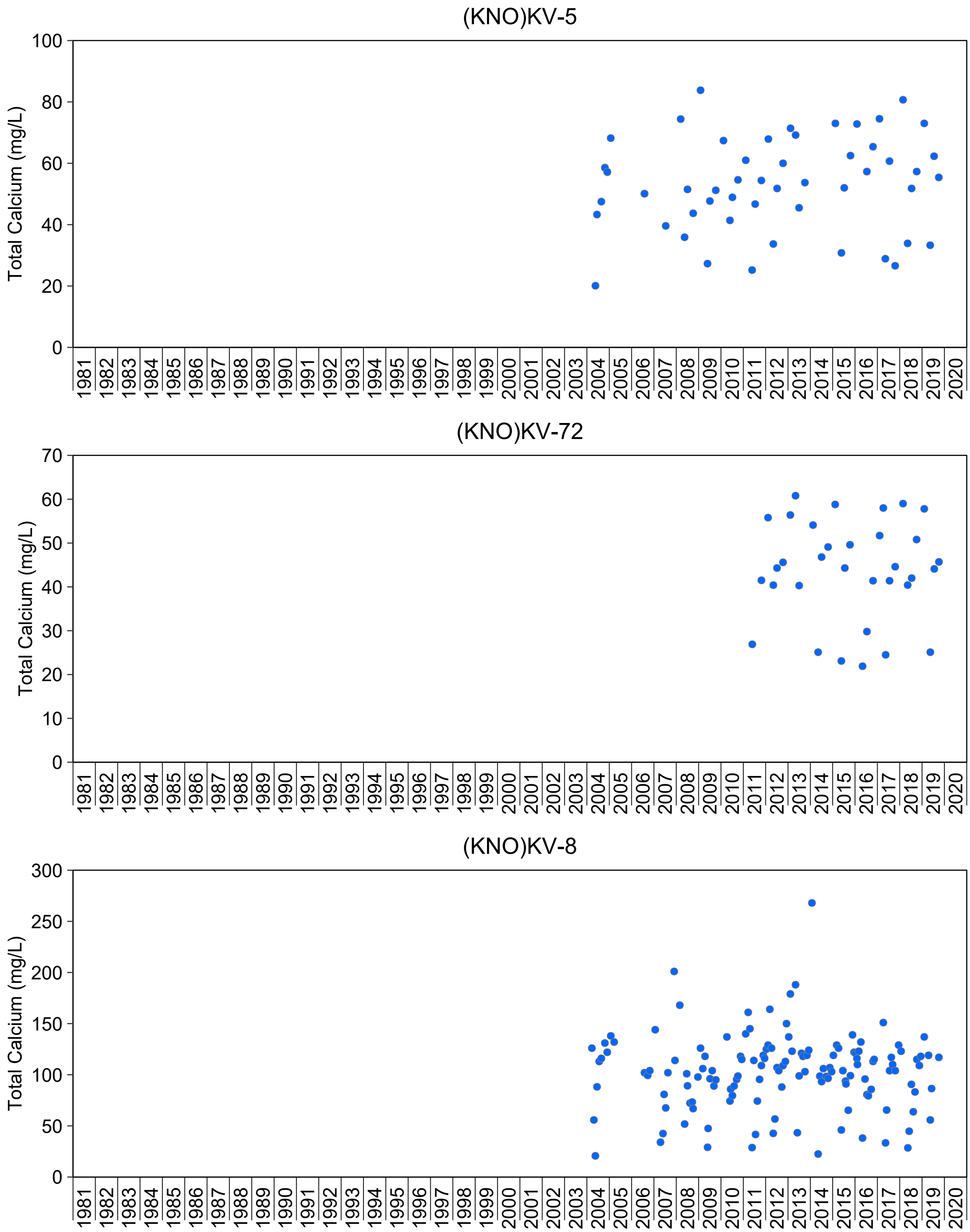


Figure A.41: Time Series Plots of Total Calcium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

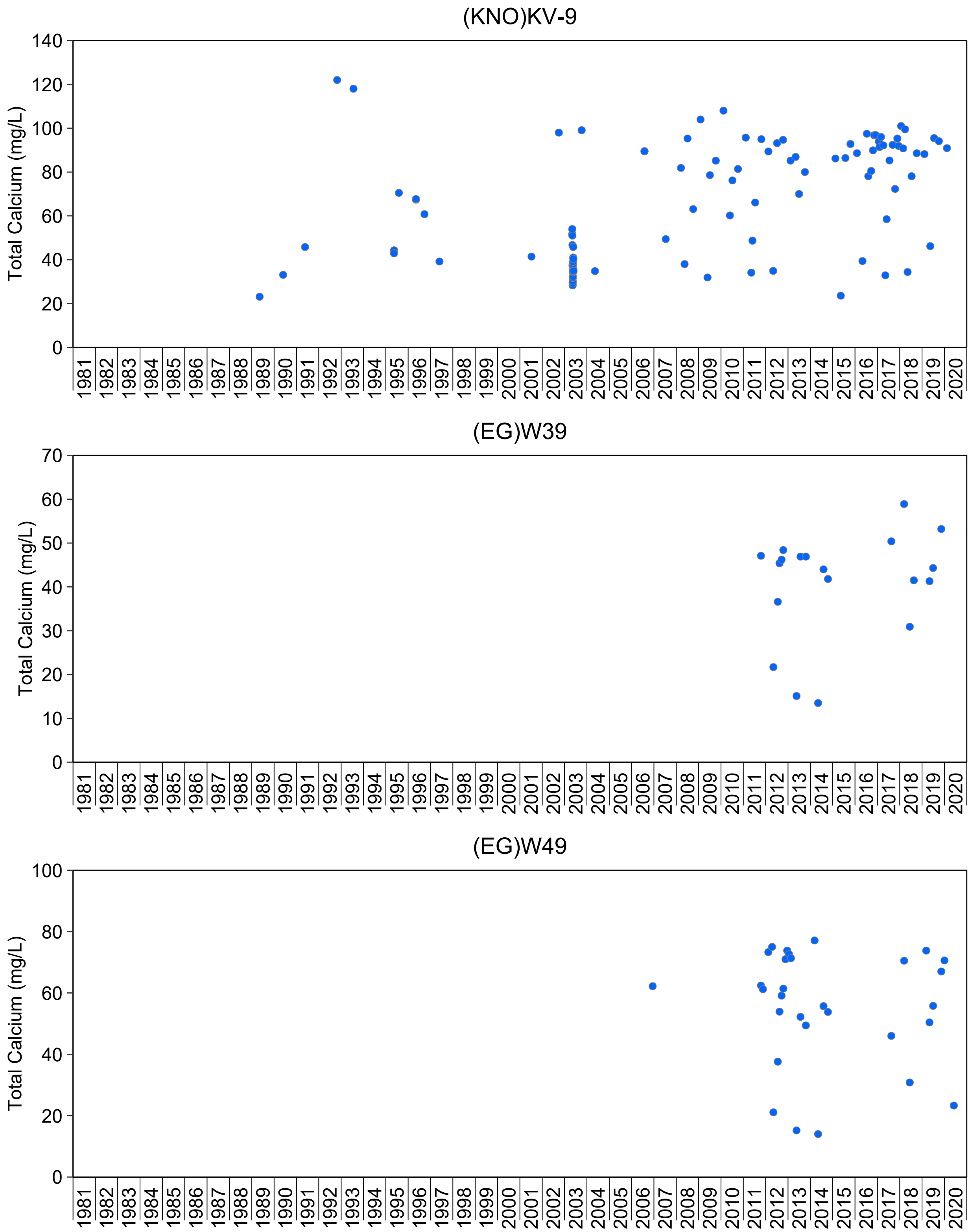


Figure A.41: Time Series Plots of Total Calcium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

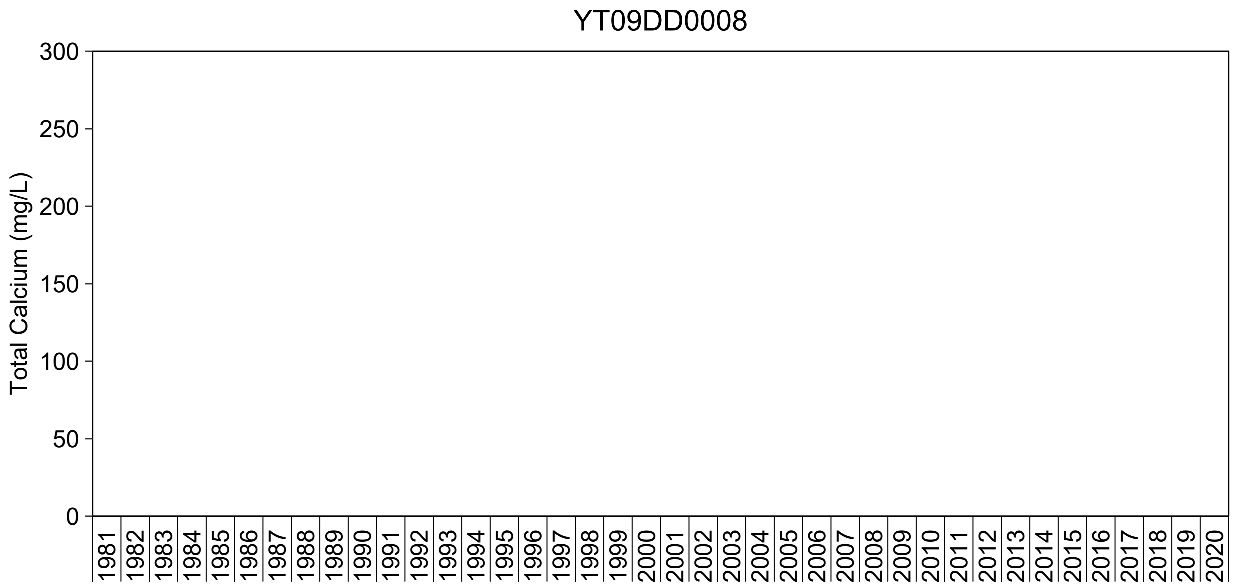


Figure A.41: Time Series Plots of Total Calcium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

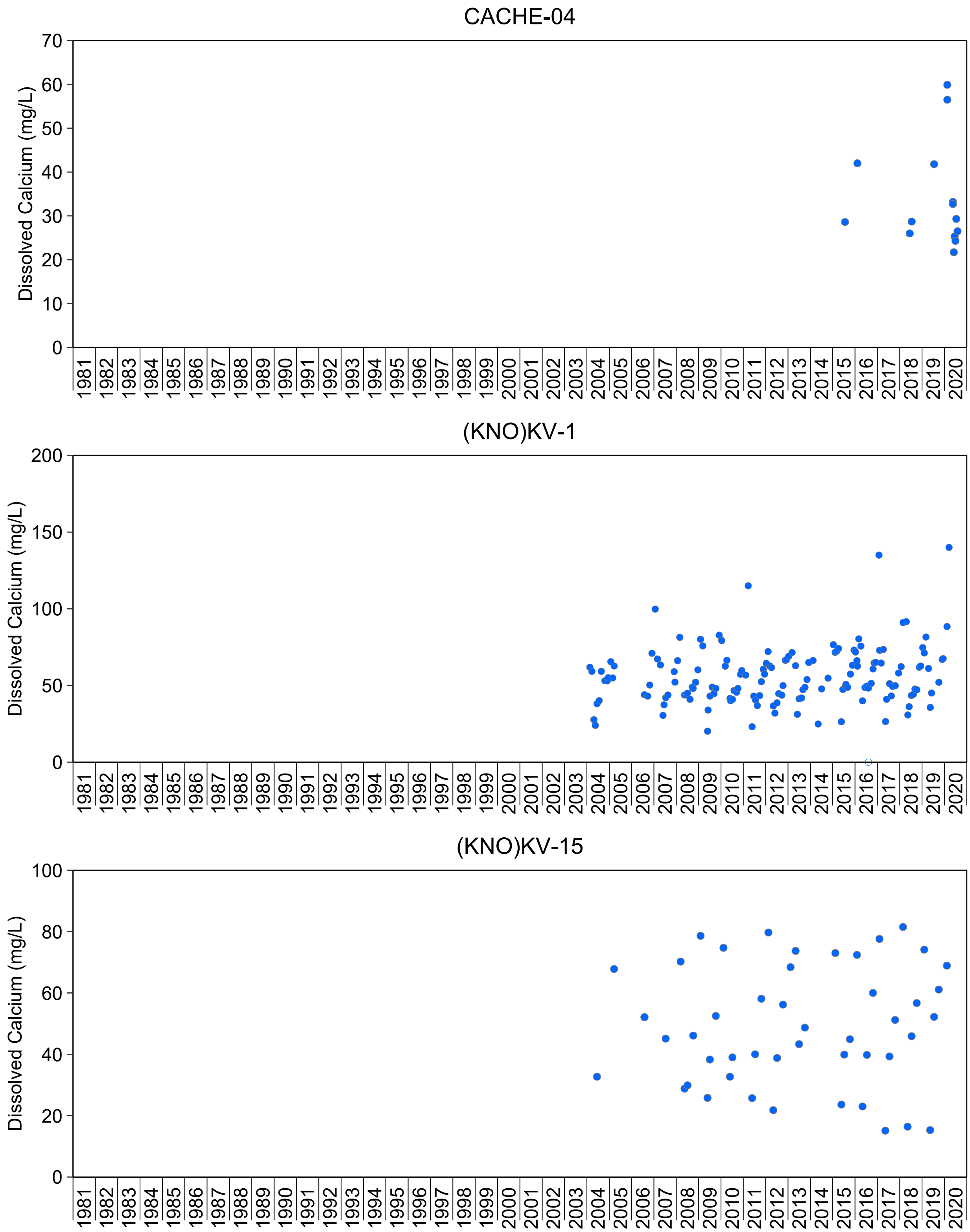


Figure A.42: Time Series Plots for Dissolved Calcium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

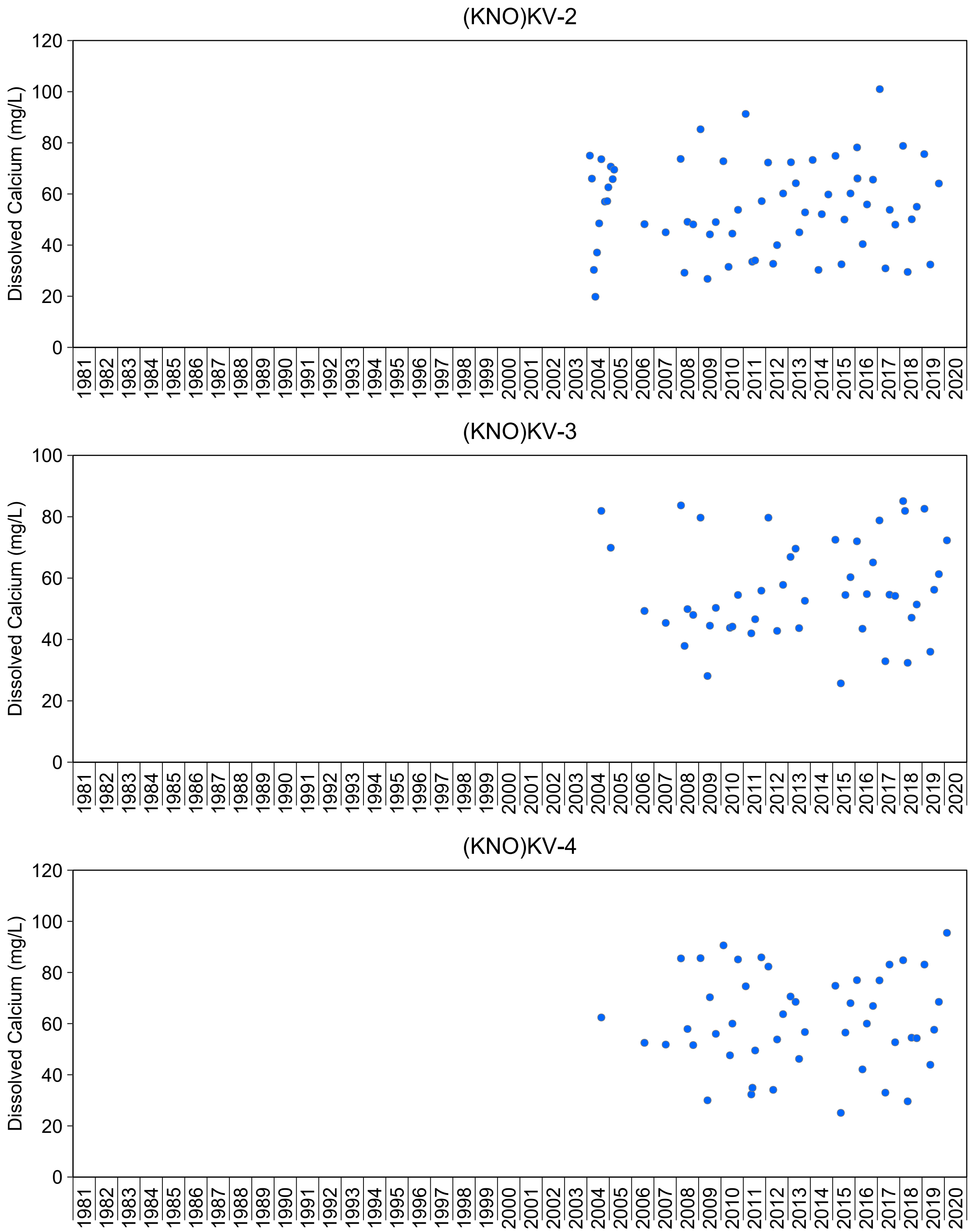


Figure A.42: Time Series Plots for Dissolved Calcium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

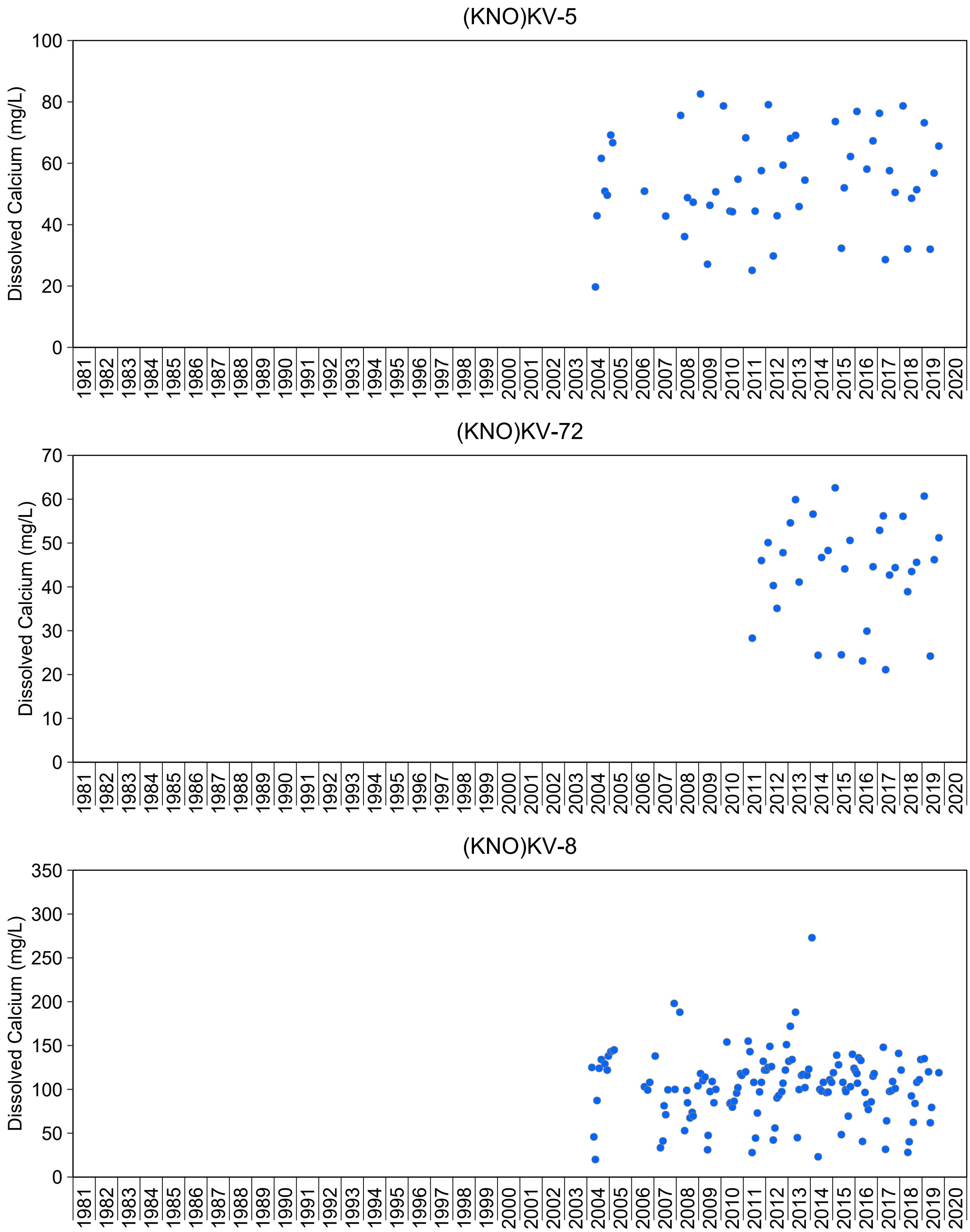


Figure A.42: Time Series Plots for Dissolved Calcium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

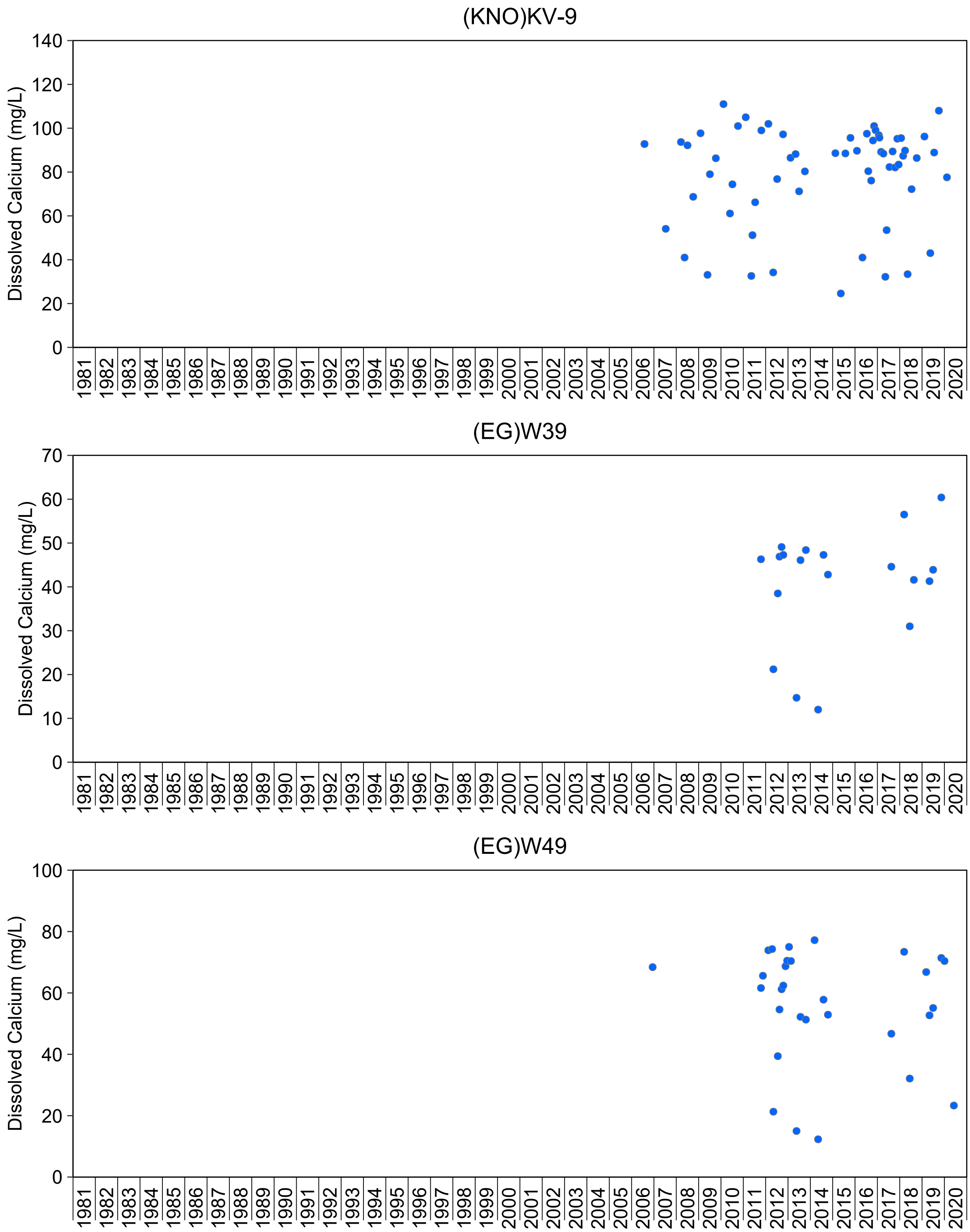


Figure A.42: Time Series Plots for Dissolved Calcium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

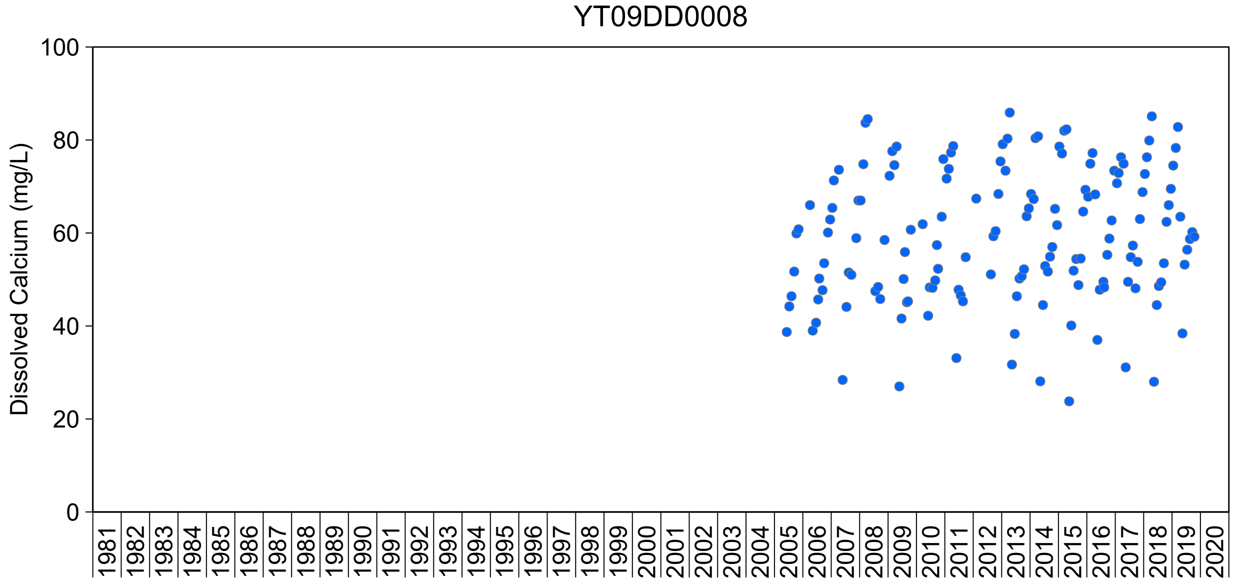


Figure A.42: Time Series Plots for Dissolved Calcium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

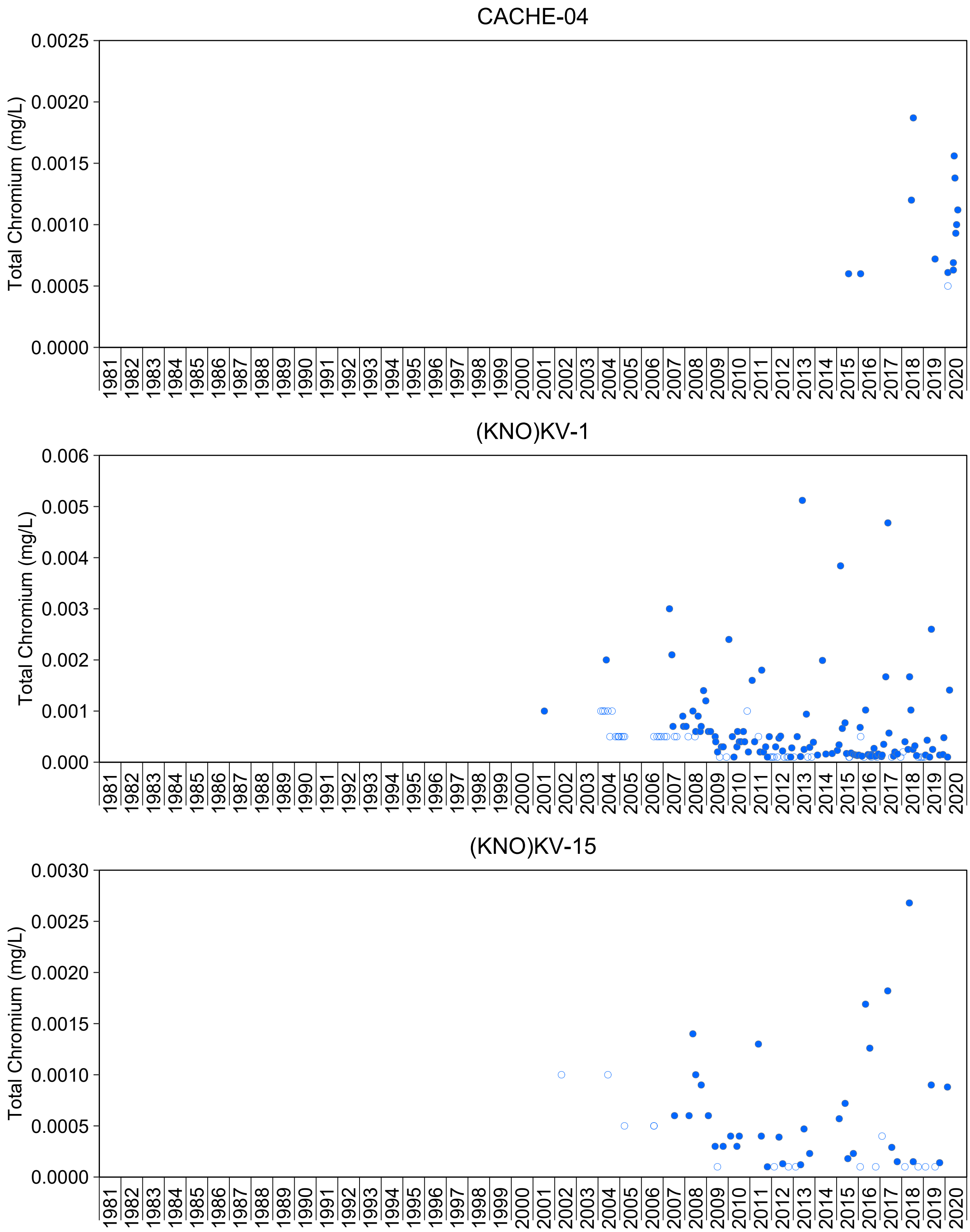


Figure A.43: Time Series Plots of Total Chromium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

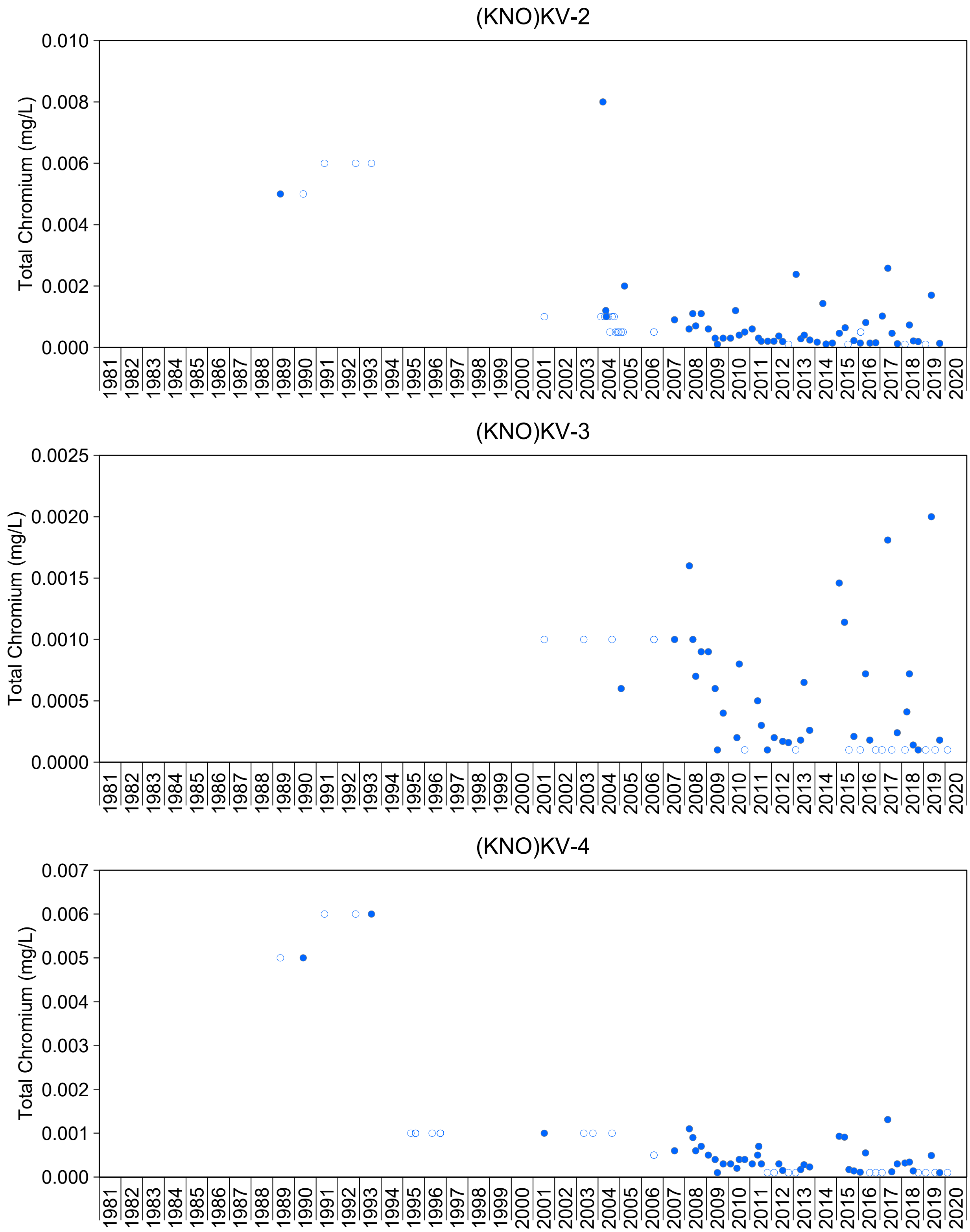


Figure A.43: Time Series Plots of Total Chromium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

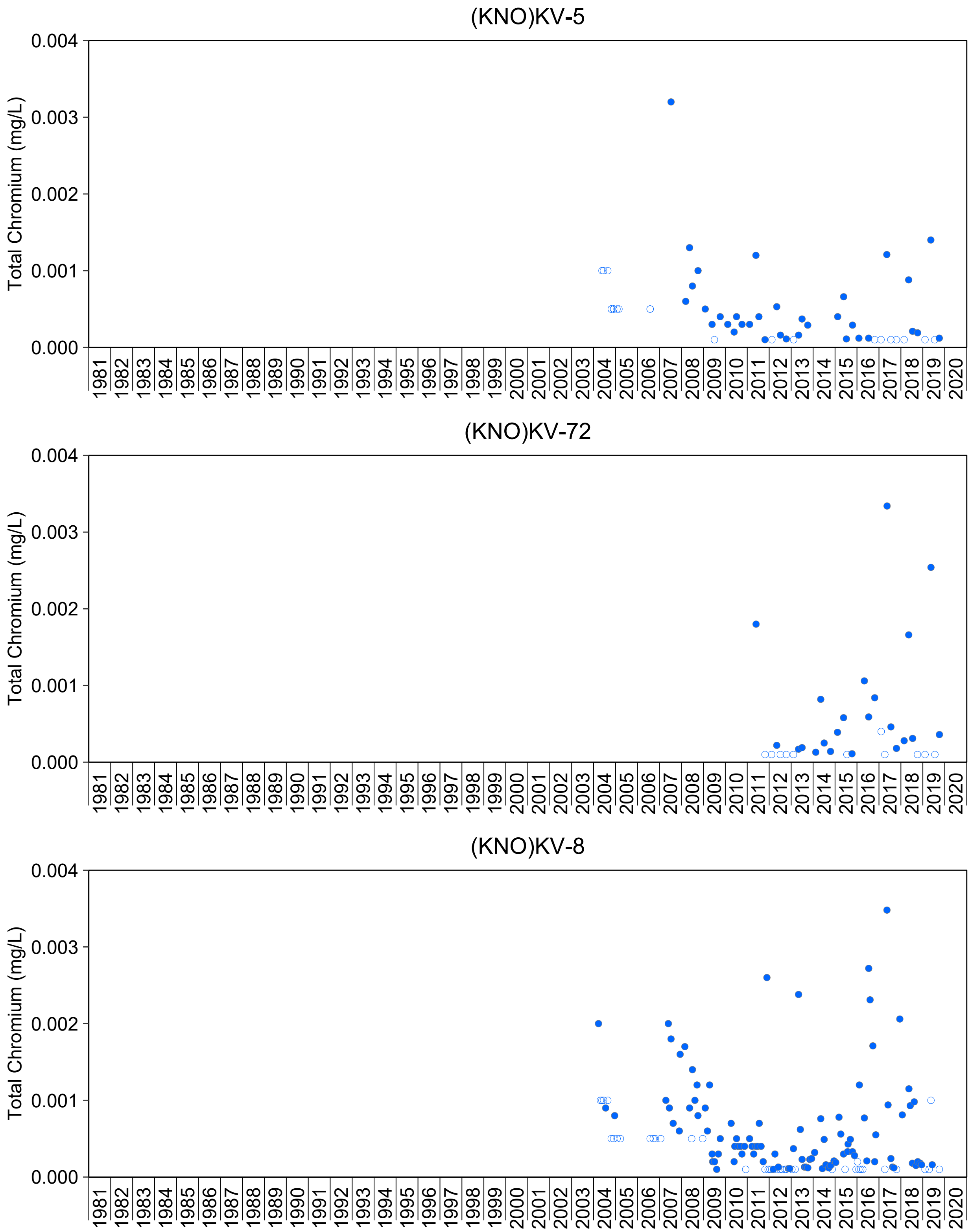


Figure A.43: Time Series Plots of Total Chromium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

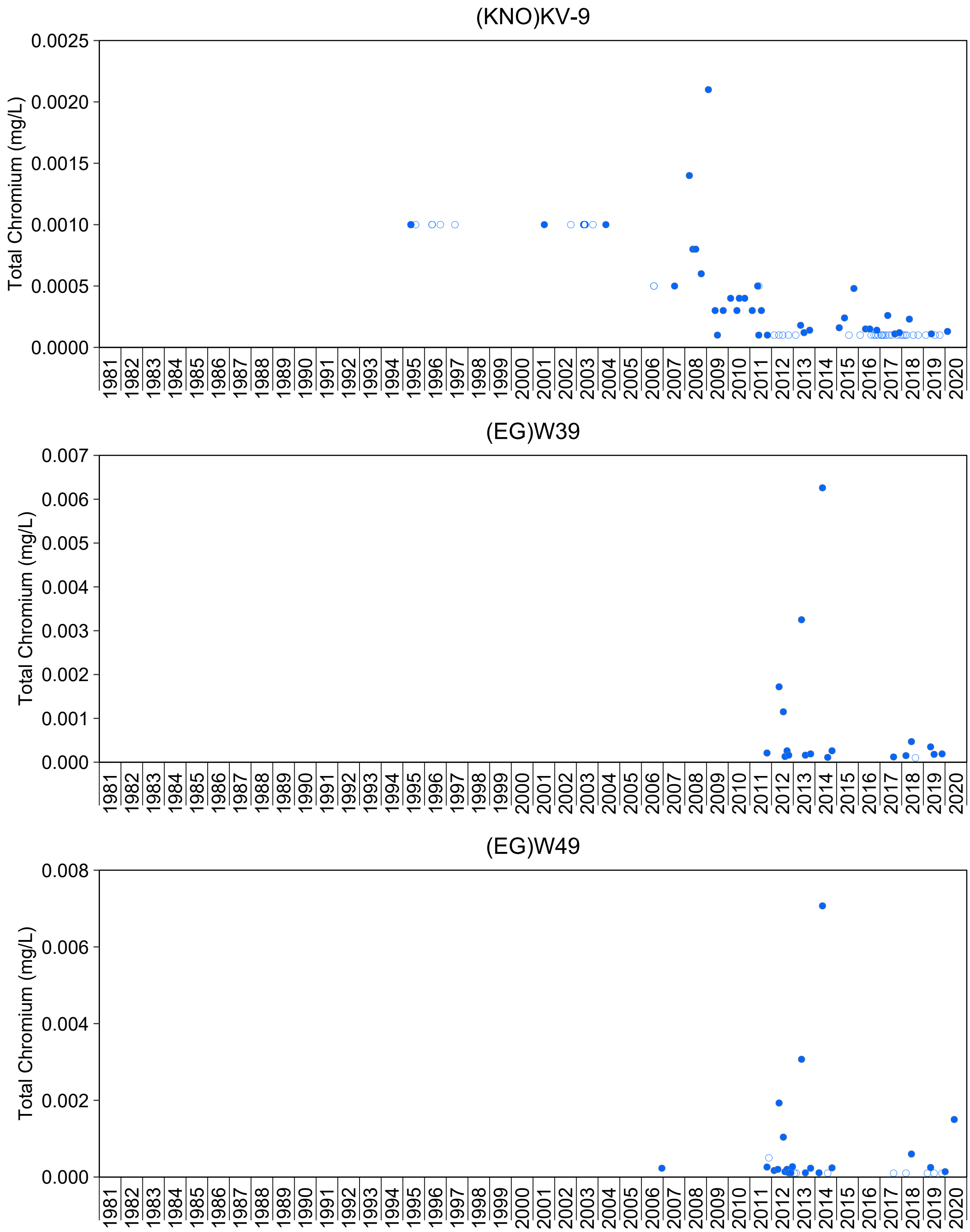


Figure A.43: Time Series Plots of Total Chromium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

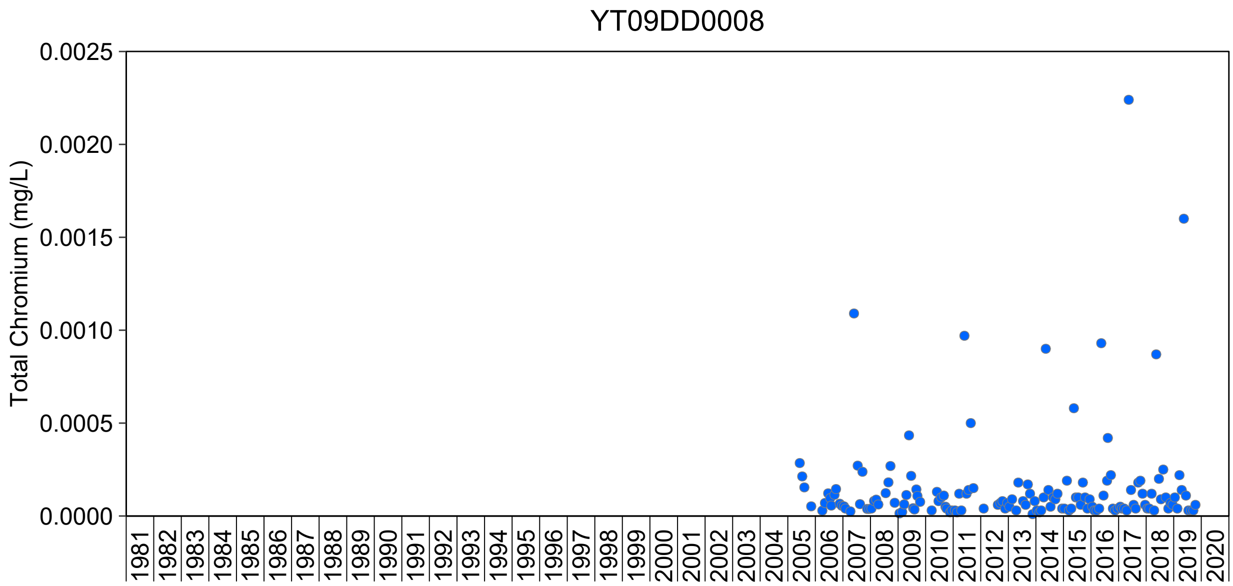


Figure A.43: Time Series Plots of Total Chromium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

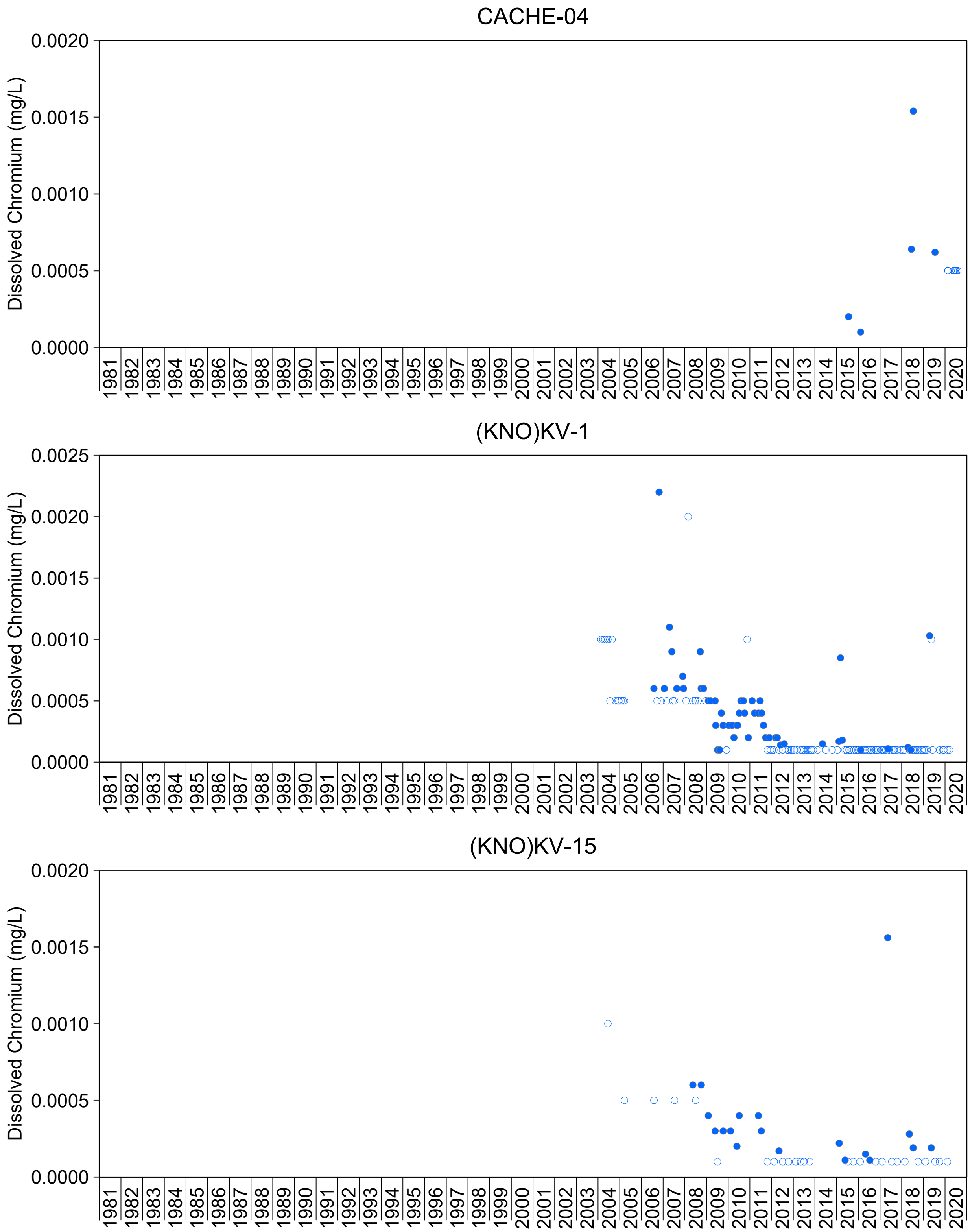
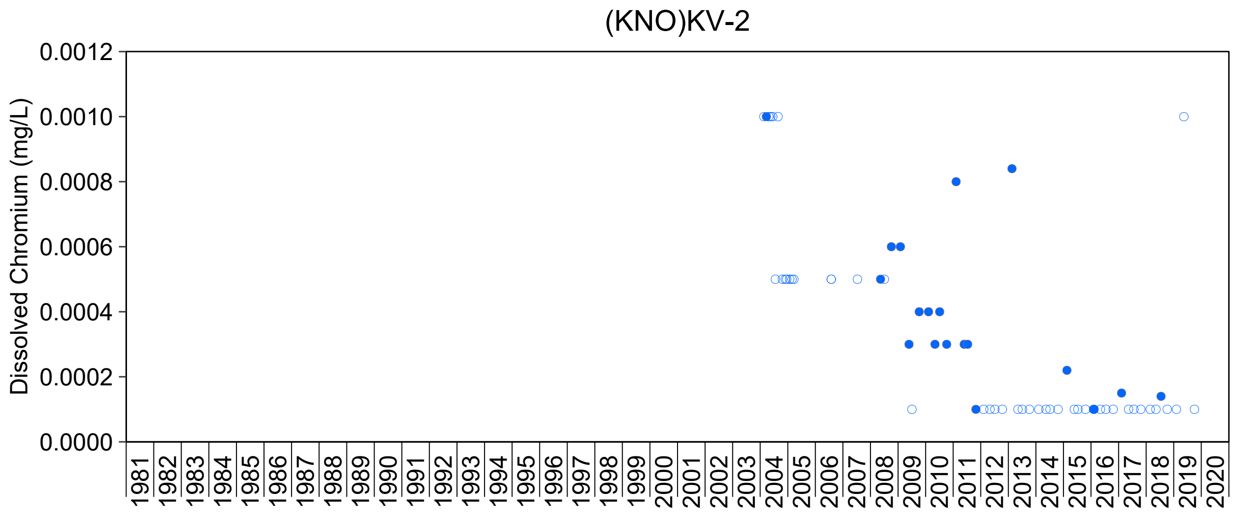
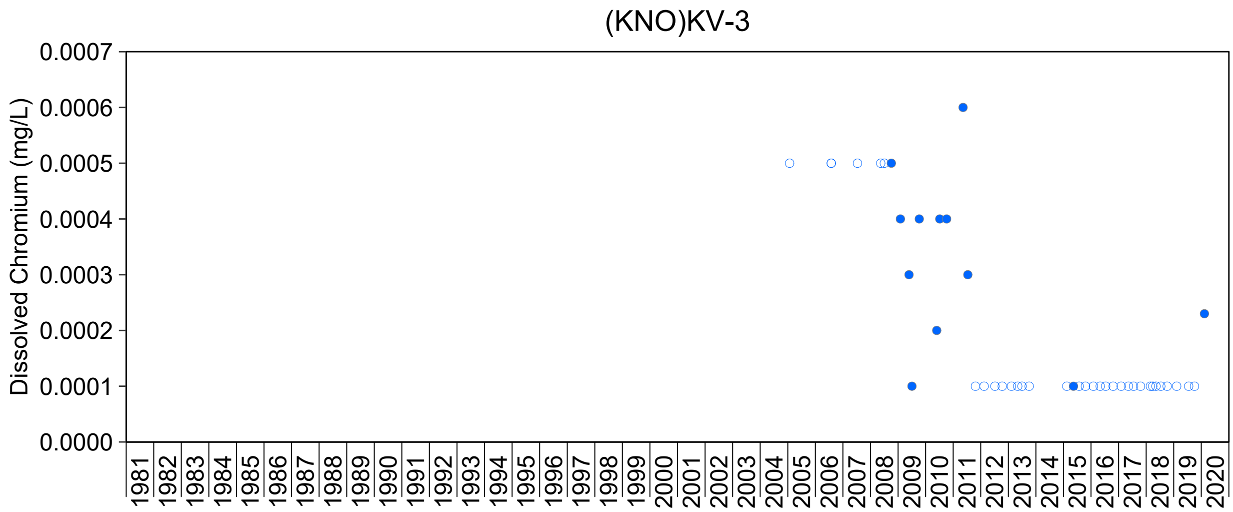


Figure A.44: Time Series Plots of Dissolved Chromium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.





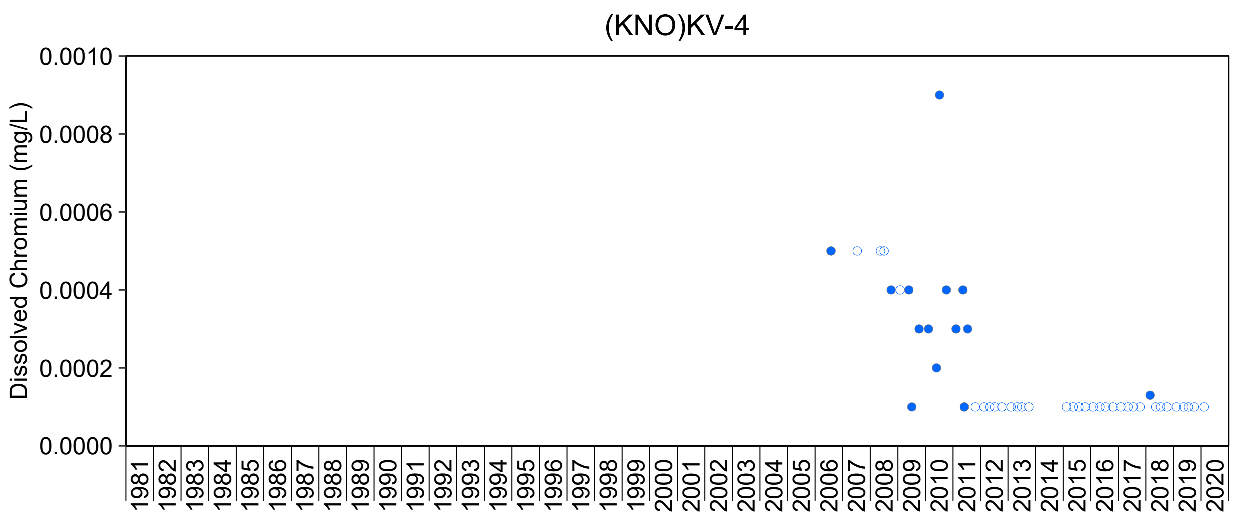


Figure A.44: Time Series Plots of Dissolved Chromium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

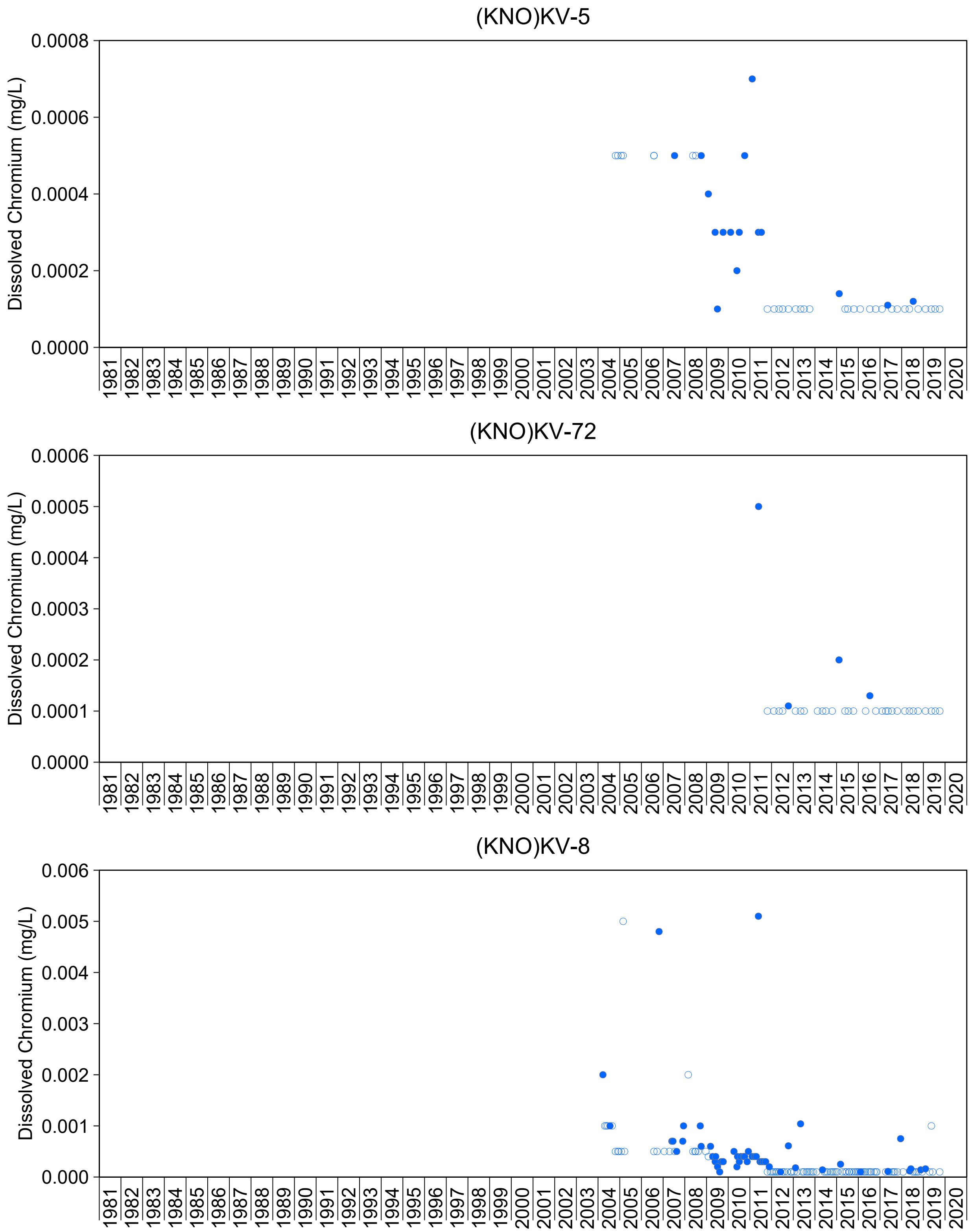


Figure A.44: Time Series Plots of Dissolved Chromium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

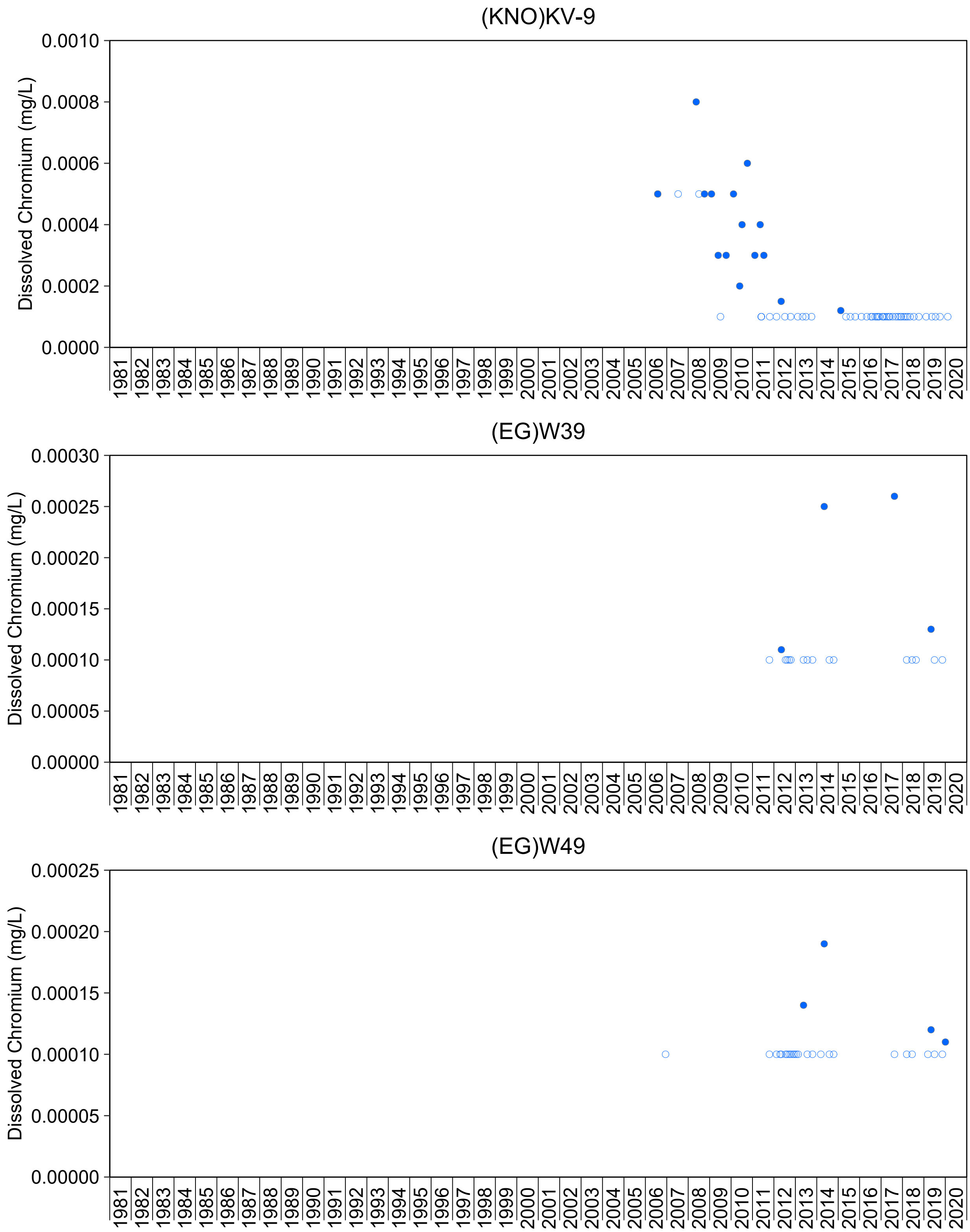


Figure A.44: Time Series Plots of Dissolved Chromium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

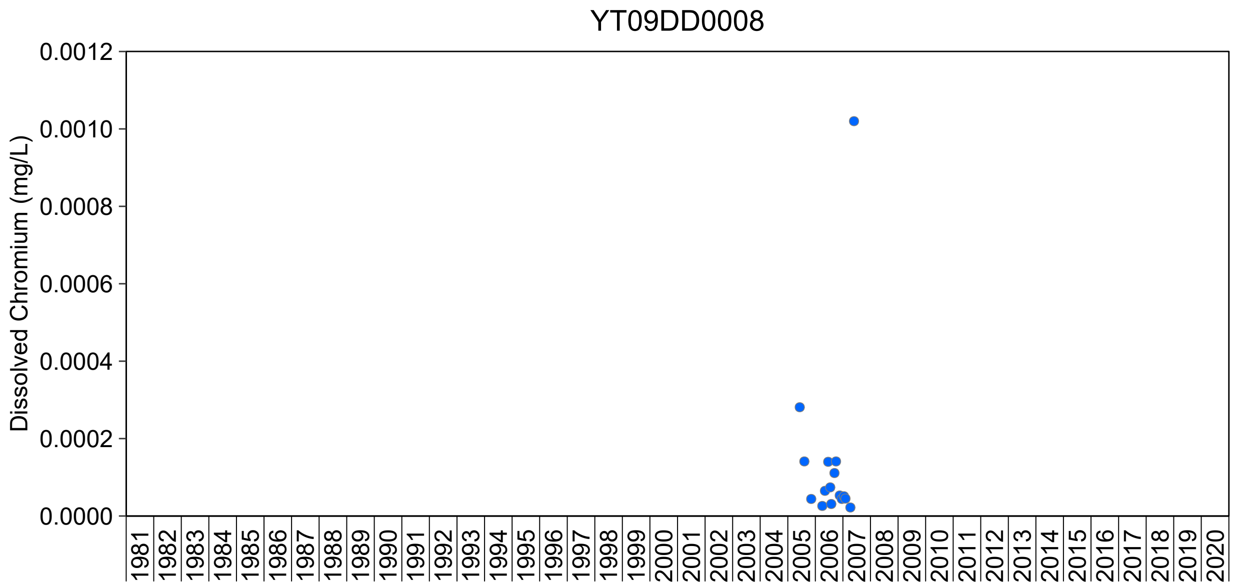


Figure A.44: Time Series Plots of Dissolved Chromium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

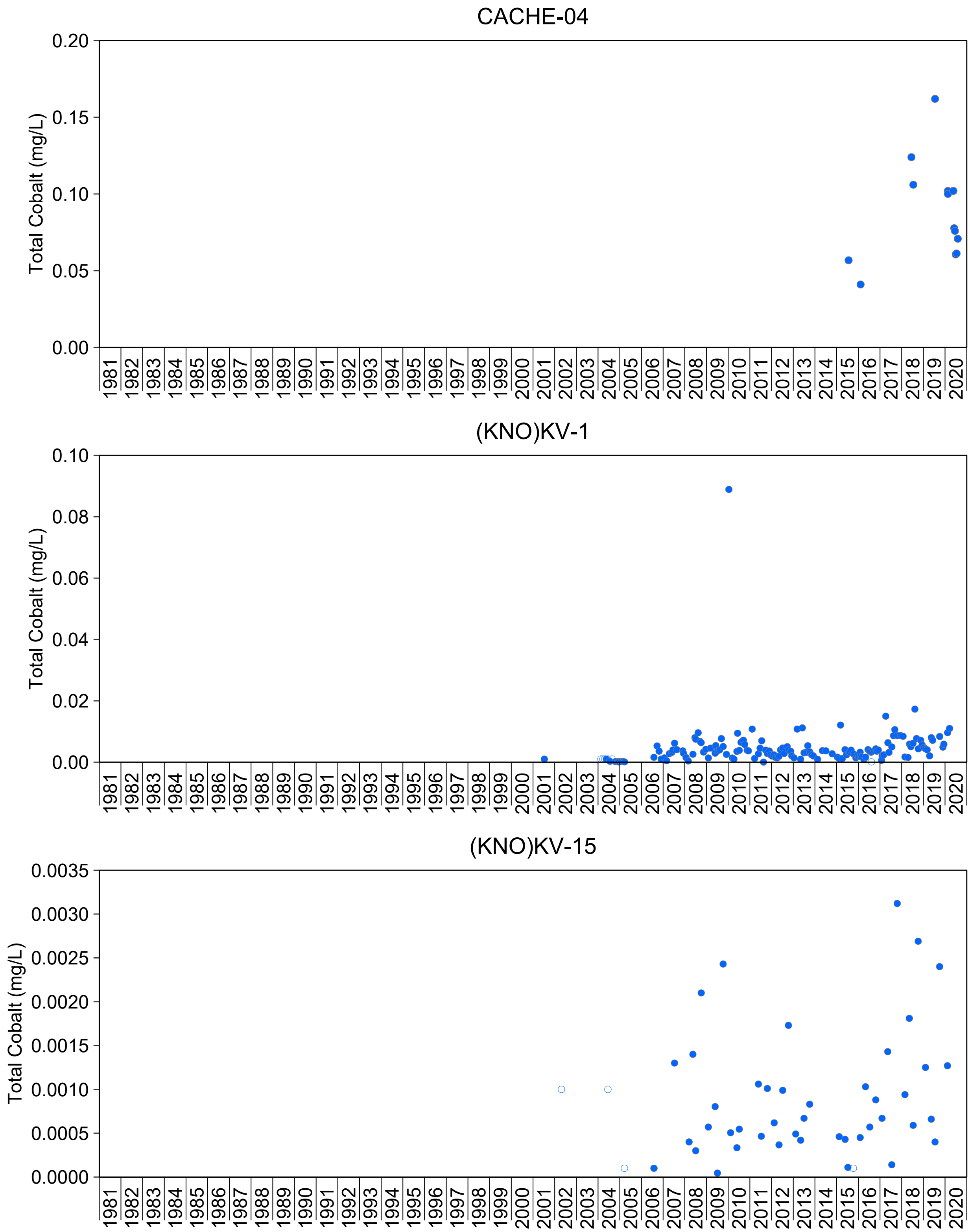


Figure A.45: Time Series Plots of Total Cobalt Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

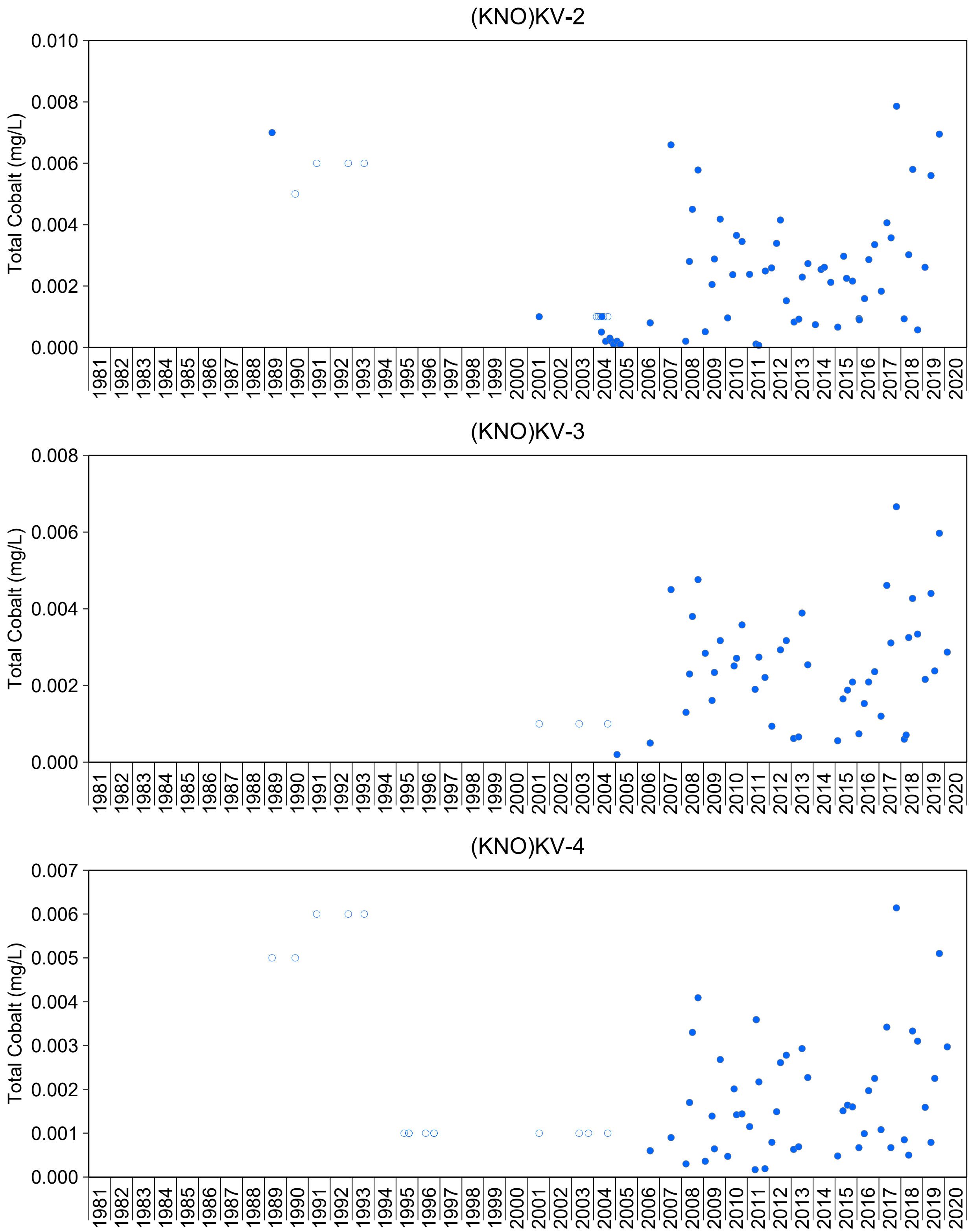


Figure A.45: Time Series Plots of Total Cobalt Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

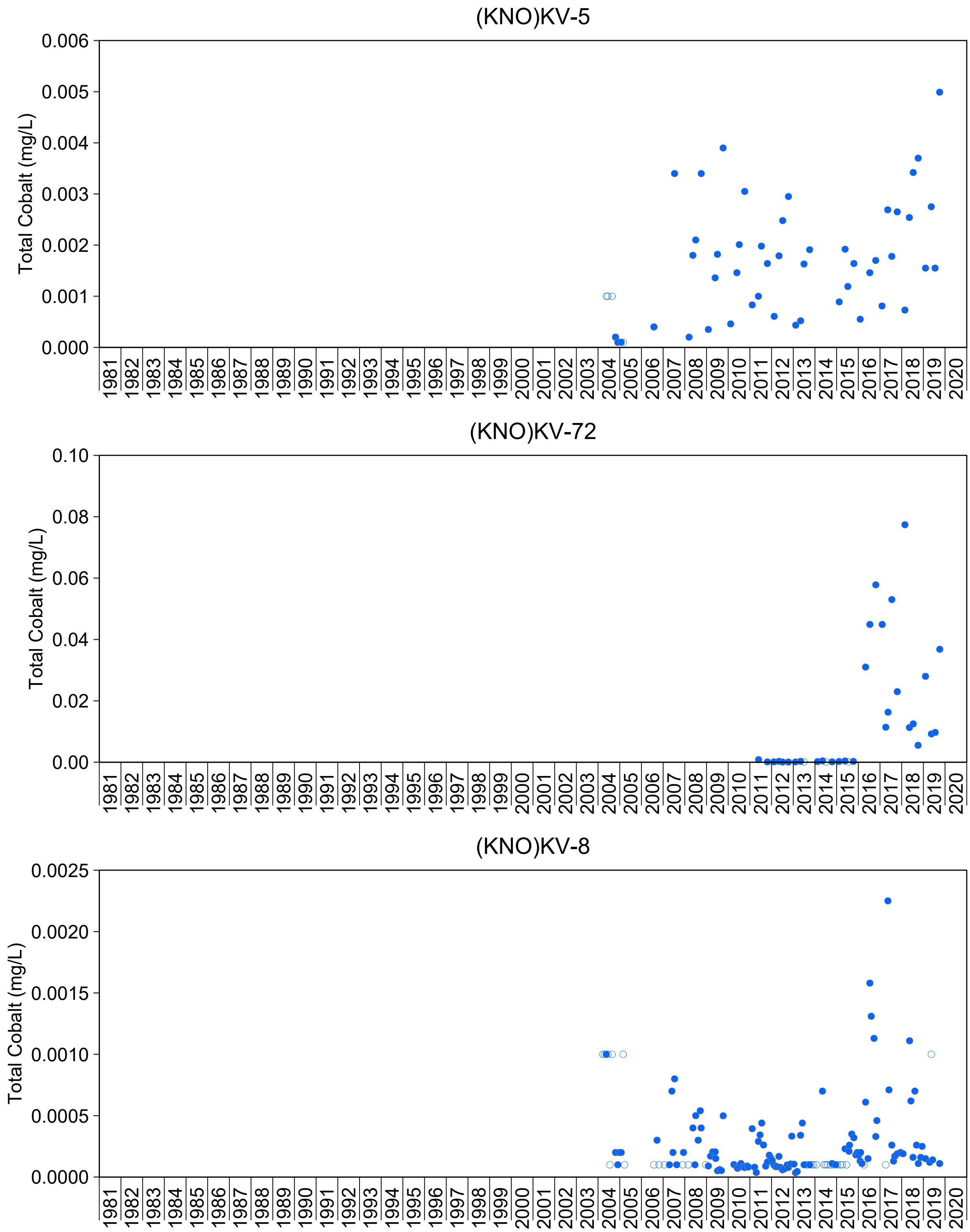


Figure A.45: Time Series Plots of Total Cobalt Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

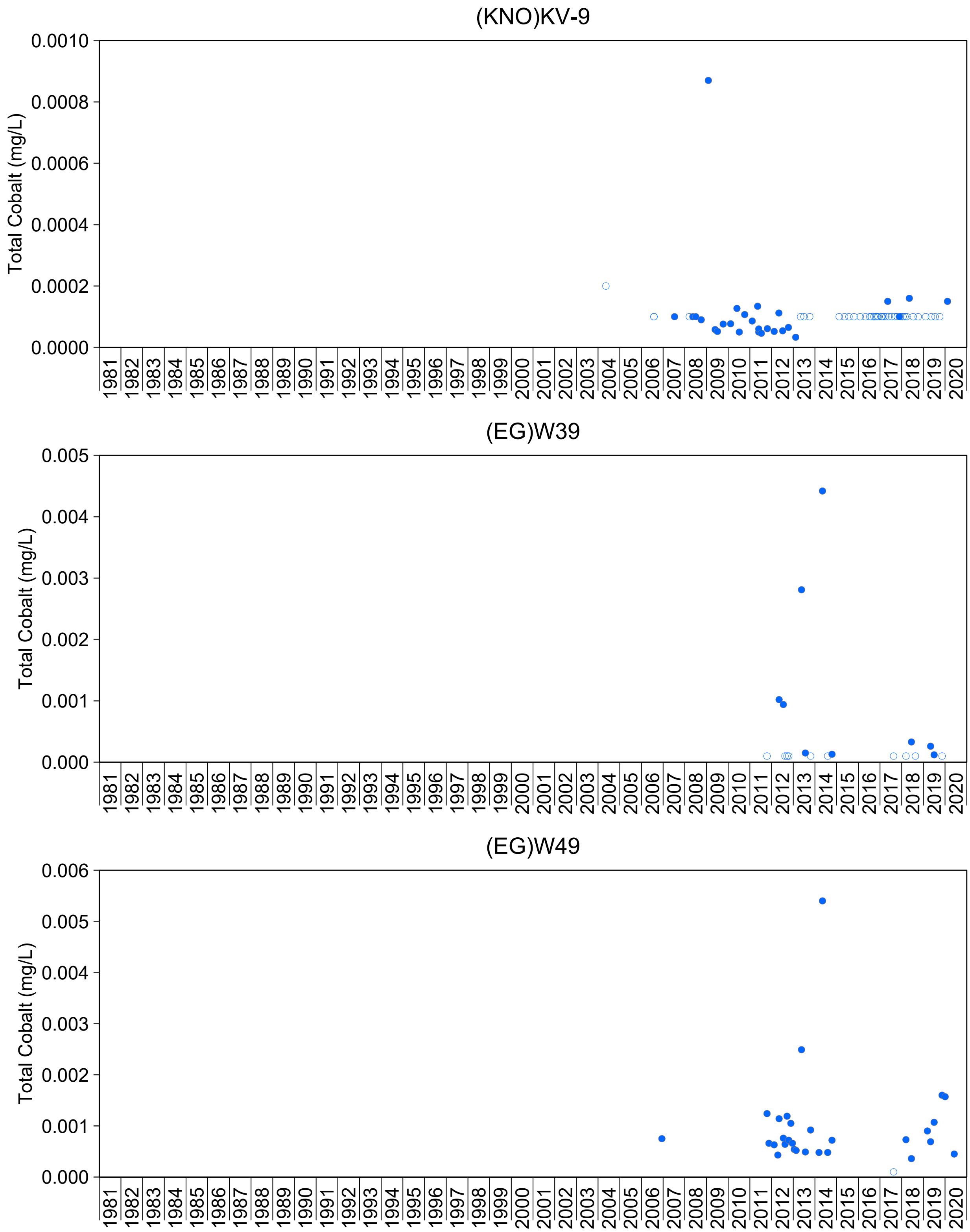


Figure A.45: Time Series Plots of Total Cobalt Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

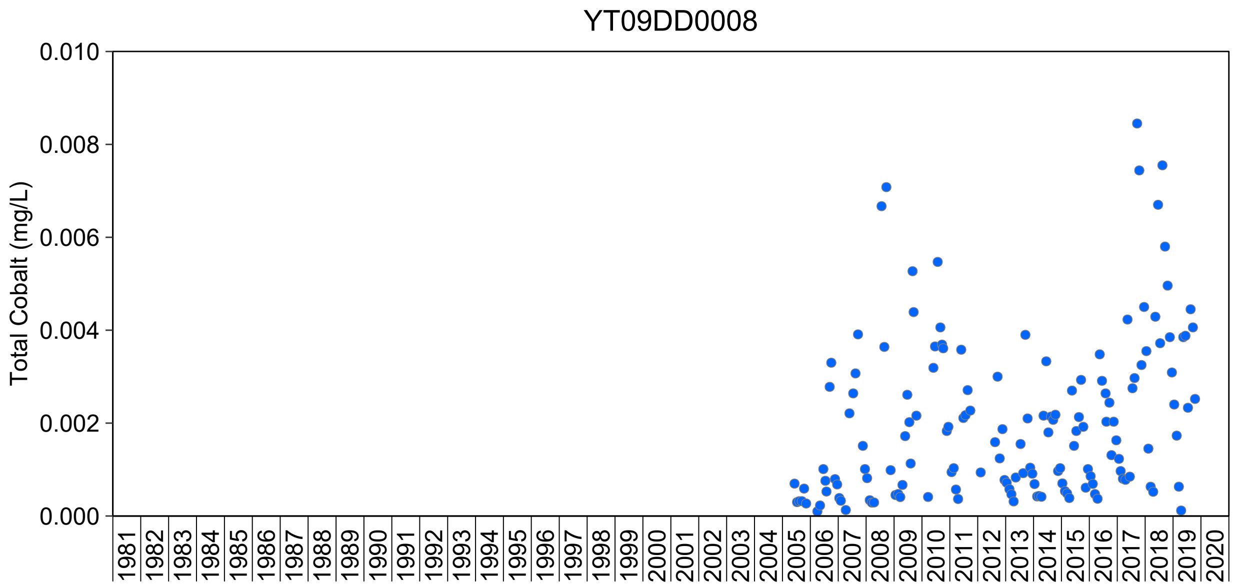


Figure A.45: Time Series Plots of Total Cobalt Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

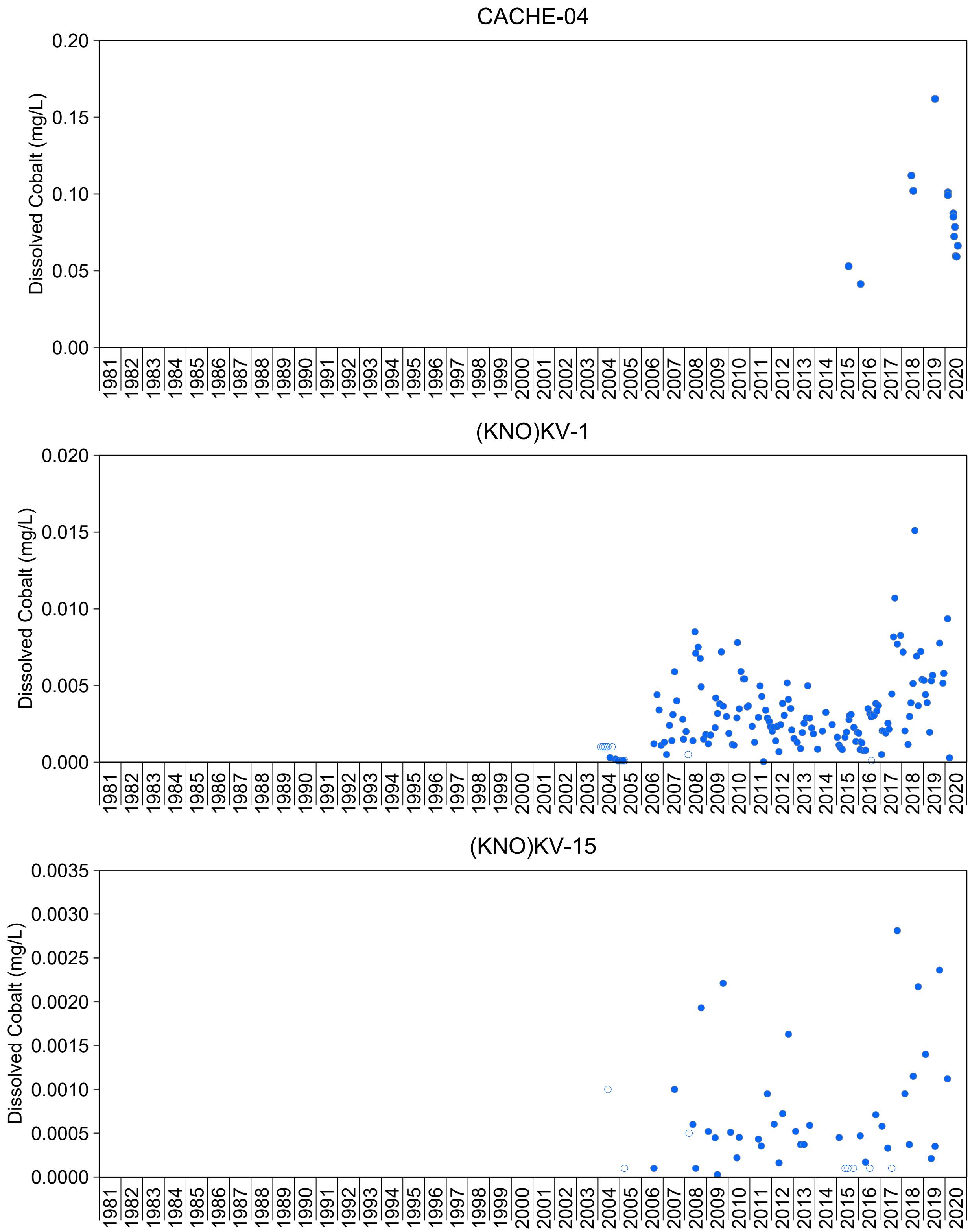
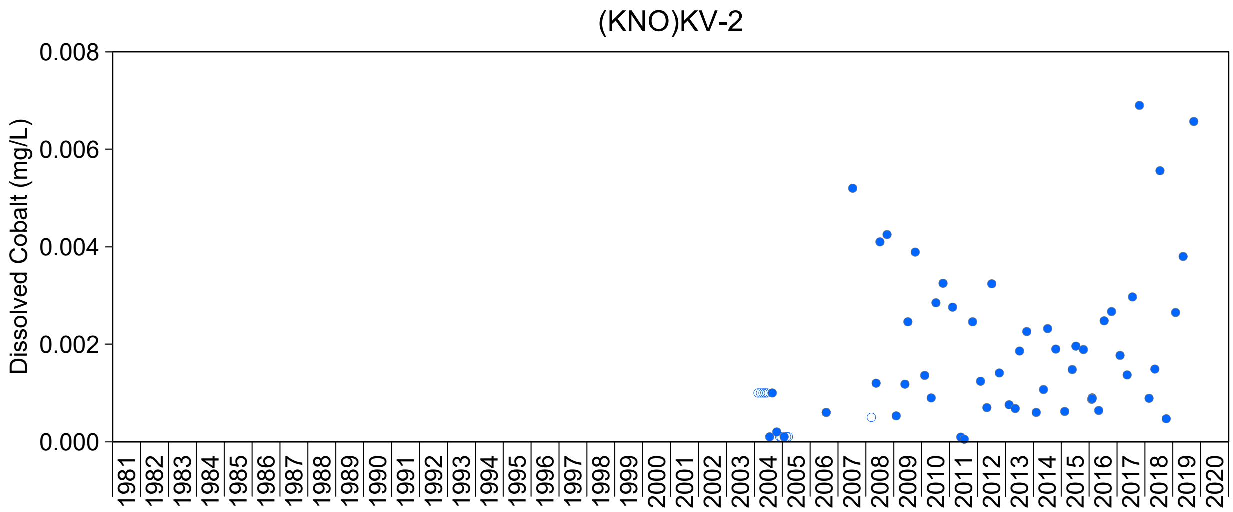
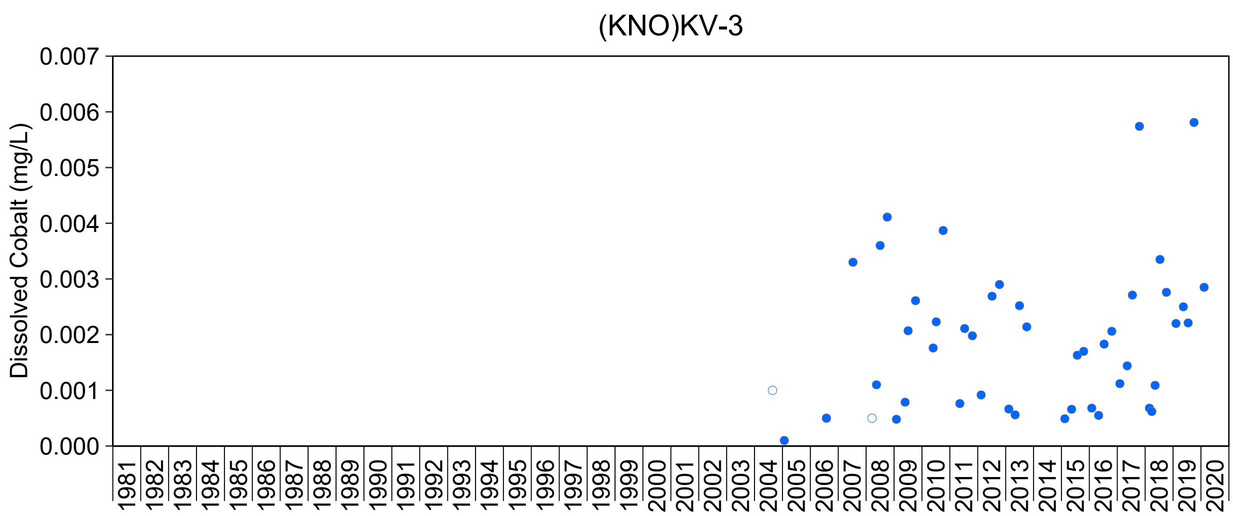


Figure A.46: Time Series Plots of Dissolved Cobalt Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.





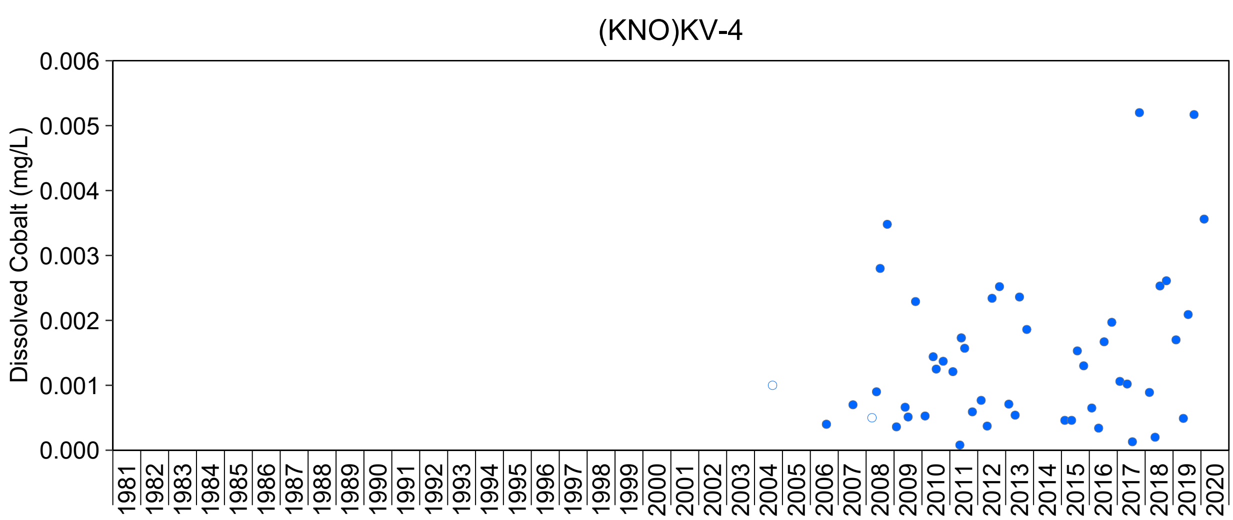


Figure A.46: Time Series Plots of Dissolved Cobalt Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

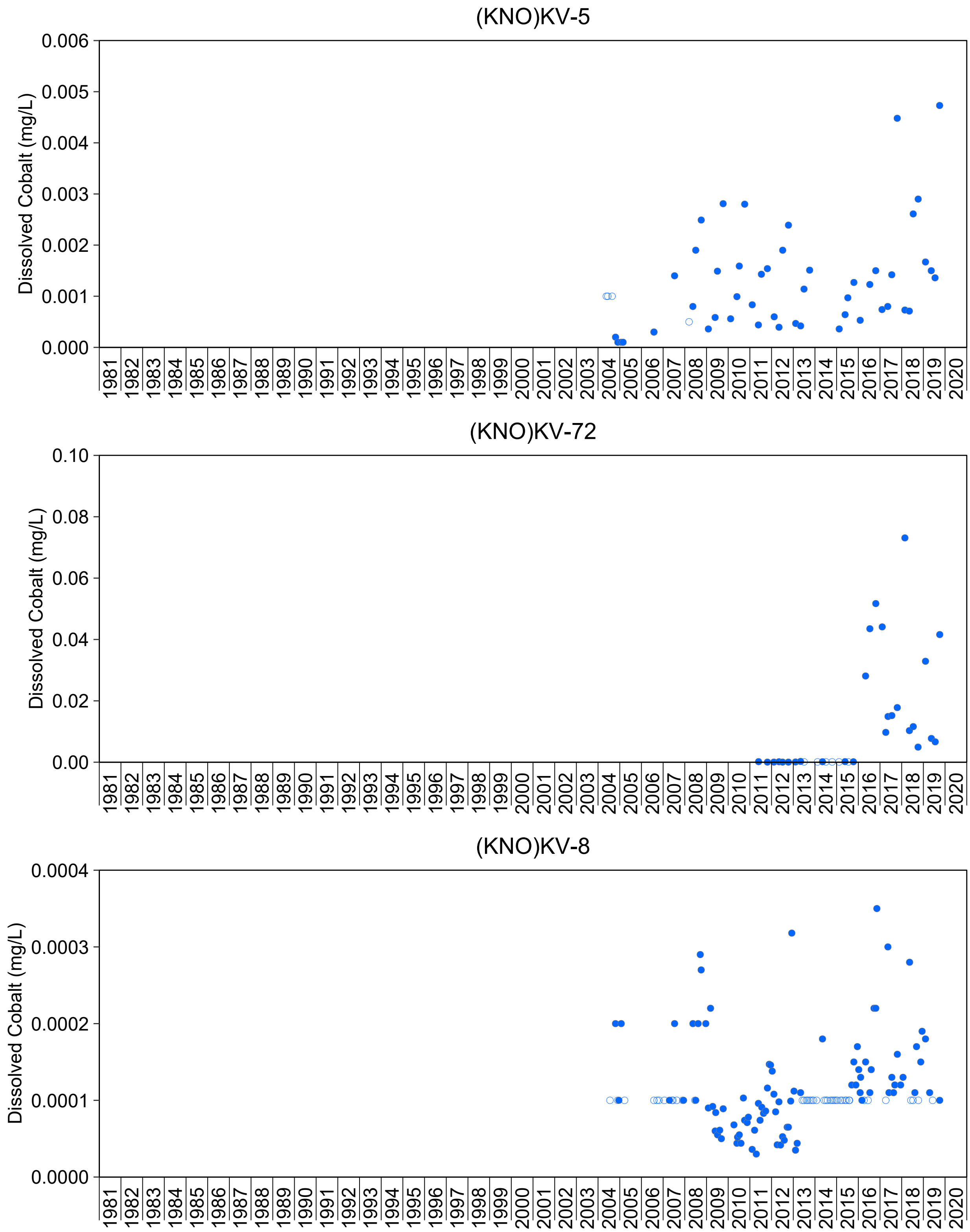


Figure A.46: Time Series Plots of Dissolved Cobalt Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

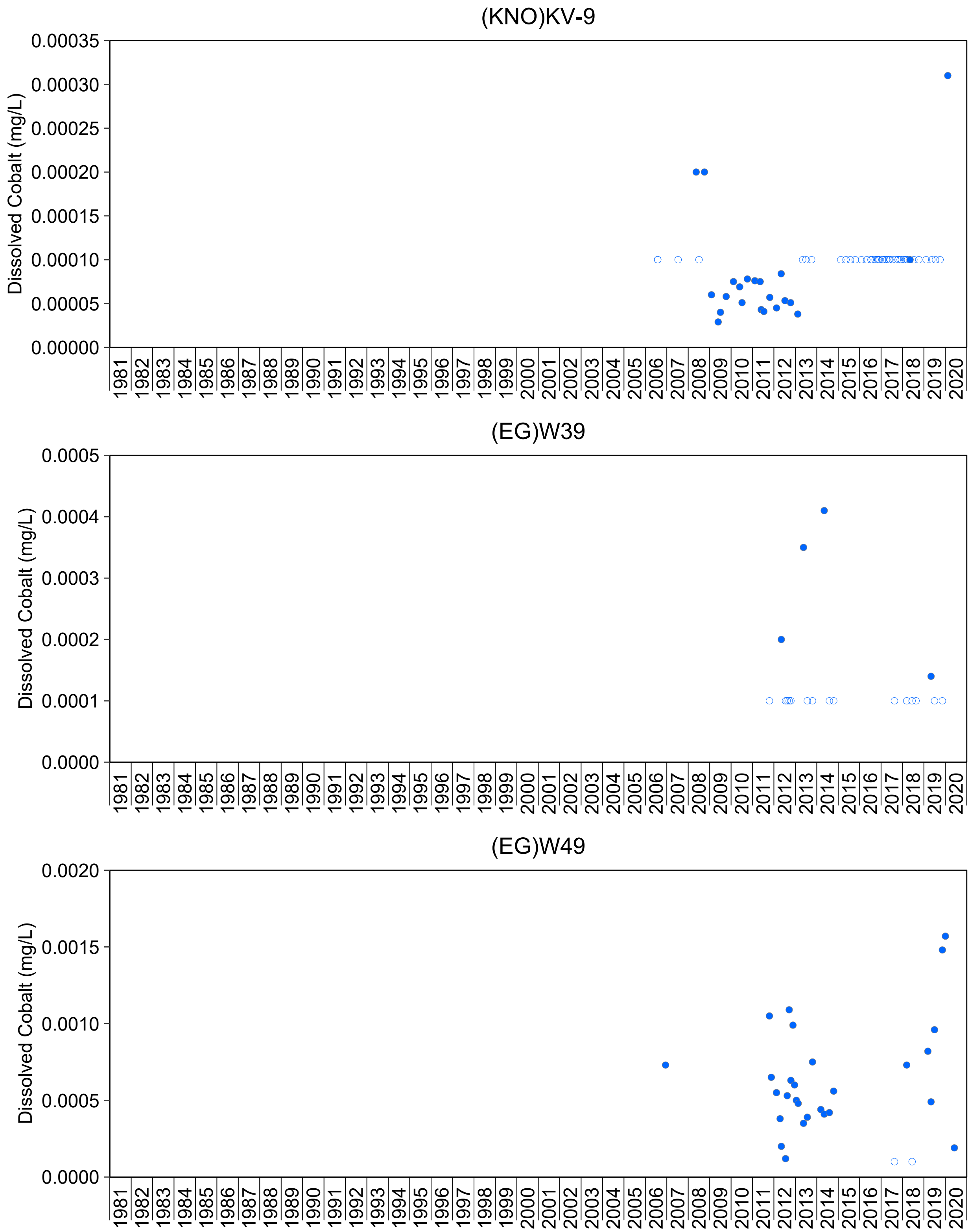


Figure A.46: Time Series Plots of Dissolved Cobalt Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

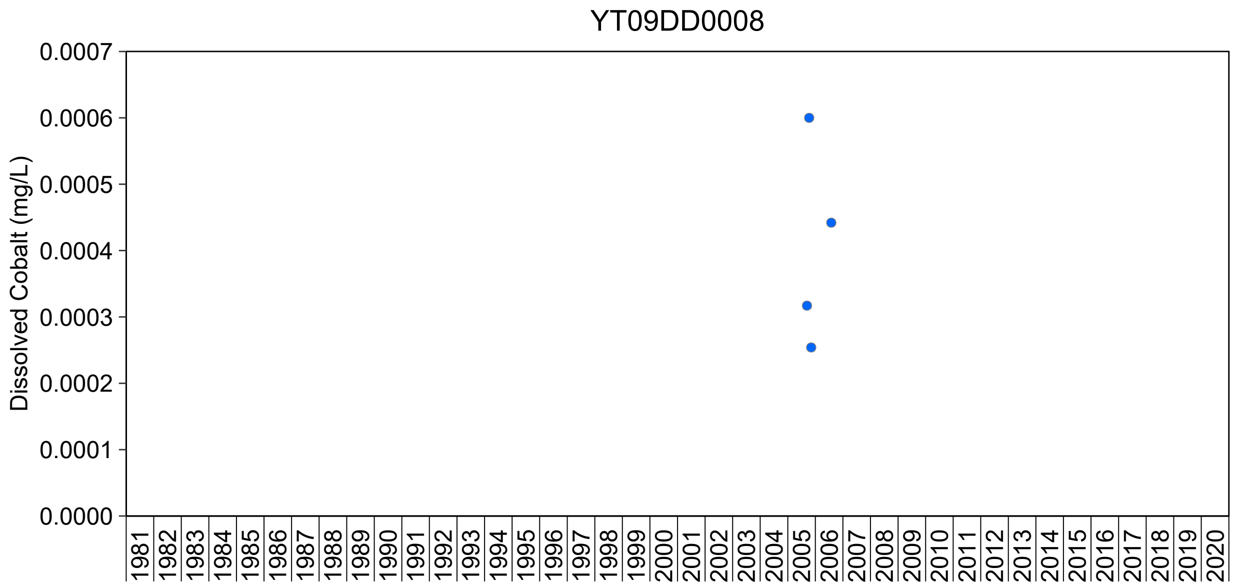


Figure A.46: Time Series Plots of Dissolved Cobalt Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

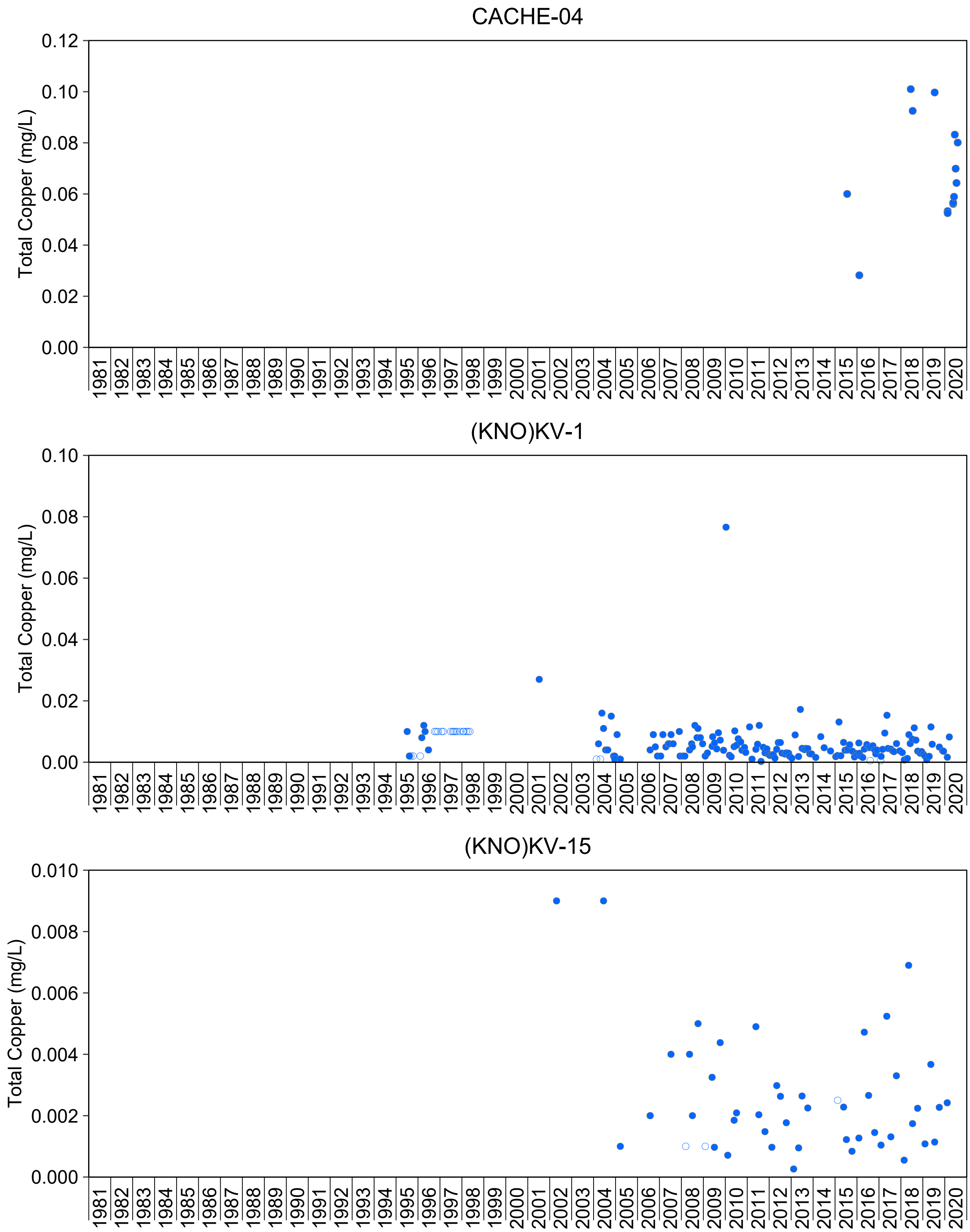


Figure A.47: Time Series Plots of Total Copper Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

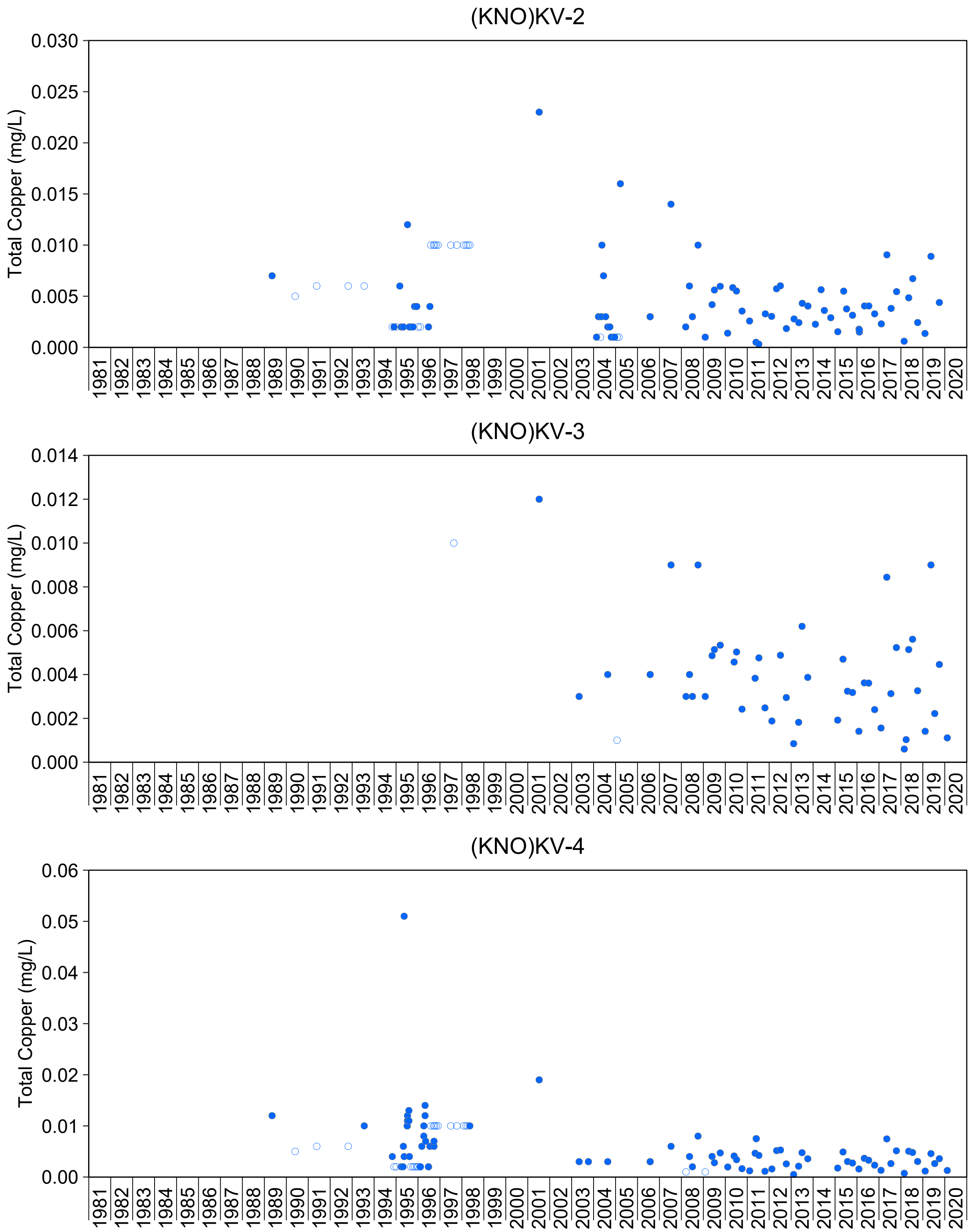


Figure A.47: Time Series Plots of Total Copper Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

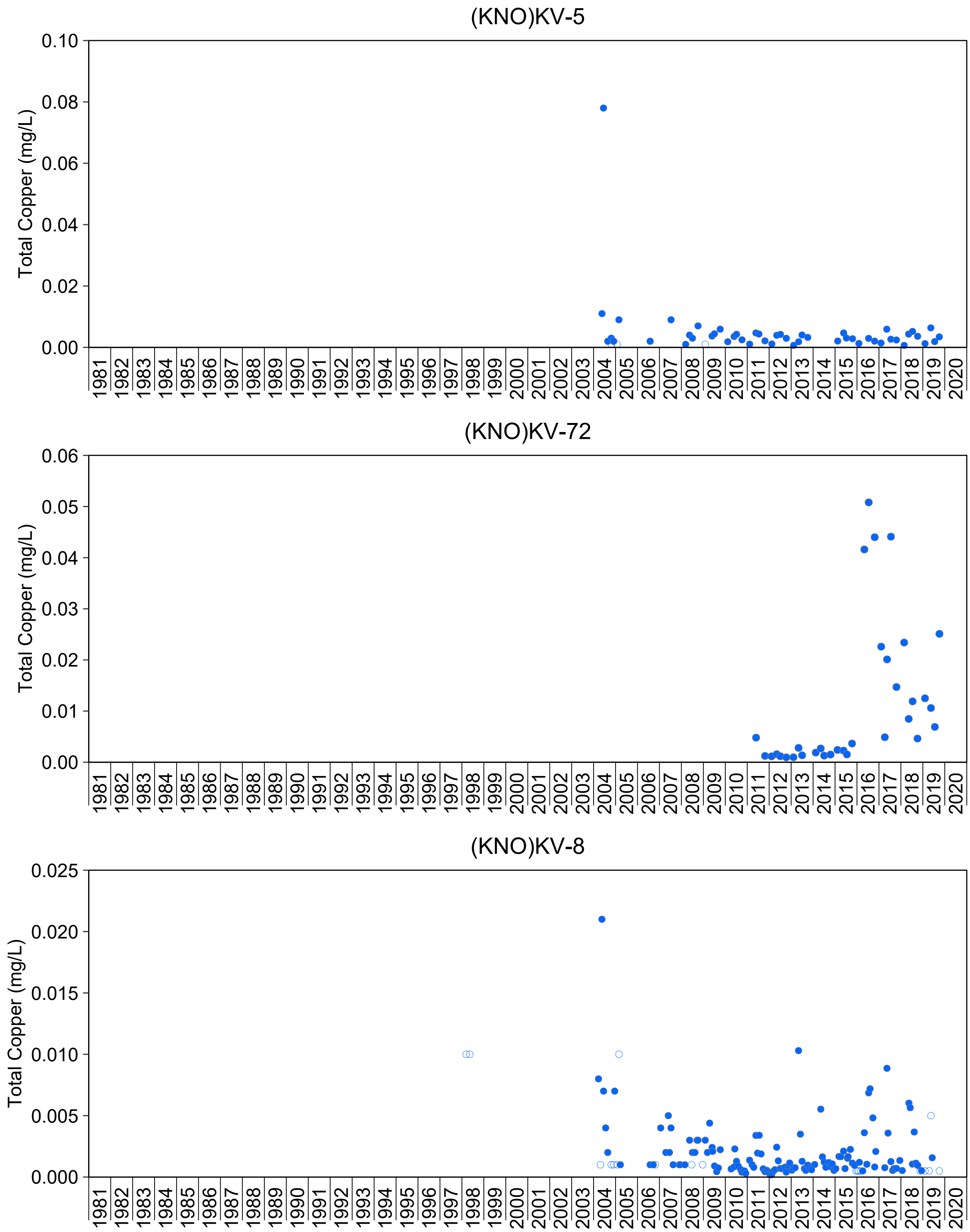


Figure A.47: Time Series Plots of Total Copper Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

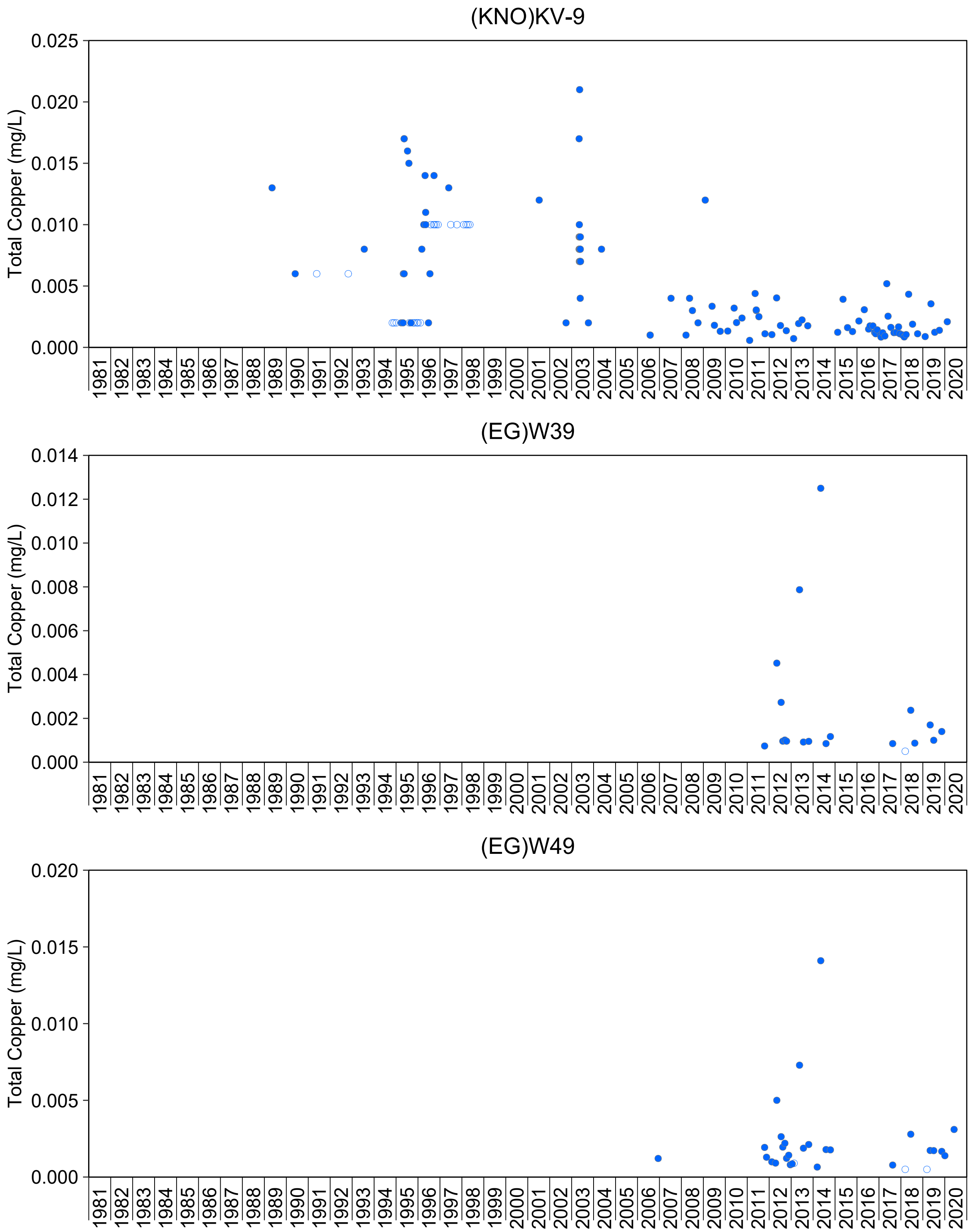


Figure A.47: Time Series Plots of Total Copper Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

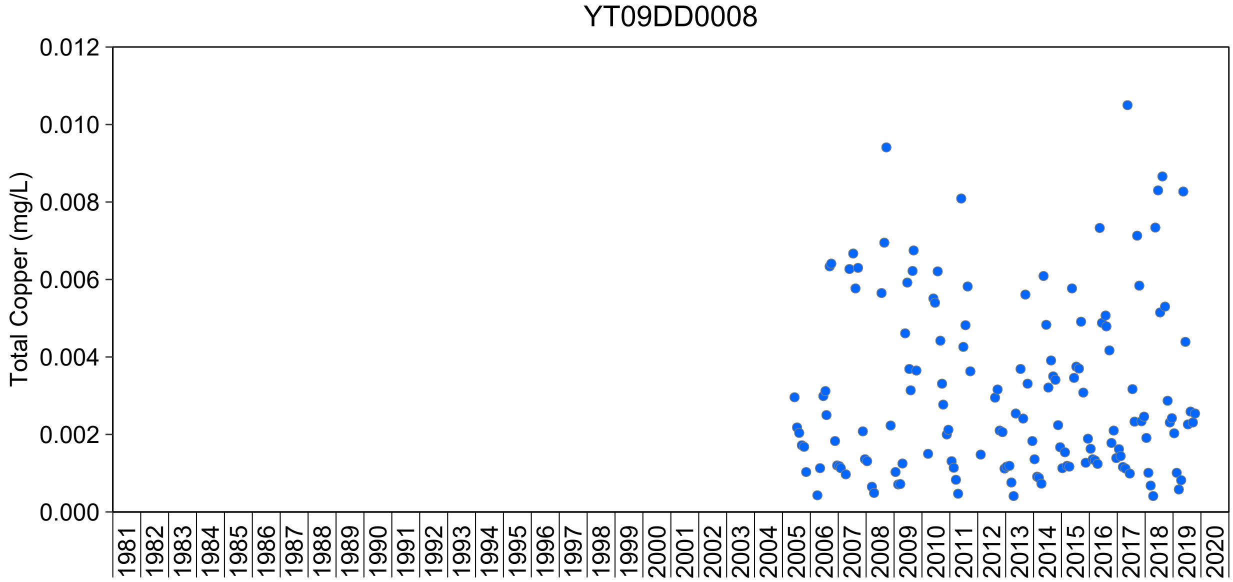


Figure A.47: Time Series Plots of Total Copper Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

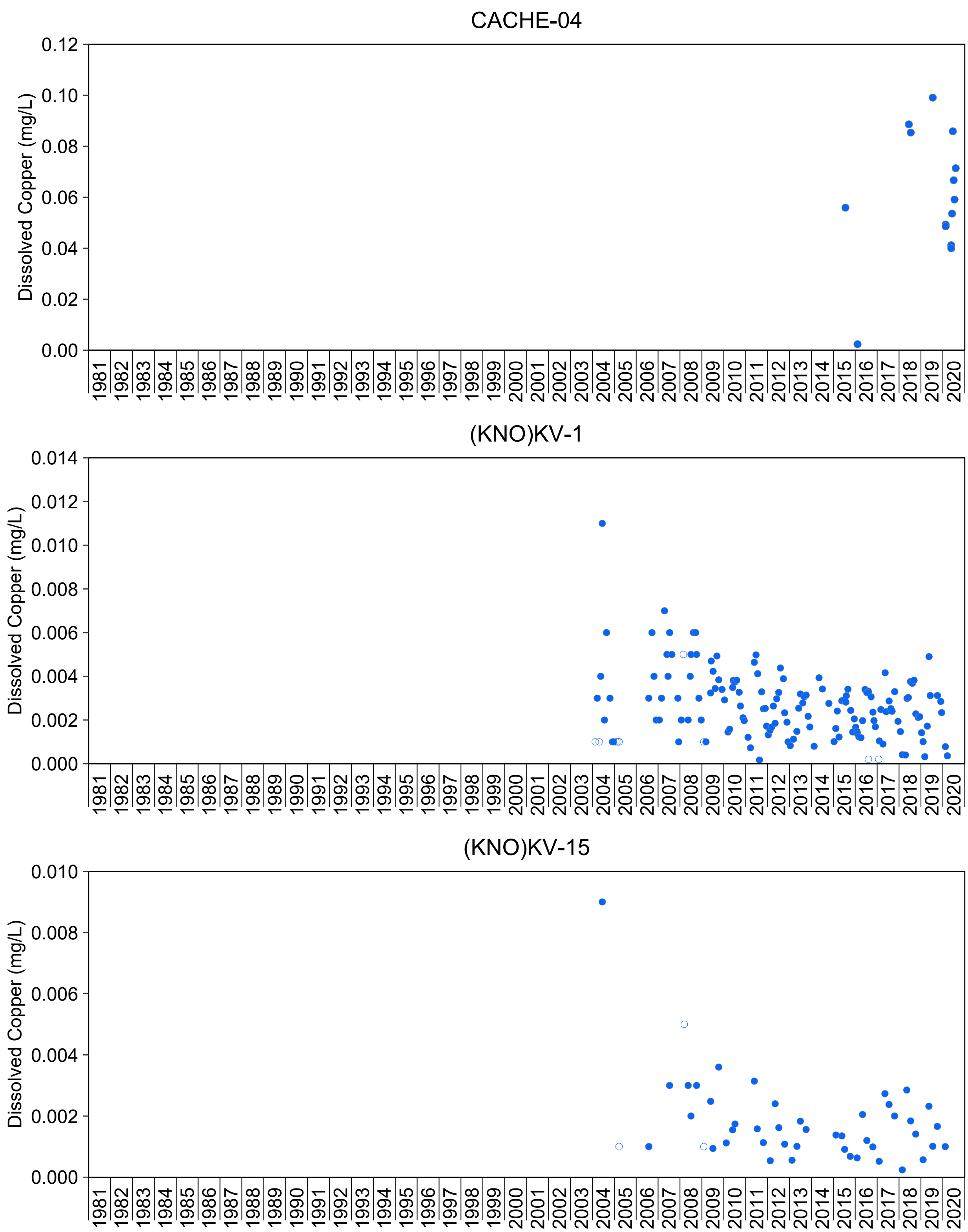
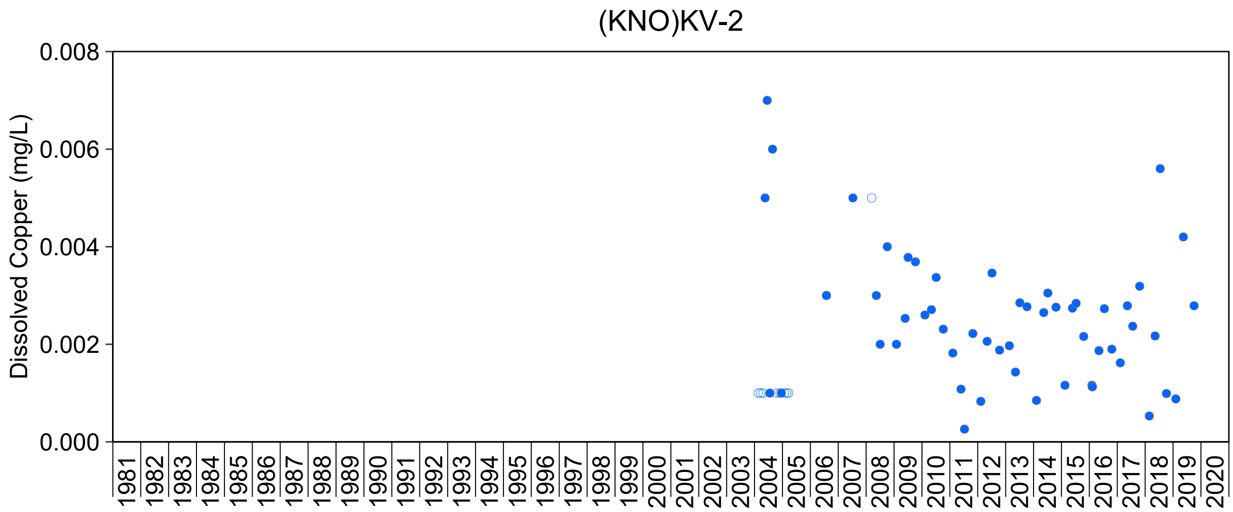
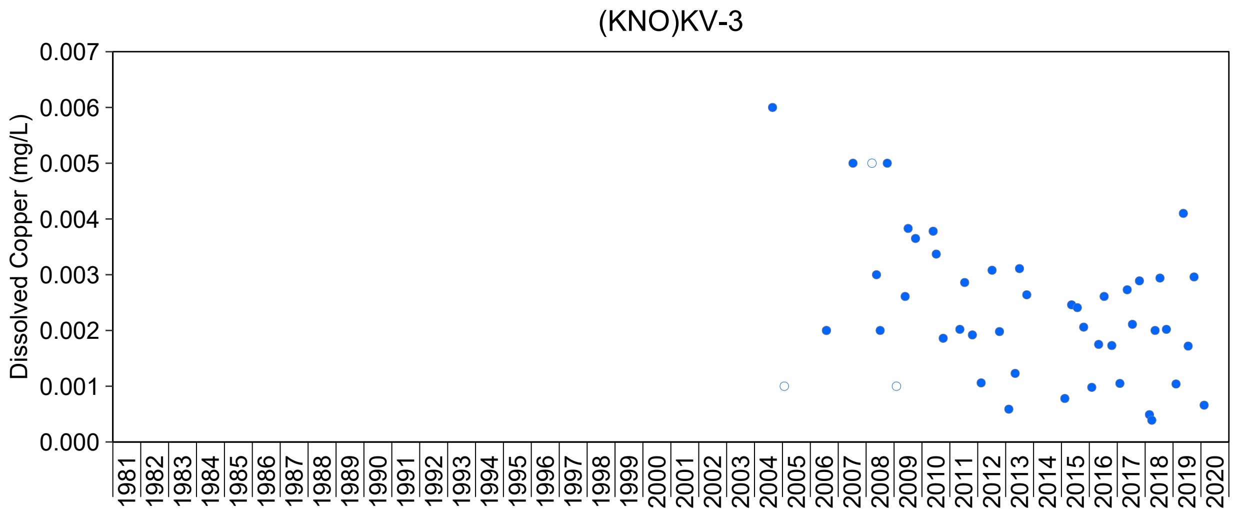


Figure A.48: Time Series Plots of Dissolved Copper Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.





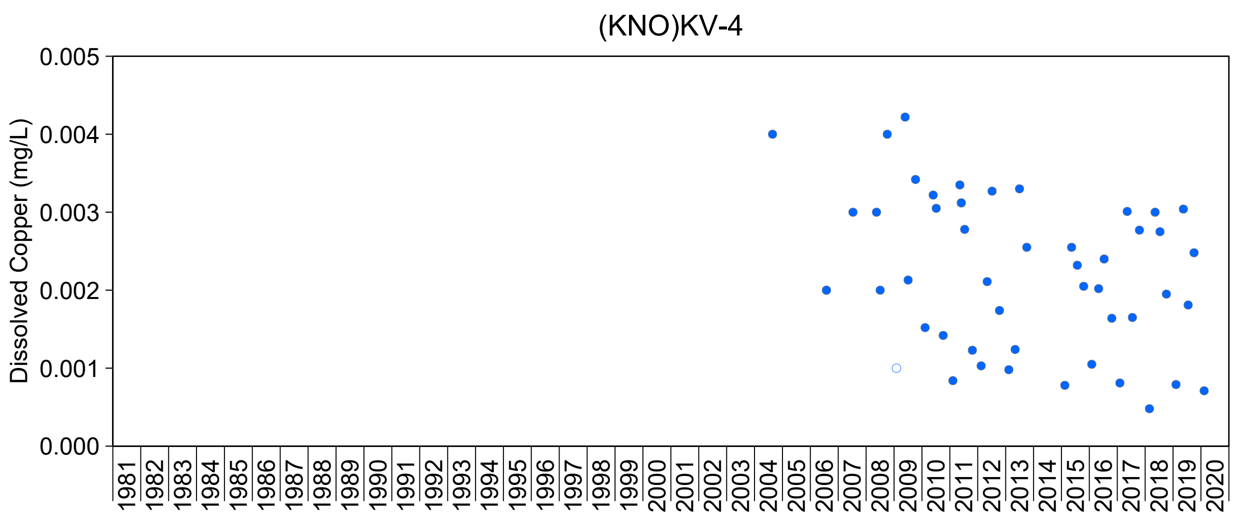


Figure A.48: Time Series Plots of Dissolved Copper Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

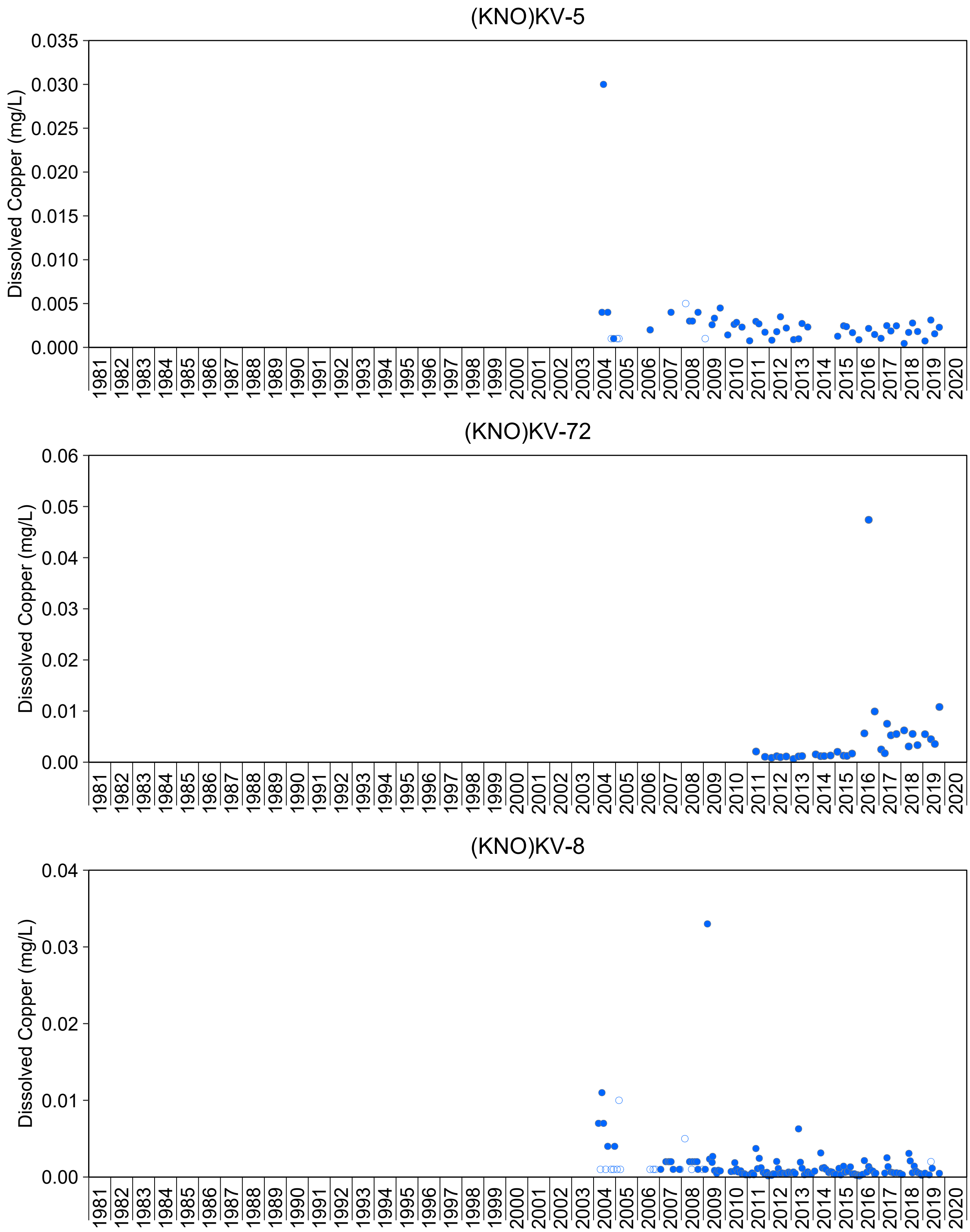
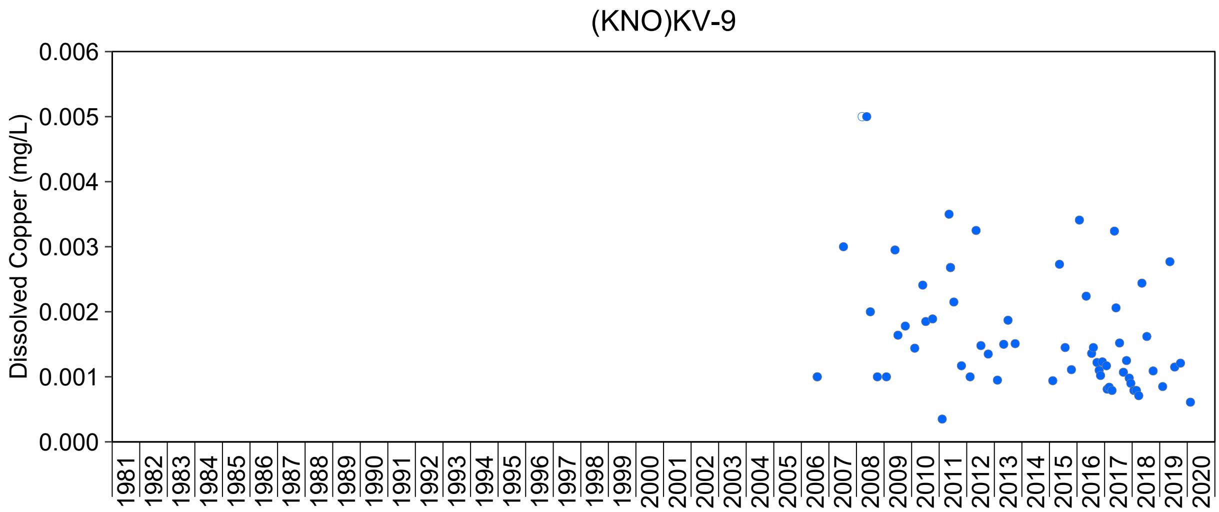
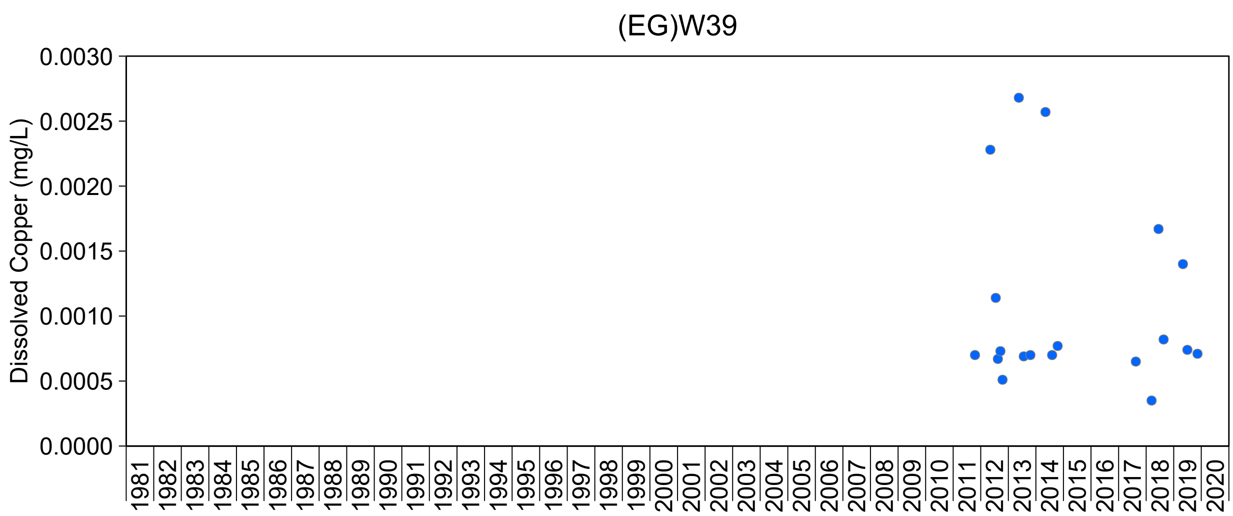


Figure A.48: Time Series Plots of Dissolved Copper Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.





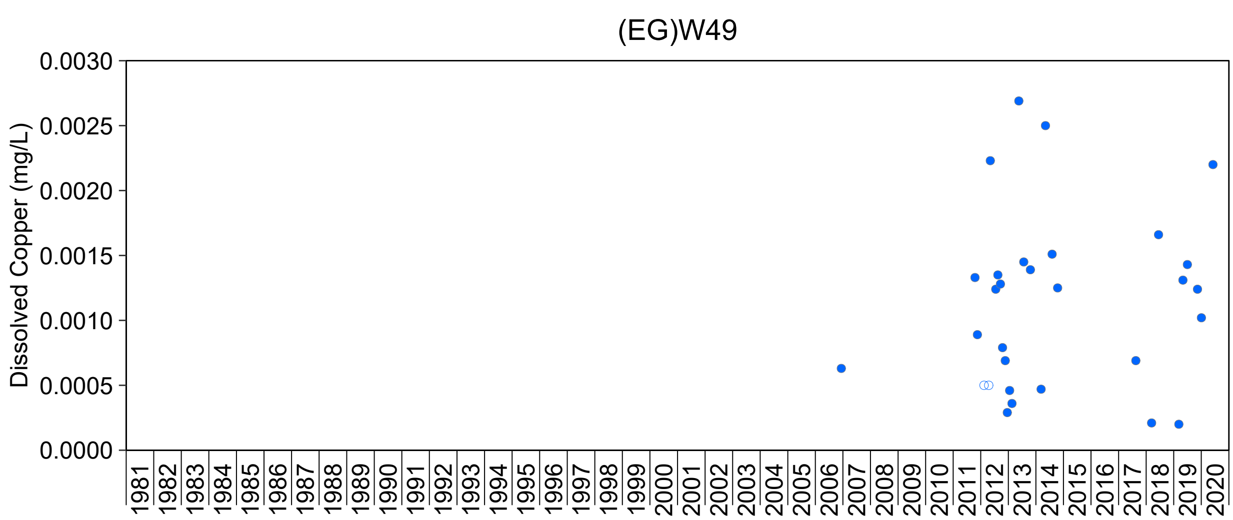


Figure A.48: Time Series Plots of Dissolved Copper Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

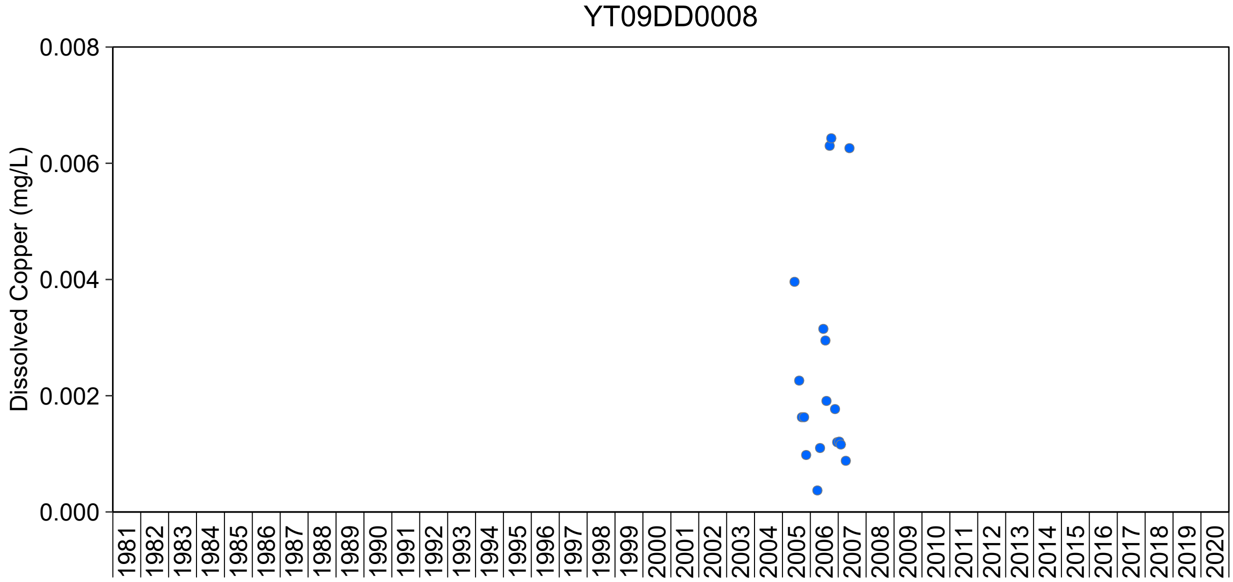


Figure A.48: Time Series Plots of Dissolved Copper Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

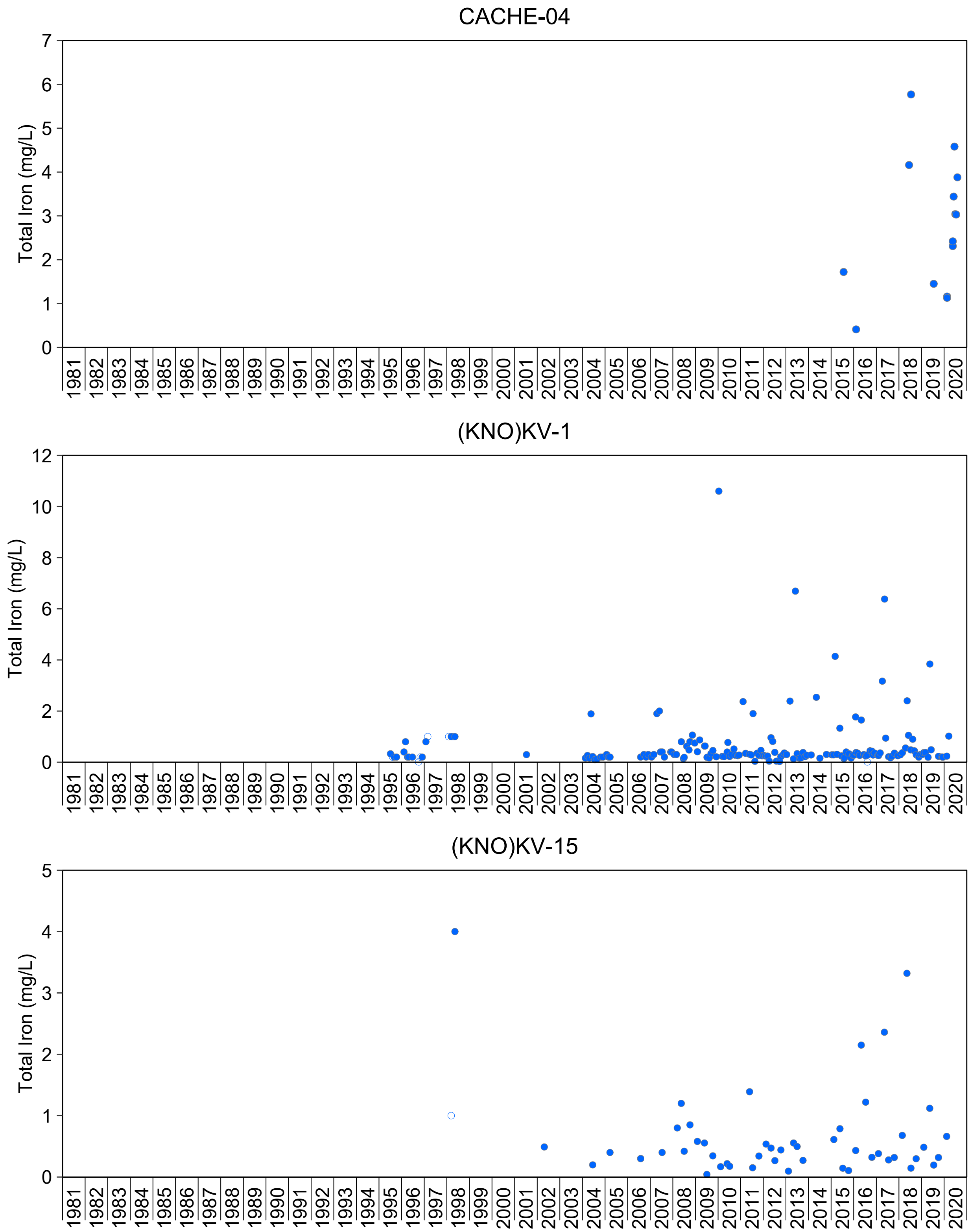


Figure A.49: Time Series Plots of Total Iron Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

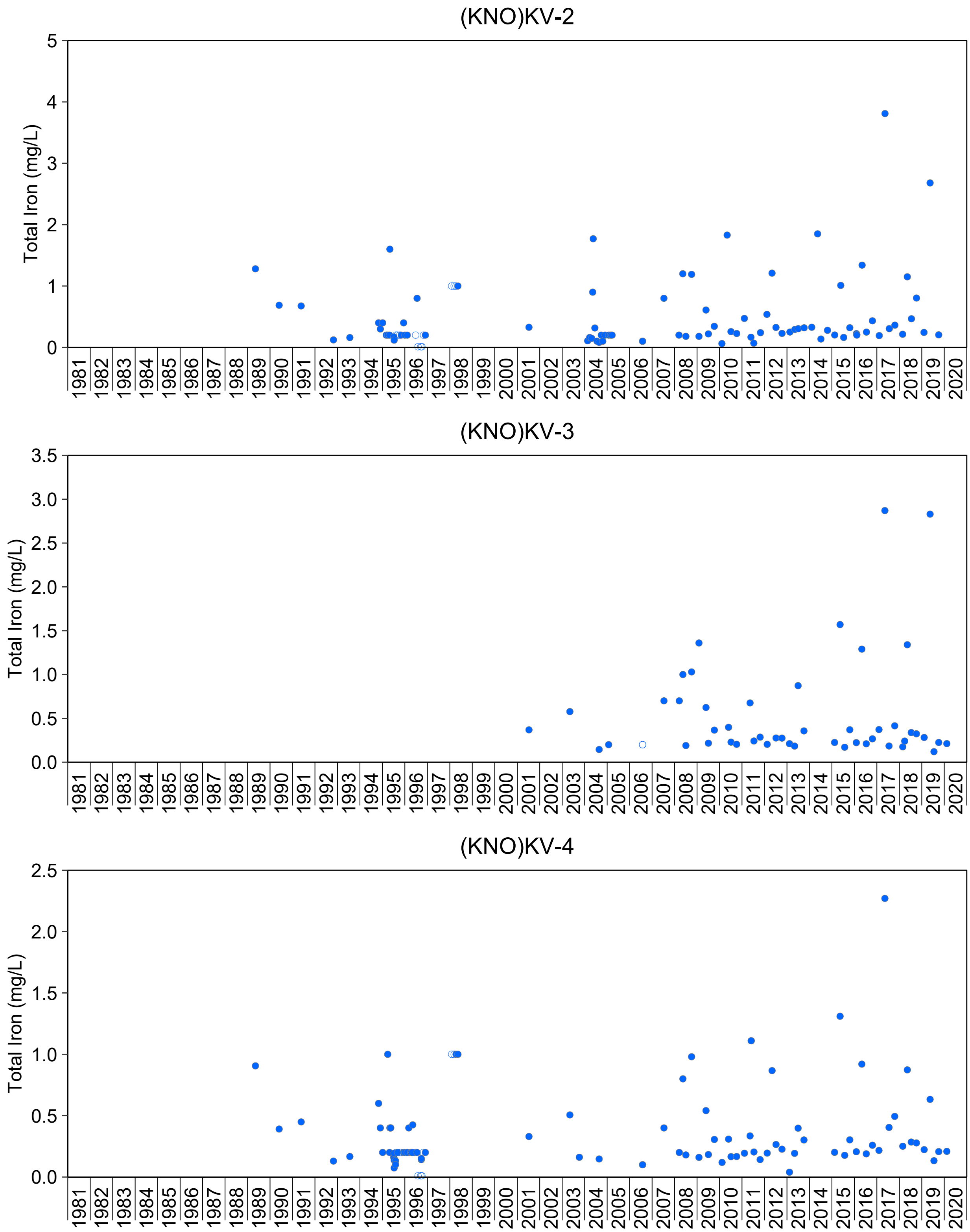


Figure A.49: **Time Series Plots of Total Iron Concentrations (mg/L) in the South McQuesten River, 1981 to 2020**

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

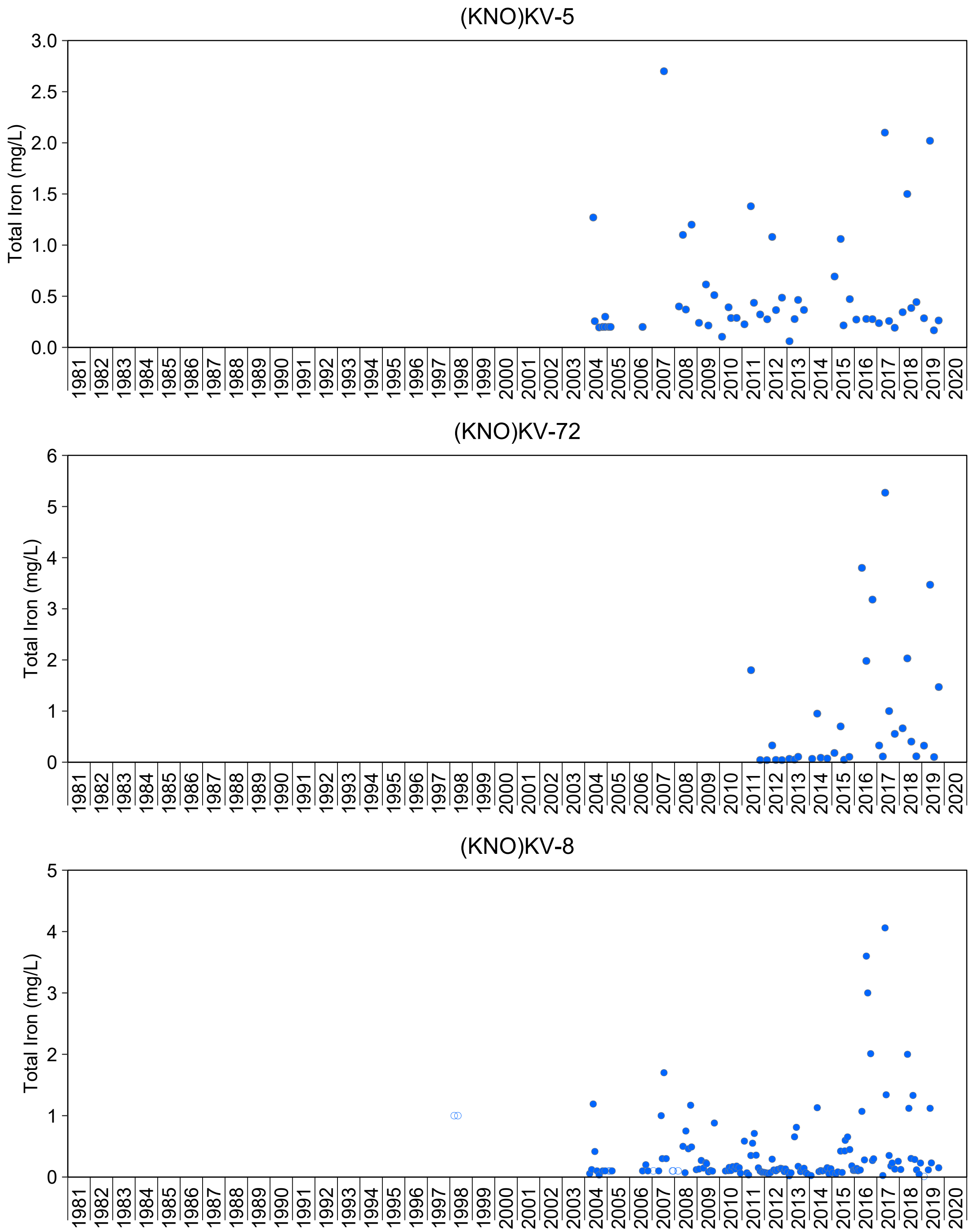


Figure A.49: Time Series Plots of Total Iron Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

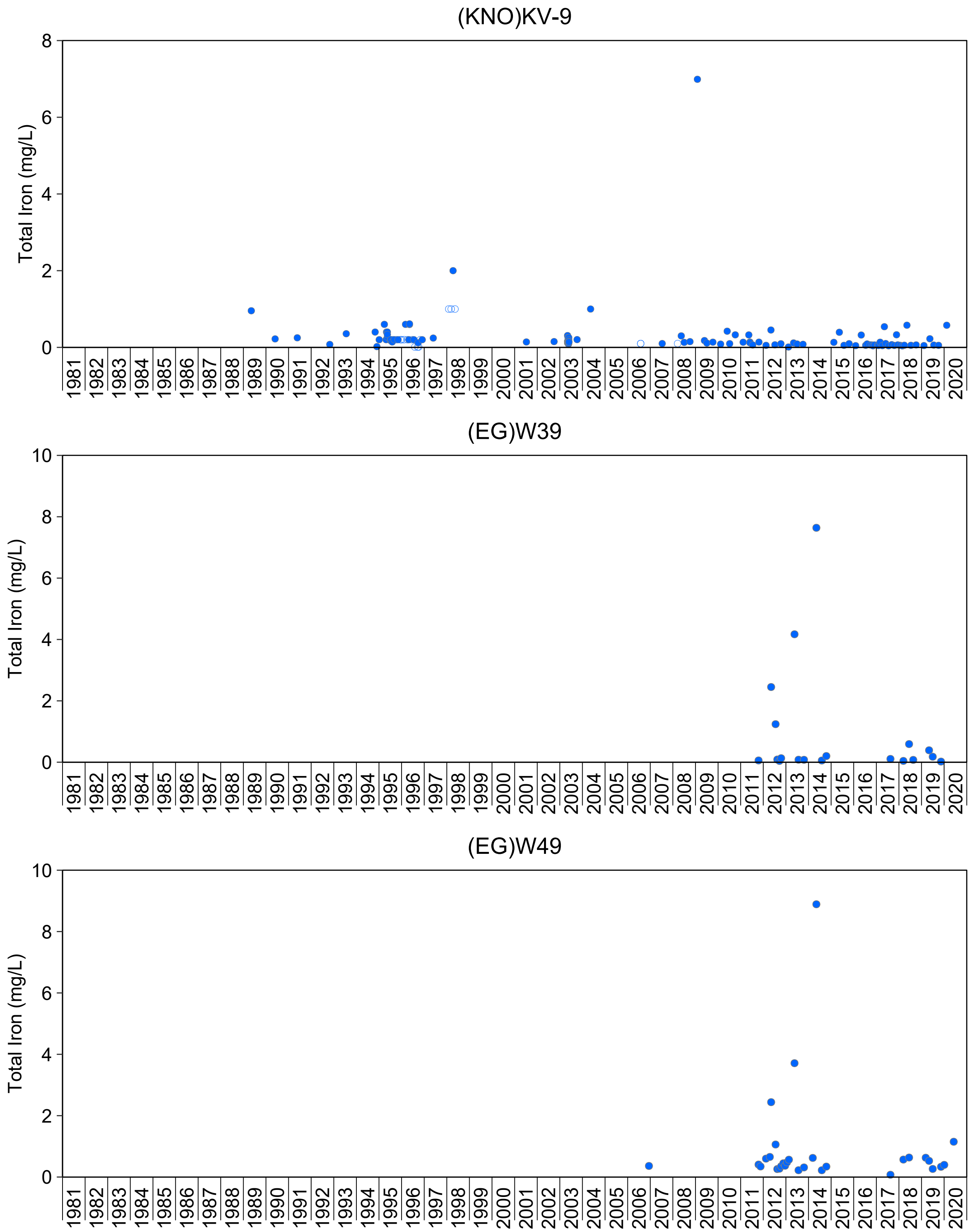


Figure A.49: Time Series Plots of Total Iron Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

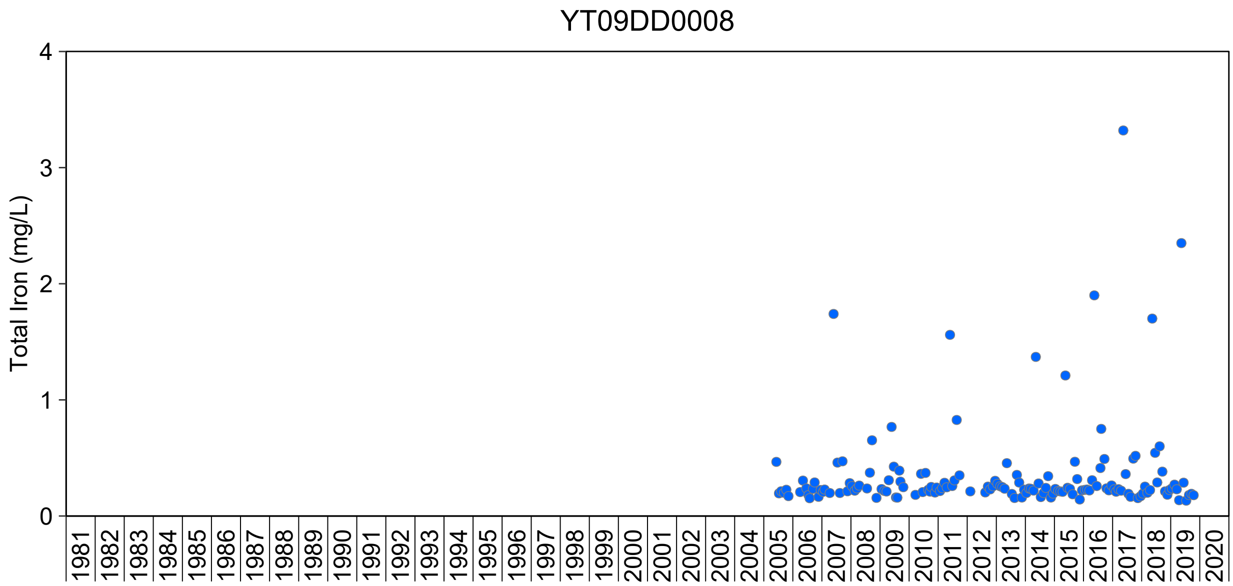


Figure A.49: Time Series Plots of Total Iron Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

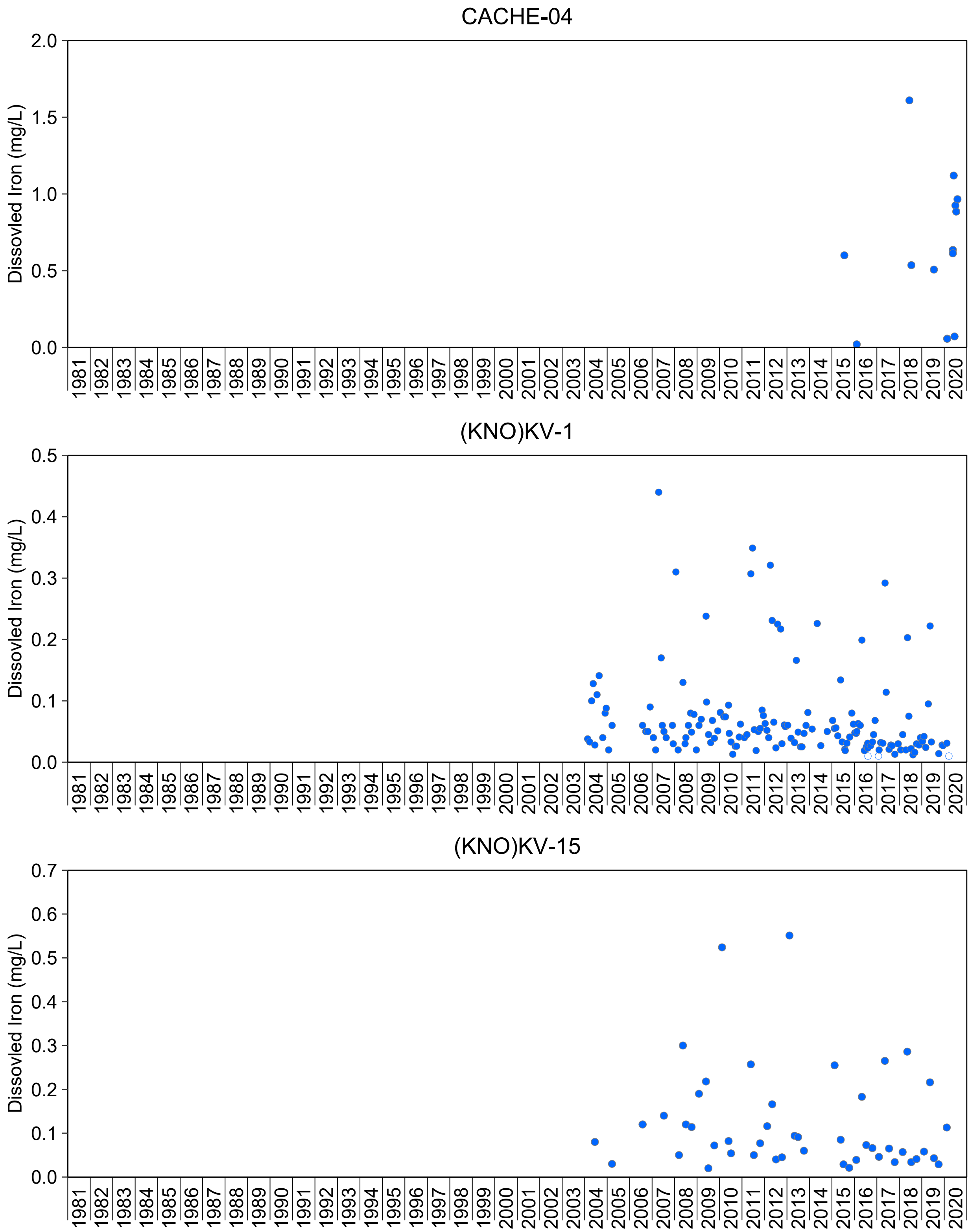


Figure A.50: Time Series Plots of Dissolved Iron Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

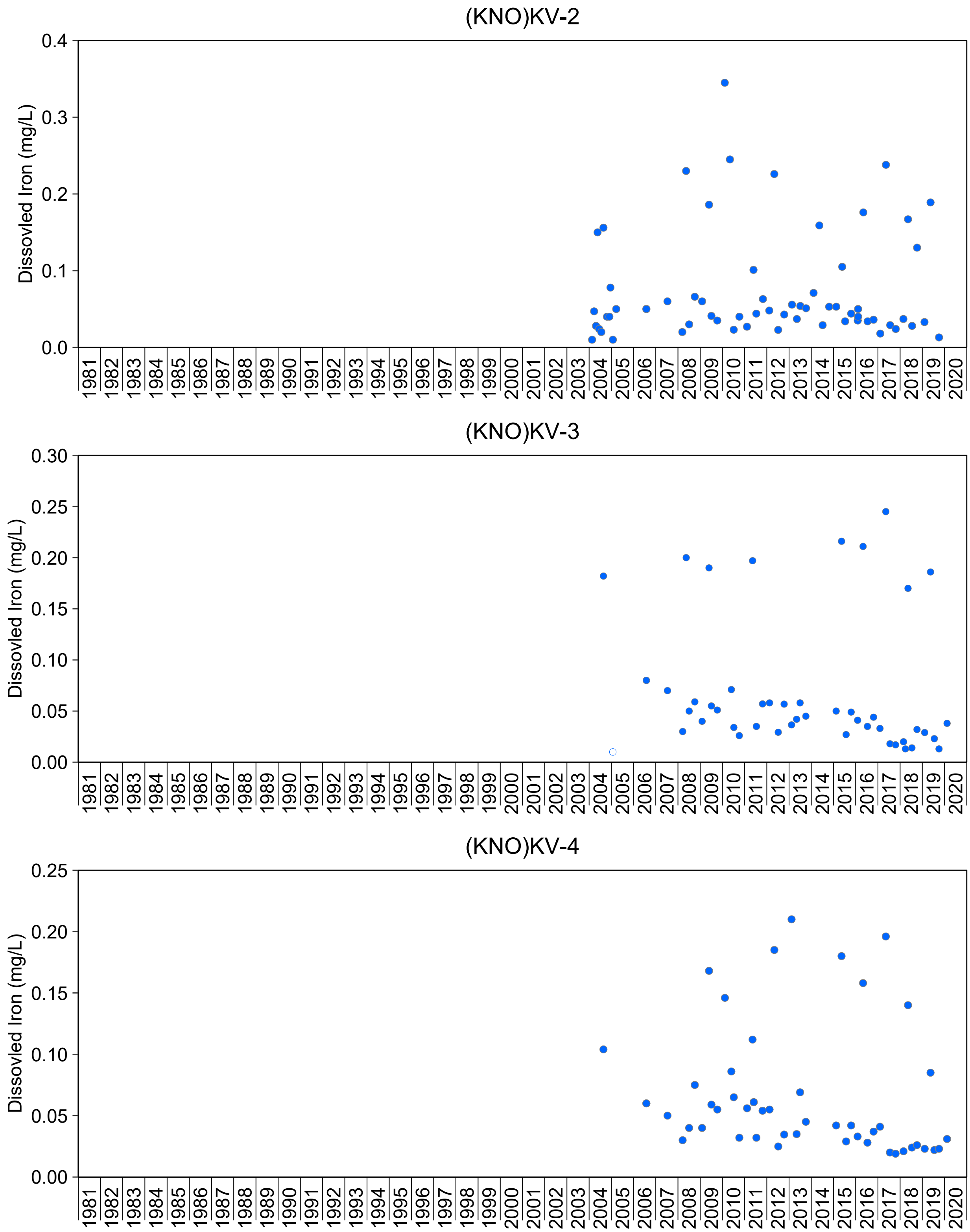


Figure A.50: Time Series Plots of Dissolved Iron Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

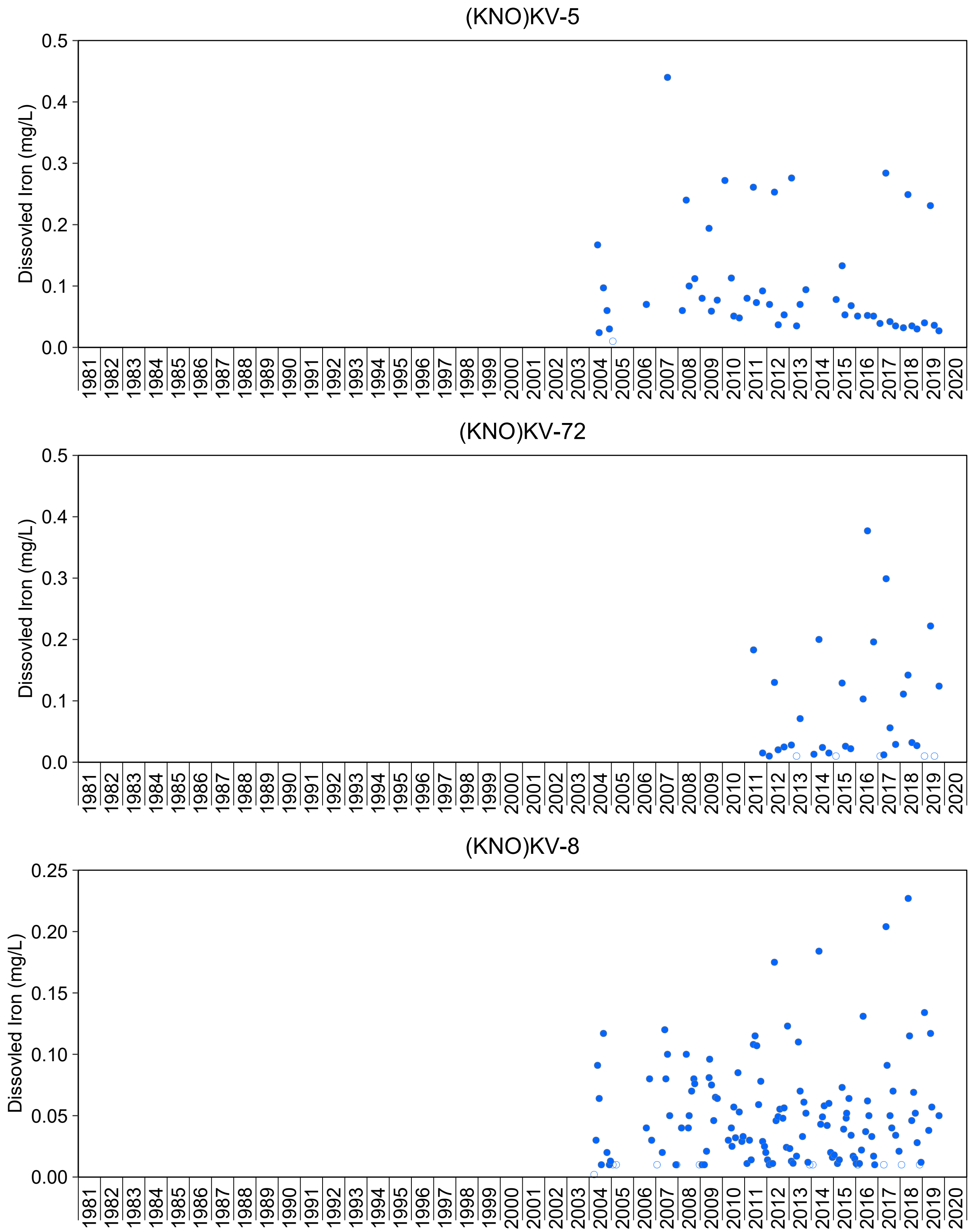


Figure A.50: Time Series Plots of Dissolved Iron Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

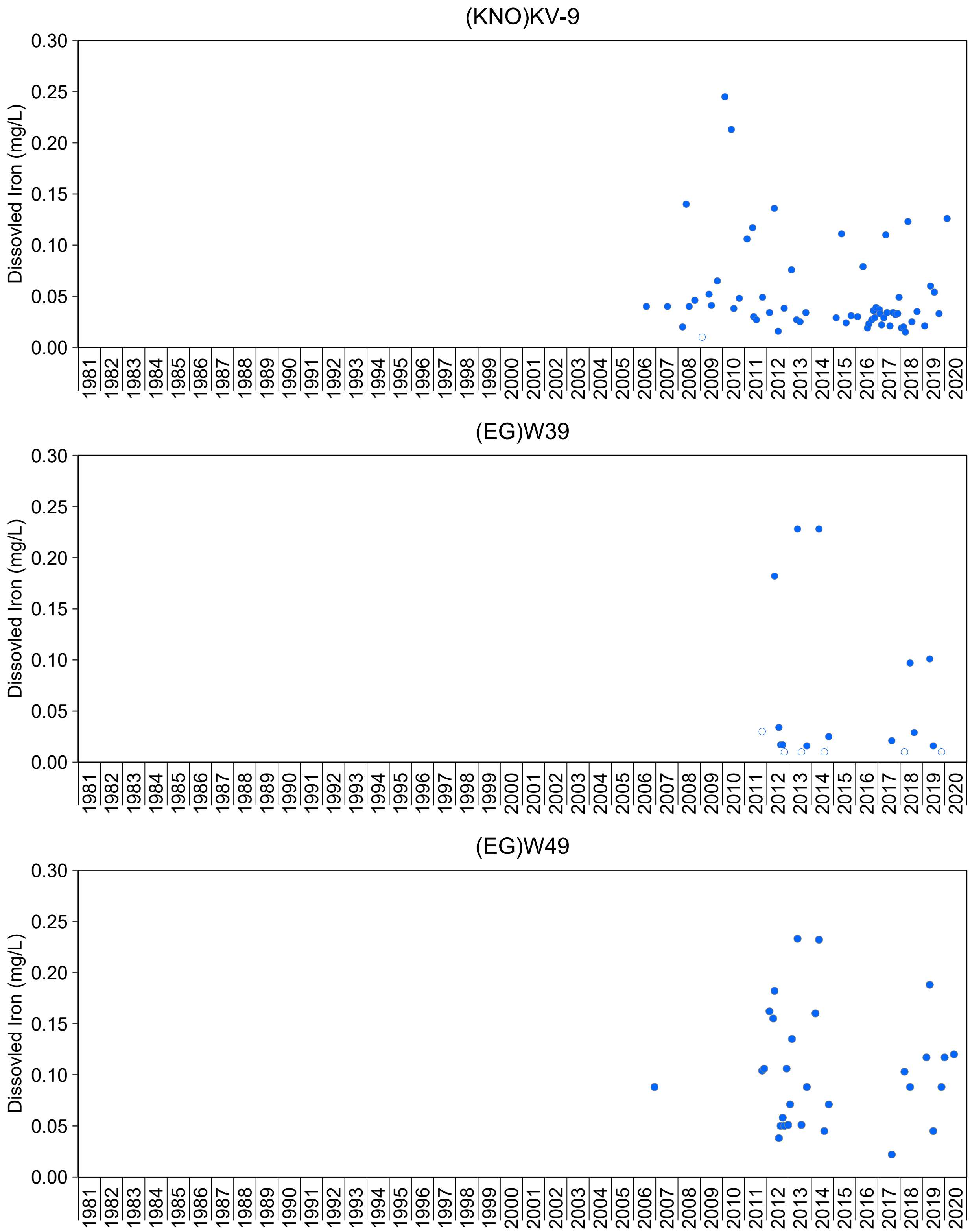


Figure A.50: Time Series Plots of Dissolved Iron Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

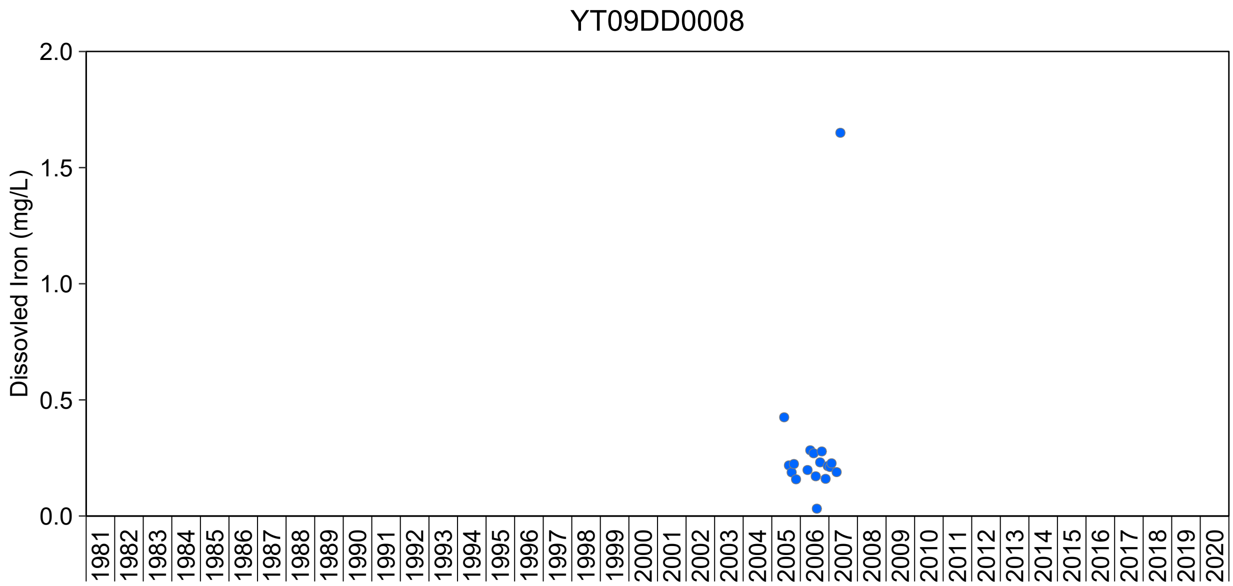


Figure A.50: Time Series Plots of Dissolved Iron Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

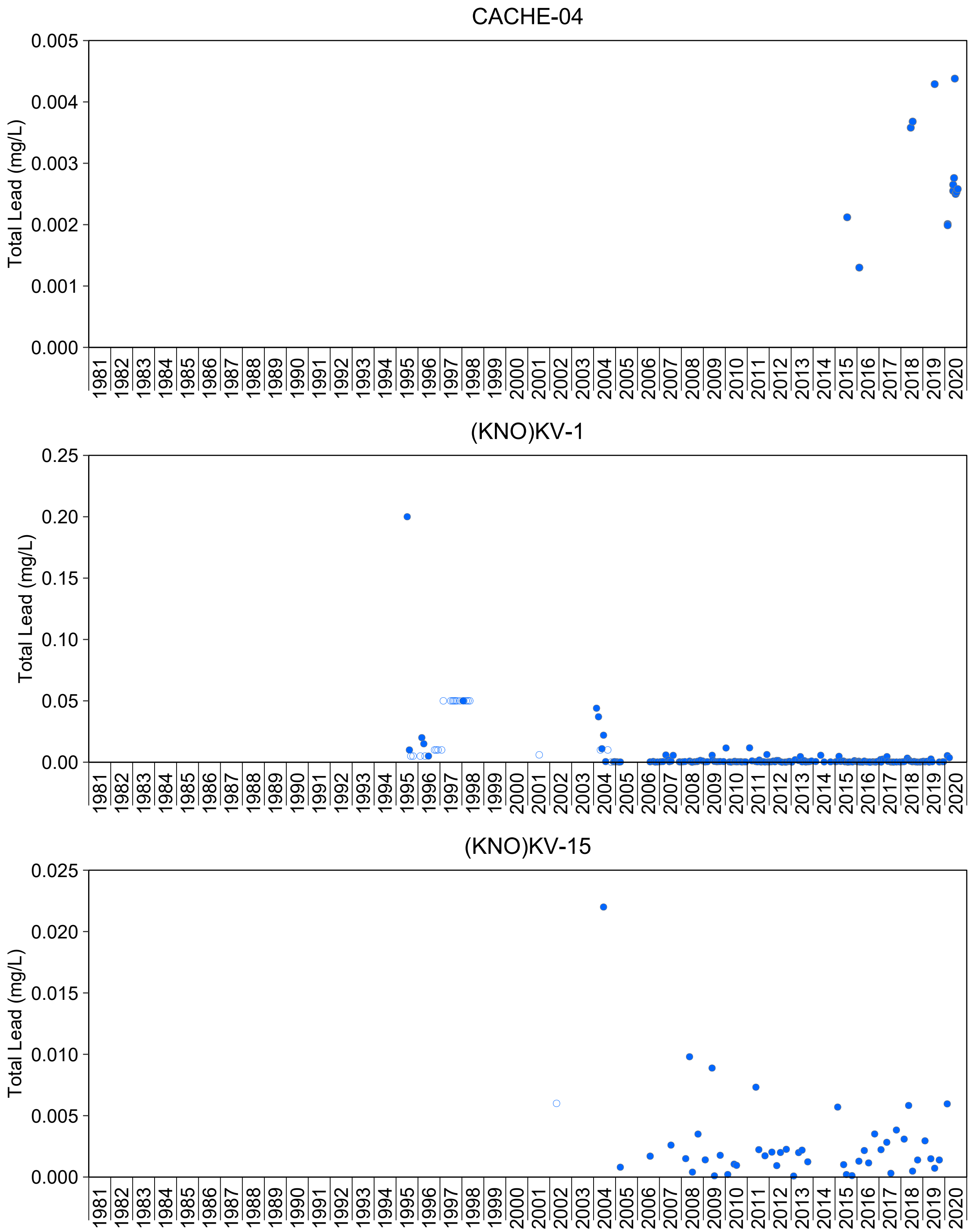


Figure A.51: Time Series Plots of Total Lead Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

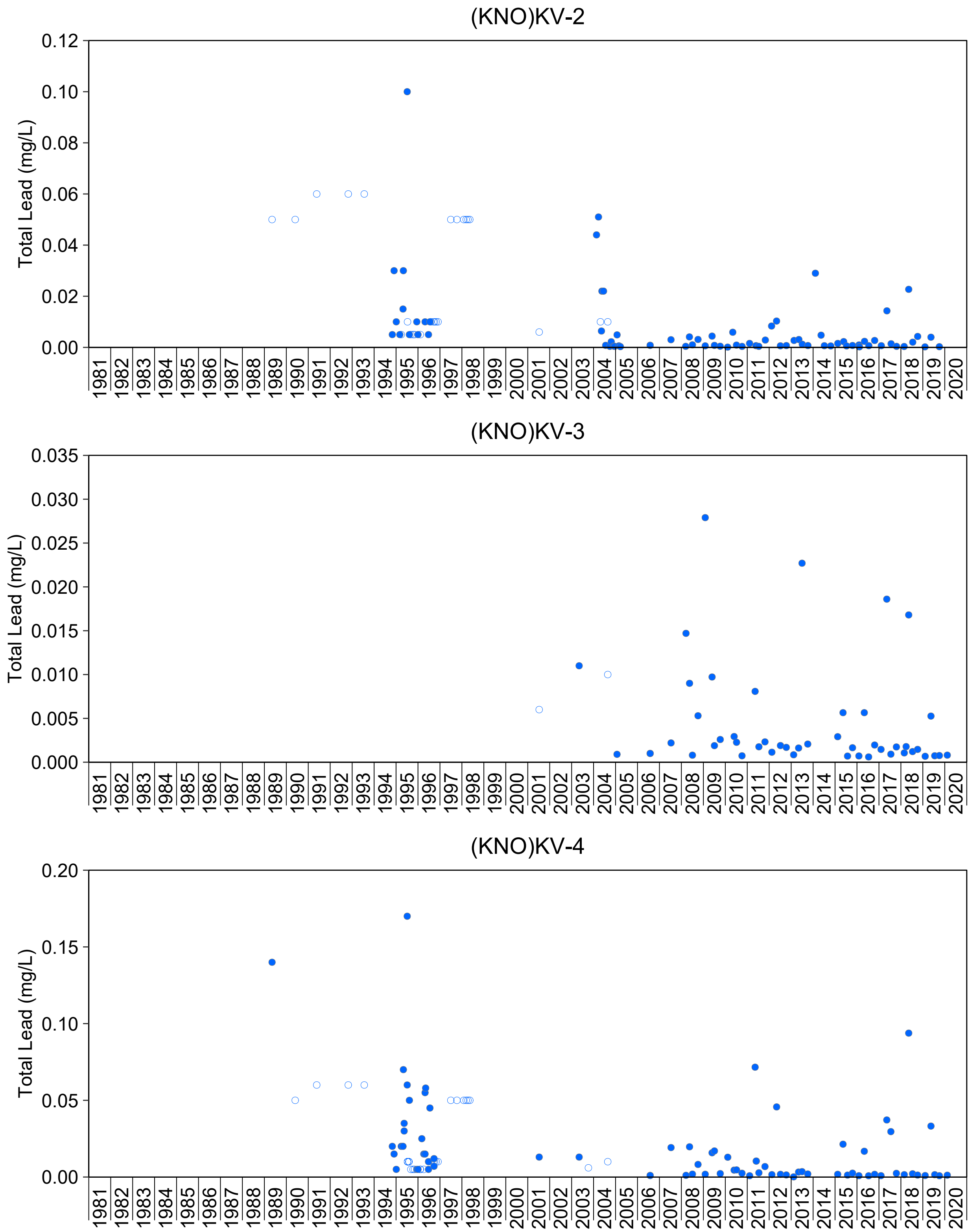


Figure A.51: Time Series Plots of Total Lead Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

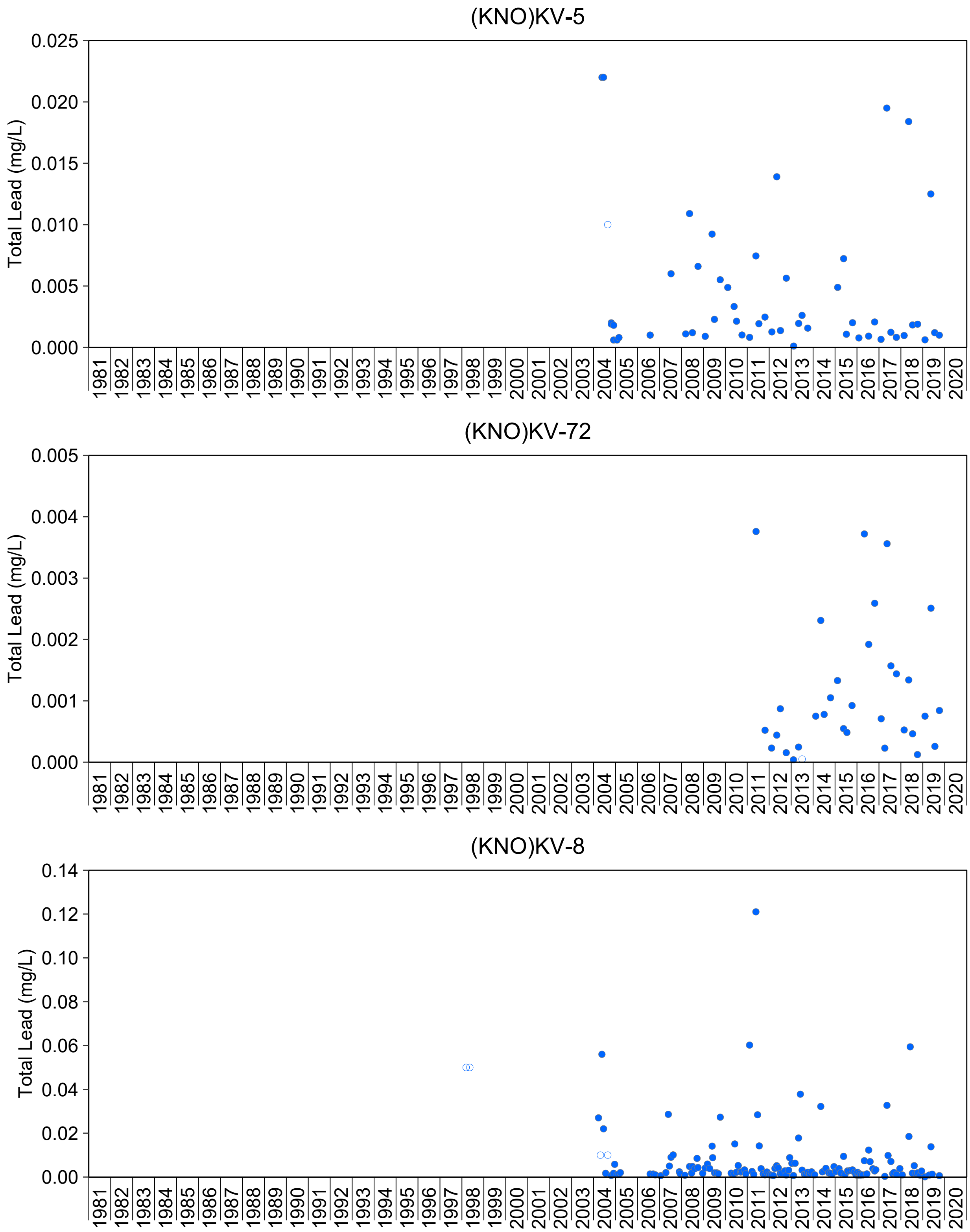


Figure A.51: Time Series Plots of Total Lead Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

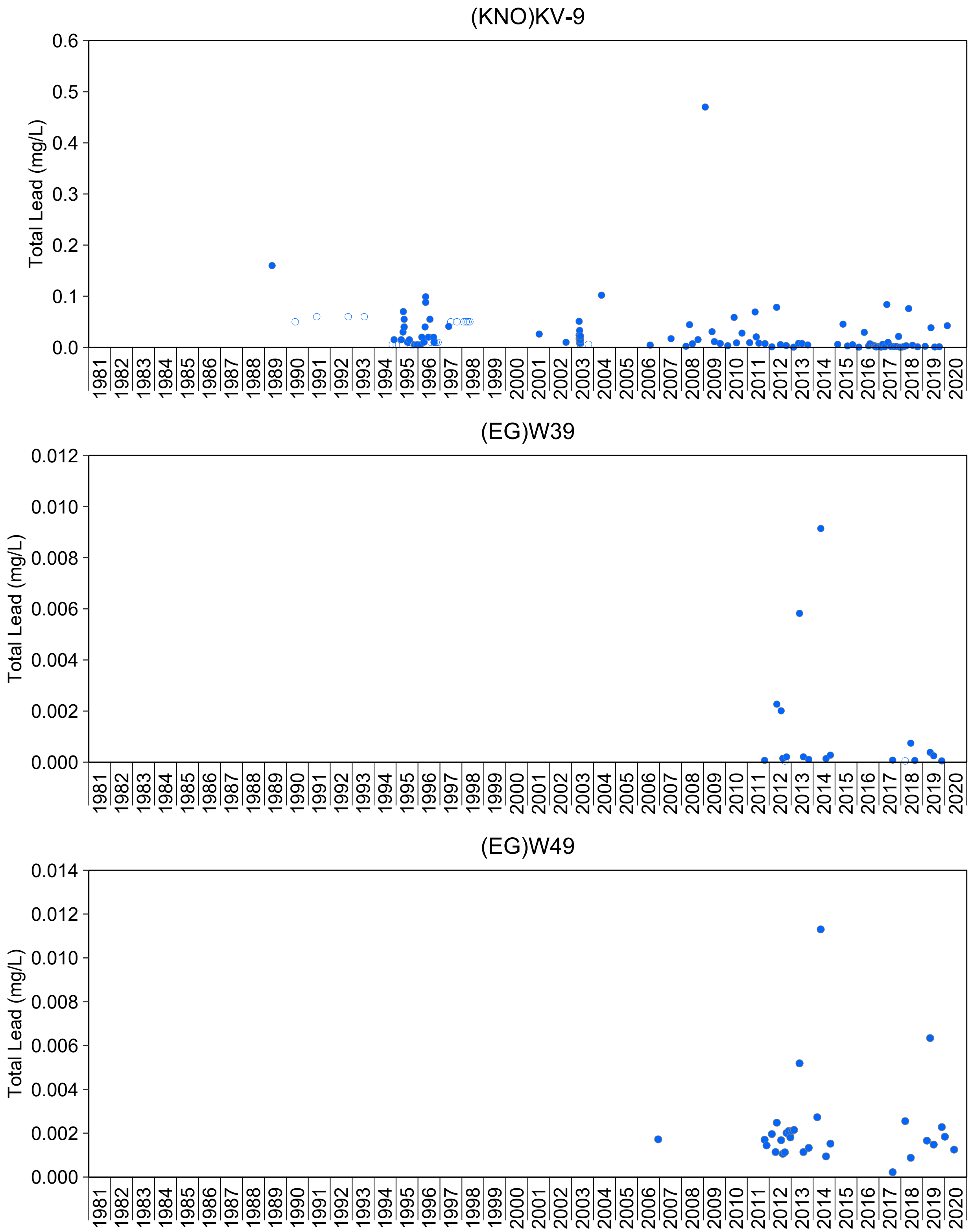


Figure A.51: Time Series Plots of Total Lead Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

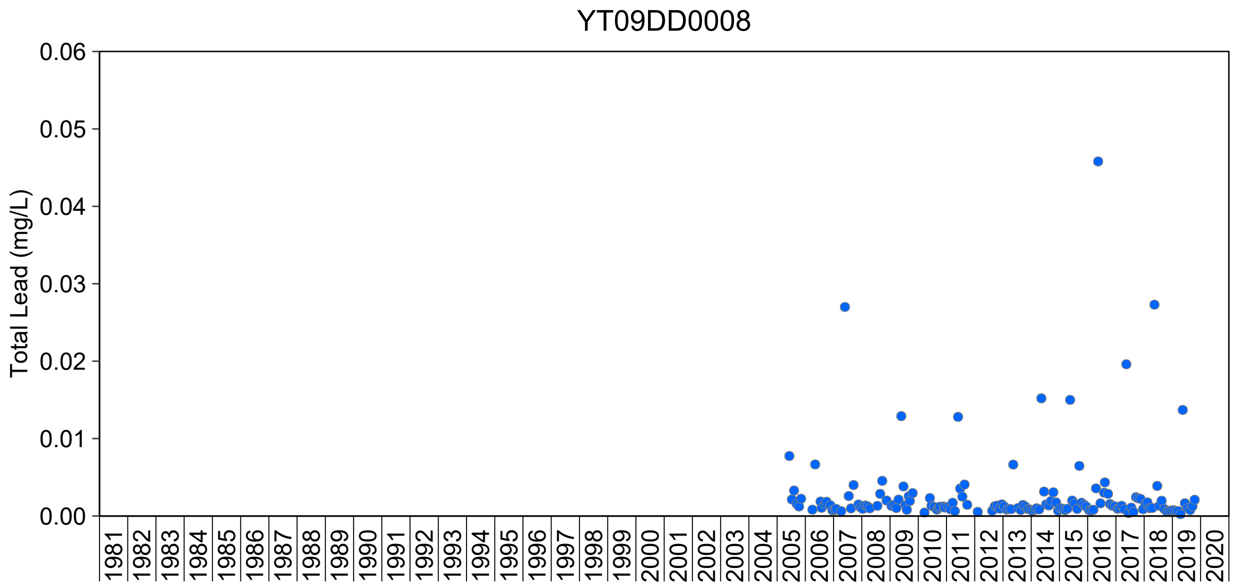


Figure A.51: Time Series Plots of Total Lead Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

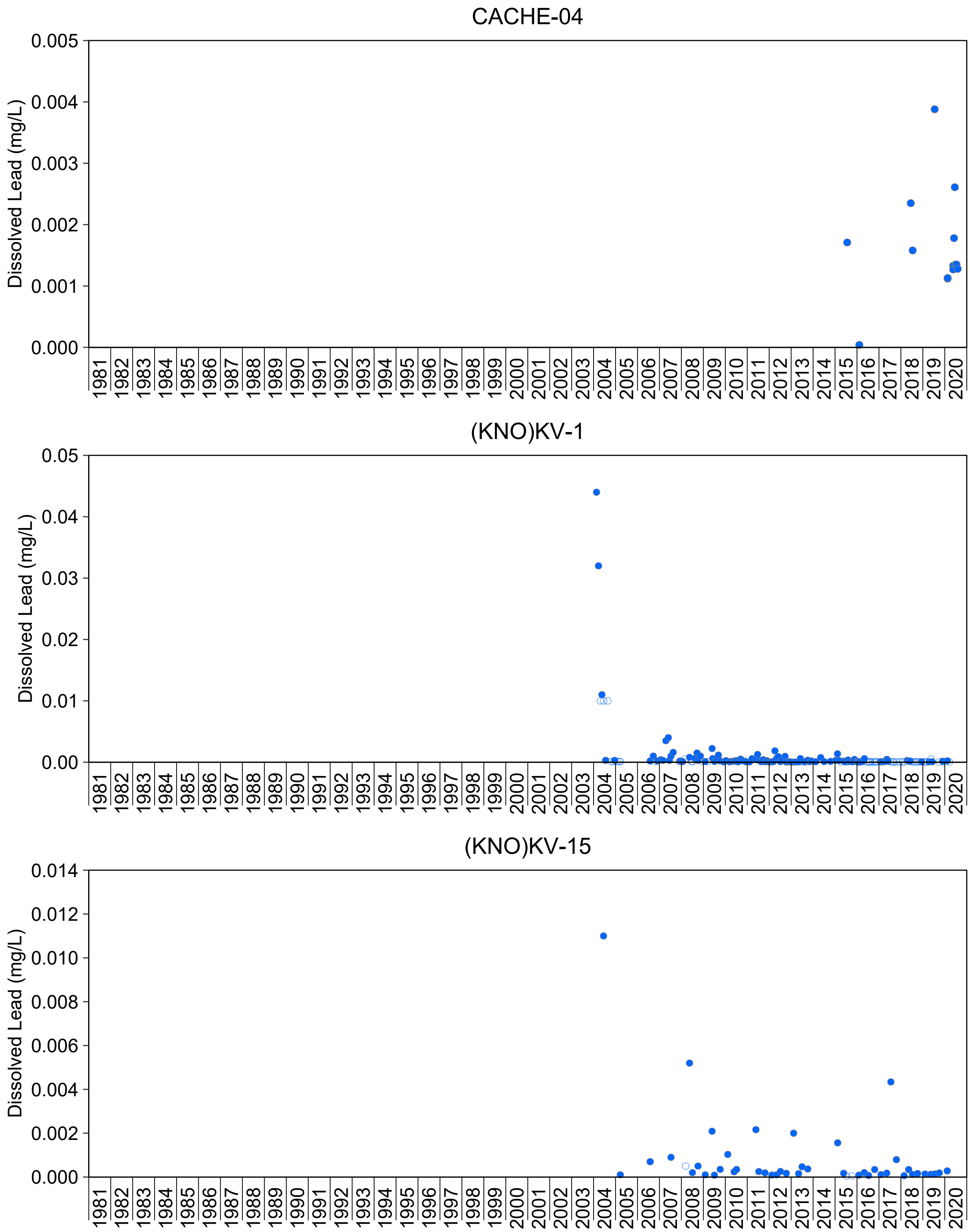


Figure A.52: Time Series Plots of Dissolved Lead Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

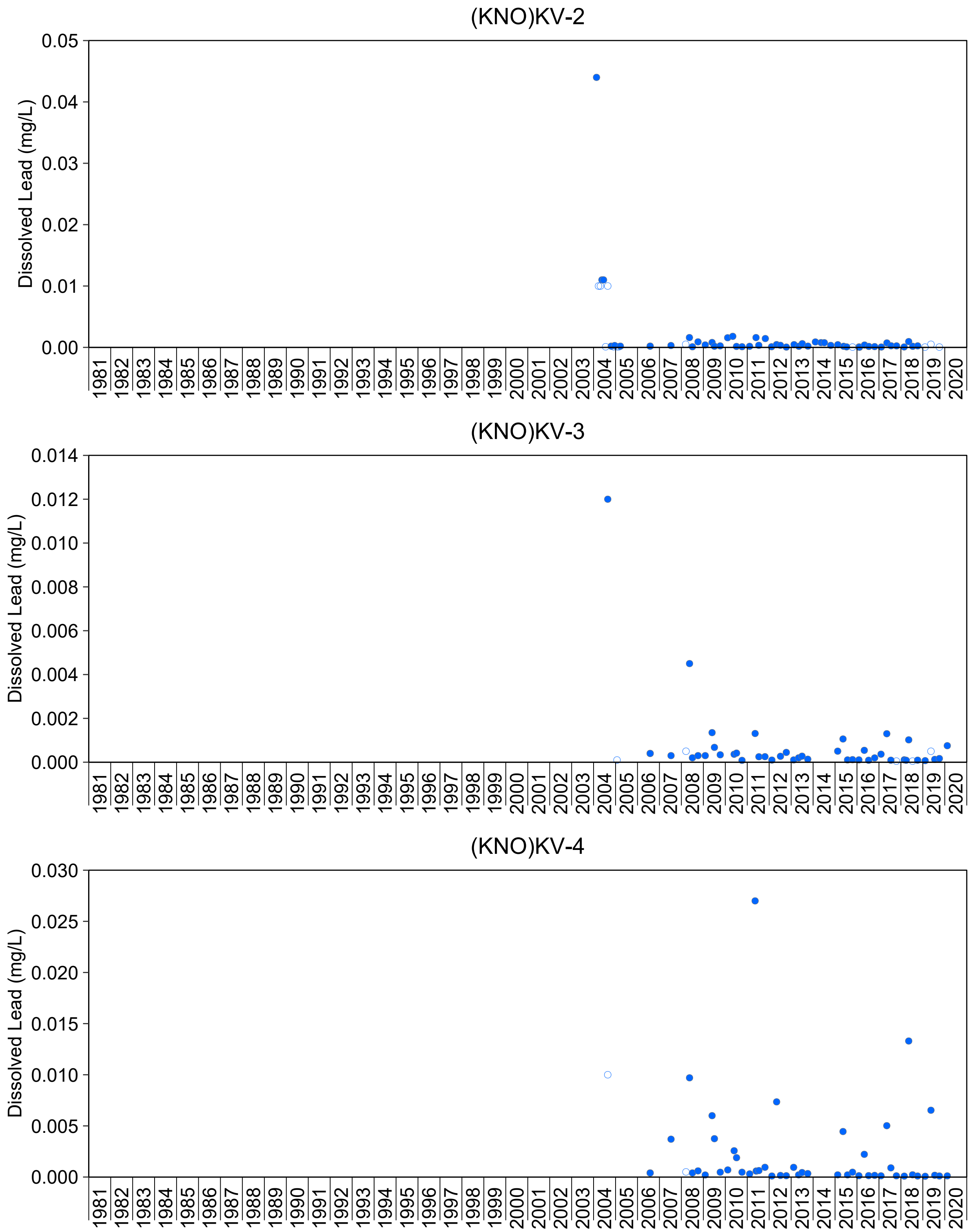


Figure A.52: Time Series Plots of Dissolved Lead Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

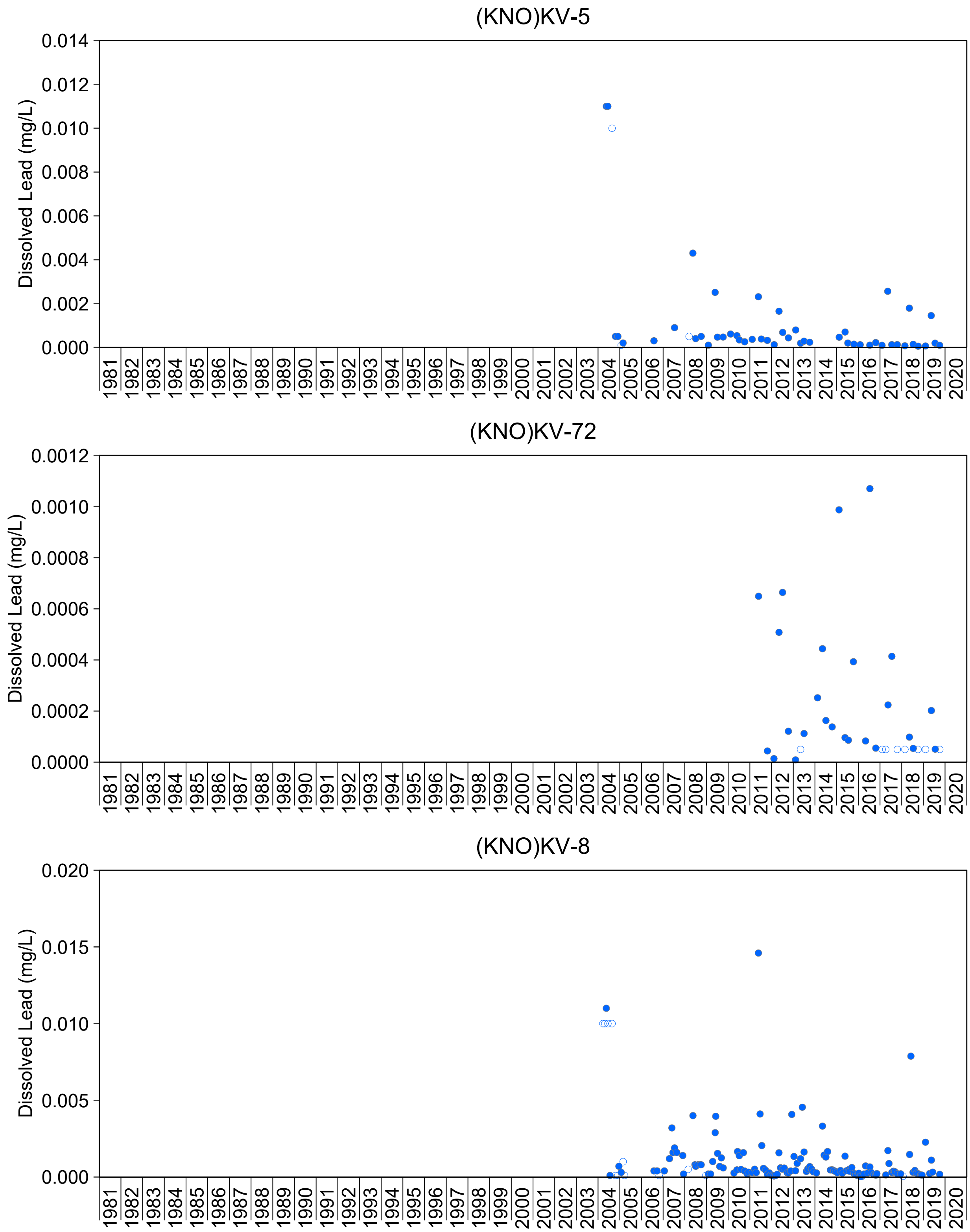


Figure A.52: Time Series Plots of Dissolved Lead Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

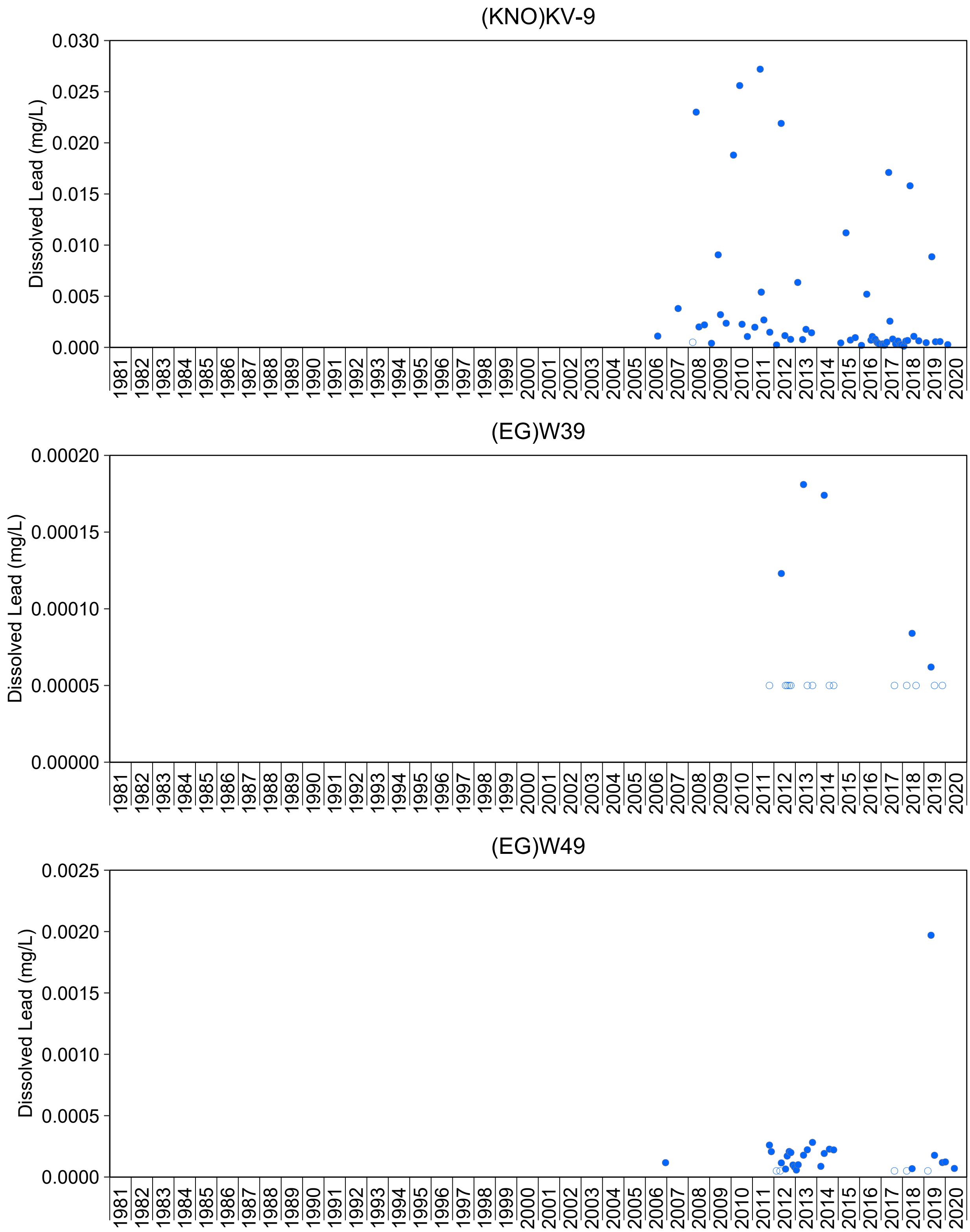


Figure A.52: **Time Series Plots of Dissolved Lead Concentrations (mg/L) in the South McQuesten River, 1981 to 2020**

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

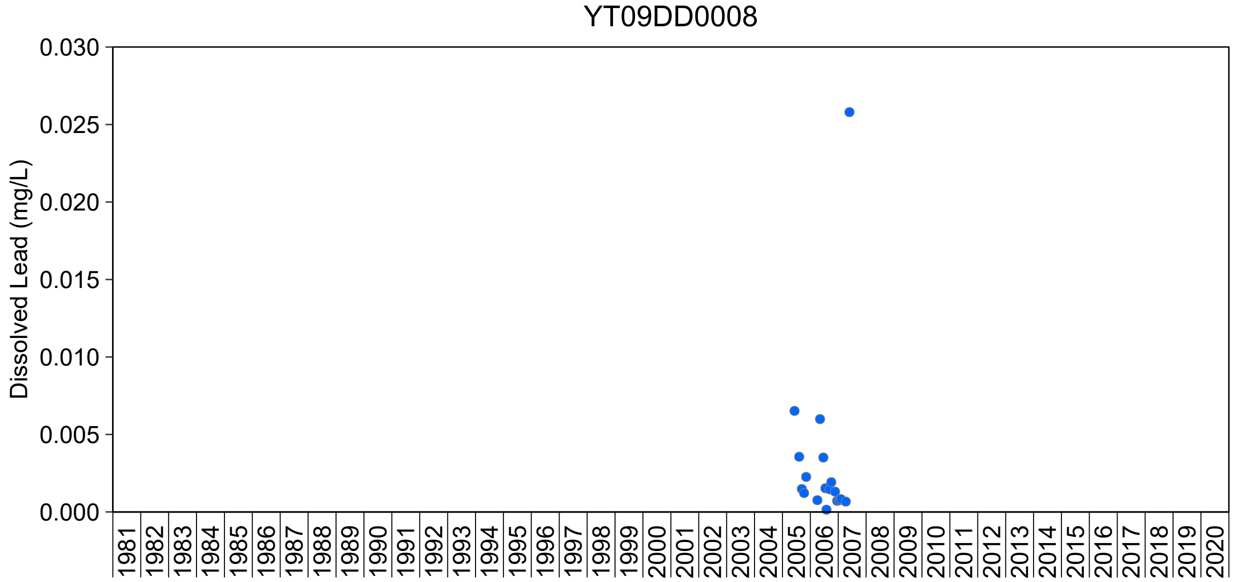


Figure A.52: Time Series Plots of Dissolved Lead Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

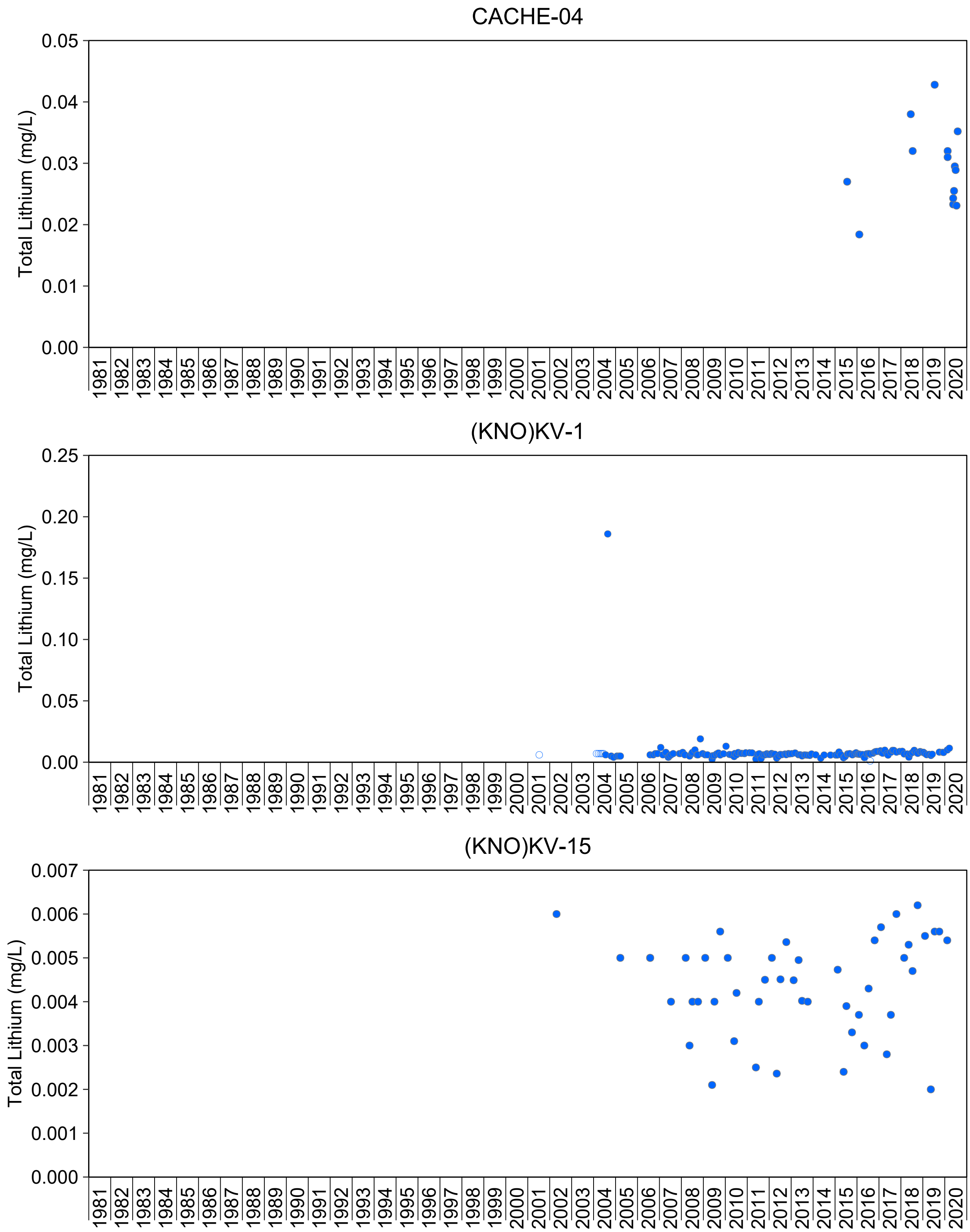


Figure A.53: Time Series Plots of Total Lithium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

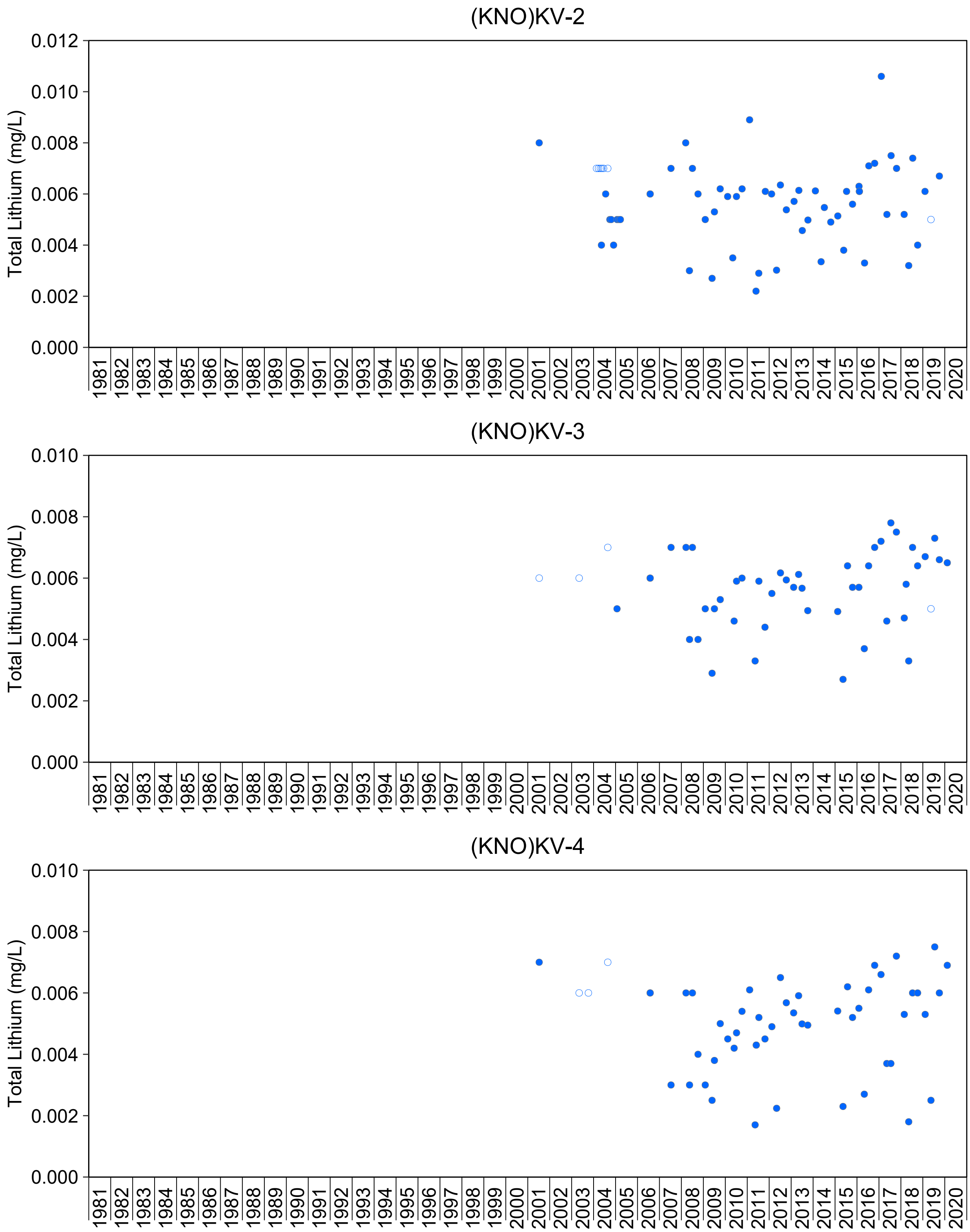


Figure A.53: Time Series Plots of Total Lithium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

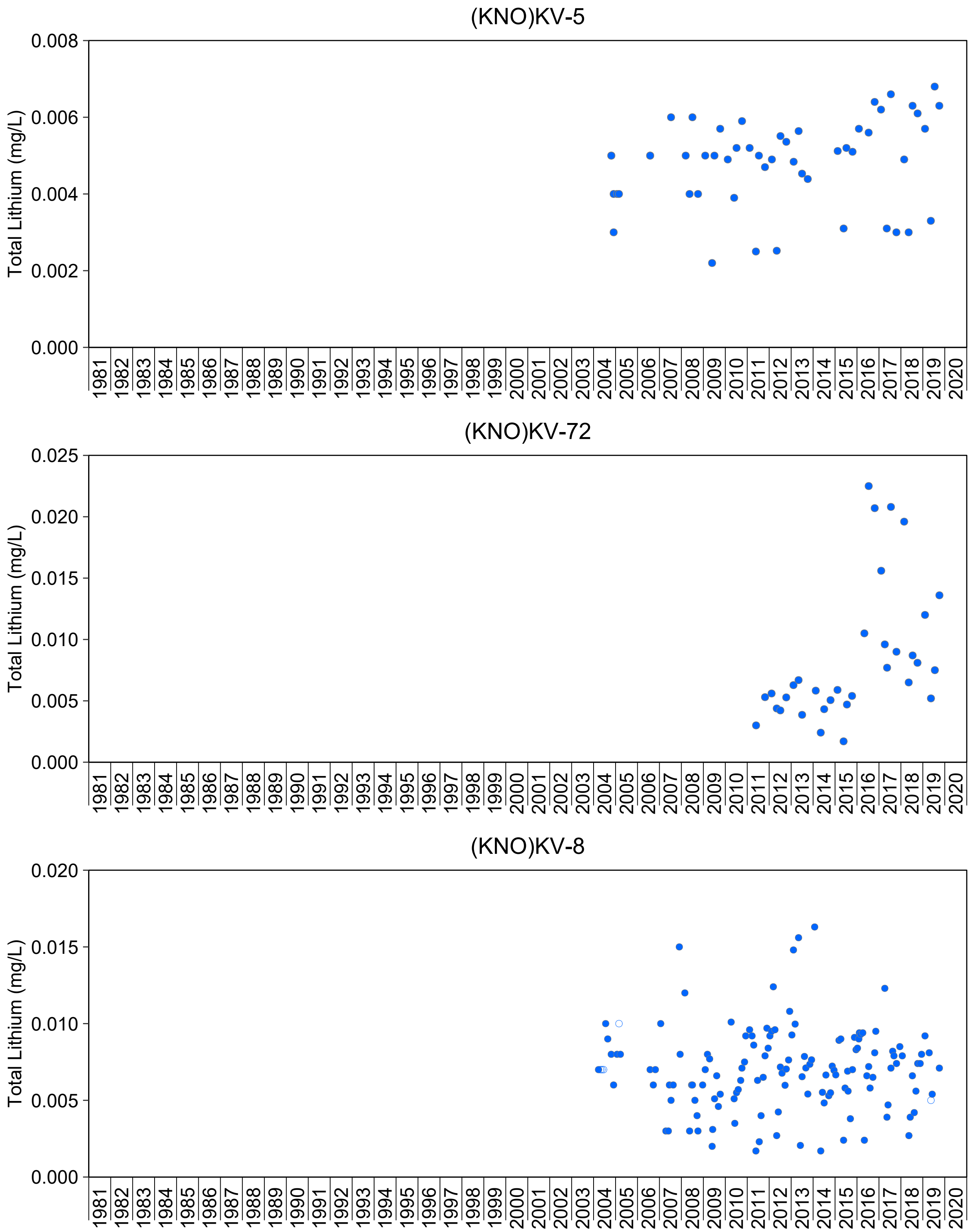


Figure A.53: Time Series Plots of Total Lithium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

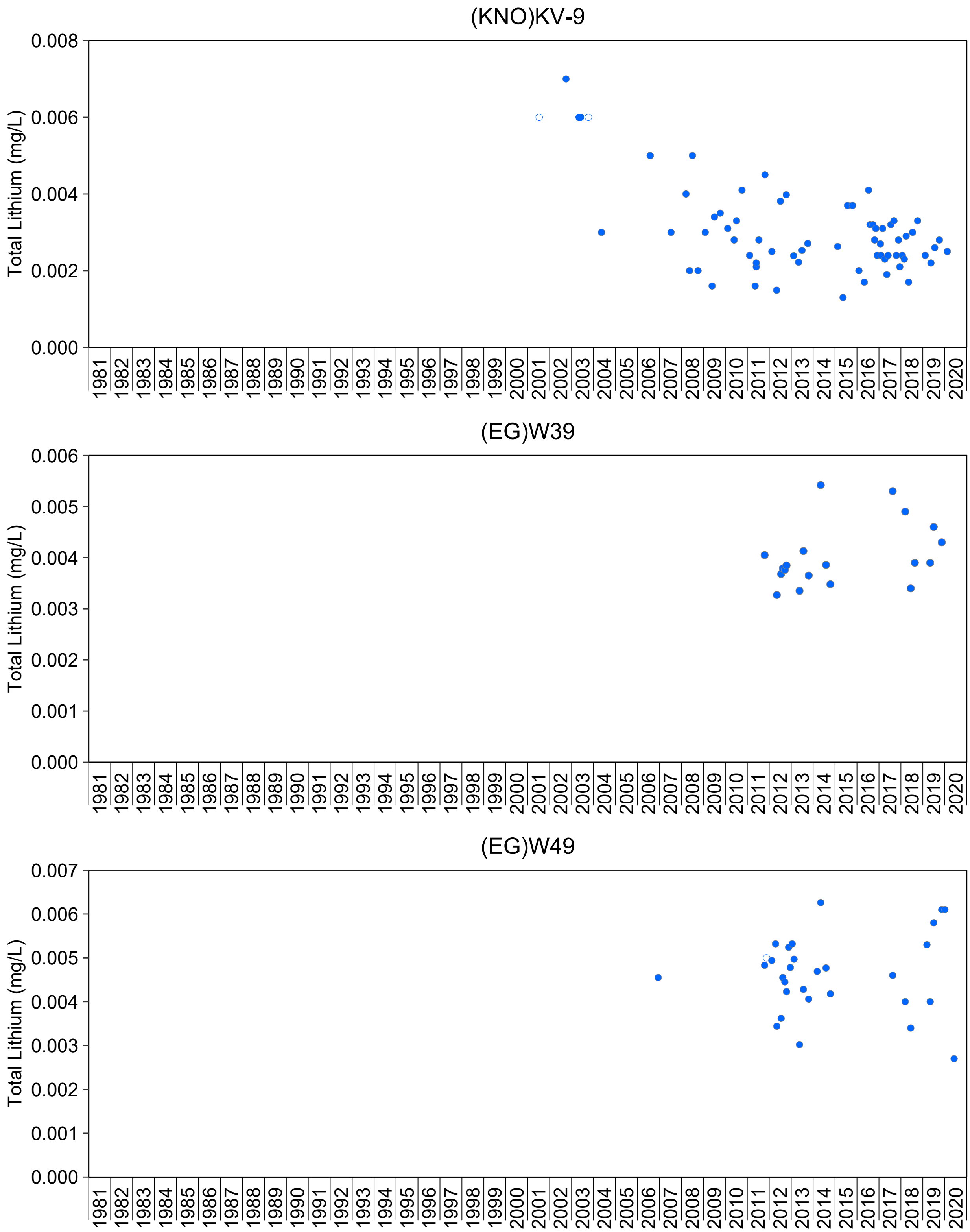


Figure A.53: Time Series Plots of Total Lithium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

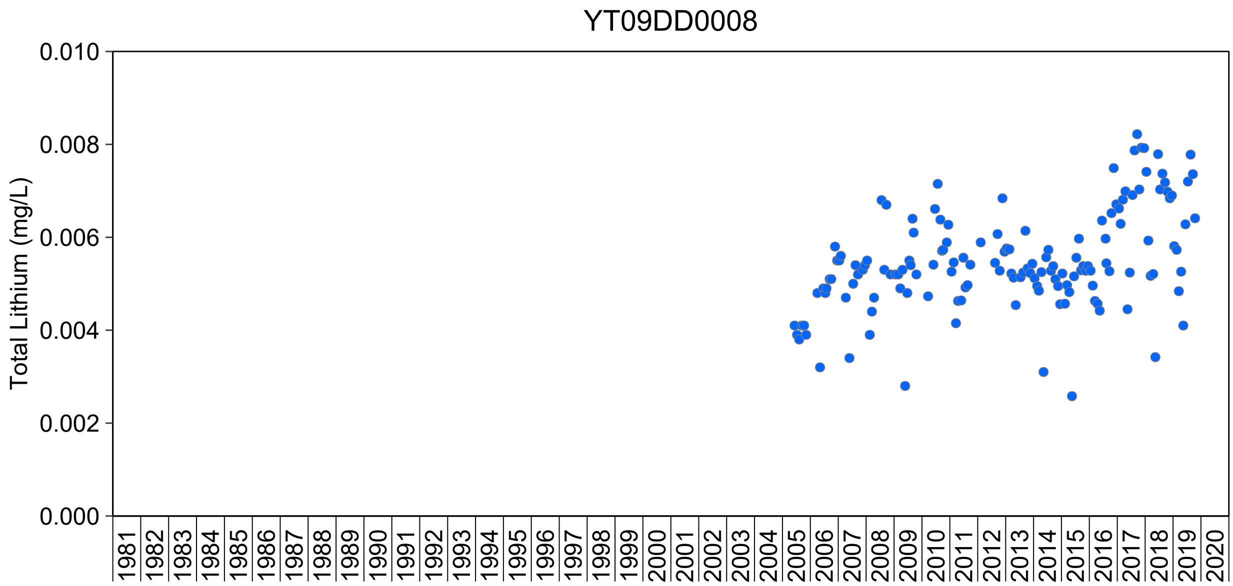


Figure A.53: Time Series Plots of Total Lithium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

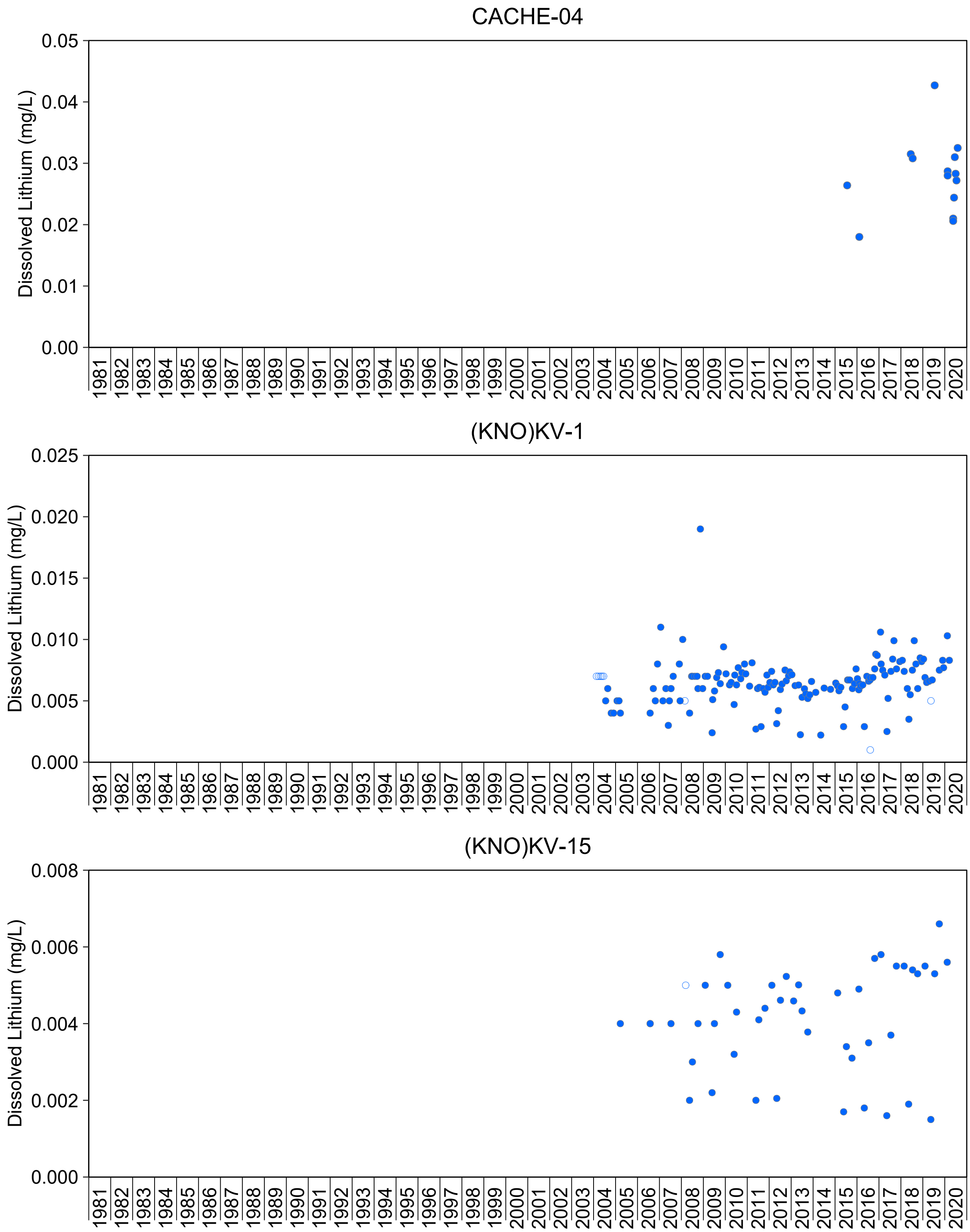


Figure A.54: Time Series Plots of Dissolved Lithium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

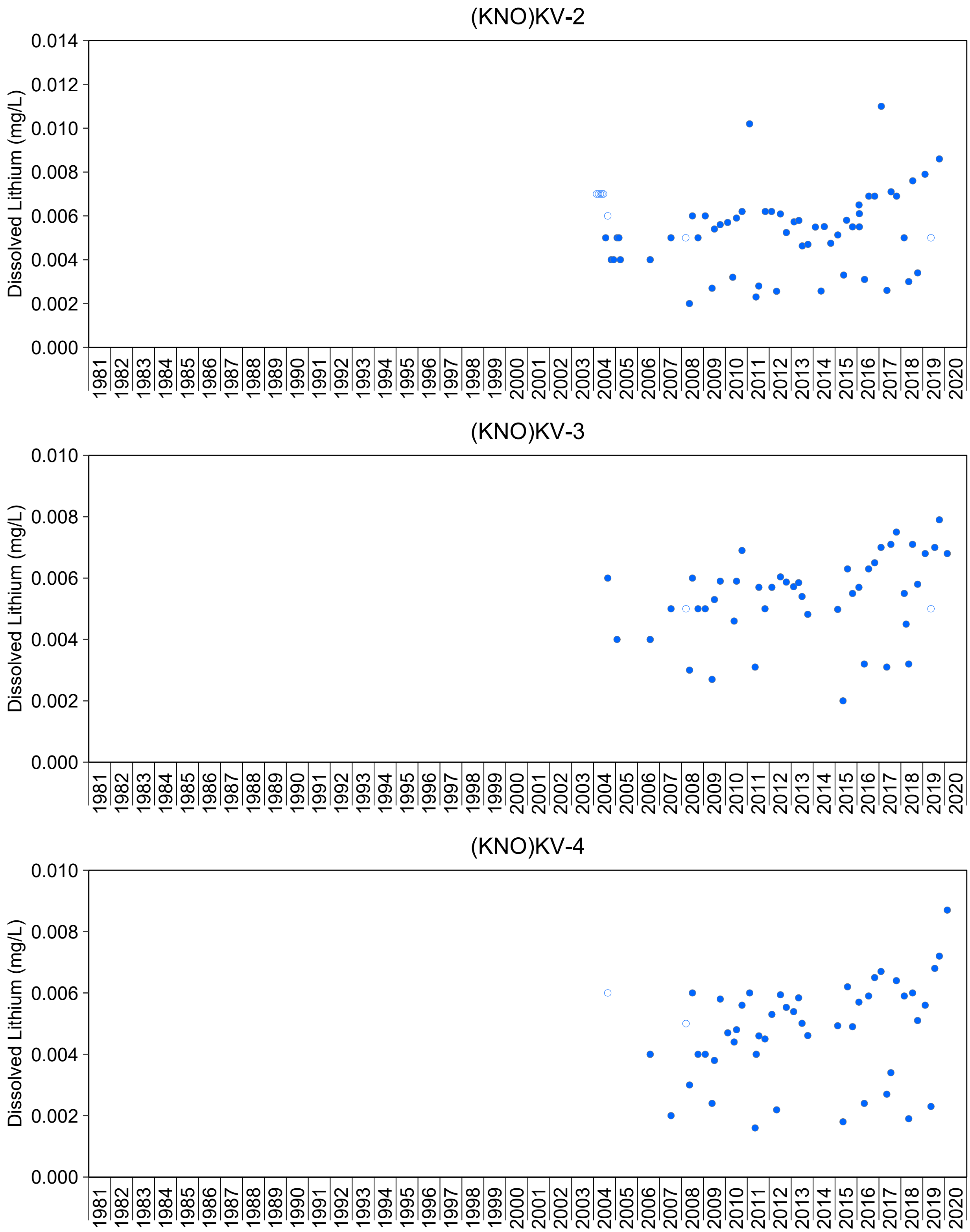


Figure A.54: Time Series Plots of Dissolved Lithium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

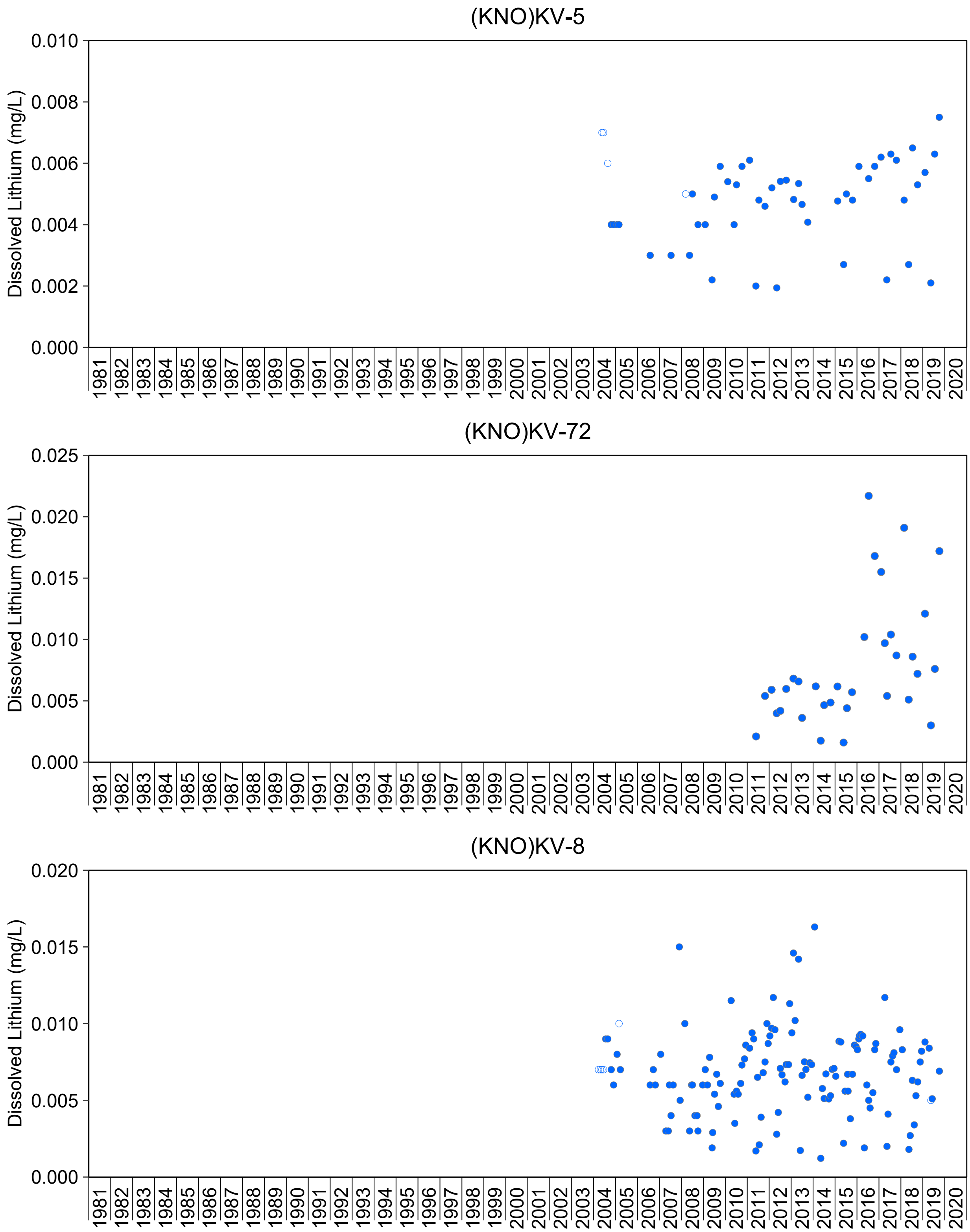


Figure A.54: Time Series Plots of Dissolved Lithium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

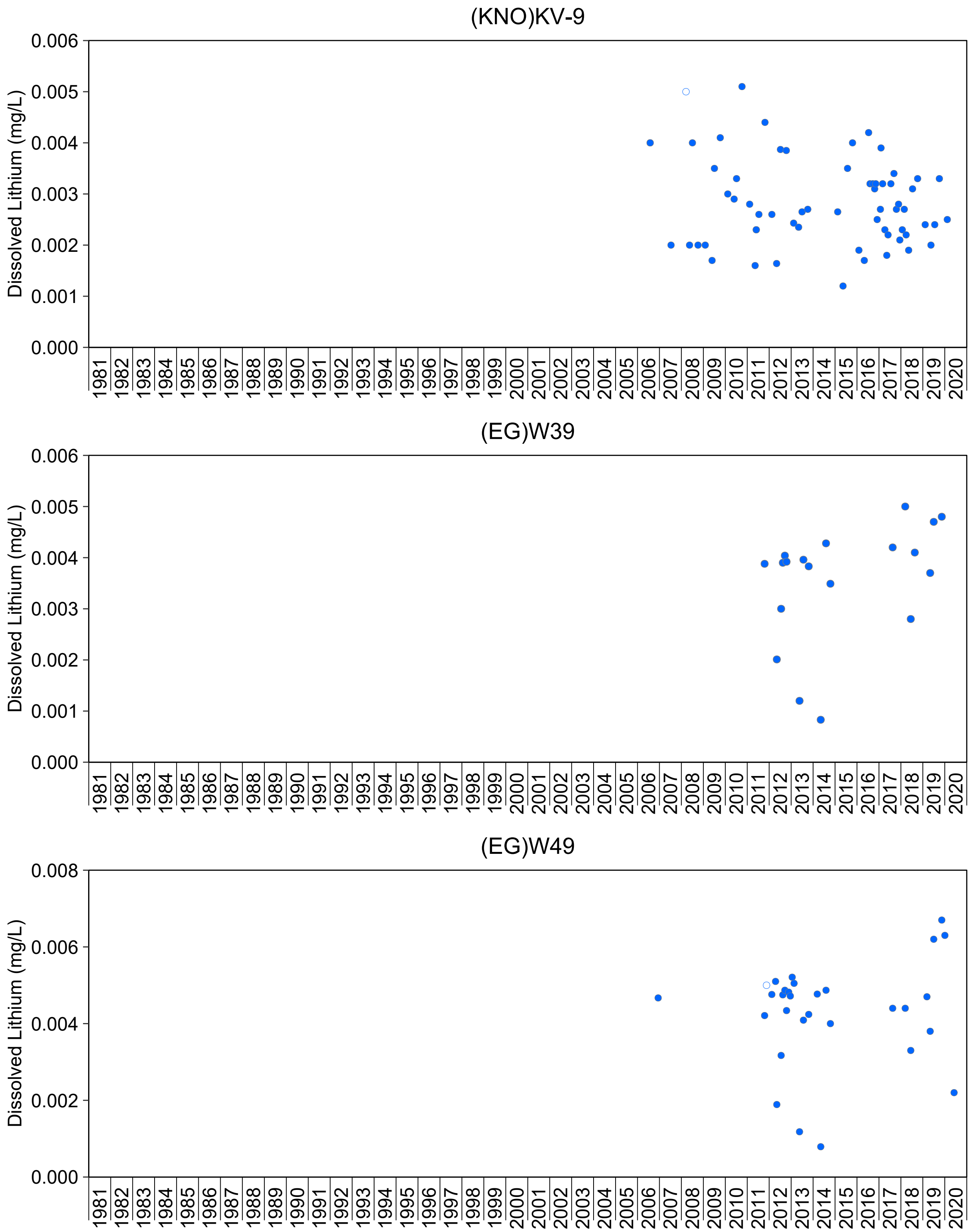


Figure A.54: Time Series Plots of Dissolved Lithium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

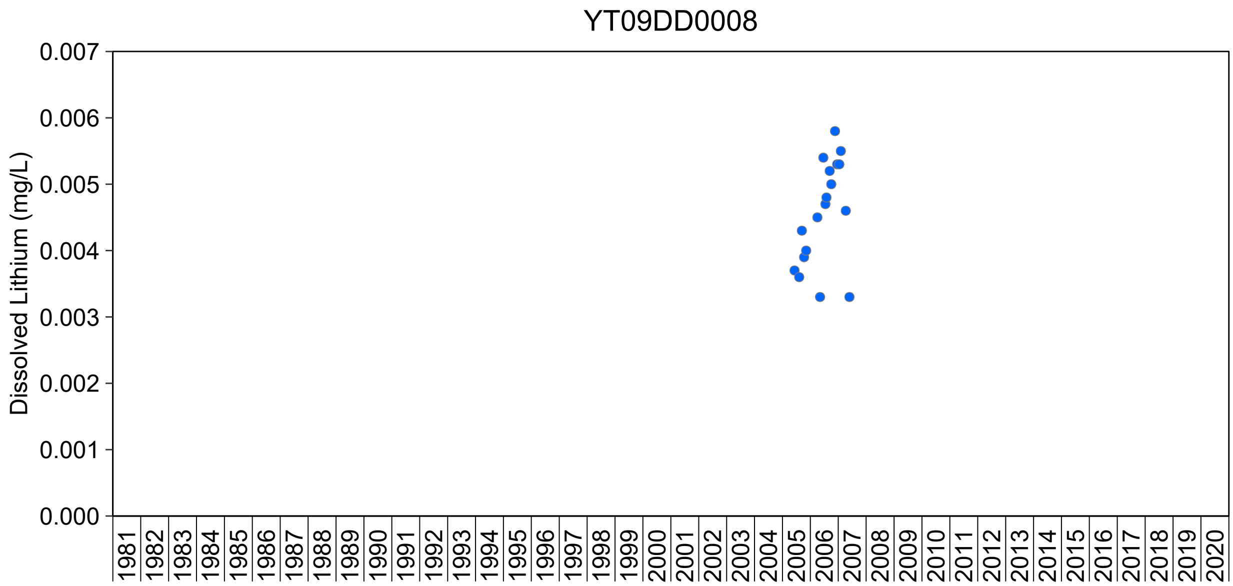


Figure A.54: Time Series Plots of Dissolved Lithium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

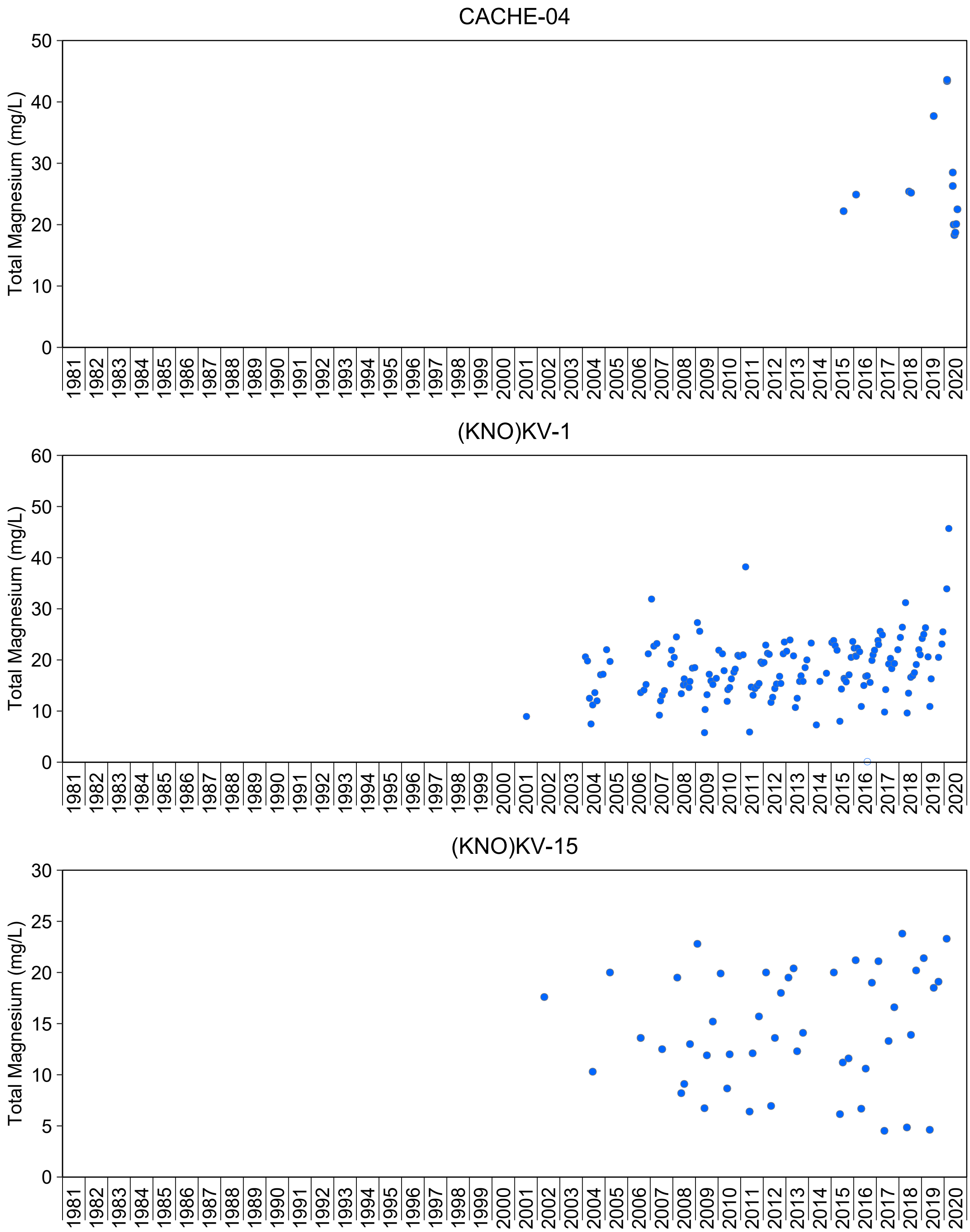


Figure A.55: Time Series Plots of Total Magnesium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

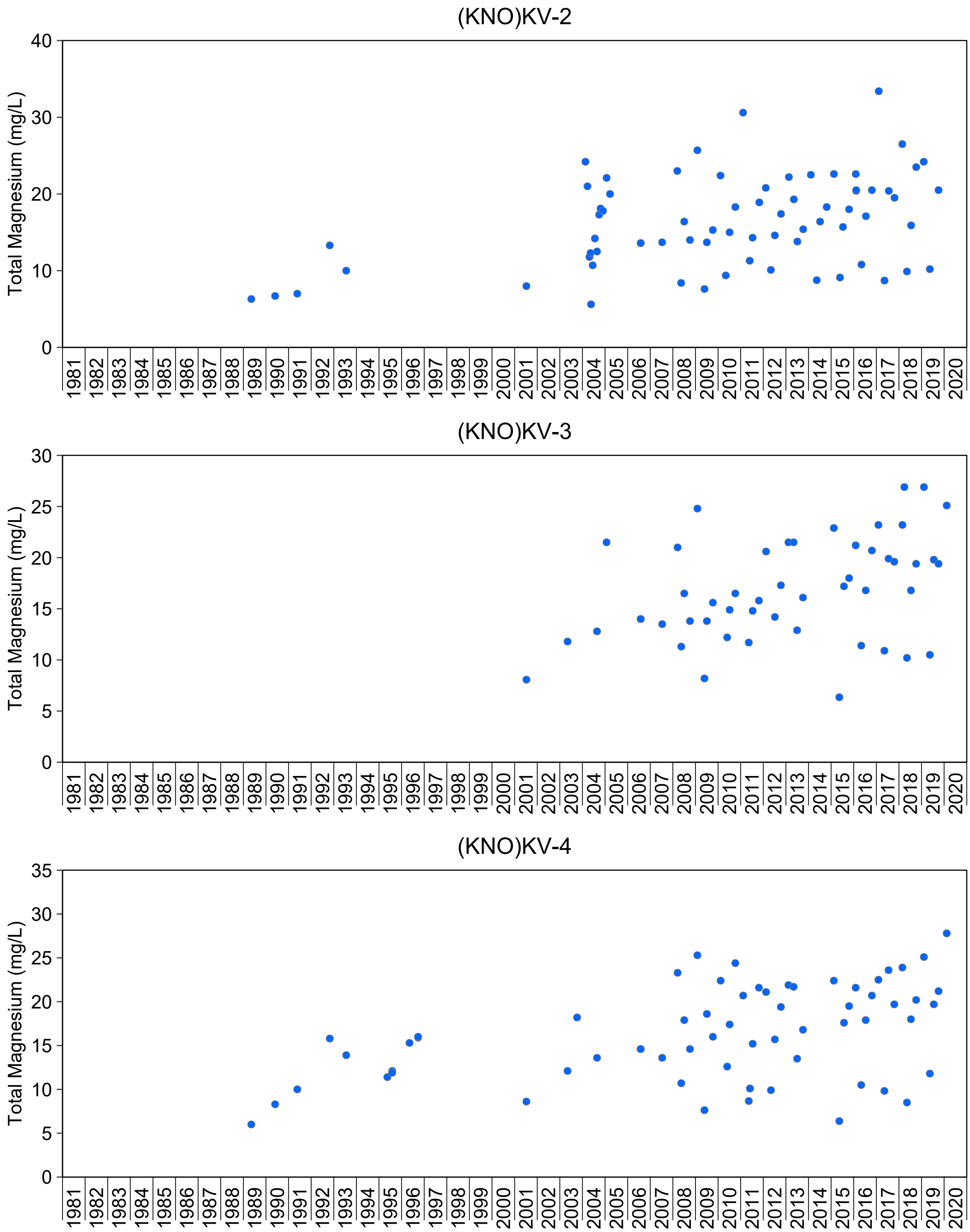


Figure A.55: Time Series Plots of Total Magnesium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

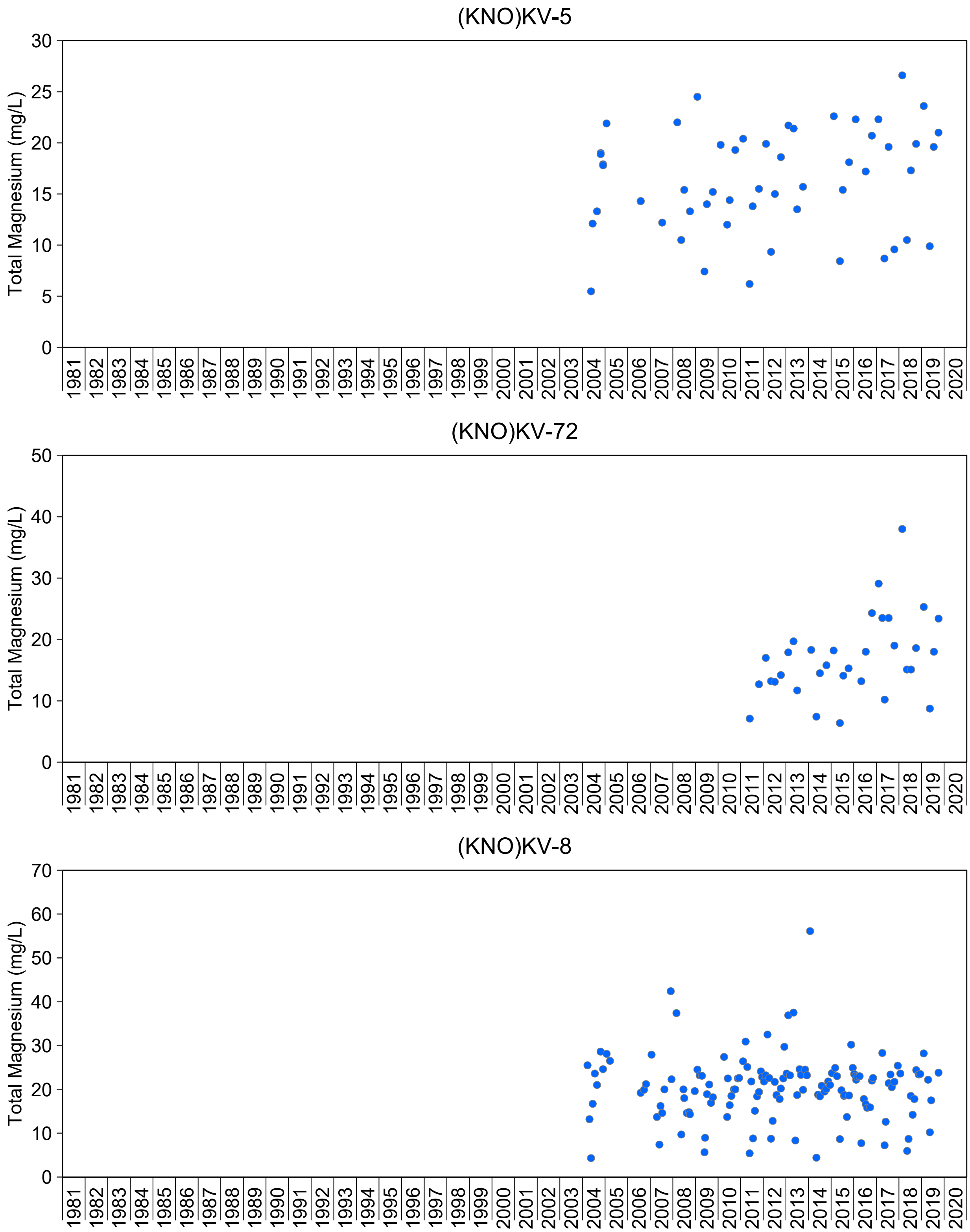


Figure A.55: Time Series Plots of Total Magnesium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

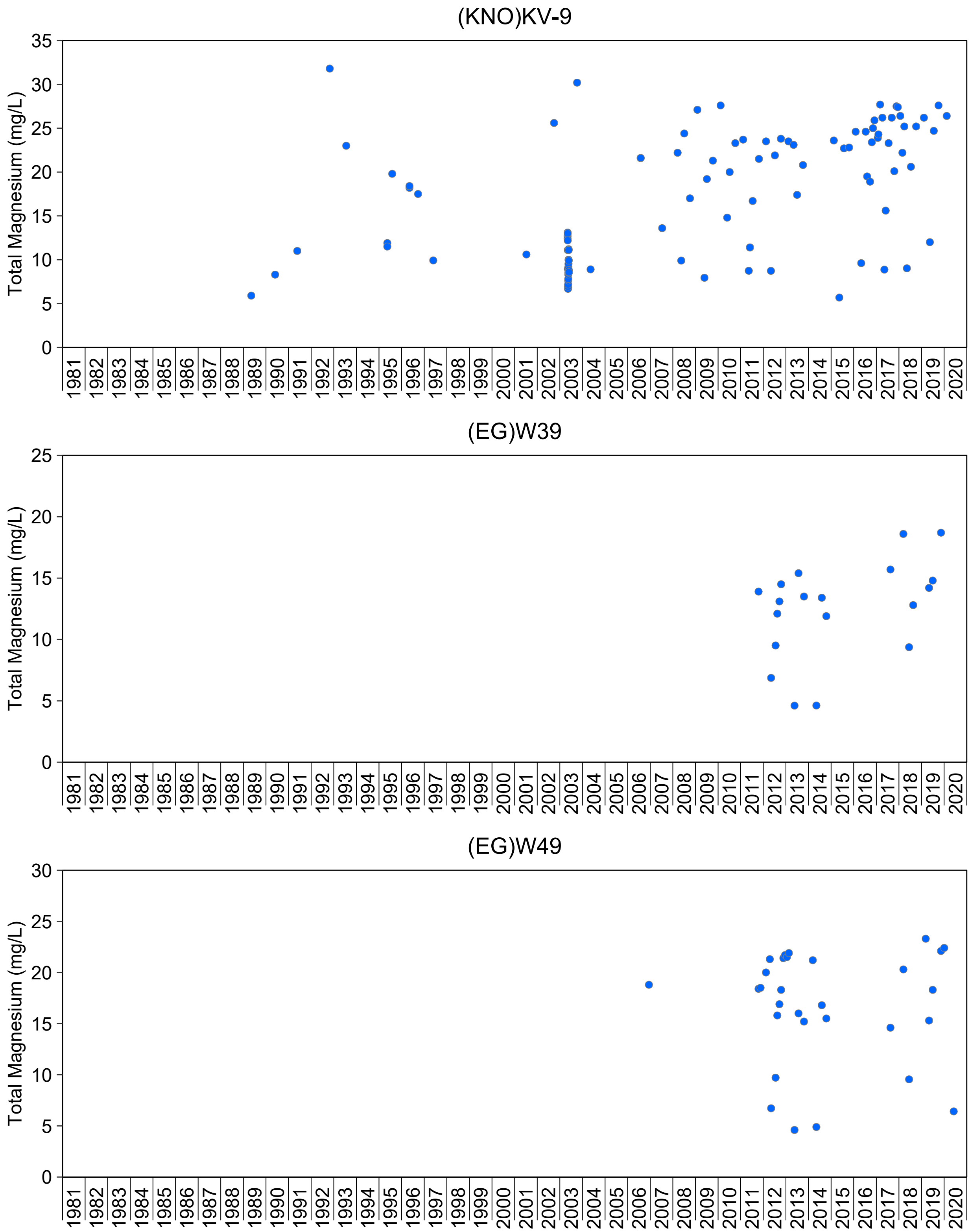


Figure A.55: Time Series Plots of Total Magnesium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

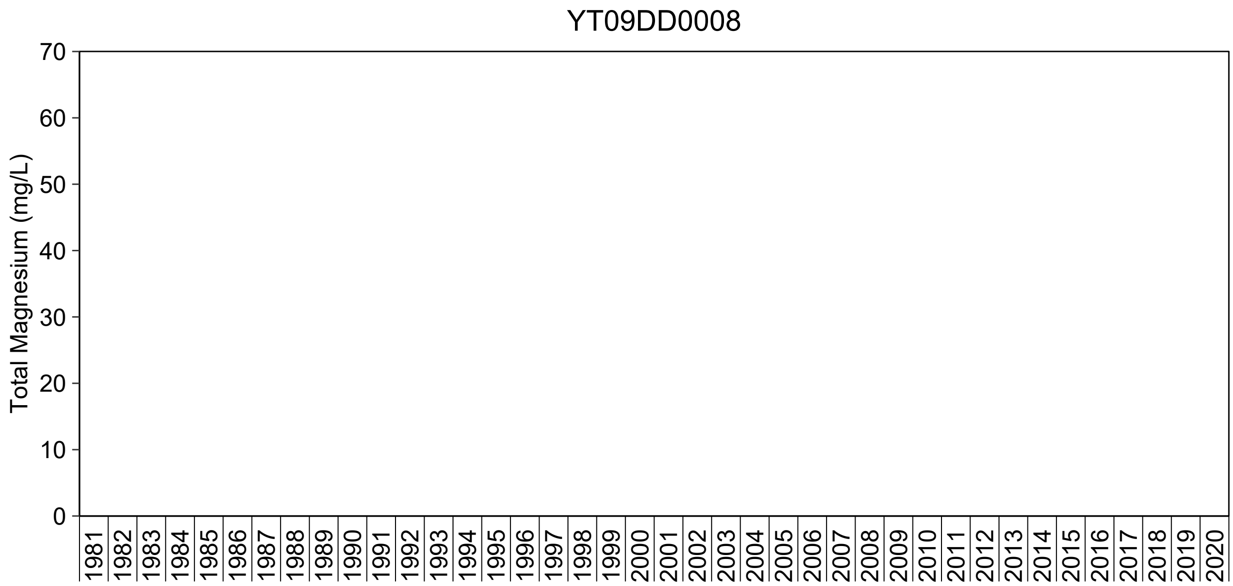


Figure A.55: Time Series Plots of Total Magnesium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

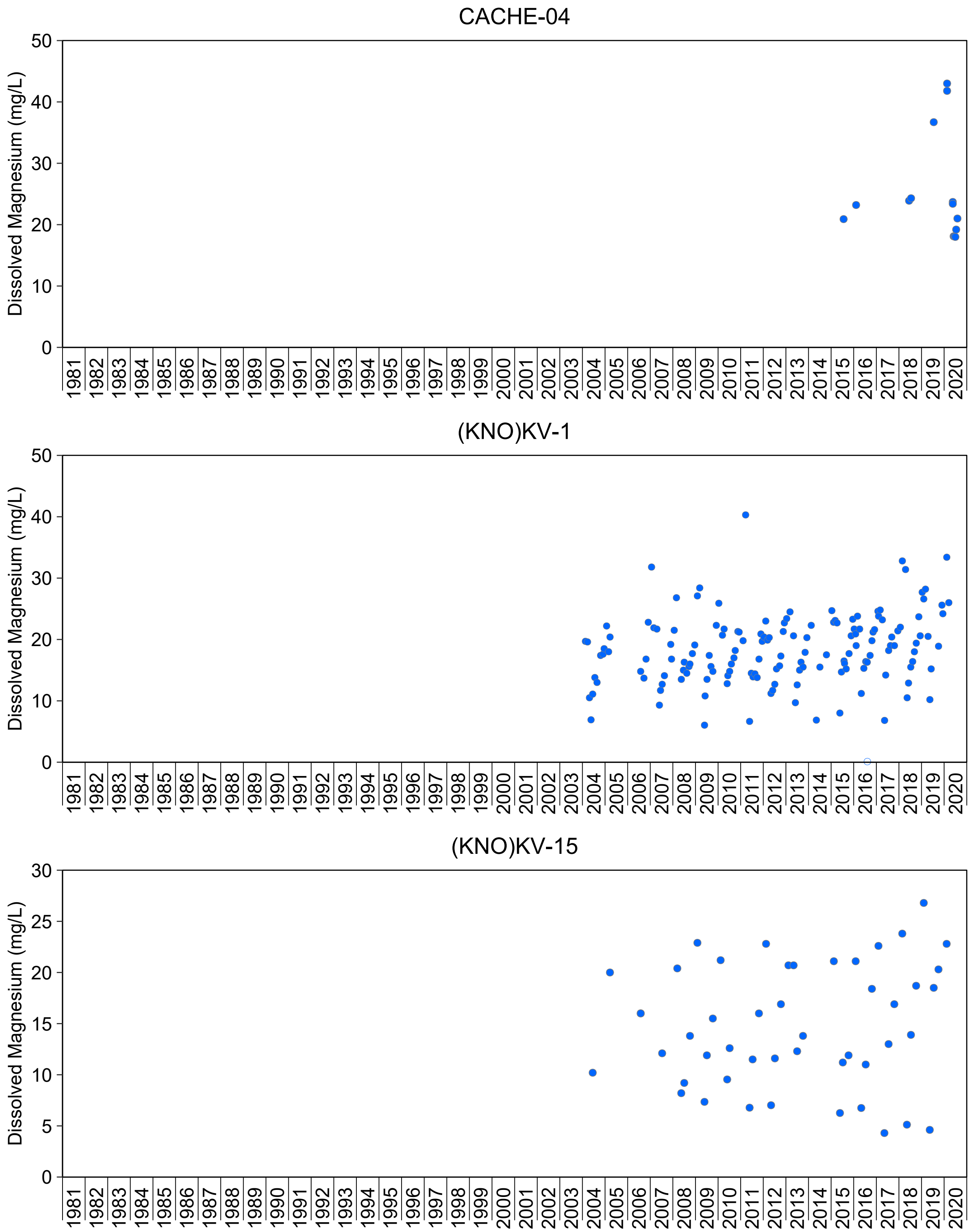


Figure A.56: Time Series Plots of Dissolved Magnesium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

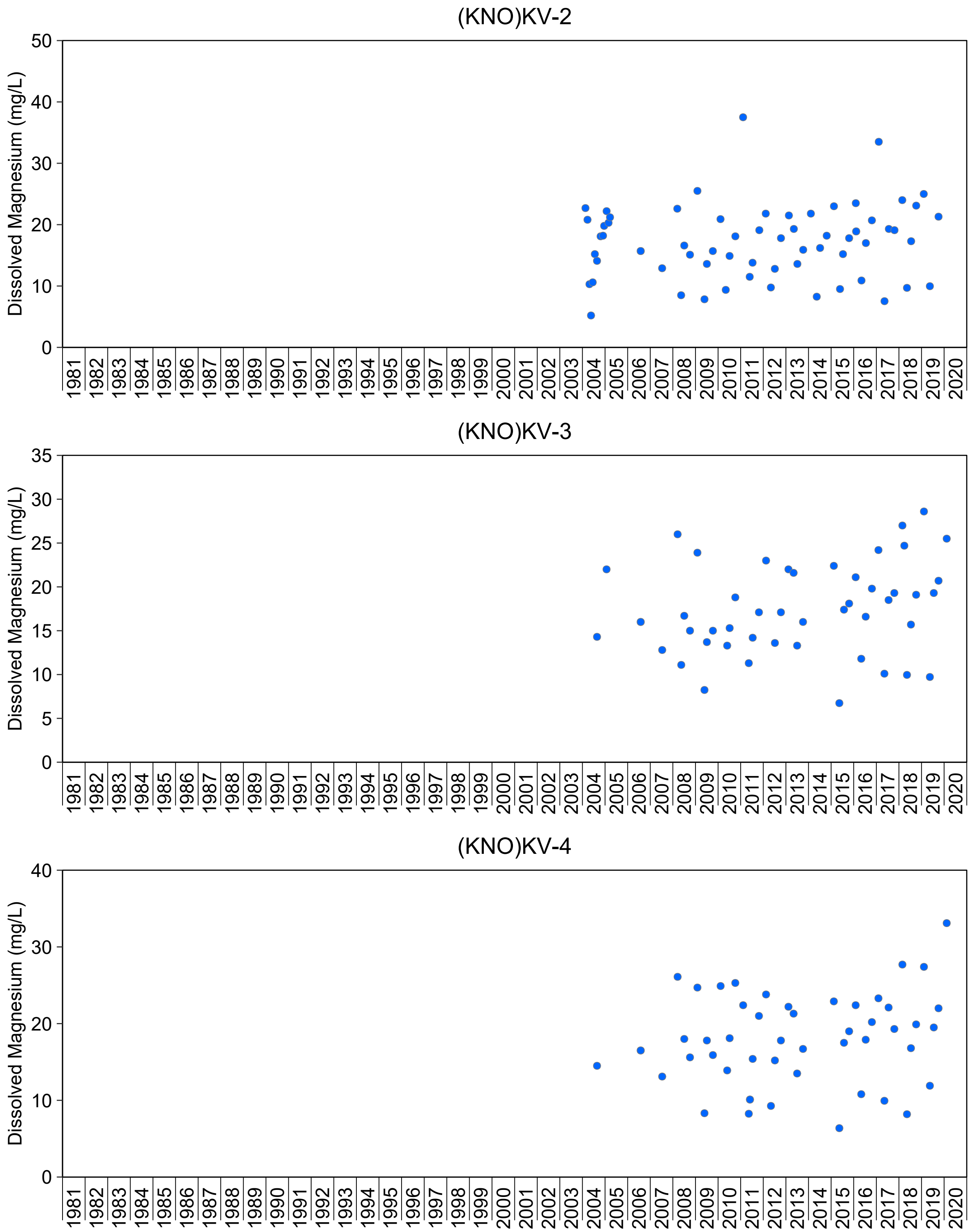


Figure A.56: Time Series Plots of Dissolved Magnesium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

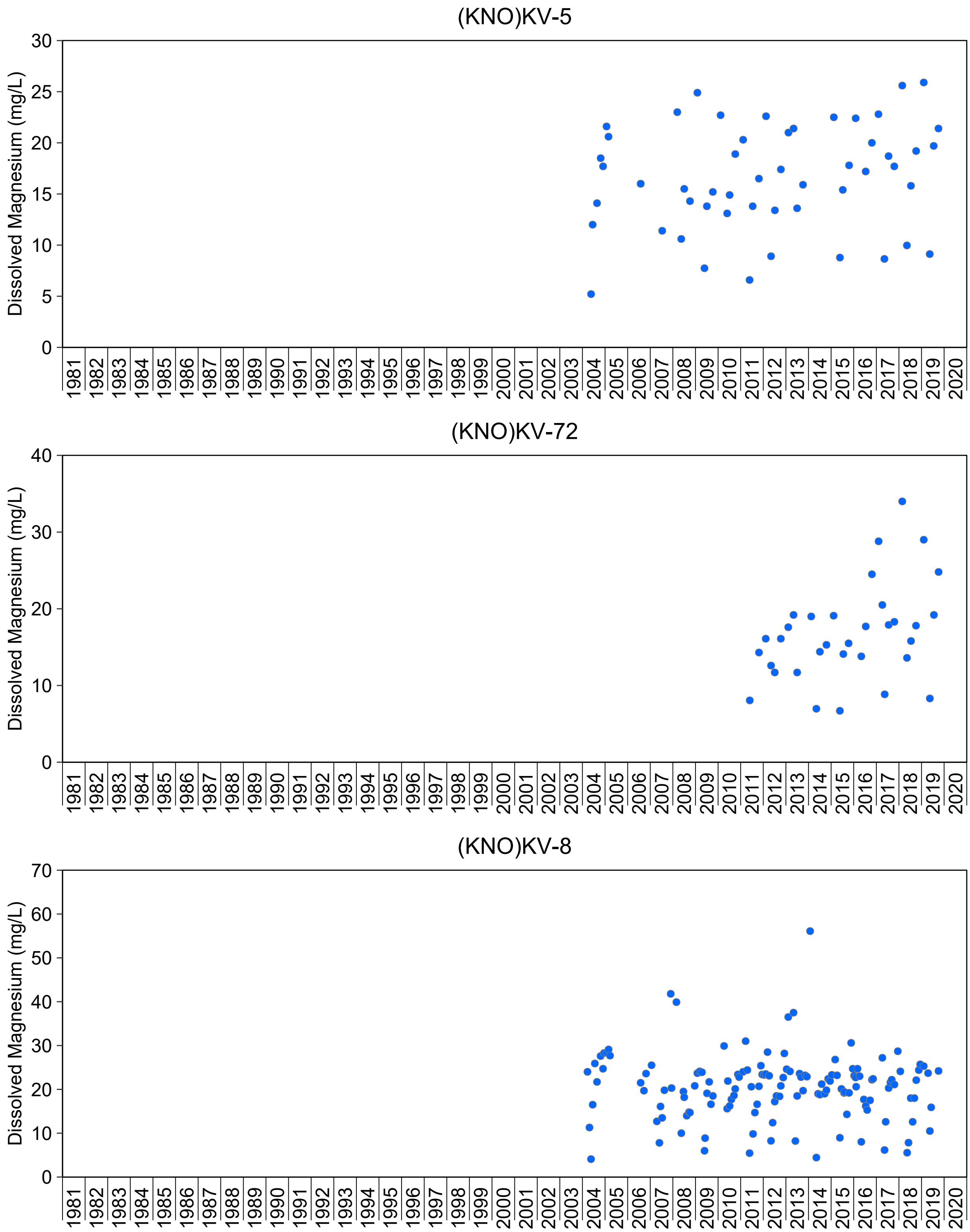


Figure A.56: **Time Series Plots of Dissolved Magnesium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020**

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

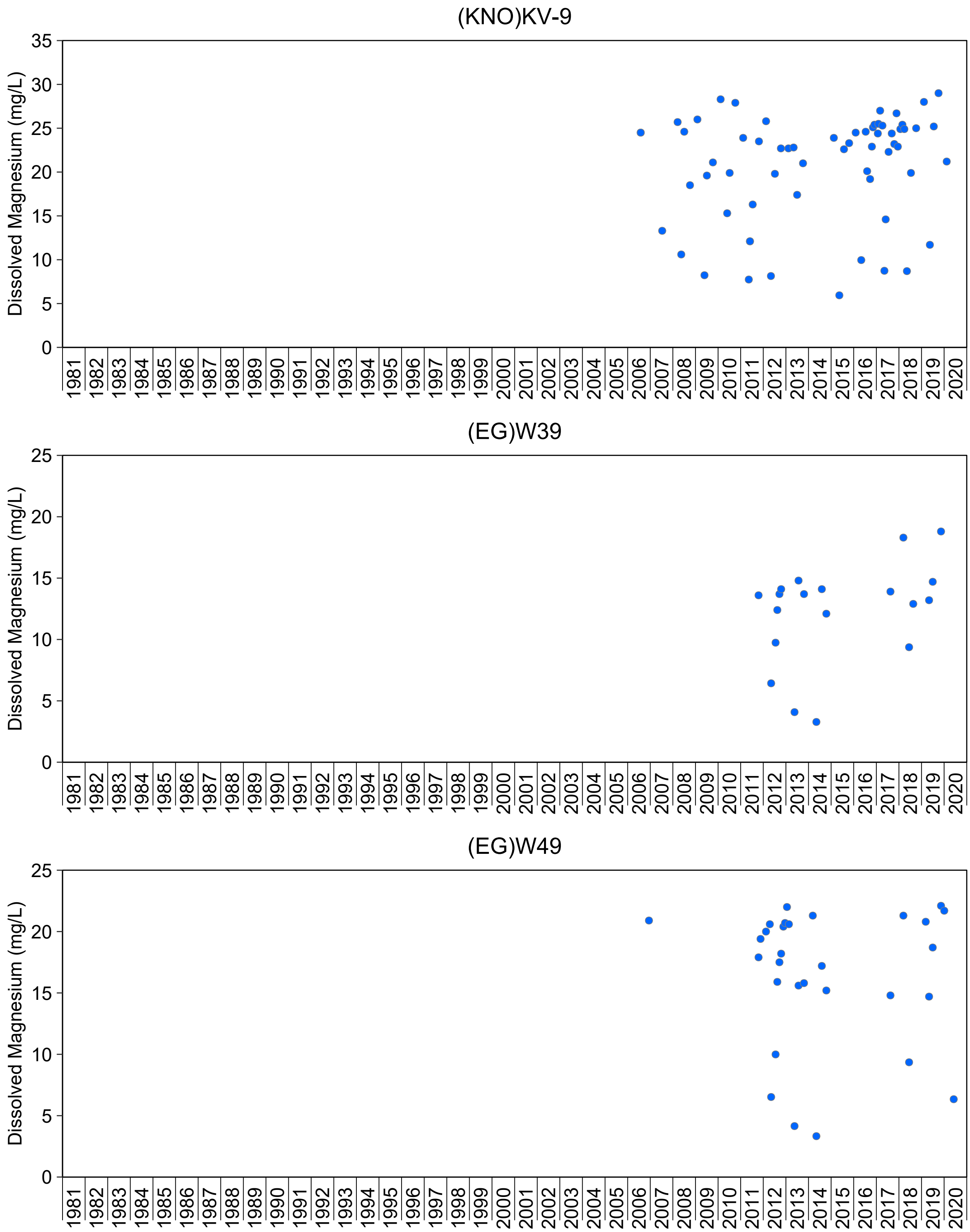


Figure A.56: Time Series Plots of Dissolved Magnesium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

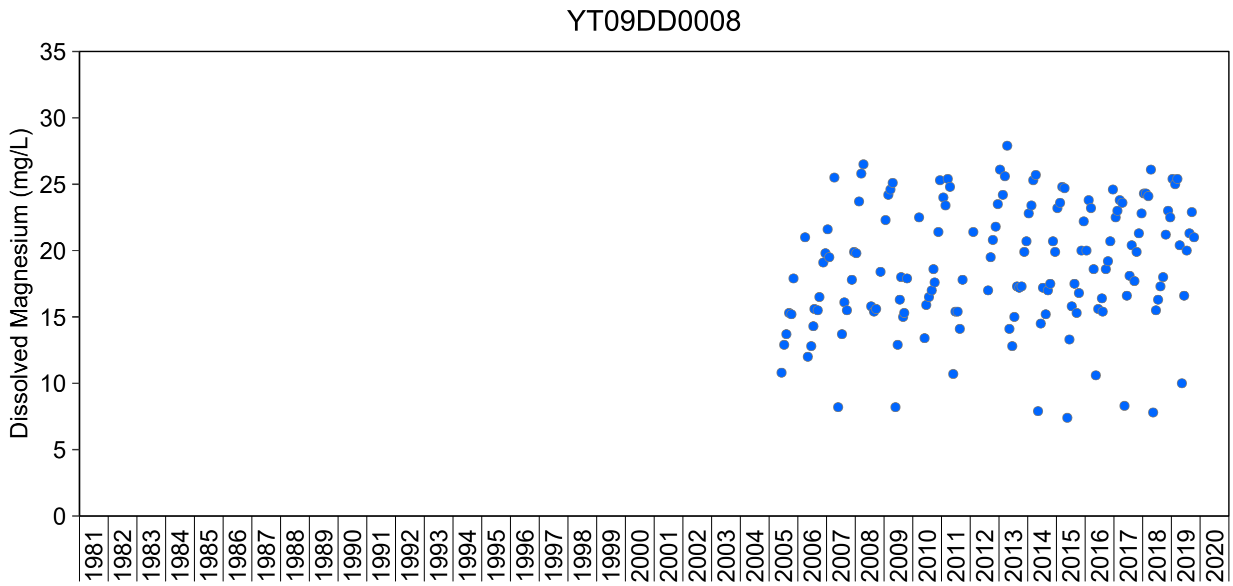


Figure A.56: **Time Series Plots of Dissolved Magnesium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020**

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

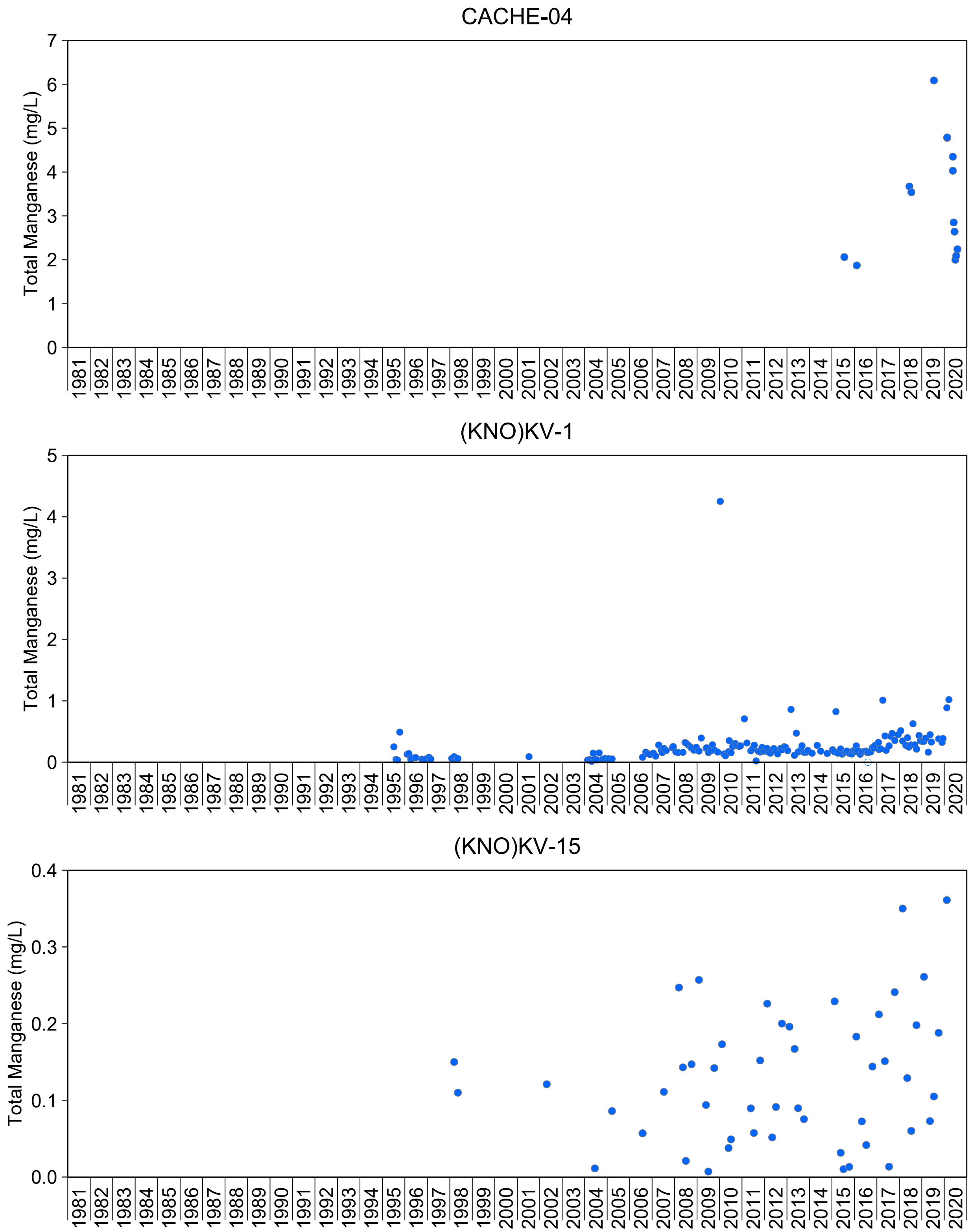


Figure A.57: Time Series Plots of Total Manganese Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

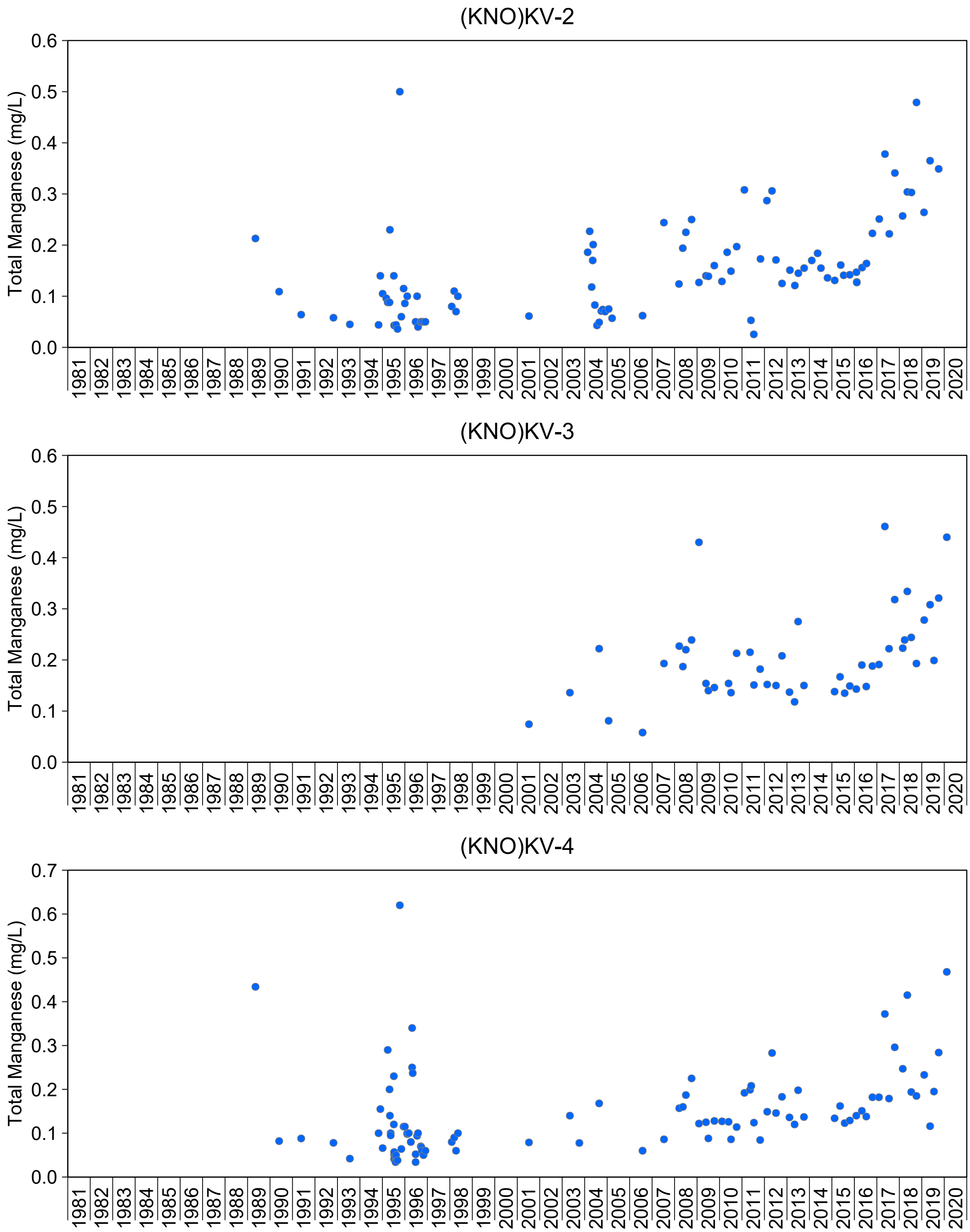


Figure A.57: Time Series Plots of Total Manganese Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

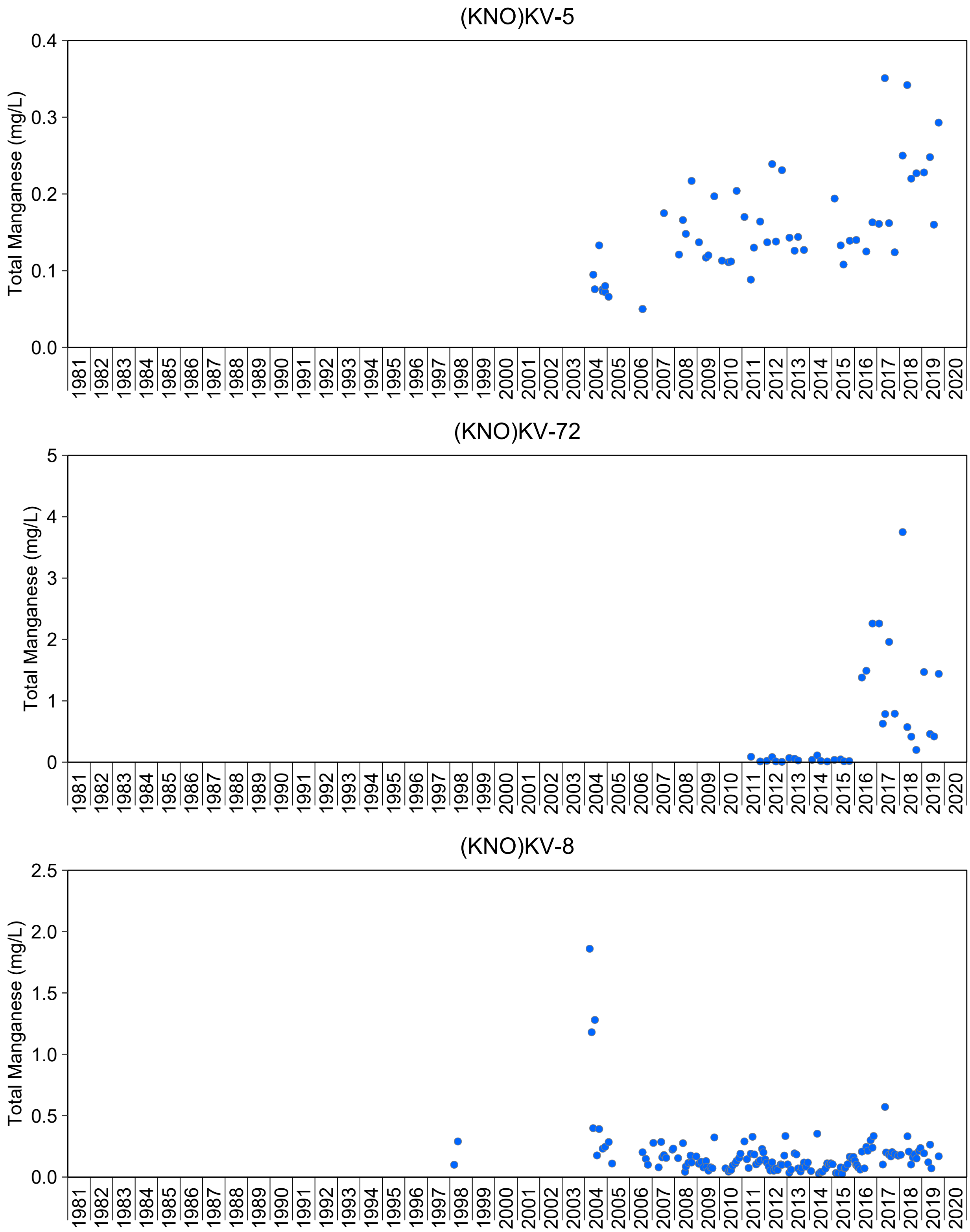


Figure A.57: Time Series Plots of Total Manganese Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

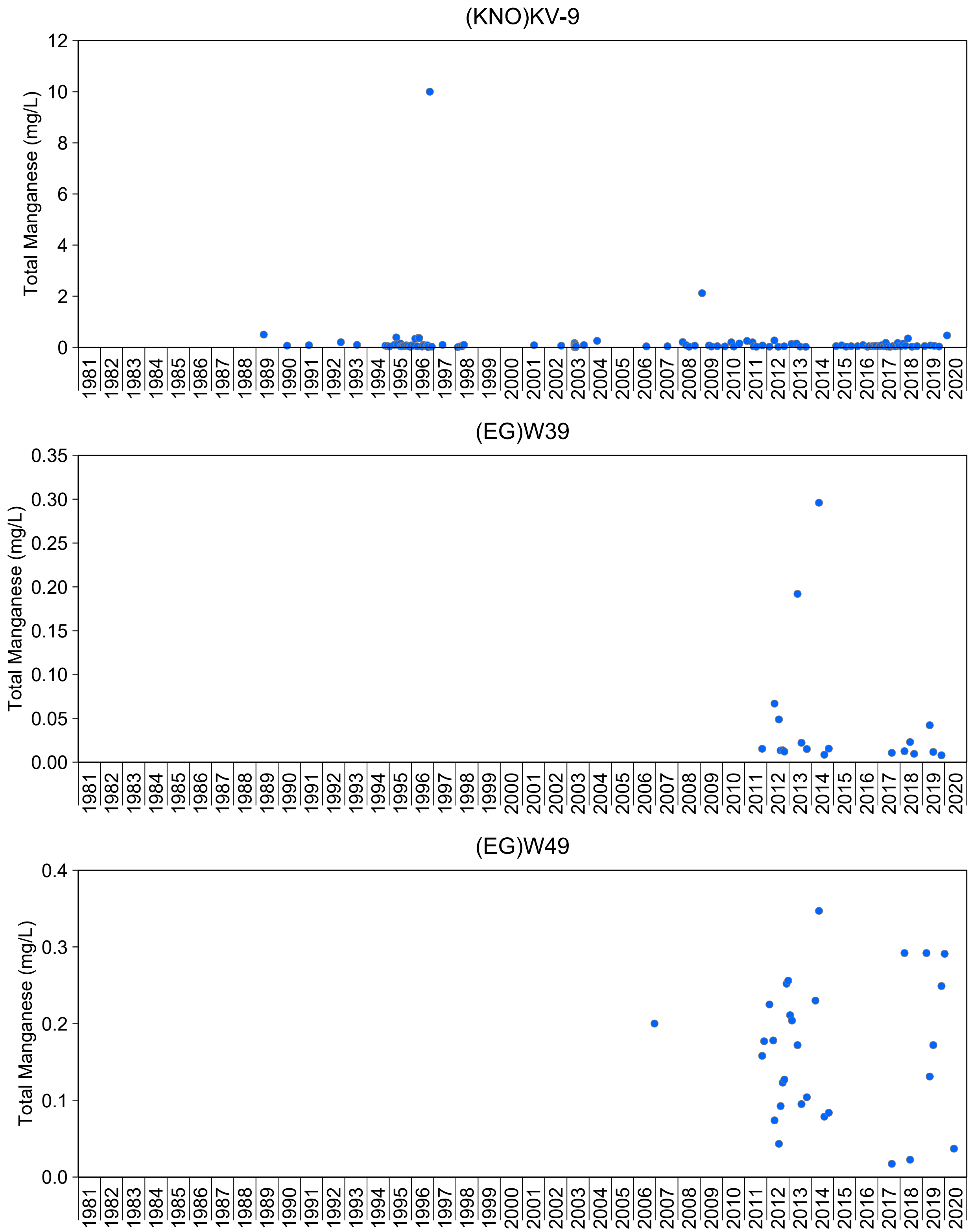


Figure A.57: Time Series Plots of Total Manganese Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

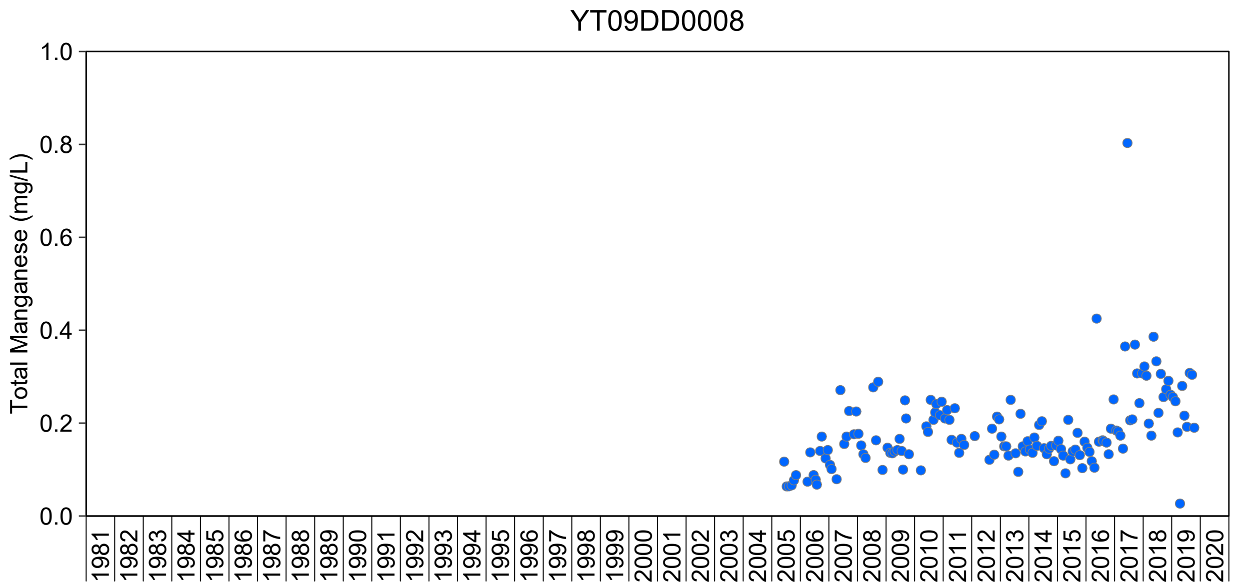
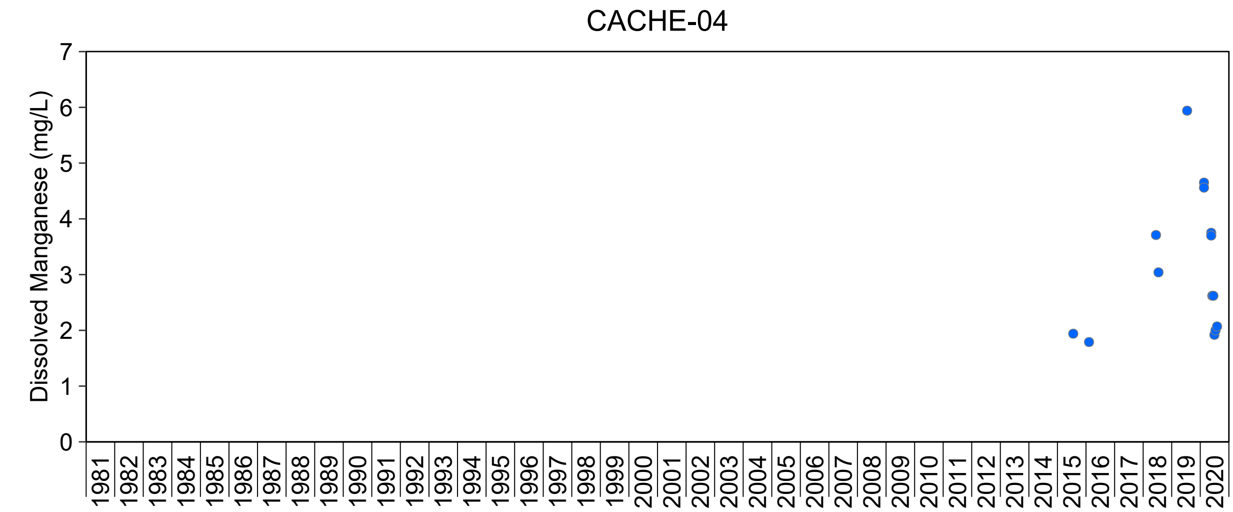
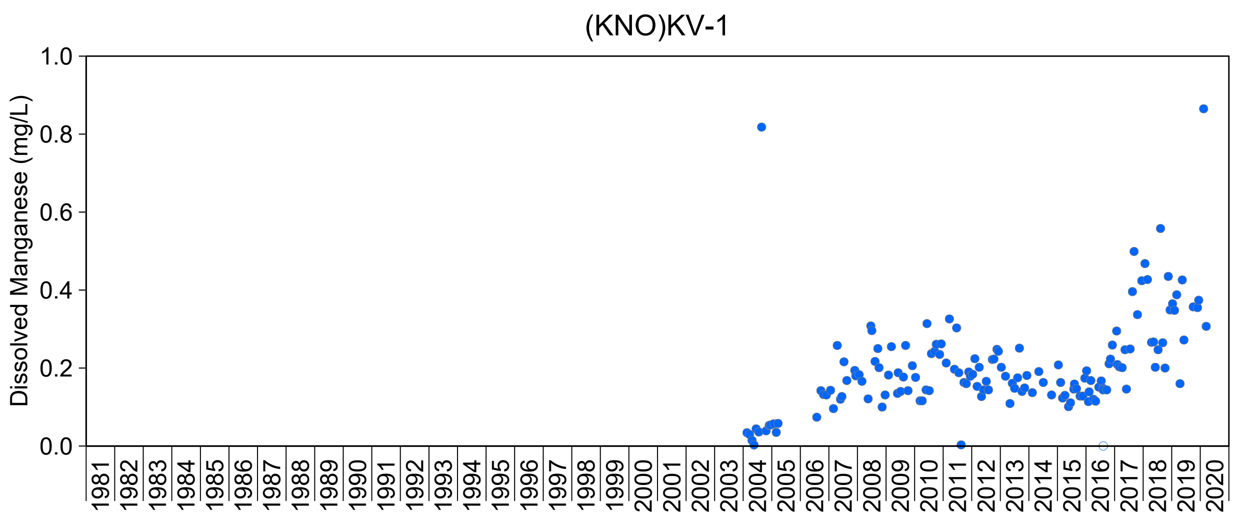


Figure A.57: Time Series Plots of Total Manganese Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.





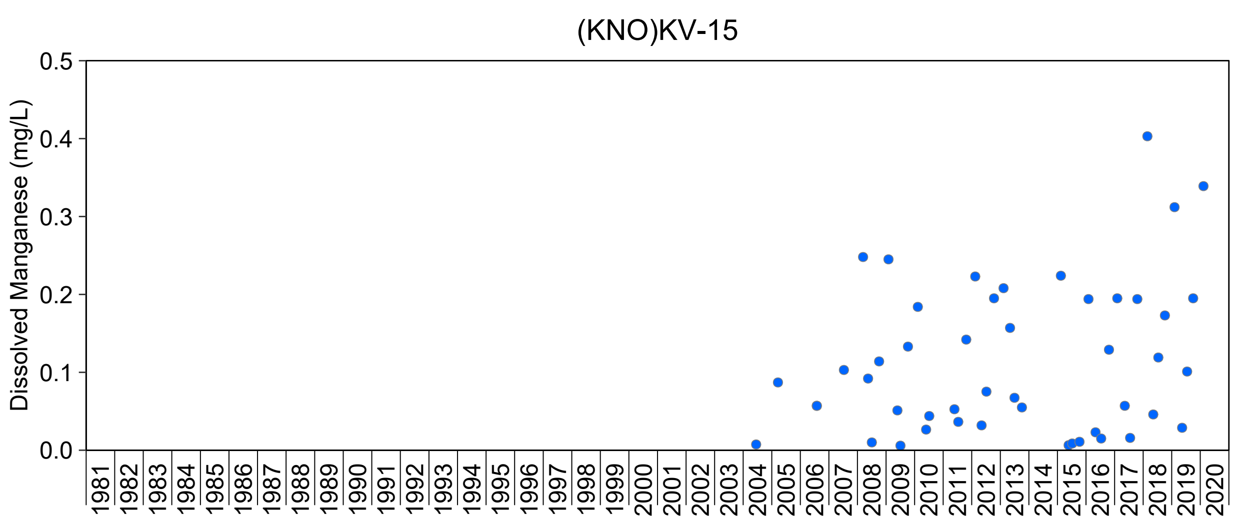


Figure A.58: Time Series Plots of Dissolved Manganese Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

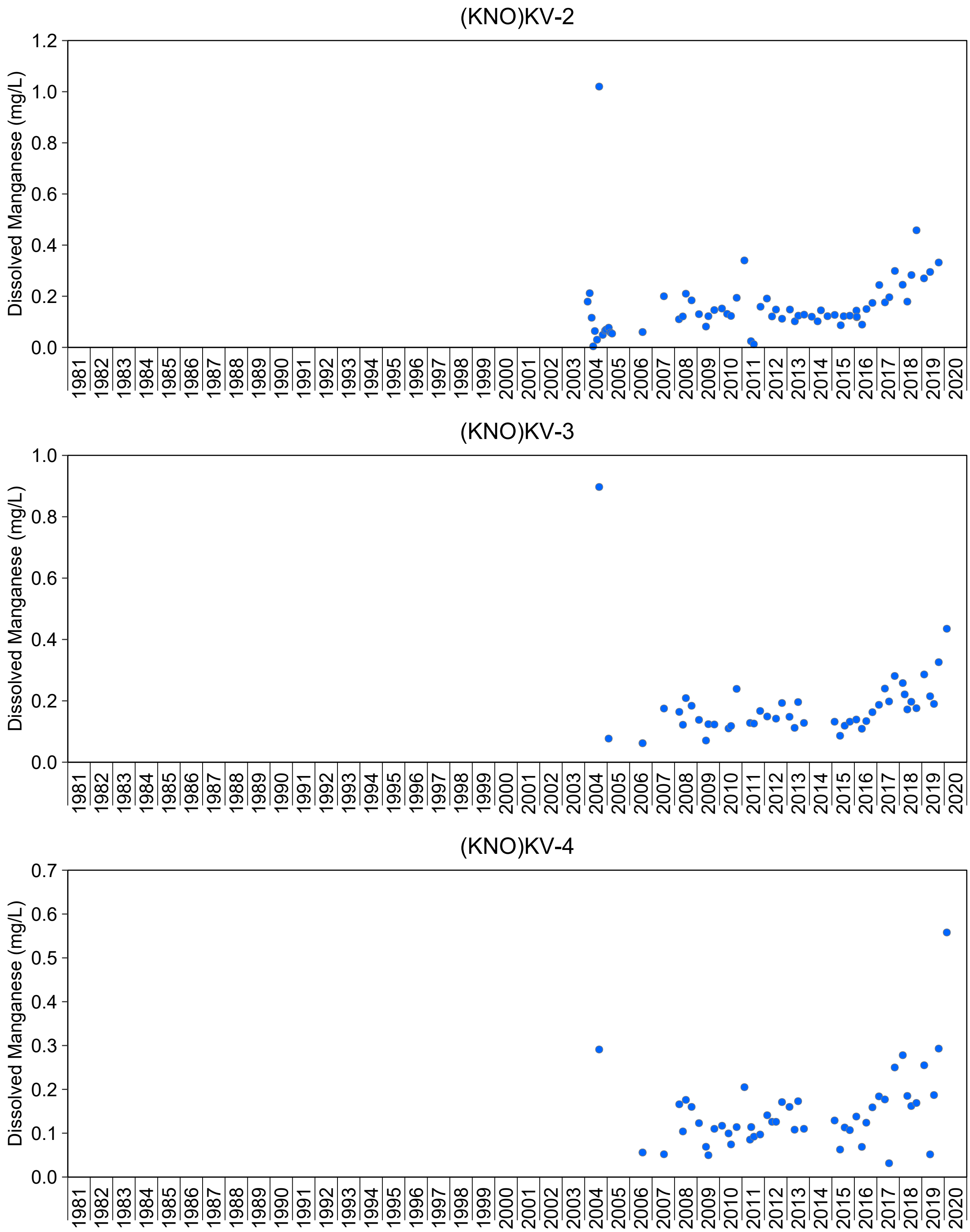


Figure A.58: Time Series Plots of Dissolved Manganese Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

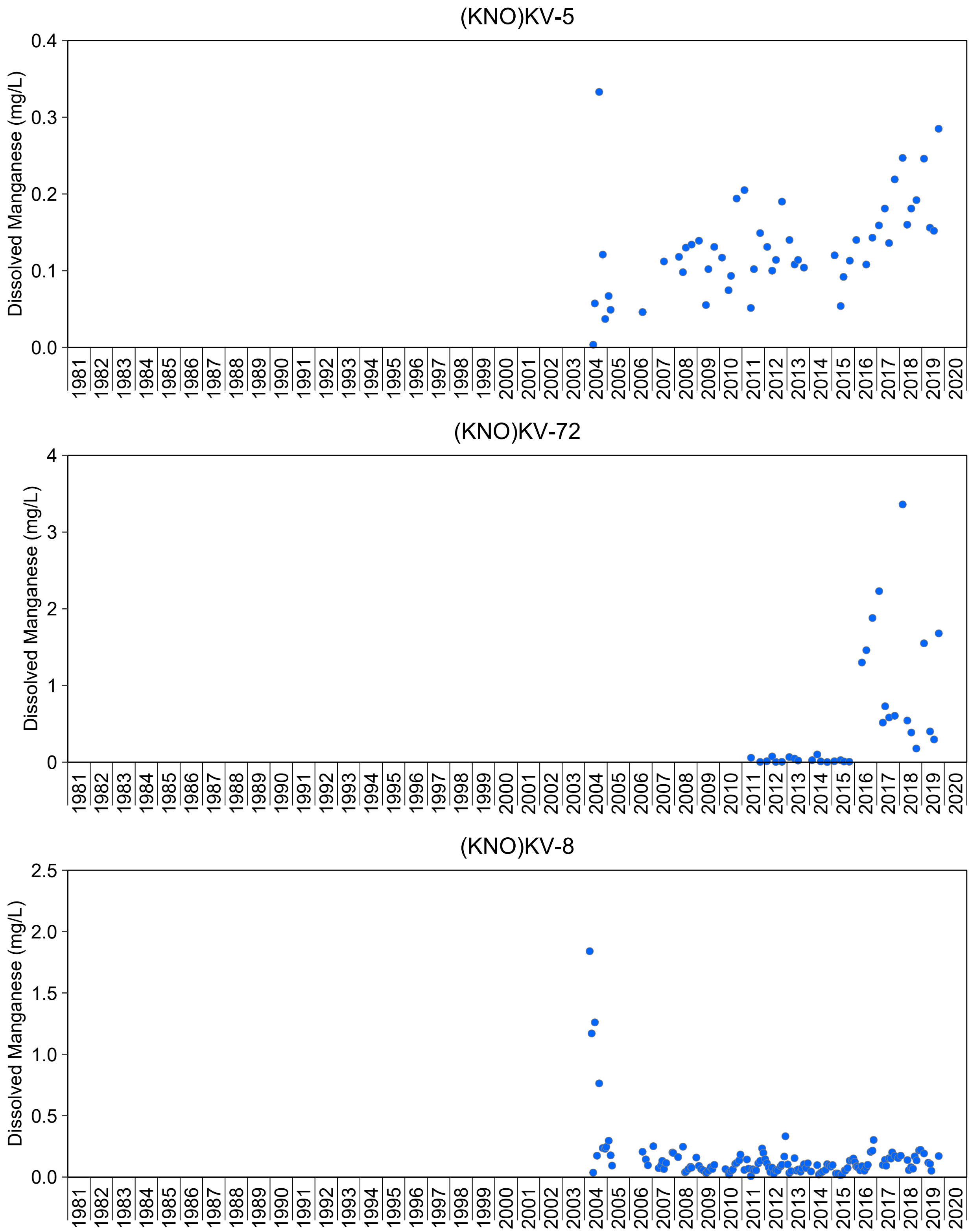


Figure A.58: Time Series Plots of Dissolved Manganese Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

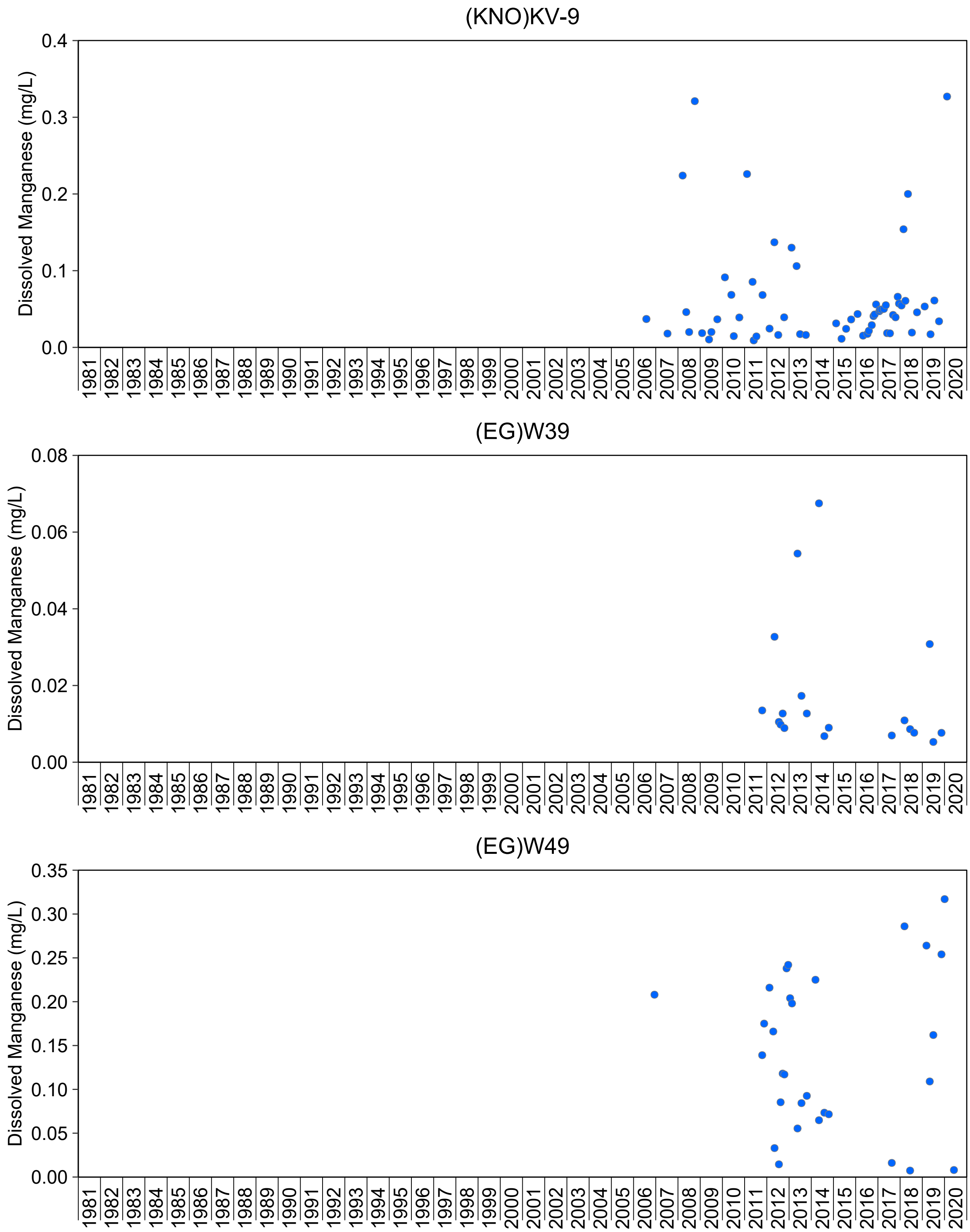


Figure A.58: Time Series Plots of Dissolved Manganese Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

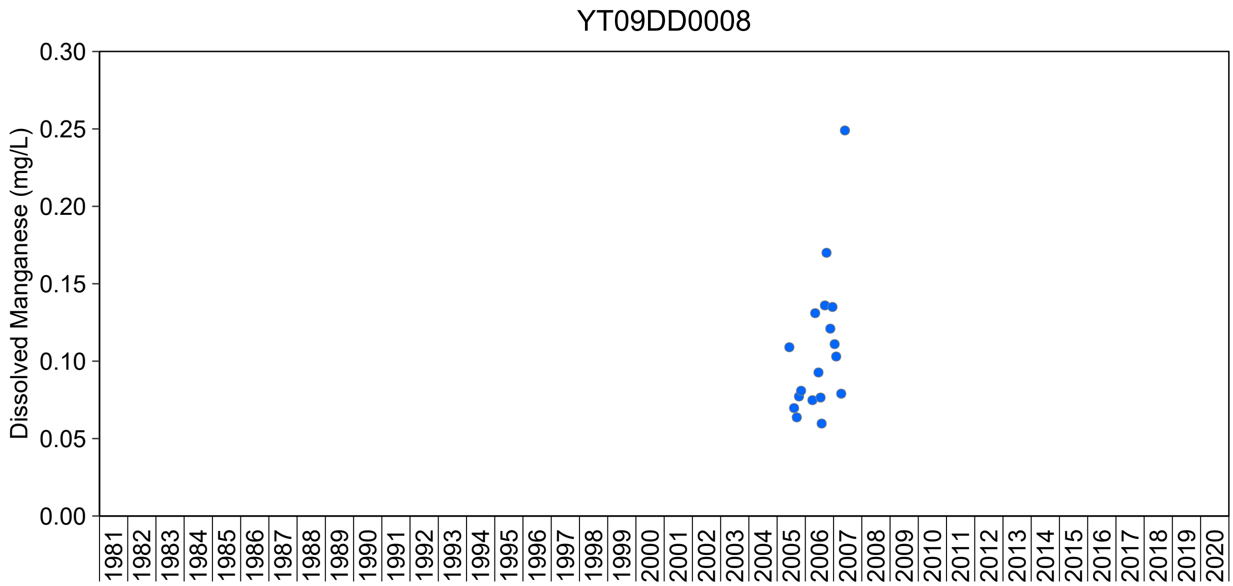


Figure A.58: Time Series Plots of Dissolved Manganese Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

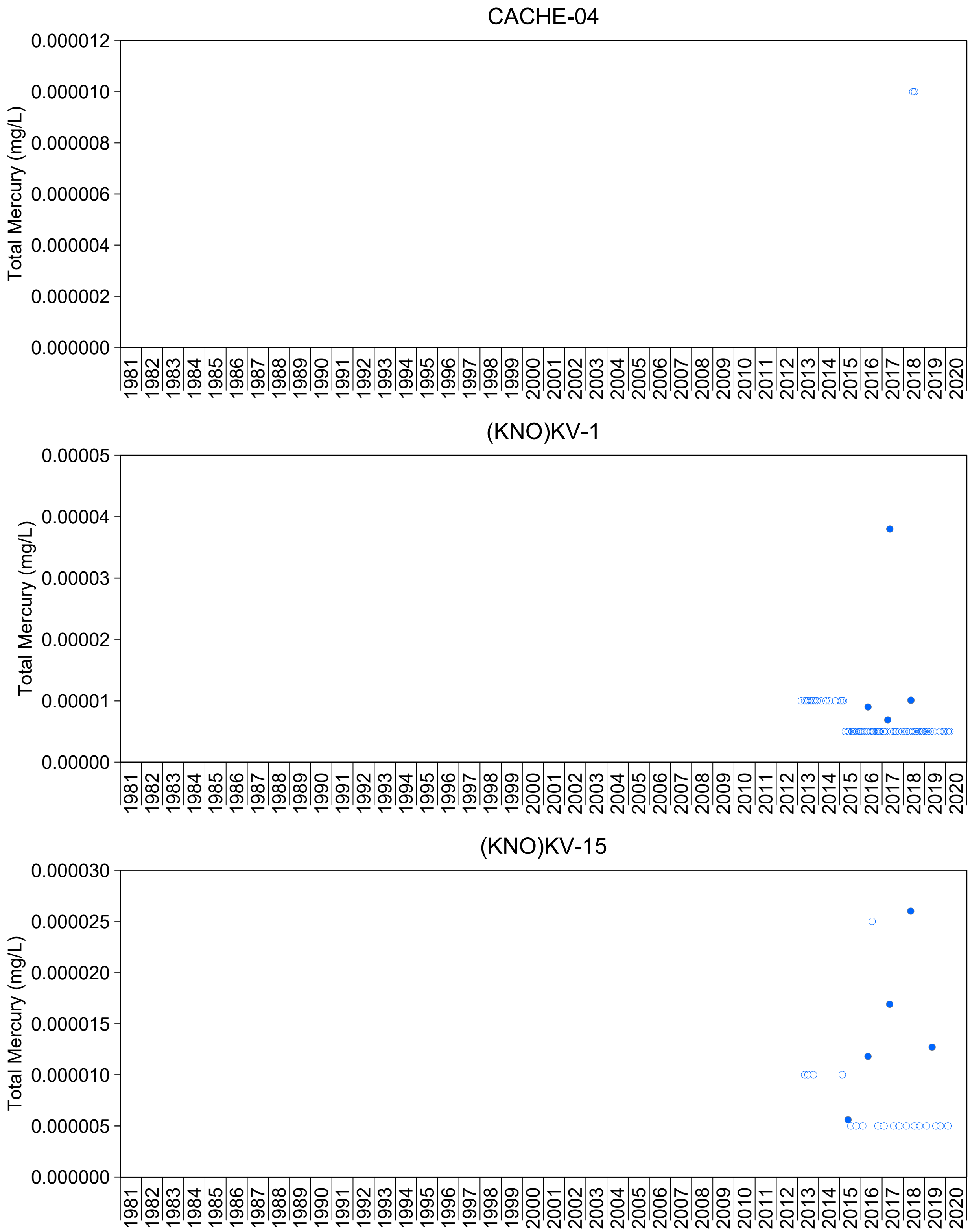


Figure A.59: Time Series Plots of Total Mercury Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

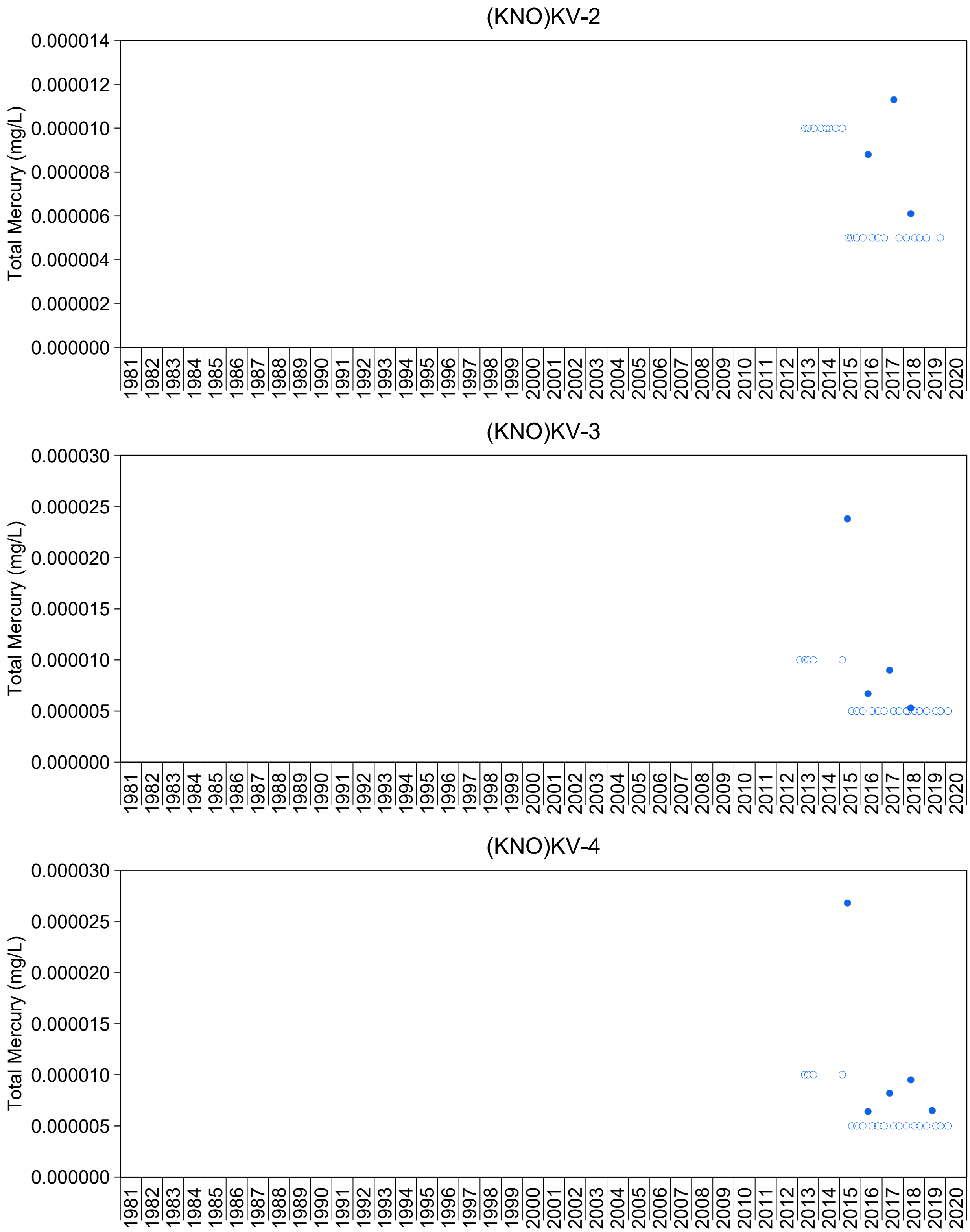


Figure A.59: Time Series Plots of Total Mercury Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

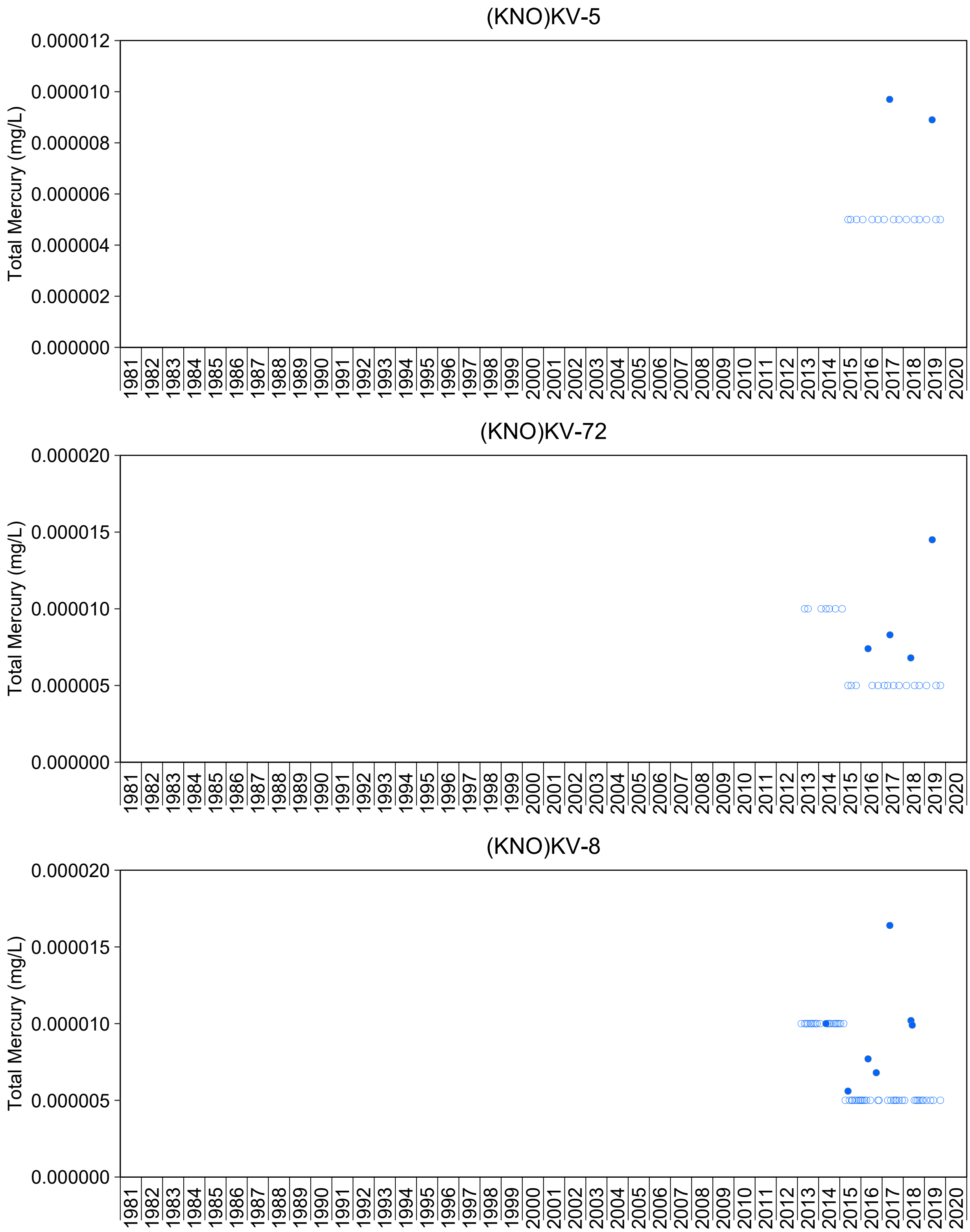


Figure A.59: Time Series Plots of Total Mercury Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

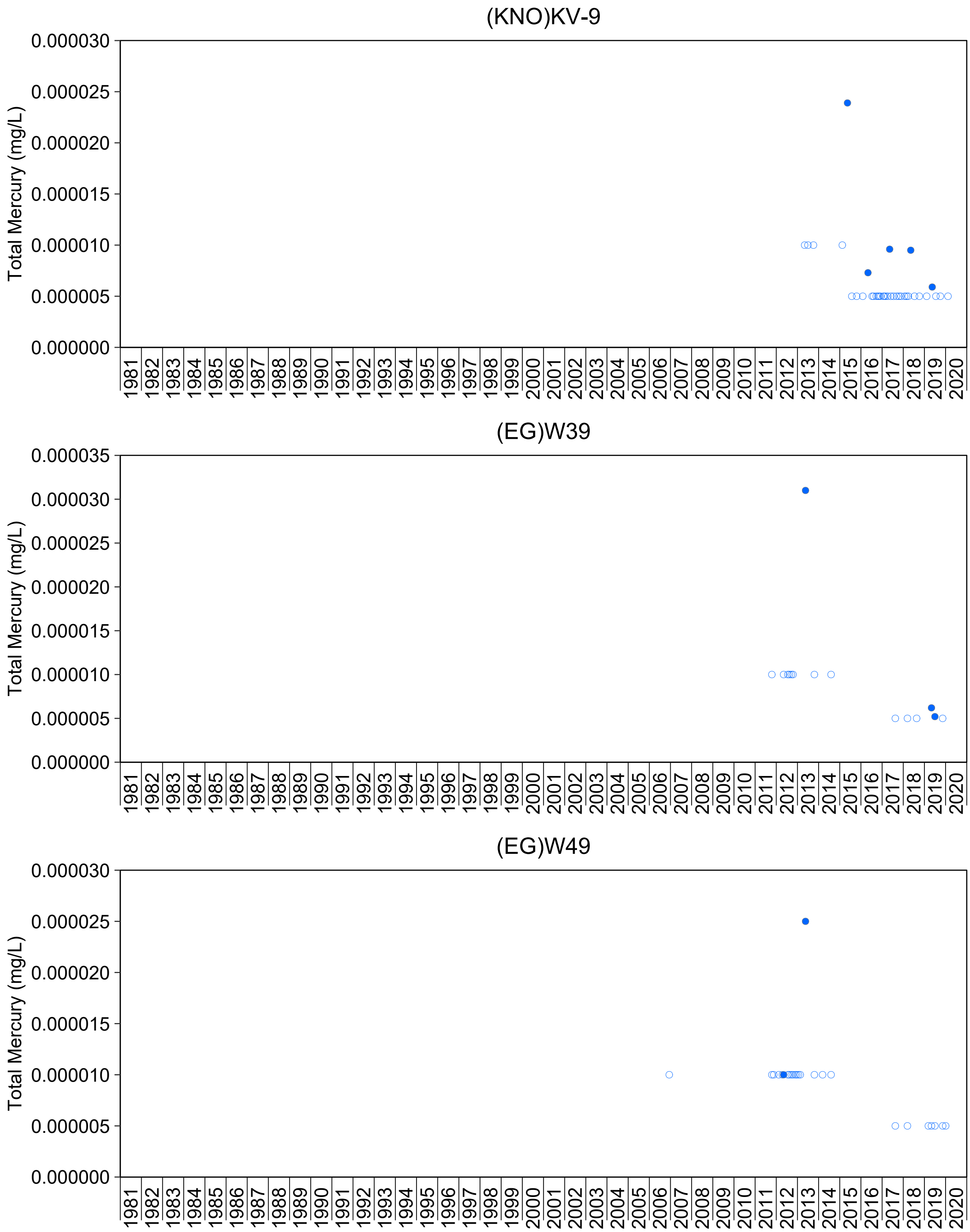


Figure A.59: Time Series Plots of Total Mercury Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

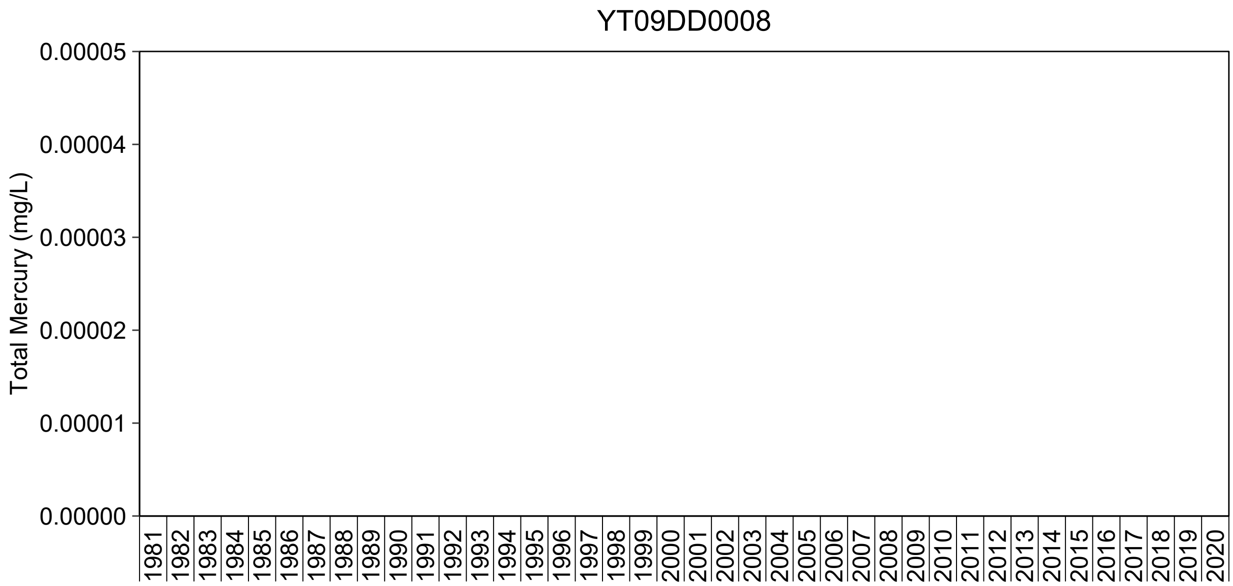


Figure A.59: Time Series Plots of Total Mercury Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

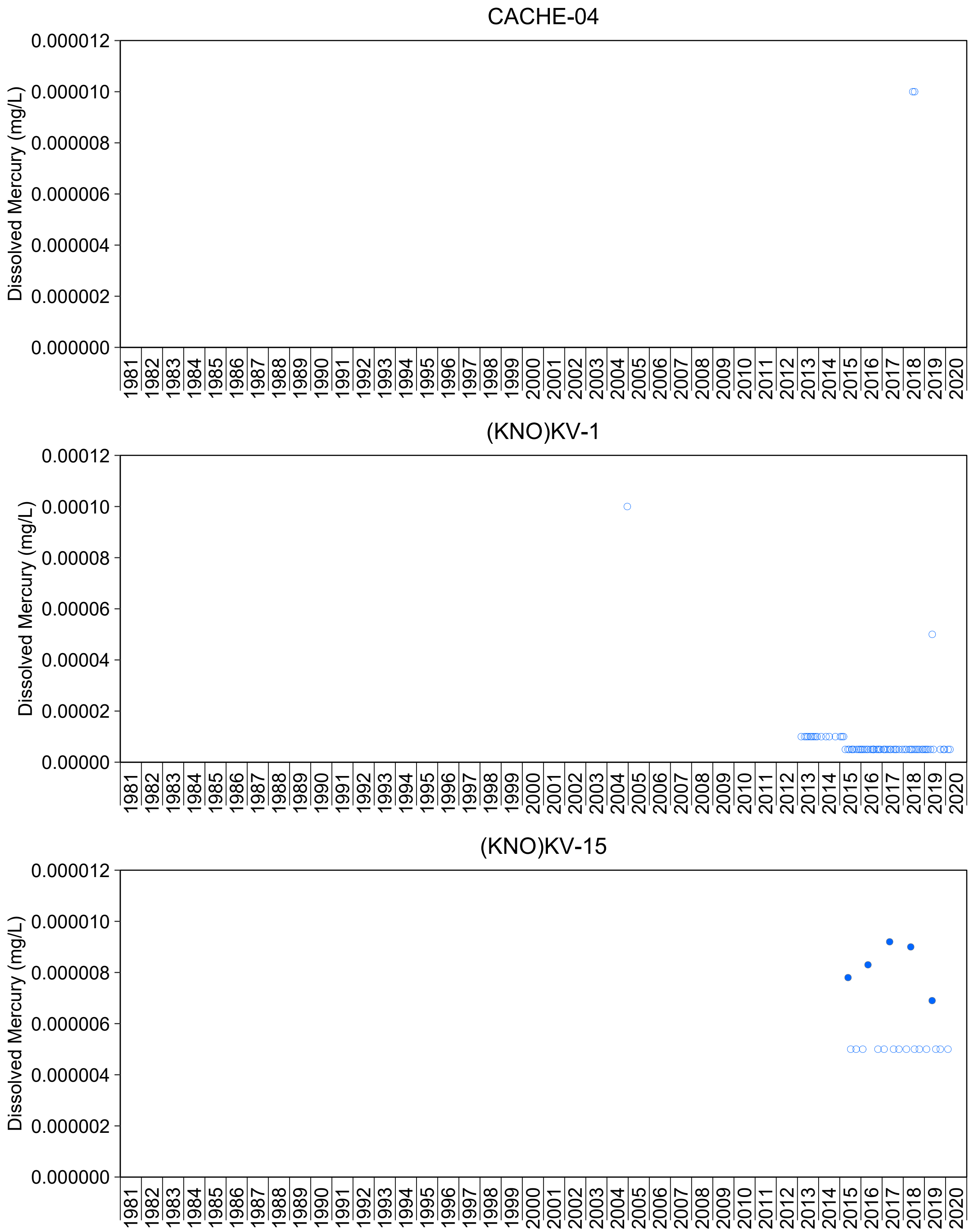


Figure A.60: Time Series Plots of Dissolved Mercury Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

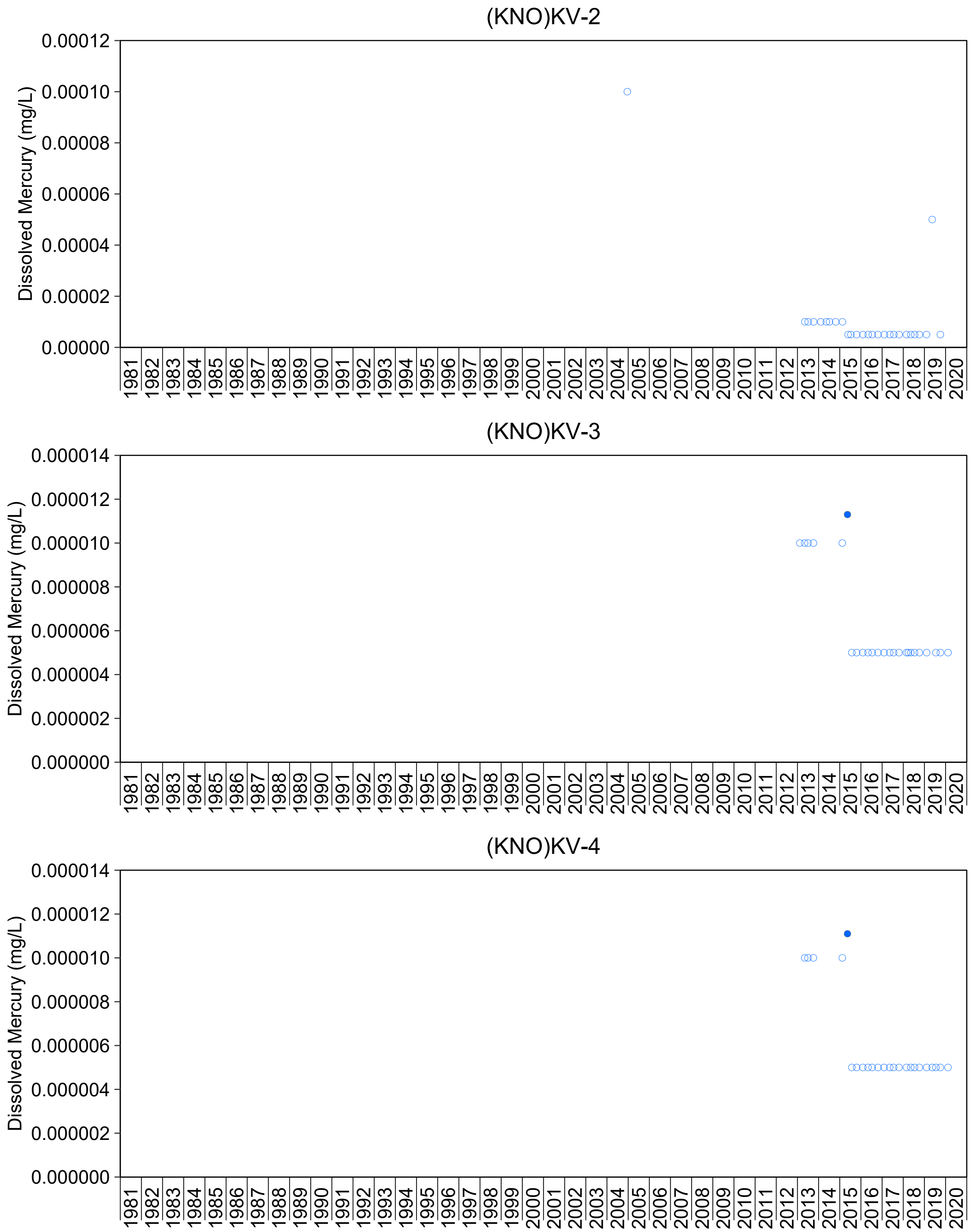


Figure A.60: Time Series Plots of Dissolved Mercury Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

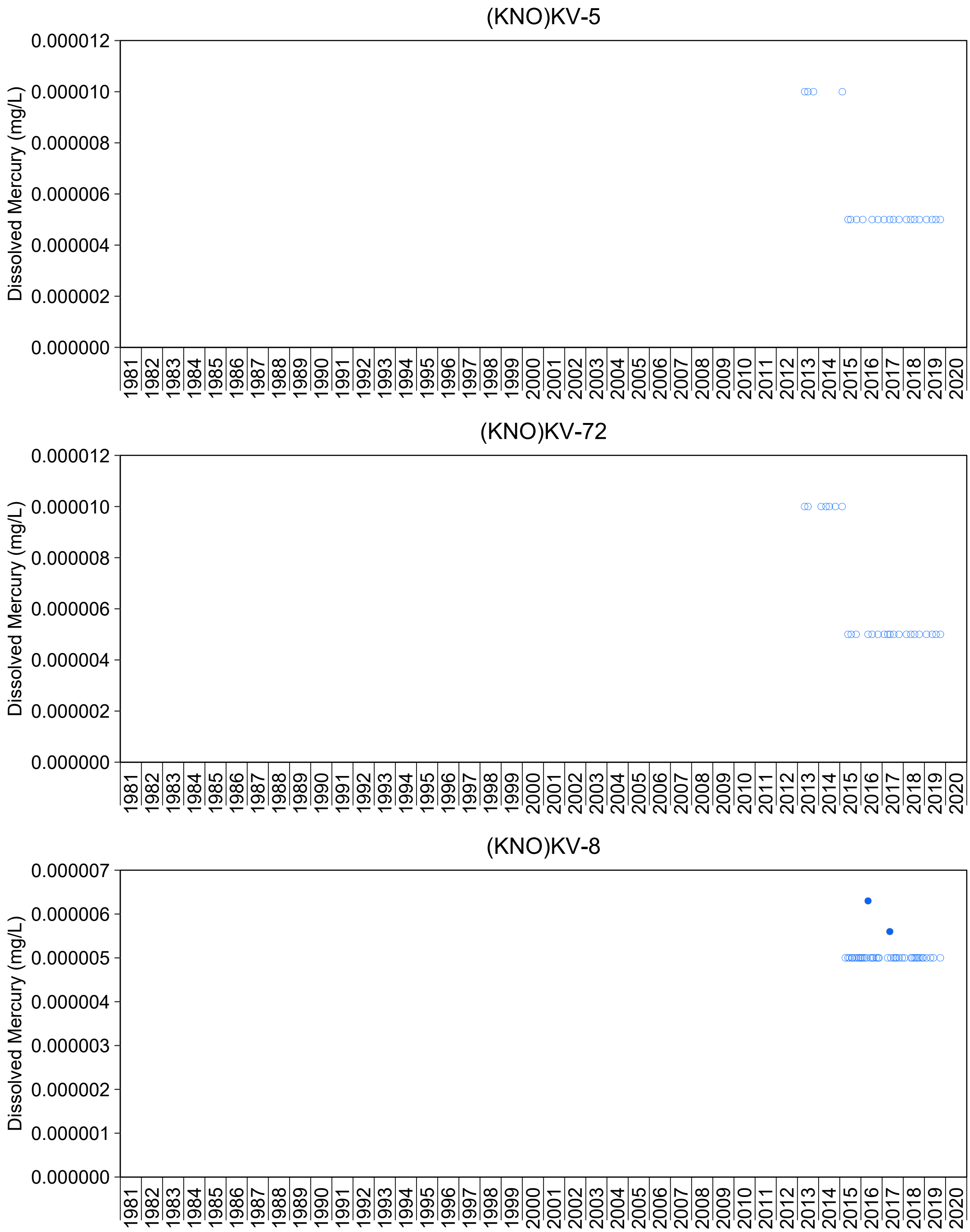


Figure A.60: Time Series Plots of Dissolved Mercury Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

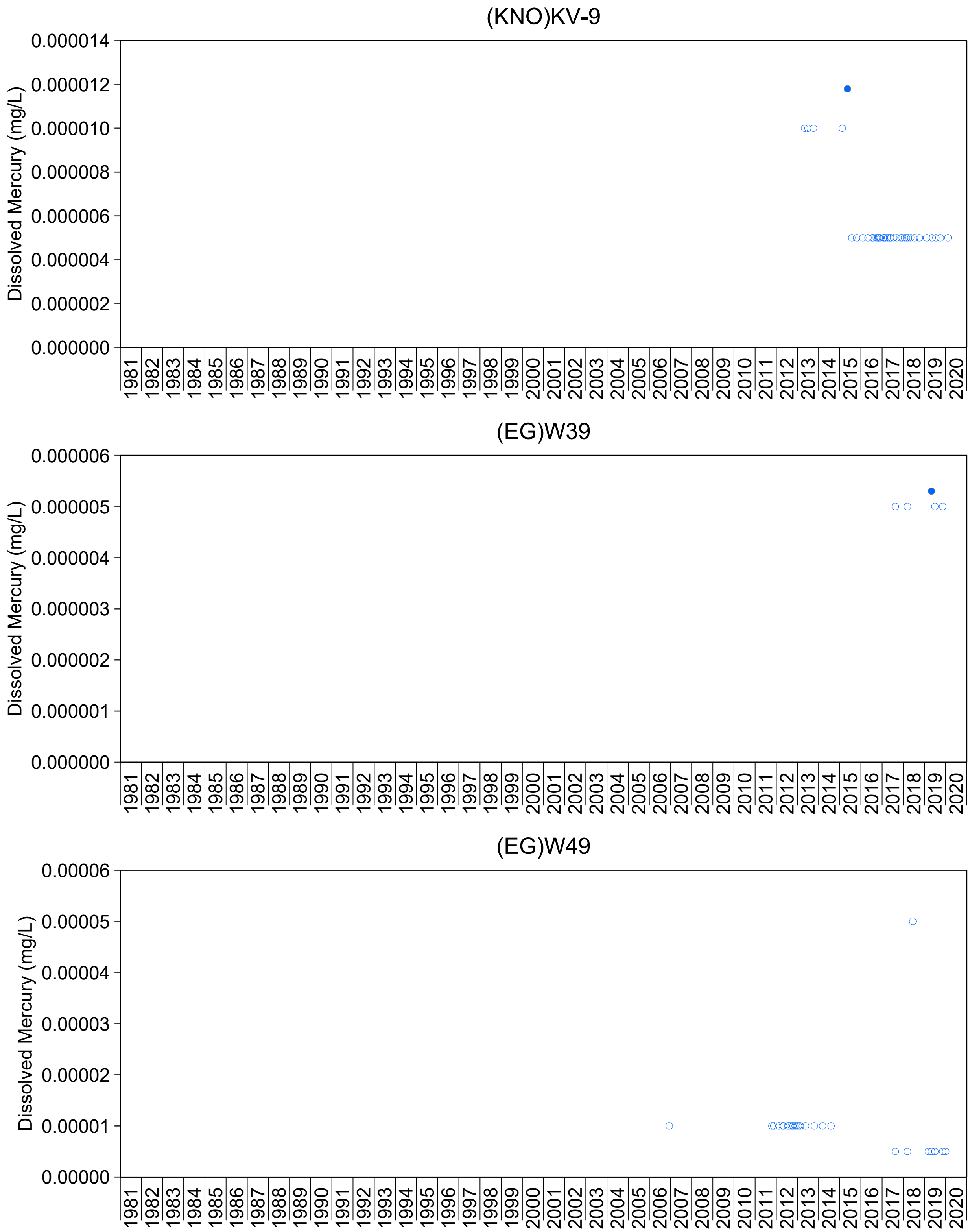


Figure A.60: Time Series Plots of Dissolved Mercury Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

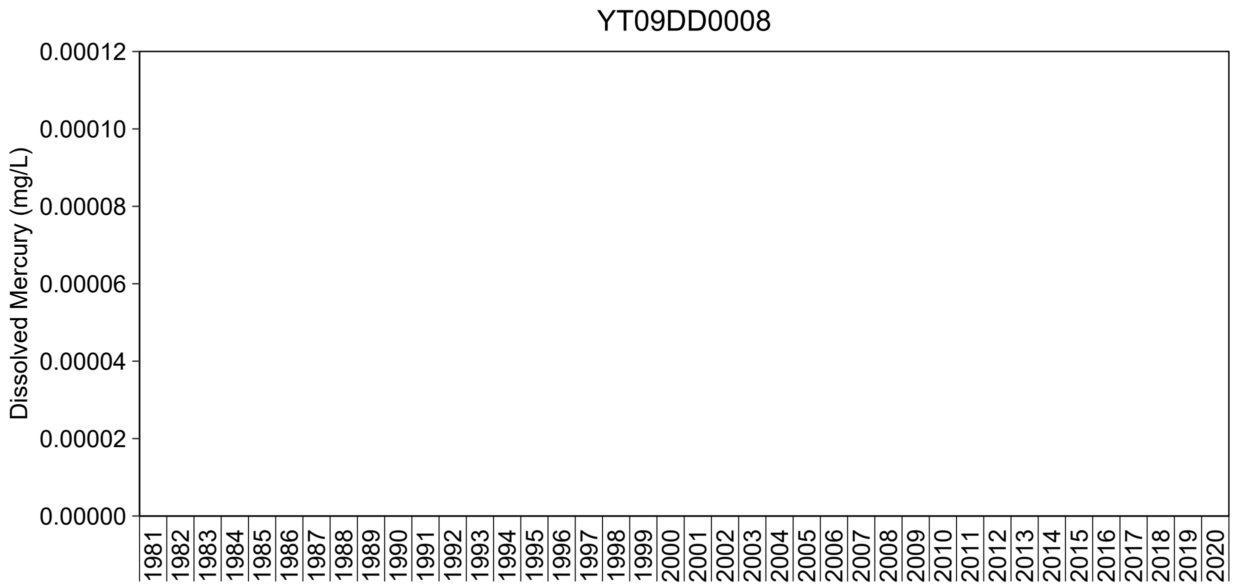


Figure A.60: Time Series Plots of Dissolved Mercury Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

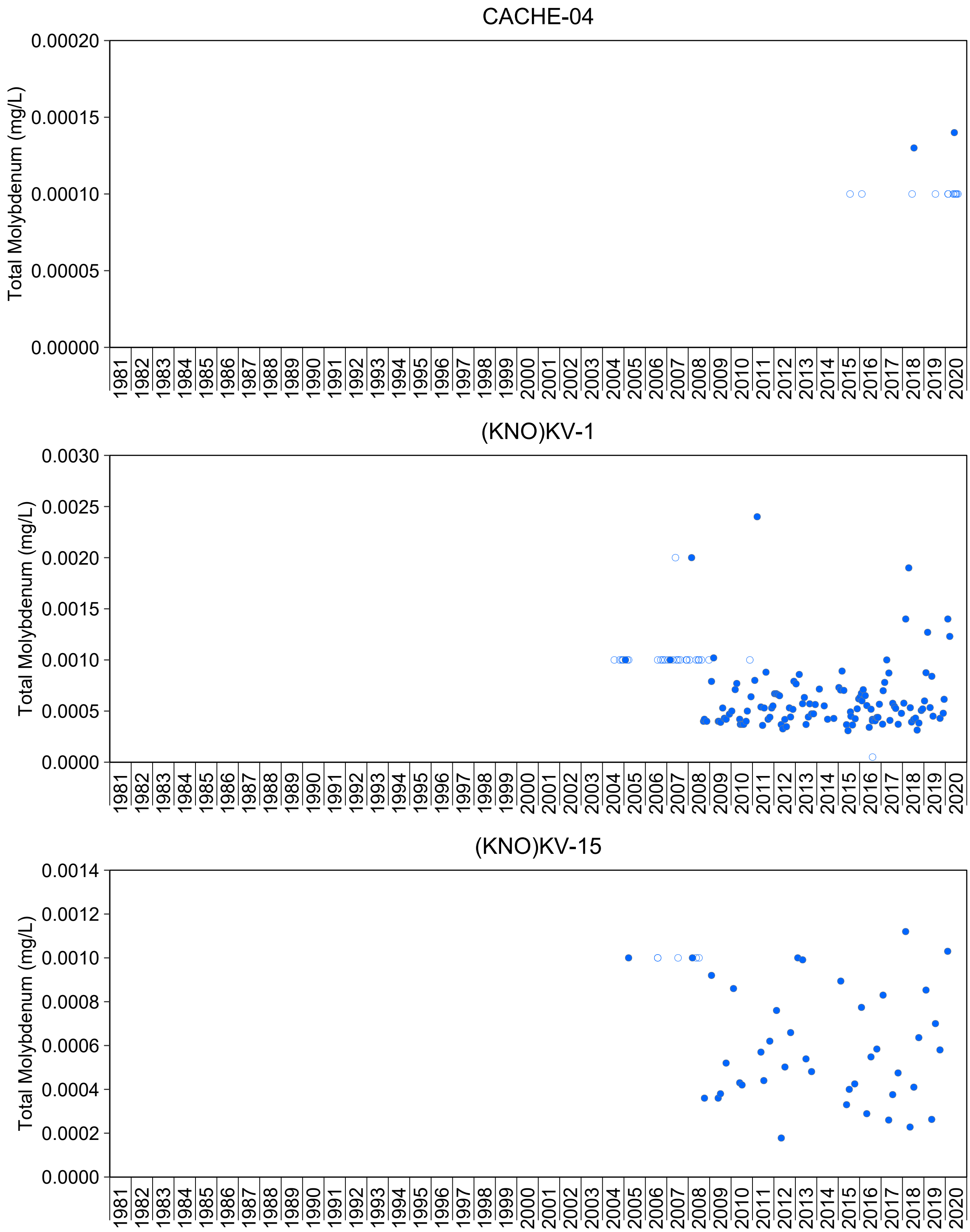


Figure A.61: Time Series Plots of Total Molybdenum Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

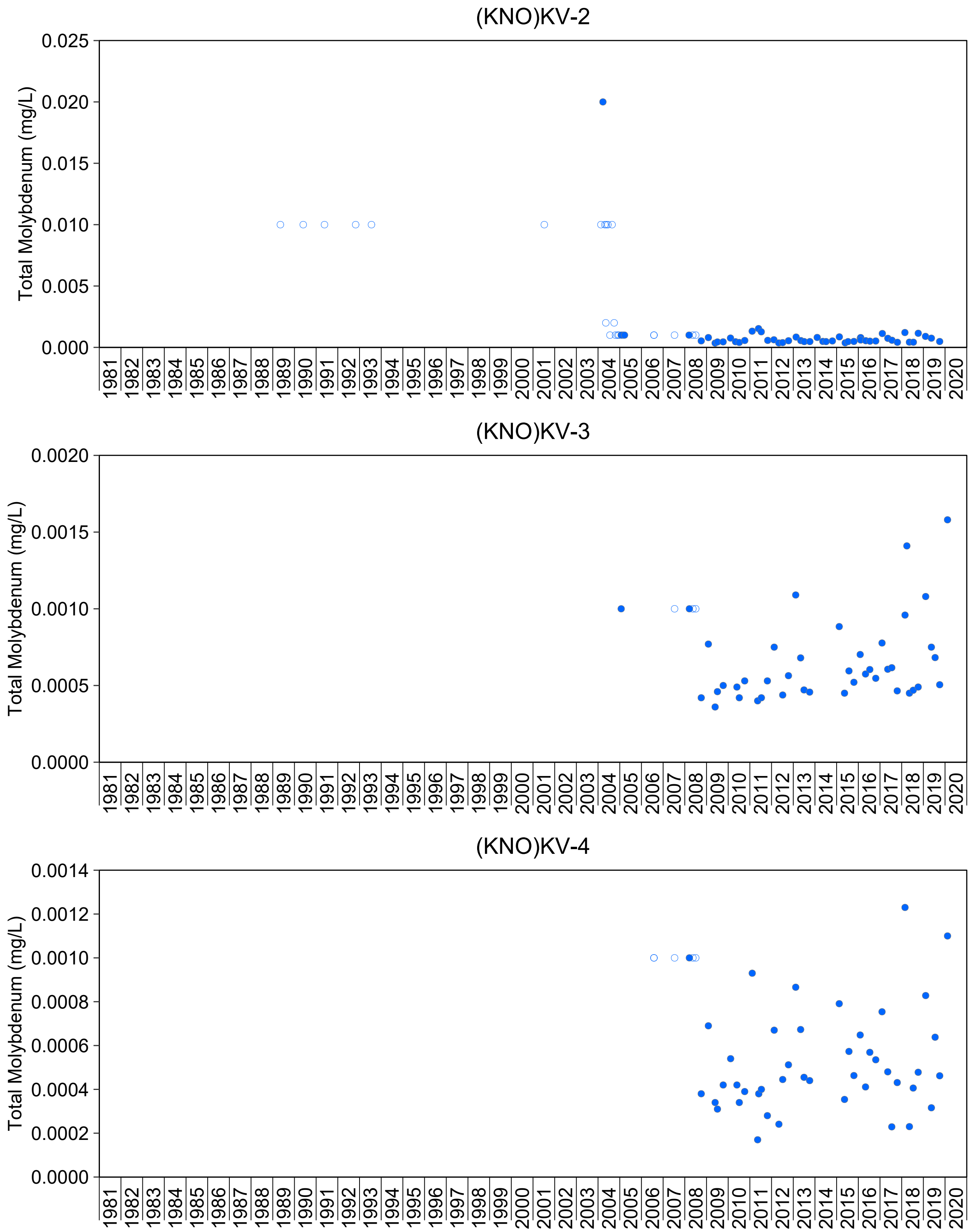


Figure A.61: Time Series Plots of Total Molybdenum Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

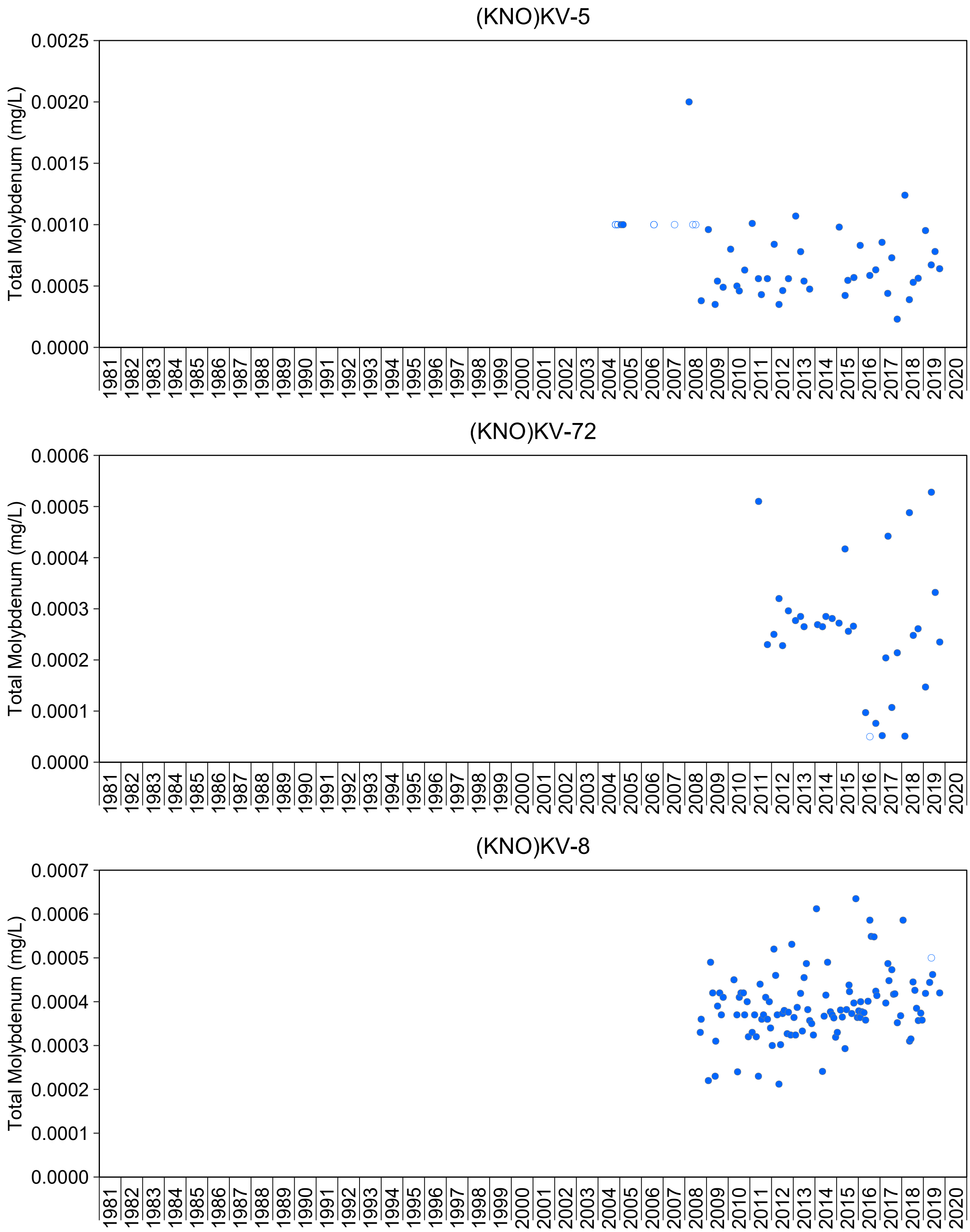


Figure A.61: Time Series Plots of Total Molybdenum Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

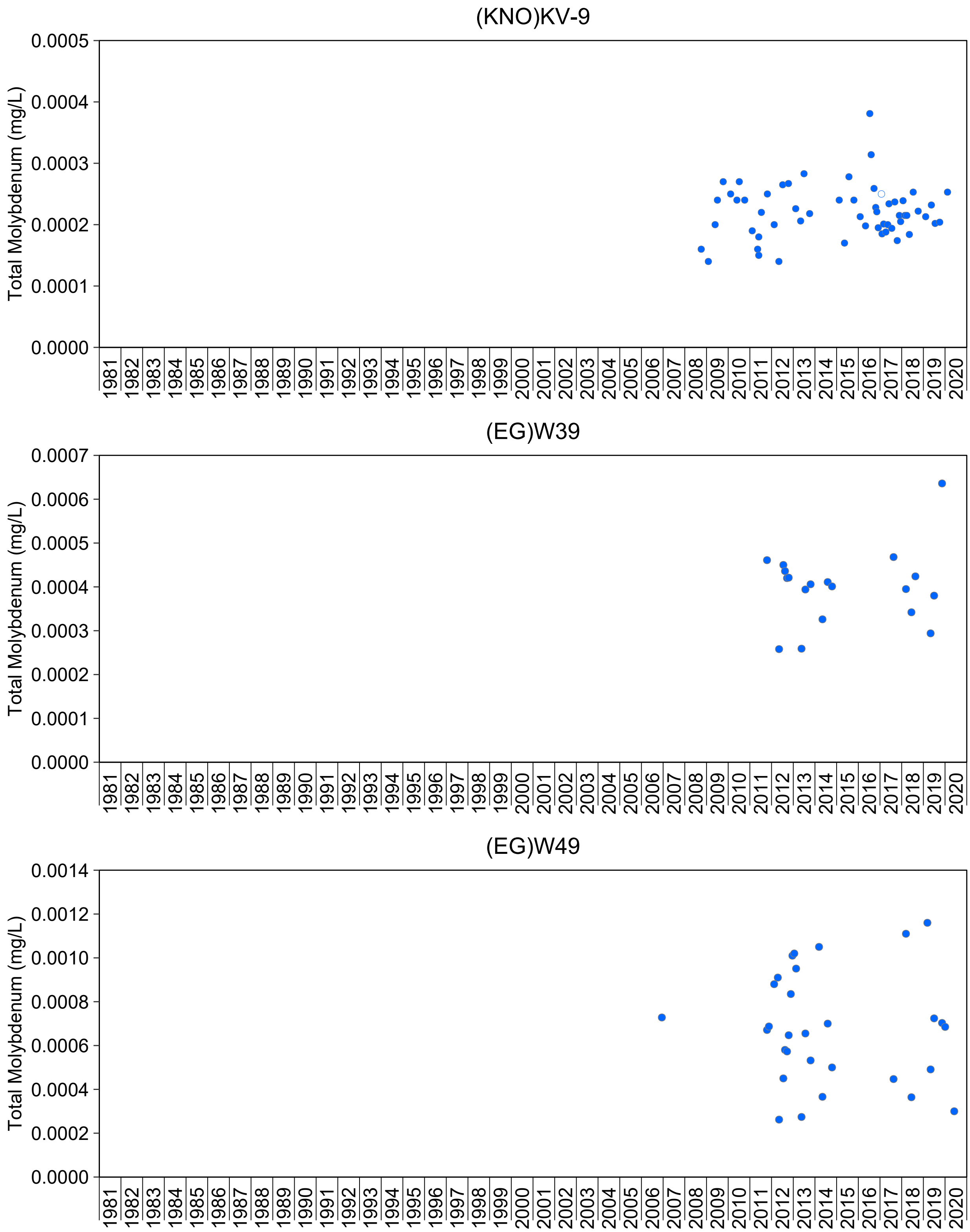


Figure A.61: Time Series Plots of Total Molybdenum Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

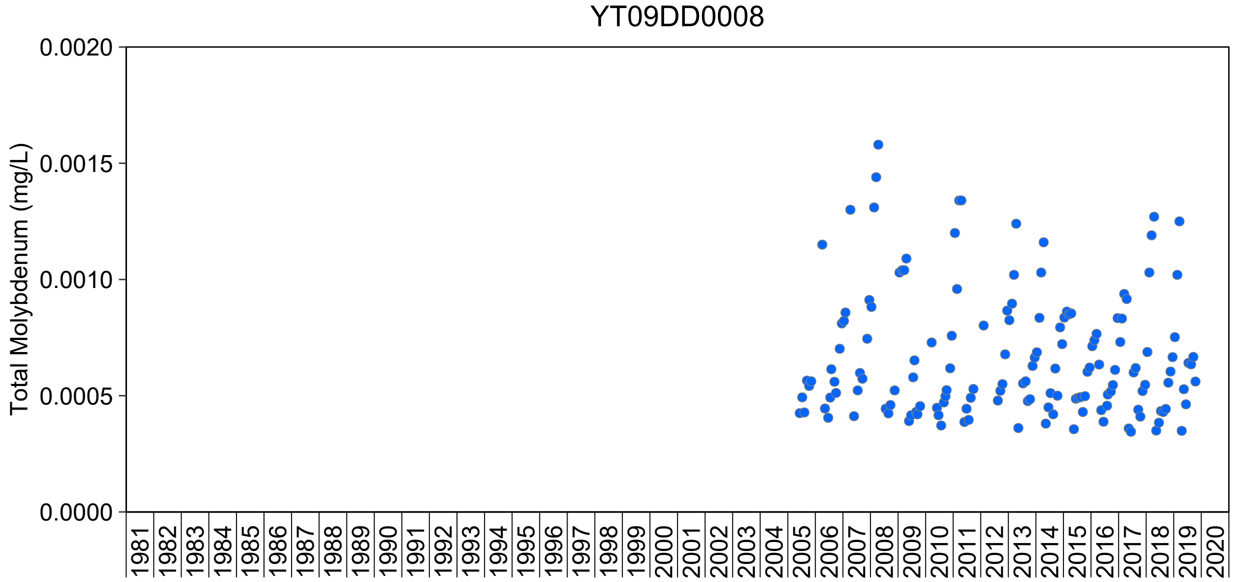


Figure A.61: Time Series Plots of Total Molybdenum Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

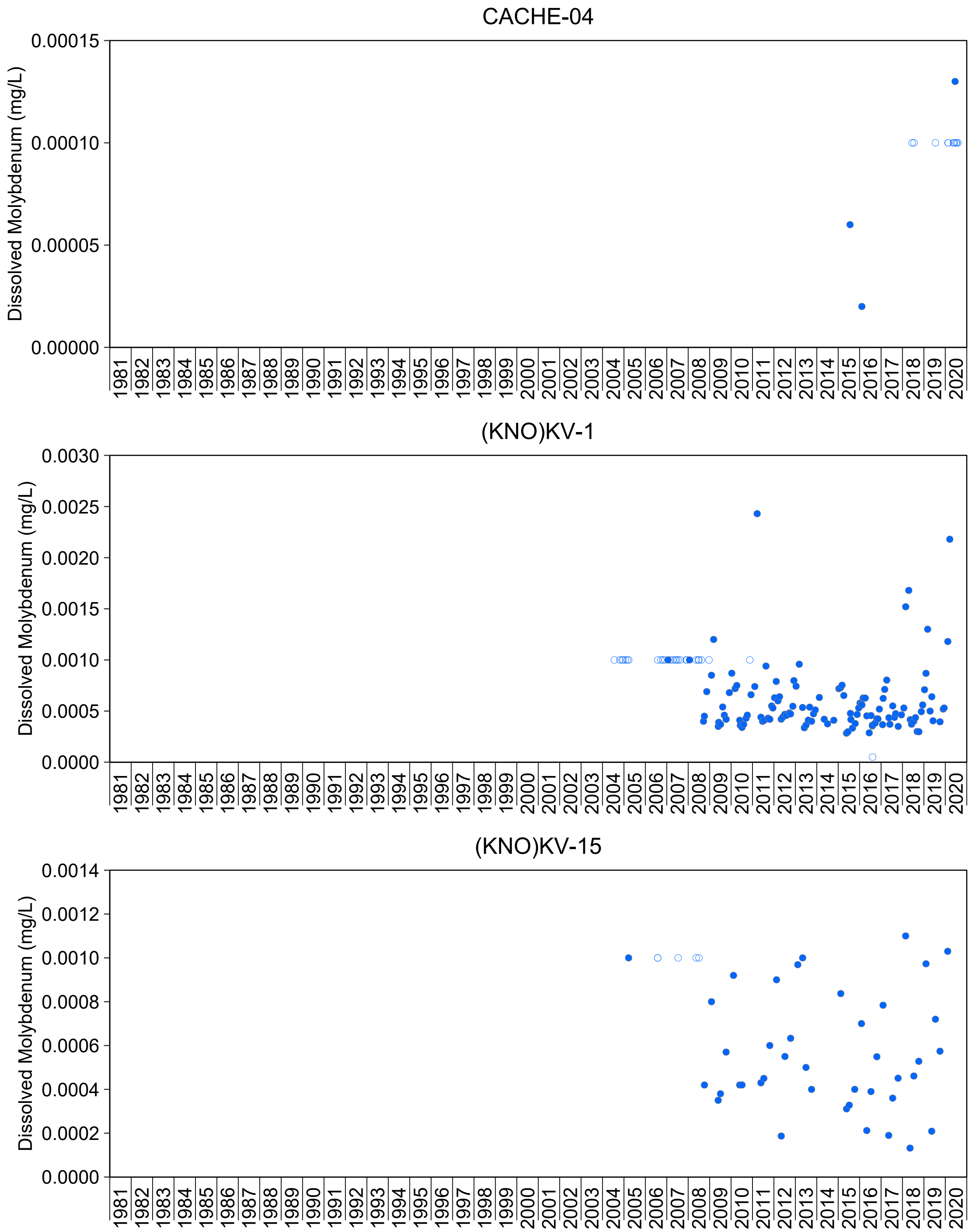


Figure A.62: Time Series Plots of Dissolved Molybdenum Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

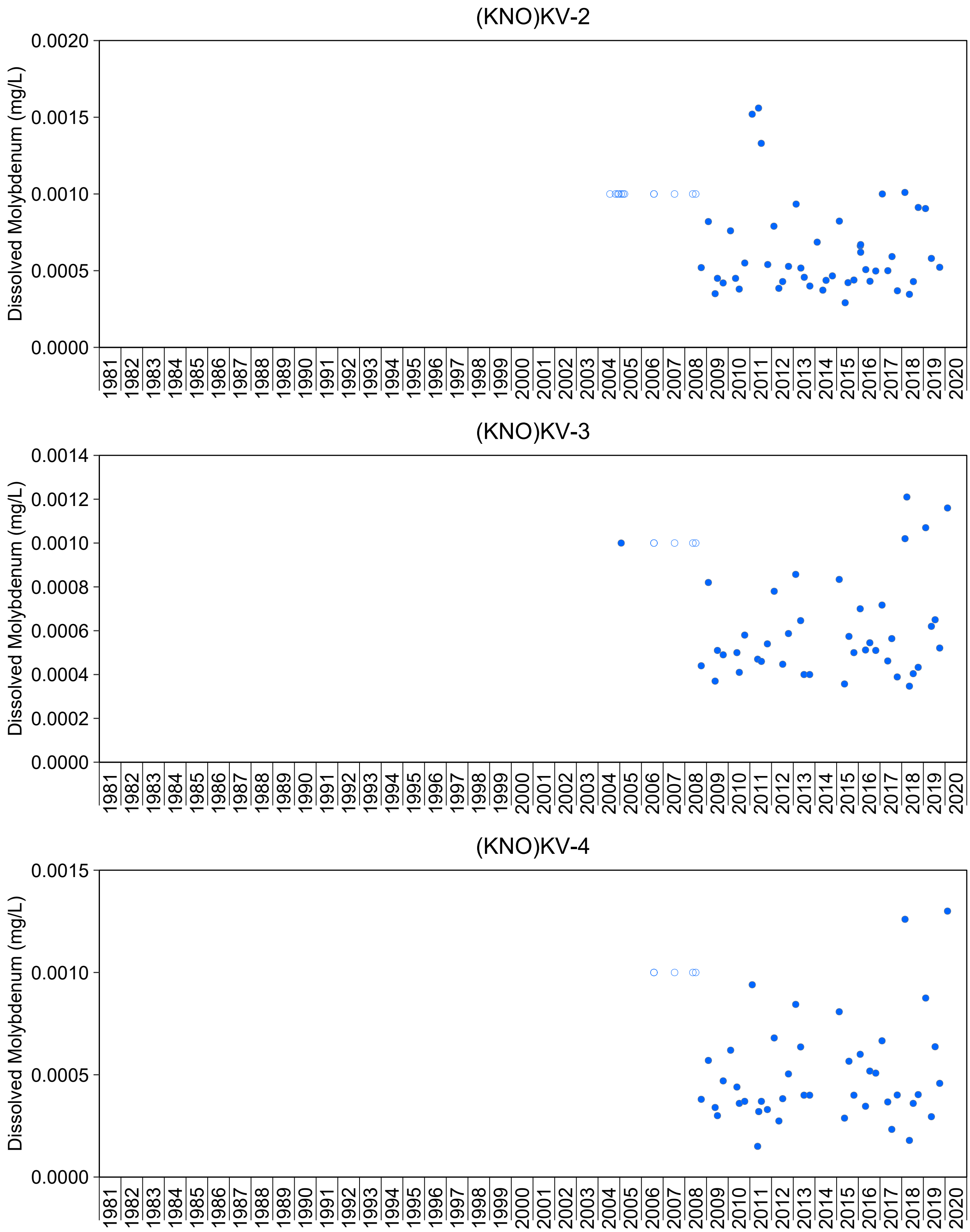


Figure A.62: Time Series Plots of Dissolved Molybdenum Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

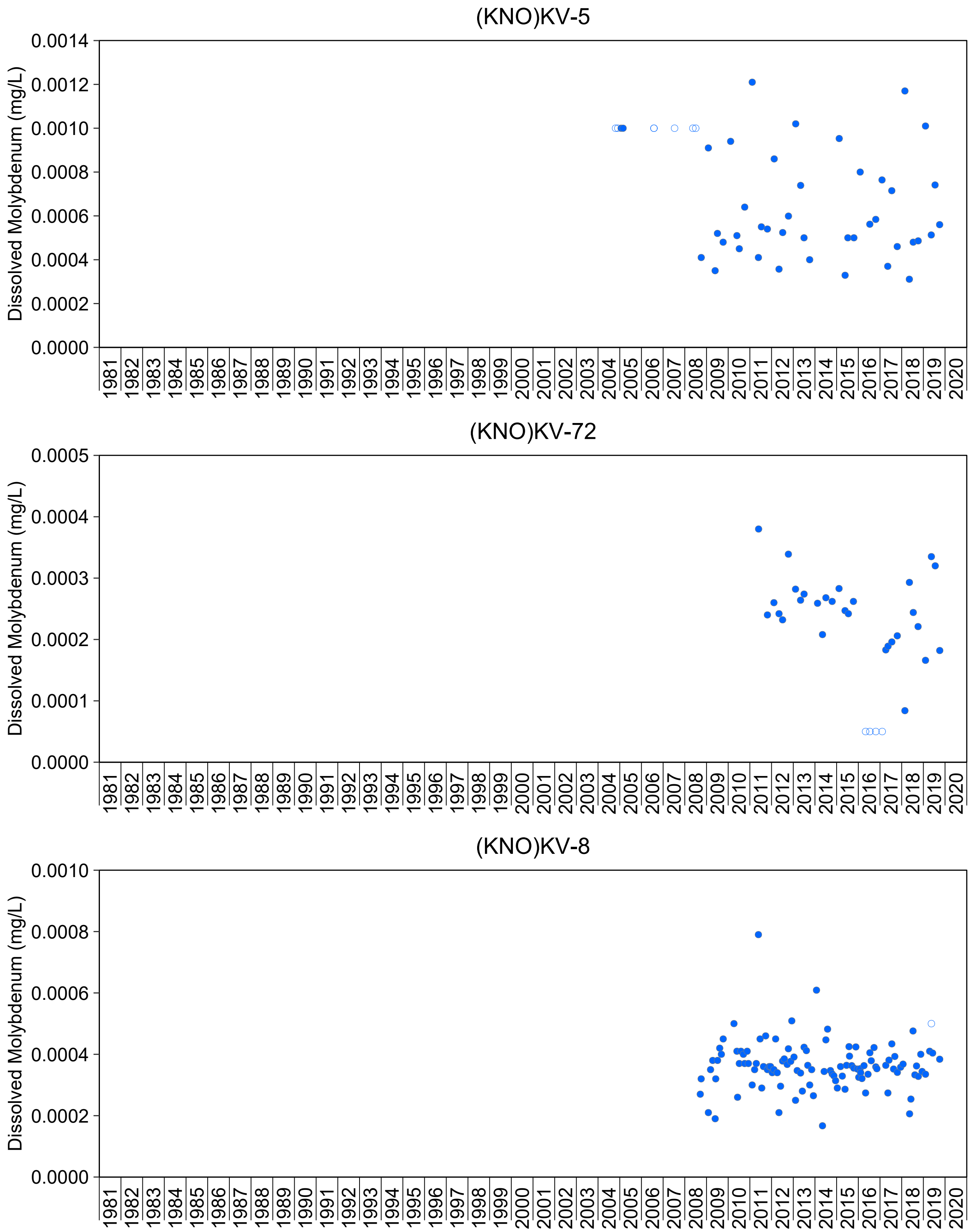


Figure A.62: Time Series Plots of Dissolved Molybdenum Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

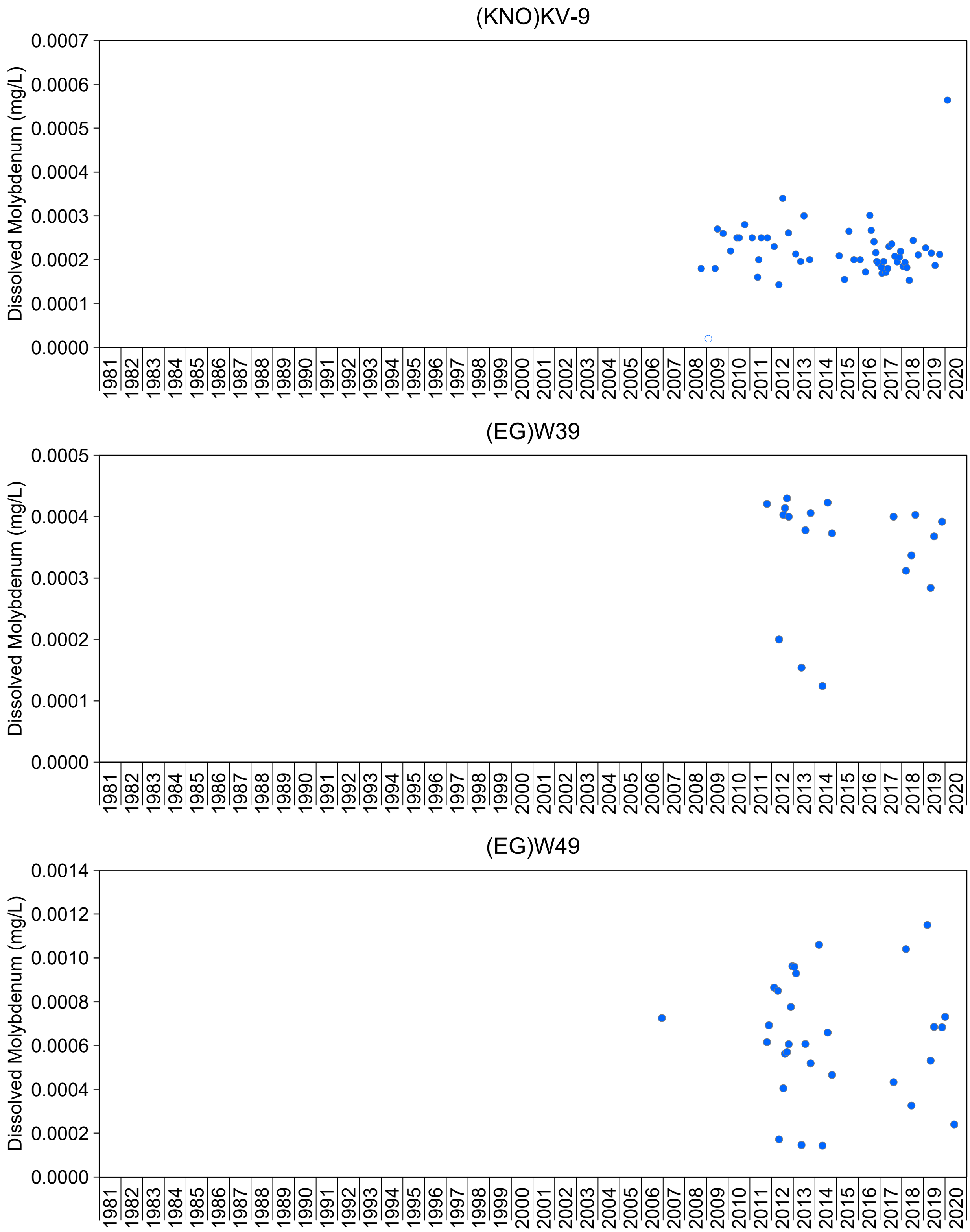


Figure A.62: Time Series Plots of Dissolved Molybdenum Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

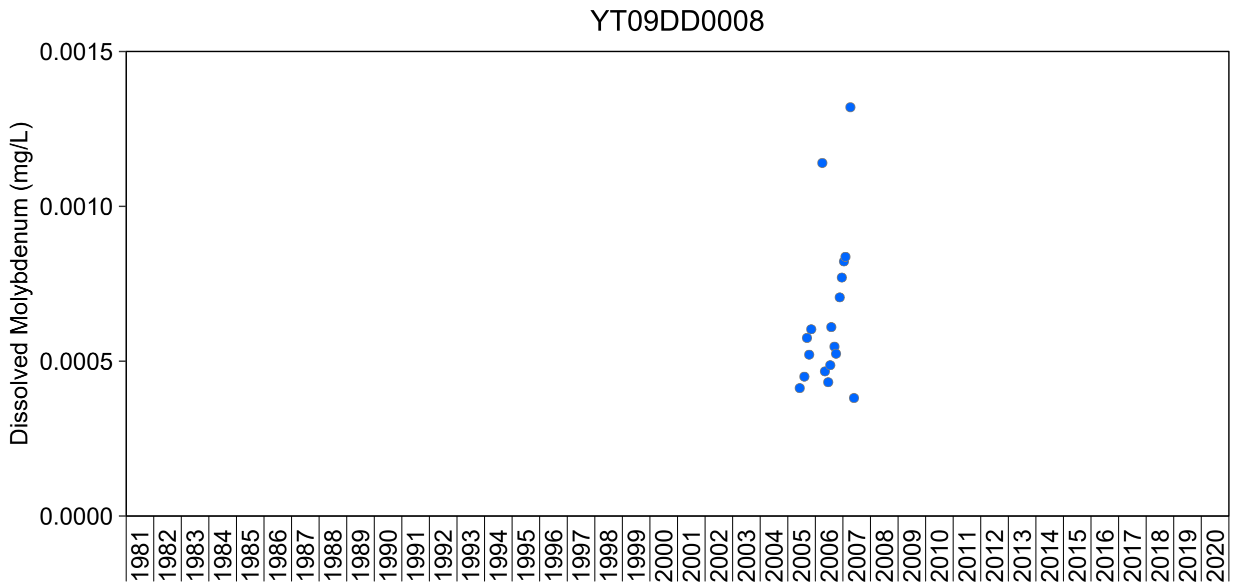


Figure A.62: **Time Series Plots of Dissolved Molybdenum Concentrations (mg/L) in the South McQuesten River, 1981 to 2020**

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

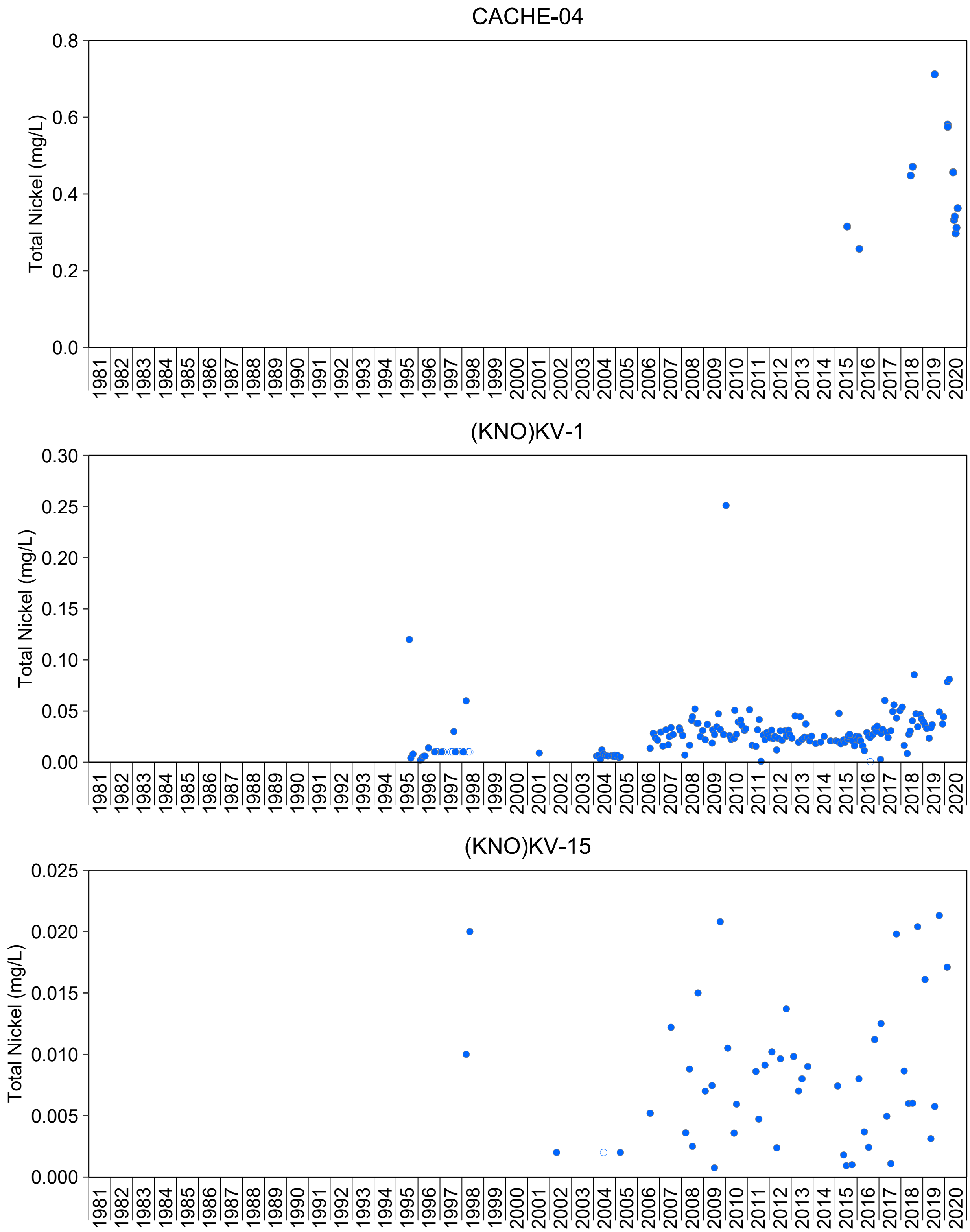


Figure A.63: Time Series Plots of Total Nickel Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

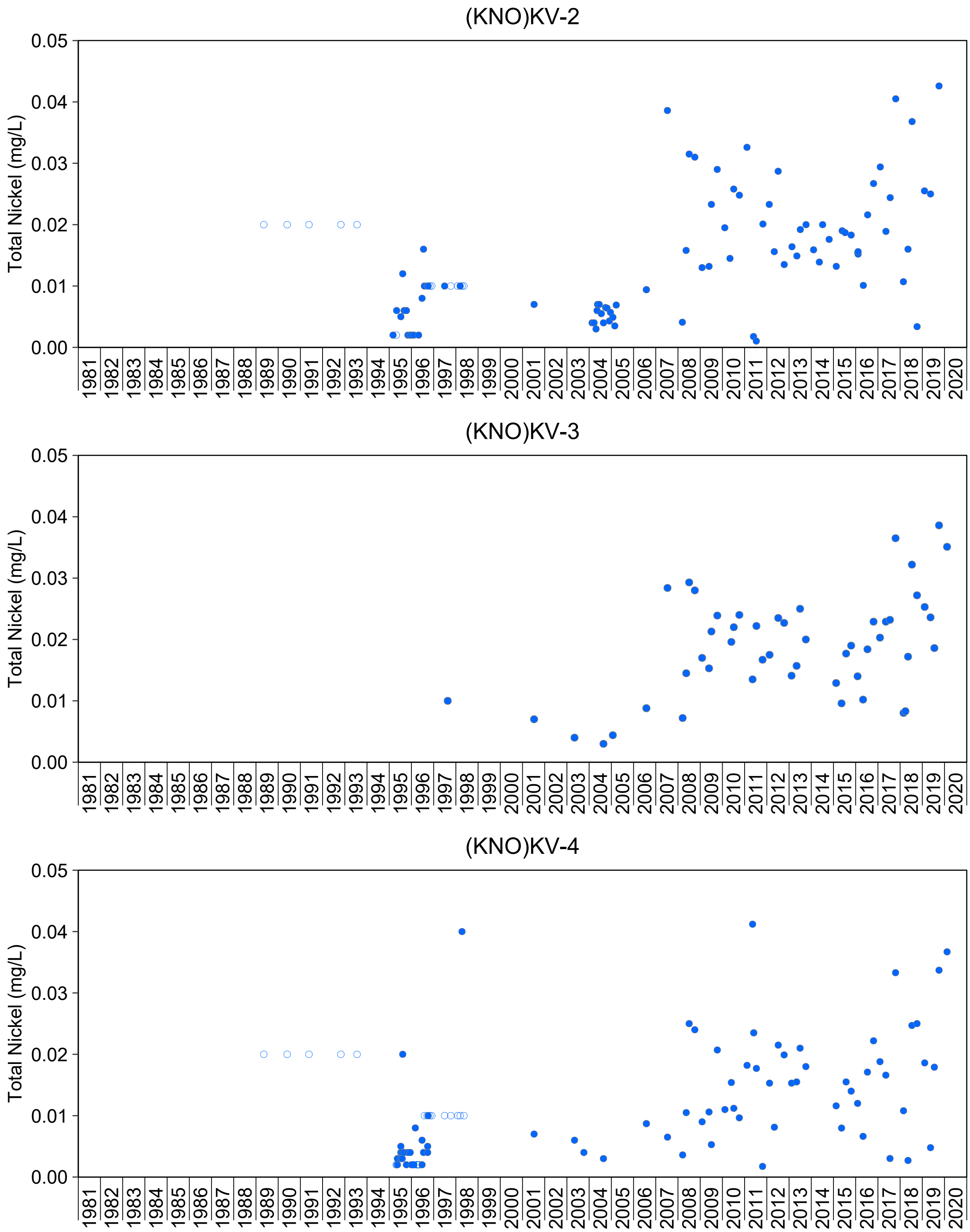


Figure A.63: Time Series Plots of Total Nickel Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

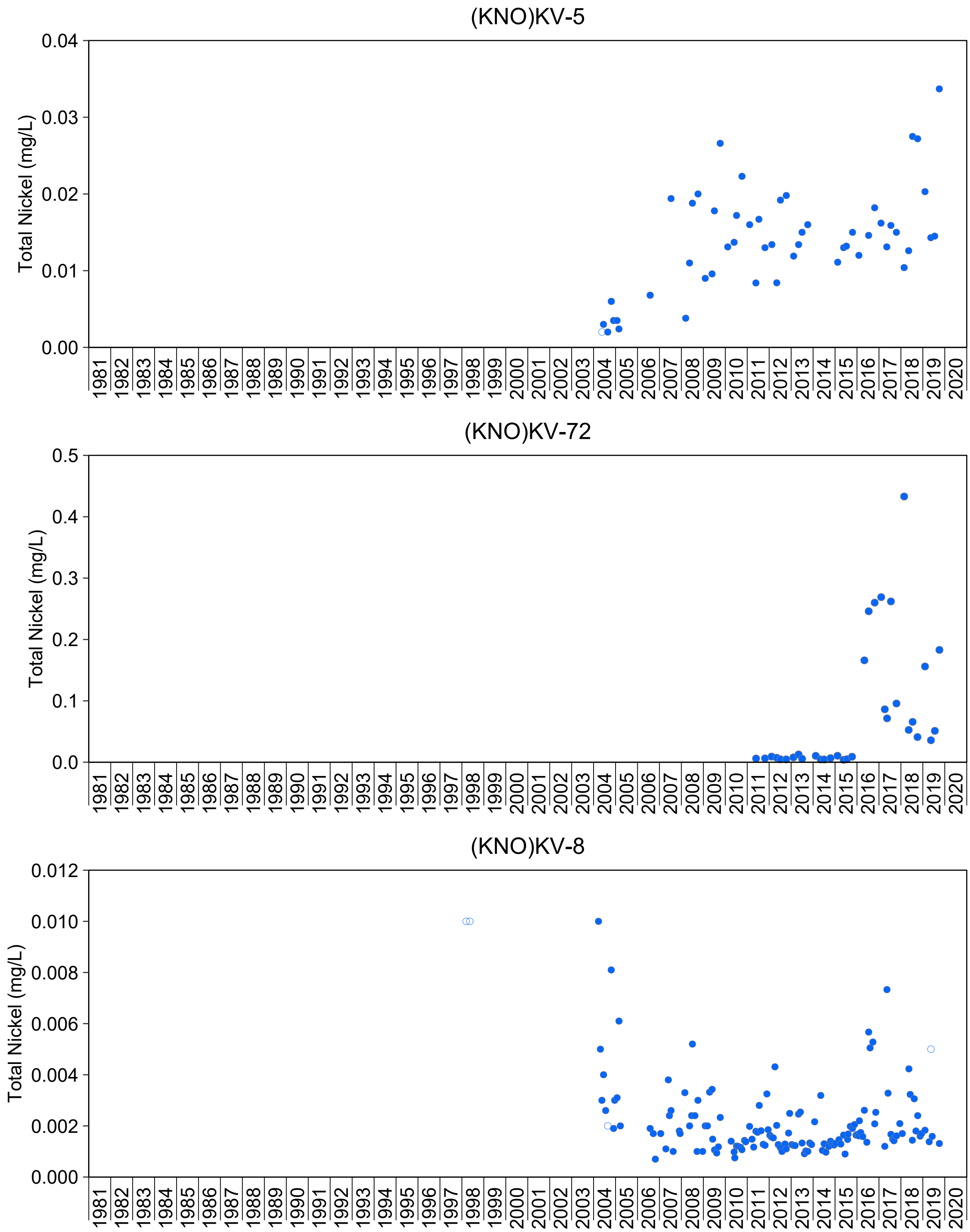


Figure A.63: Time Series Plots of Total Nickel Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

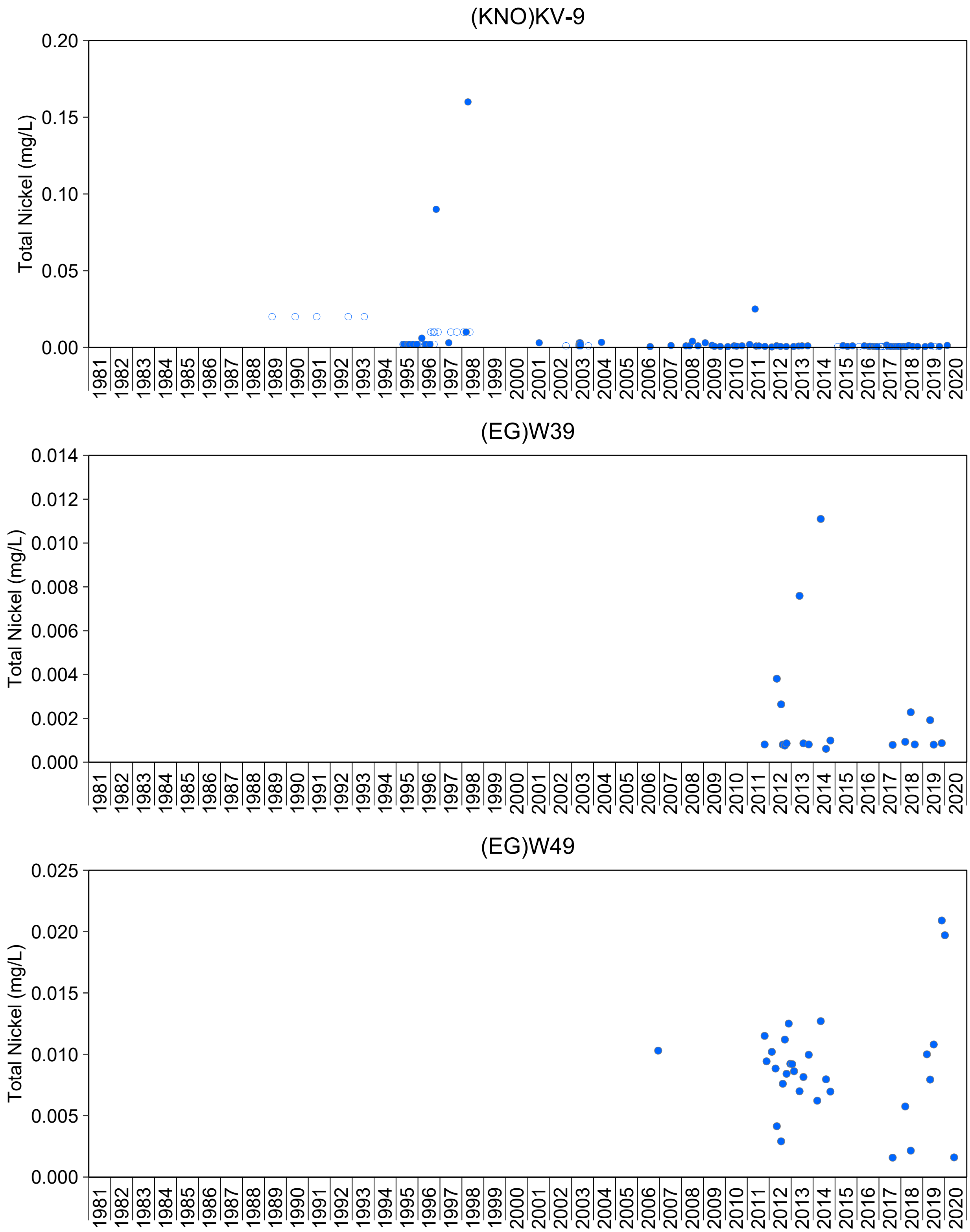
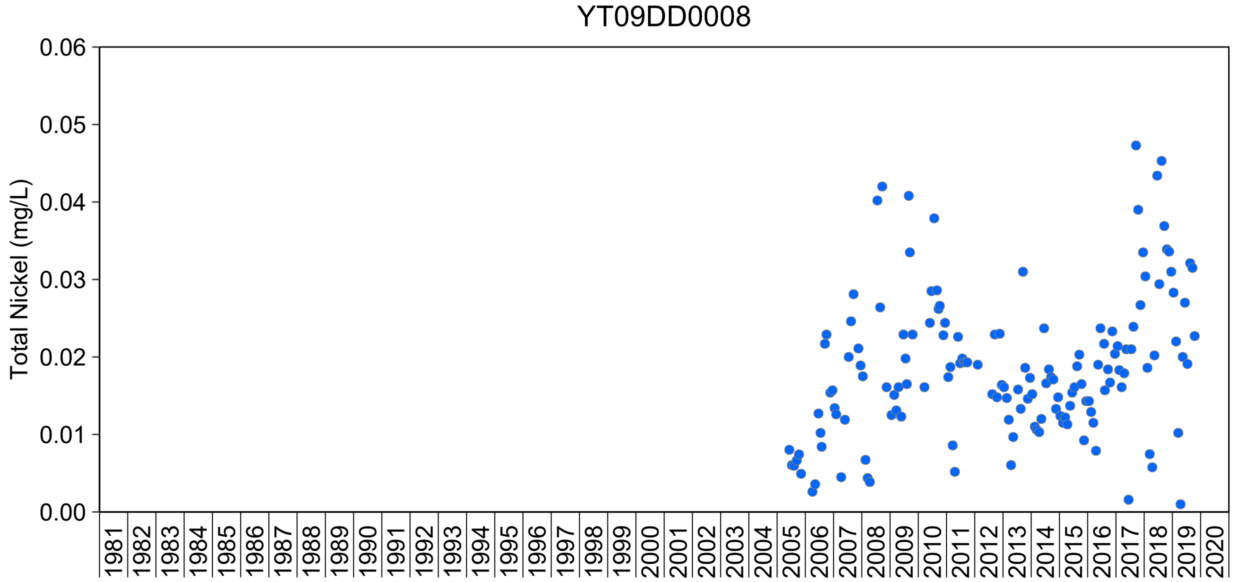


Figure A.63: Time Series Plots of Total Nickel Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.



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Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

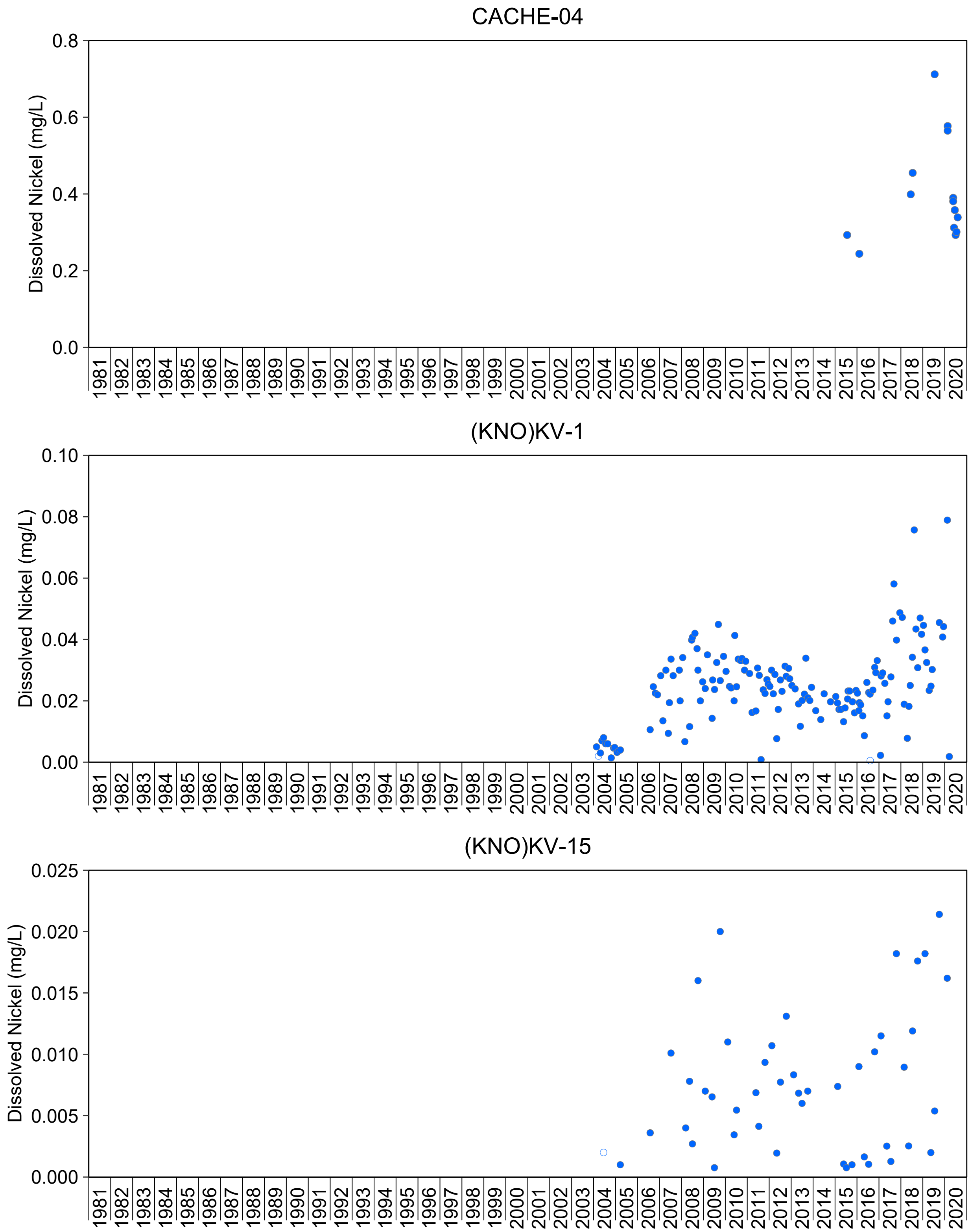


Figure A.64: Time Series Plots of Dissolved Nickel Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

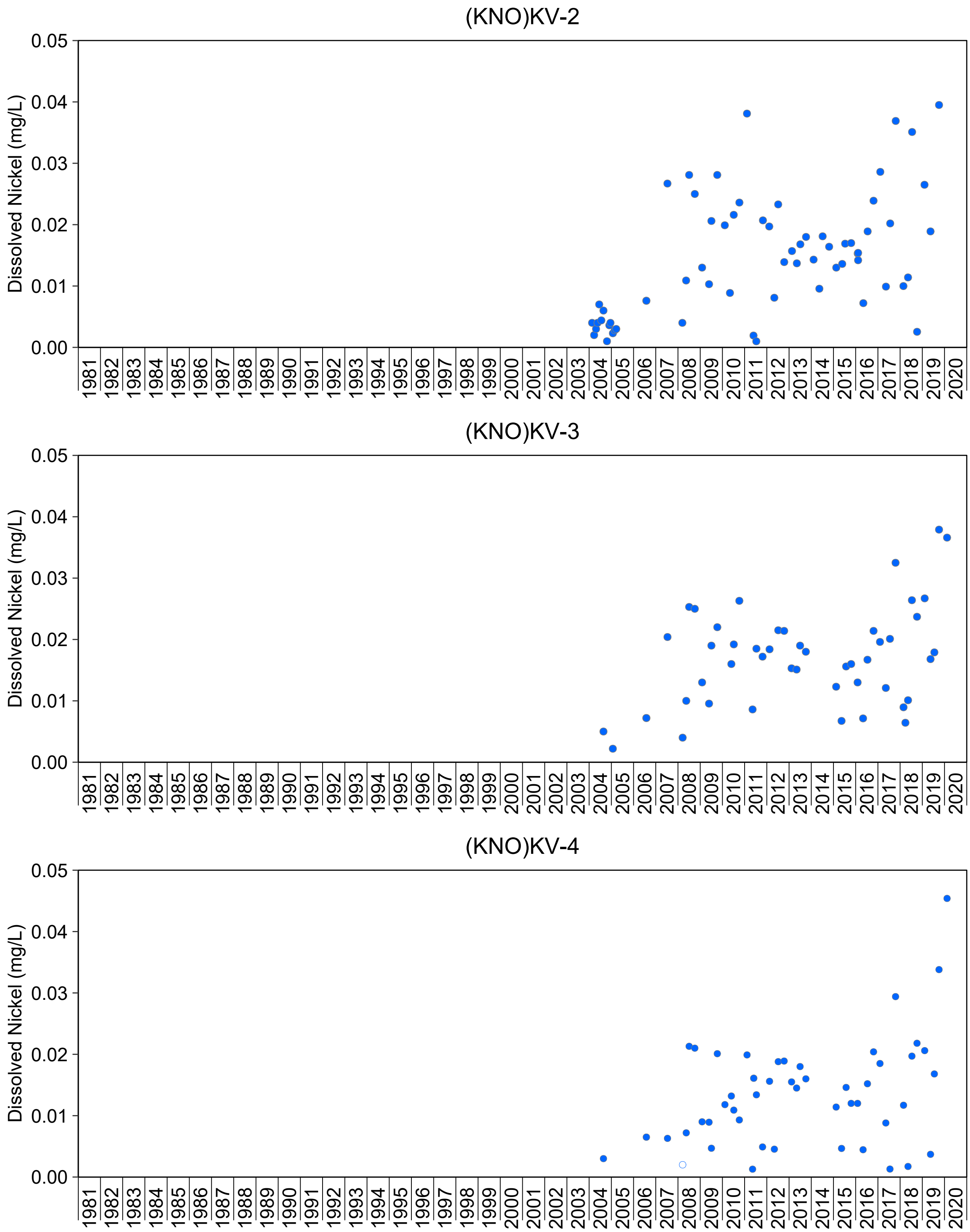


Figure A.64: Time Series Plots of Dissolved Nickel Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

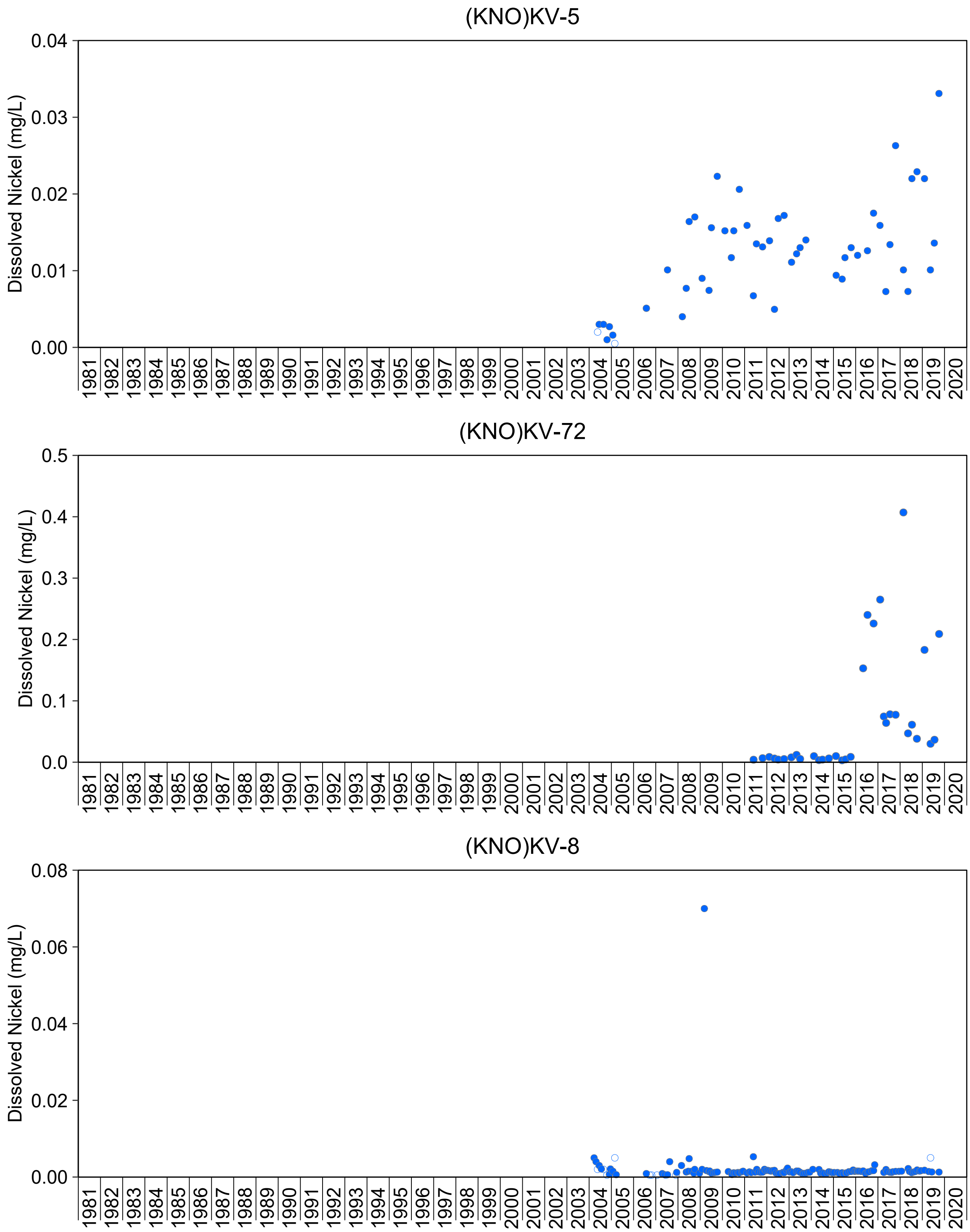


Figure A.64: Time Series Plots of Dissolved Nickel Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

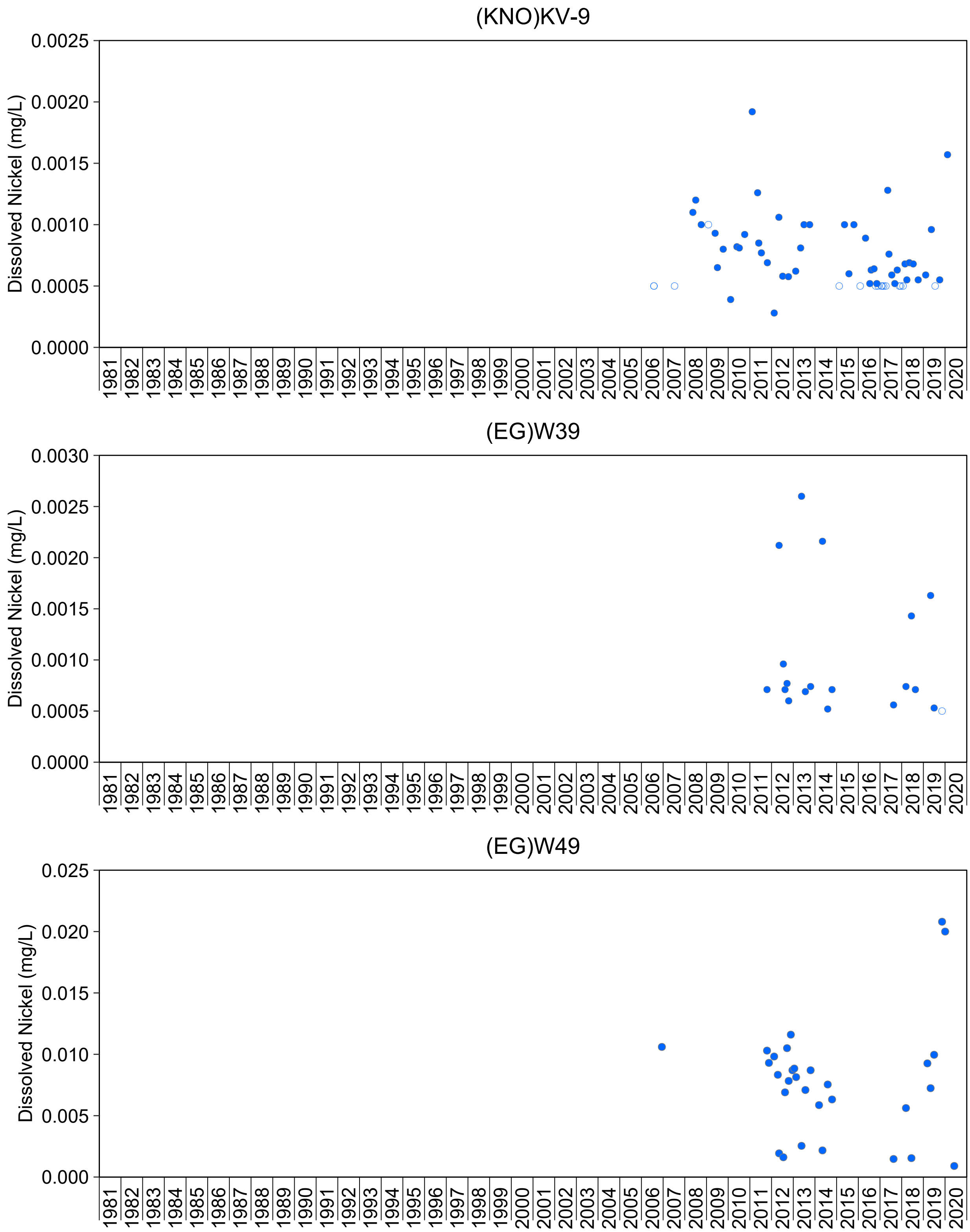


Figure A.64: Time Series Plots of Dissolved Nickel Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

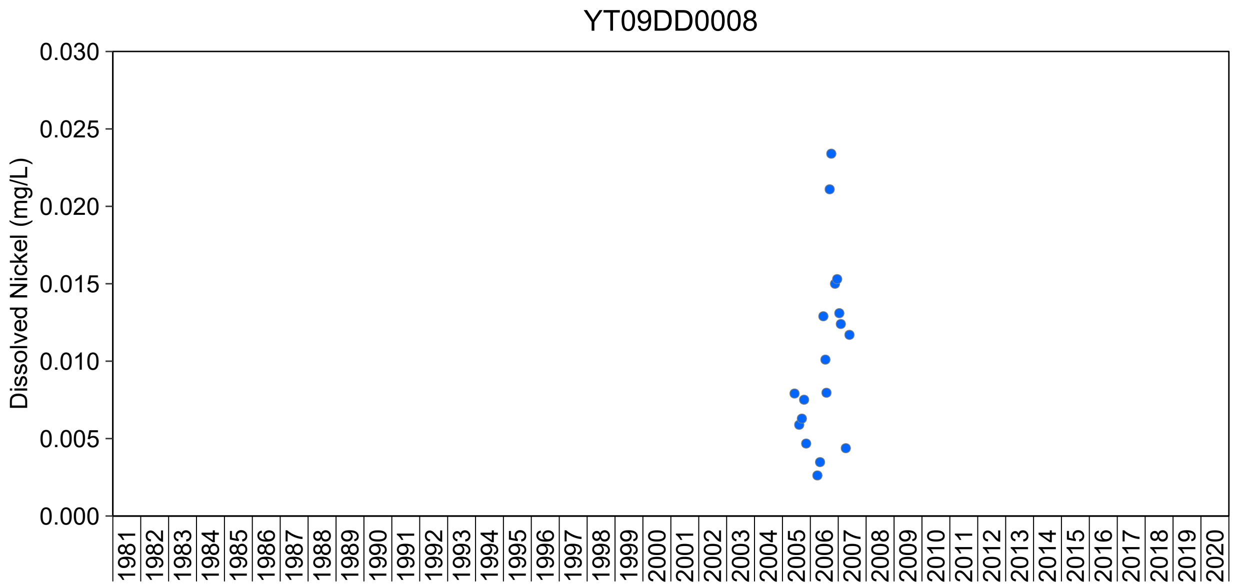


Figure A.64: Time Series Plots of Dissolved Nickel Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

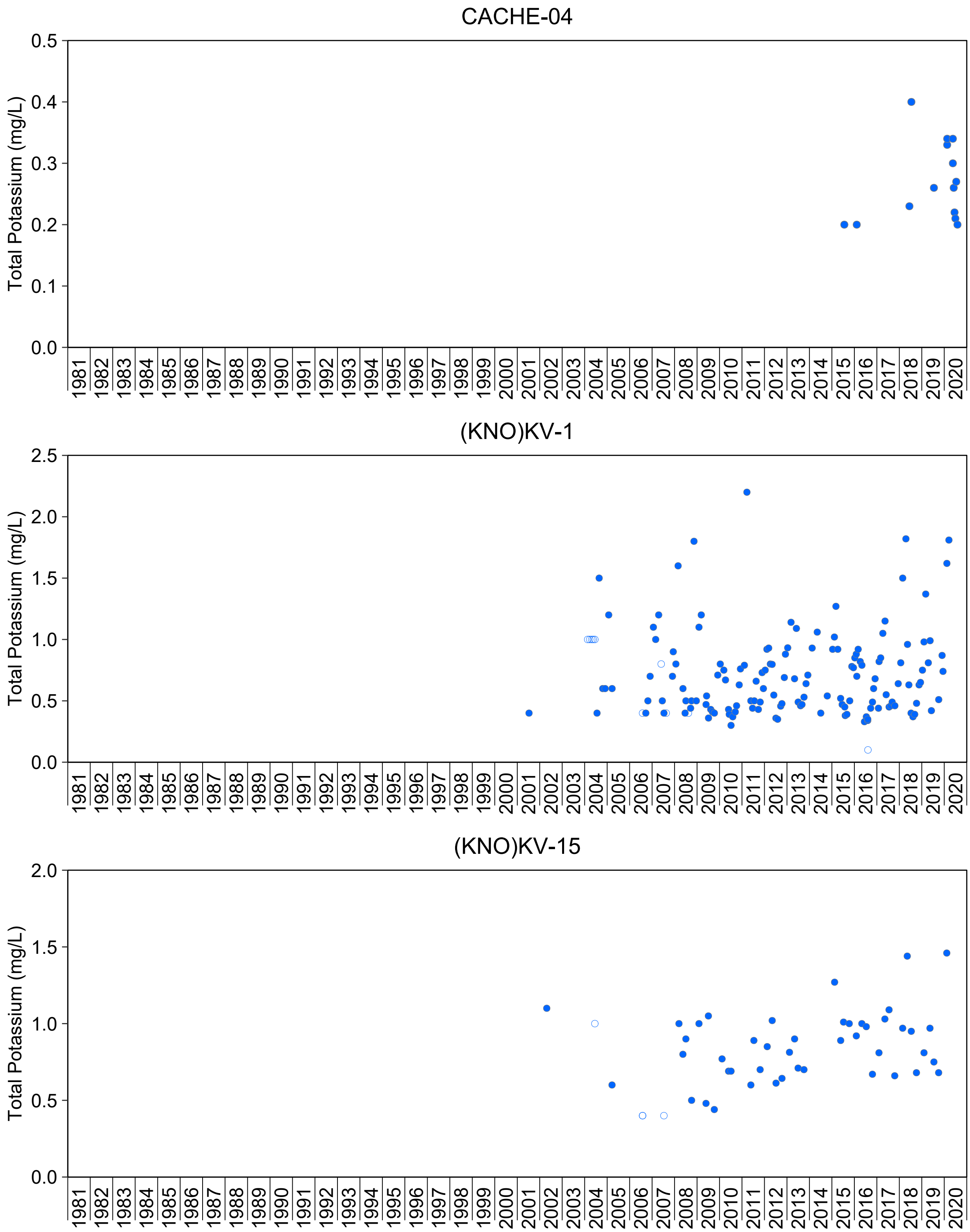


Figure A.65: Time Series Plots of Total Potassium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

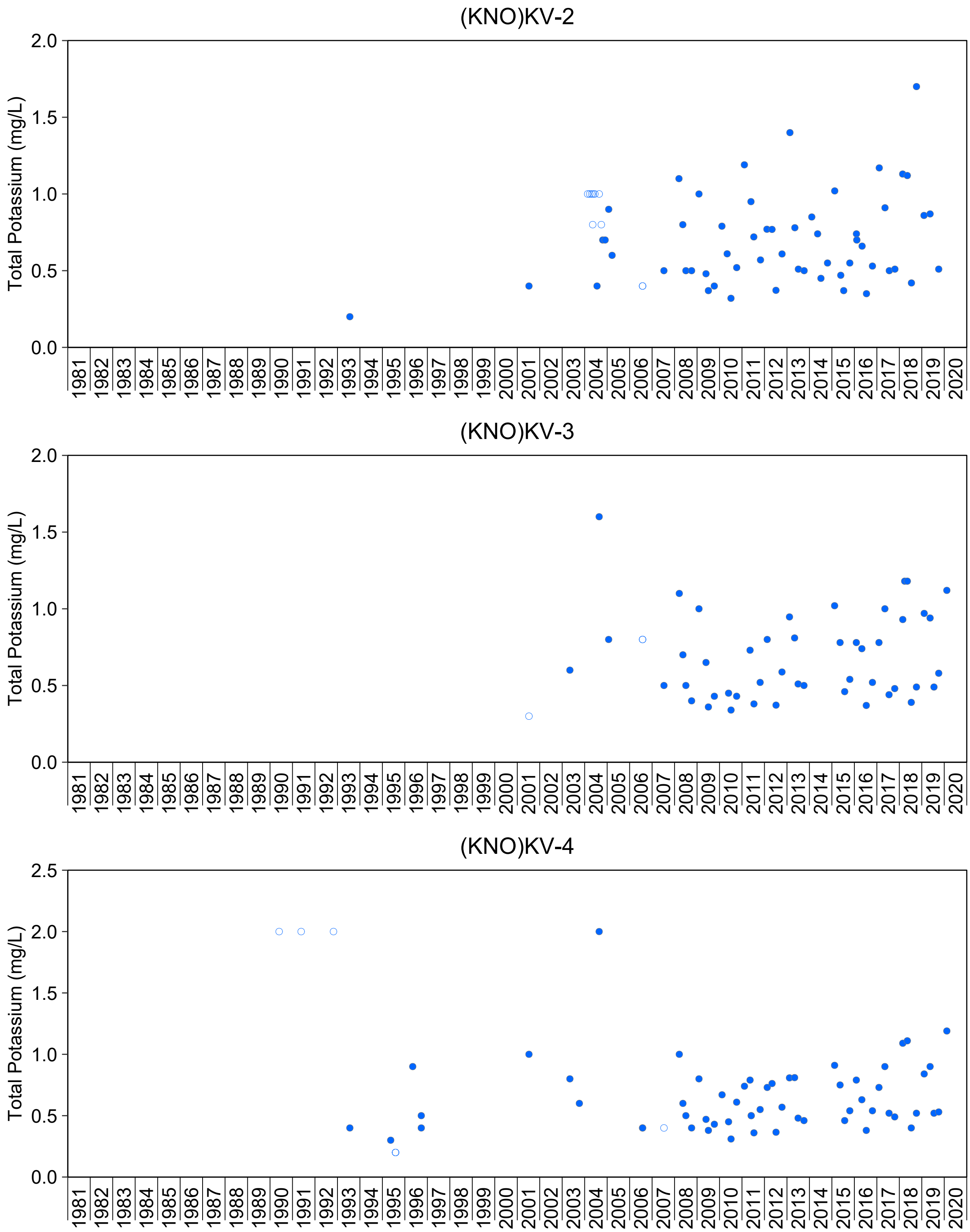


Figure A.65: Time Series Plots of Total Potassium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

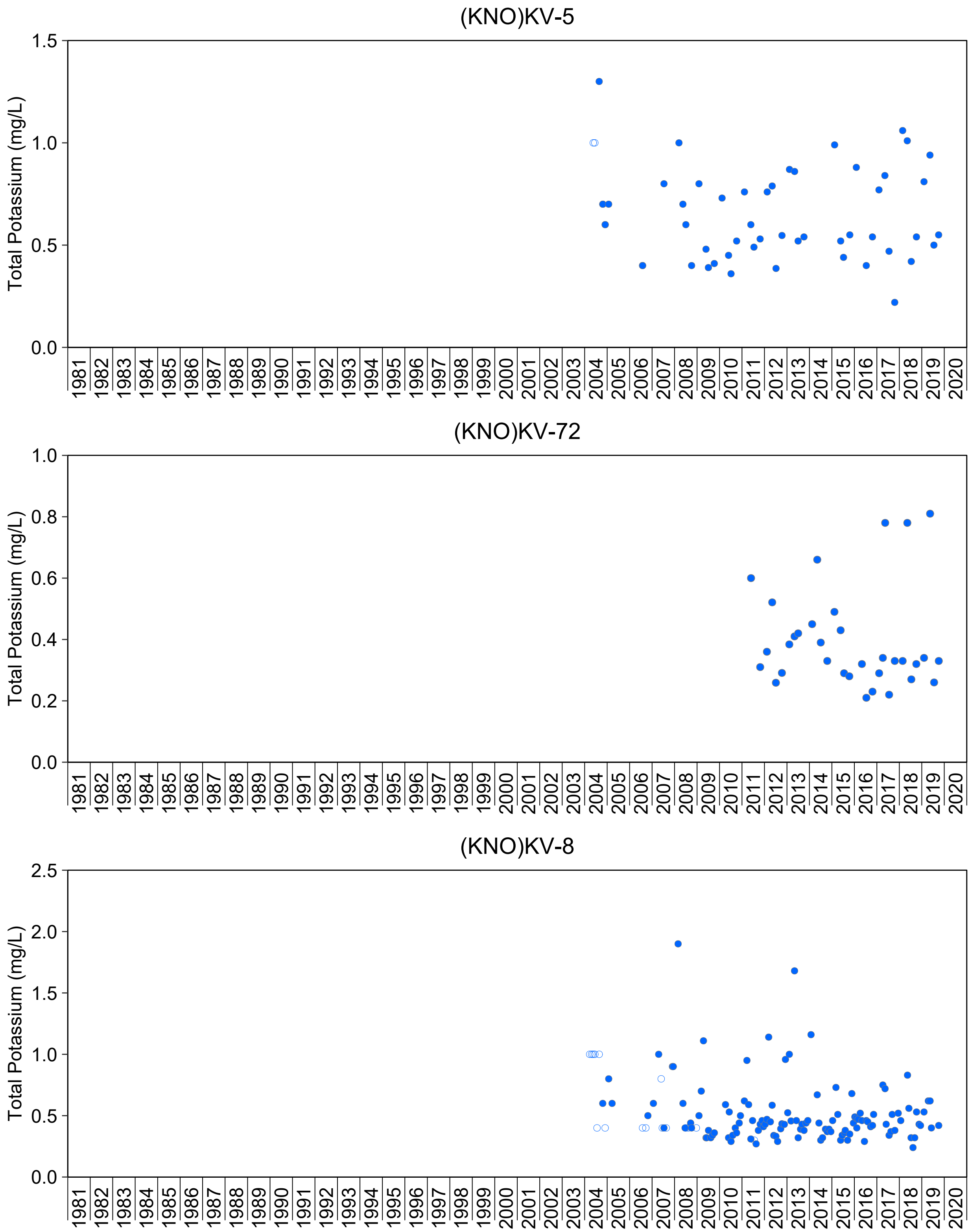


Figure A.65: Time Series Plots of Total Potassium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

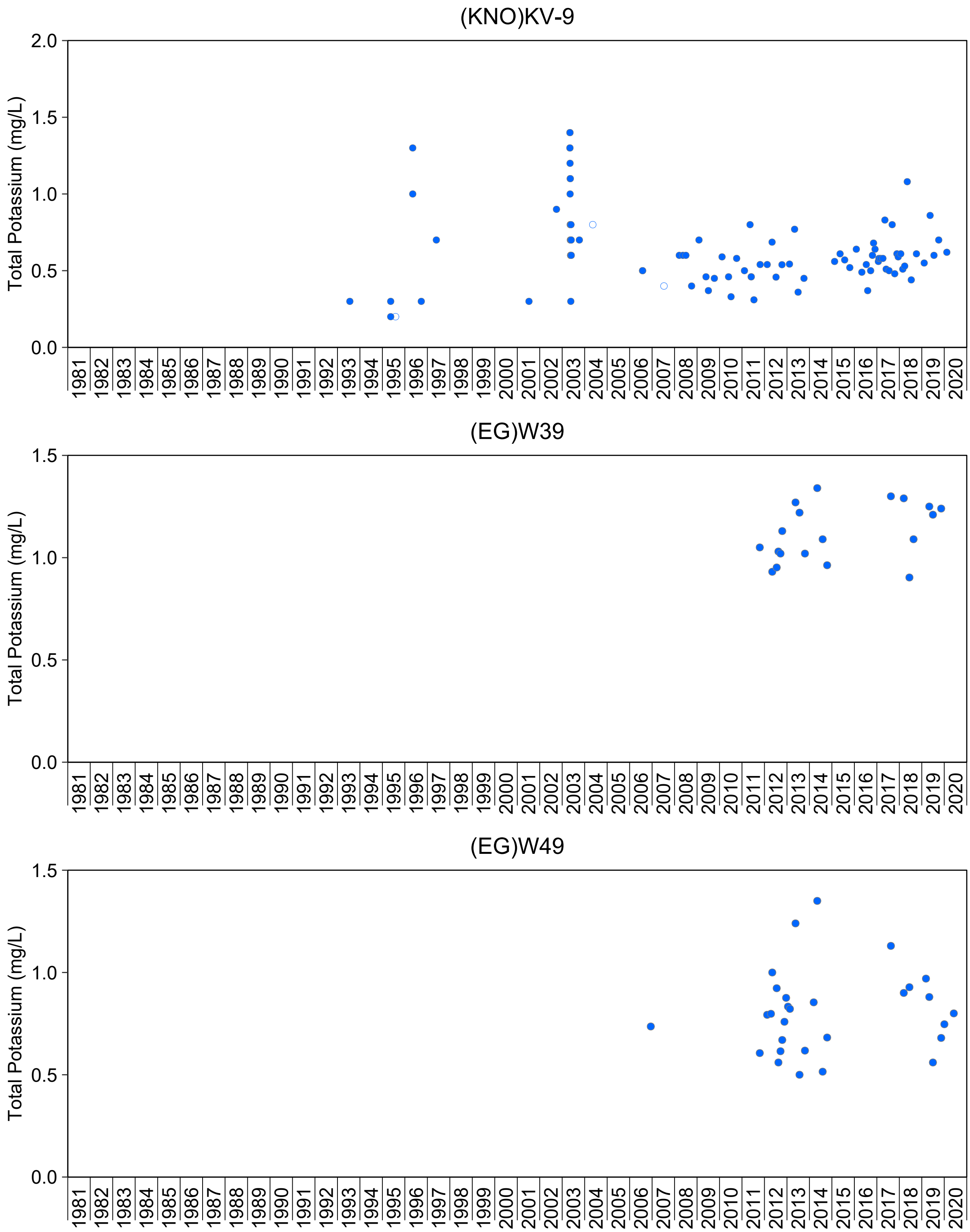


Figure A.65: Time Series Plots of Total Potassium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

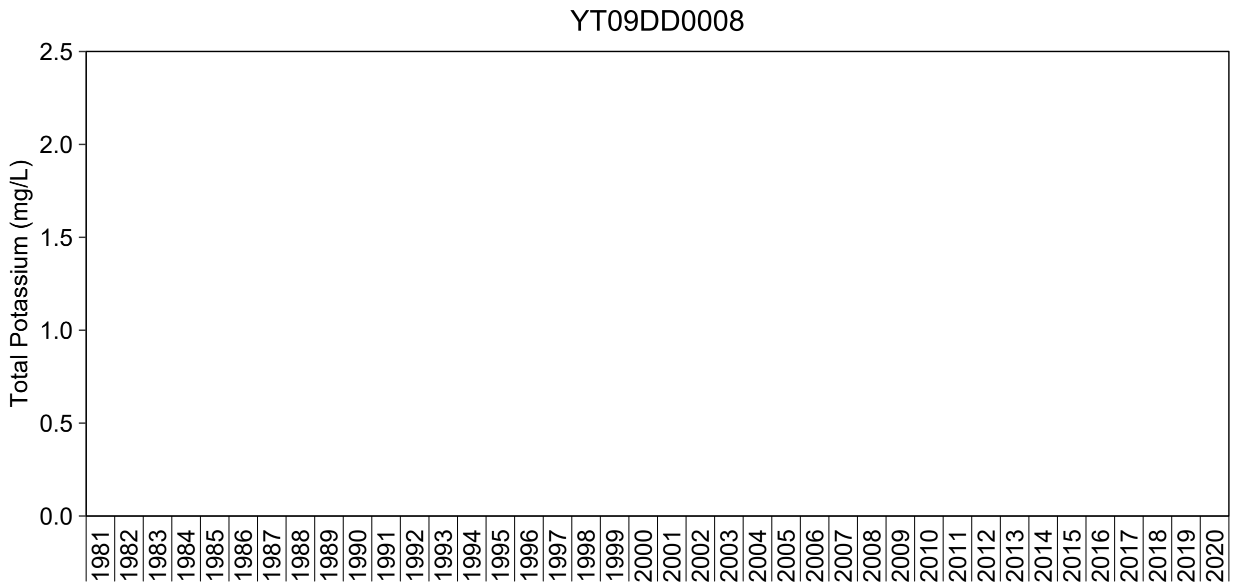


Figure A.65: Time Series Plots of Total Potassium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

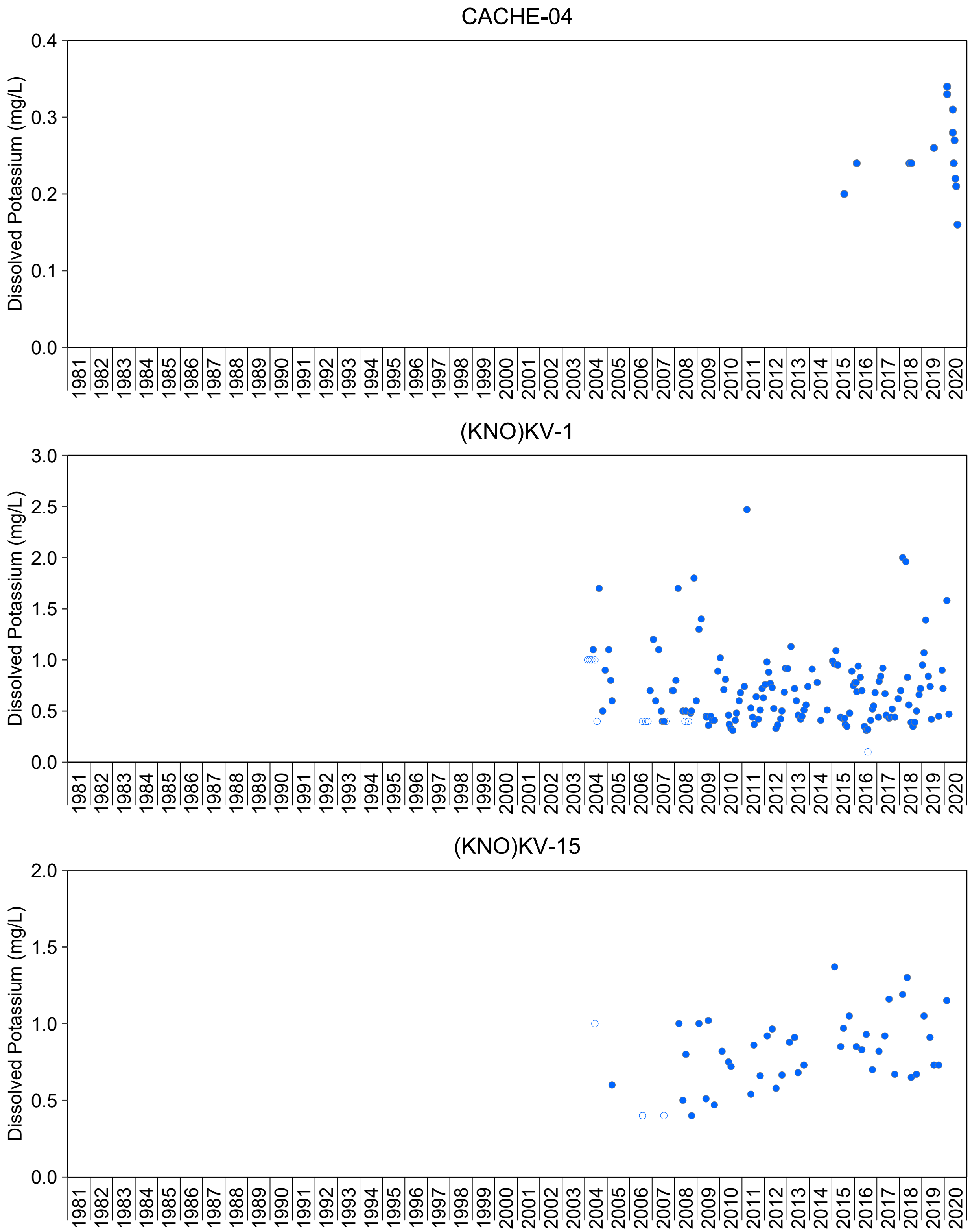


Figure A.66: Time Series Plots of Dissolved Potassium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

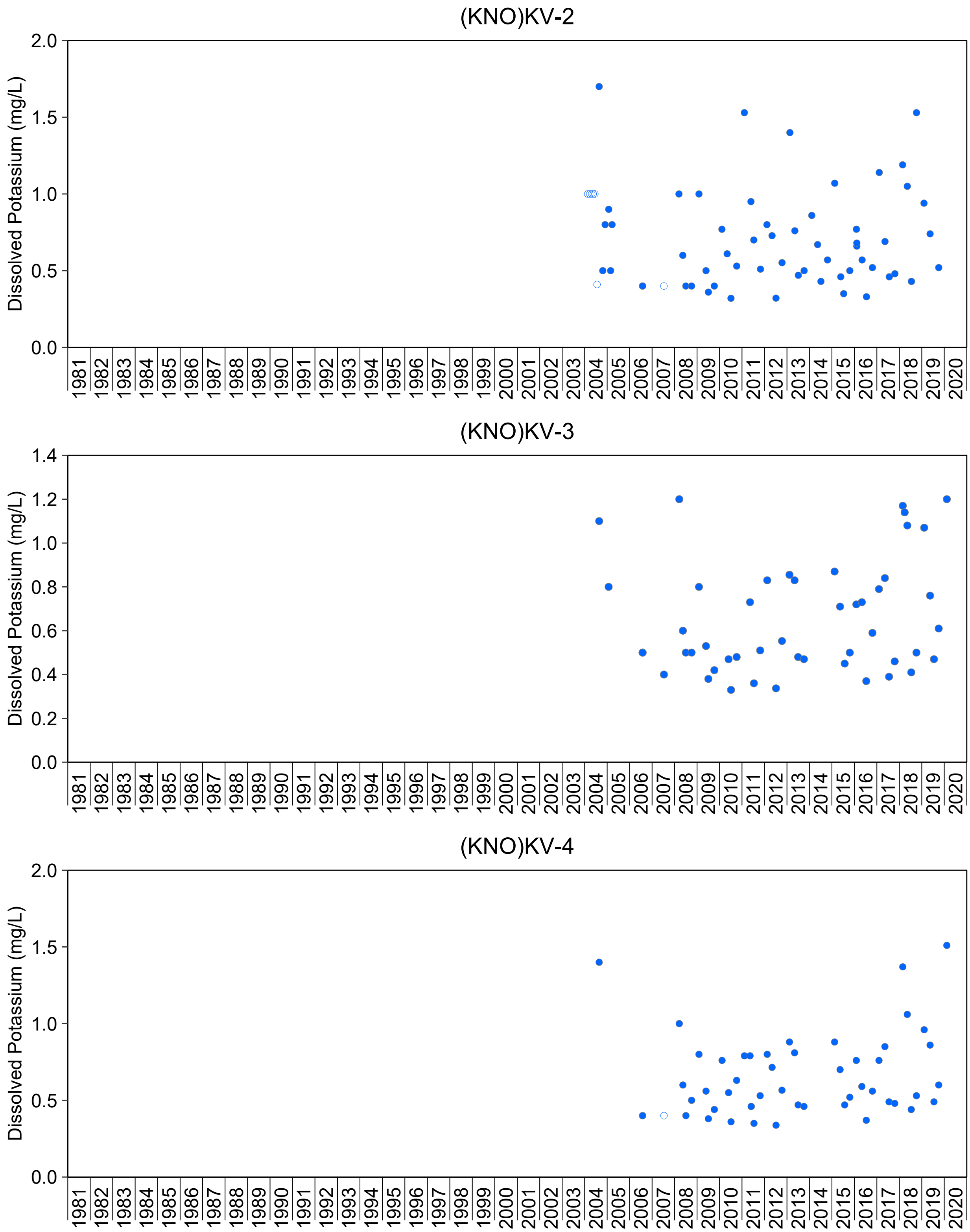


Figure A.66: Time Series Plots of Dissolved Potassium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

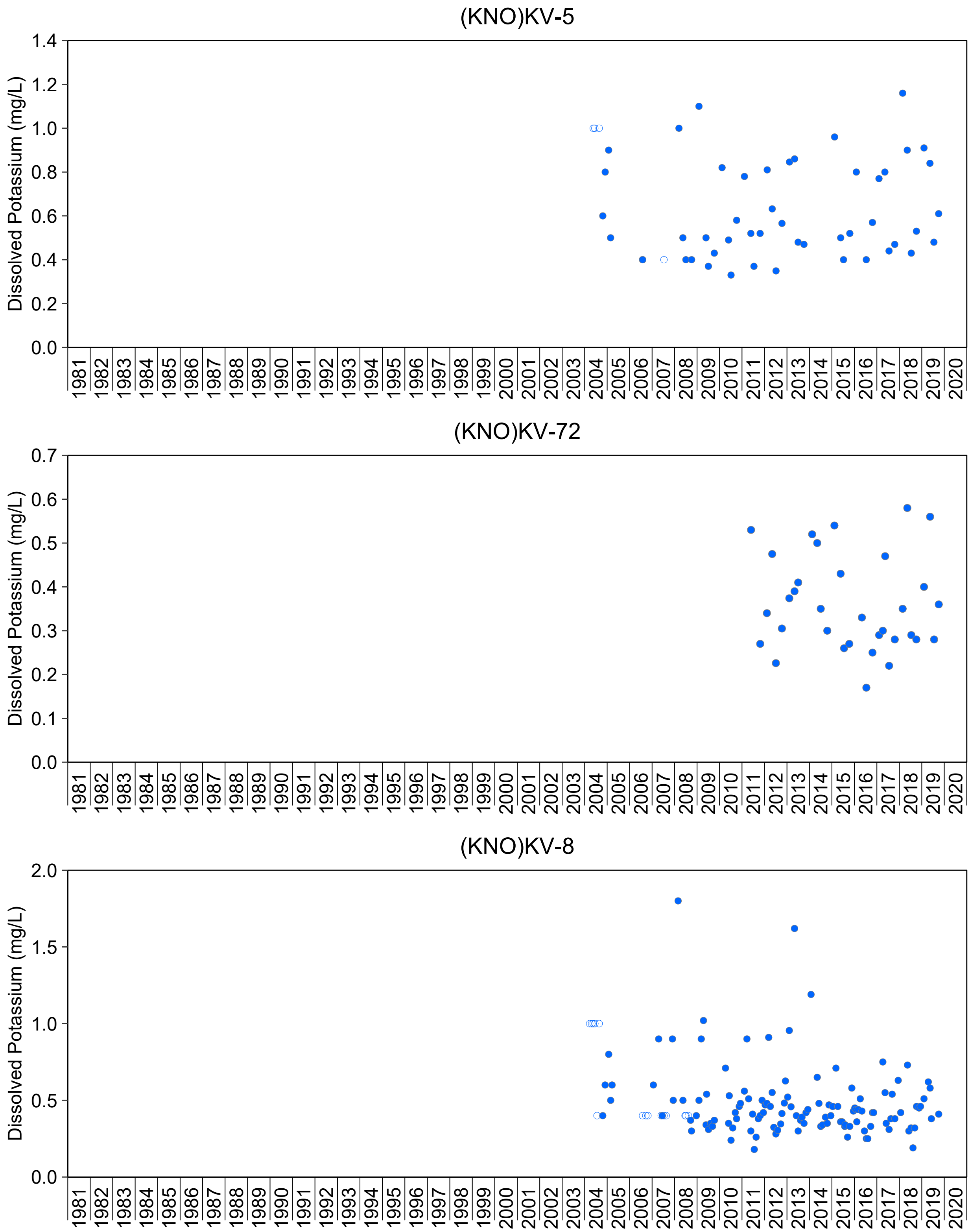


Figure A.66: Time Series Plots of Dissolved Potassium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

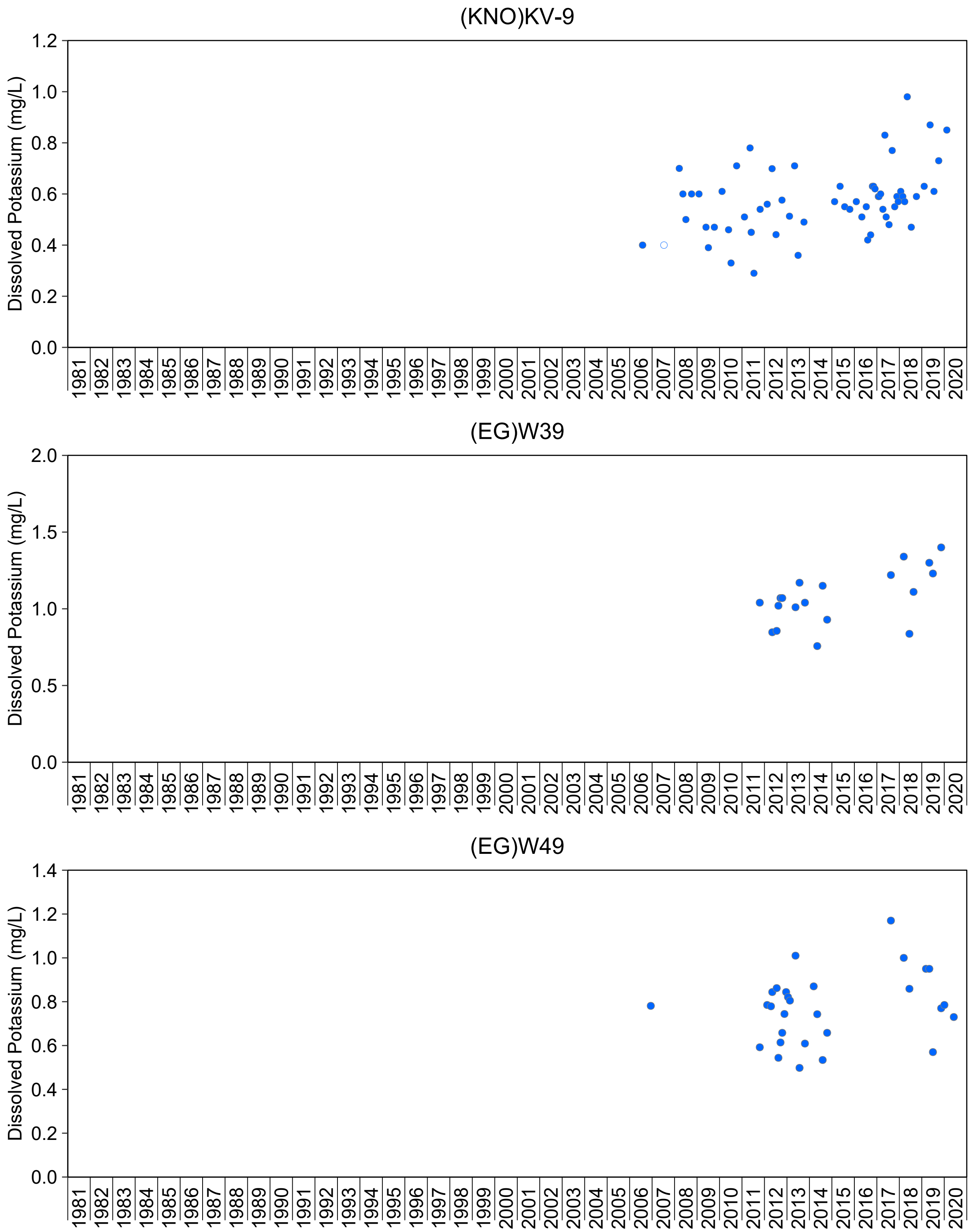


Figure A.66: Time Series Plots of Dissolved Potassium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

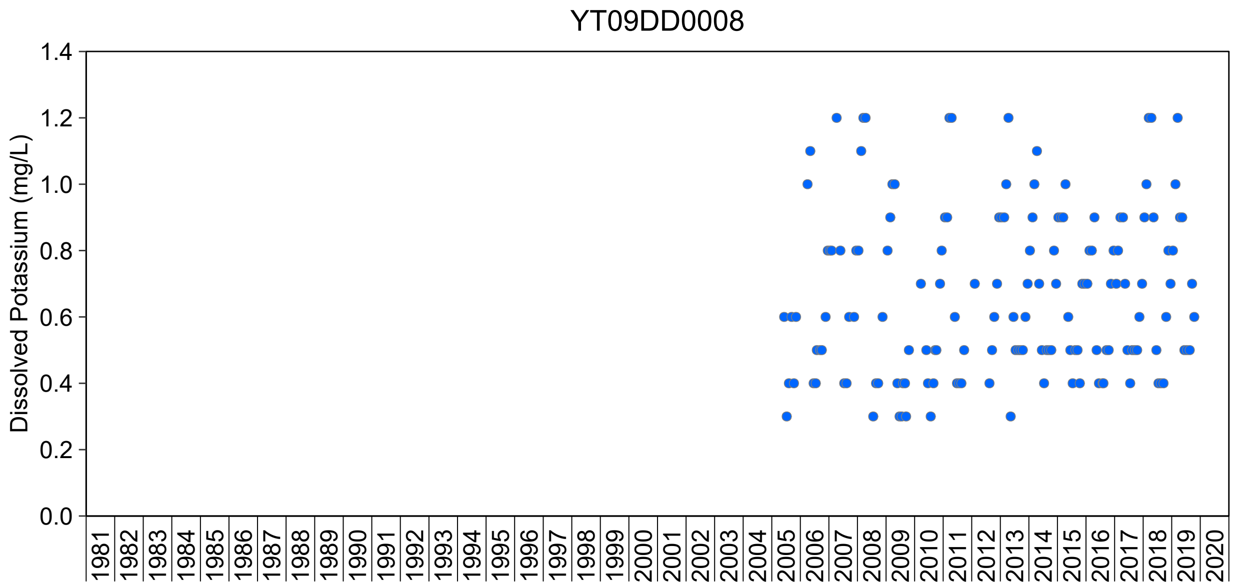


Figure A.66: Time Series Plots of Dissolved Potassium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

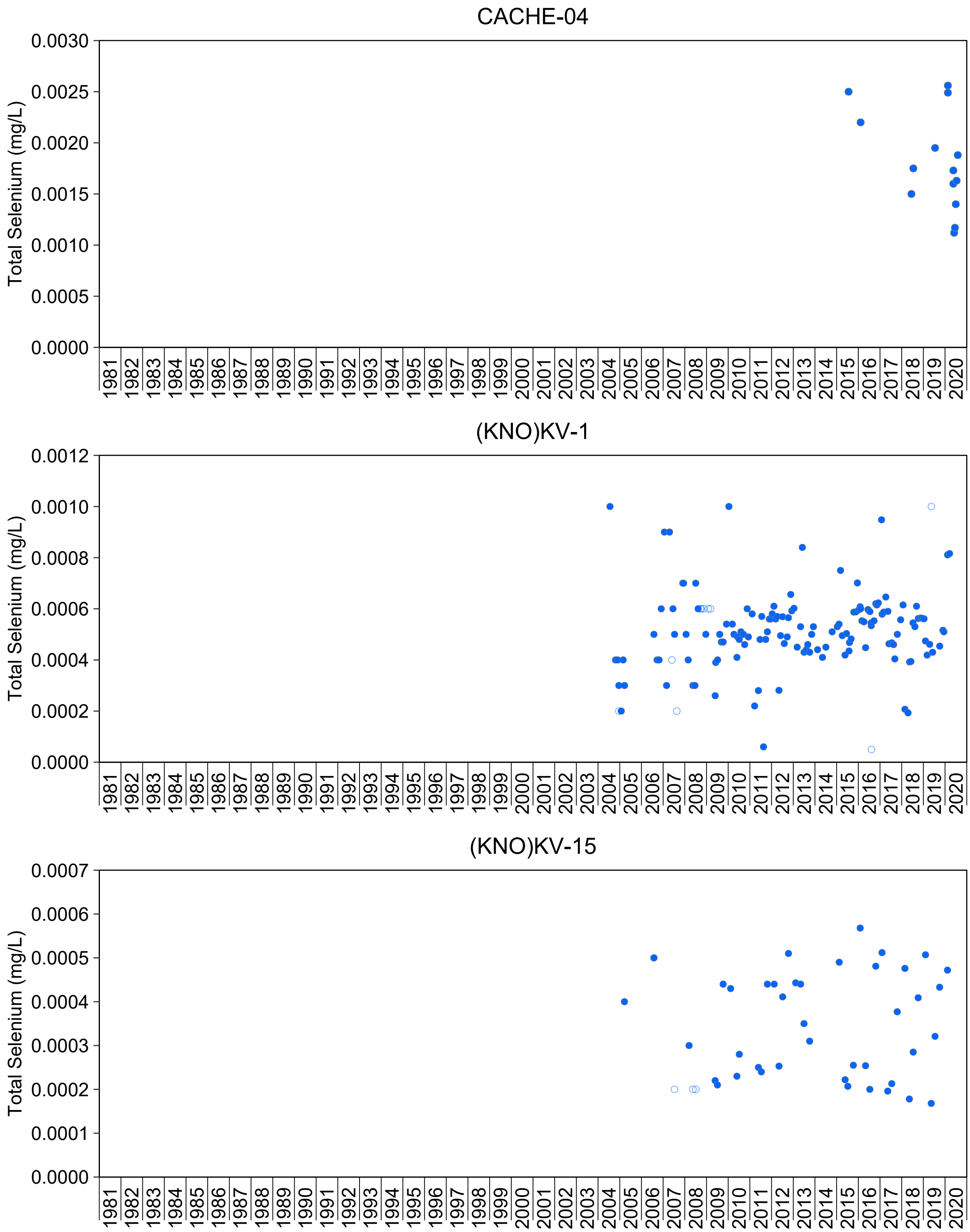


Figure A.67: Time Series Plots of Total Selenium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

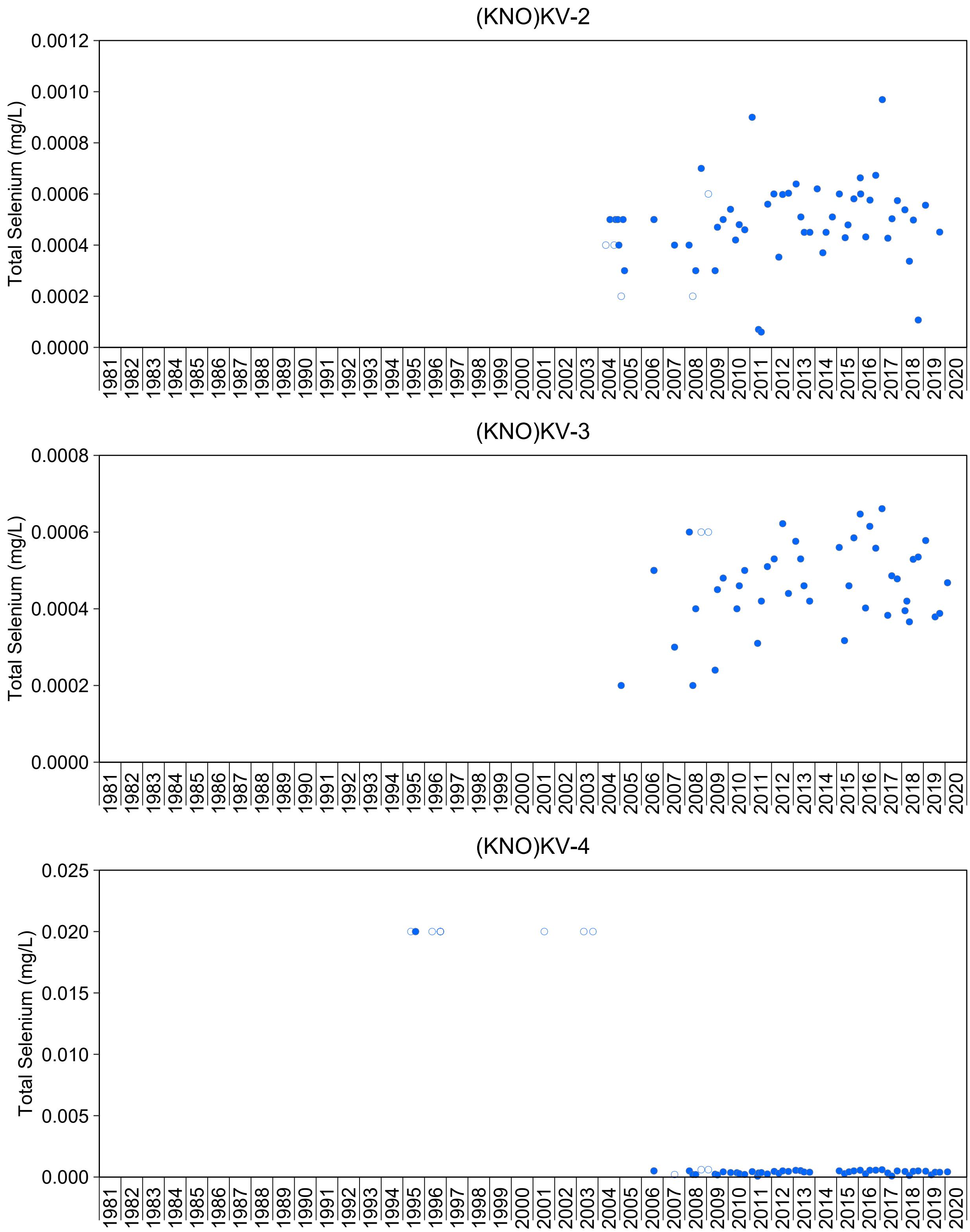


Figure A.67: Time Series Plots of Total Selenium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

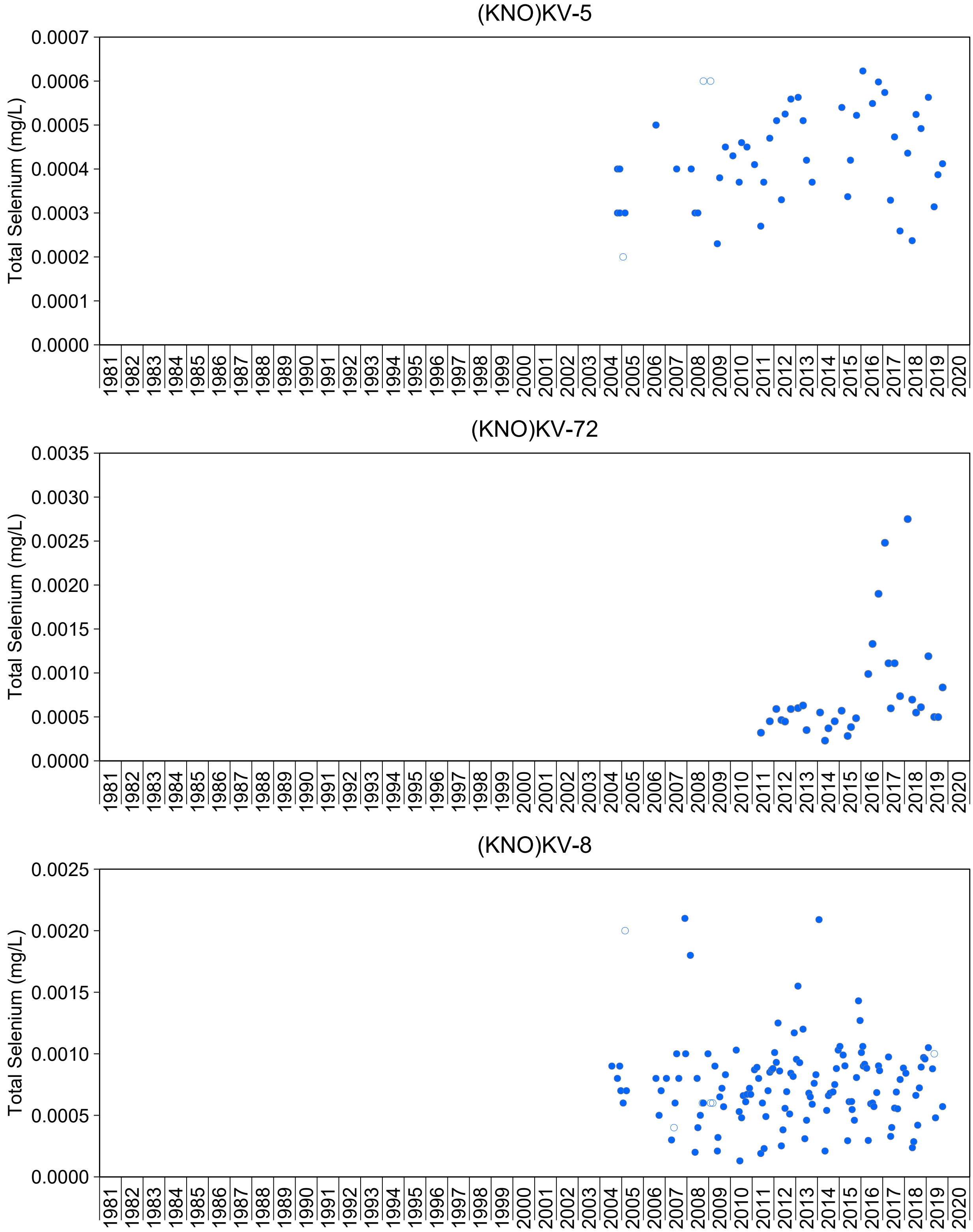


Figure A.67: Time Series Plots of Total Selenium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

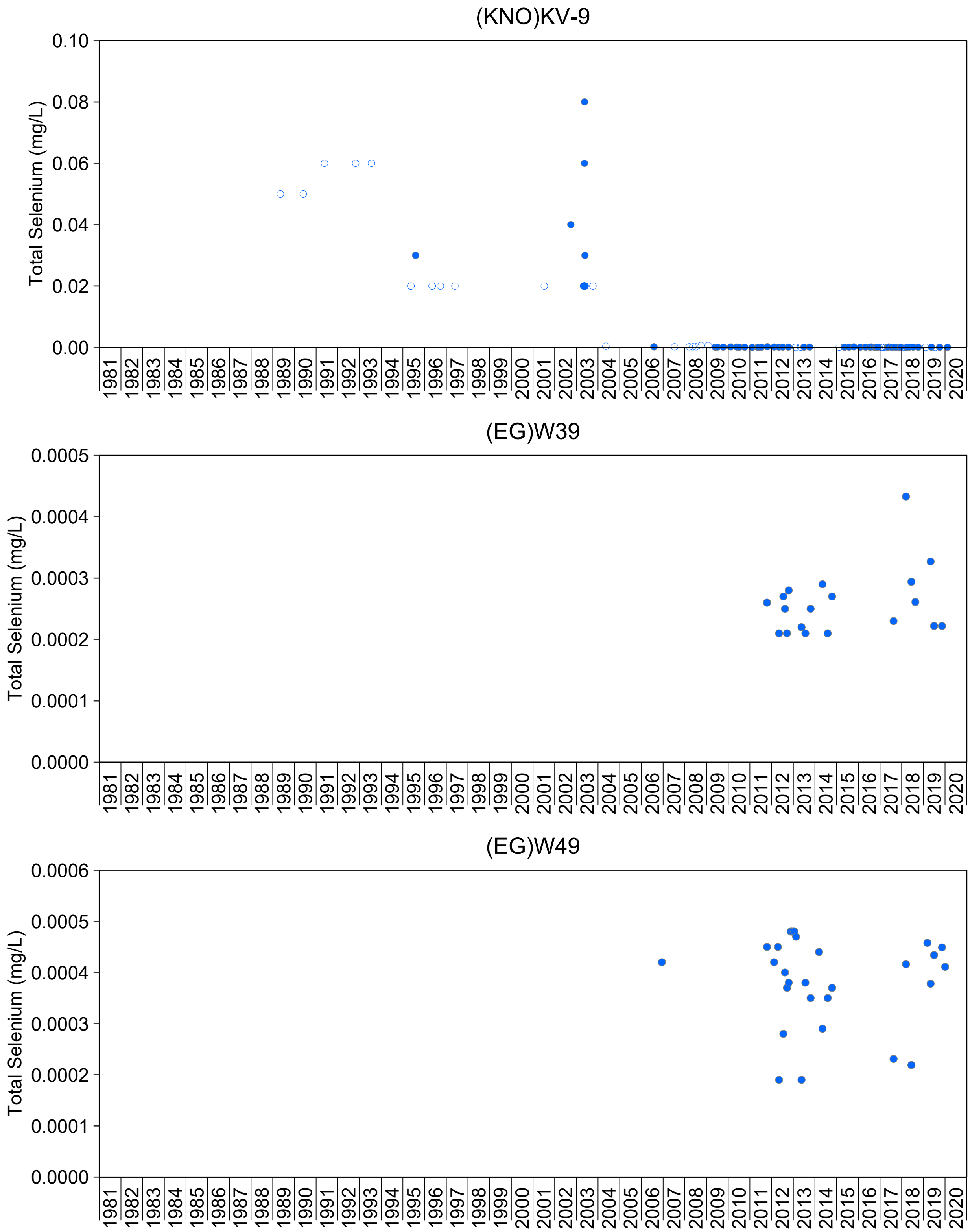


Figure A.67: Time Series Plots of Total Selenium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

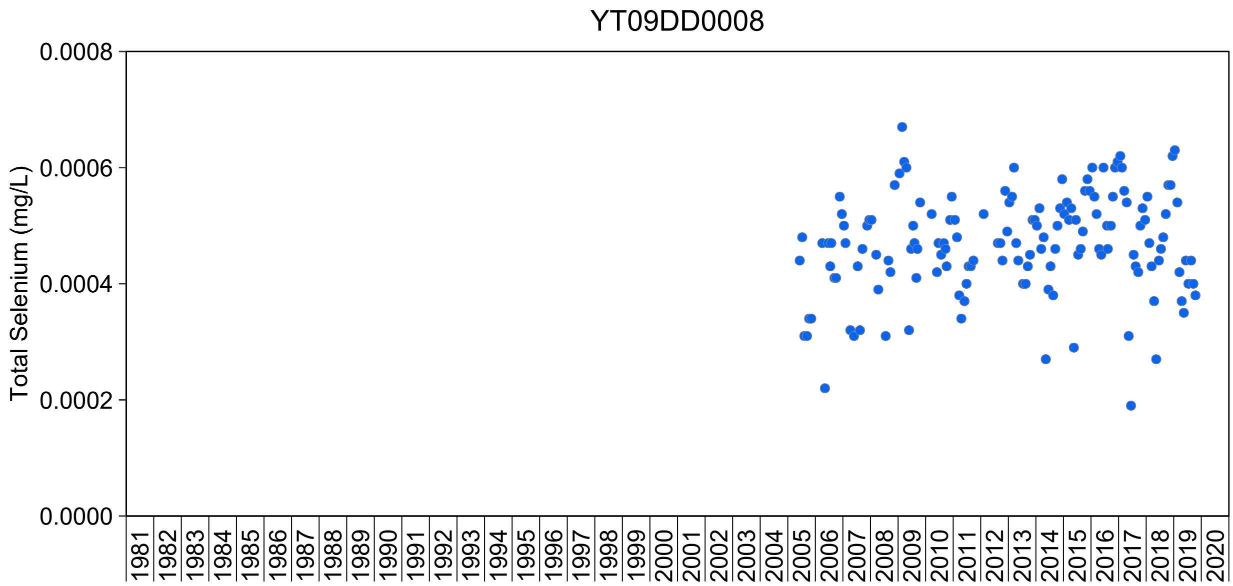


Figure A.67: Time Series Plots of Total Selenium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

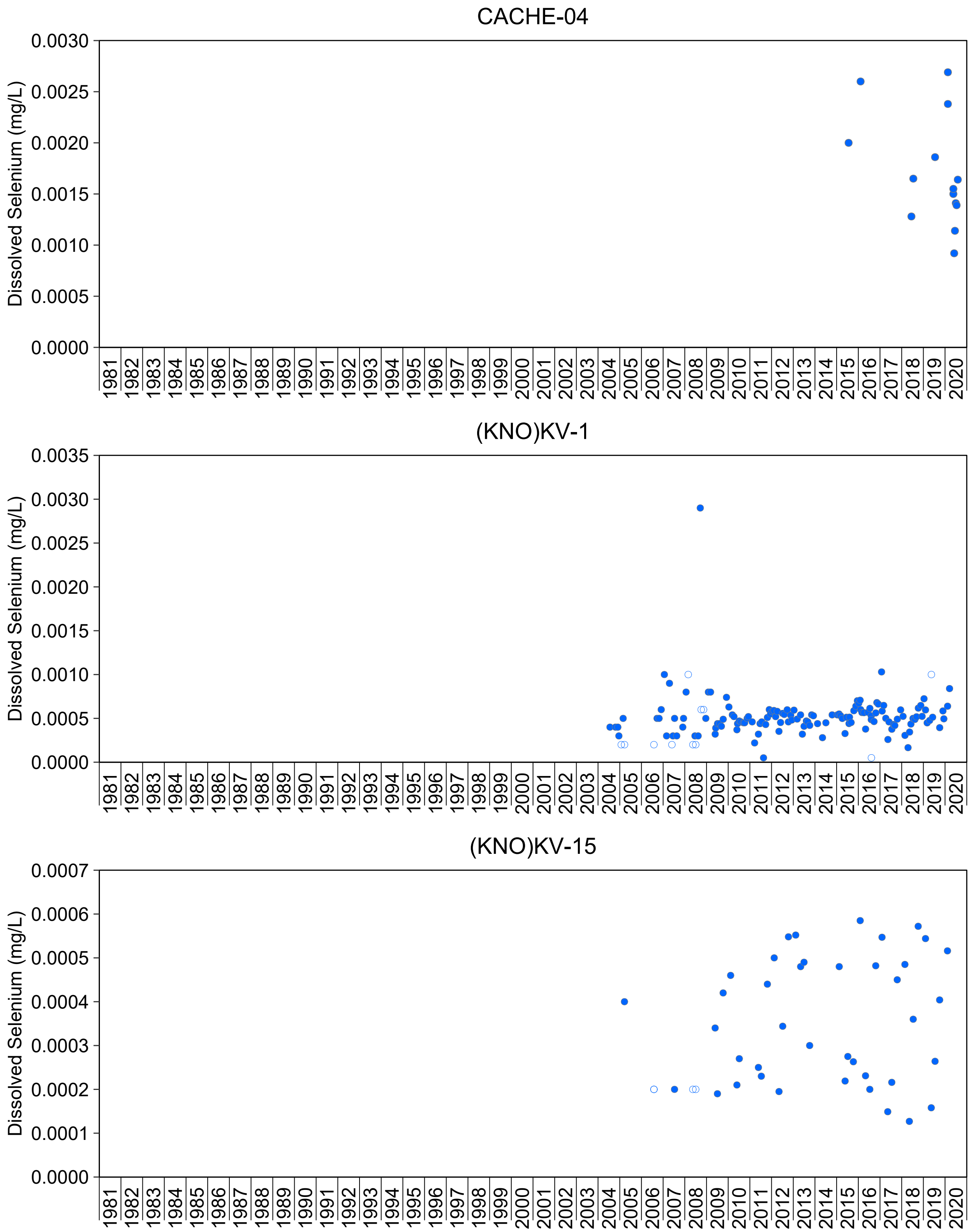


Figure A.68: Time Series Plots of Dissolved Selenium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

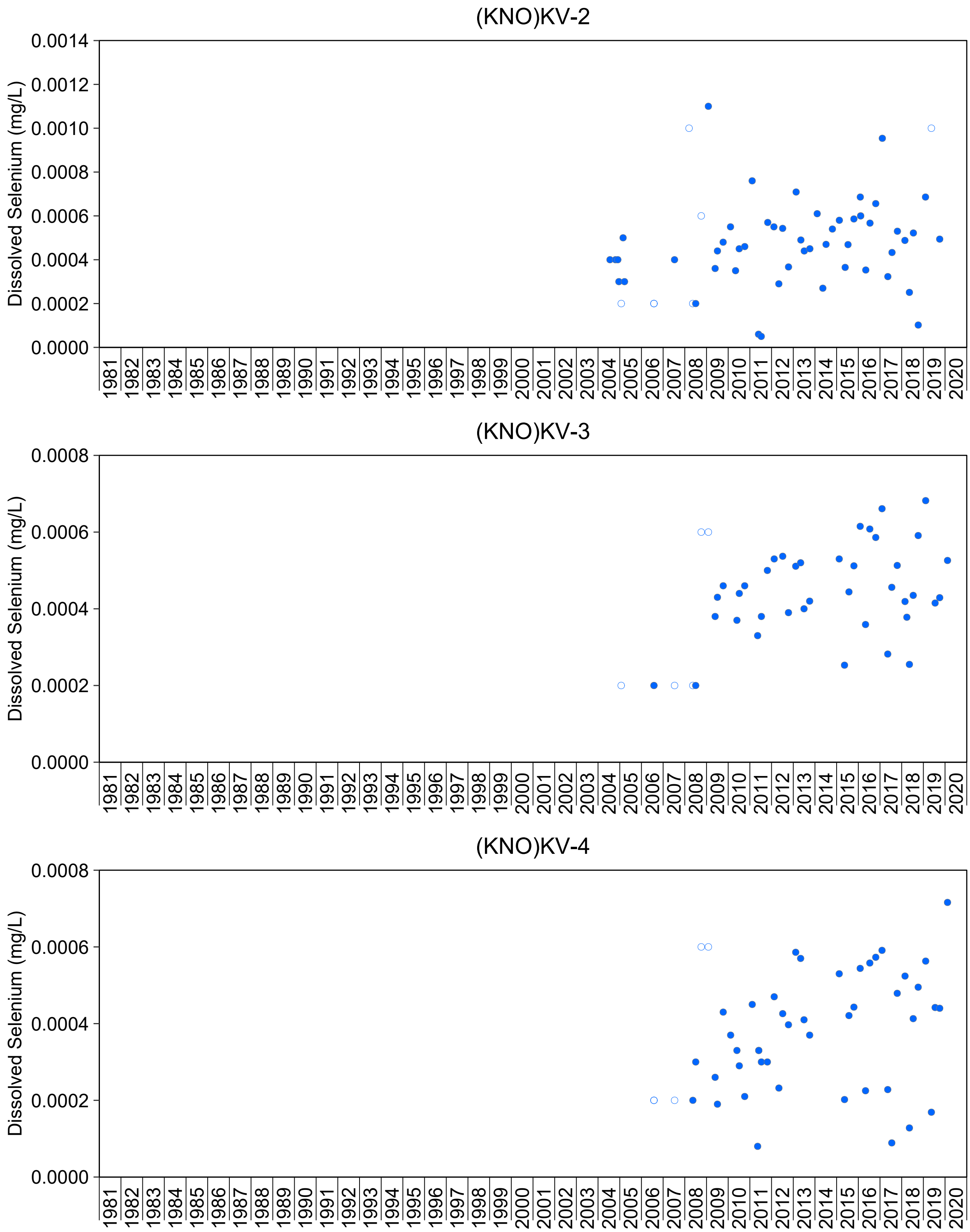


Figure A.68: Time Series Plots of Dissolved Selenium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

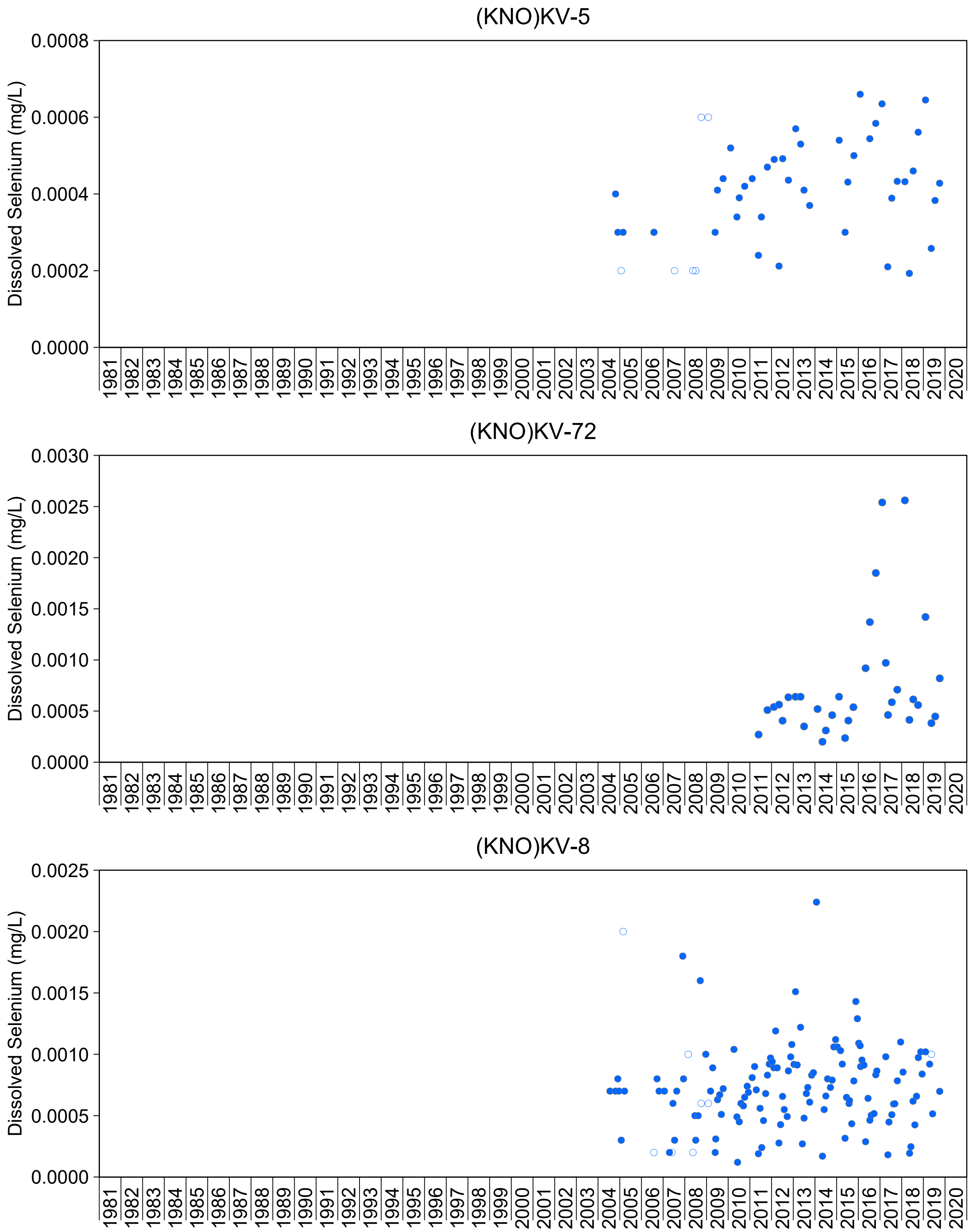


Figure A.68: Time Series Plots of Dissolved Selenium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

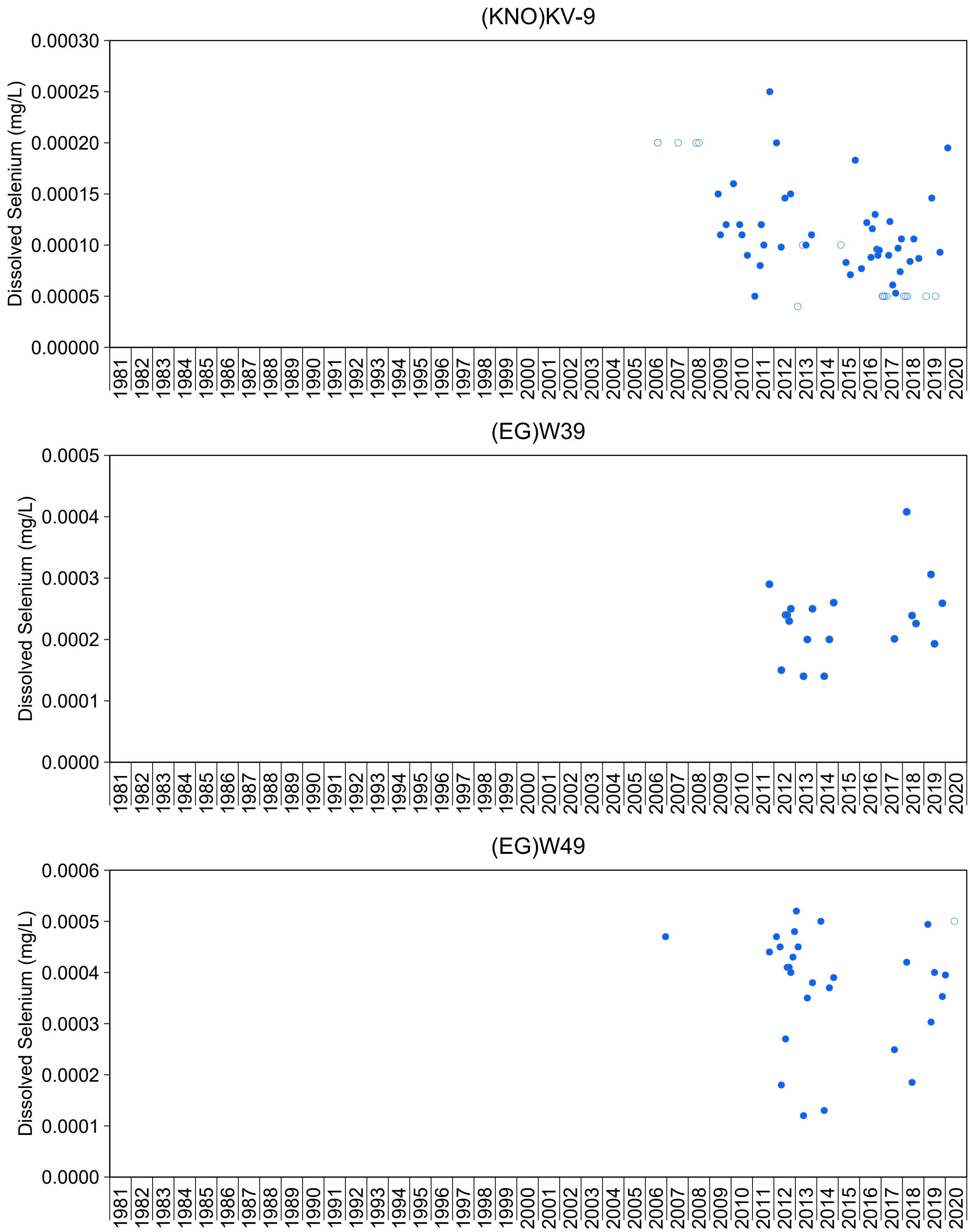


Figure A.68: Time Series Plots of Dissolved Selenium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

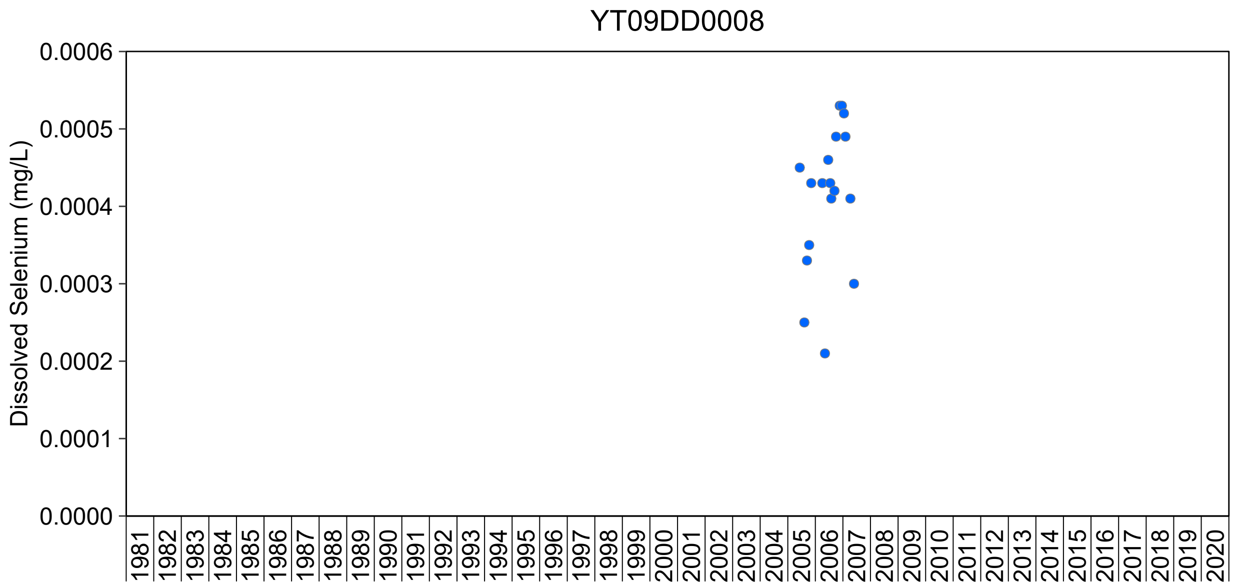


Figure A.68: Time Series Plots of Dissolved Selenium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

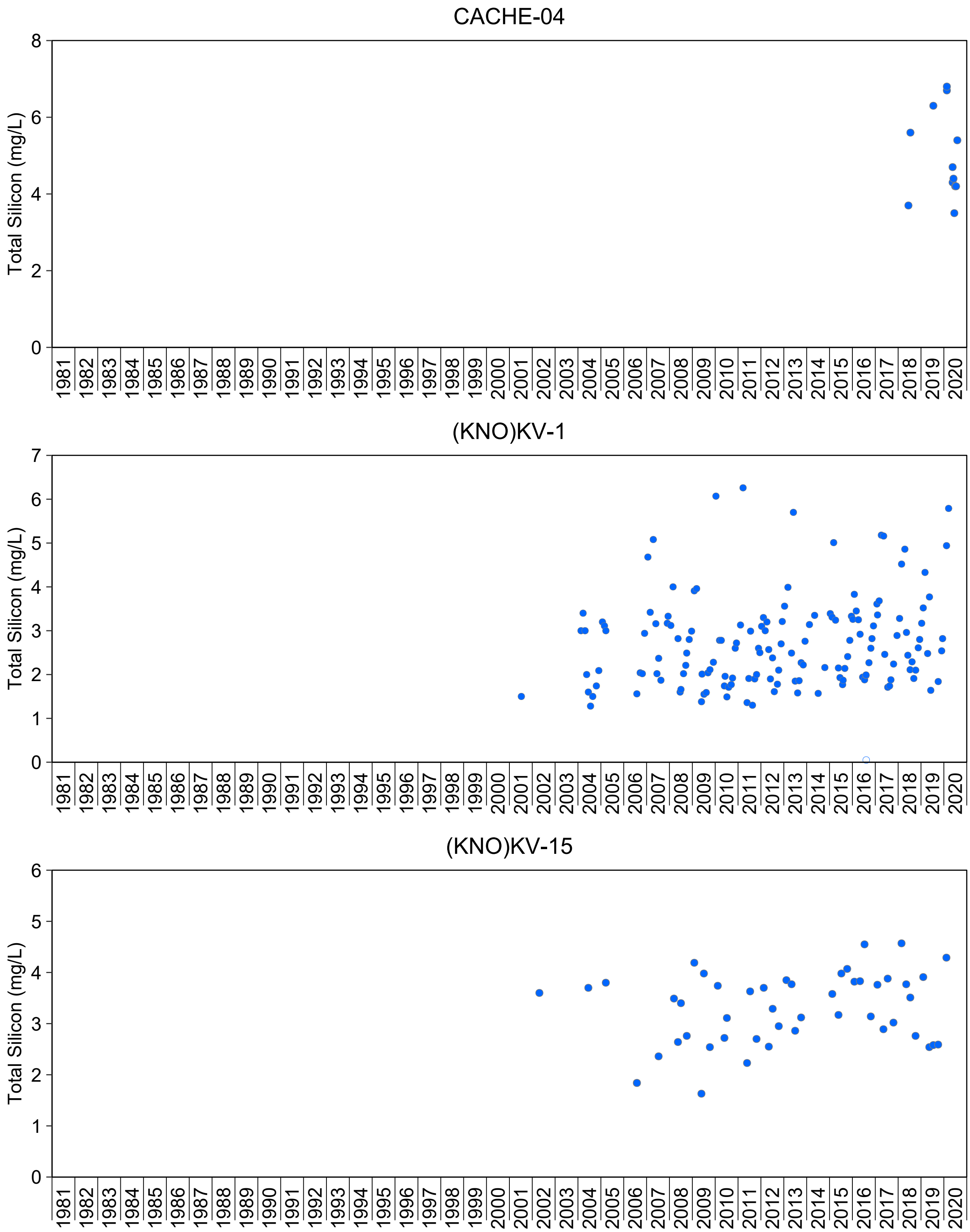
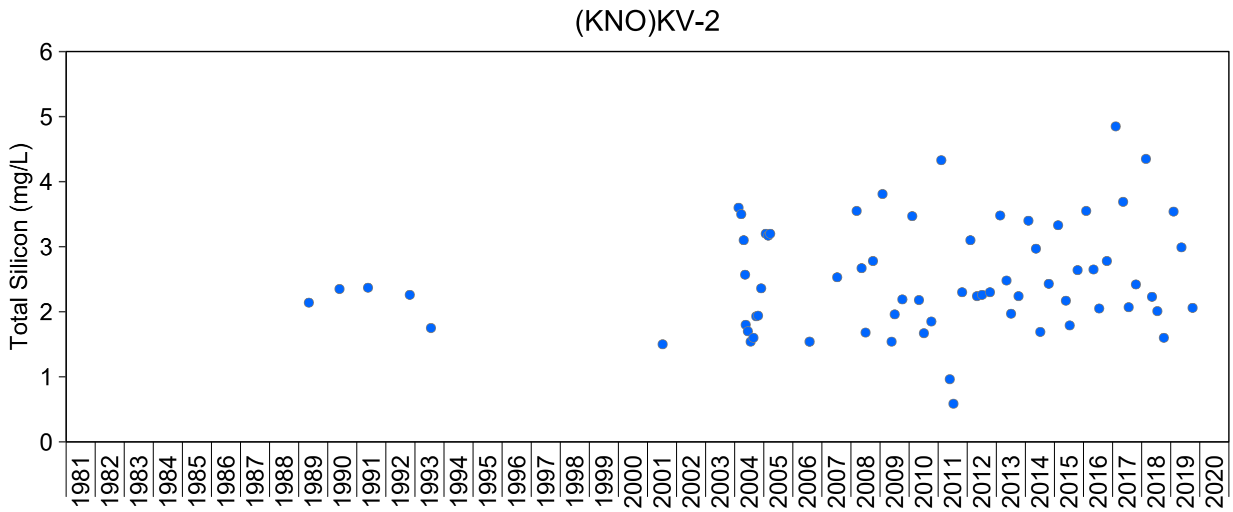
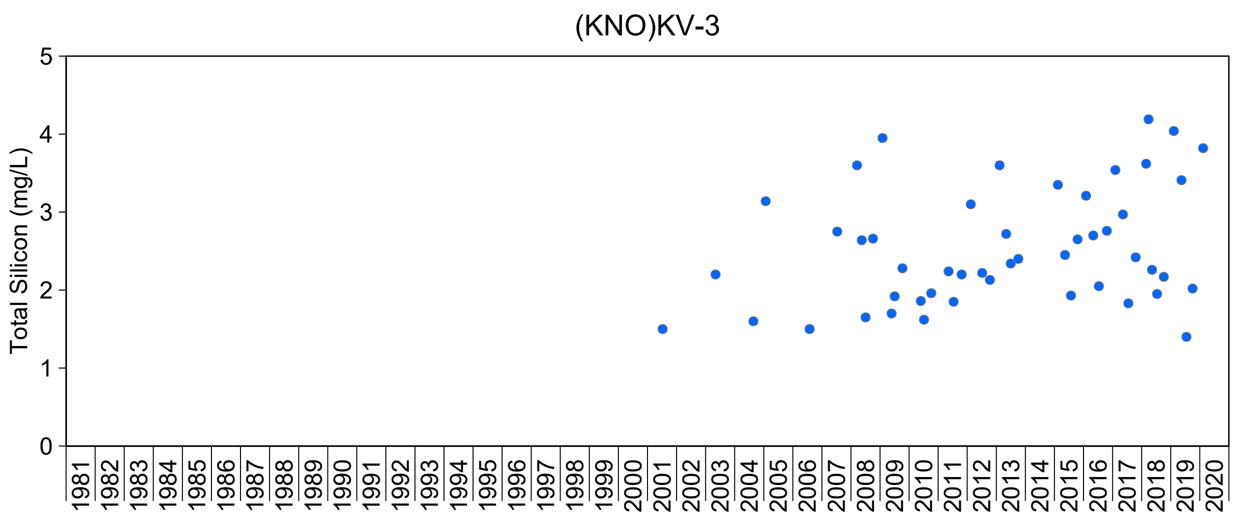


Figure A.69: Time Series Plots of Total Silicon Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.





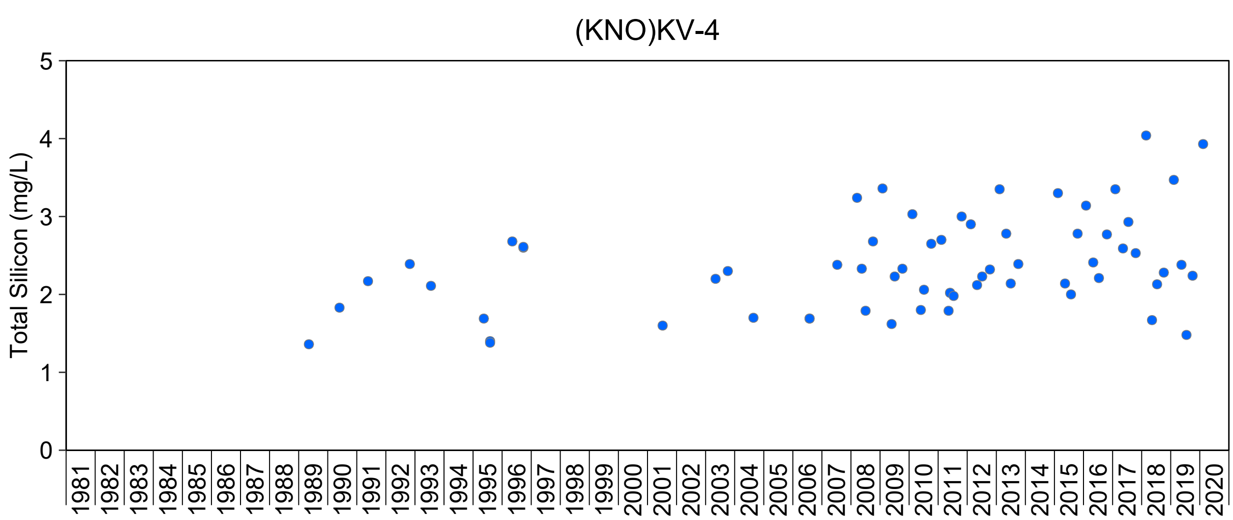


Figure A.69: Time Series Plots of Total Silicon Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

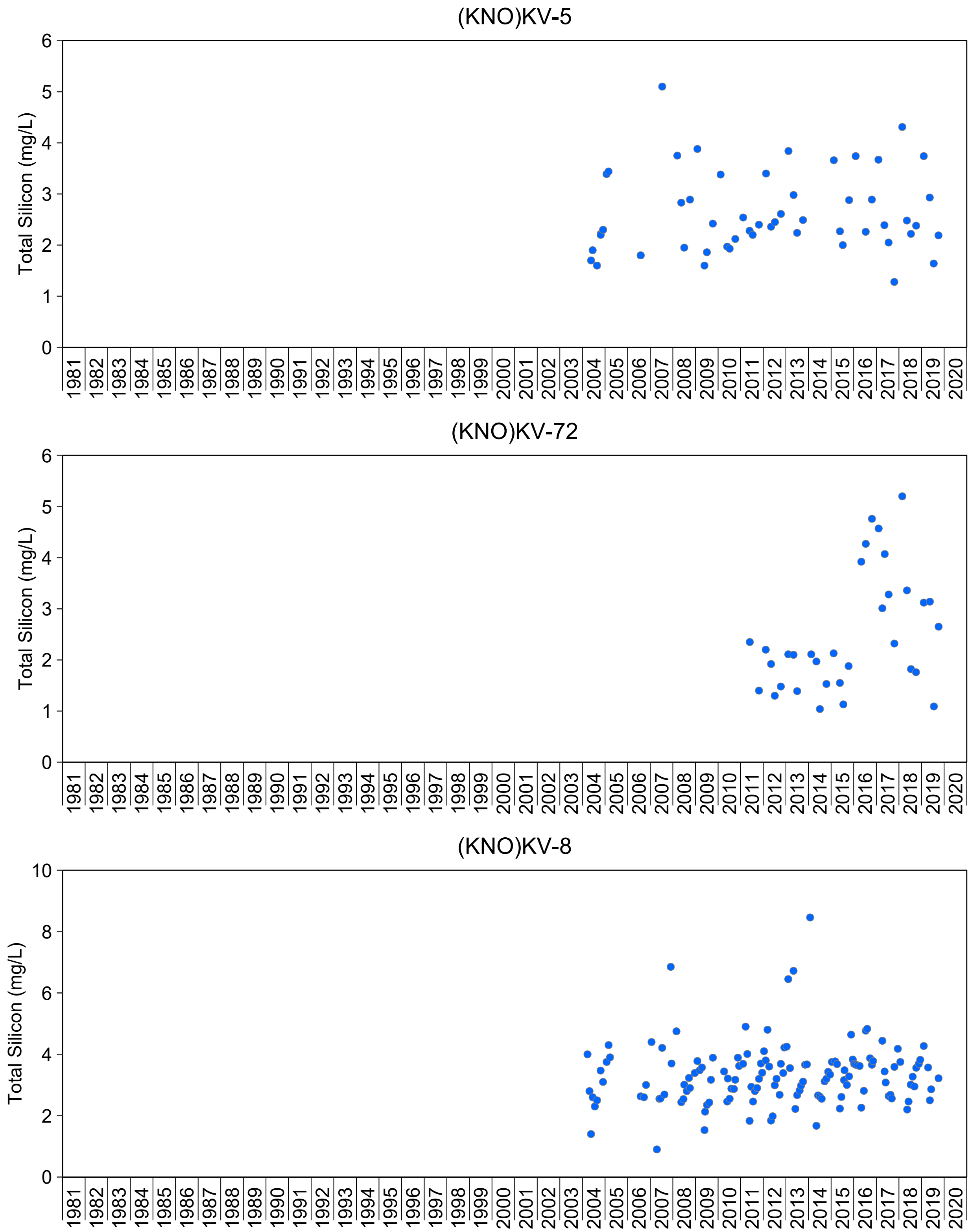


Figure A.69: Time Series Plots of Total Silicon Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

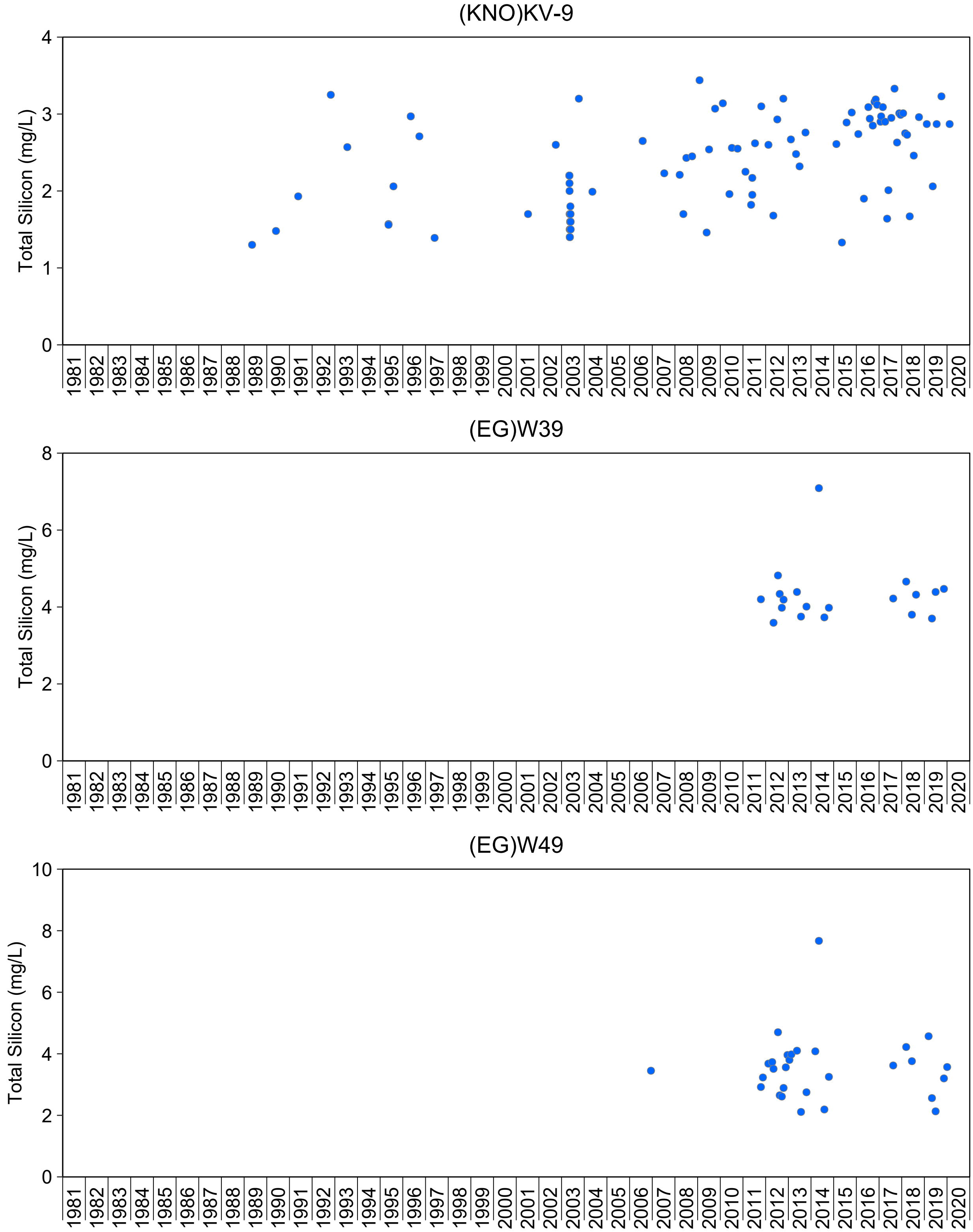


Figure A.69: Time Series Plots of Total Silicon Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

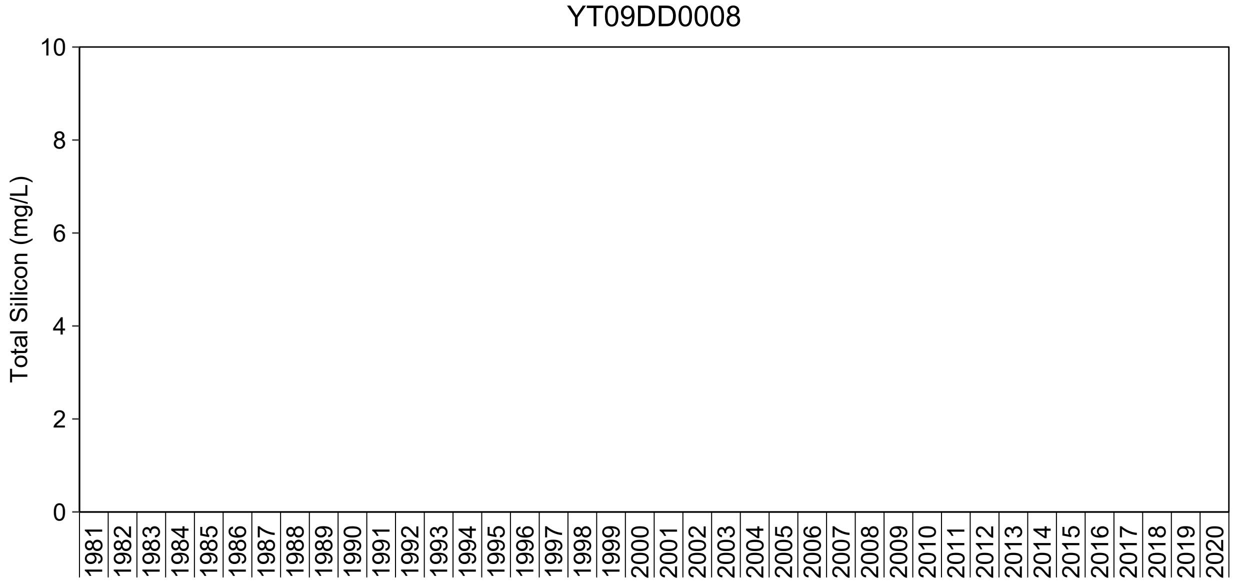


Figure A.69: Time Series Plots of Total Silicon Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

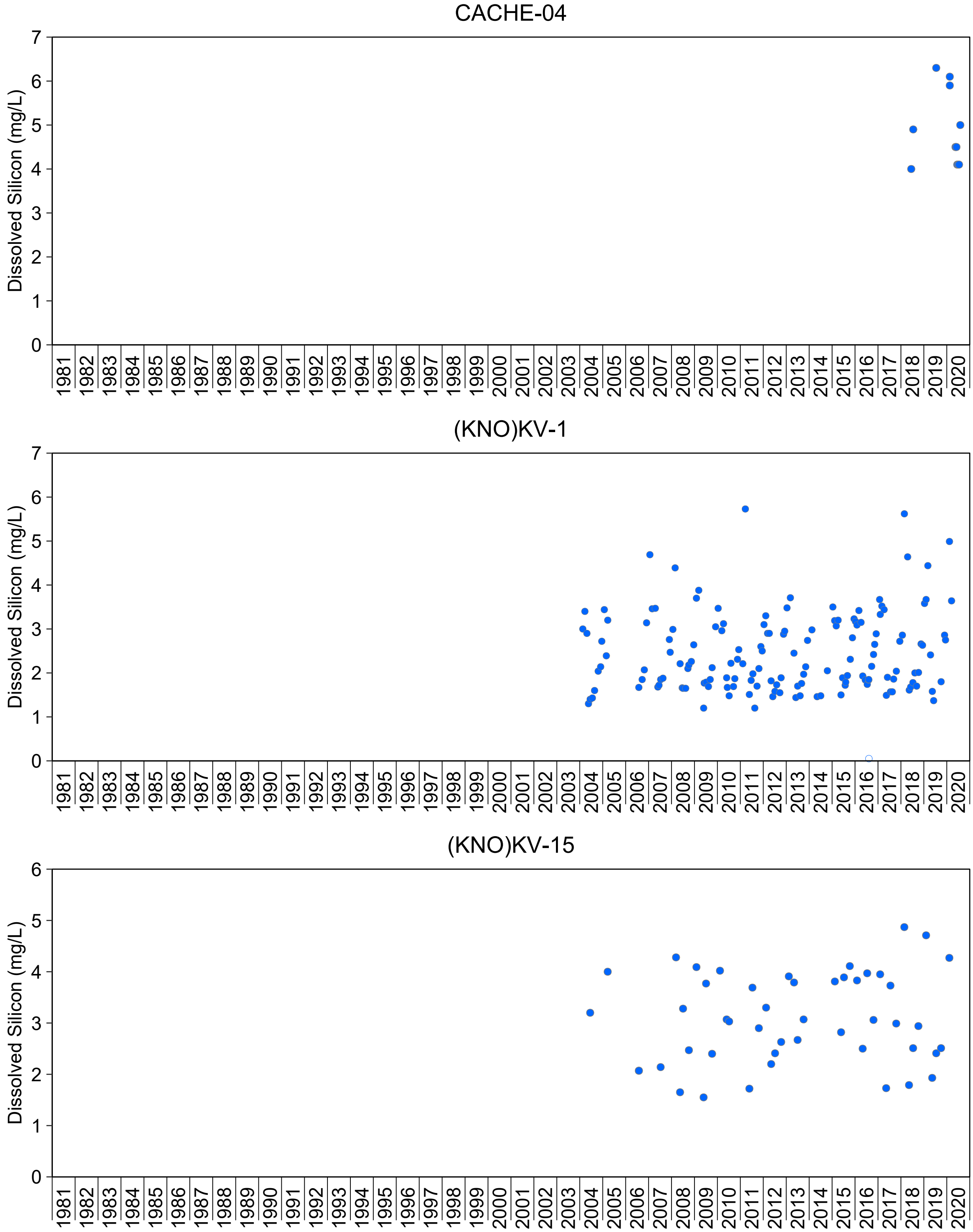


Figure A.70: Time Series Plots of Dissolved Silicon Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

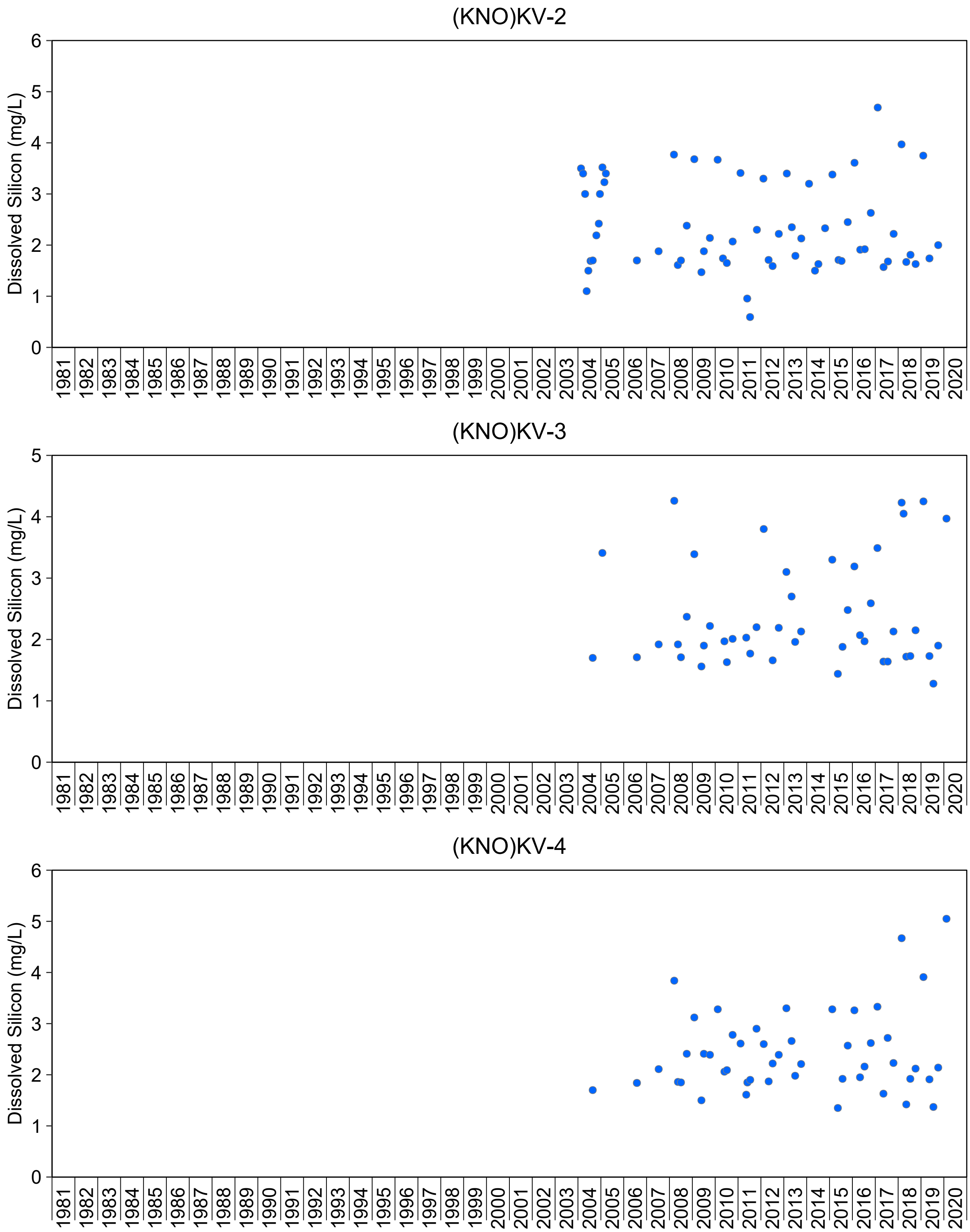


Figure A.70: Time Series Plots of Dissolved Silicon Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

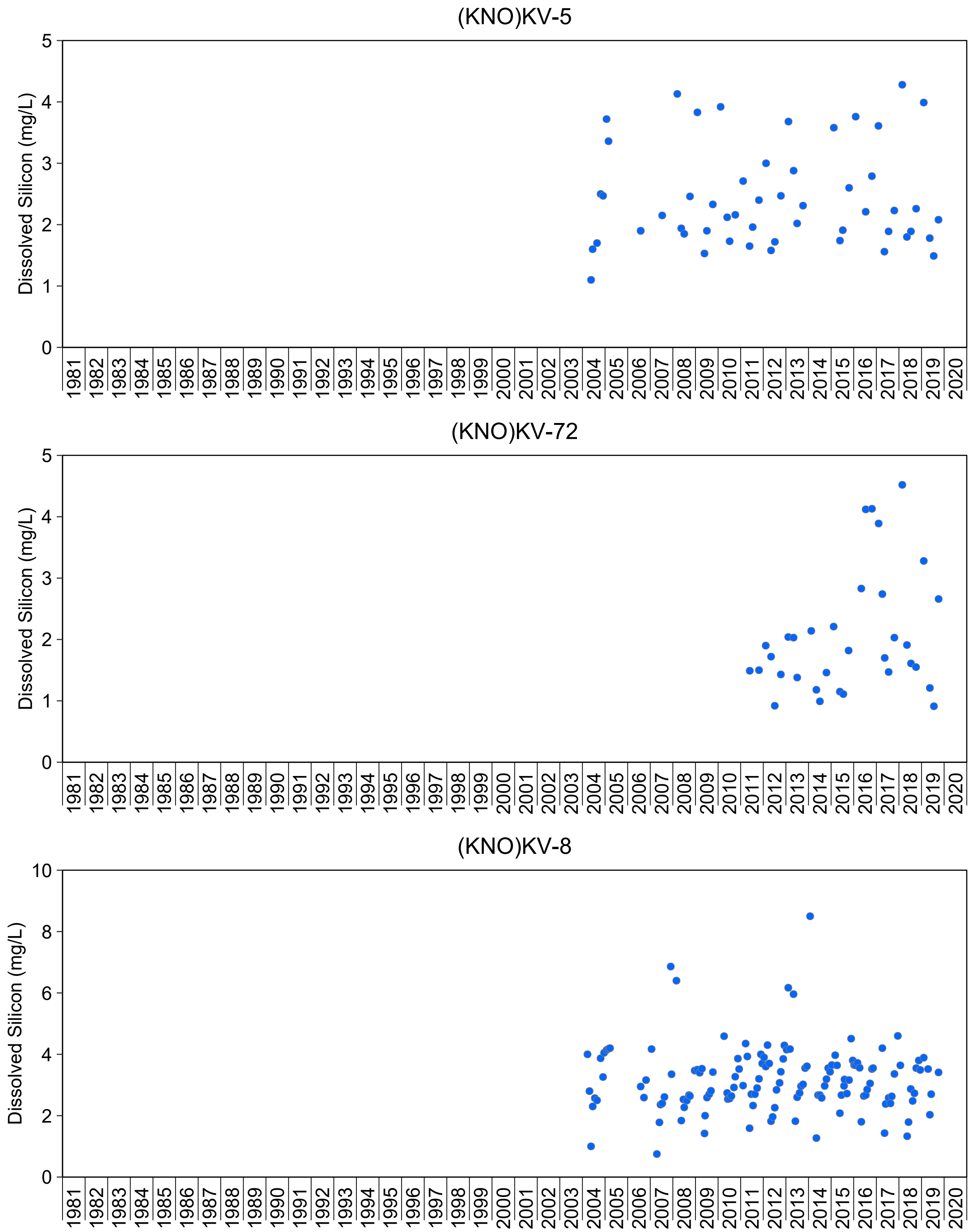


Figure A.70: Time Series Plots of Dissolved Silicon Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

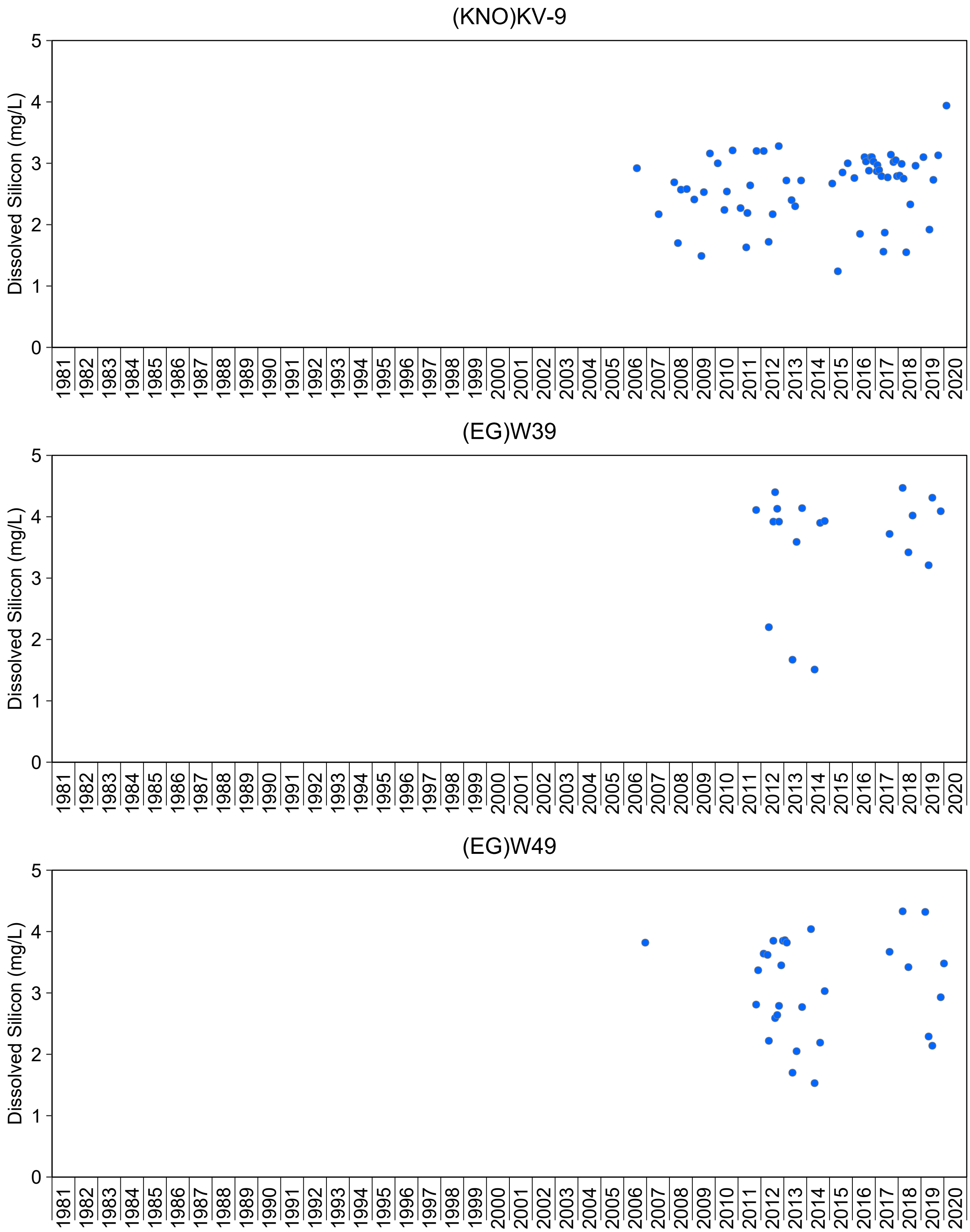


Figure A.70: **Time Series Plots of Dissolved Silicon Concentrations (mg/L) in the South McQuesten River, 1981 to 2020**

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

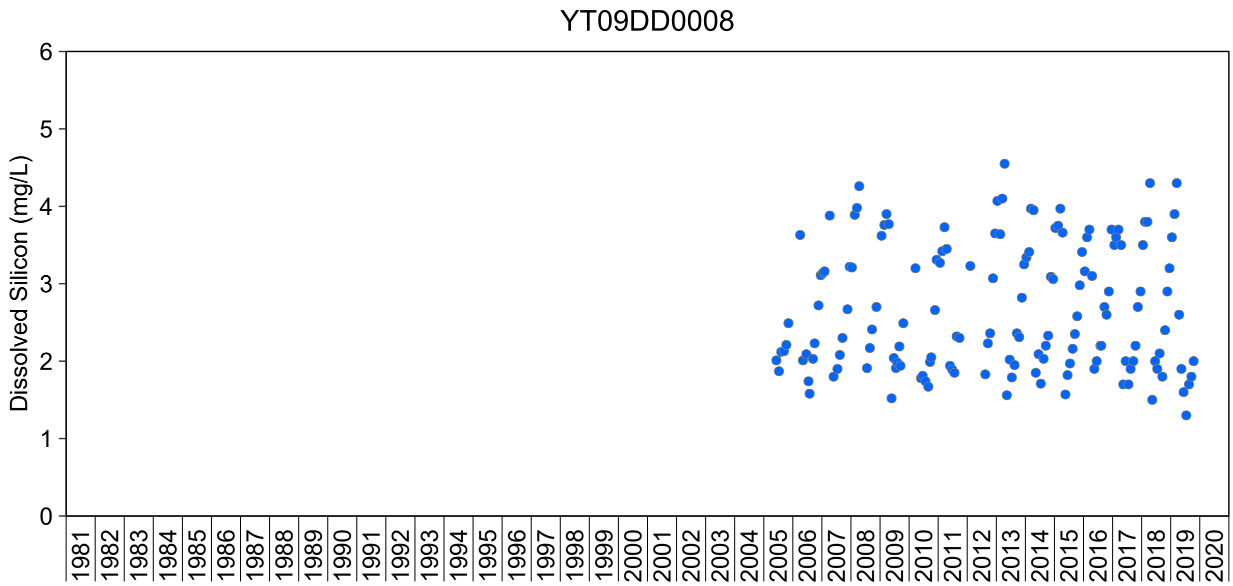


Figure A.70: Time Series Plots of Dissolved Silicon Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

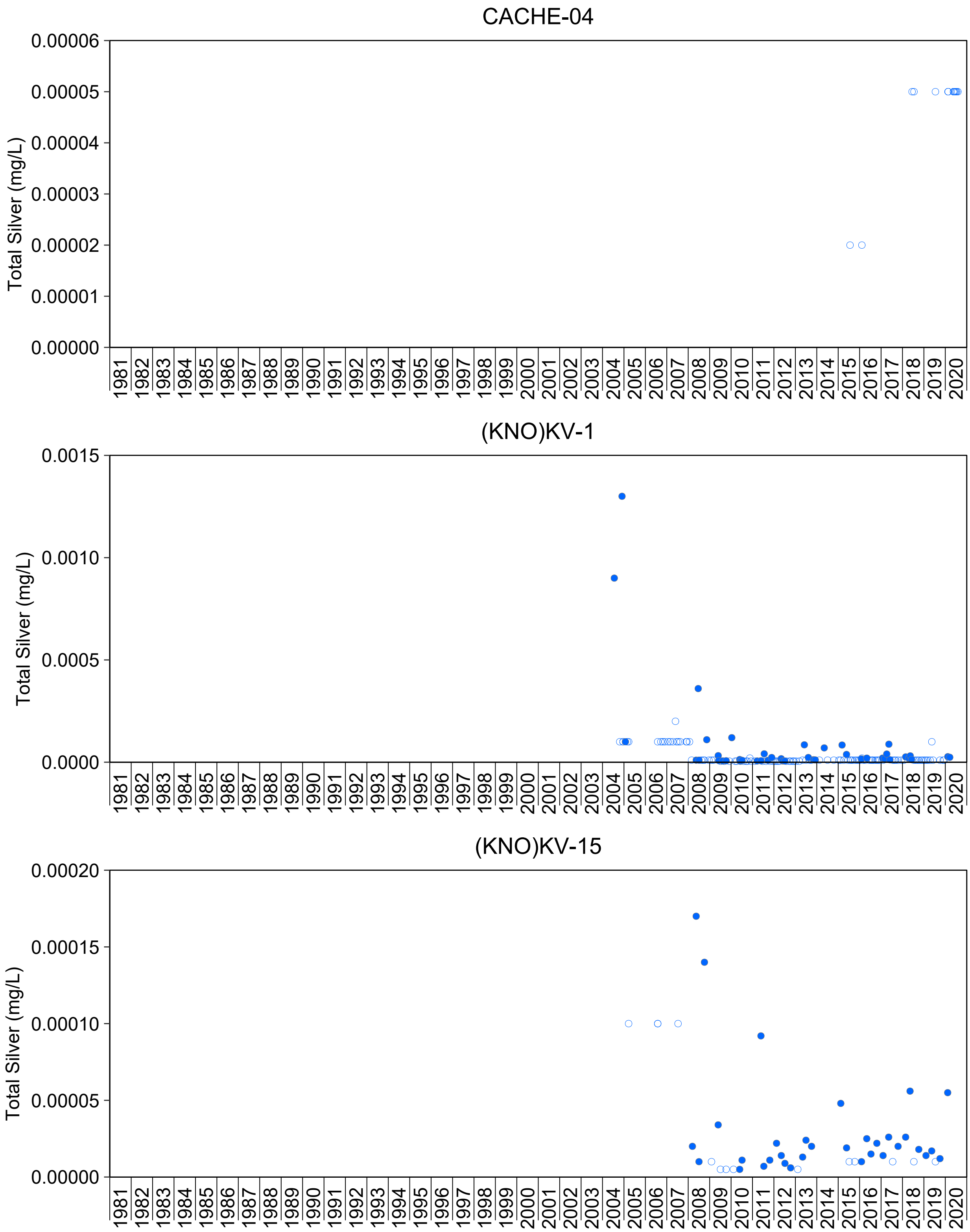


Figure A.71: Time Series Plots of Total Silver Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

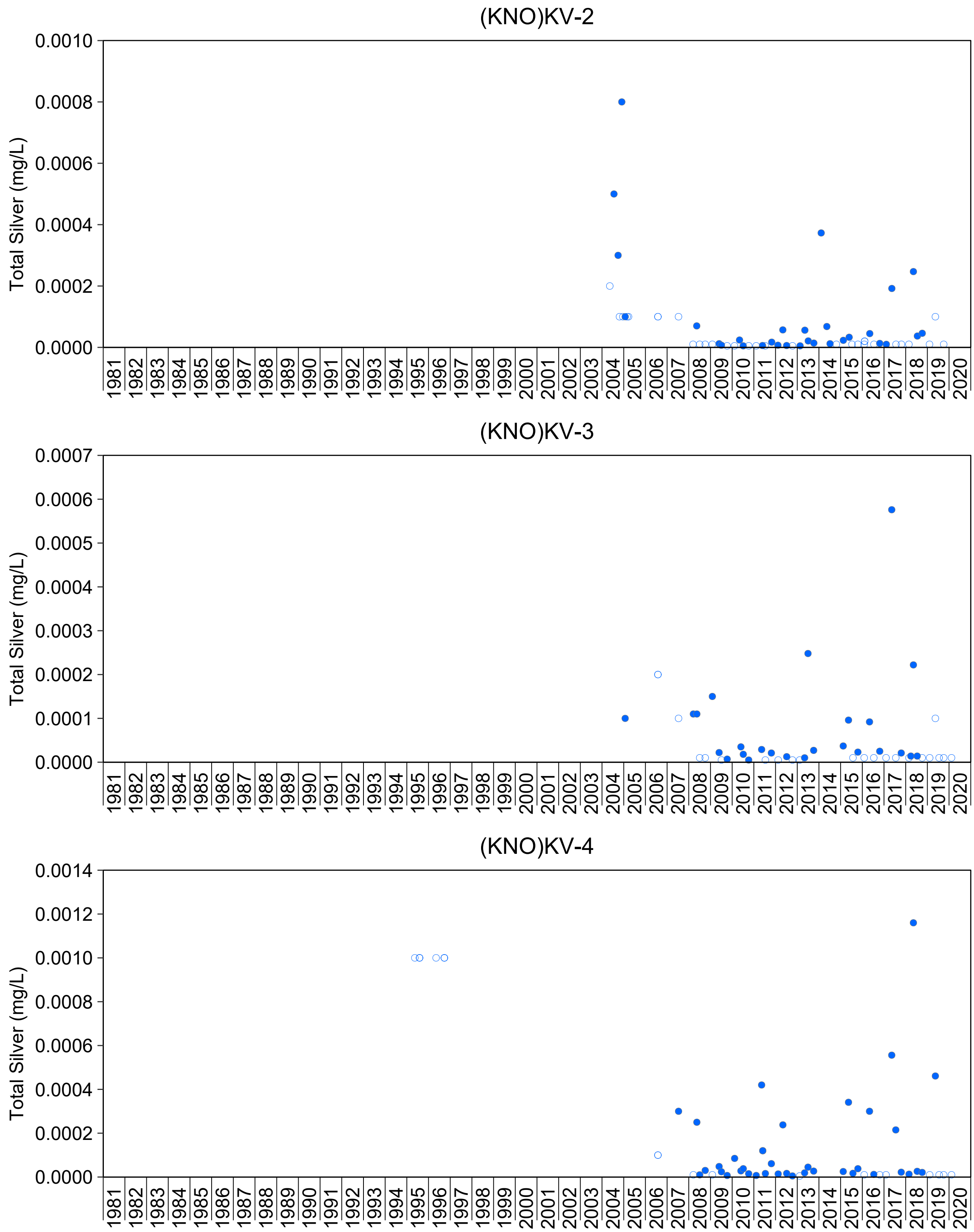


Figure A.71: Time Series Plots of Total Silver Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

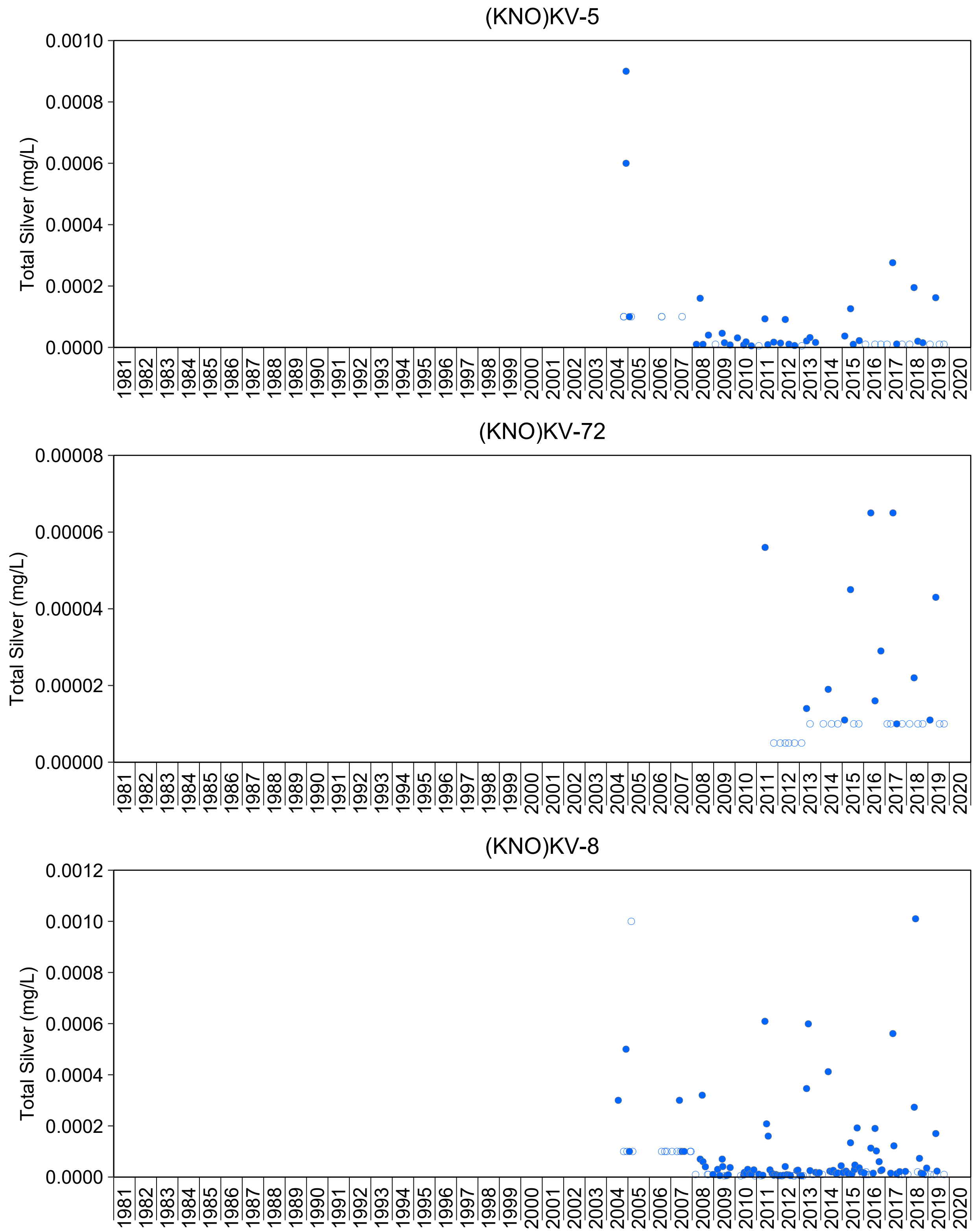


Figure A.69: Time Series Plots of Total Silver Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

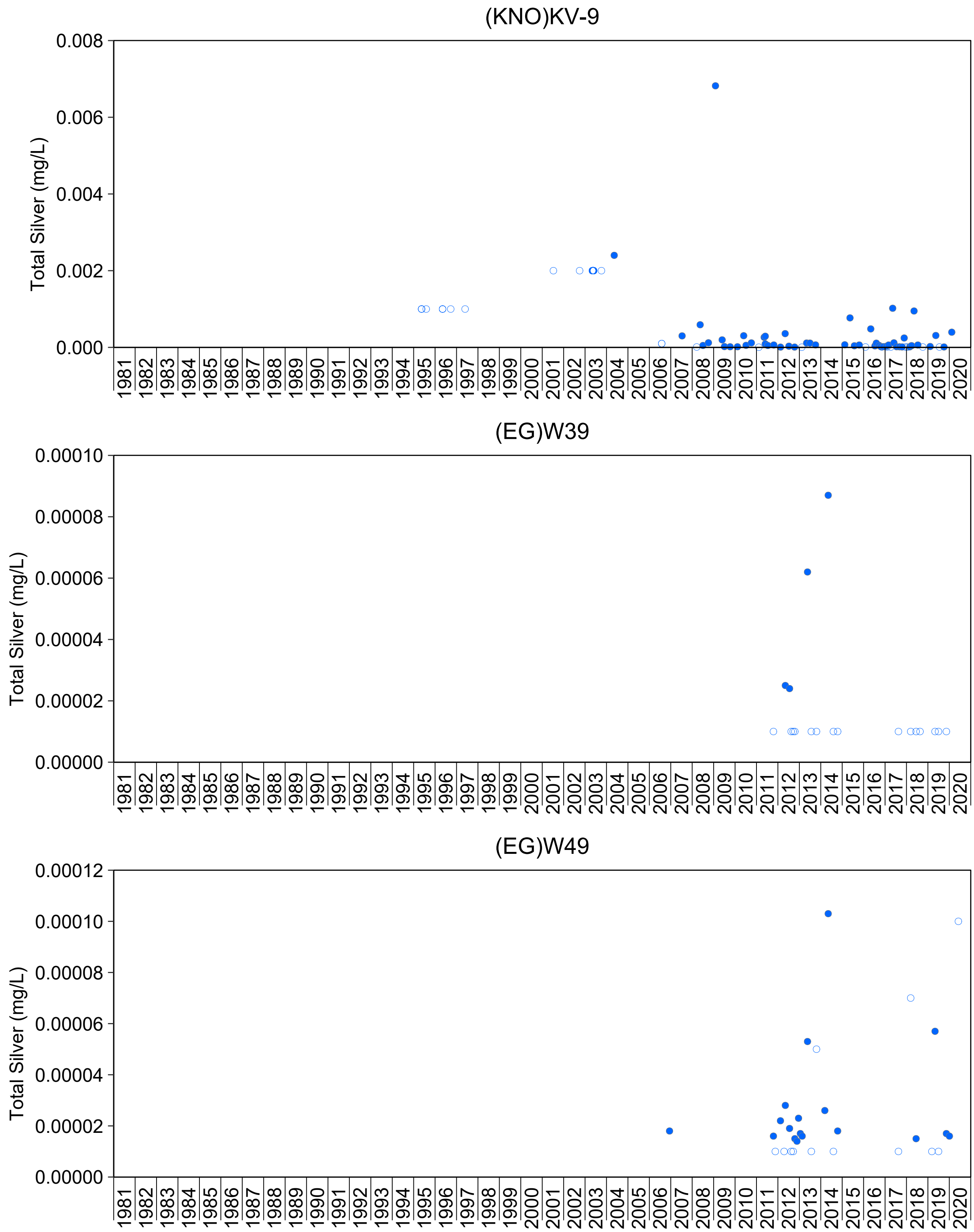


Figure A.71: Time Series Plots of Total Silver Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

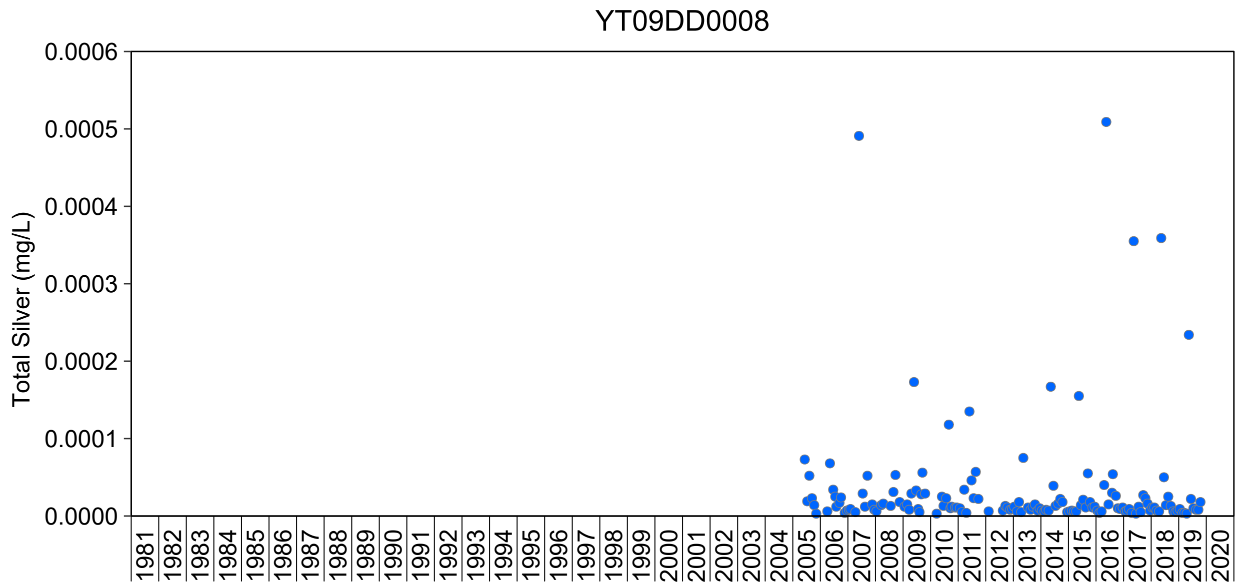


Figure A.71: Time Series Plots of Total Silver Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

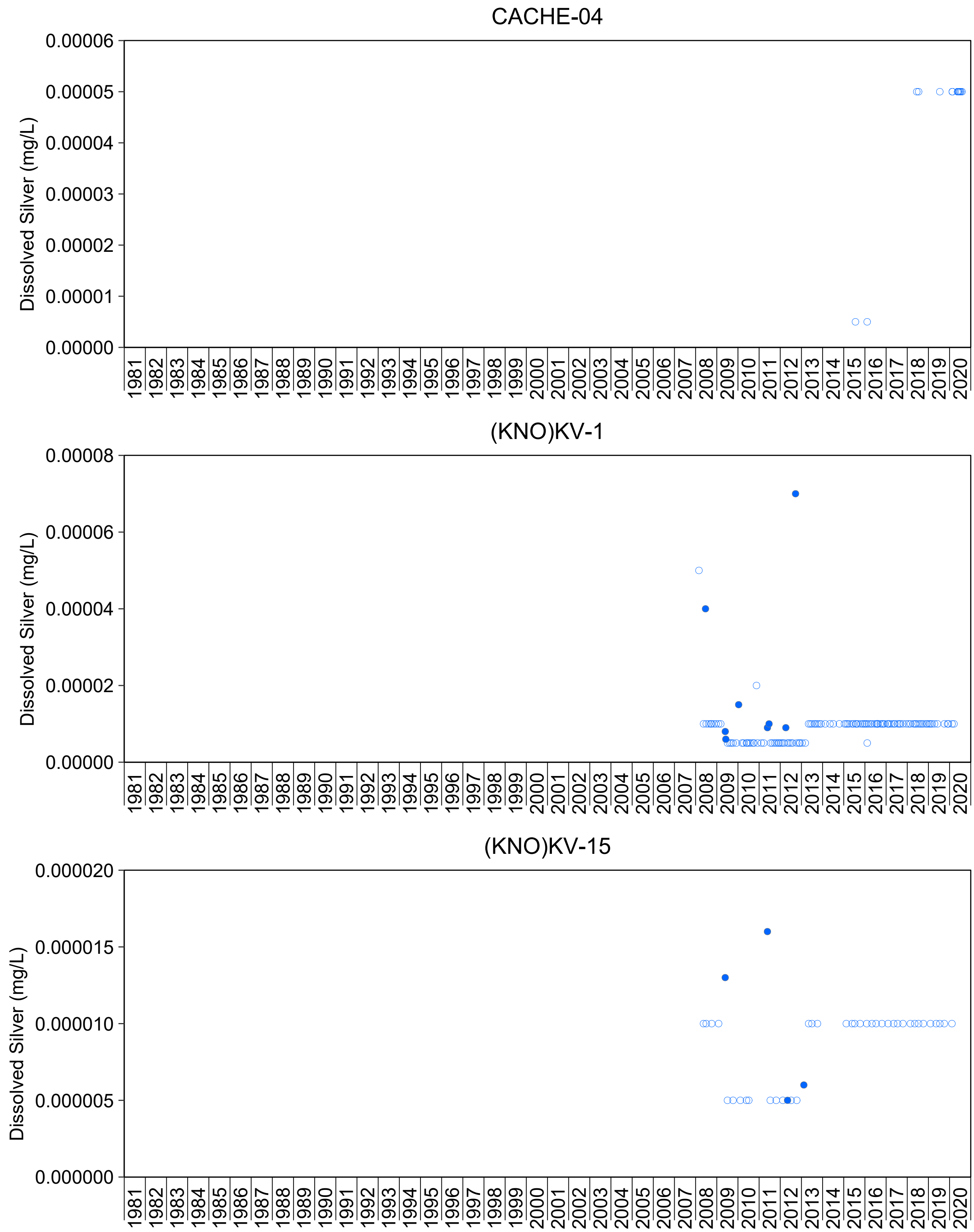


Figure A.72: Time Series Plots of Dissolved Silver Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

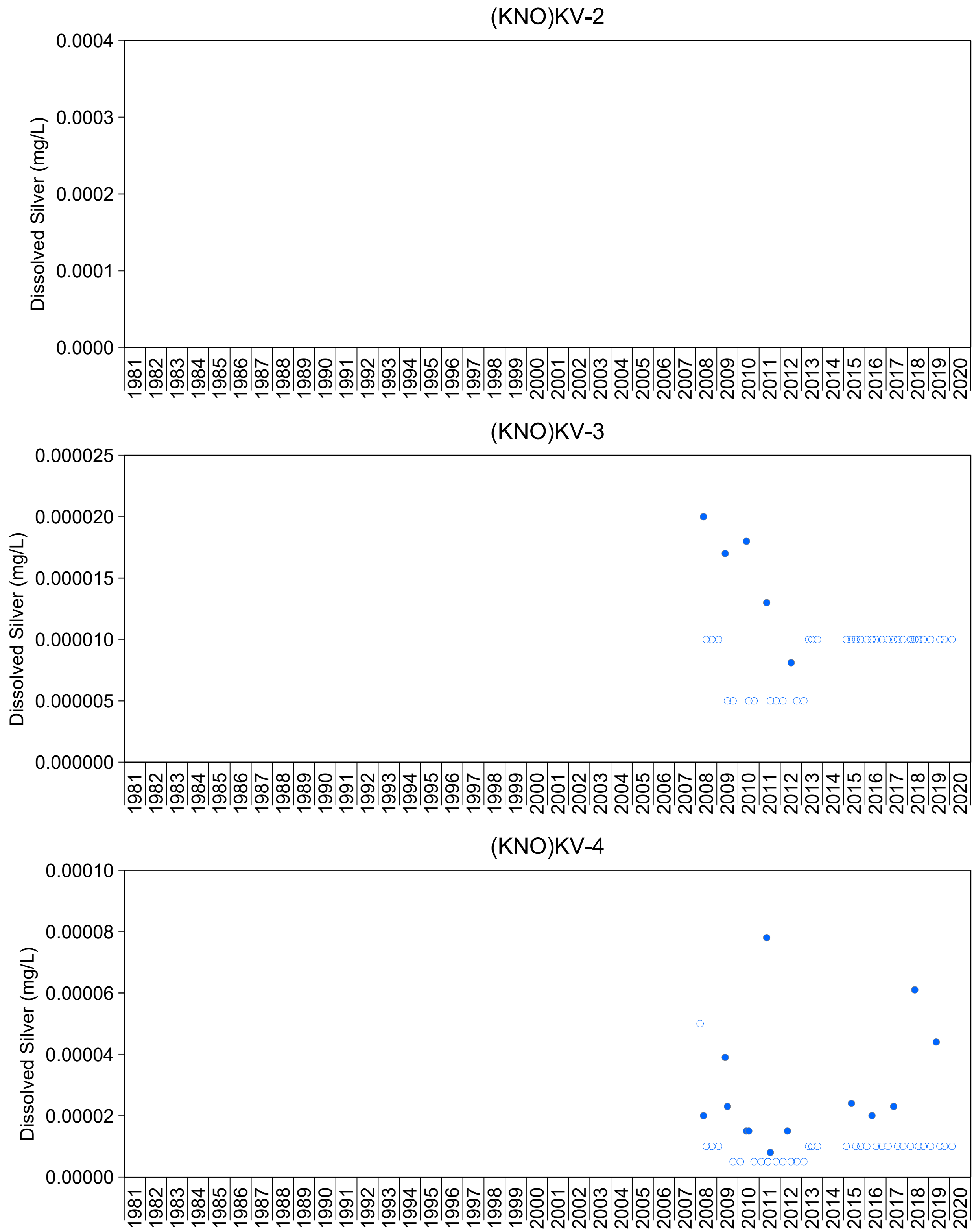


Figure A.72: Time Series Plots of Dissolved Silver Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

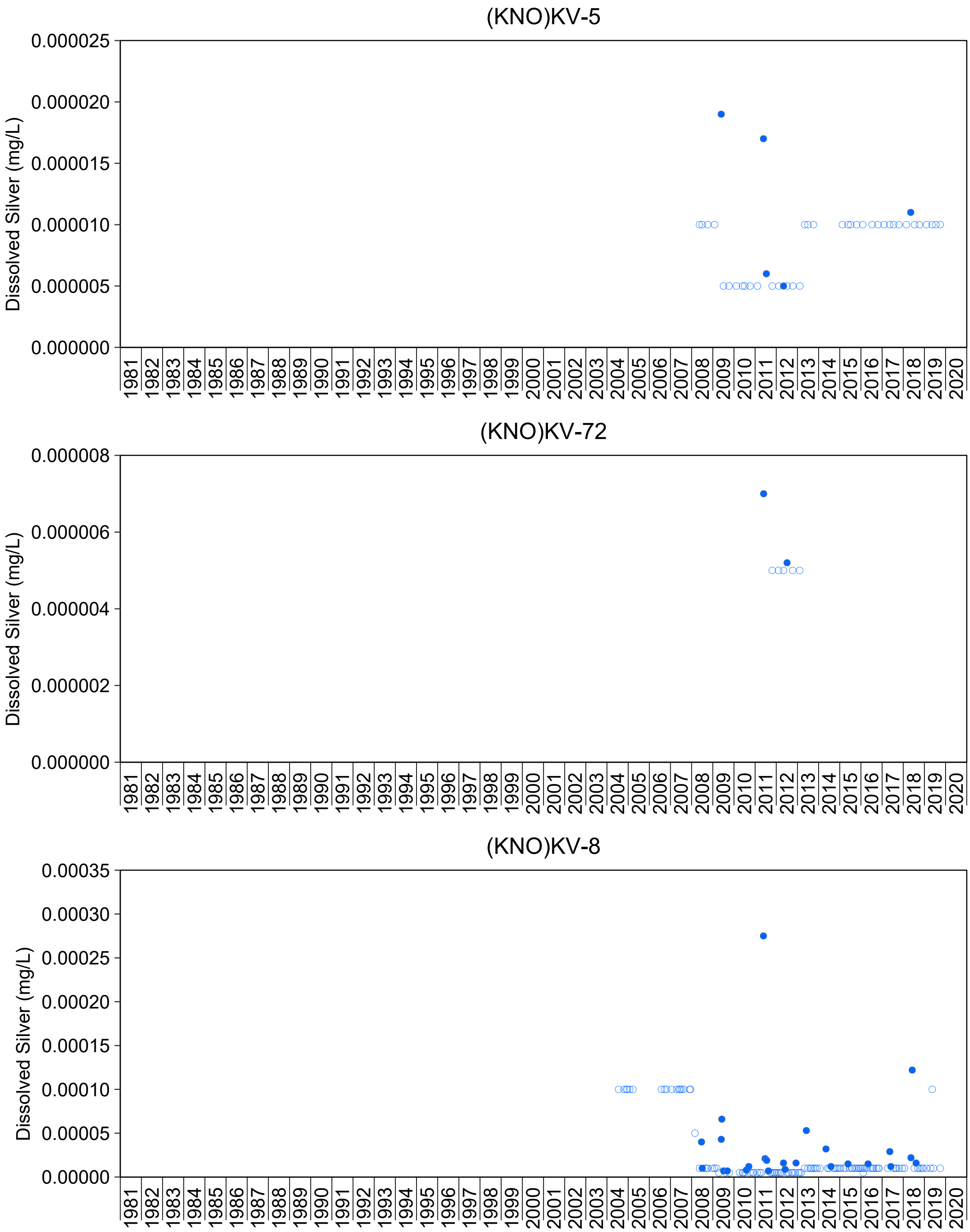


Figure A.72: Time Series Plots of Dissolved Silver Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

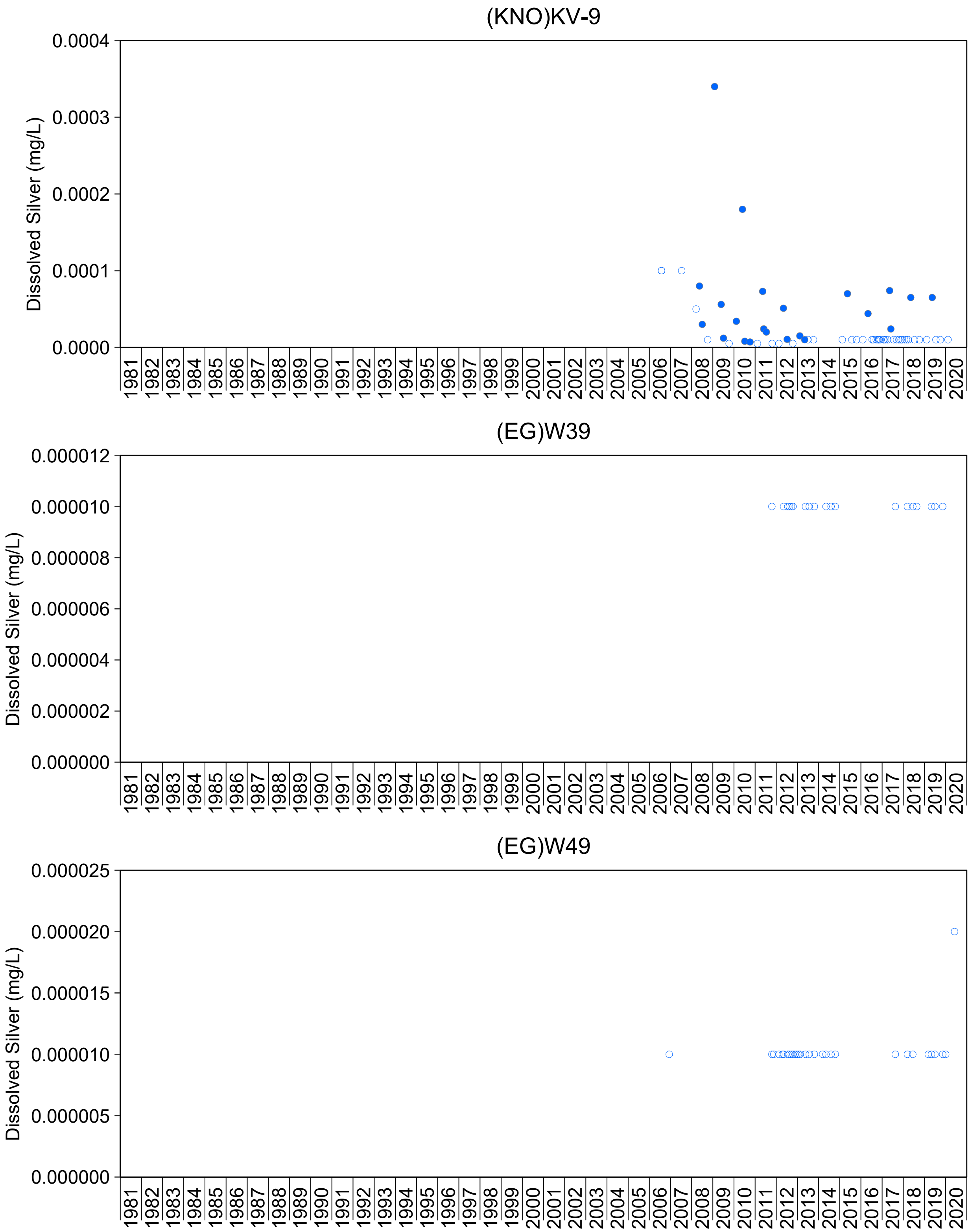


Figure A.72: Time Series Plots of Dissolved Silver Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

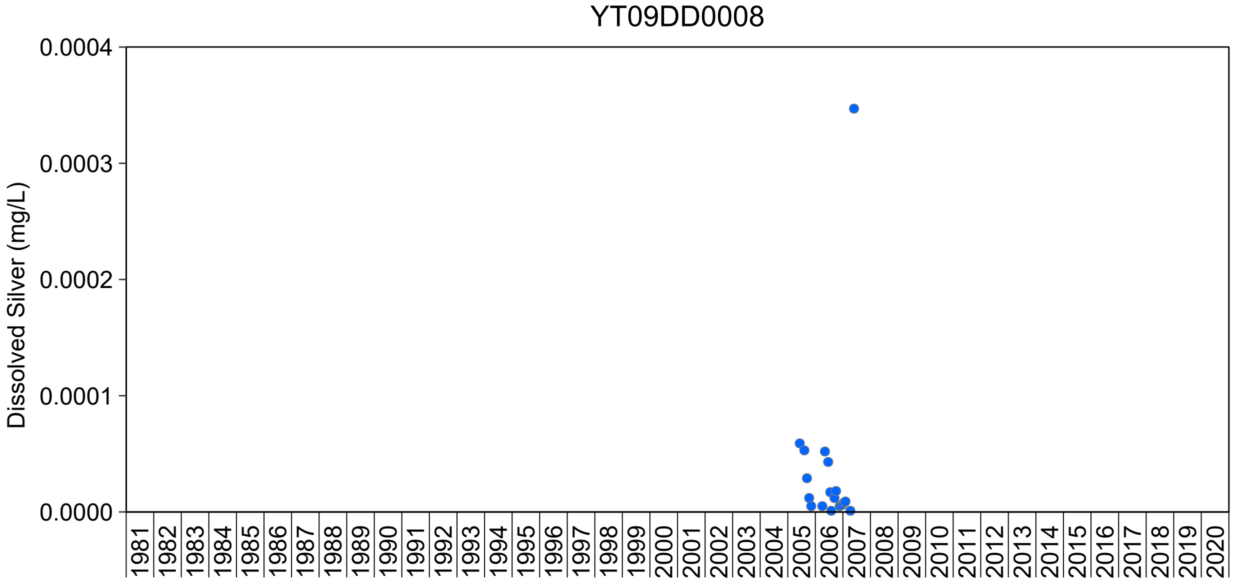


Figure A.72: Time Series Plots of Dissolved Silver Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

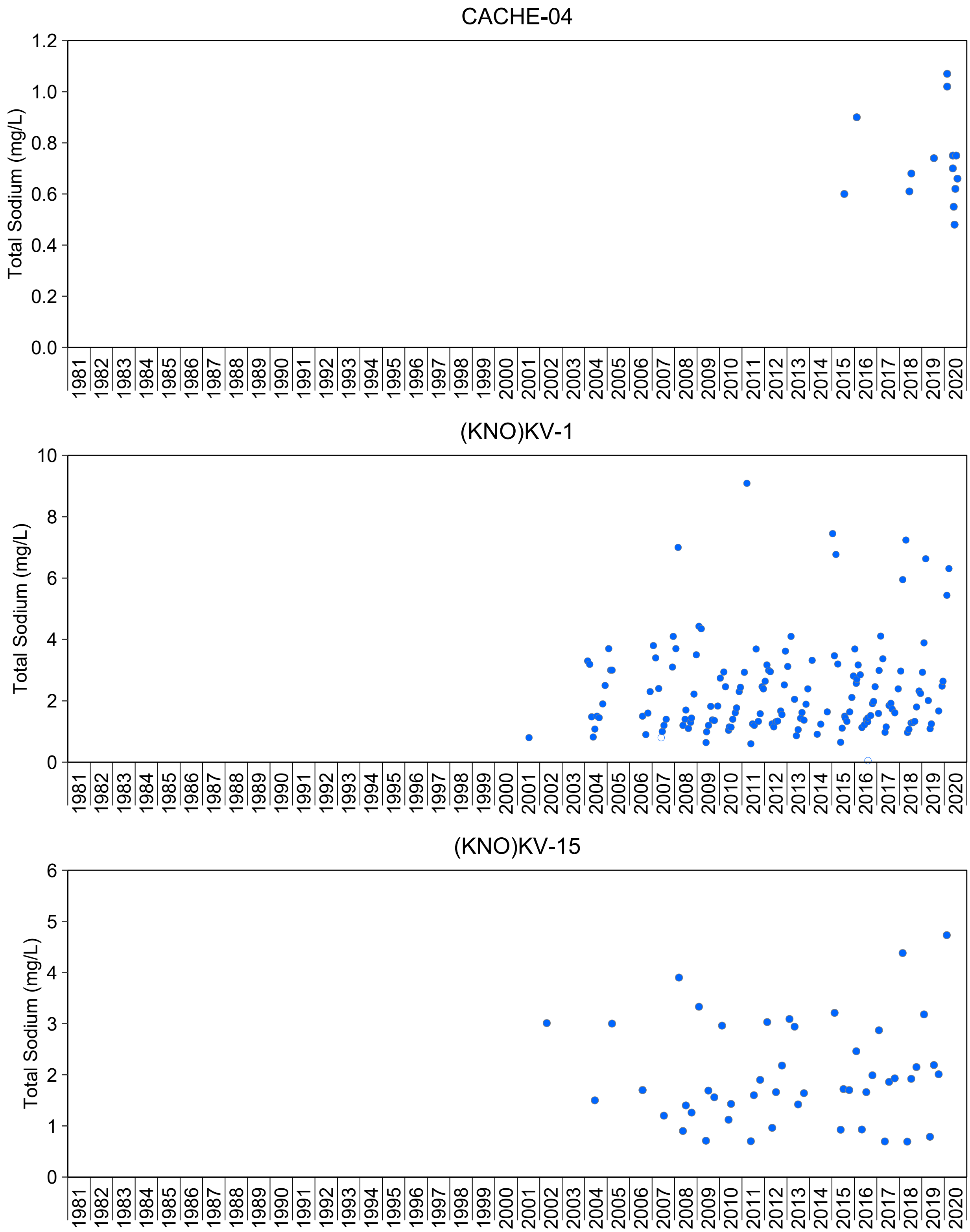


Figure A.73: Time Series Plots of Total Sodium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

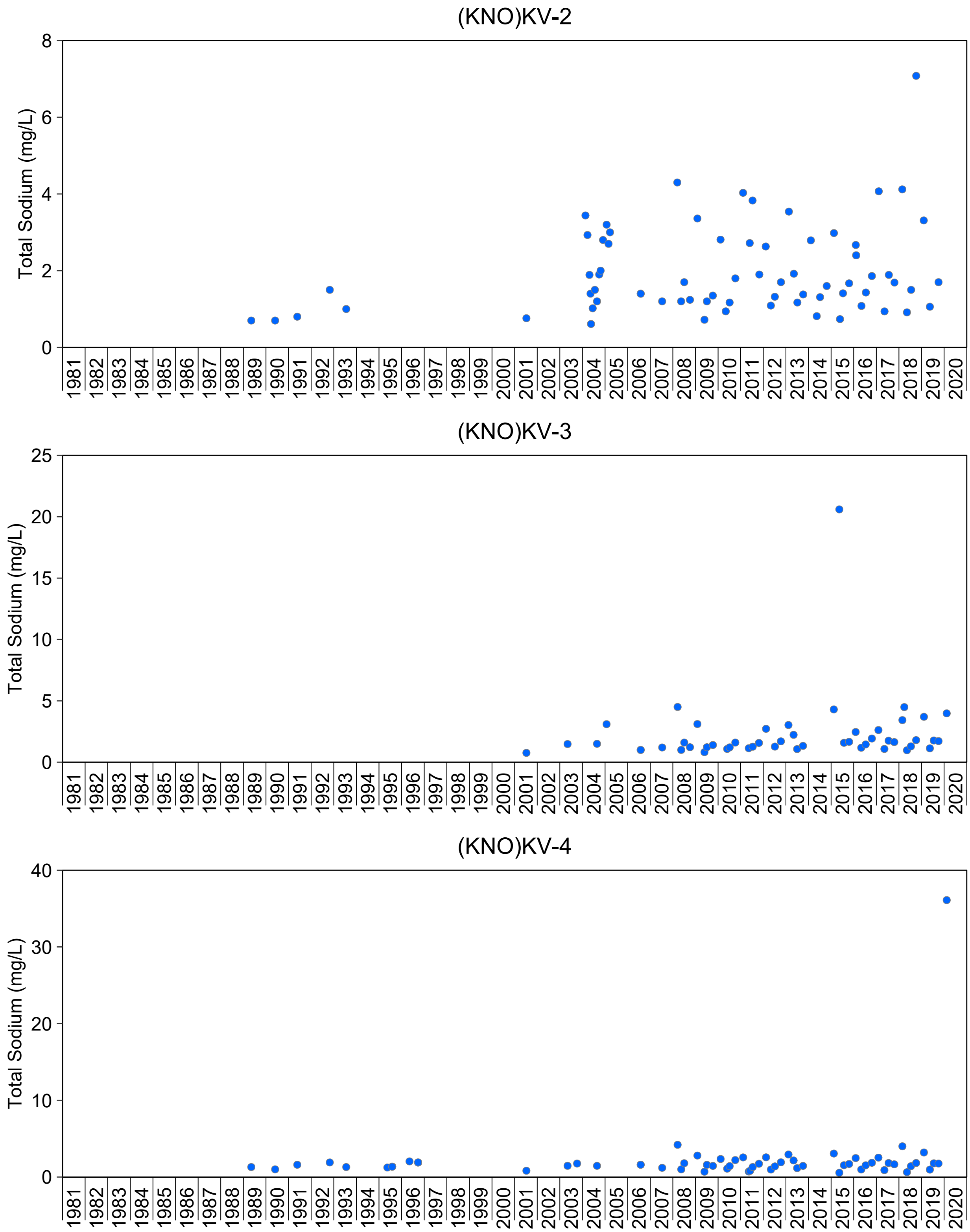


Figure A.73: Time Series Plots of Total Sodium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

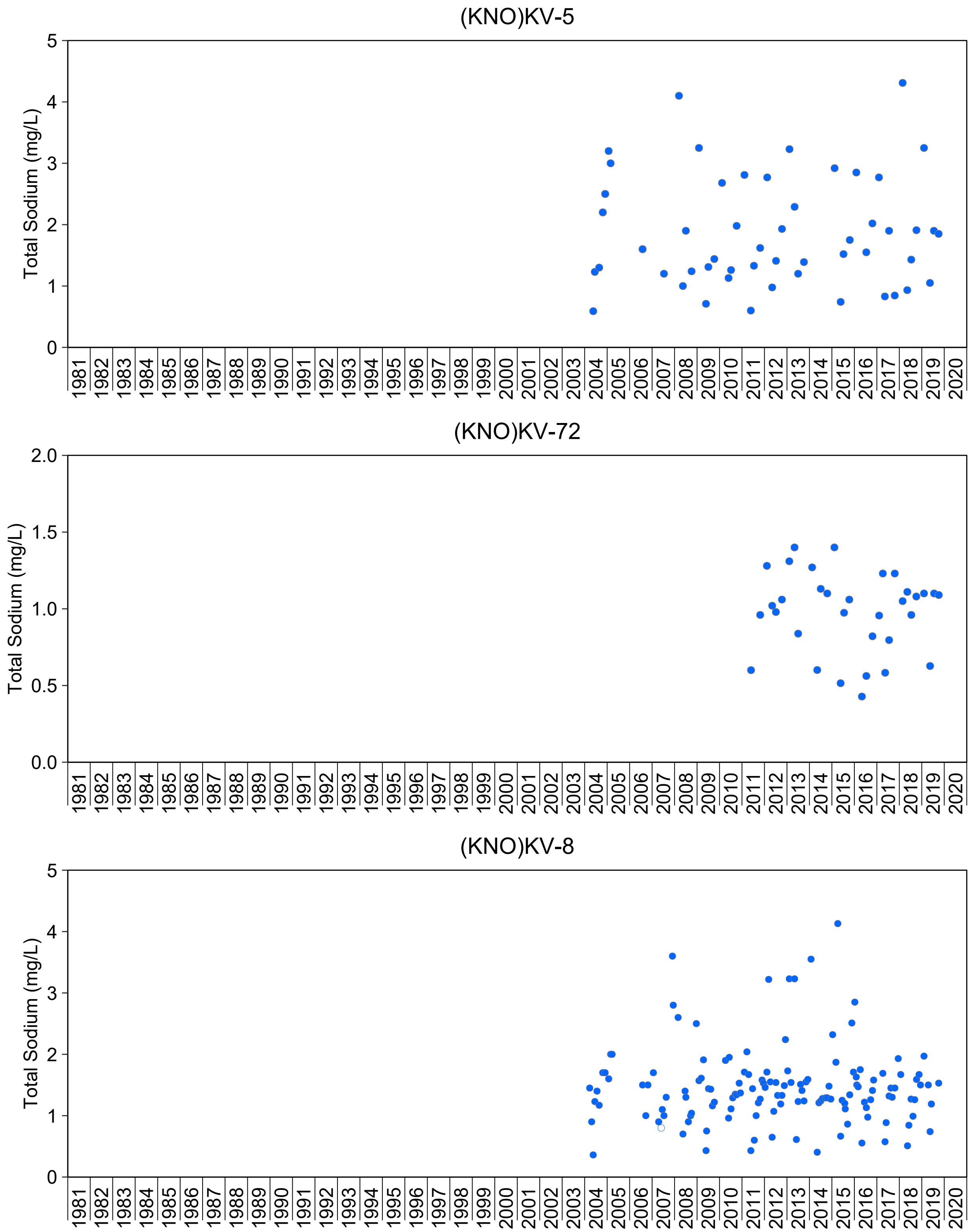


Figure A.73: Time Series Plots of Total Sodium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

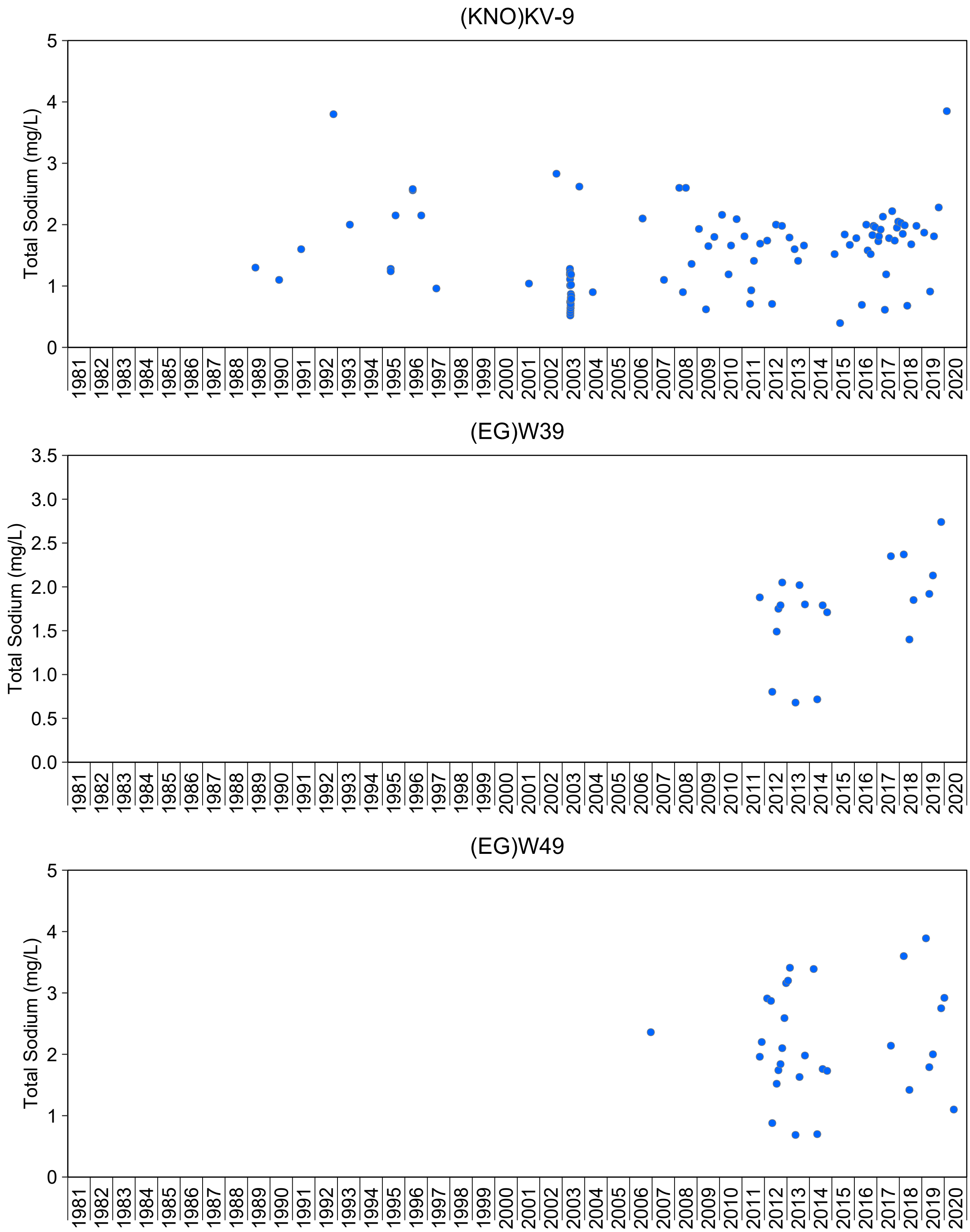


Figure A.73: Time Series Plots of Total Sodium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

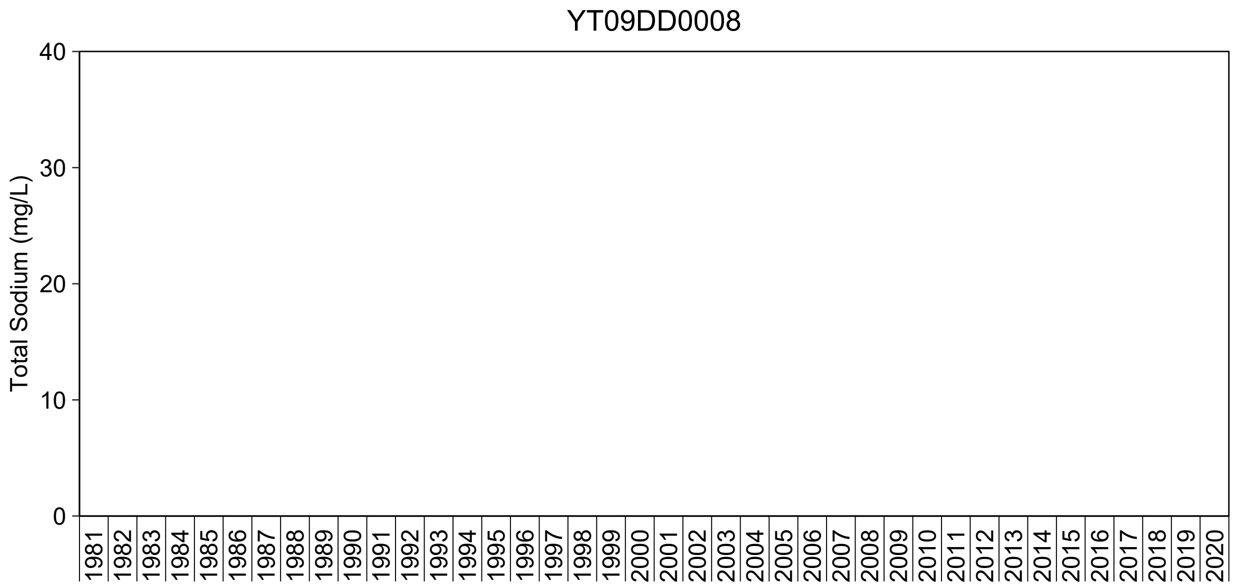


Figure A.73: Time Series Plots of Total Sodium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

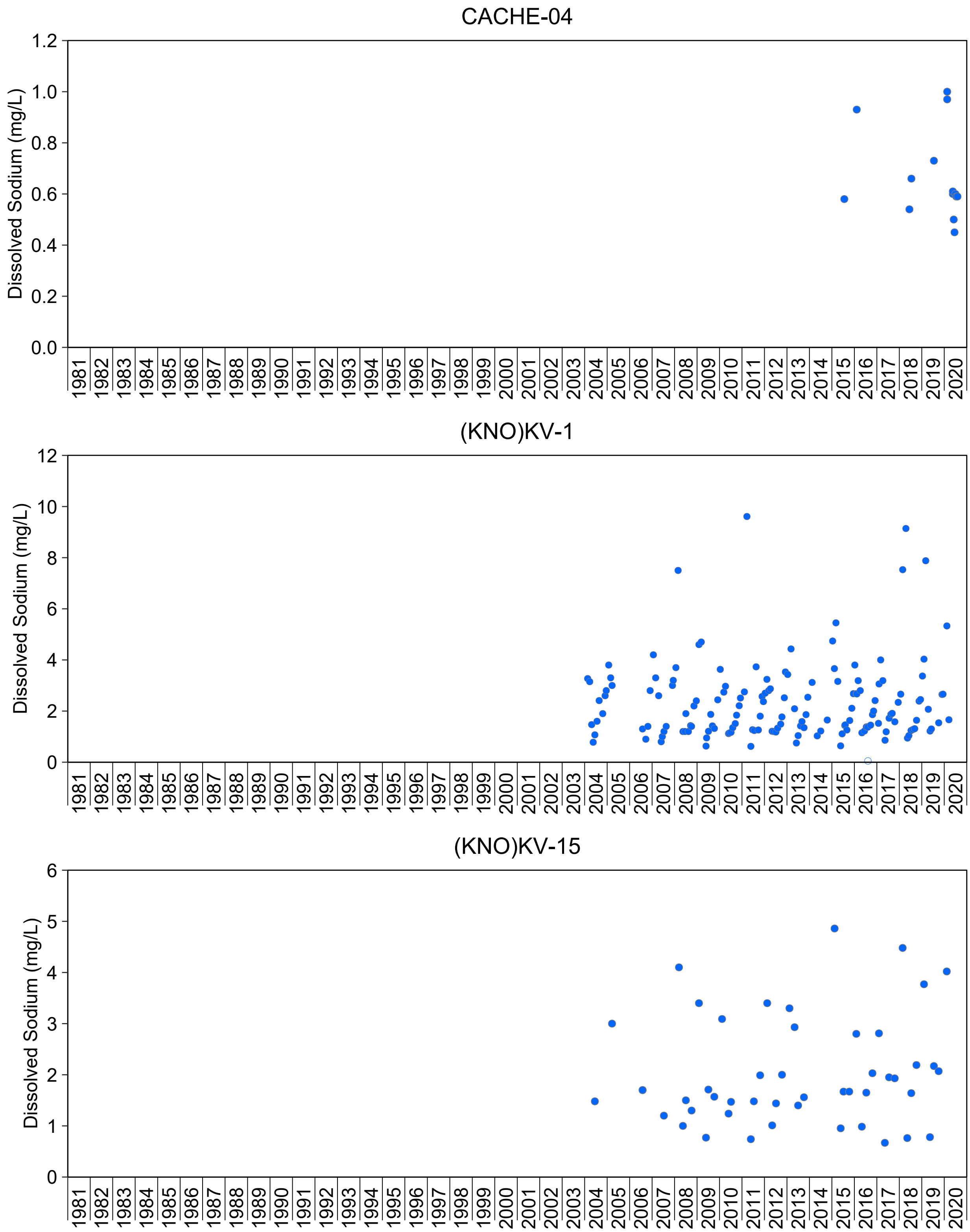


Figure A.74: Time Series Plots of Dissolved Sodium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

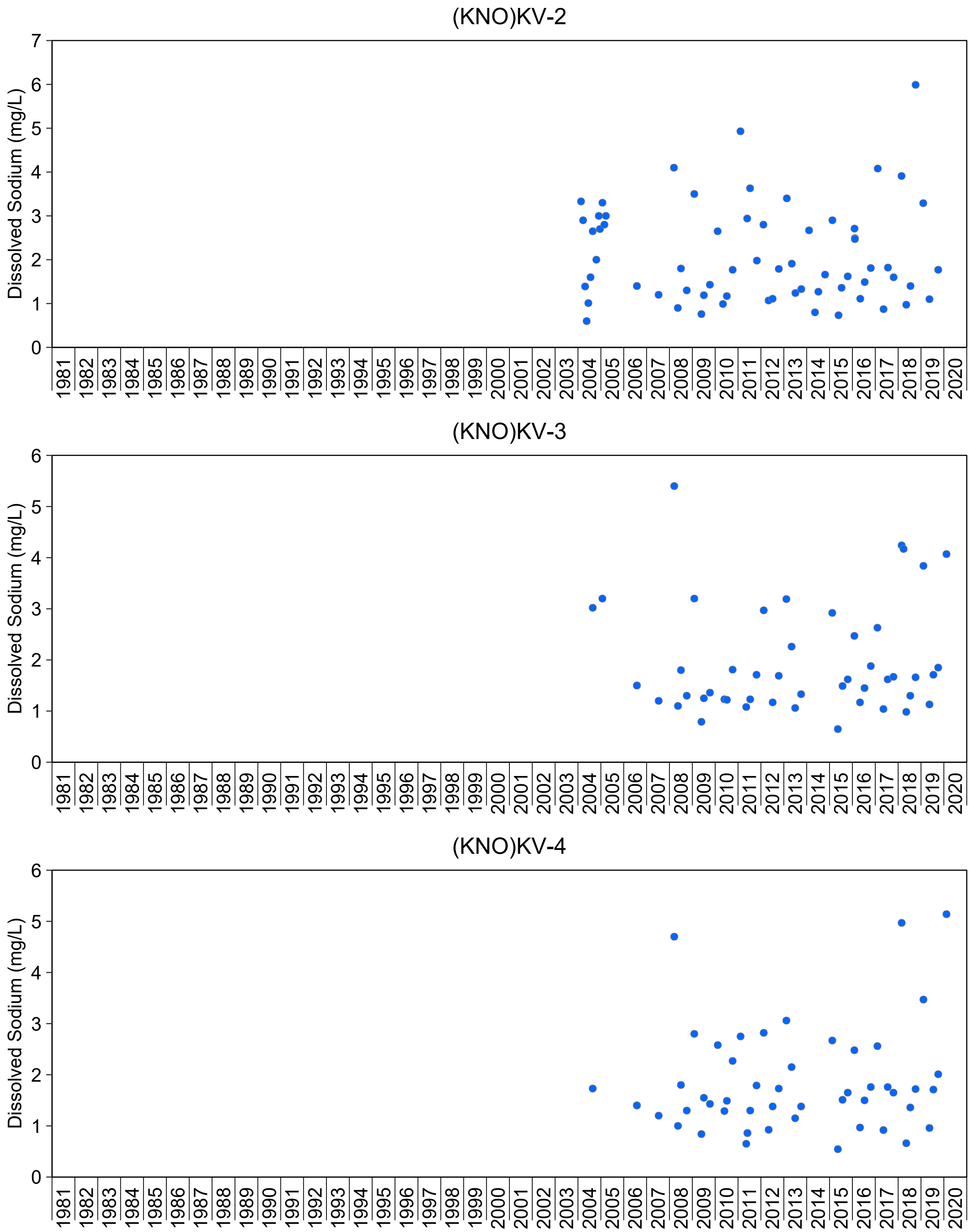


Figure A.74: Time Series Plots of Dissolved Sodium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

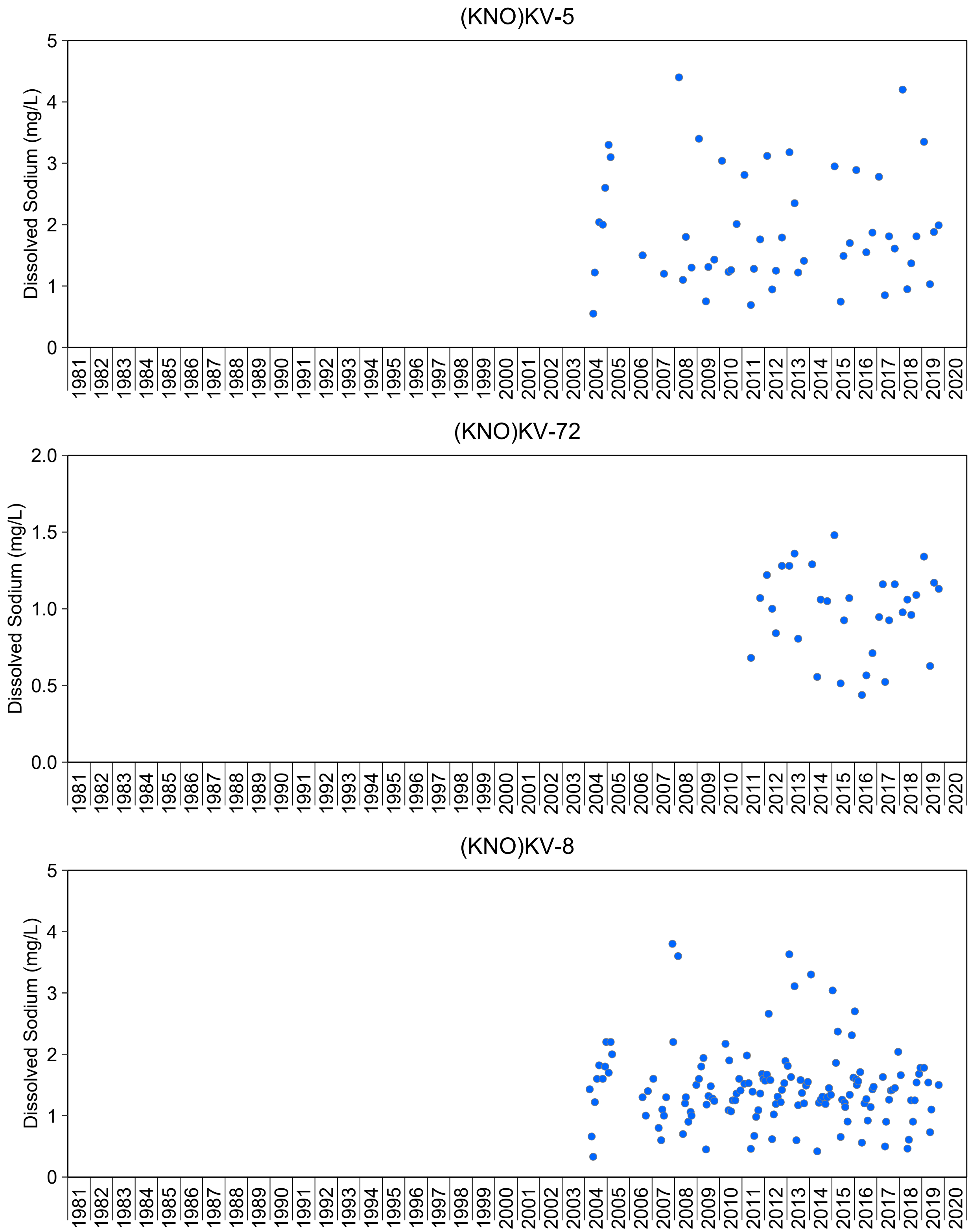


Figure A.74: Time Series Plots of Dissolved Sodium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

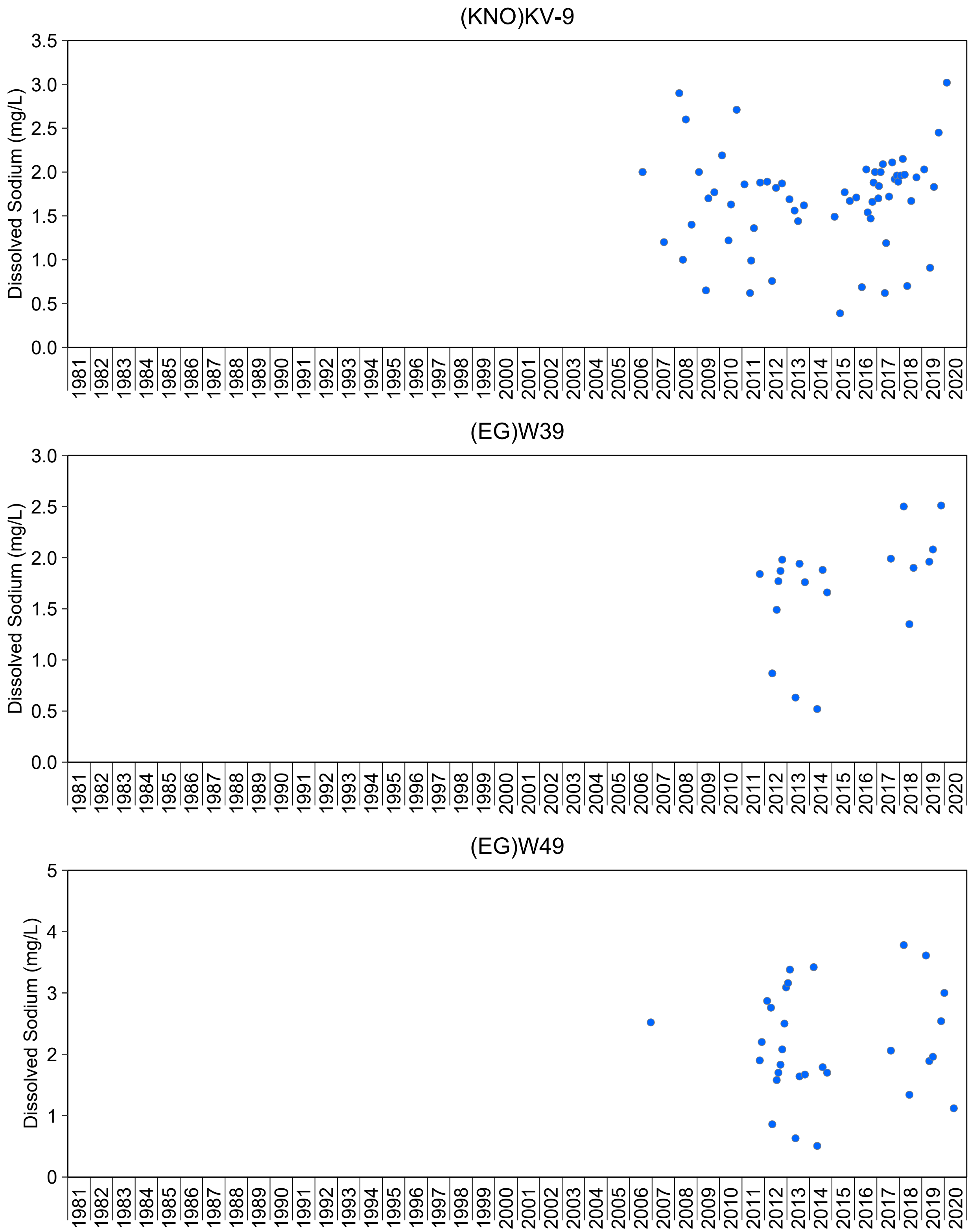


Figure A.74: Time Series Plots of Dissolved Sodium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

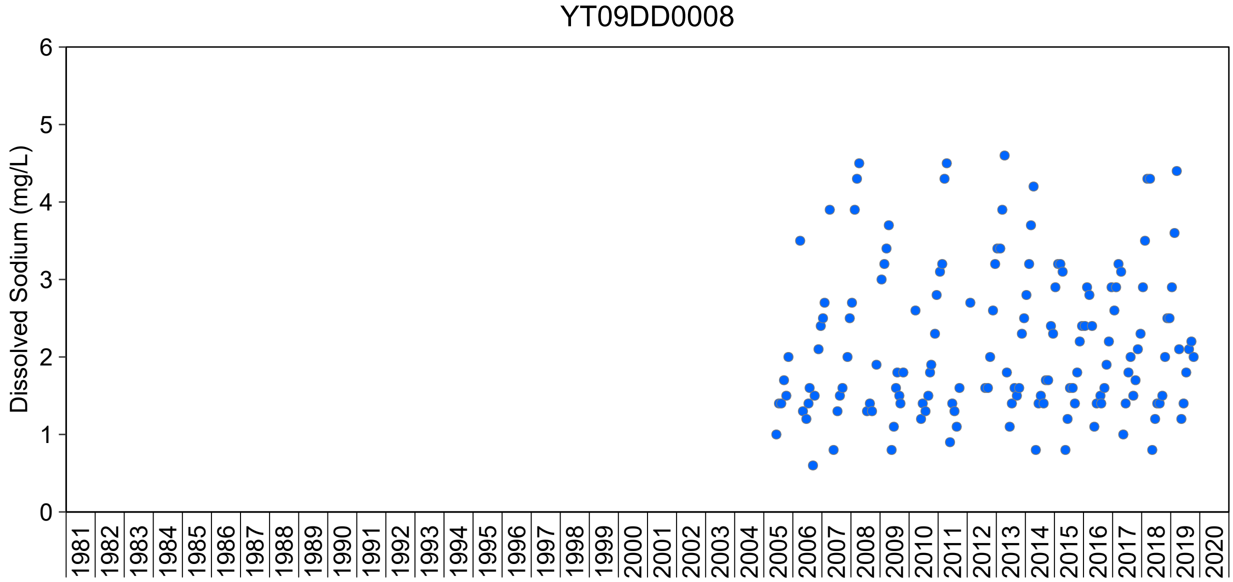
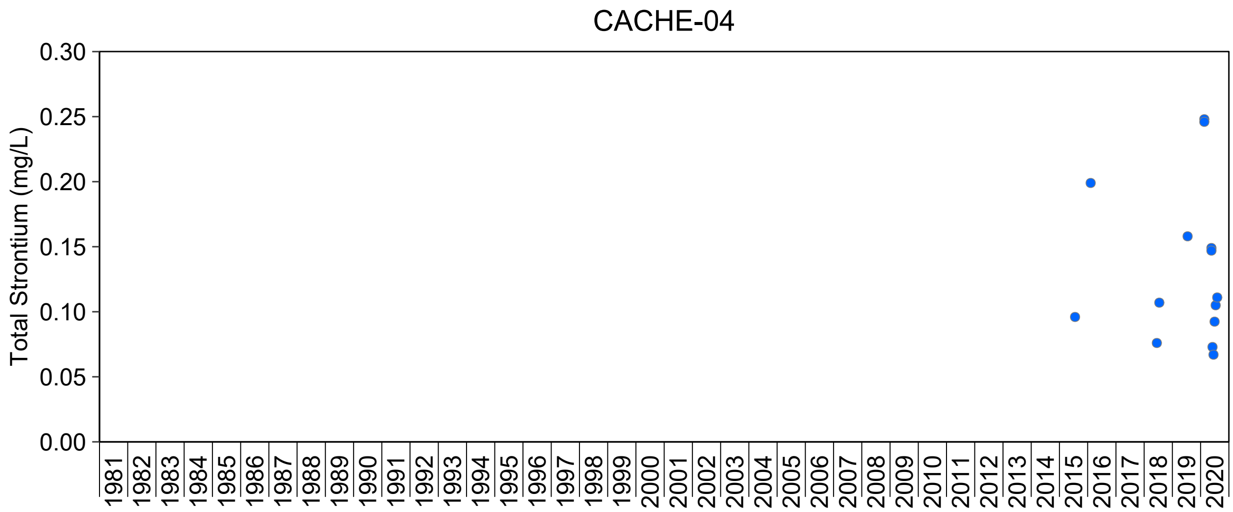
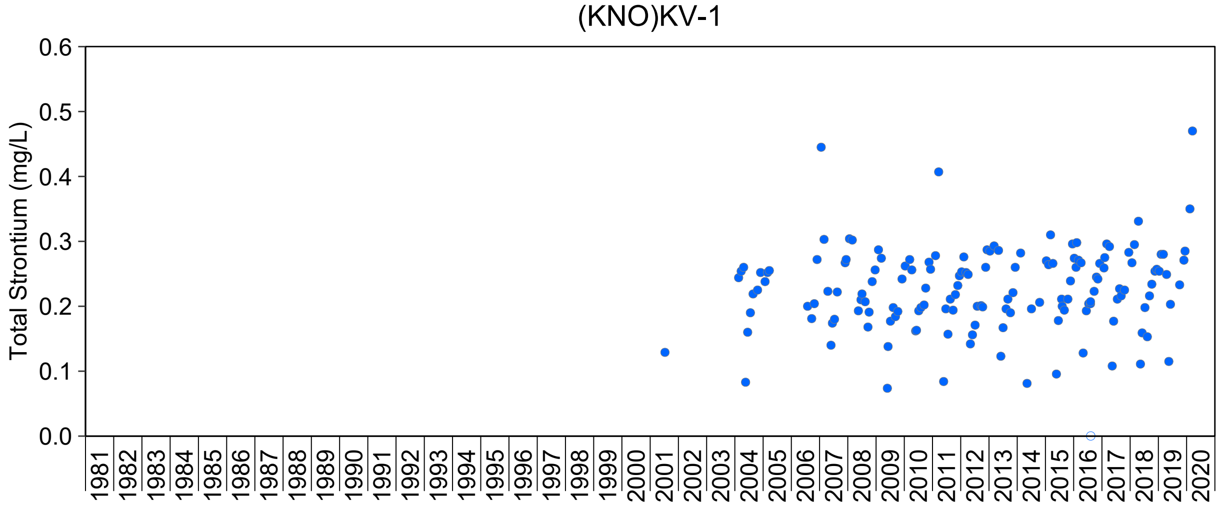


Figure A.74: Time Series Plots of Dissolved Sodium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.





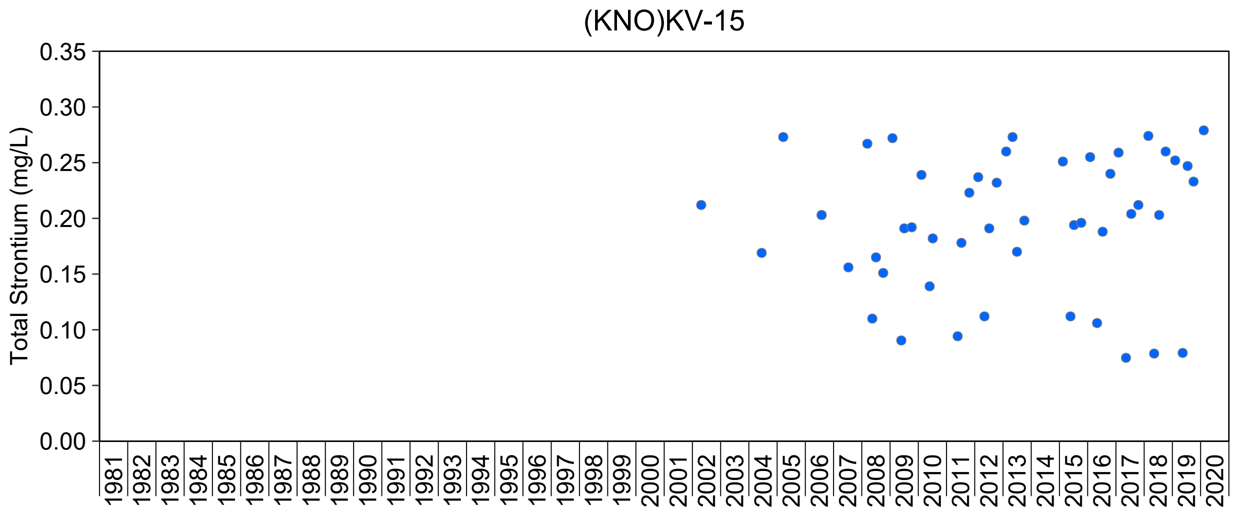


Figure A.75: Time Series Plots of Total Strontium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

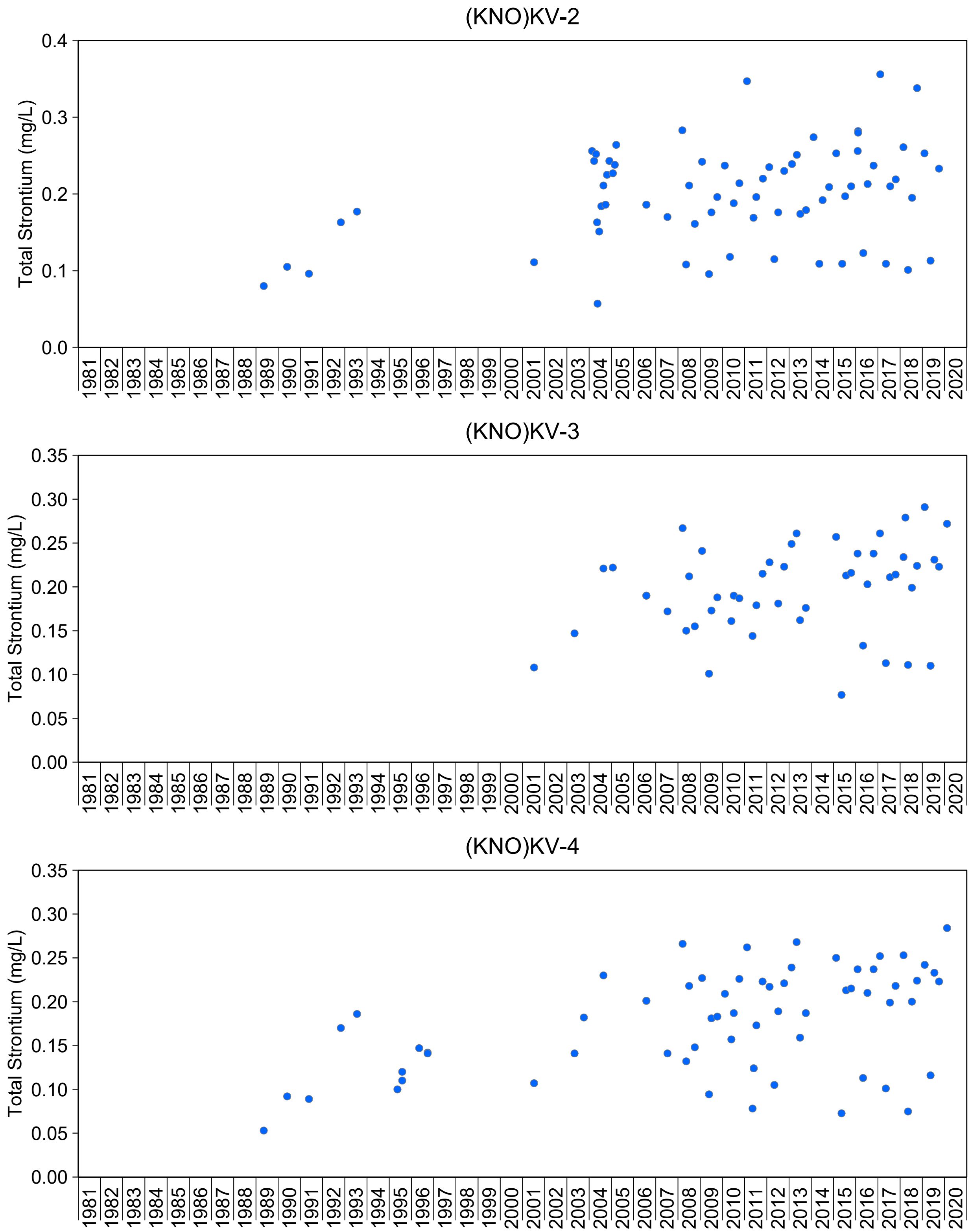


Figure A.75: Time Series Plots of Total Strontium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

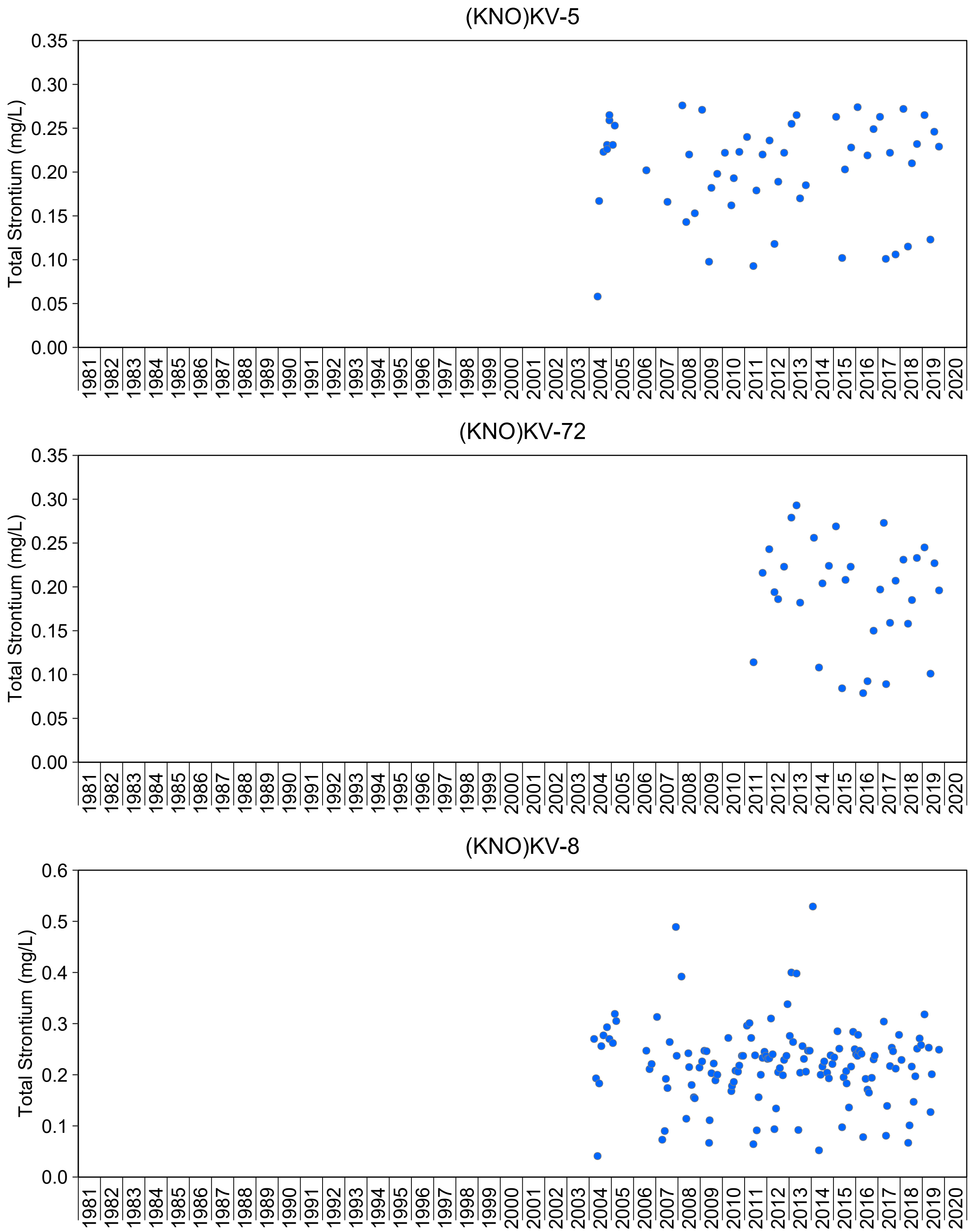


Figure A.75: Time Series Plots of Total Strontium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

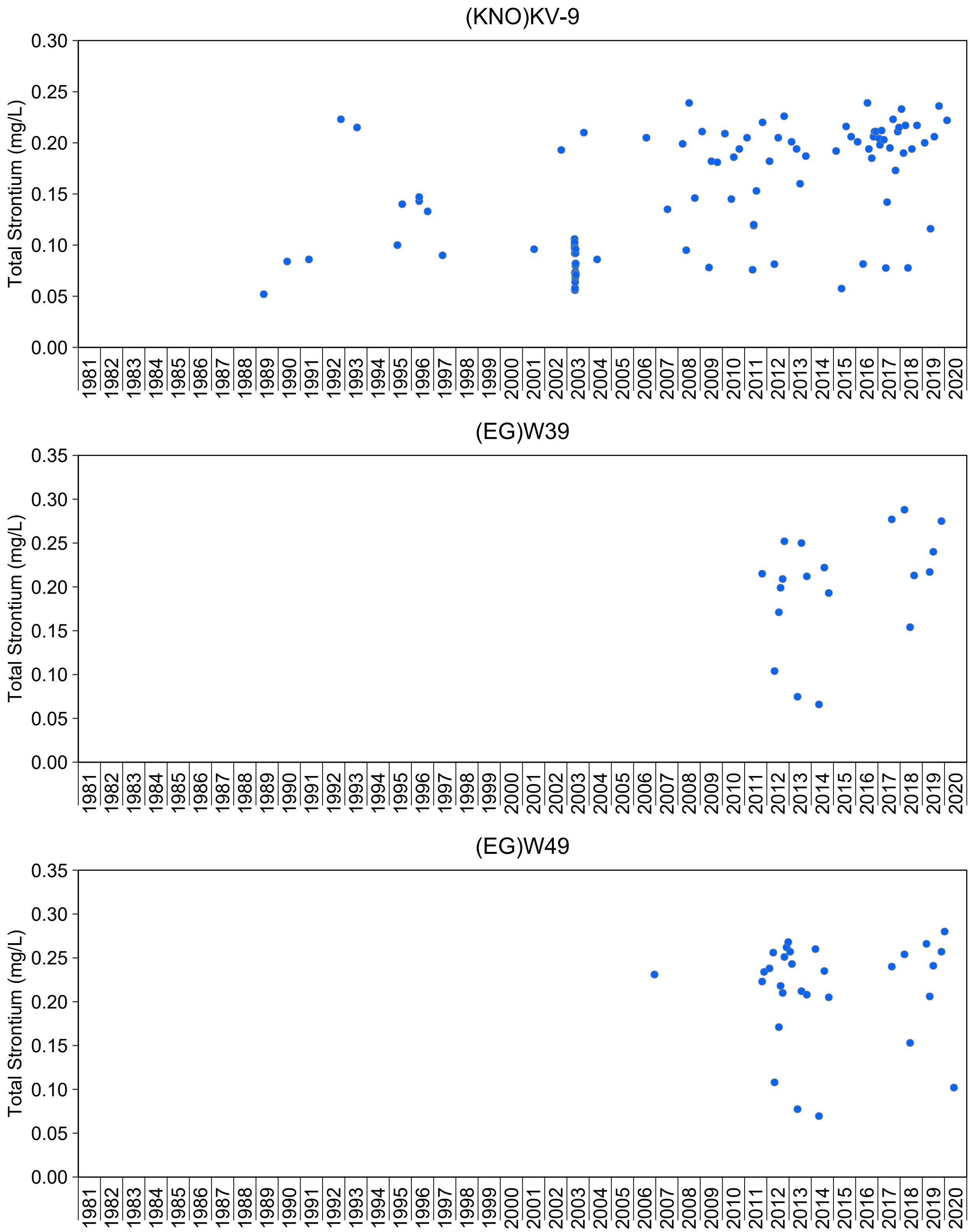


Figure A.75: Time Series Plots of Total Strontium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

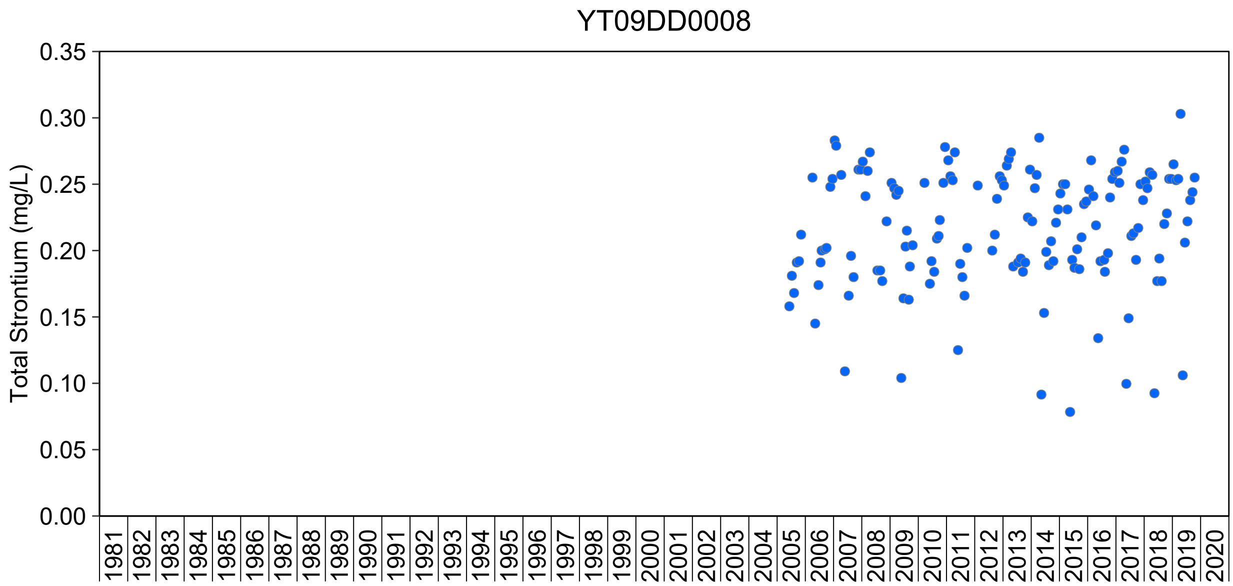


Figure A.75: Time Series Plots of Total Strontium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

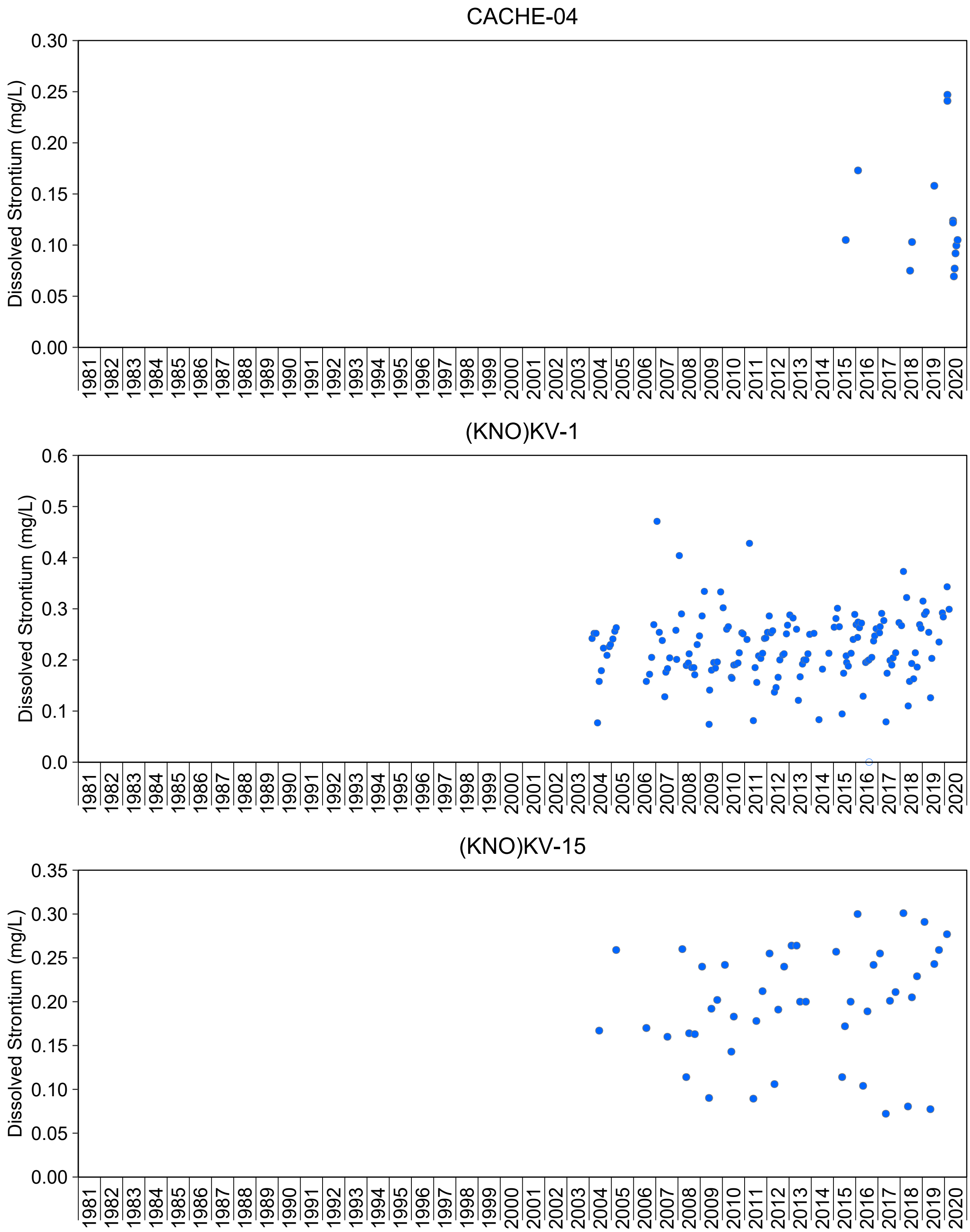
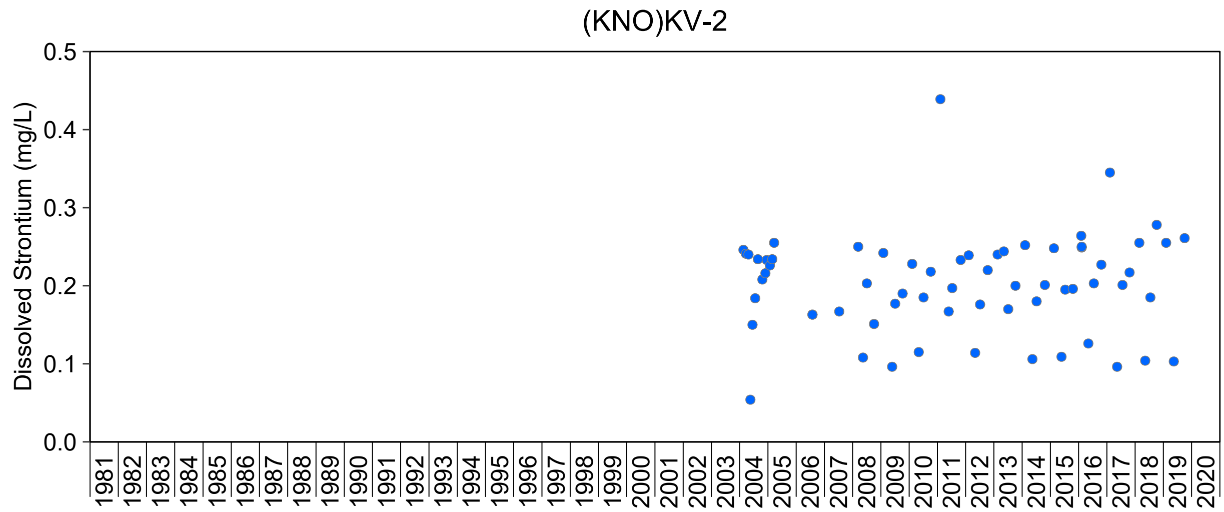
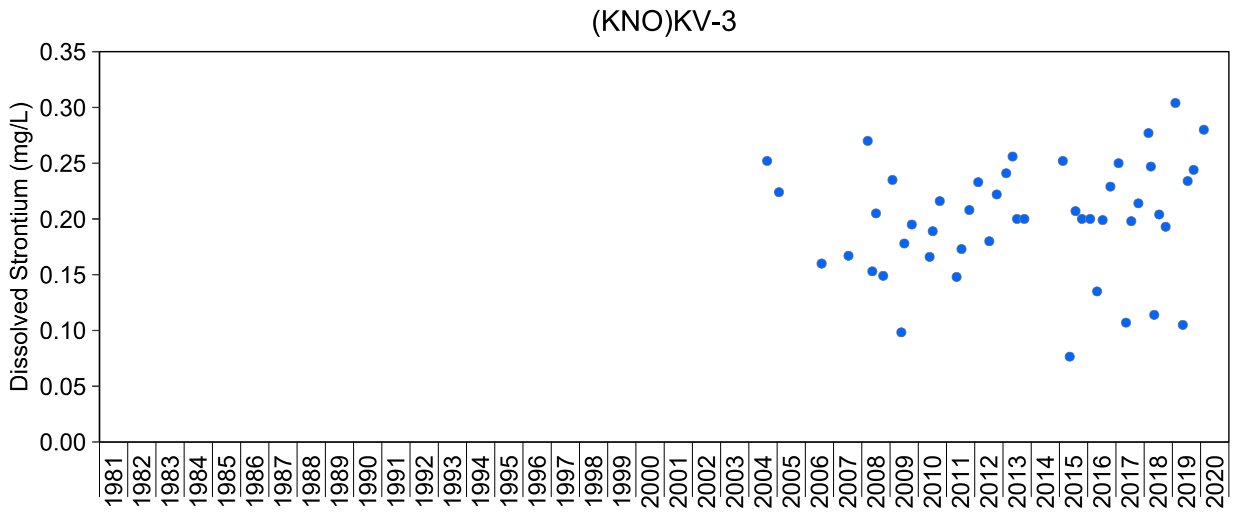


Figure A.76: Time Series Plots of Dissolved Strontium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.





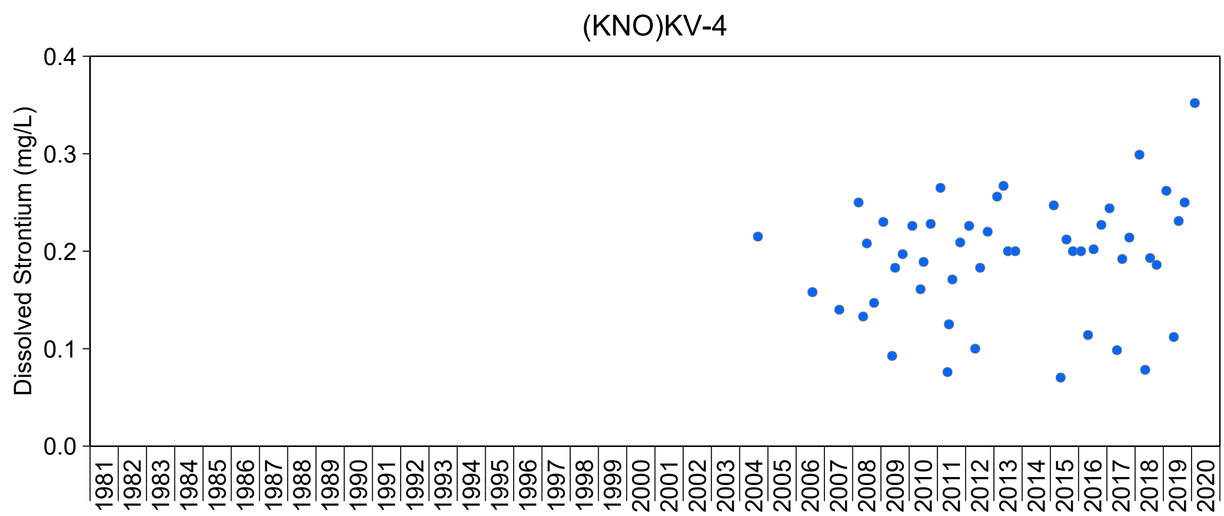


Figure A.76: Time Series Plots of Dissolved Strontium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

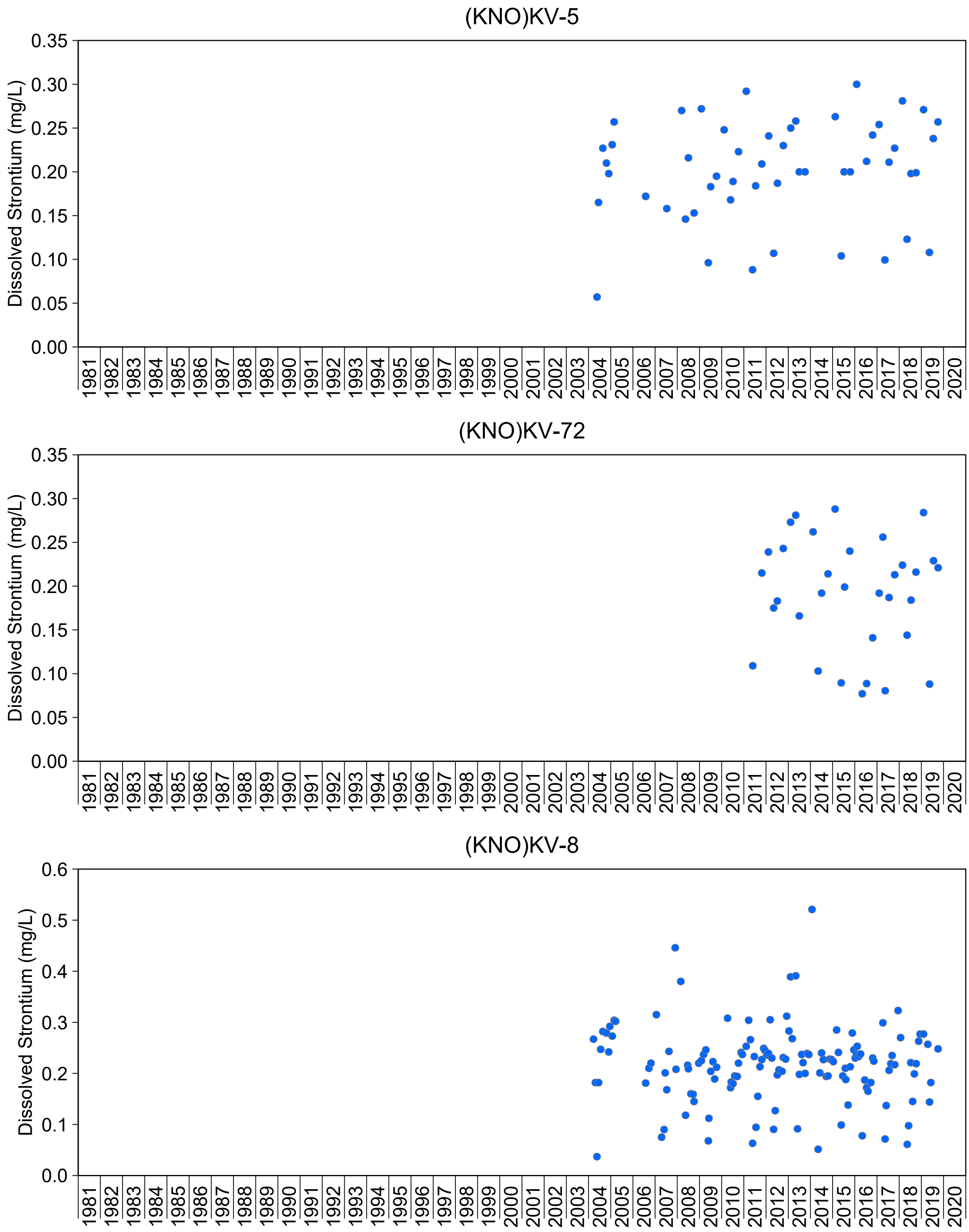


Figure A.76: Time Series Plots of Dissolved Strontium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

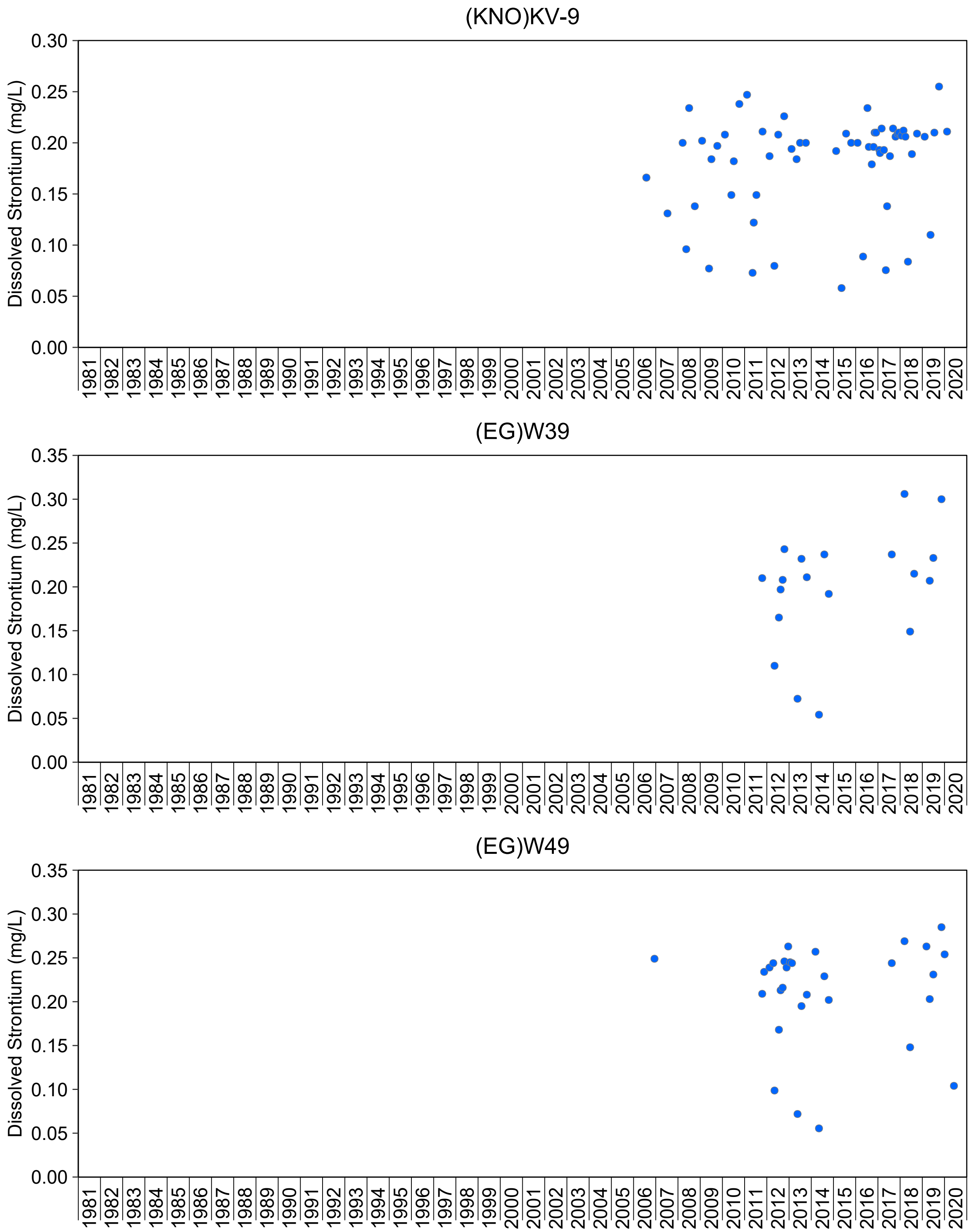


Figure A.76: Time Series Plots of Dissolved Strontium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

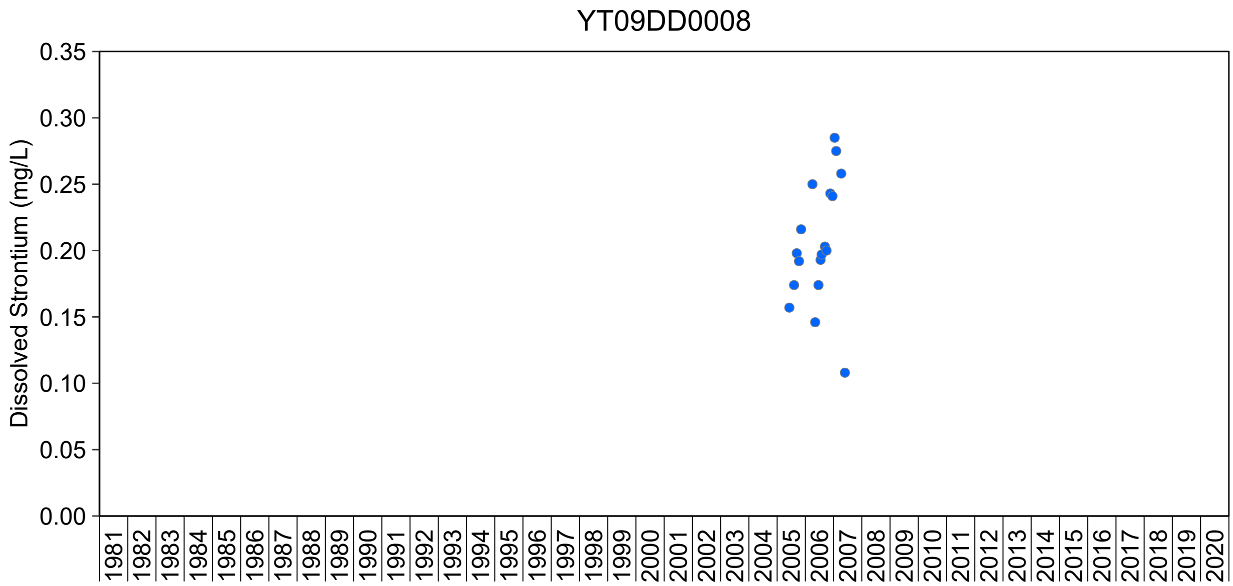


Figure A.76: Time Series Plots of Dissolved Strontium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

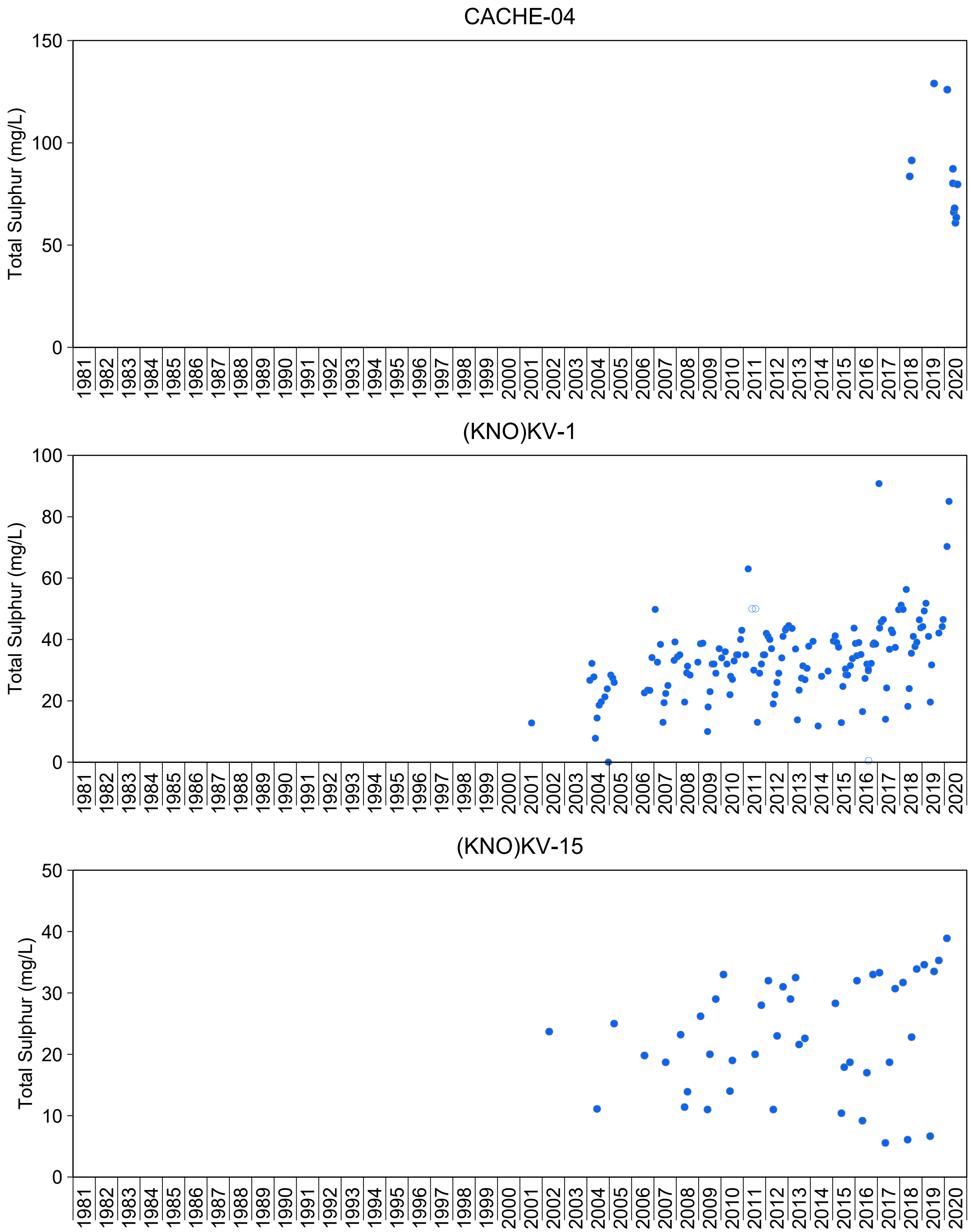


Figure A.77: Time Series Plots of Total Sulphur Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

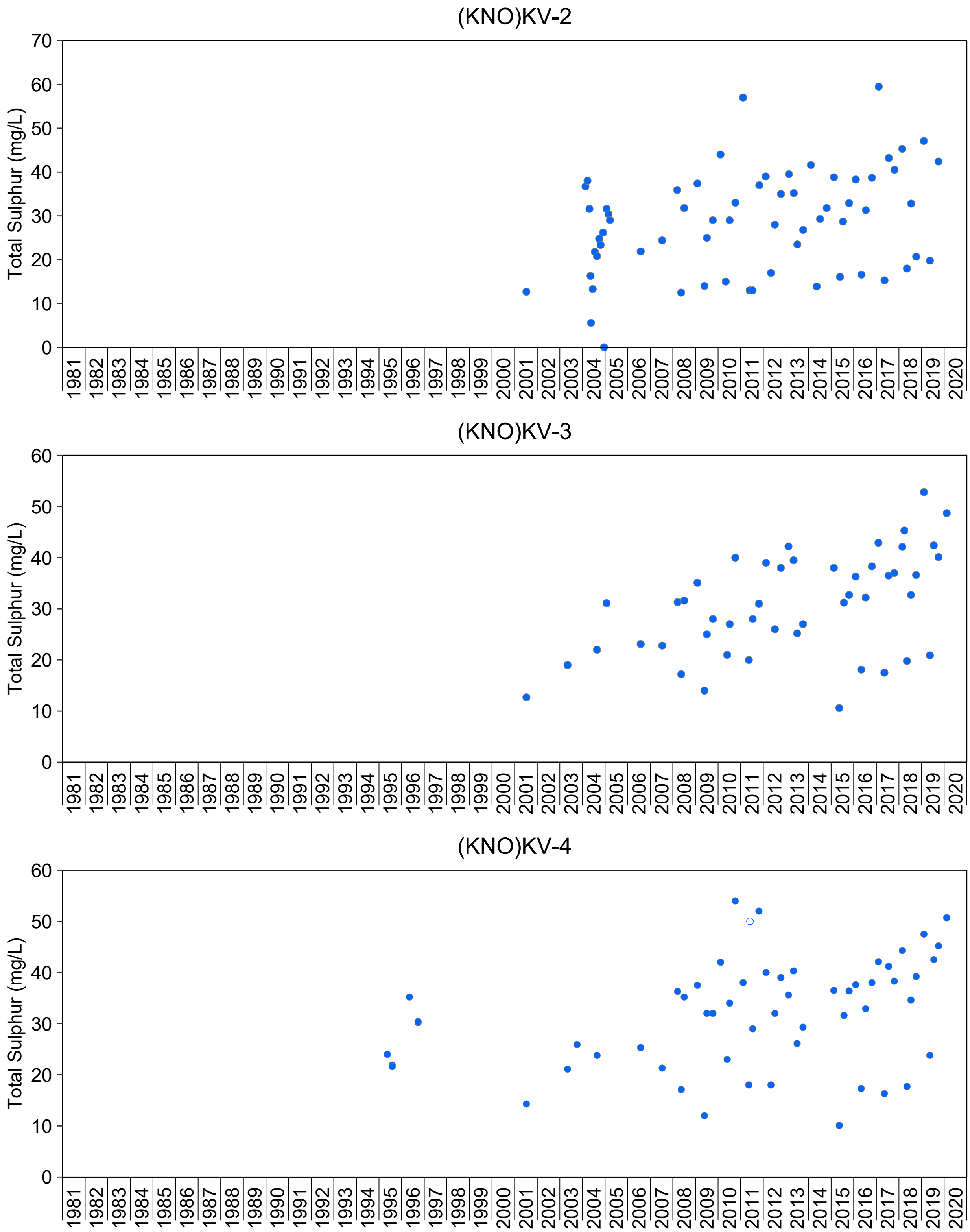


Figure A.77: Time Series Plots of Total Sulphur Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

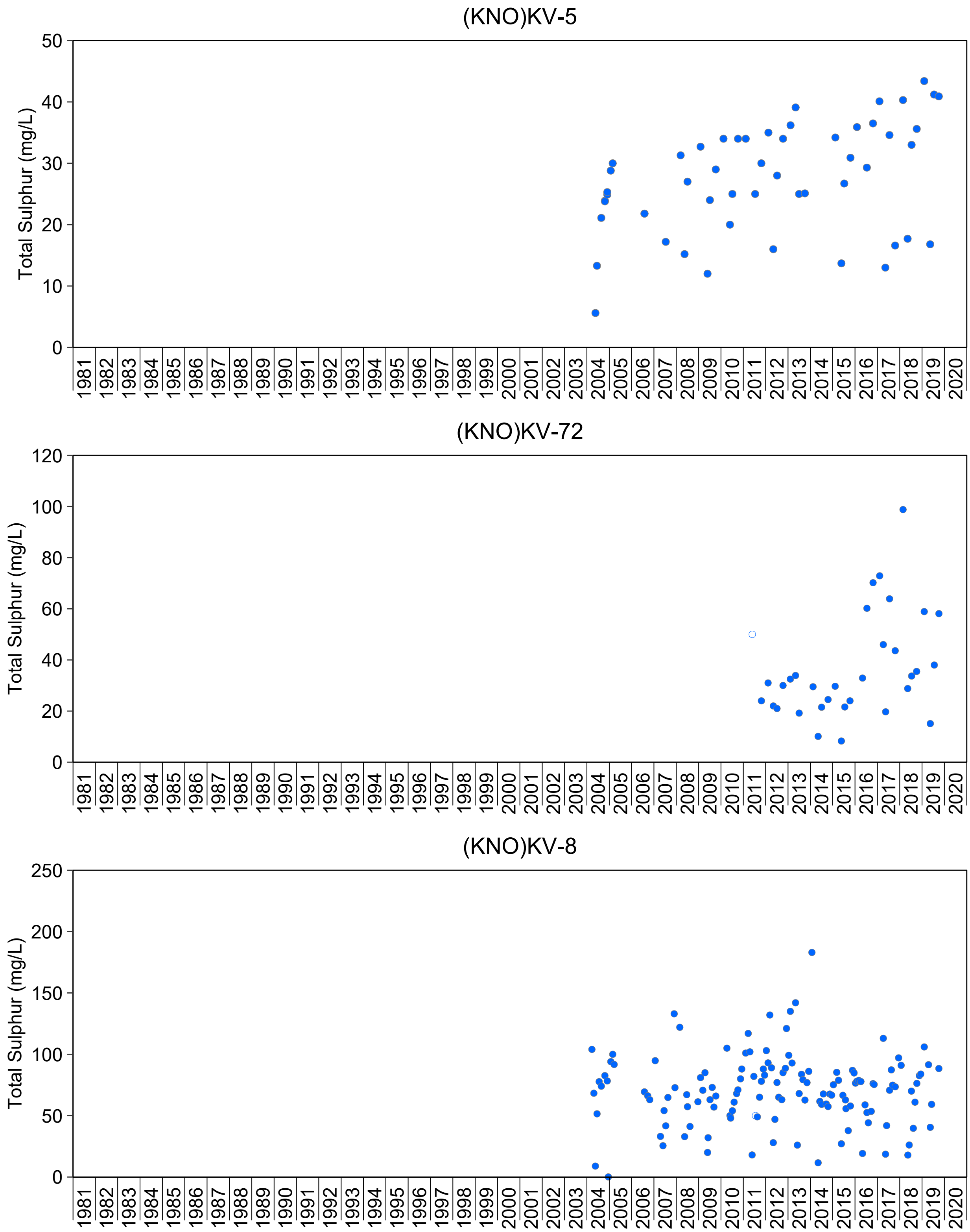


Figure A.77: Time Series Plots of Total Sulphur Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

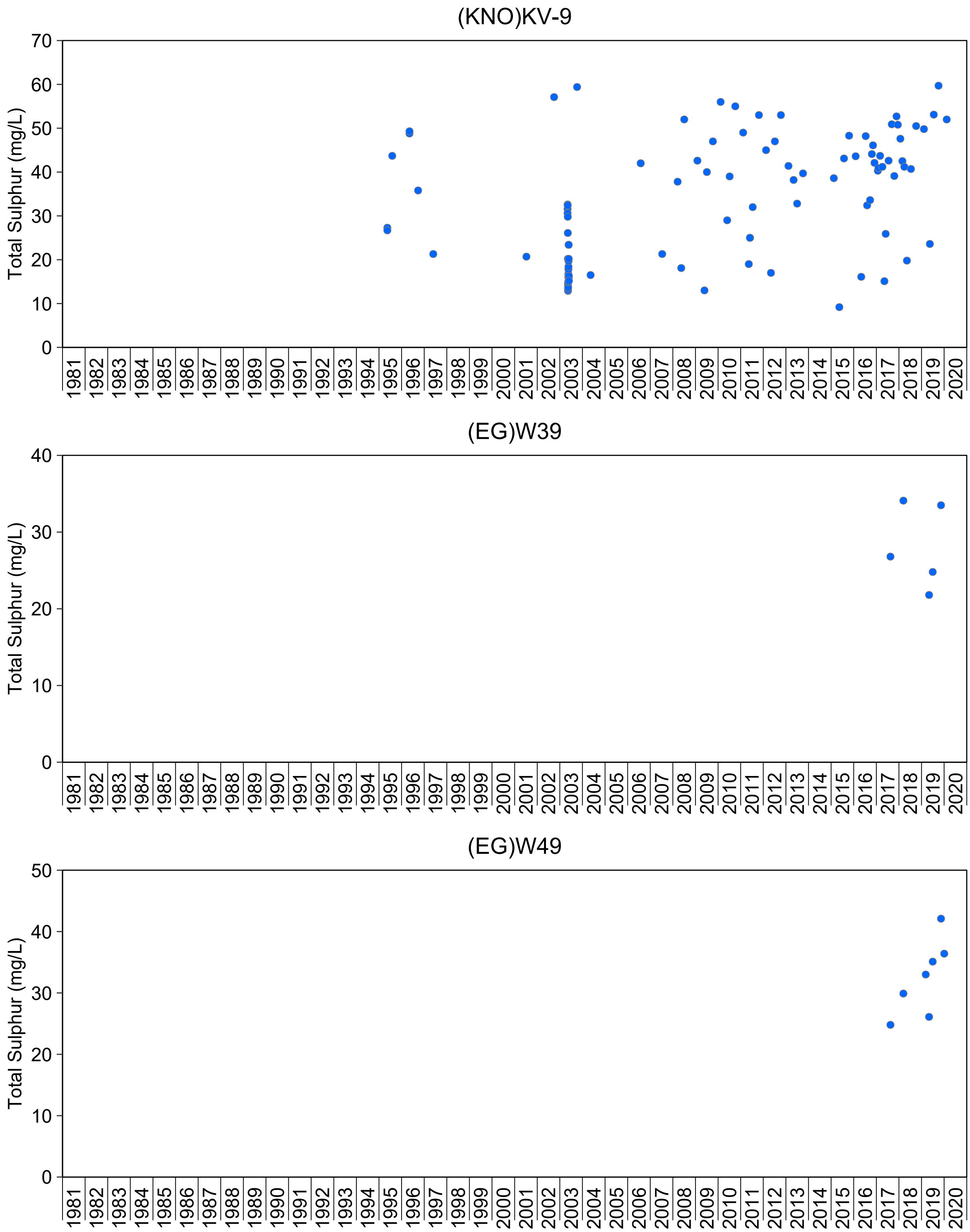


Figure A.77: Time Series Plots of Total Sulphur Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

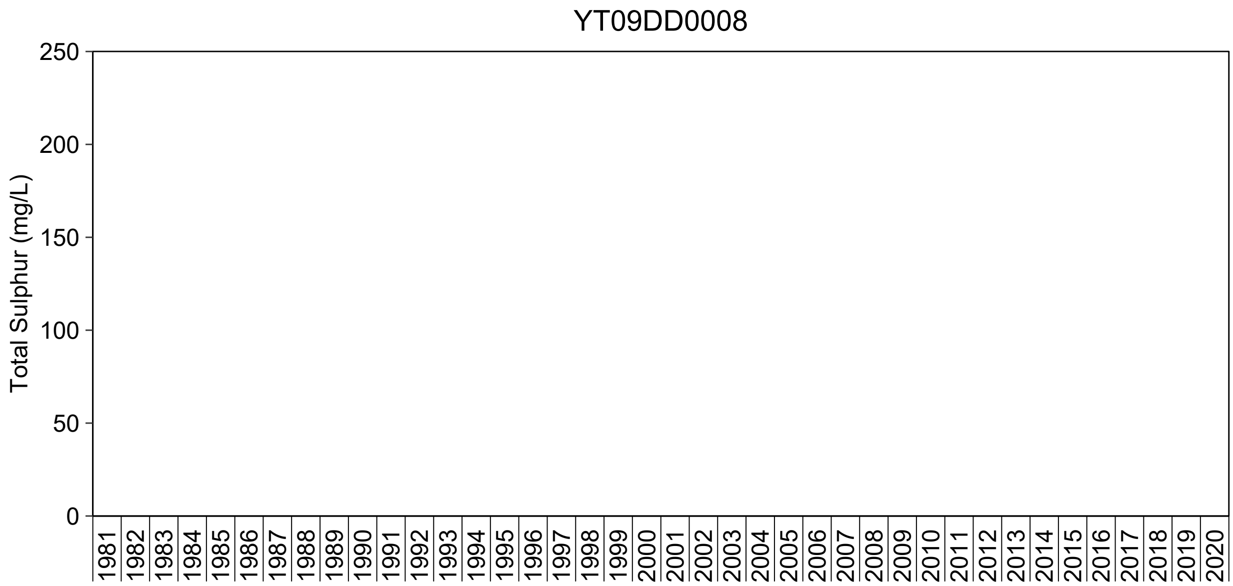


Figure A.77: Time Series Plots of Total Sulphur Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

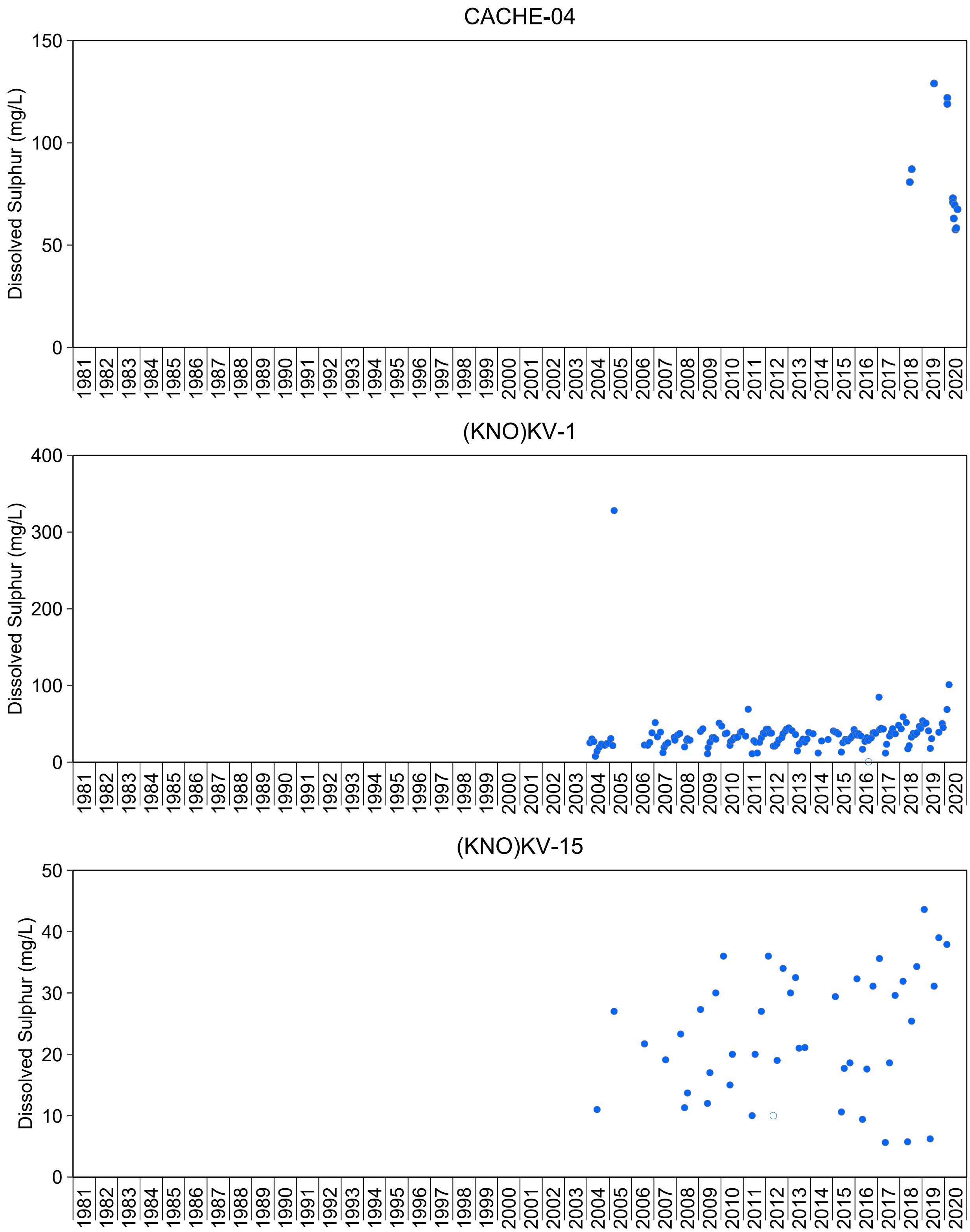


Figure A.78: Time Series Plots of Dissolved Sulphur Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

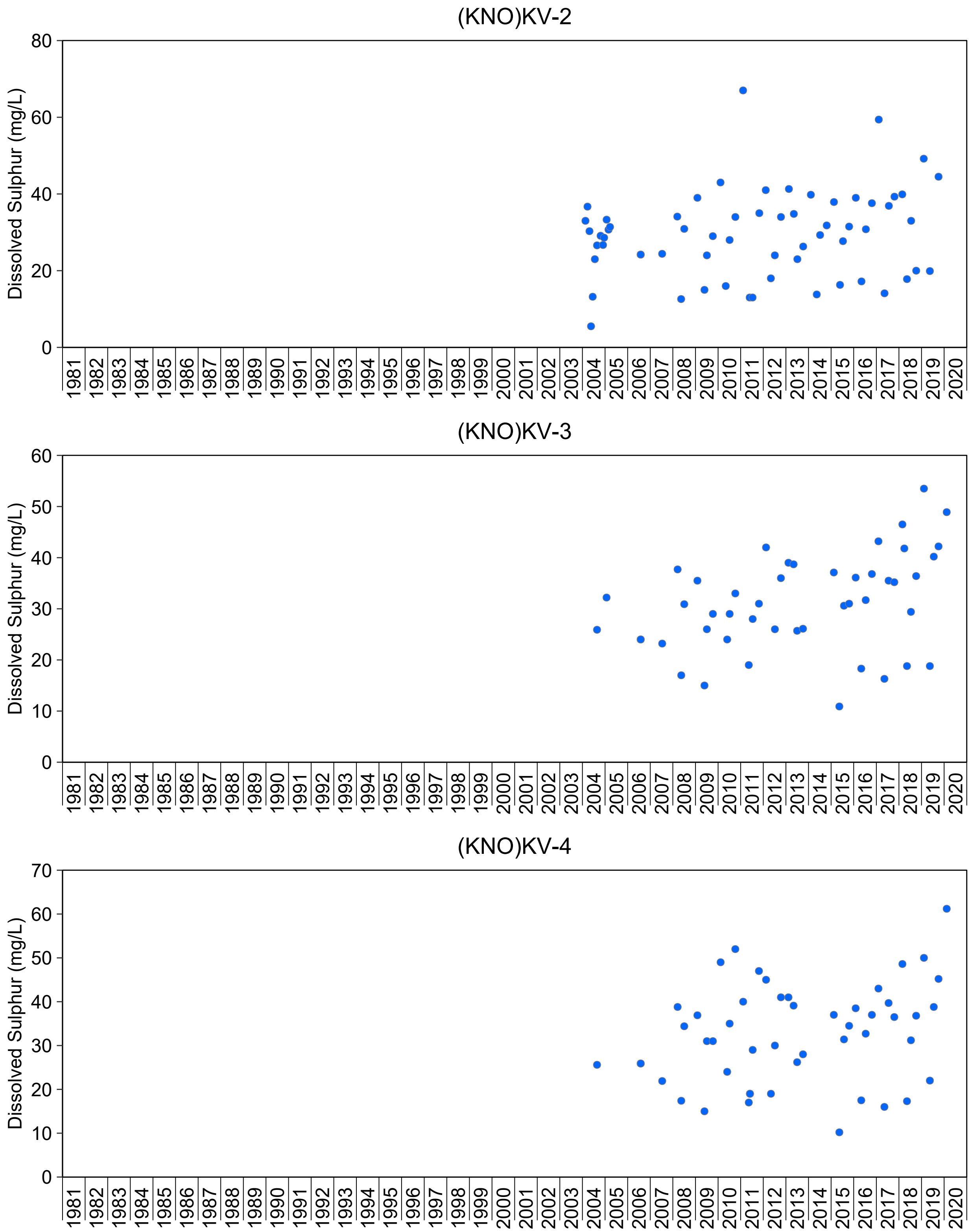


Figure A.78: Time Series Plots of Dissolved Sulphur Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

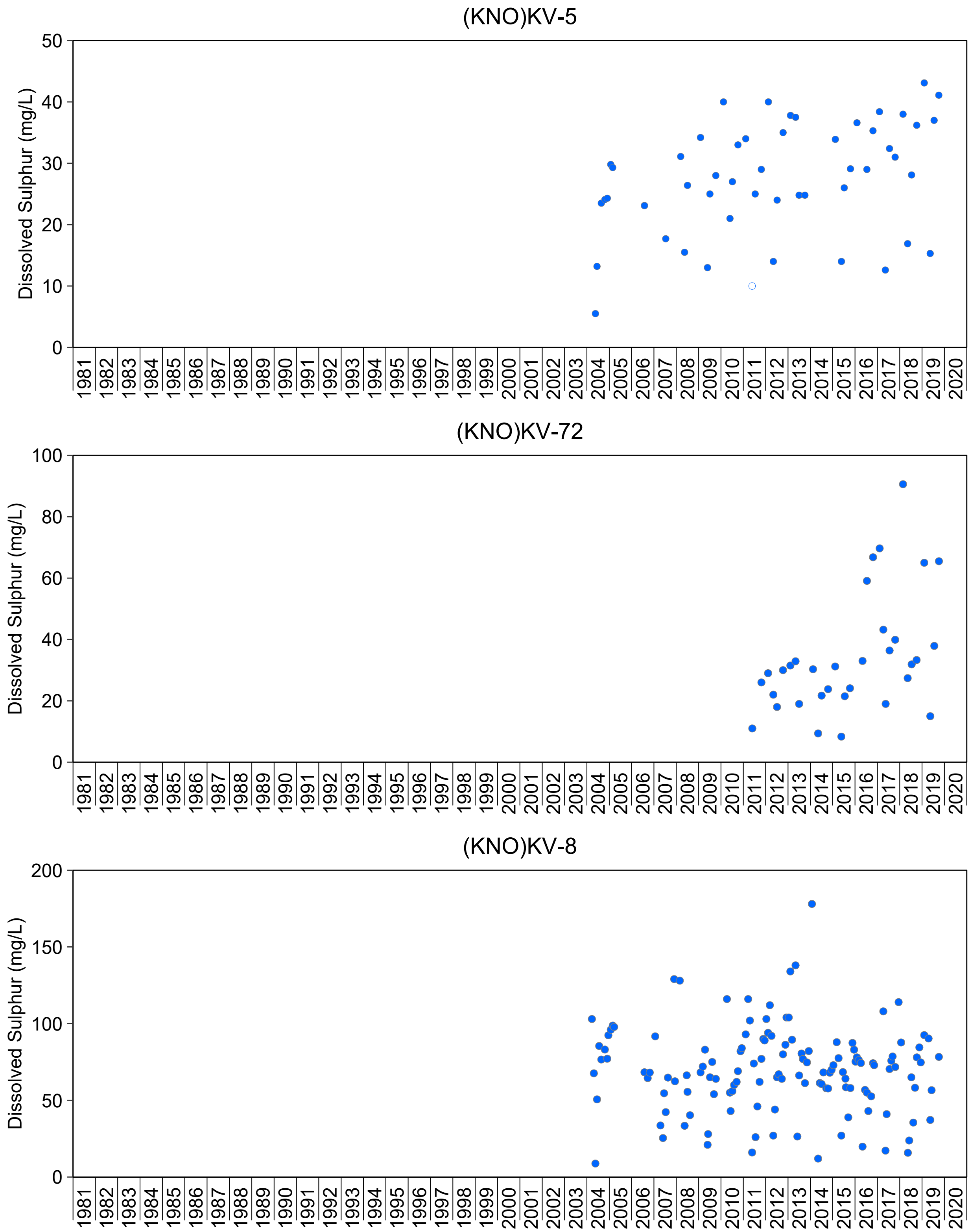
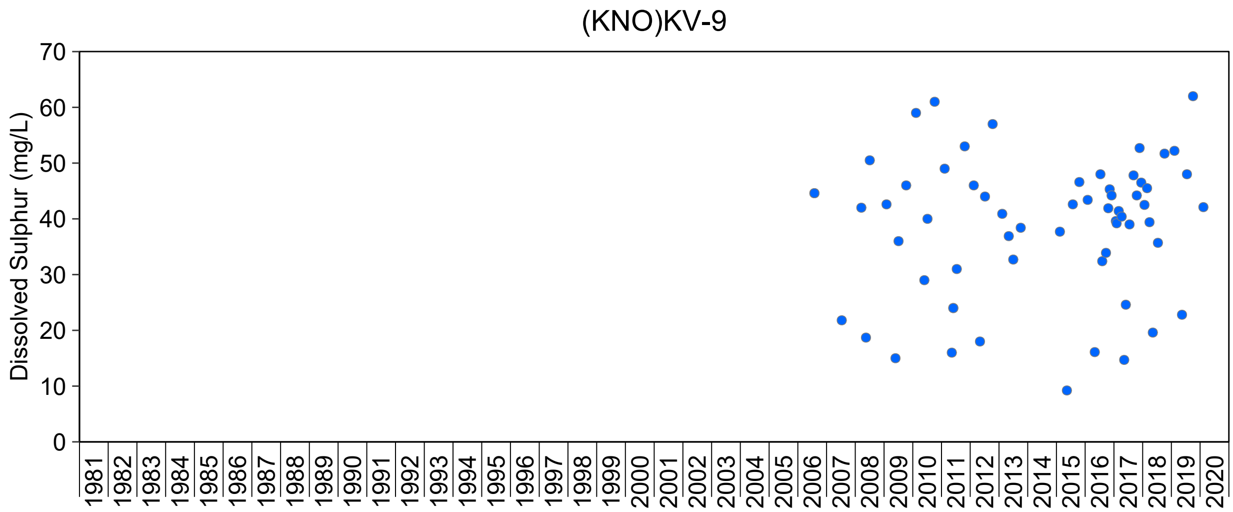
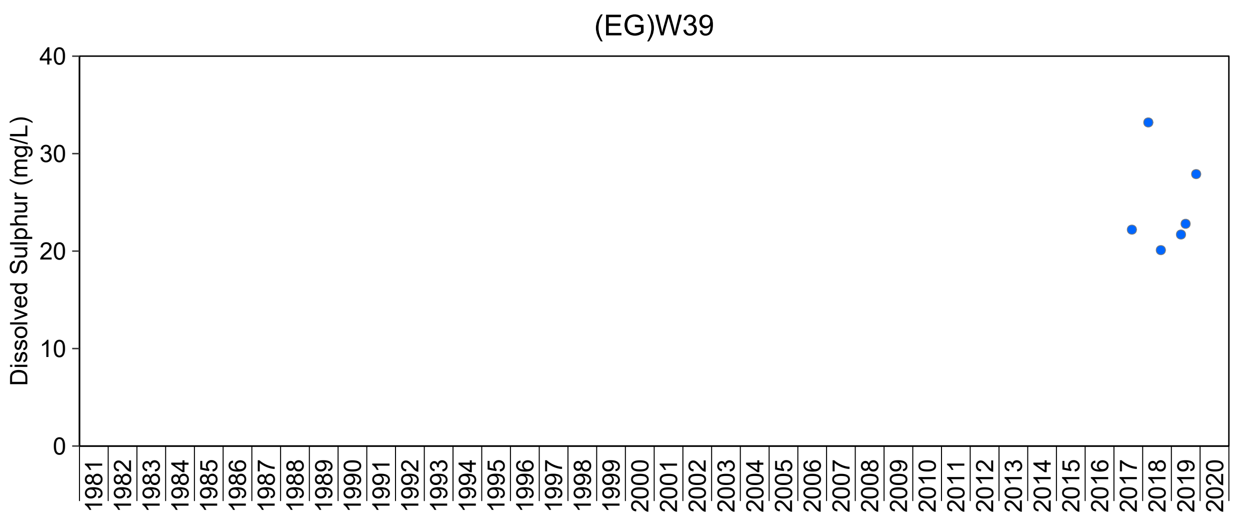


Figure A.78: **Time Series Plots of Dissolved Sulphur Concentrations (mg/L) in the South McQuesten River, 1981 to 2020**

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.





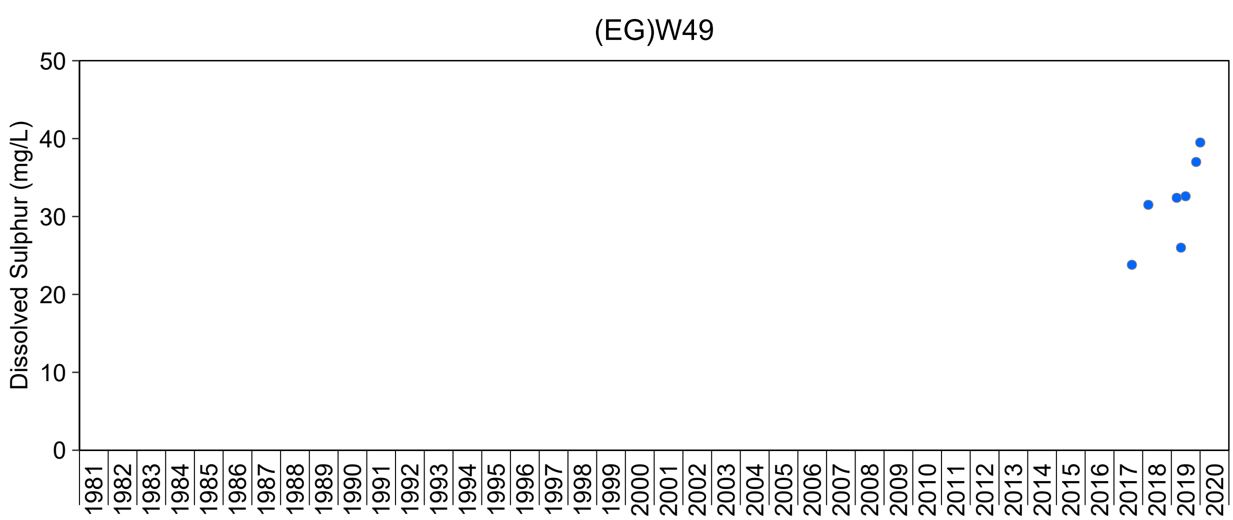


Figure A.78: Time Series Plots of Dissolved Sulphur Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

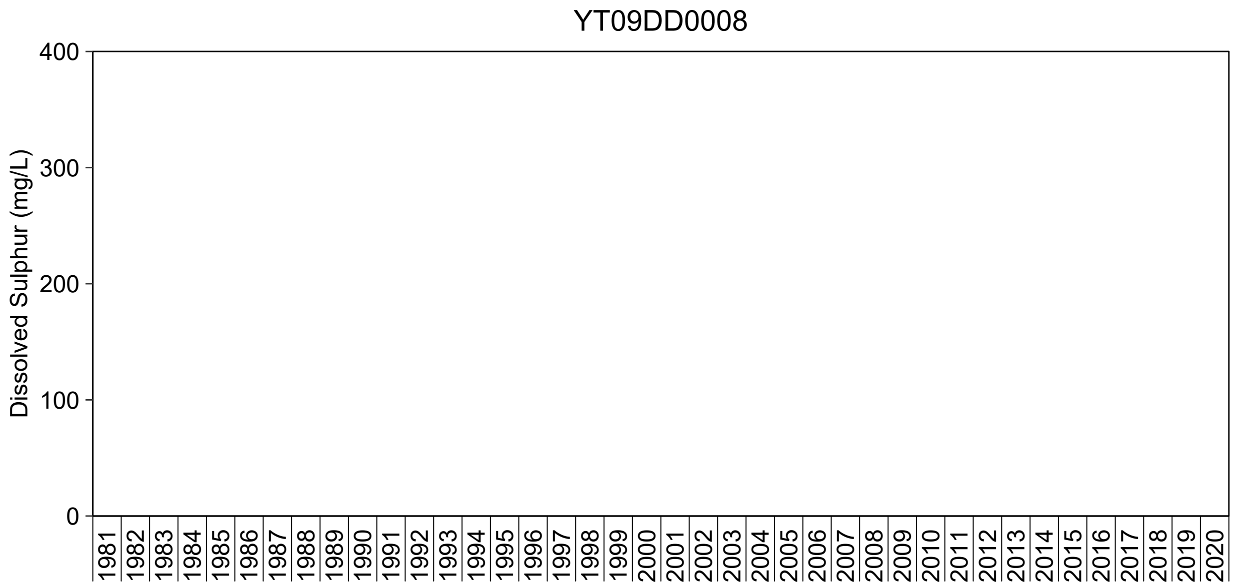


Figure A.78: Time Series Plots of Dissolved Sulphur Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

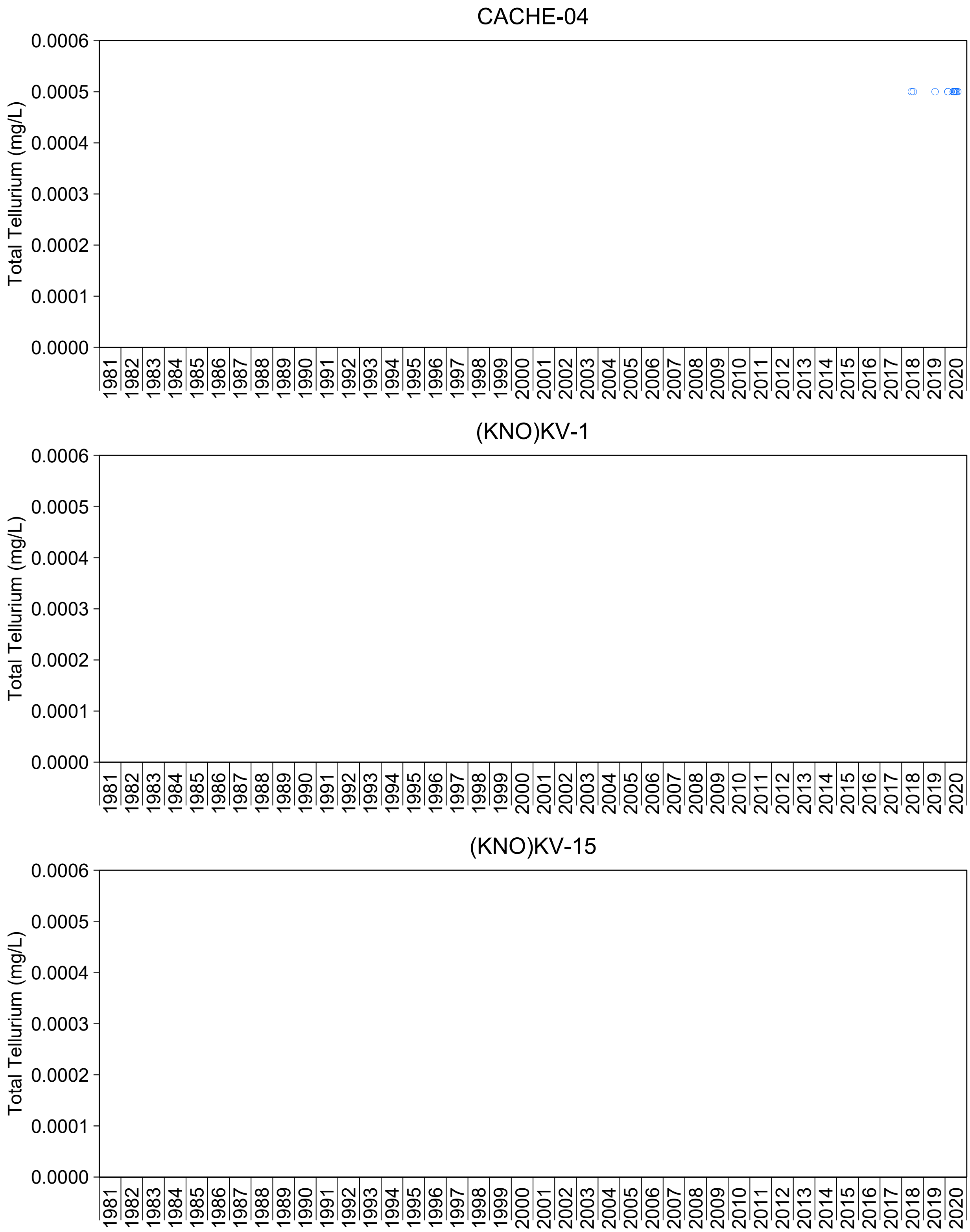


Figure A.79: Time Series Plots of Total Tellurium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

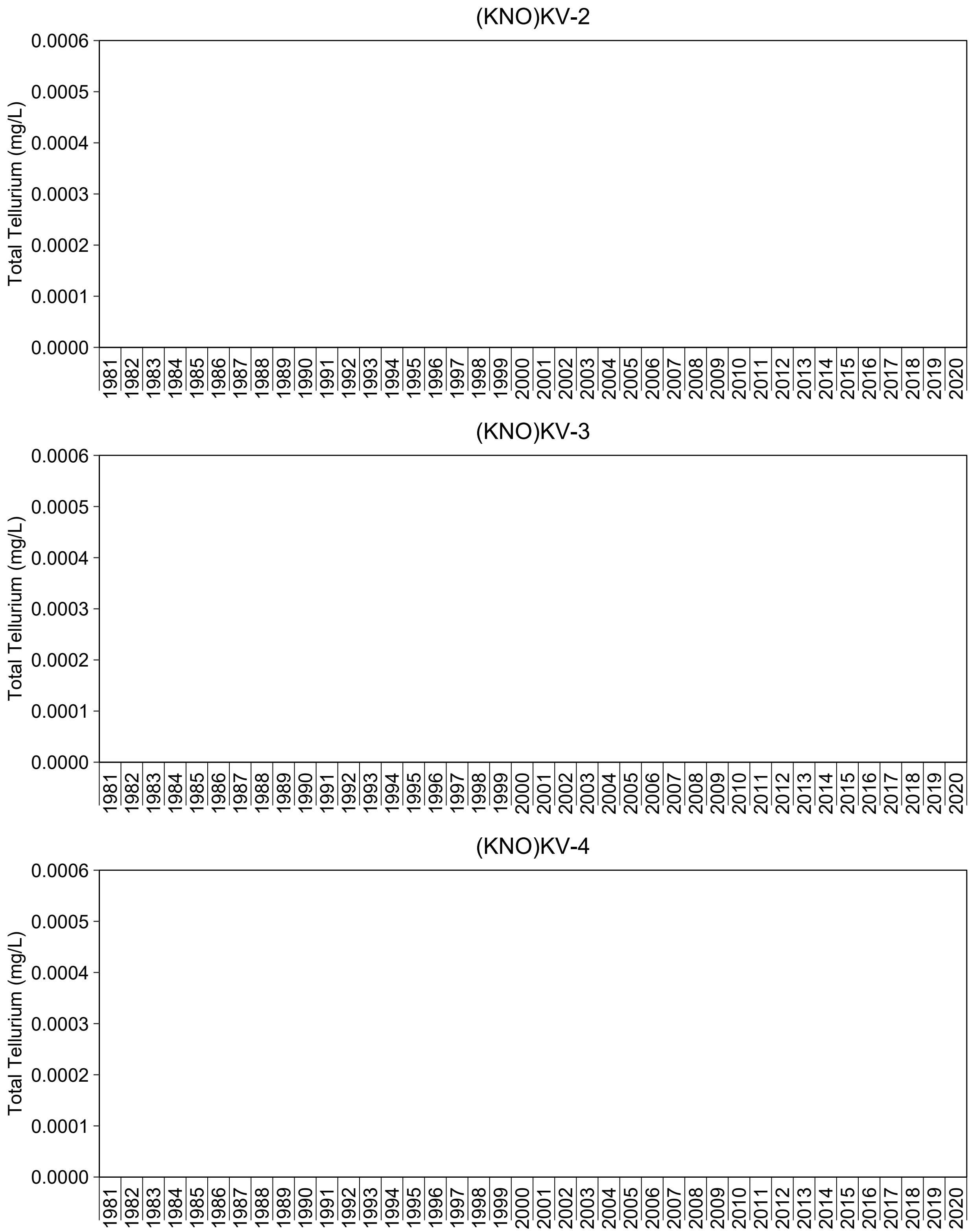


Figure A.79: Time Series Plots of Total Tellurium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

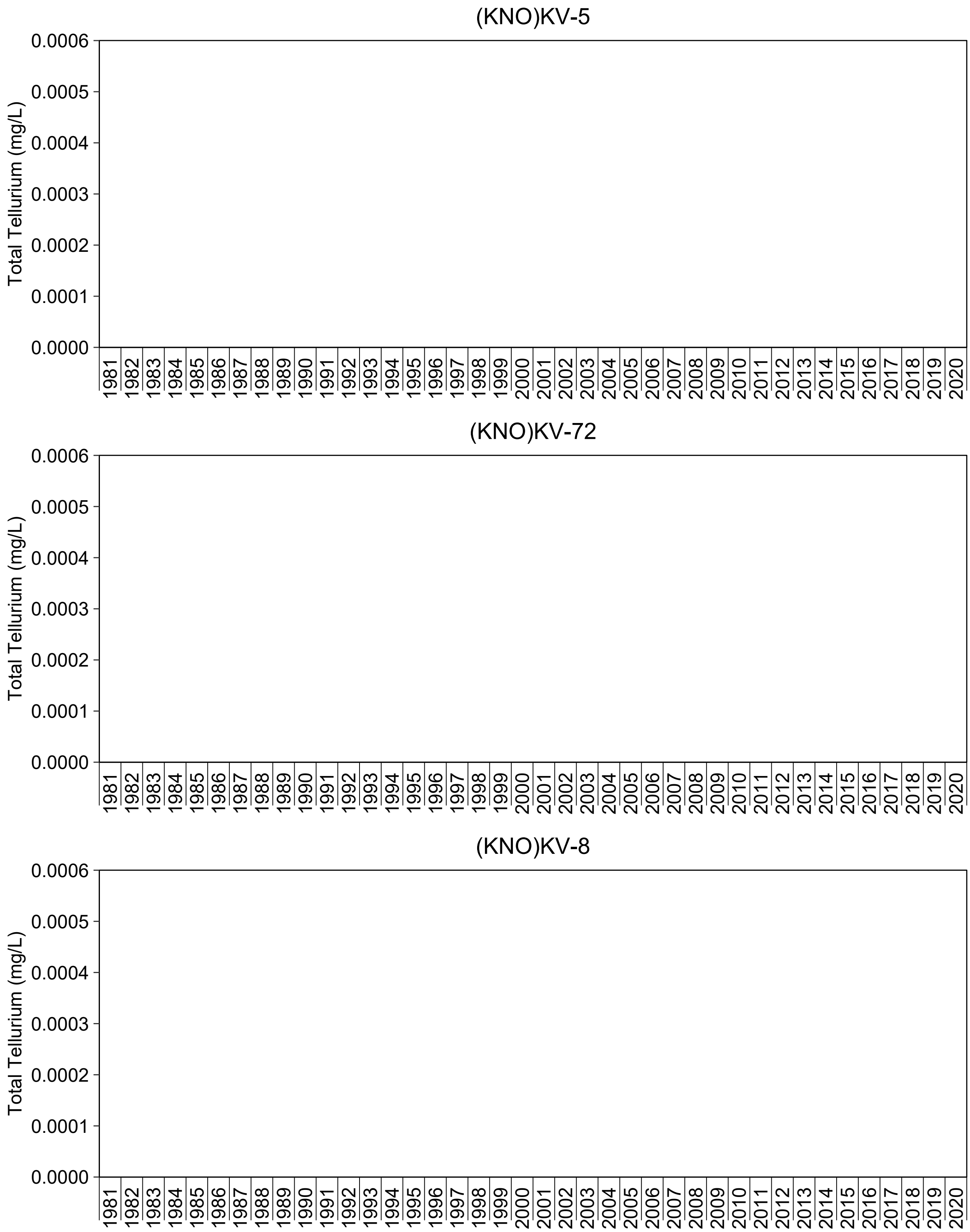


Figure A.79: Time Series Plots of Total Tellurium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

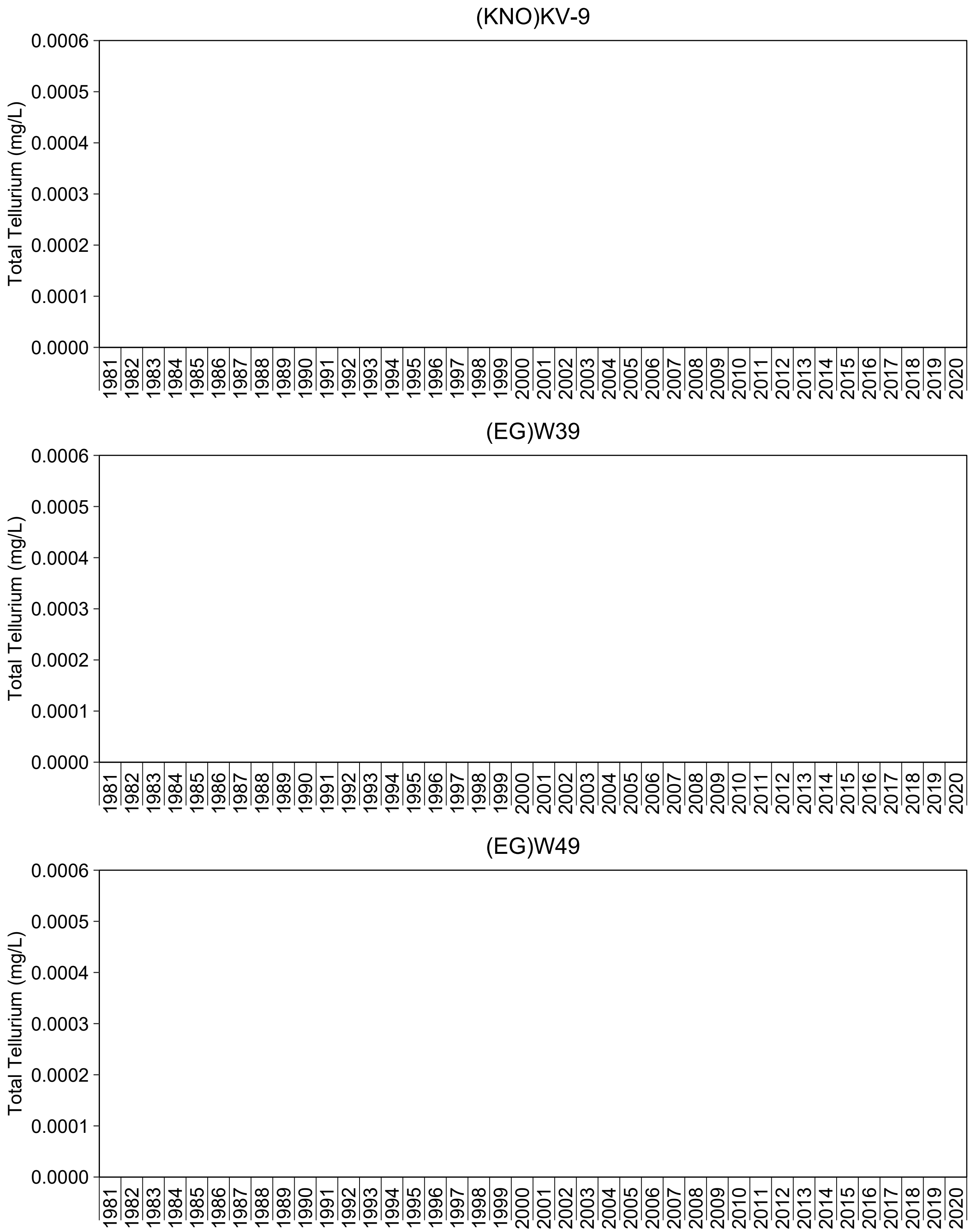


Figure A.79: Time Series Plots of Total Tellurium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

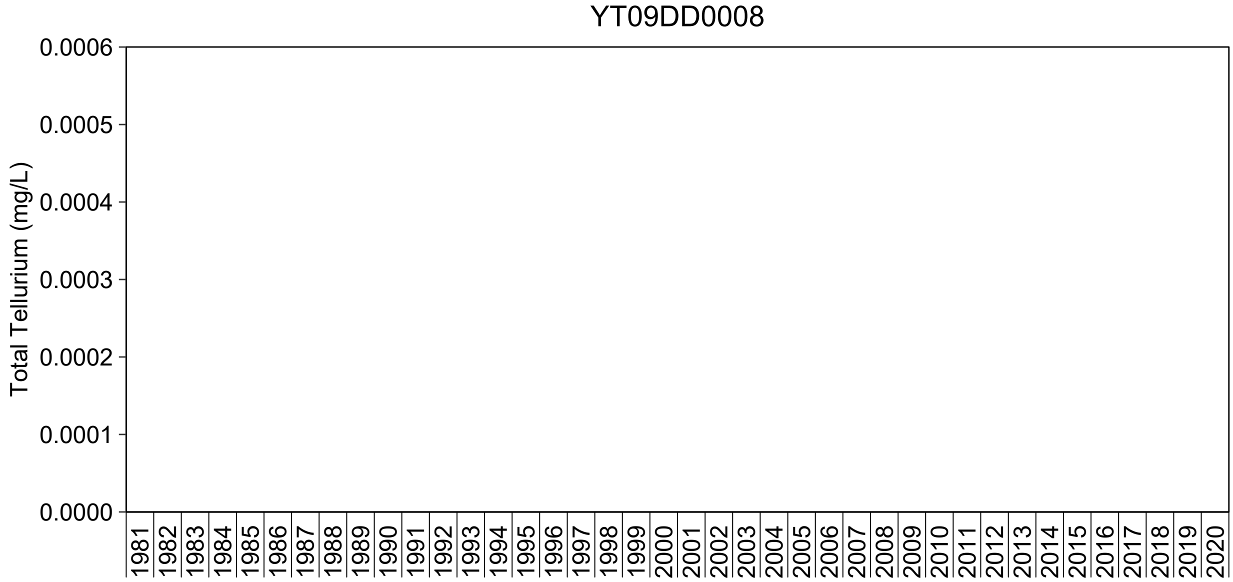
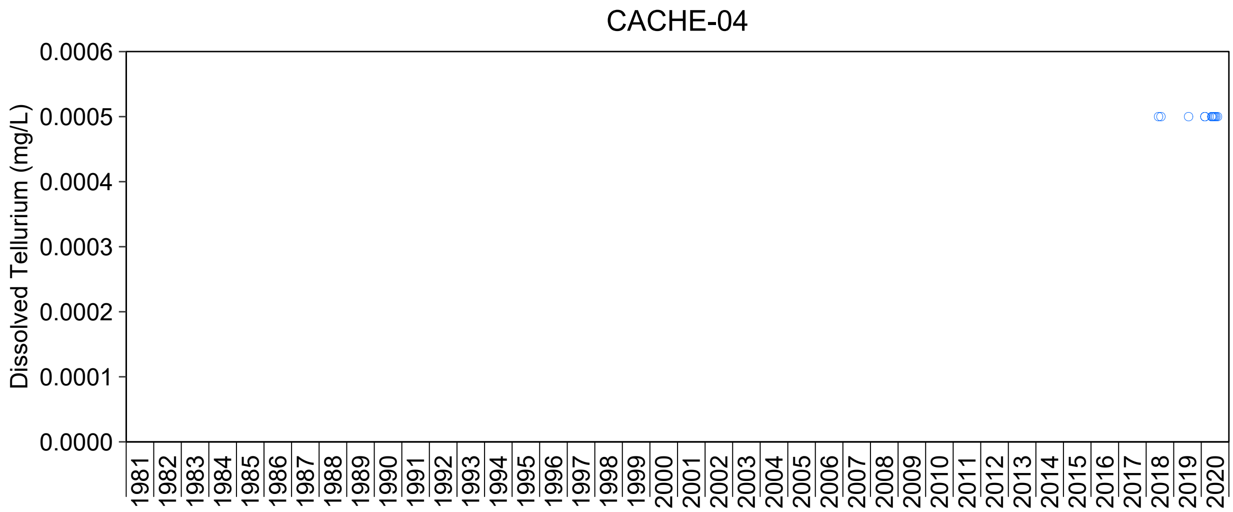
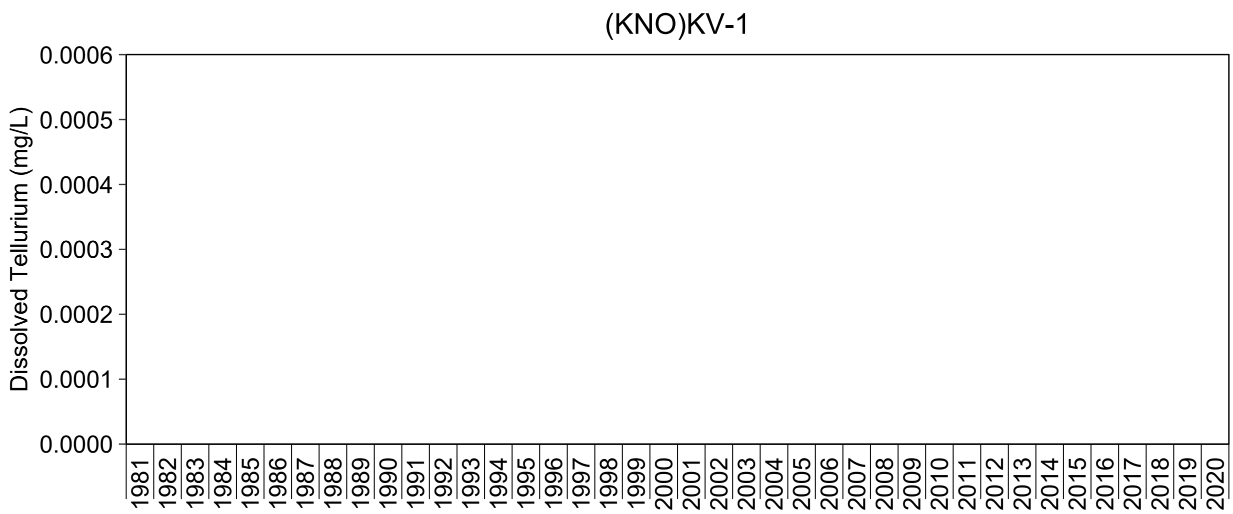


Figure A.79: Time Series Plots of Total Tellurium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.





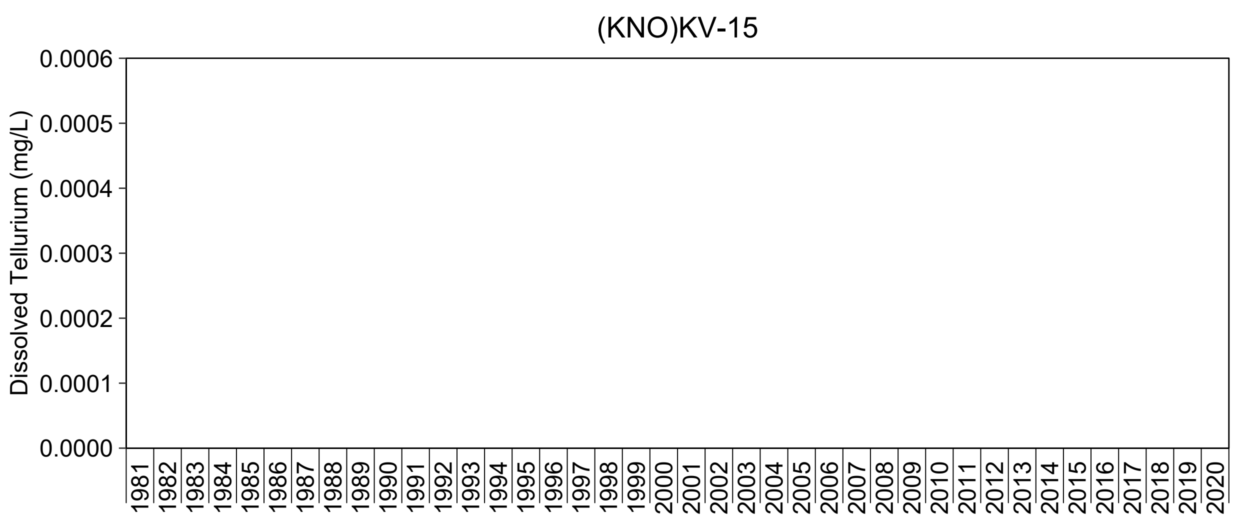
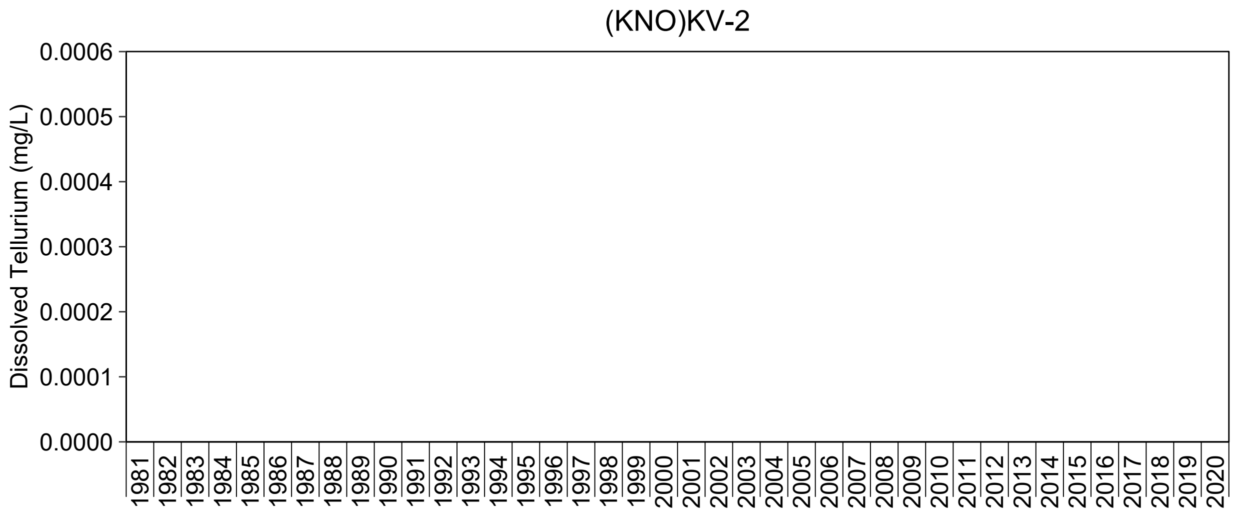
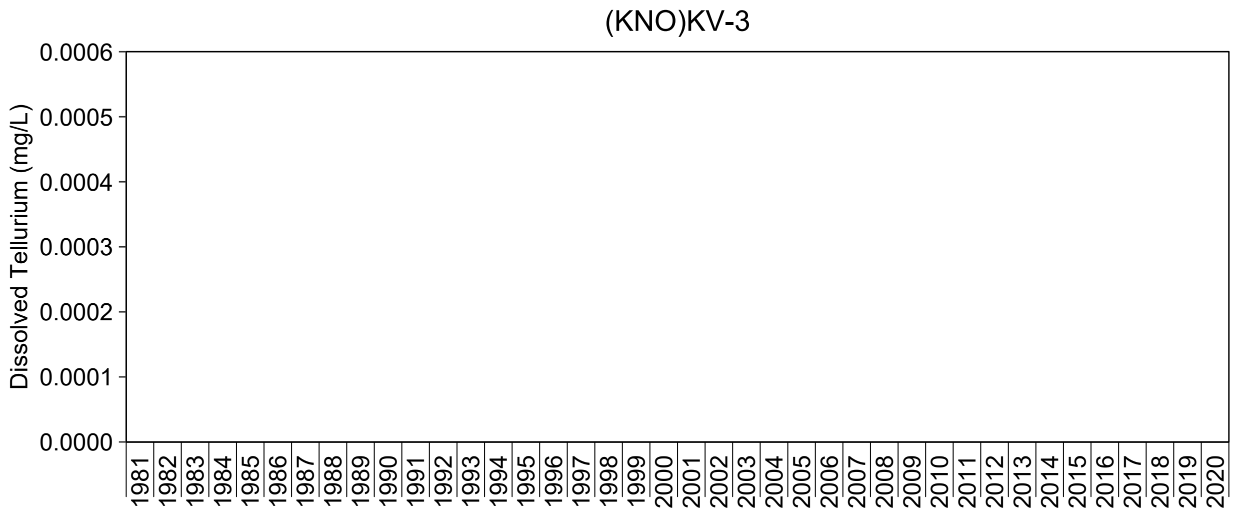


Figure A.80: Time Series Plots of Dissolved Tellurium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.





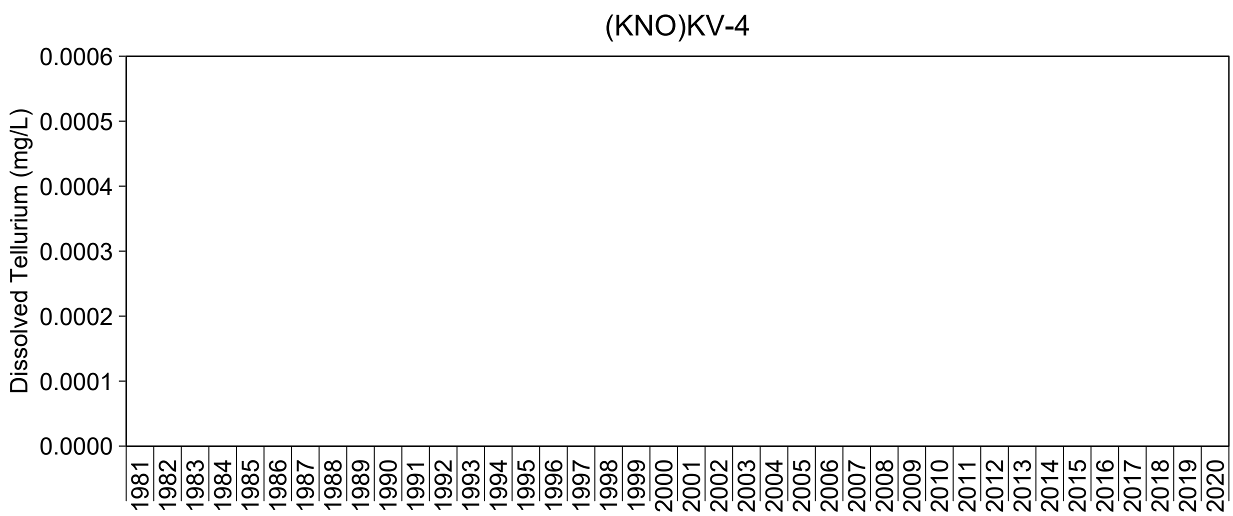


Figure A.80: Time Series Plots of Dissolved Tellurium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

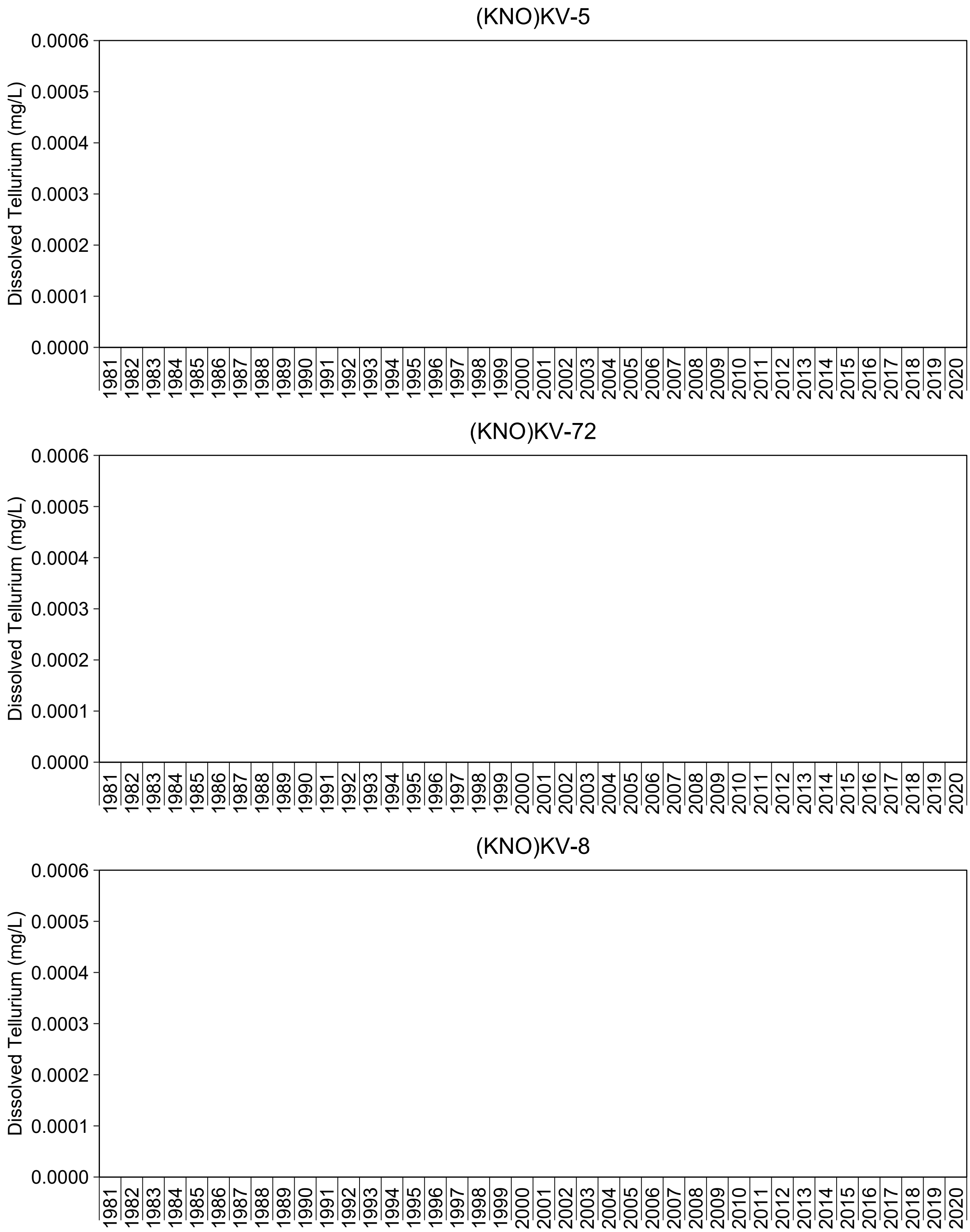


Figure A.80: Time Series Plots of Dissolved Tellurium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

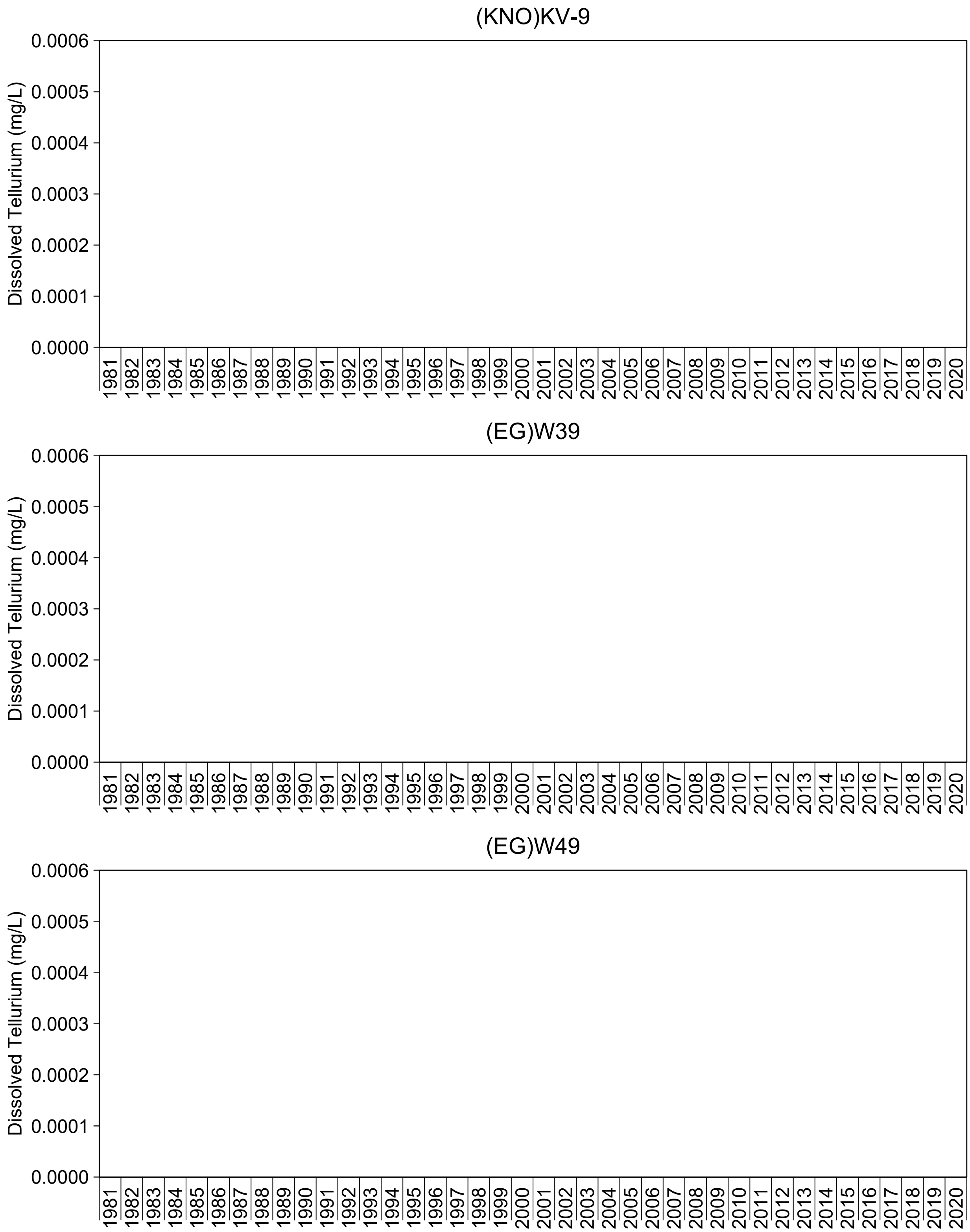


Figure A.80: Time Series Plots of Dissolved Tellurium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

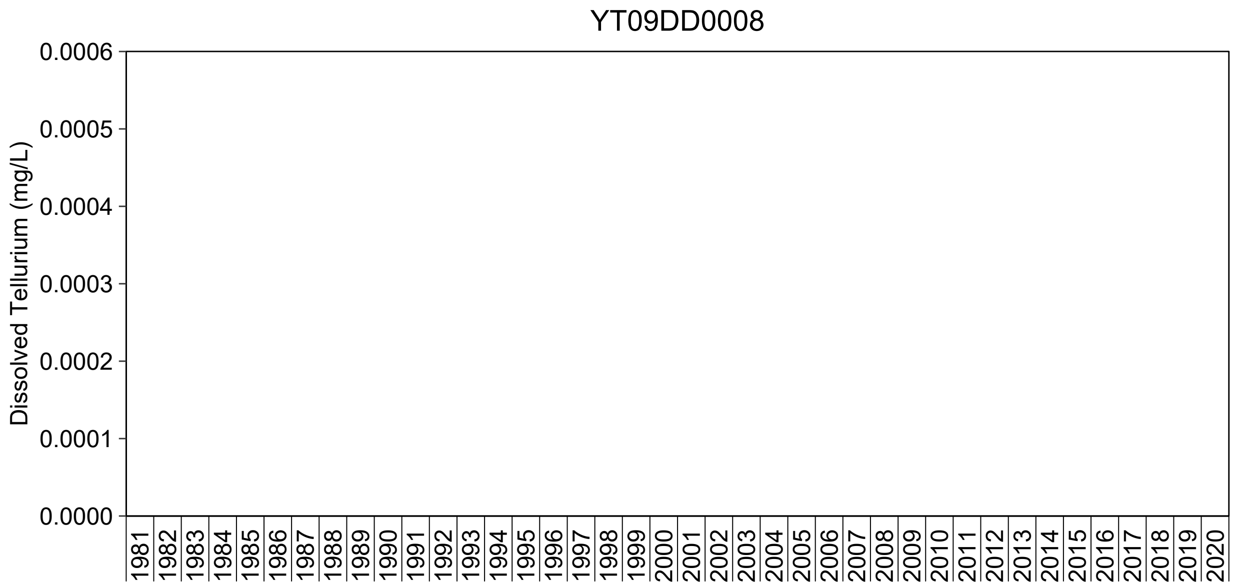


Figure A.80: Time Series Plots of Dissolved Tellurium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

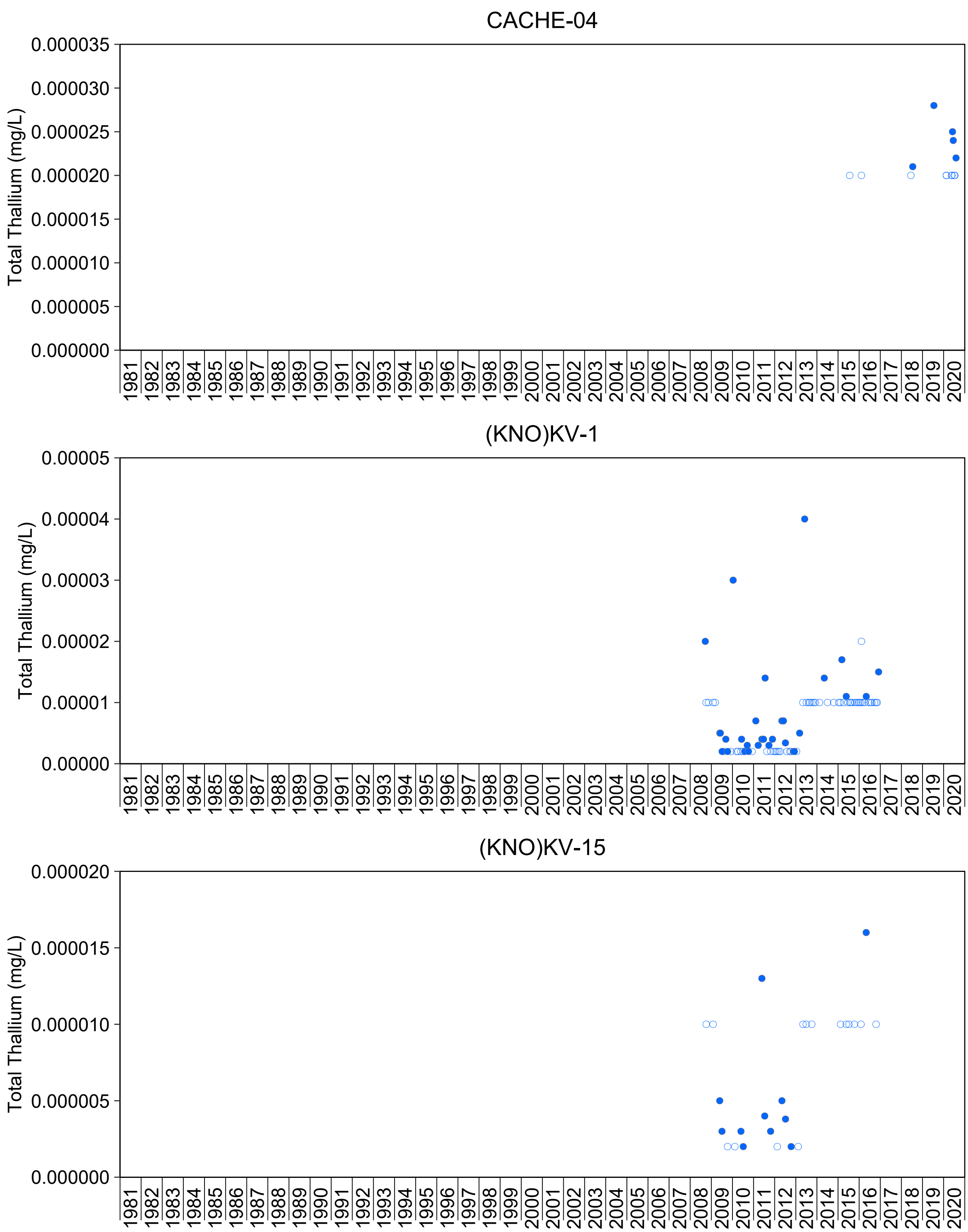


Figure A.81: Time Series Plots of Total Thallium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

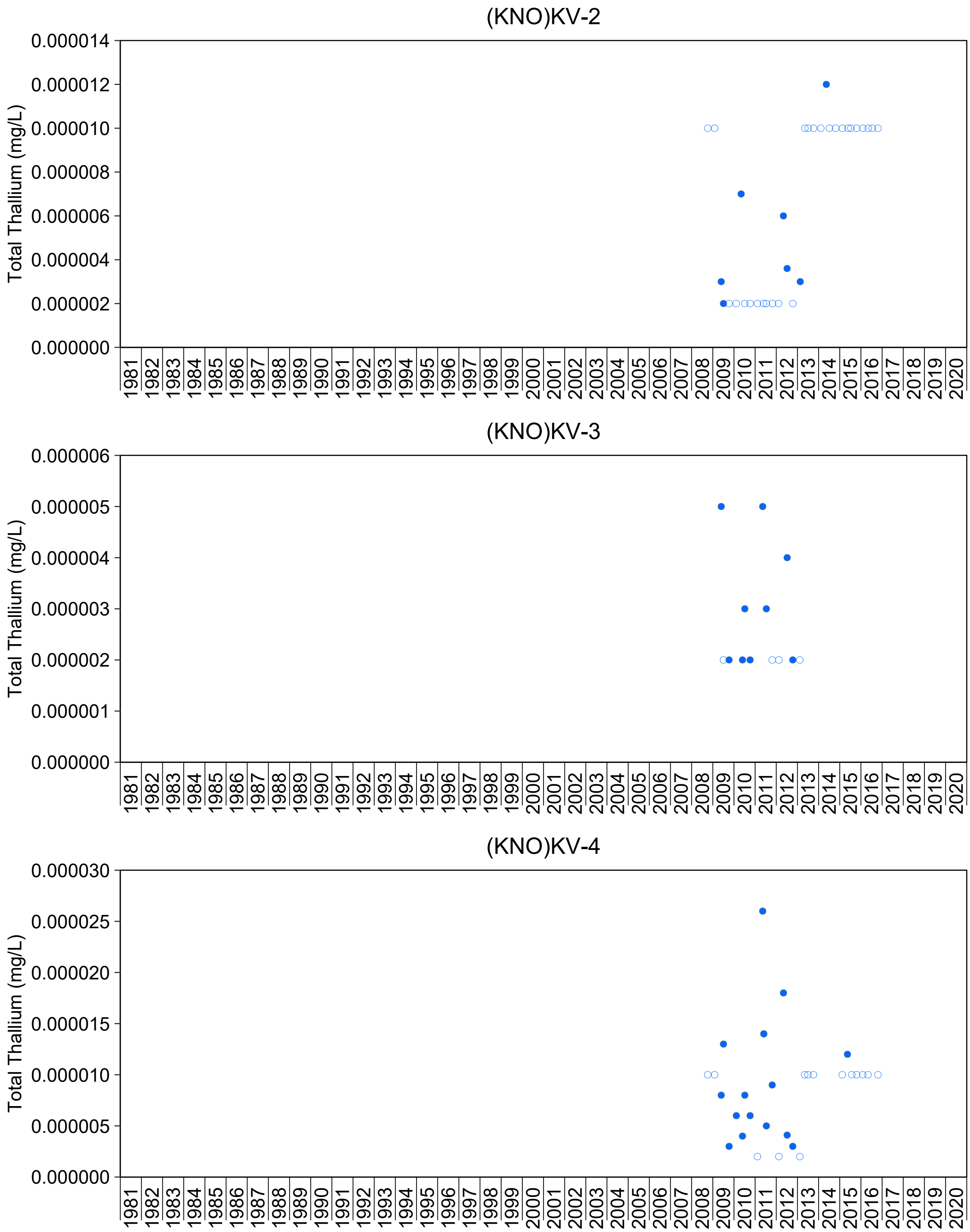


Figure A.81: Time Series Plots of Total Thallium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

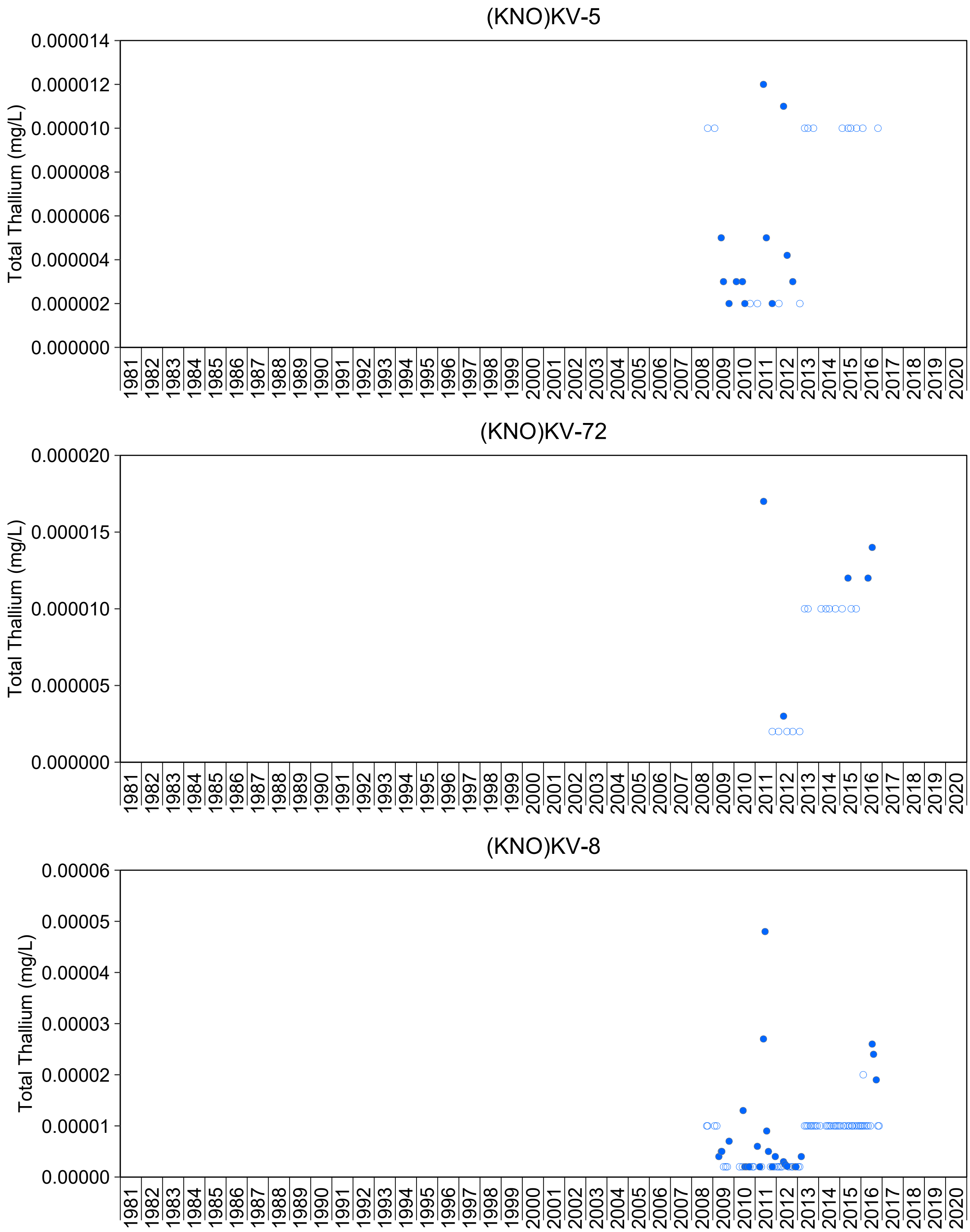
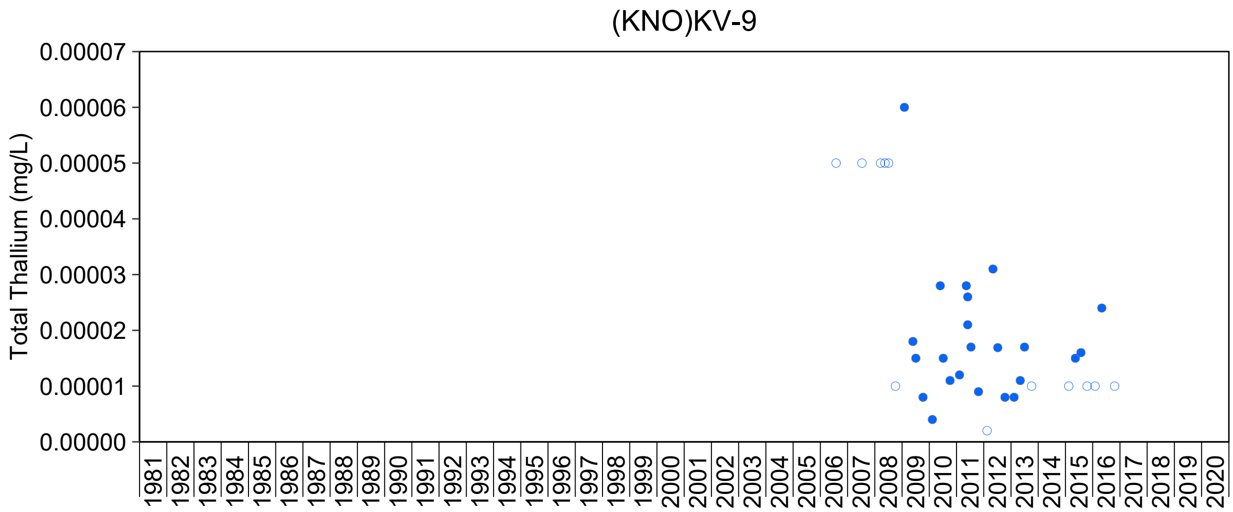
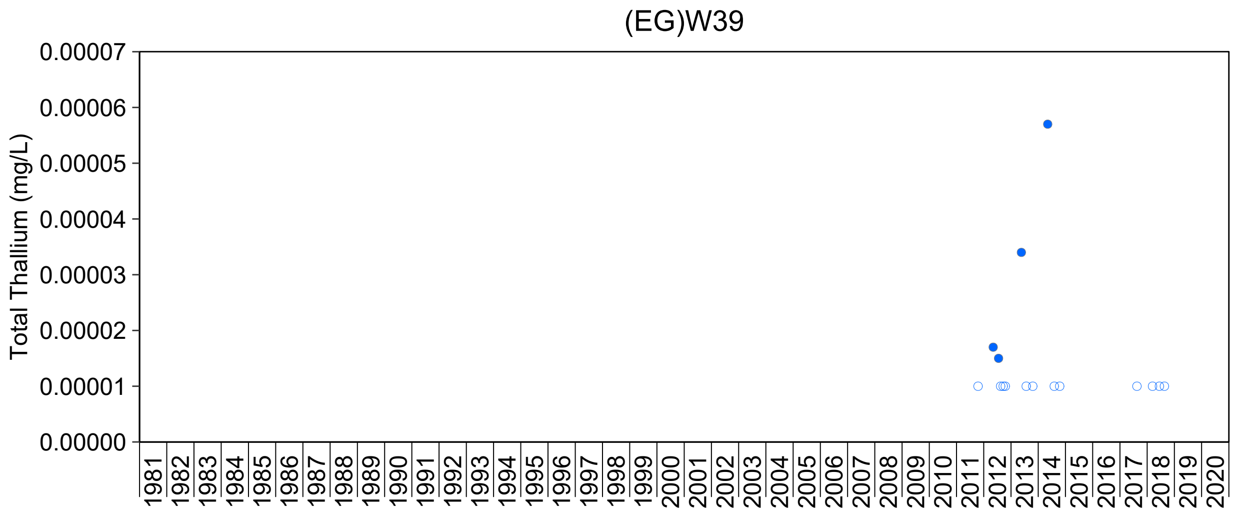


Figure A.81: Time Series Plots of Total Thallium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.





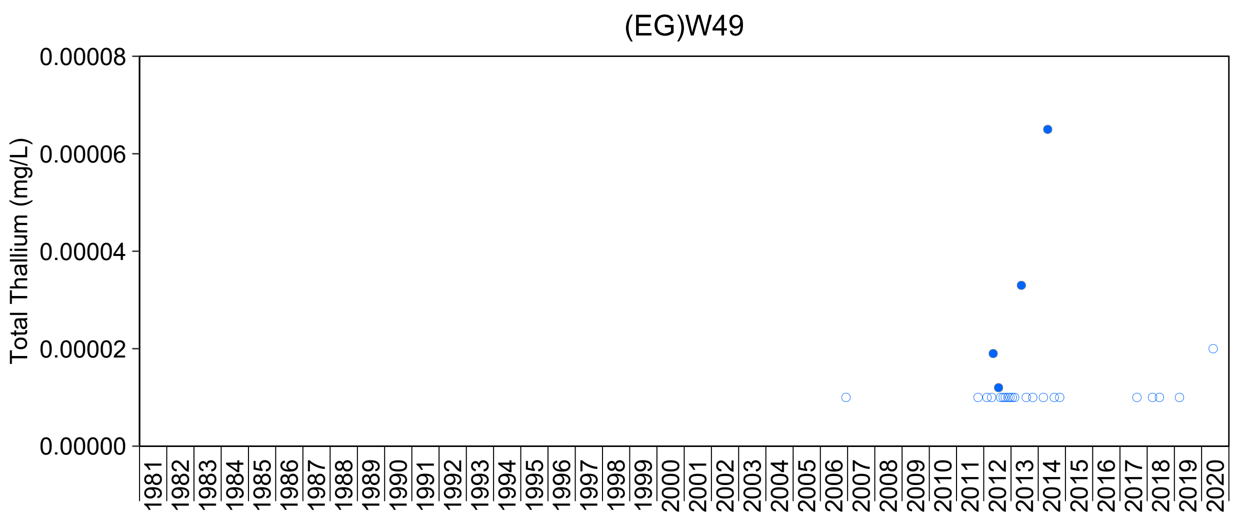


Figure A.81: Time Series Plots of Total Thallium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

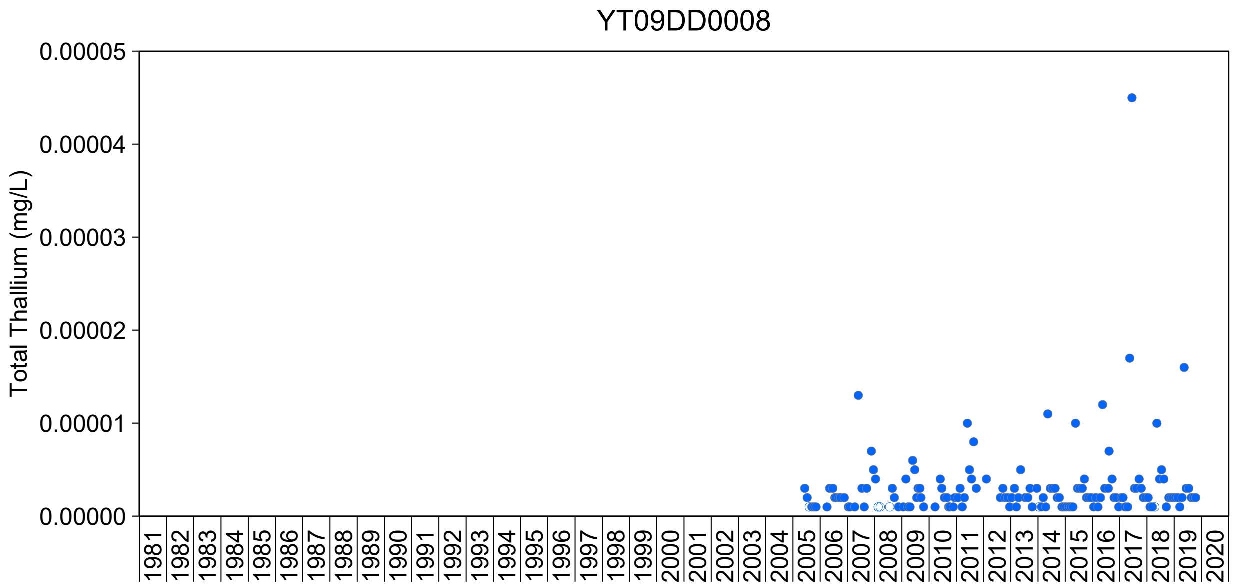


Figure A.81: Time Series Plots of Total Thallium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

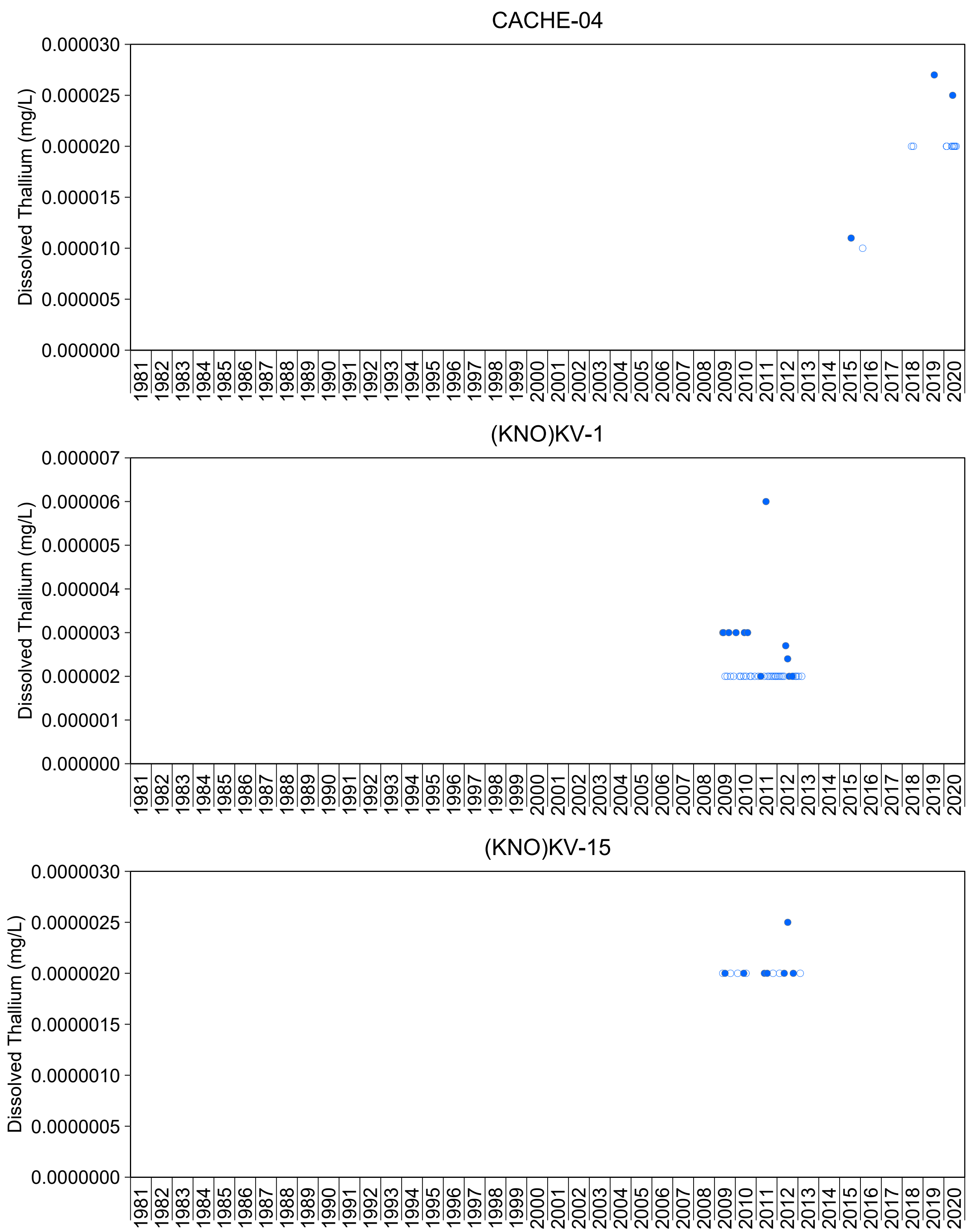


Figure A.82: Time Series Plots of Dissolved Thallium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

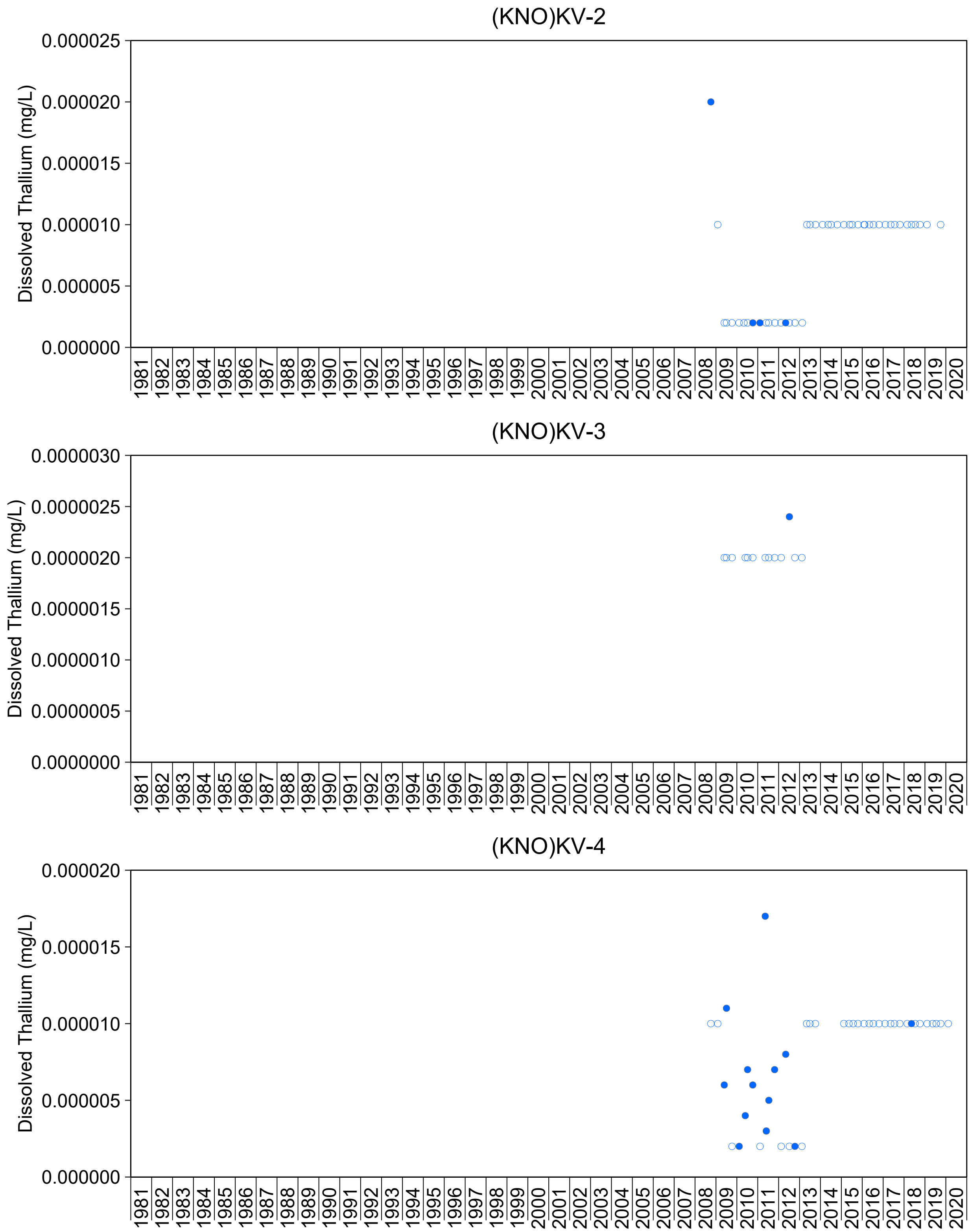


Figure A.82: Time Series Plots of Dissolved Thallium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

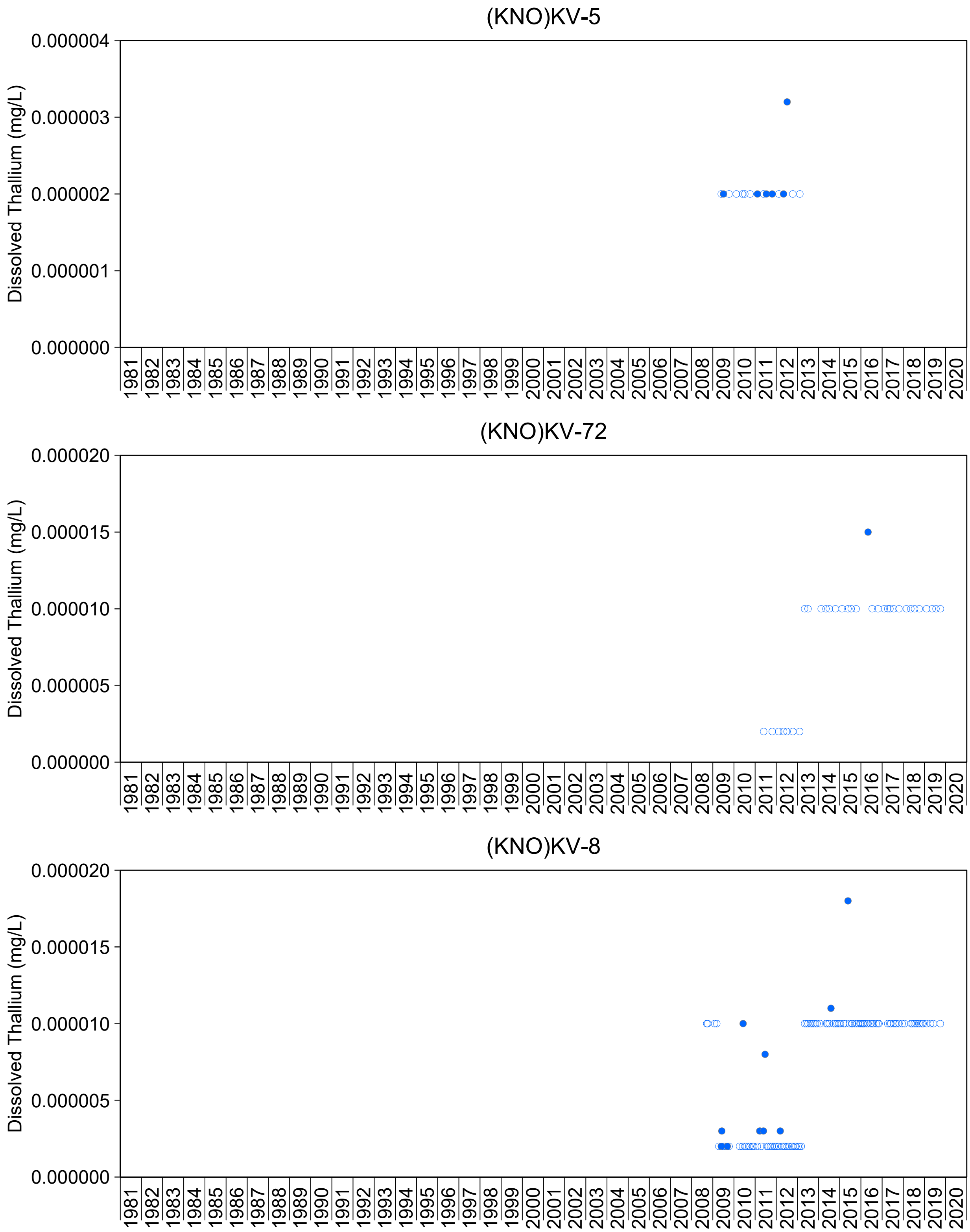


Figure A.82: Time Series Plots of Dissolved Thallium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

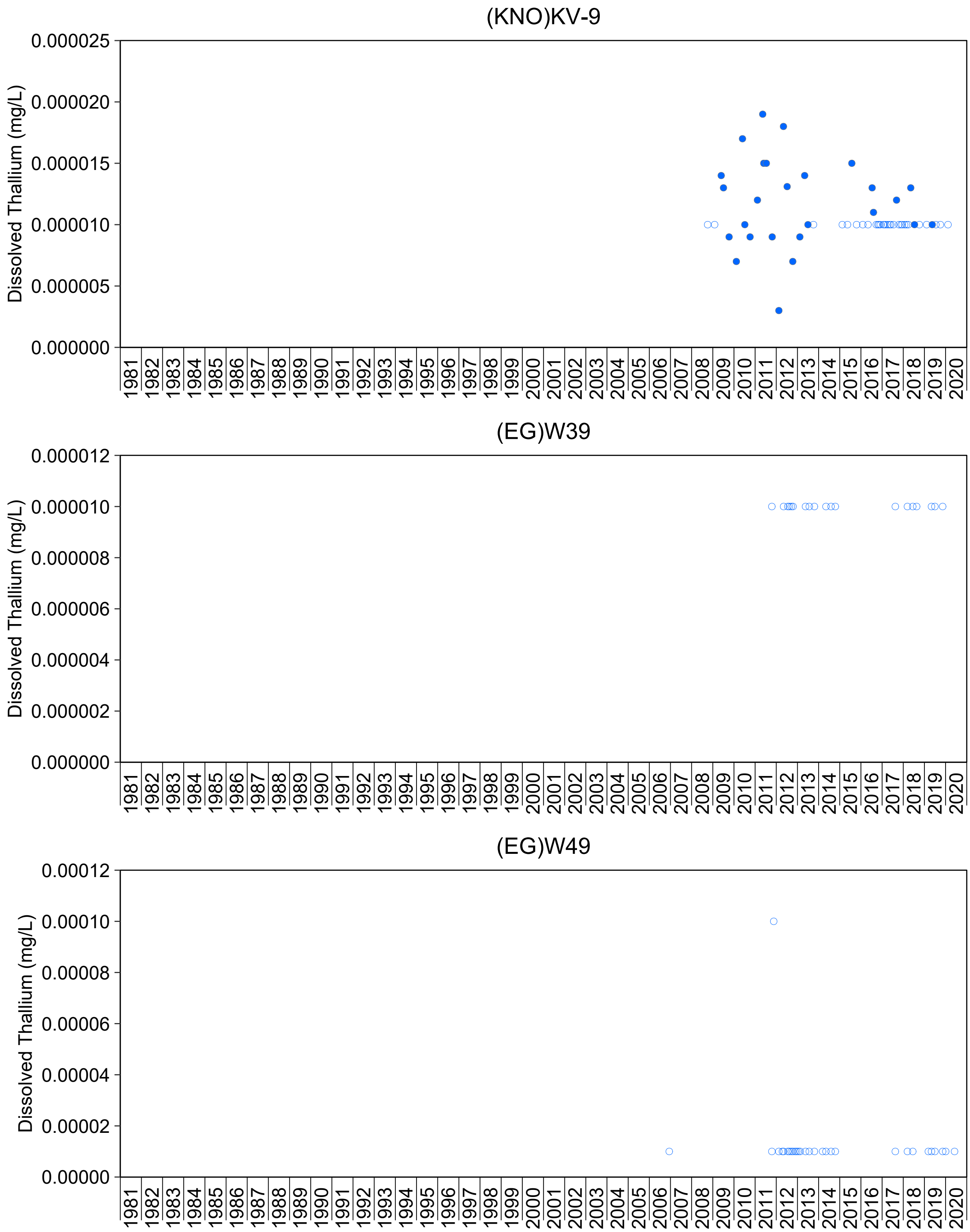


Figure A.82: Time Series Plots of Dissolved Thallium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

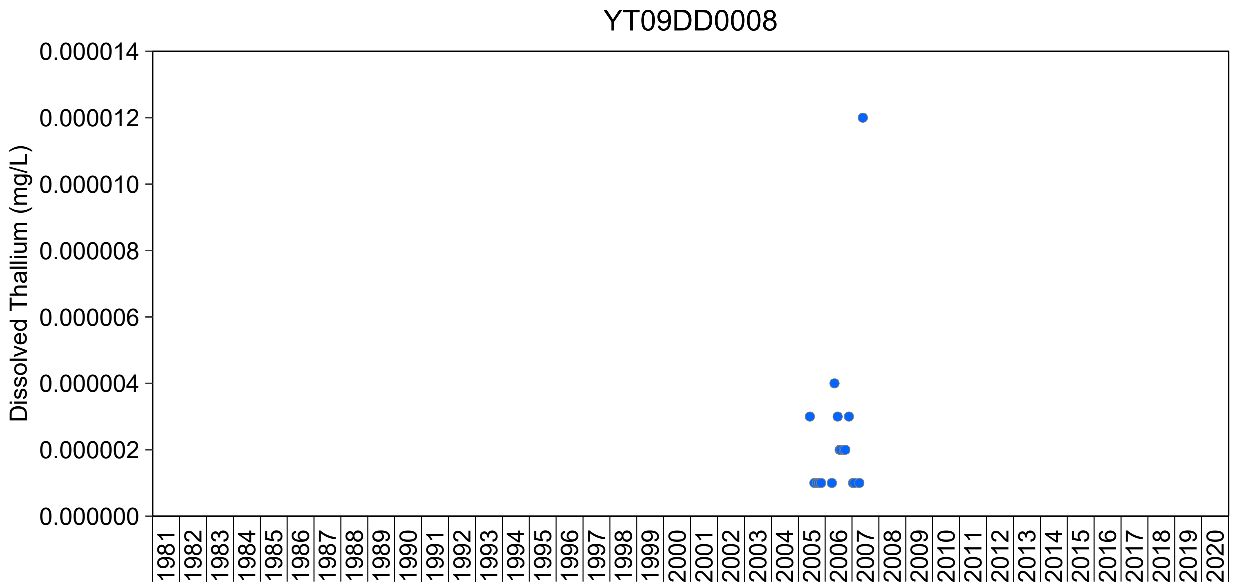


Figure A.82: Time Series Plots of Dissolved Thallium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

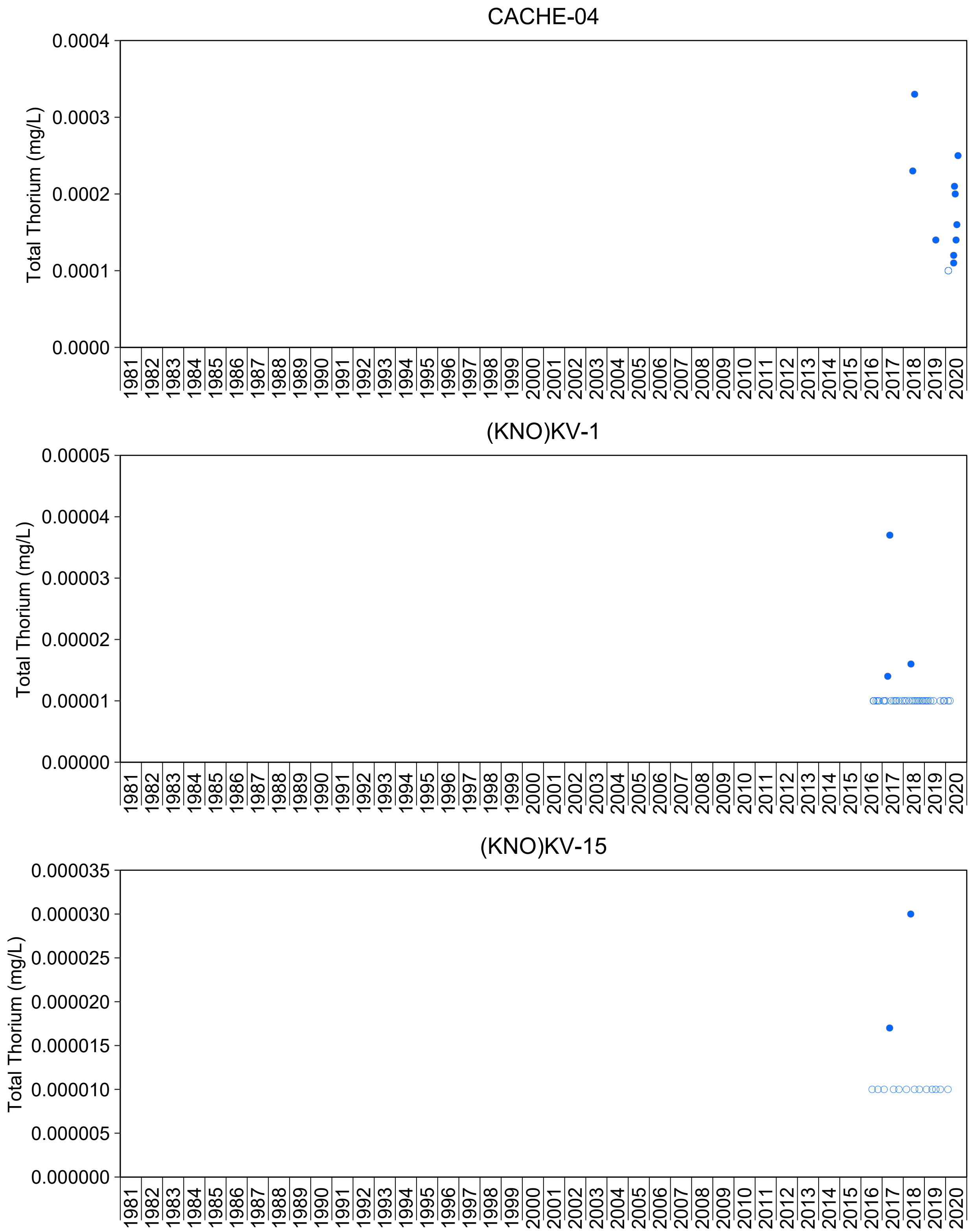


Figure A.83: **Time Series Plots of Total Thorium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020**

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

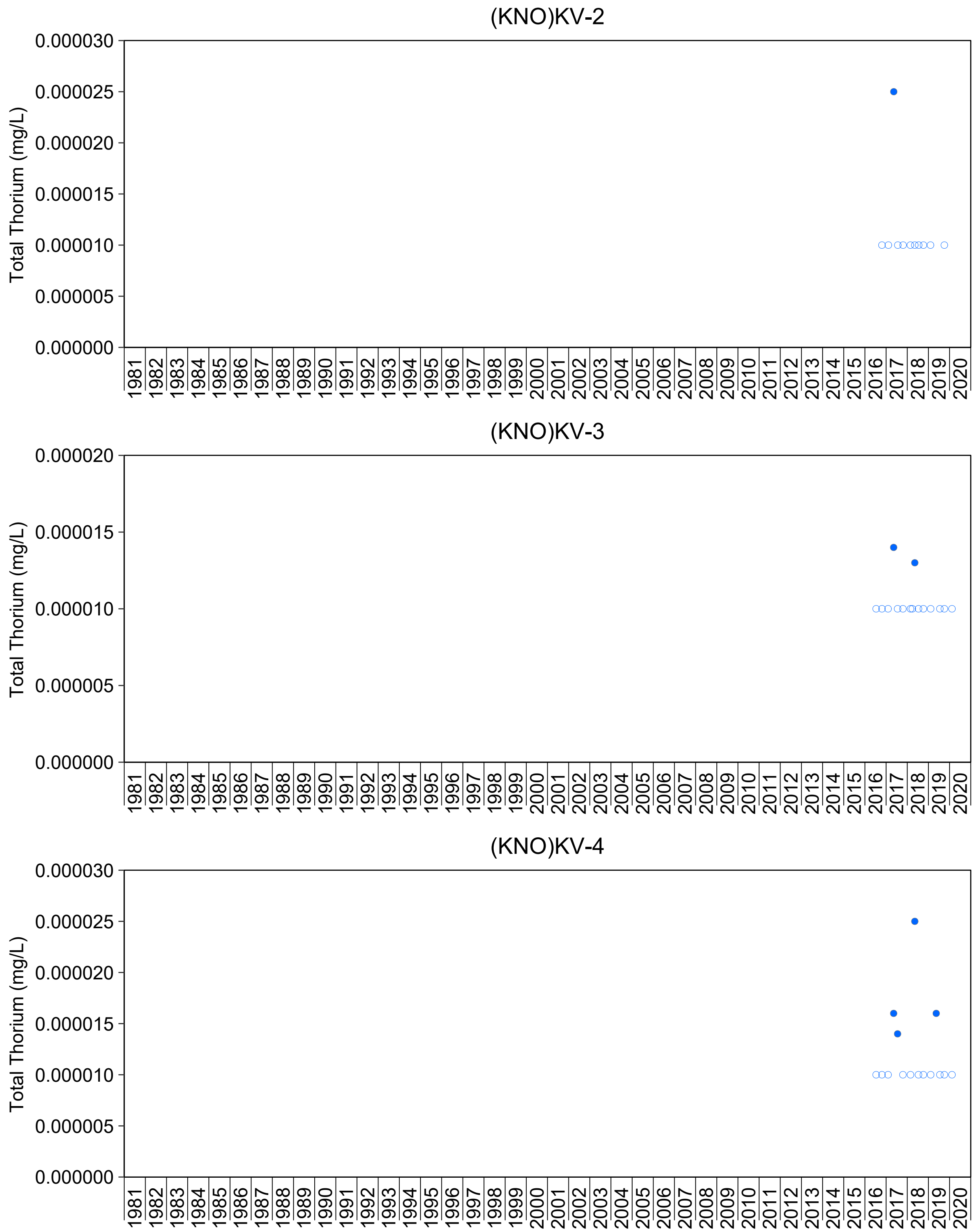


Figure A.83: Time Series Plots of Total Thorium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

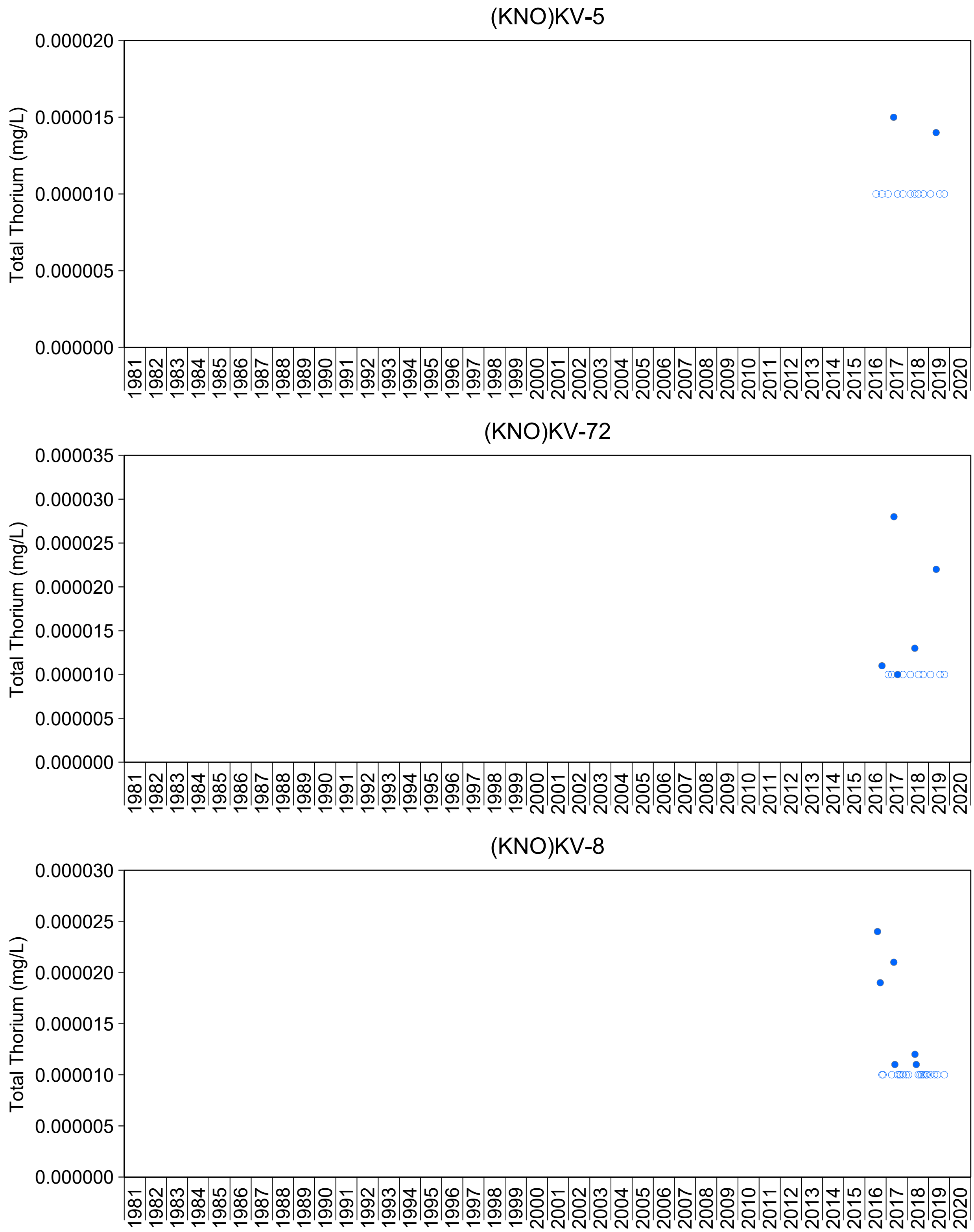
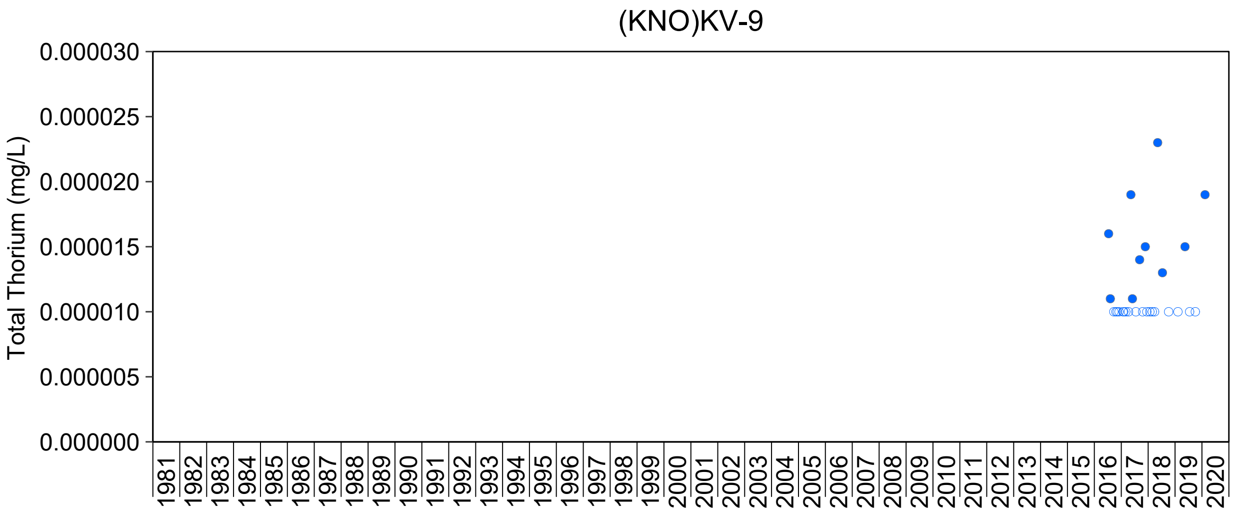
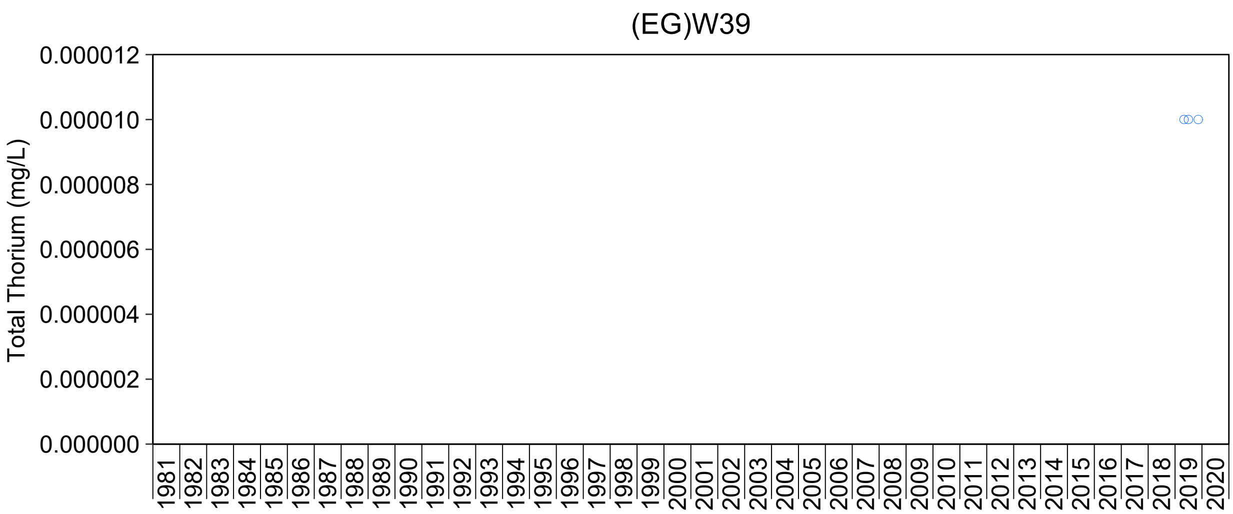


Figure A.83: Time Series Plots of Total Thorium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.





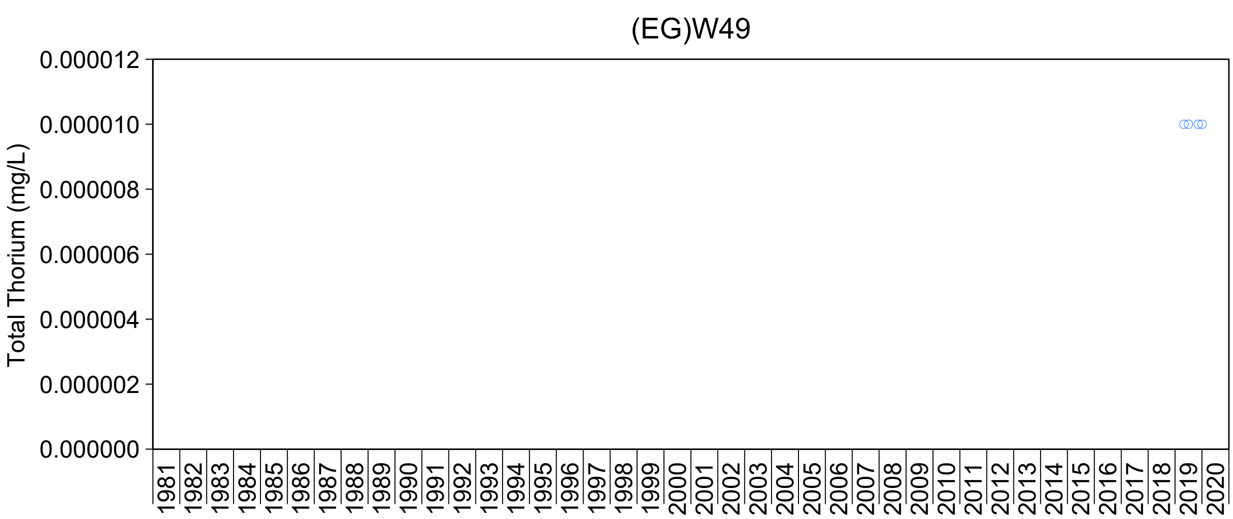


Figure A.83: Time Series Plots of Total Thorium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

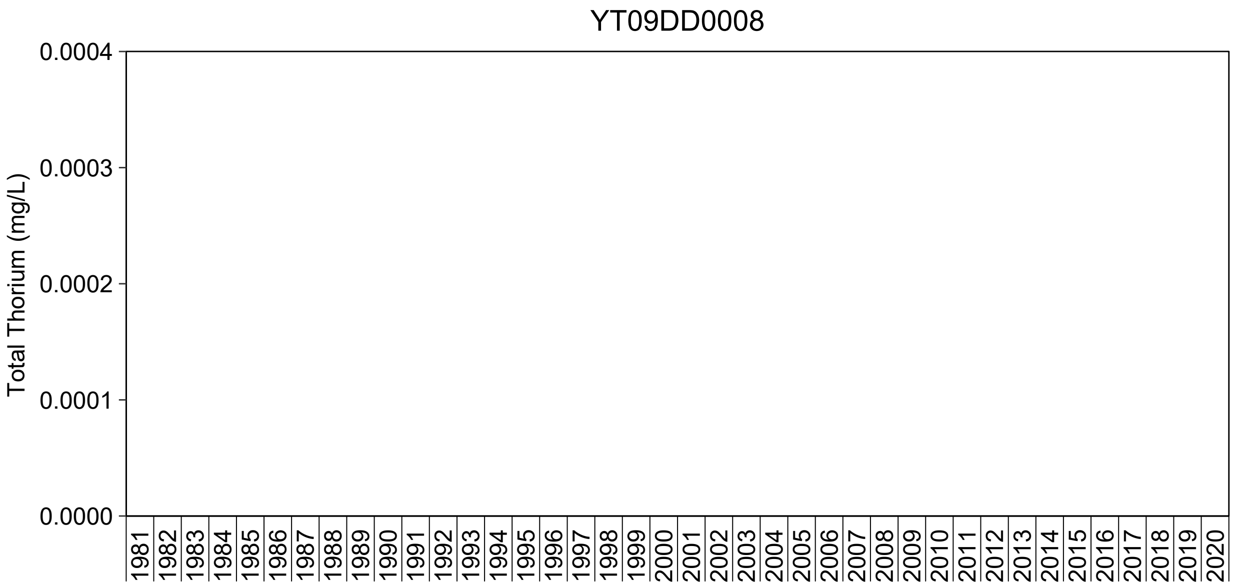


Figure A.83: Time Series Plots of Total Thorium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

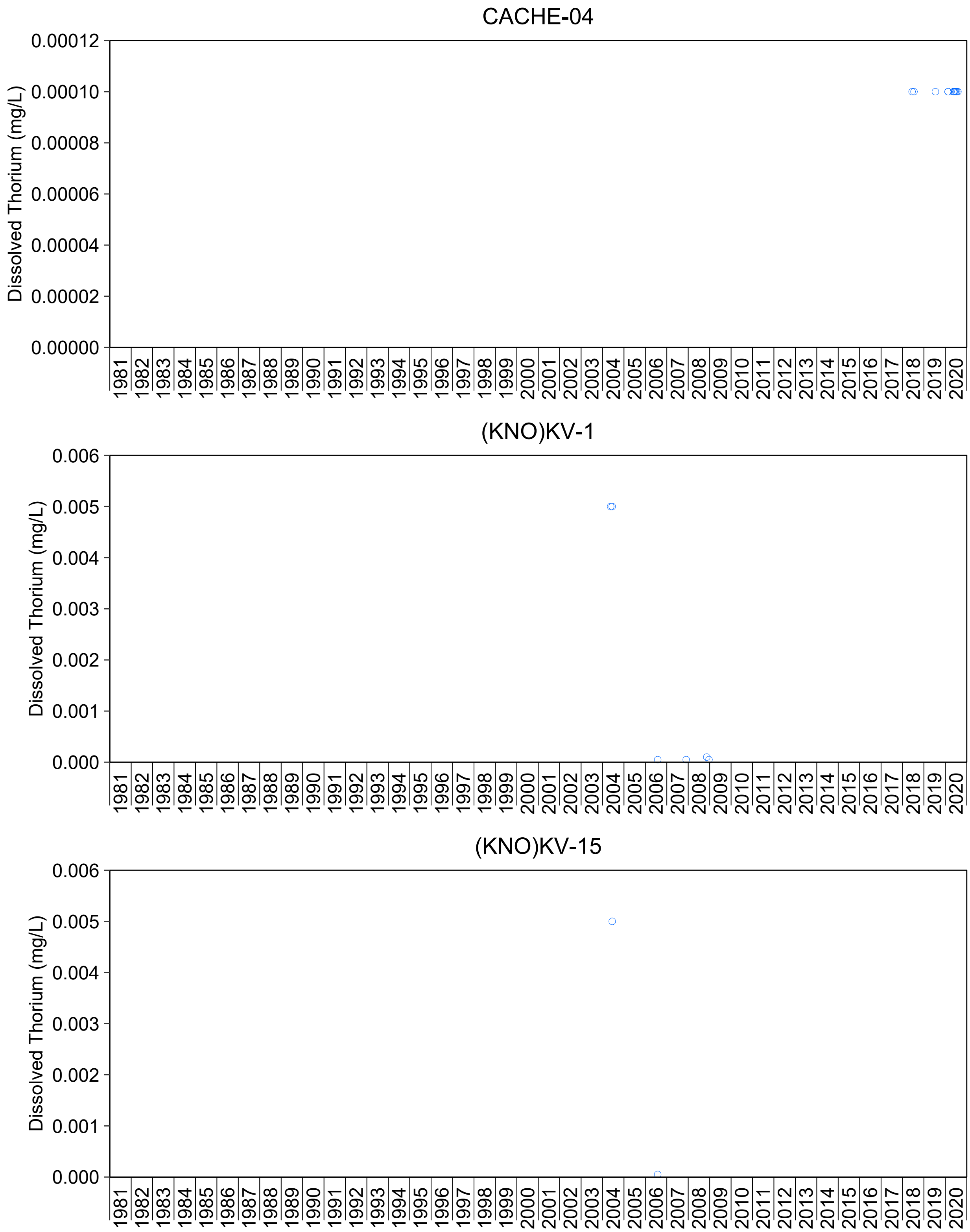
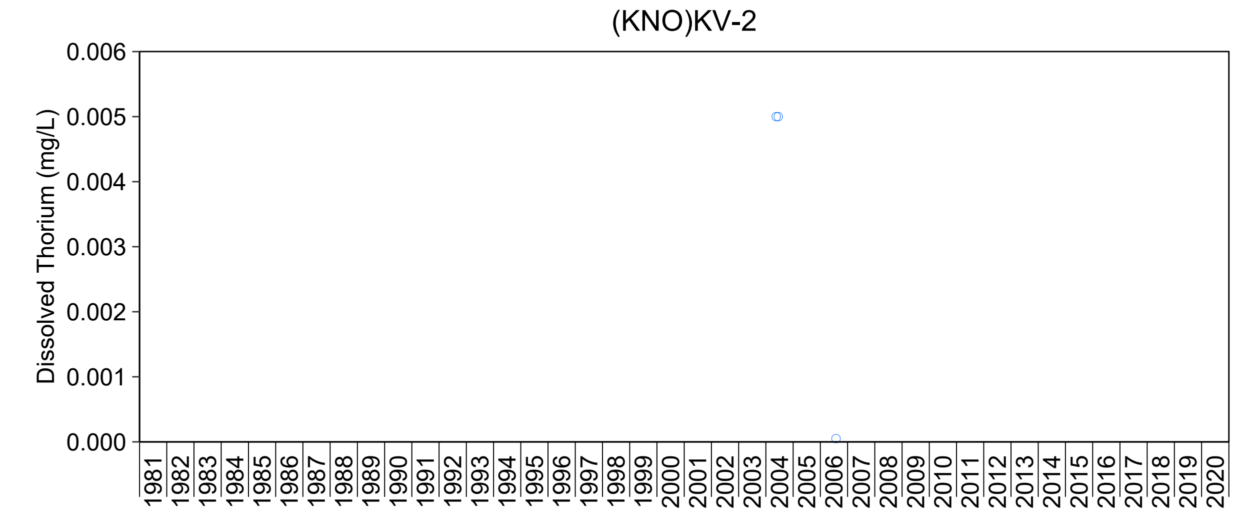
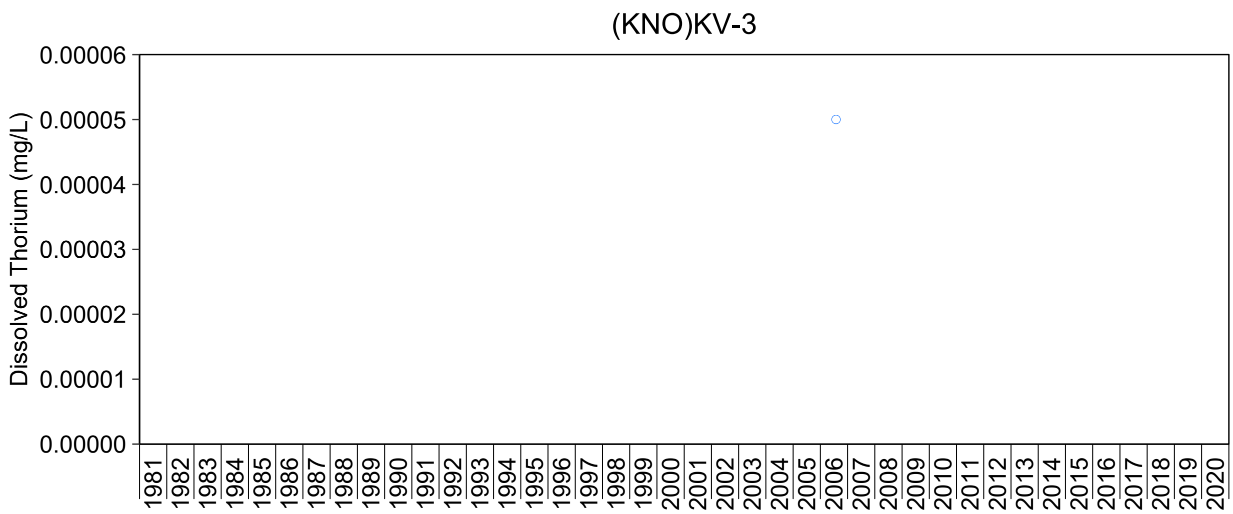


Figure A.84: Time Series Plots of Dissolved Thorium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.





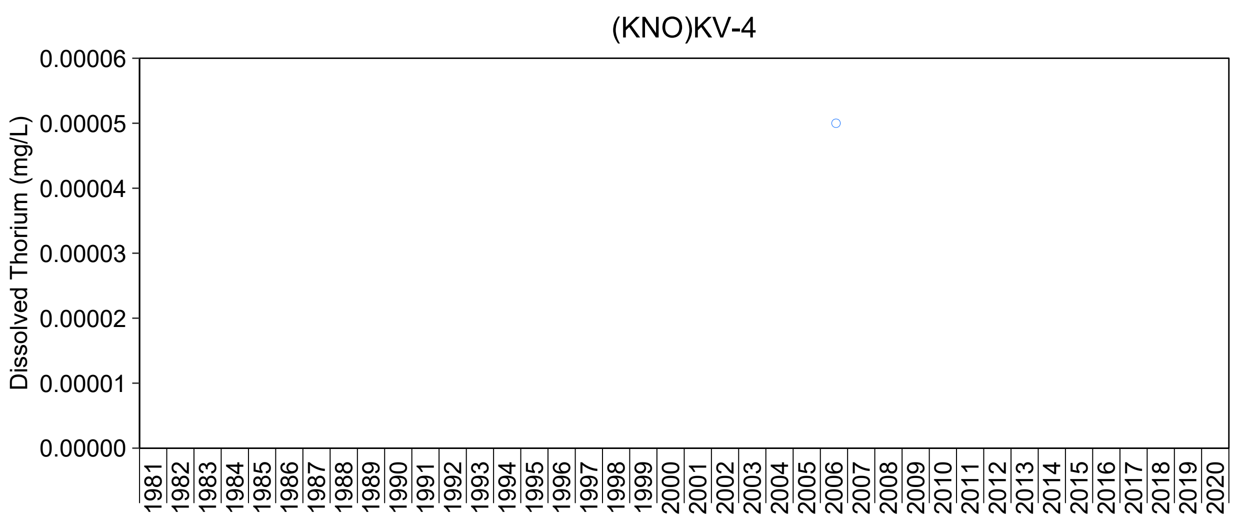


Figure A.84: Time Series Plots of Dissolved Thorium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

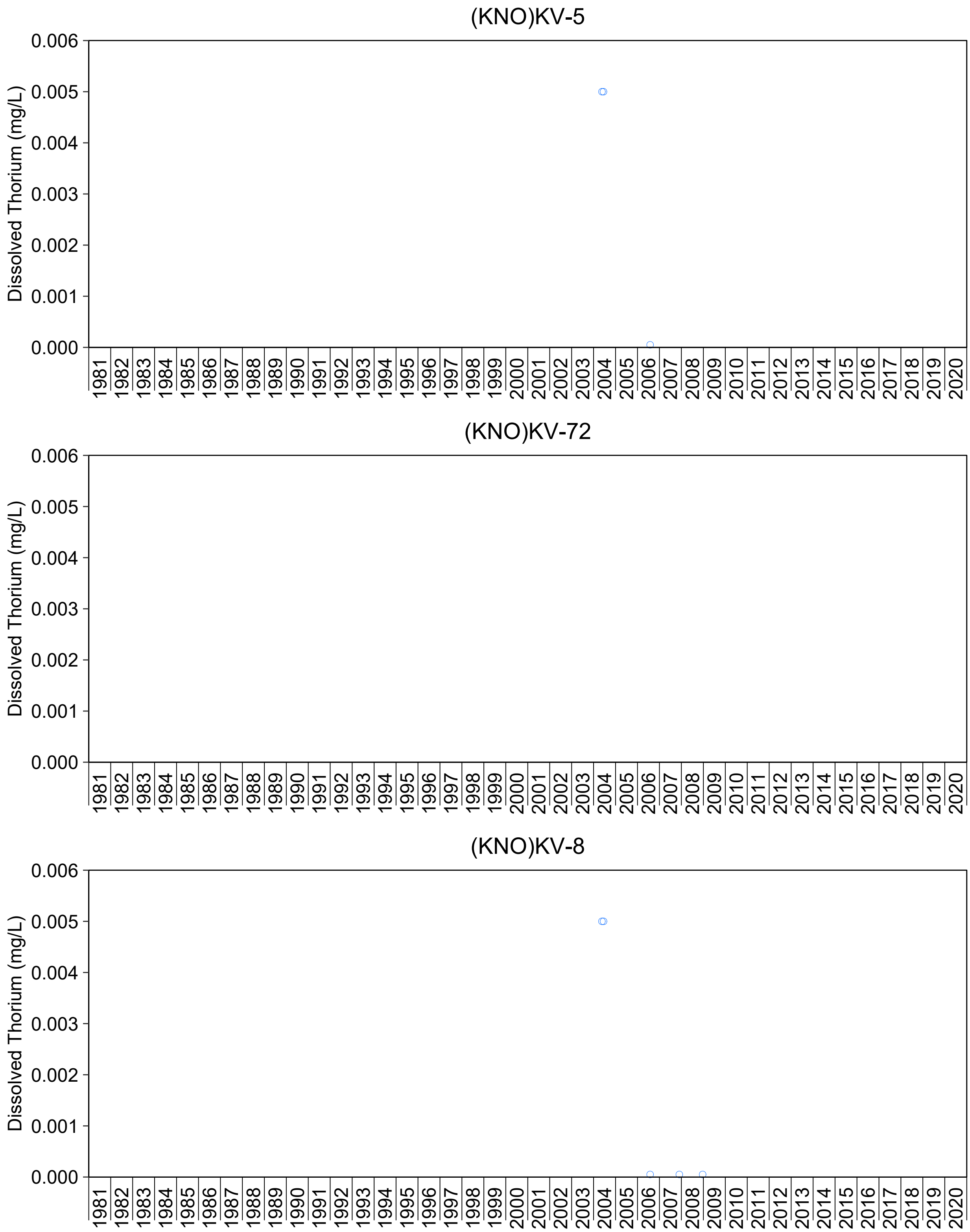


Figure A.84: Time Series Plots of Dissolved Thorium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

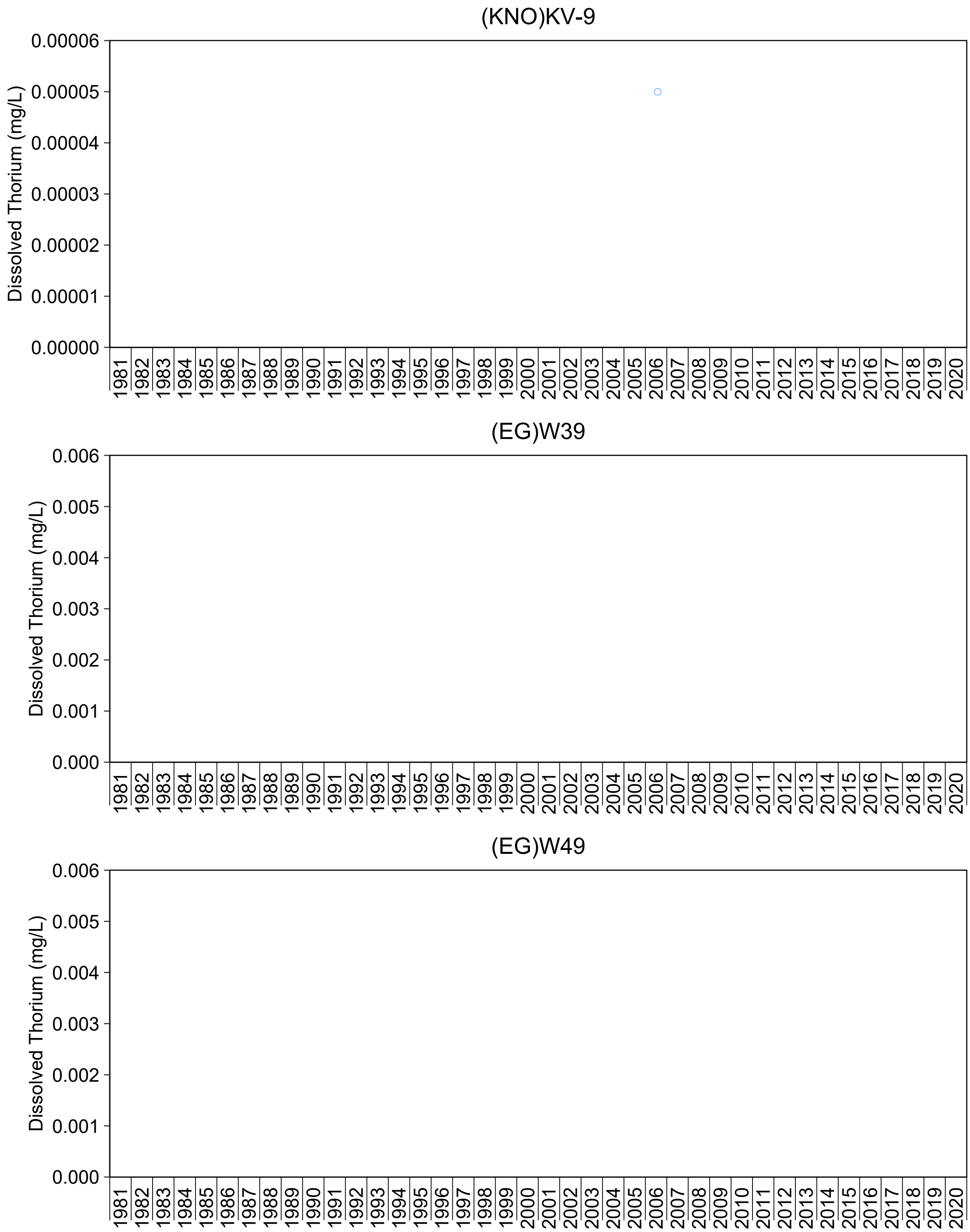


Figure A.84: Time Series Plots of Dissolved Thorium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

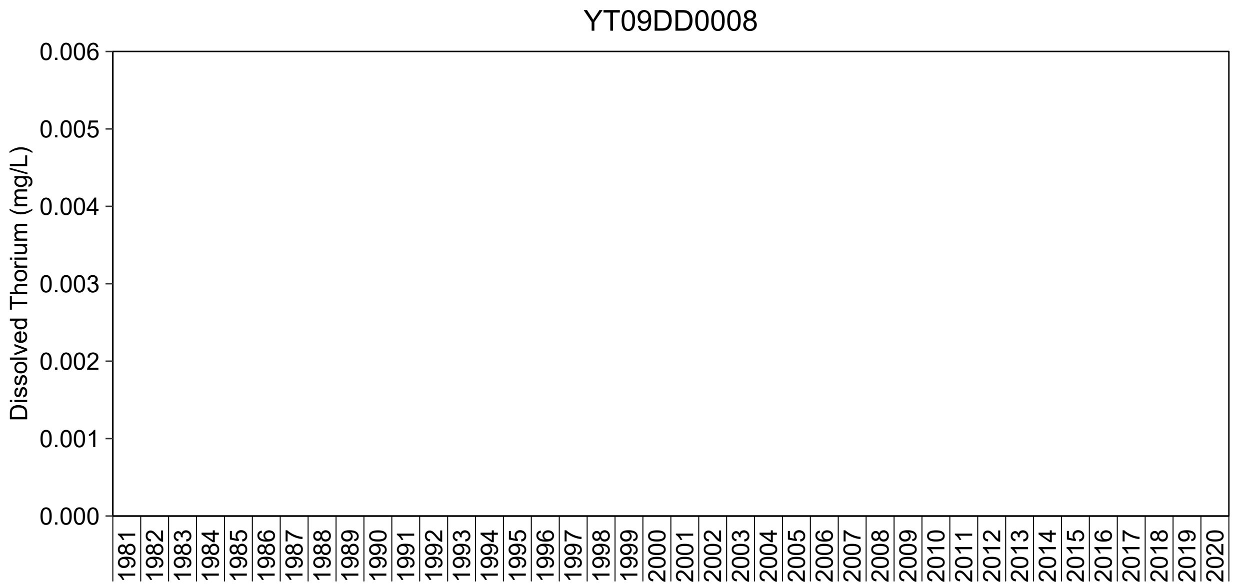


Figure A.84: Time Series Plots of Dissolved Thorium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

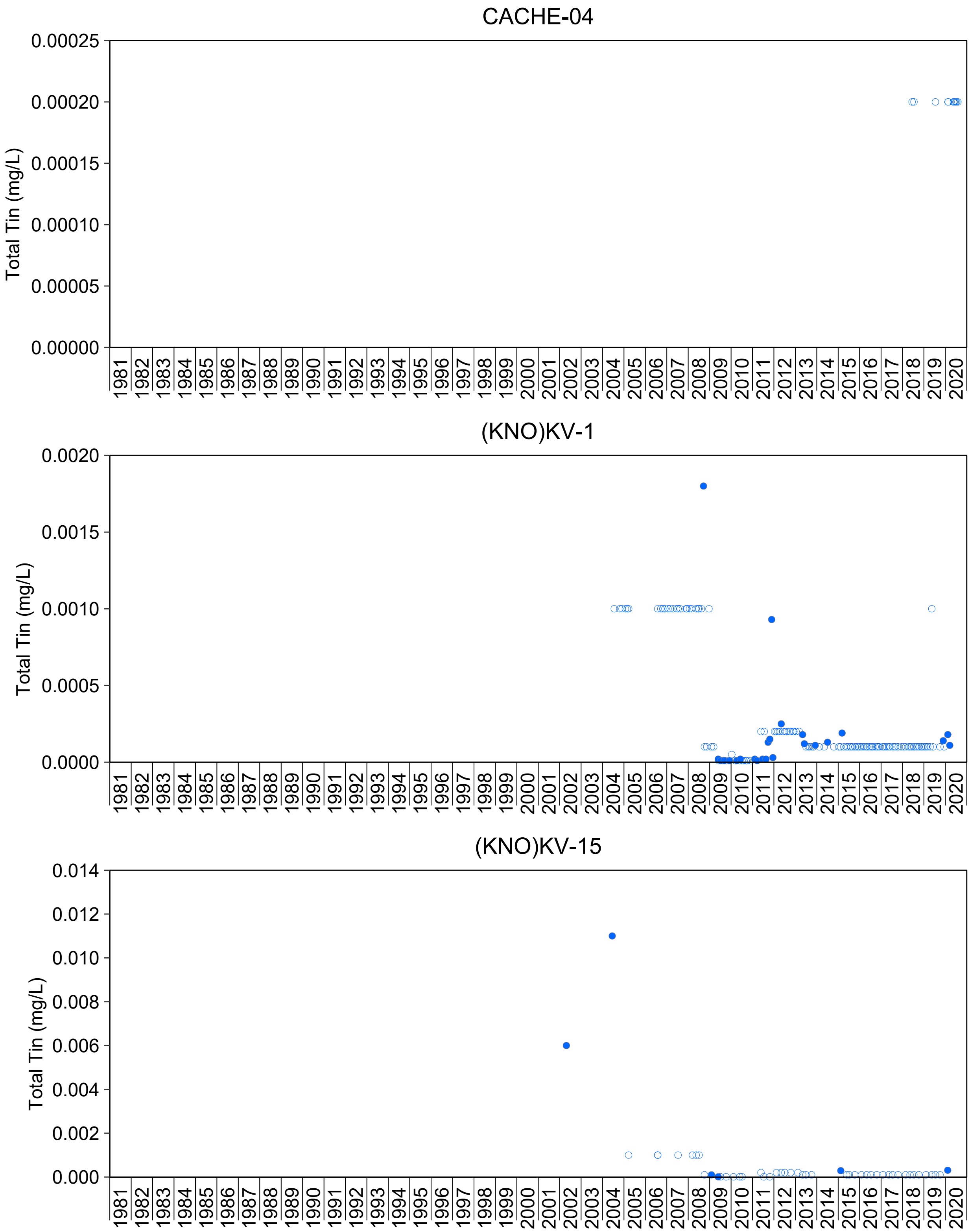


Figure A.85: Time Series Plots of Total Tin Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

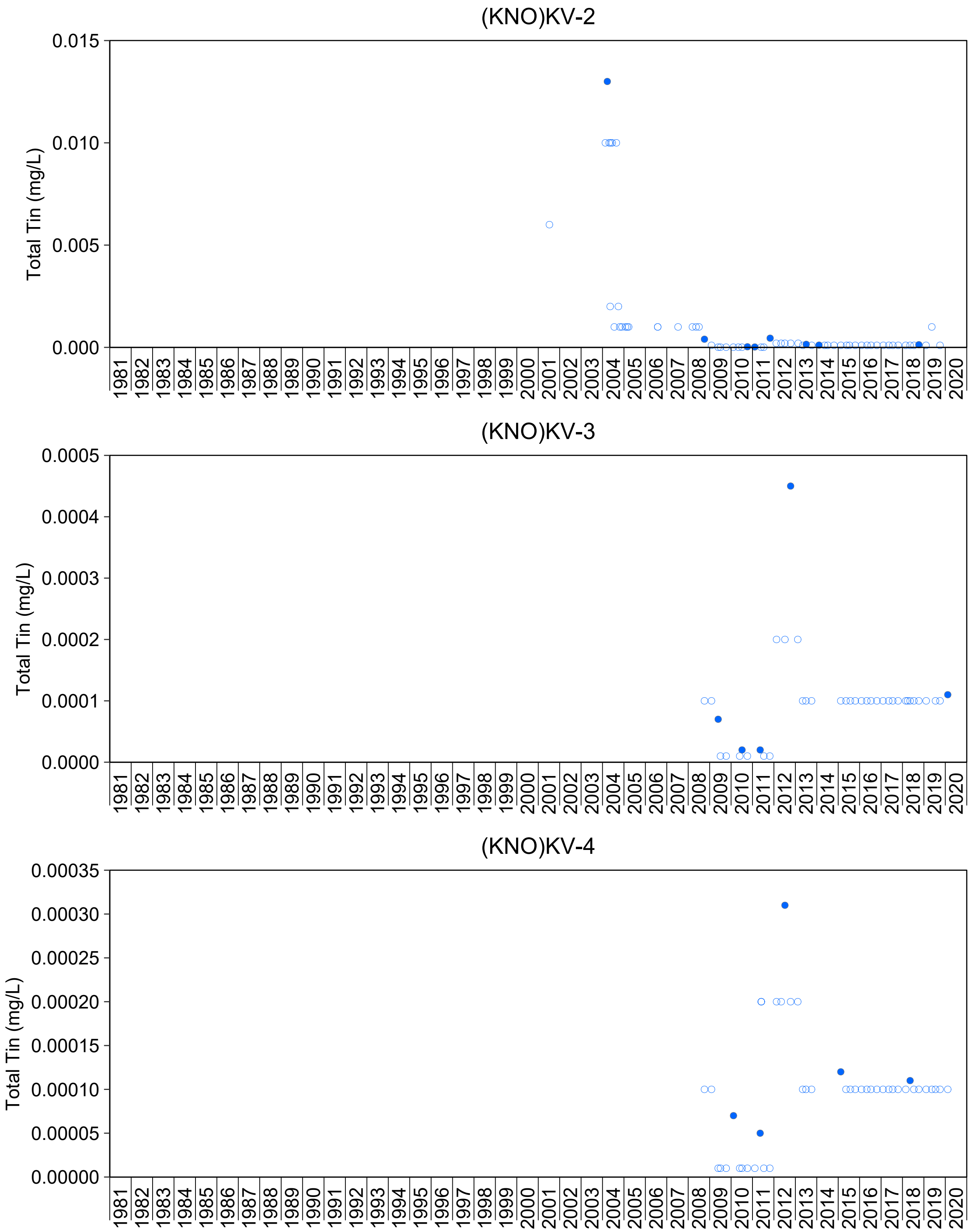


Figure A.85: Time Series Plots of Total Tin Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

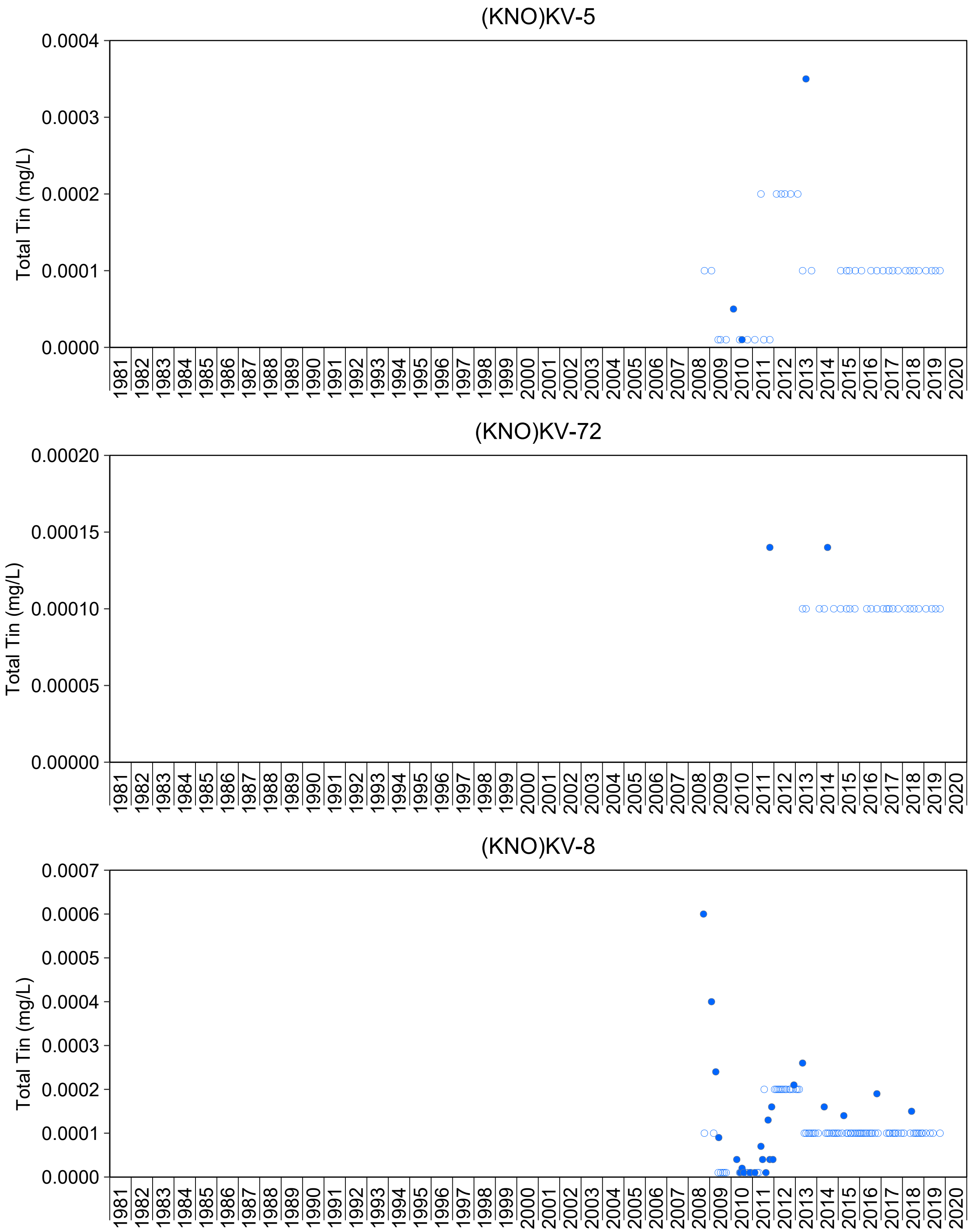


Figure A.85: Time Series Plots of Total Tin Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

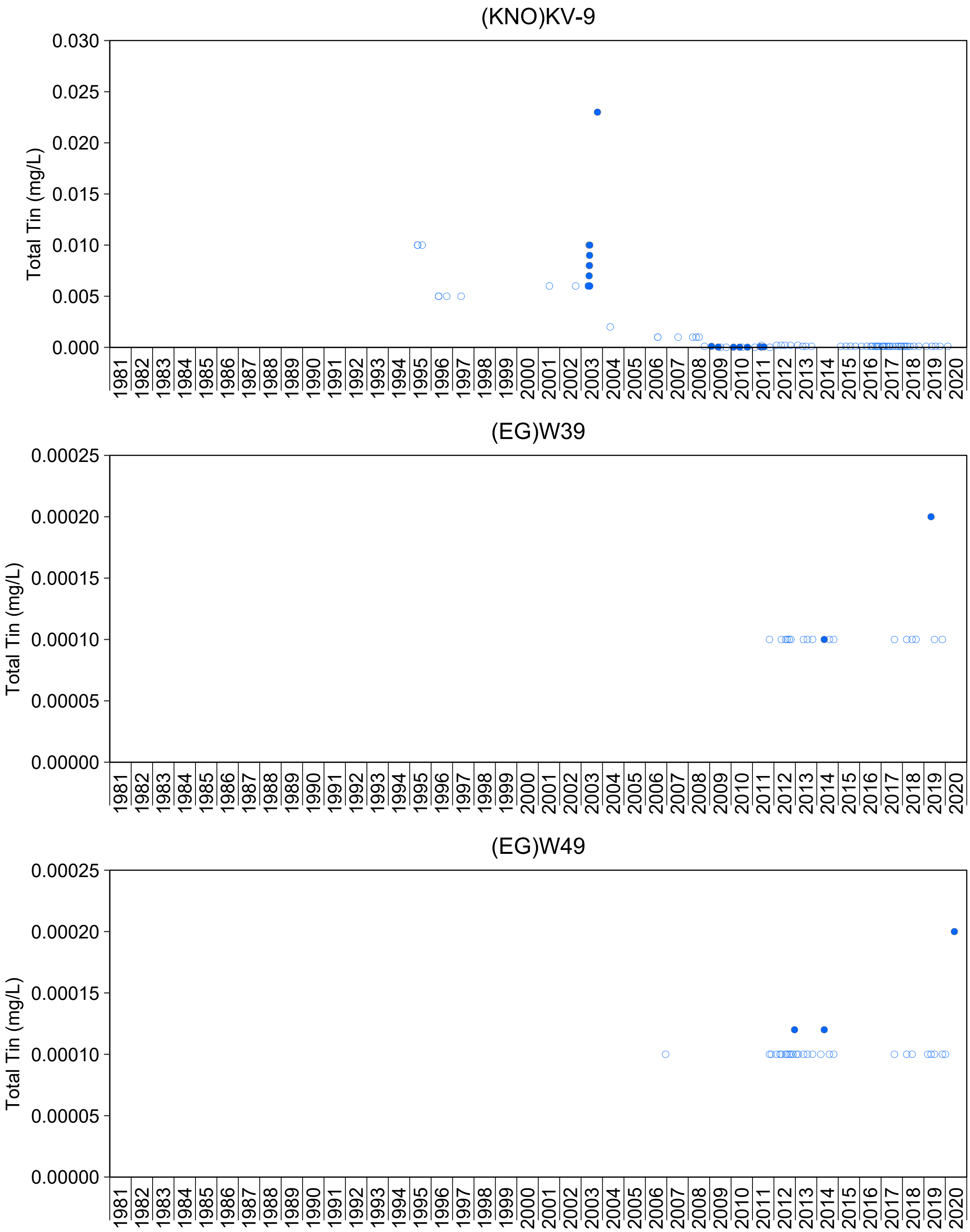


Figure A.85: Time Series Plots of Total Tin Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

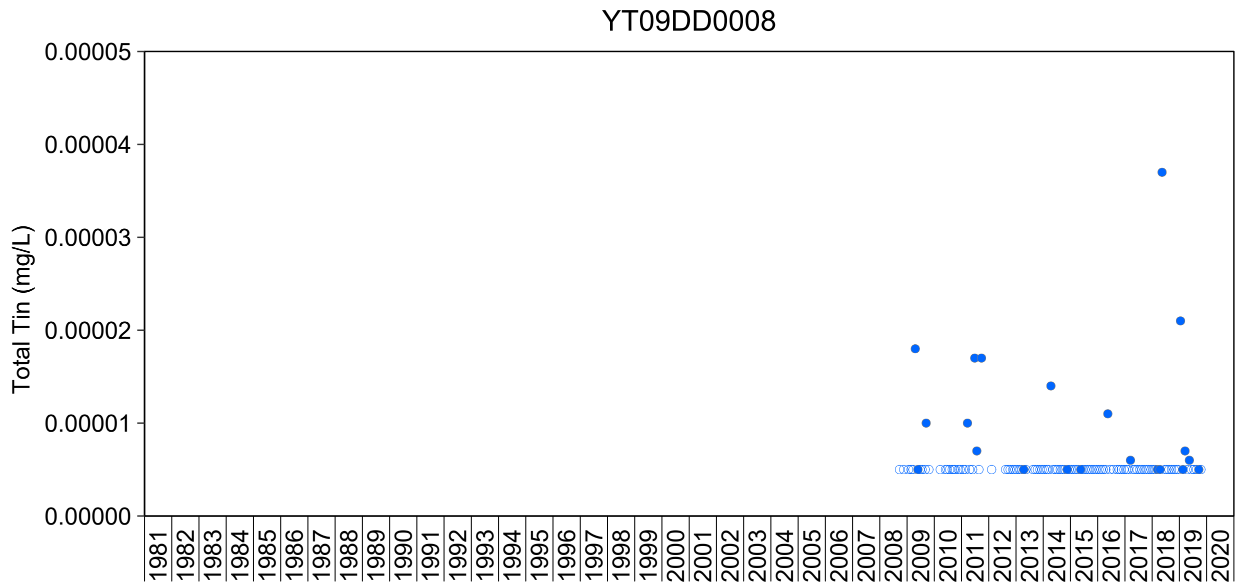


Figure A.85: Time Series Plots of Total Tin Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

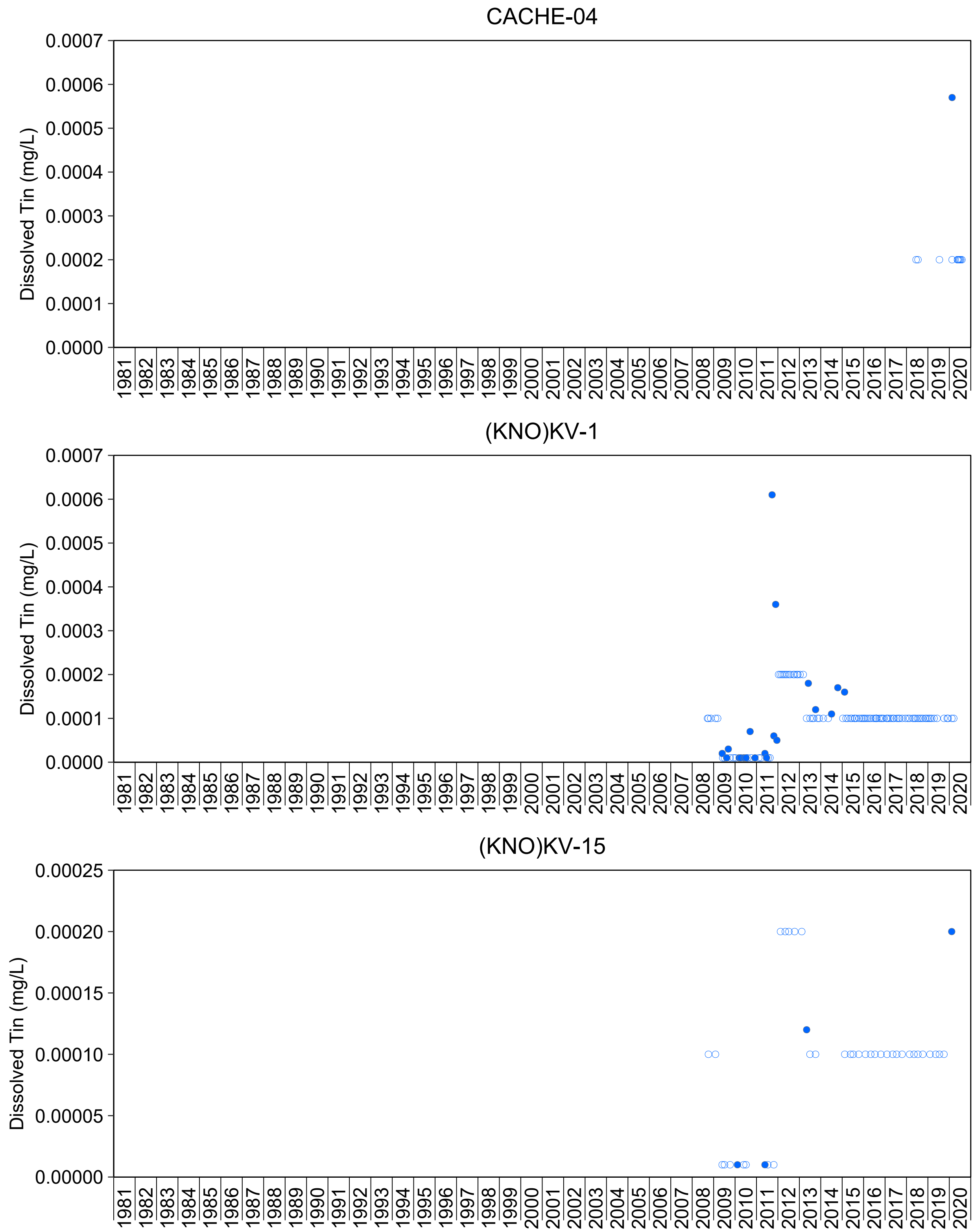


Figure A.86: Time Series Plots of Dissolved Tin Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

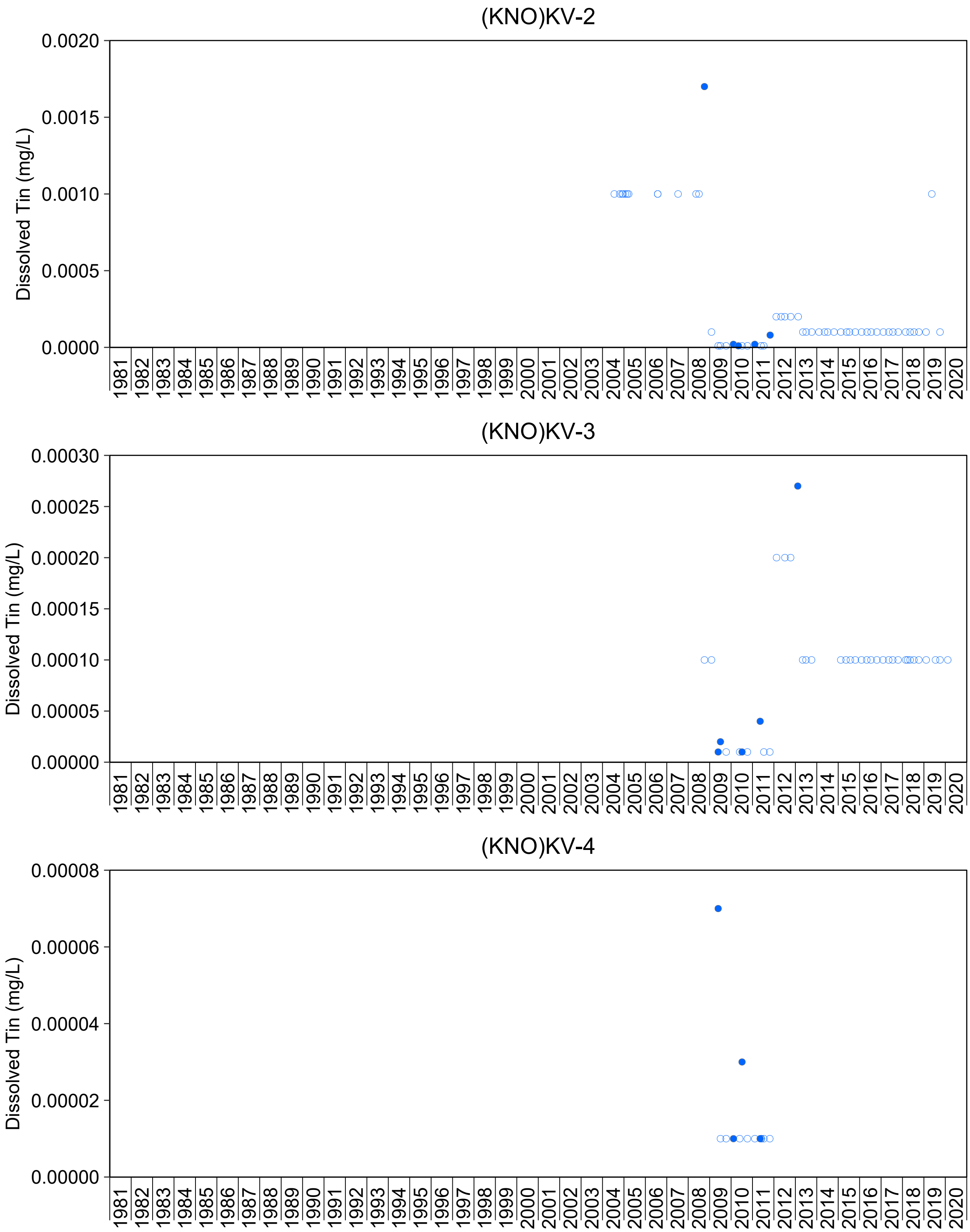


Figure A.86: Time Series Plots of Dissolved Tin Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

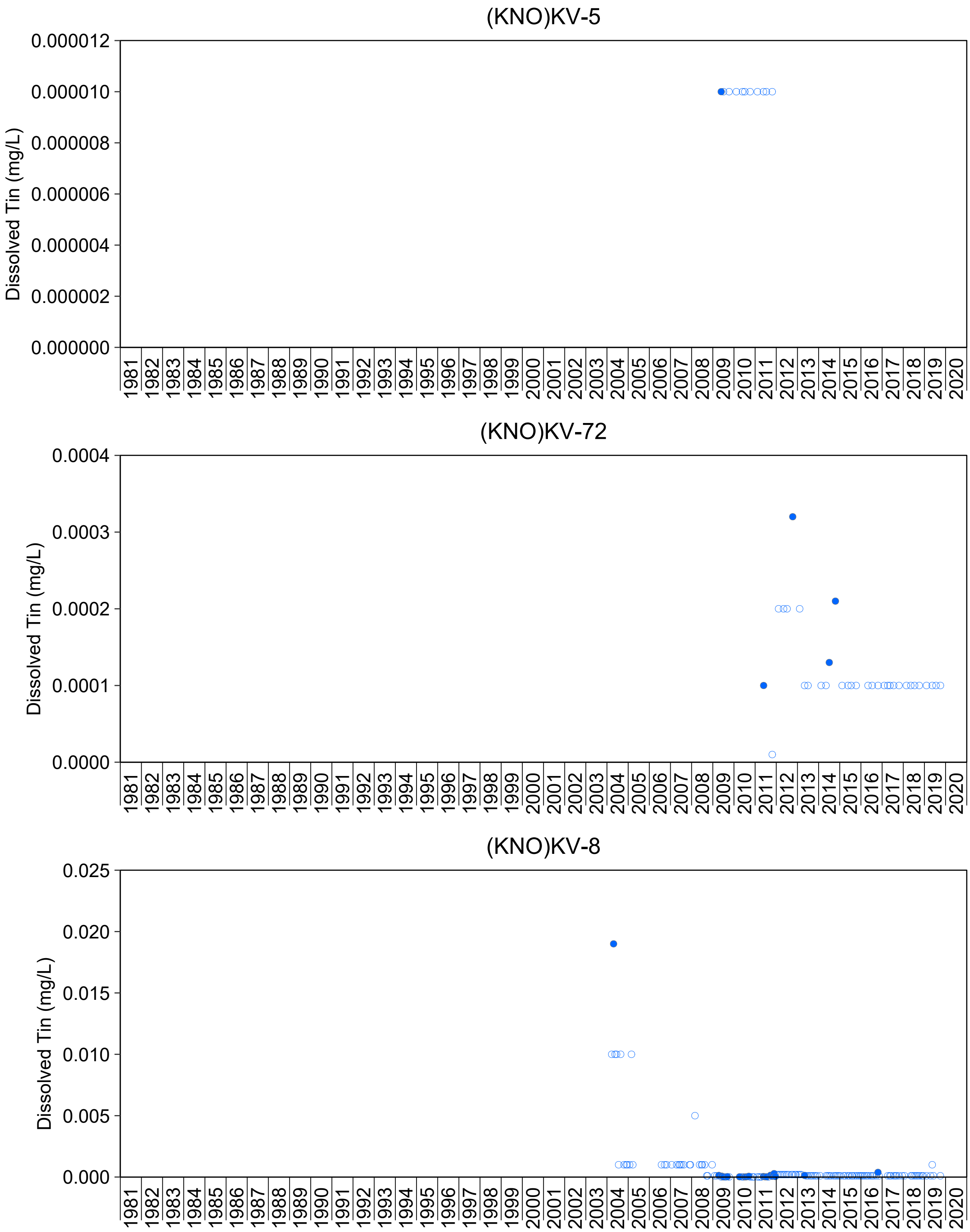


Figure A.86: Time Series Plots of Dissolved Tin Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

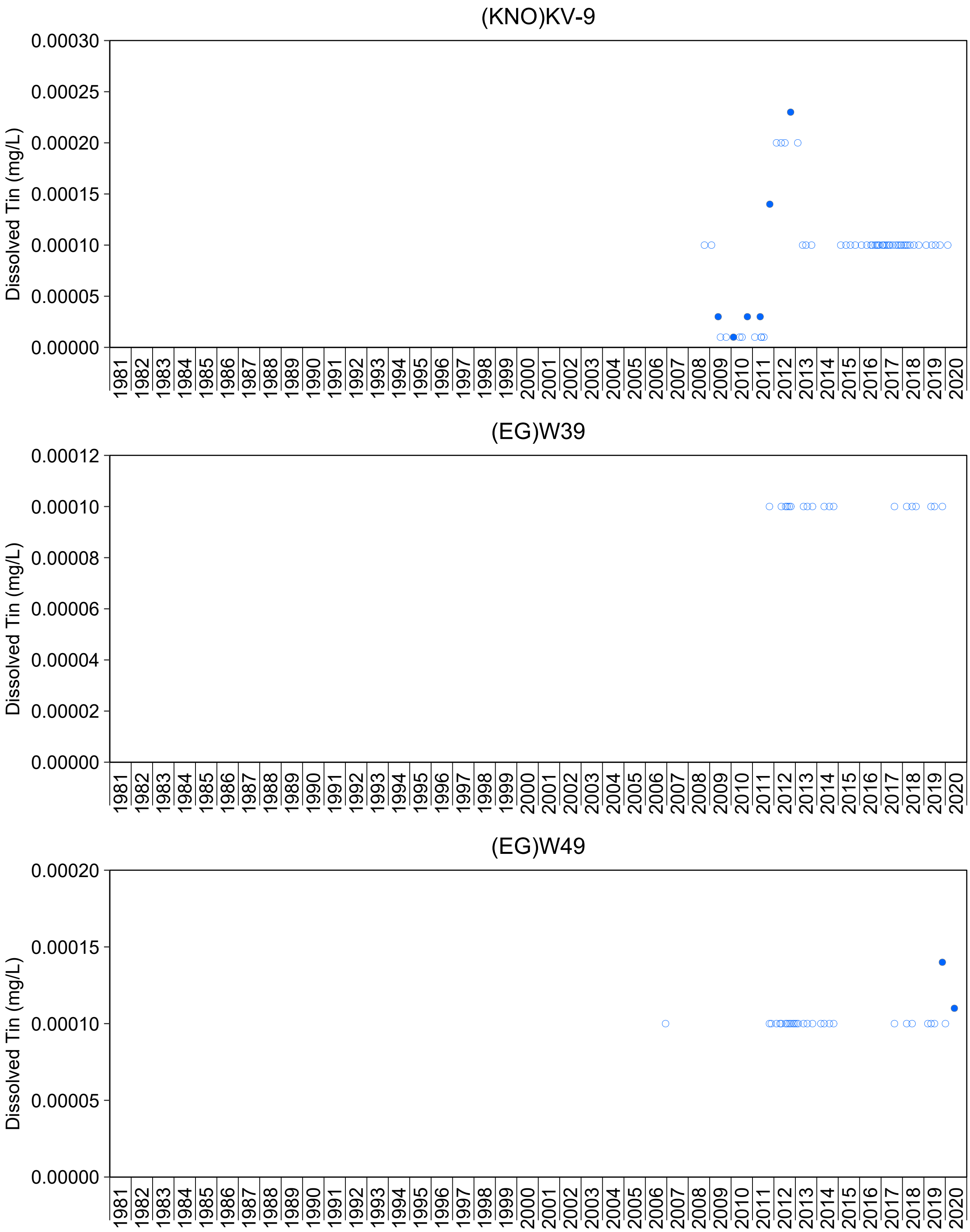


Figure A.86: Time Series Plots of Dissolved Tin Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

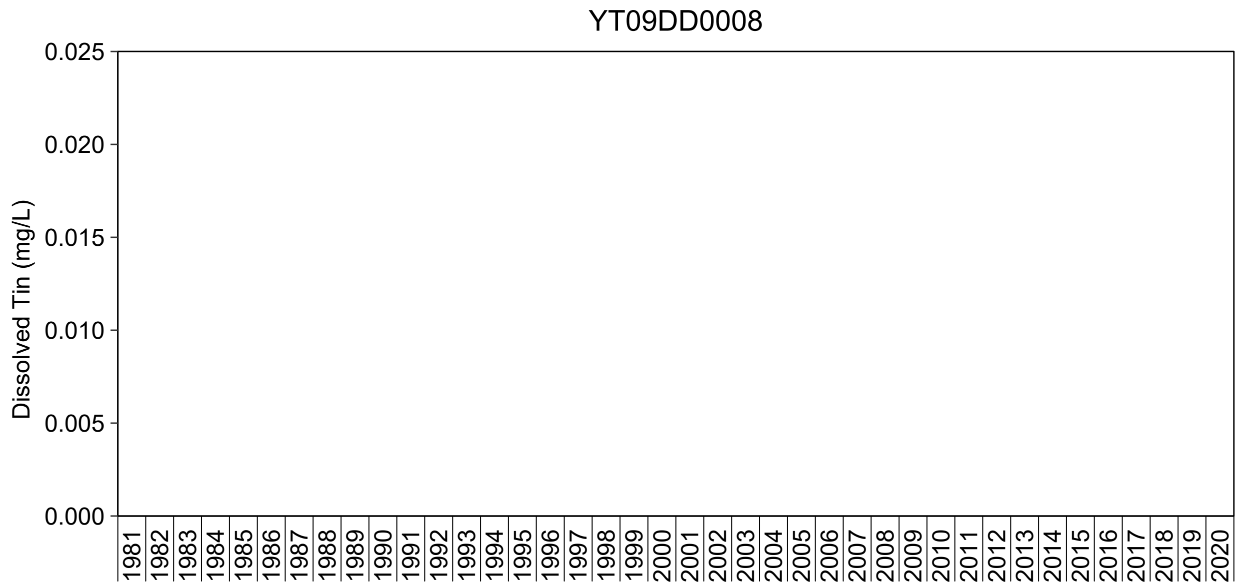


Figure A.86: Time Series Plots of Dissolved Tin Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

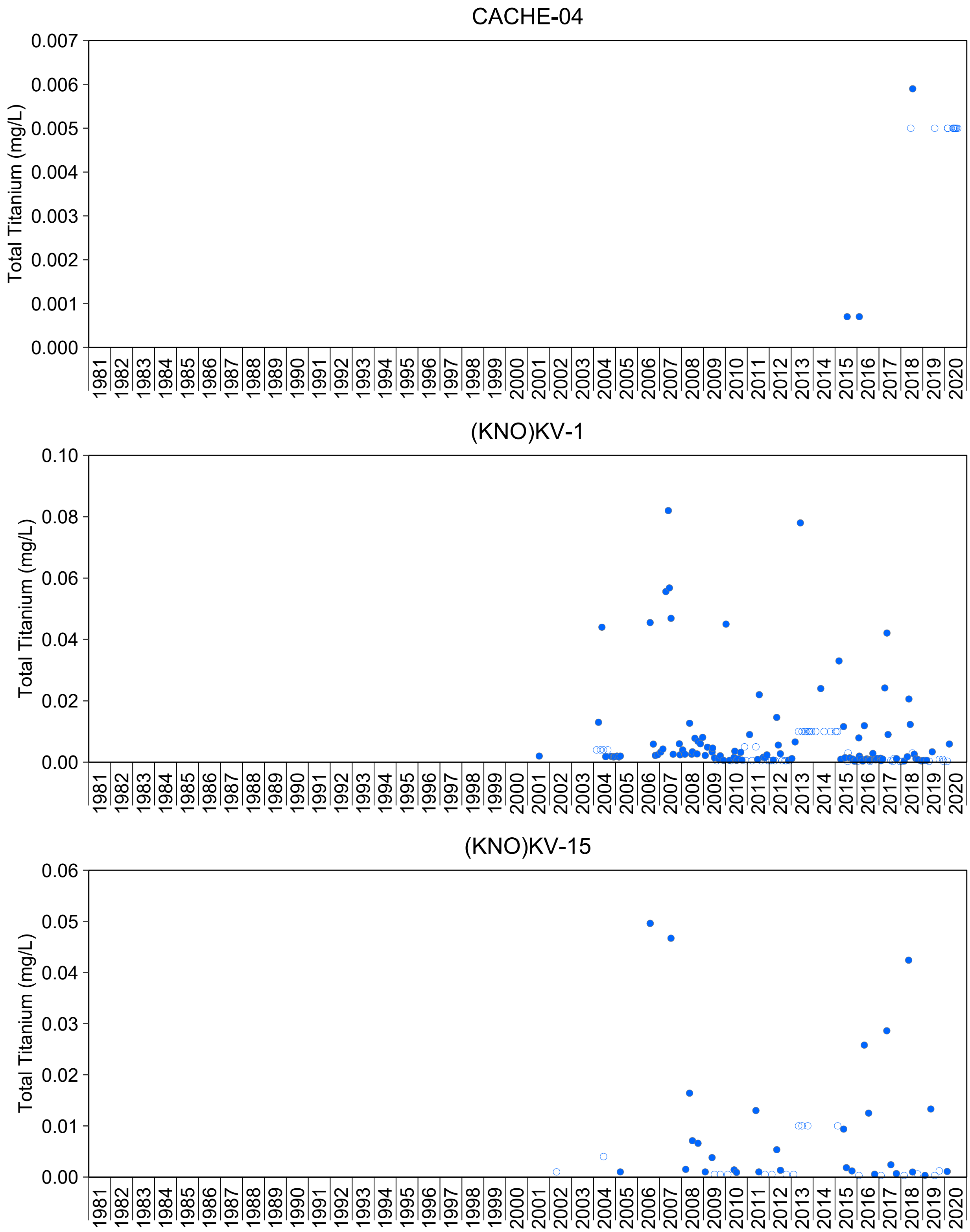


Figure A.87: Time Series Plots for Total Titanium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

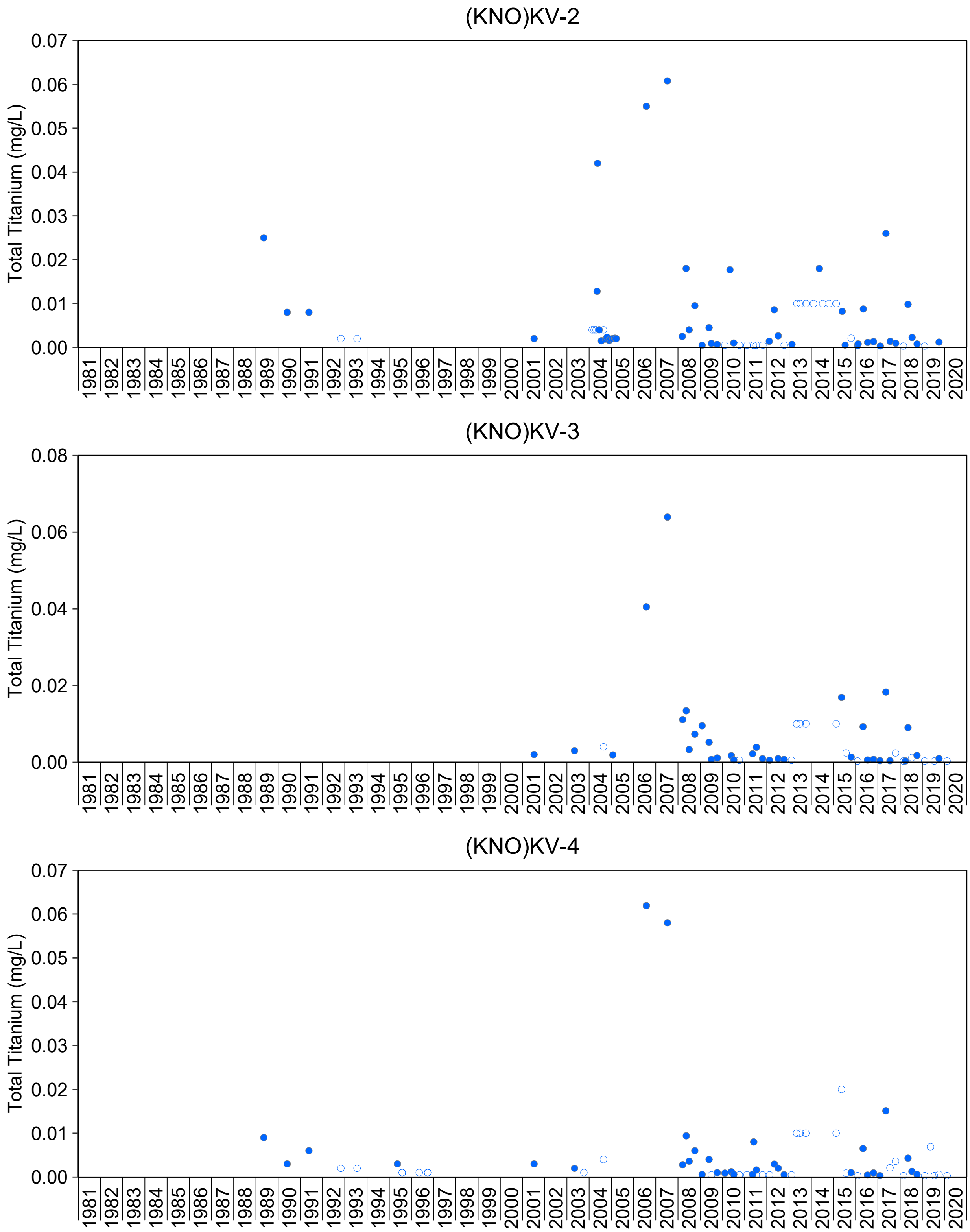


Figure A.87: Time Series Plots for Total Titanium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

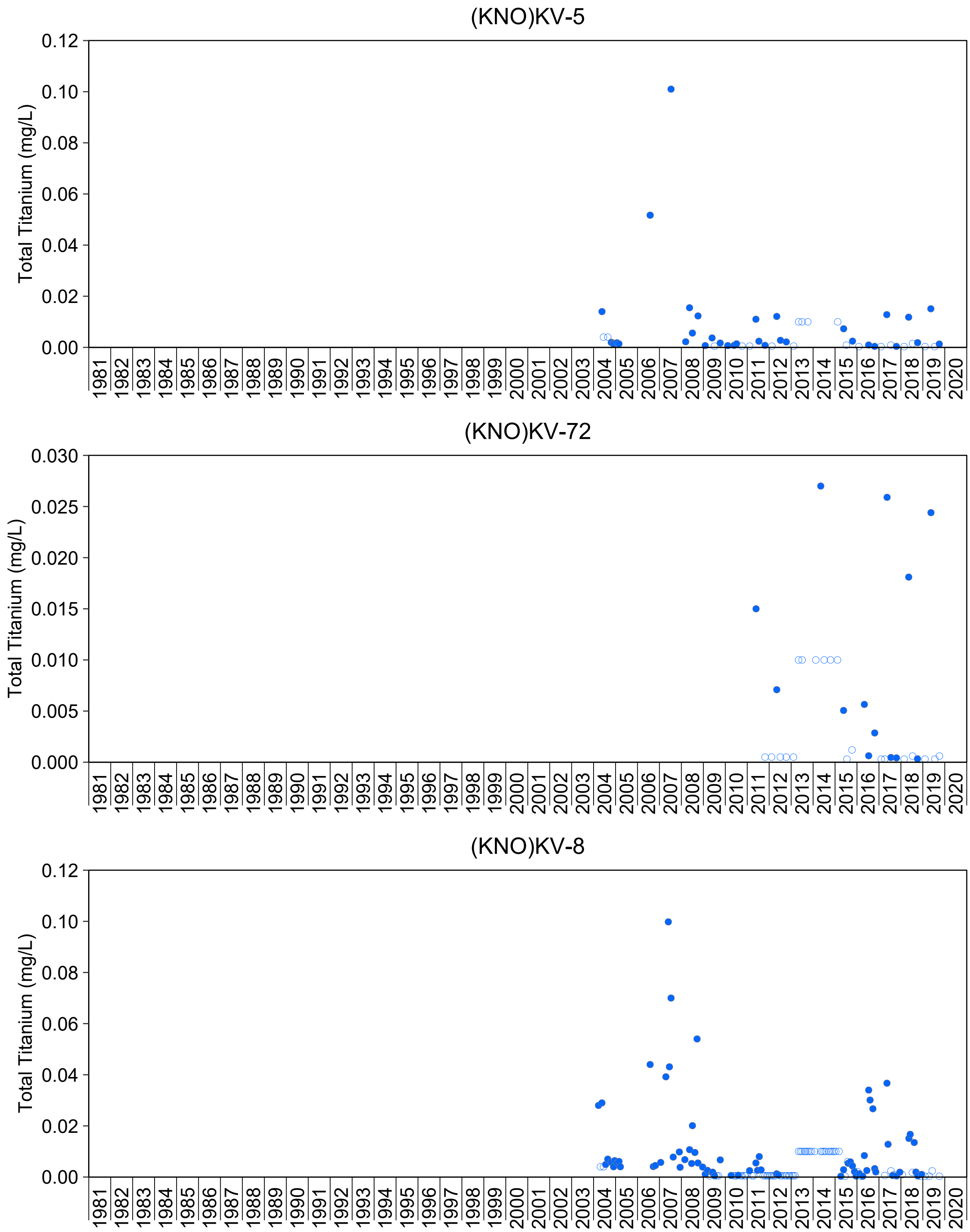


Figure A.87: Time Series Plots for Total Titanium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

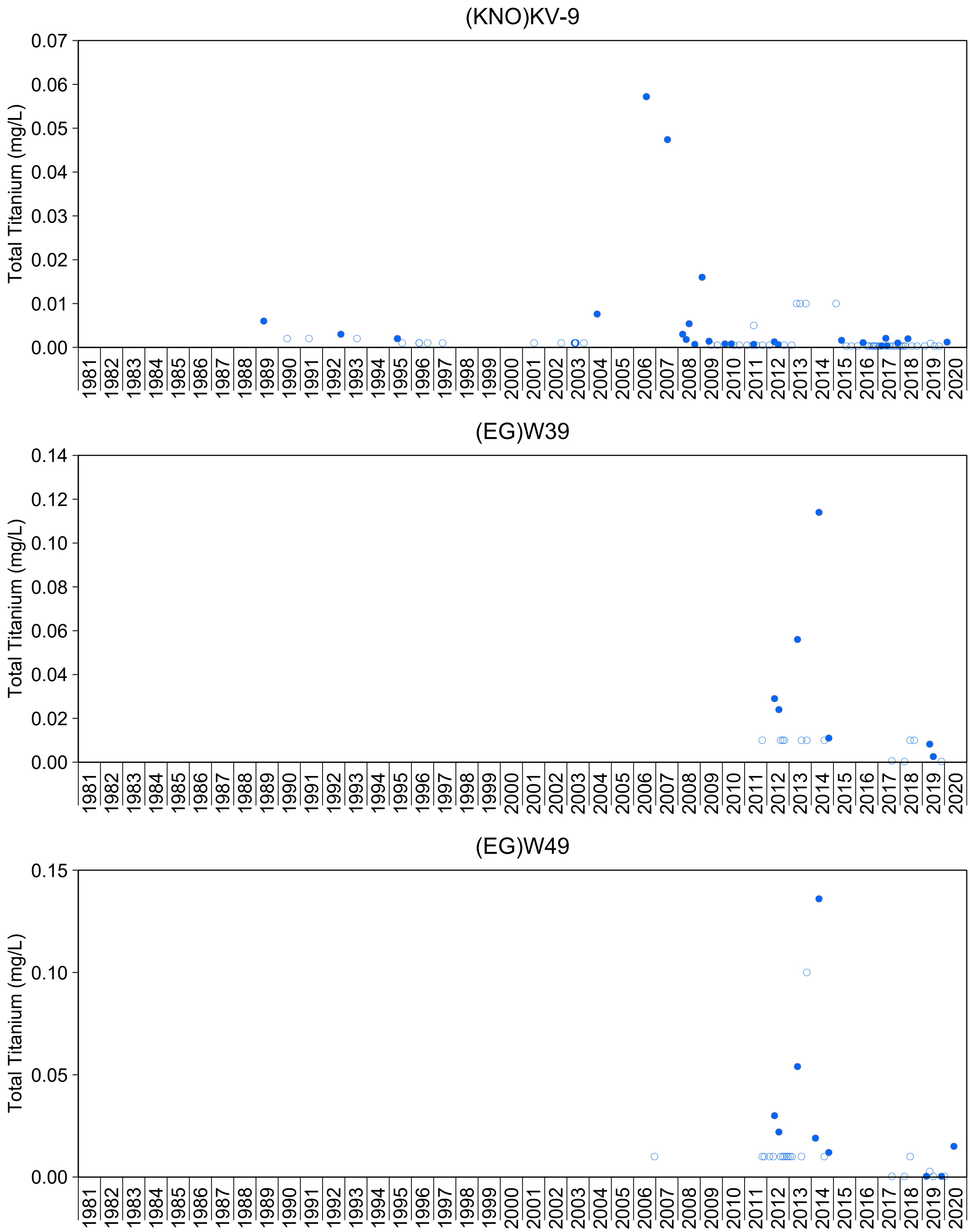


Figure A.87: Time Series Plots for Total Titanium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

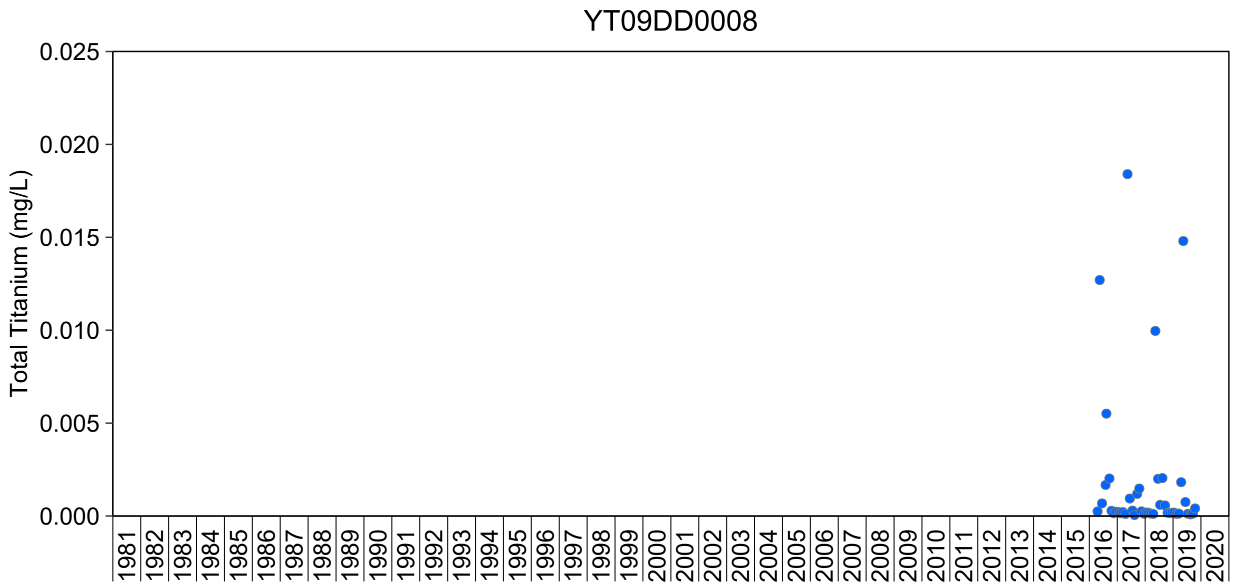


Figure A.87: Time Series Plots for Total Titanium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

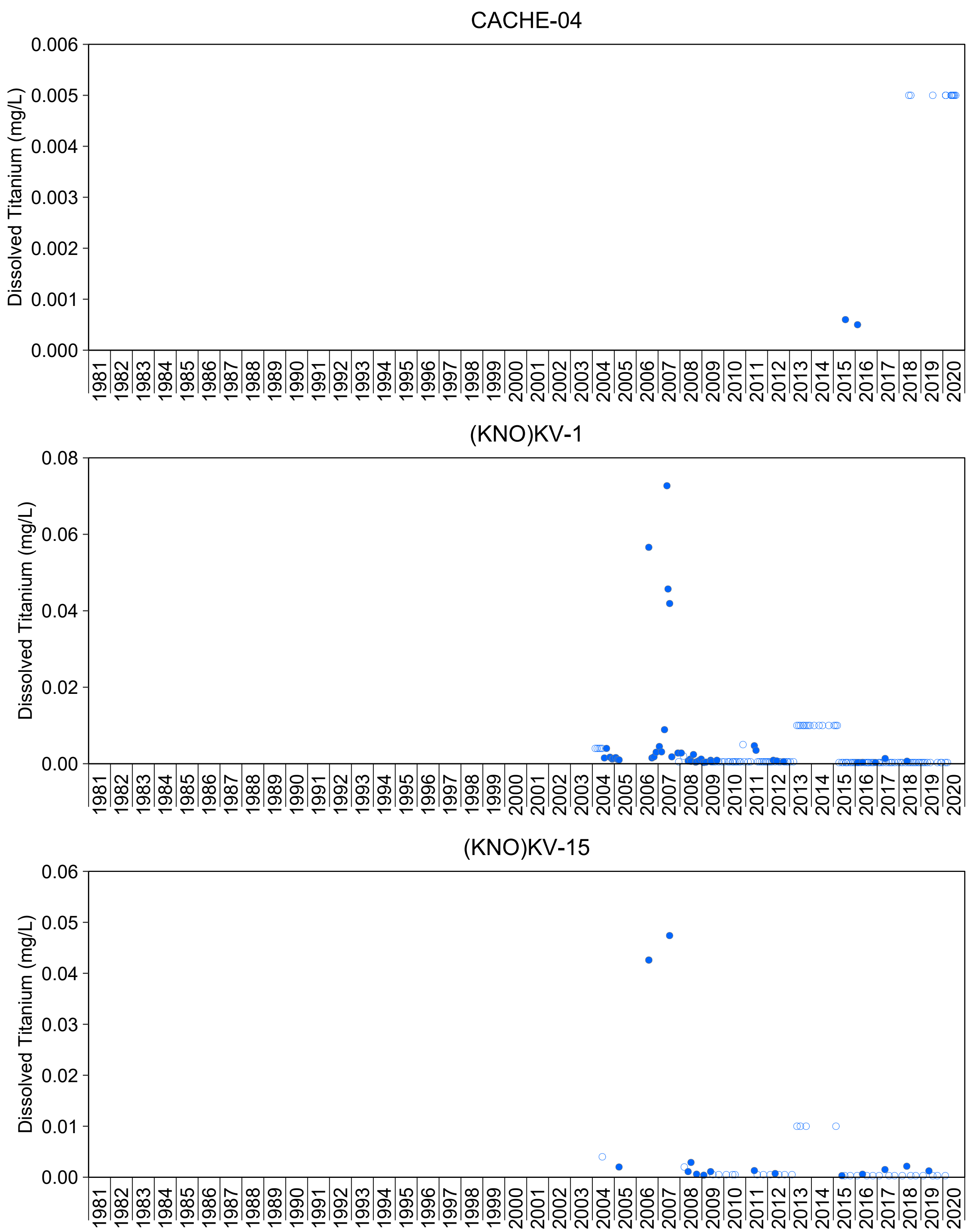


Figure A.88: Time Series Plots for Dissolved Titanium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

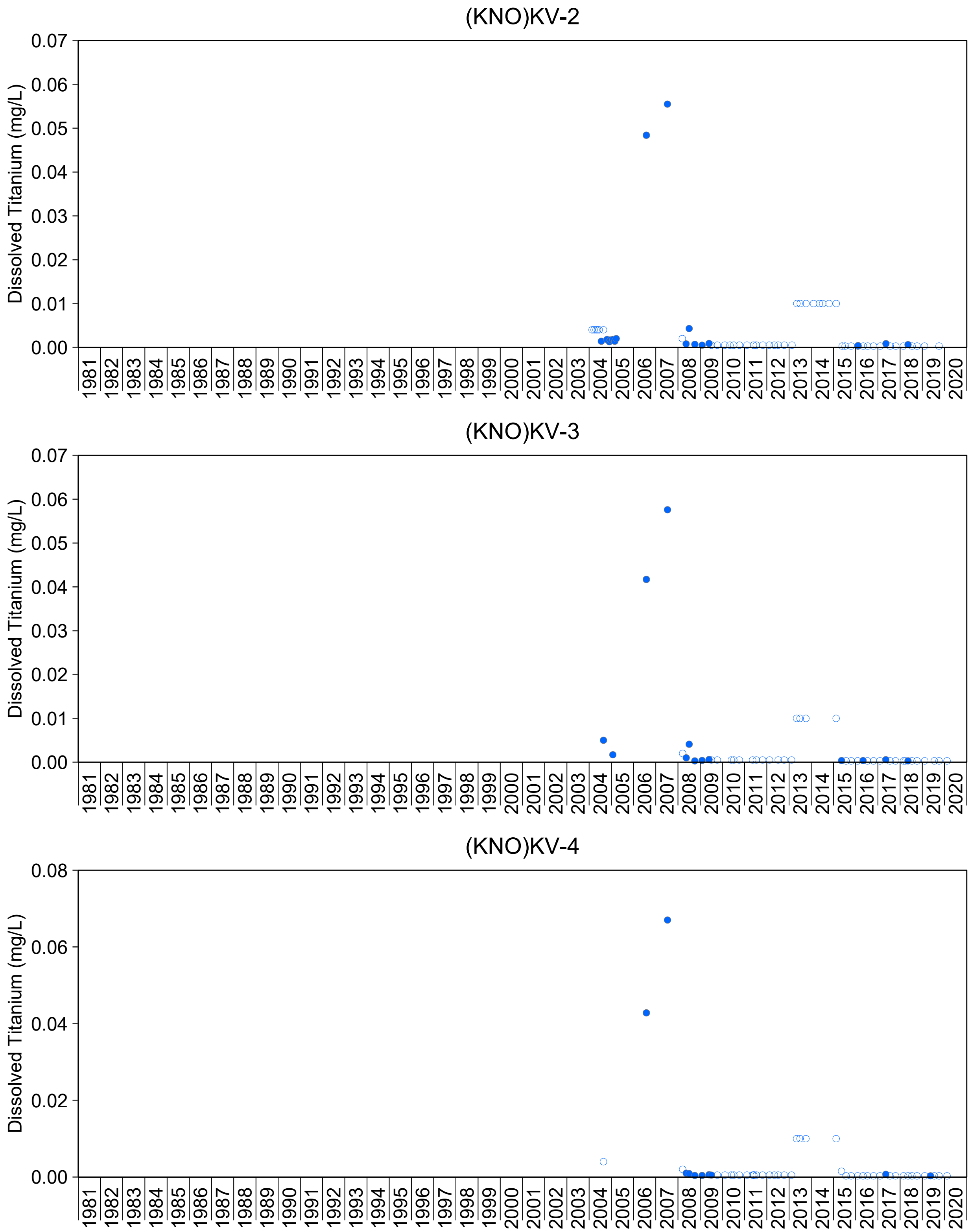


Figure A.88: Time Series Plots for Dissolved Titanium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

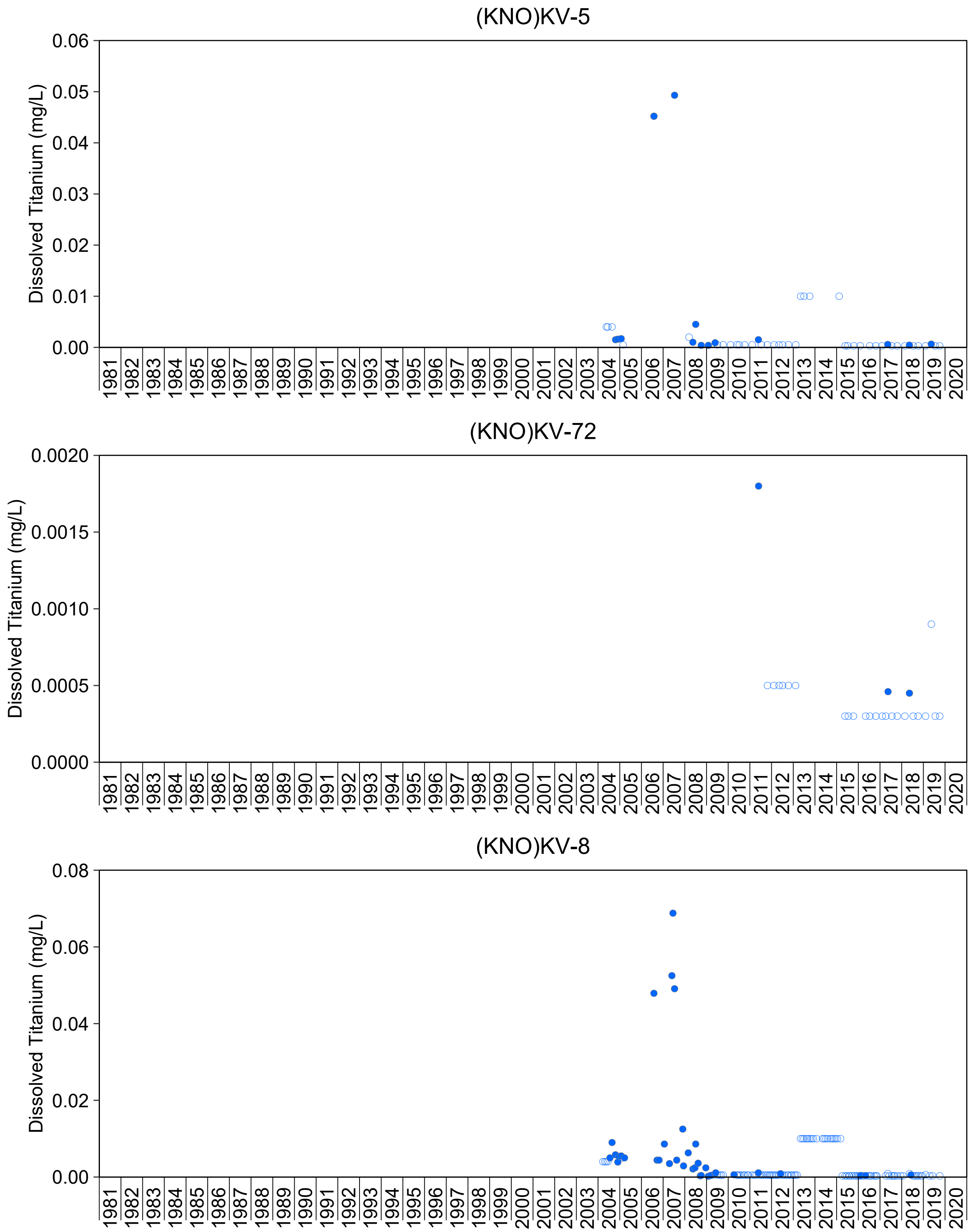


Figure A.88: Time Series Plots for Dissolved Titanium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

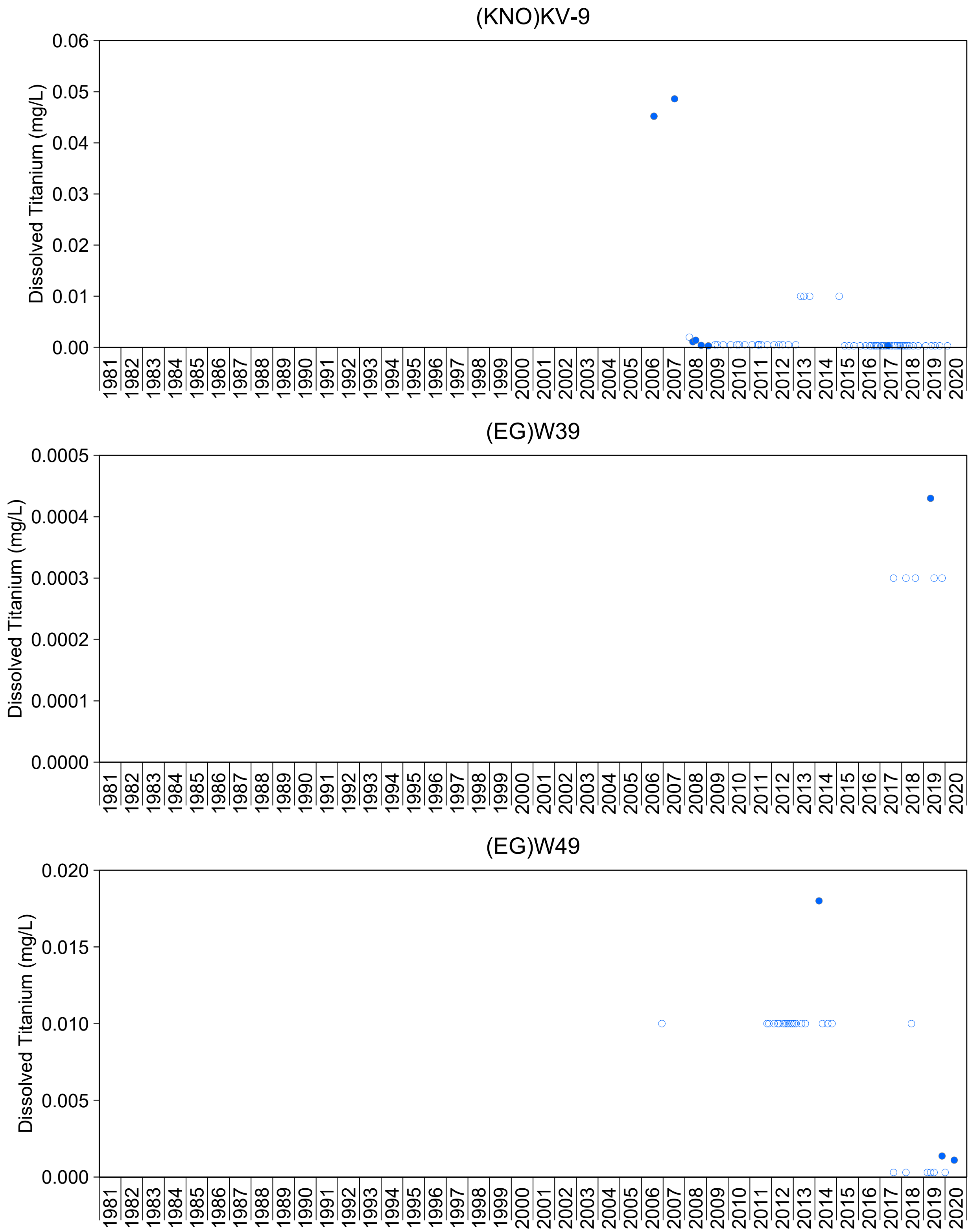


Figure A.88: Time Series Plots for Dissolved Titanium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

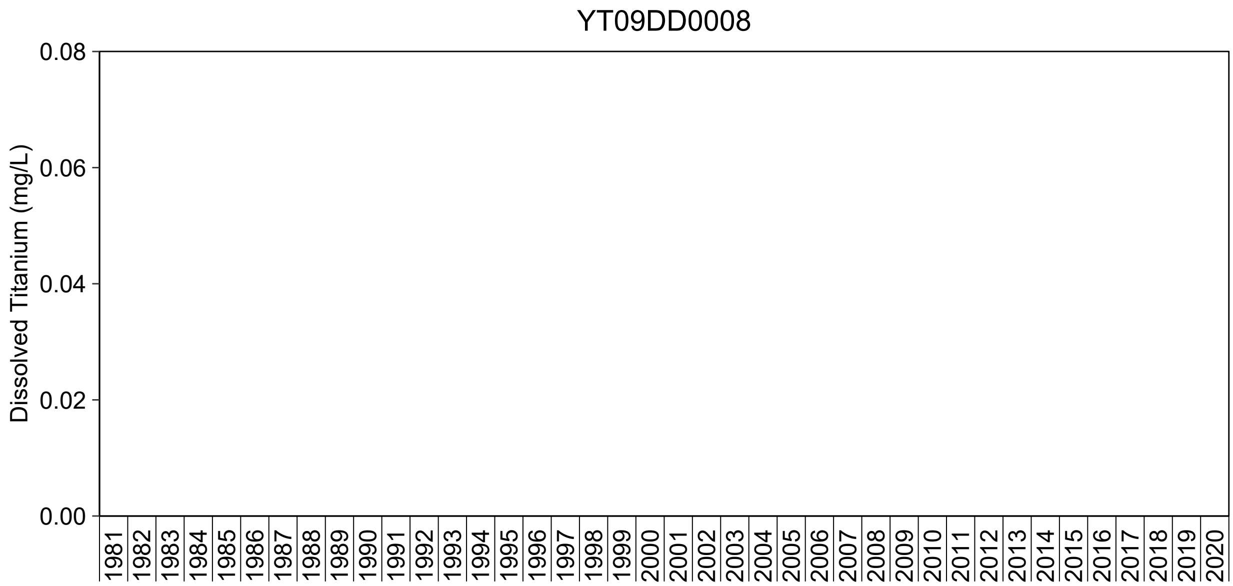


Figure A.88: Time Series Plots for Dissolved Titanium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

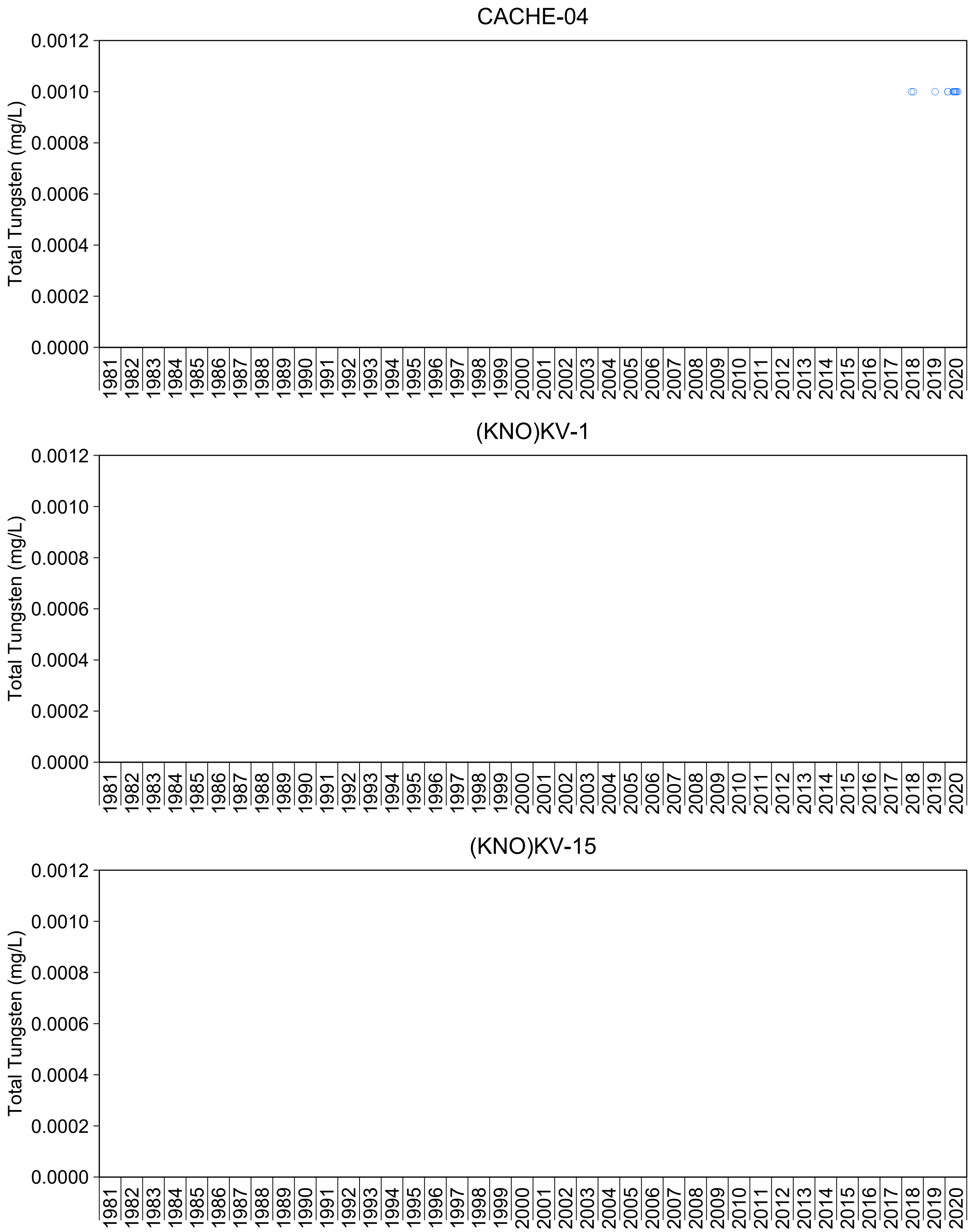
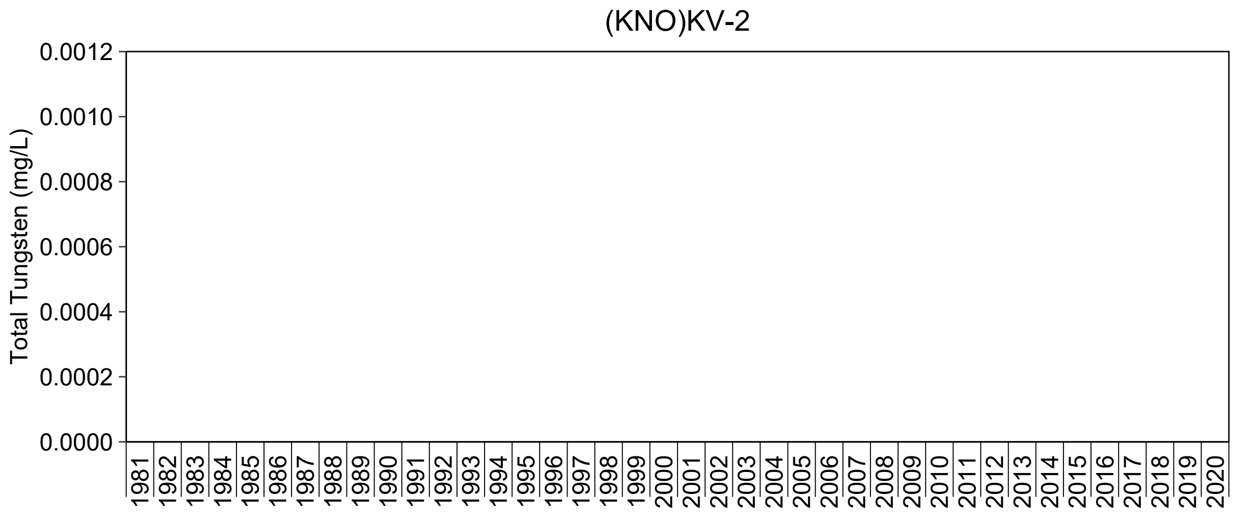
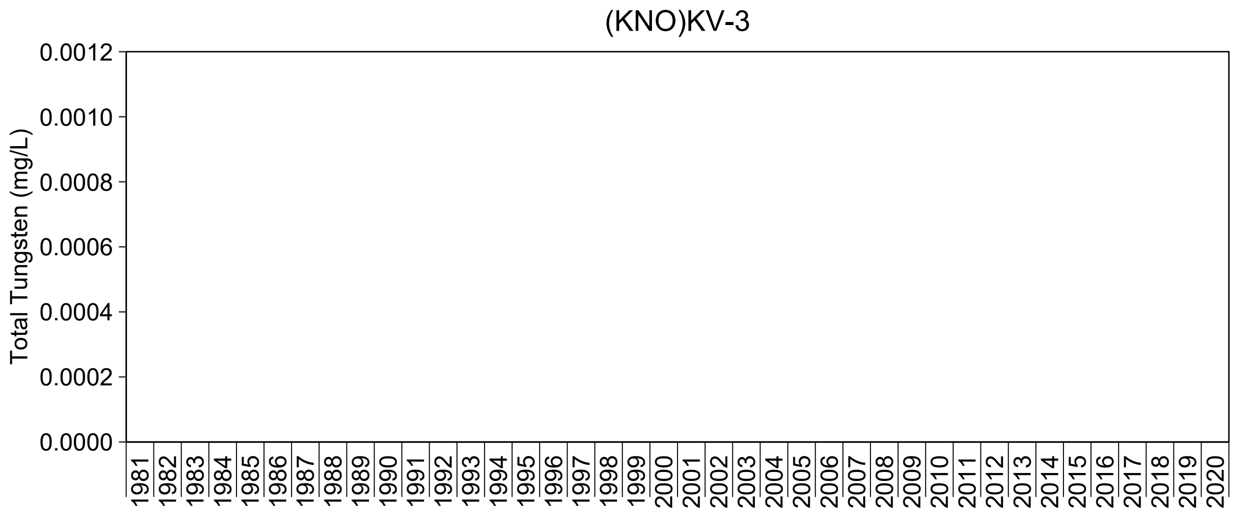


Figure A.89: Time Series Plots for Total Tungsten Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.





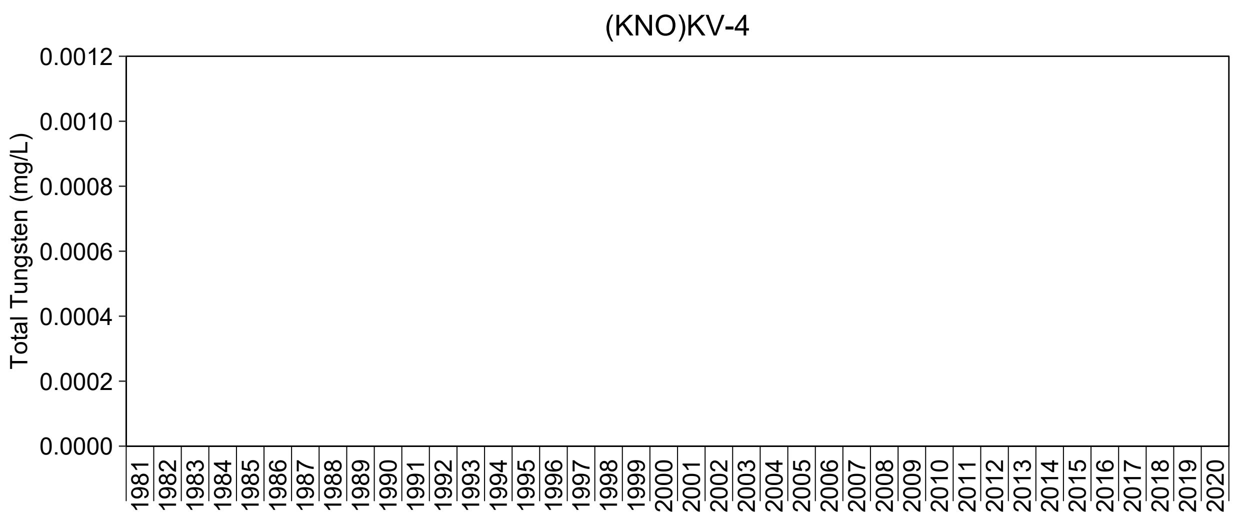
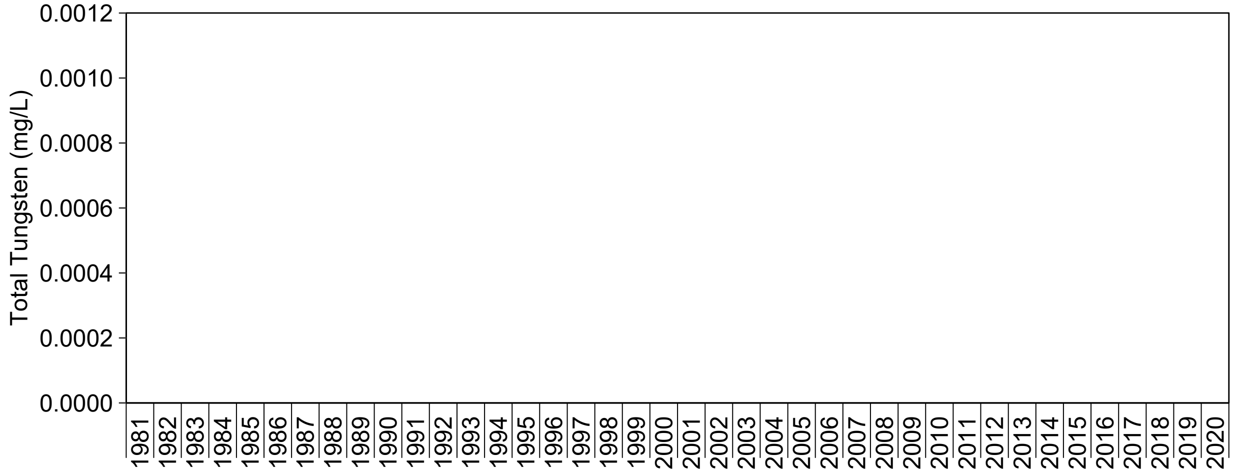


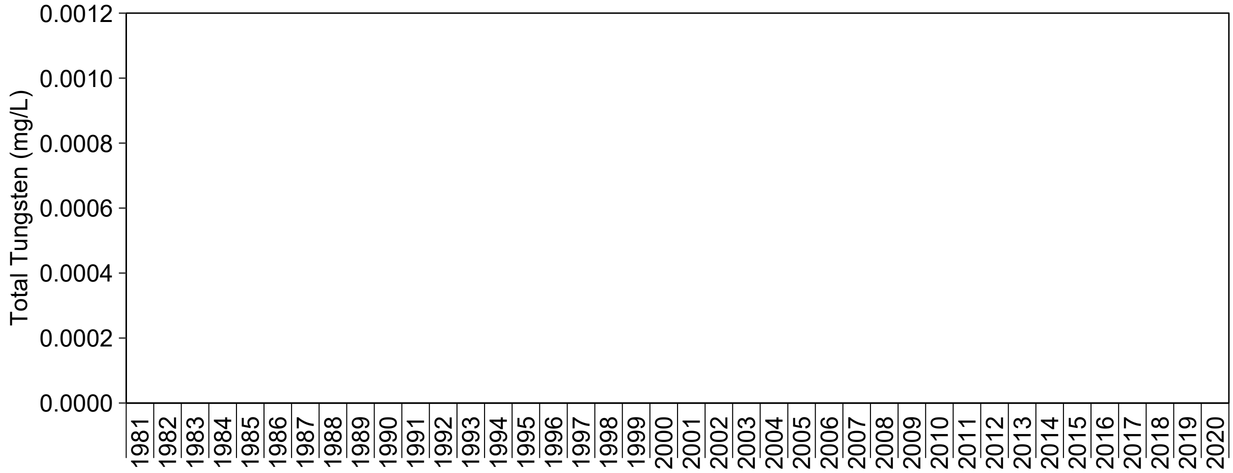
Figure A.89: Time Series Plots for Total Tungsten Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

(KNO)KV-5



(KNO)KV-72



(KNO)KV-8

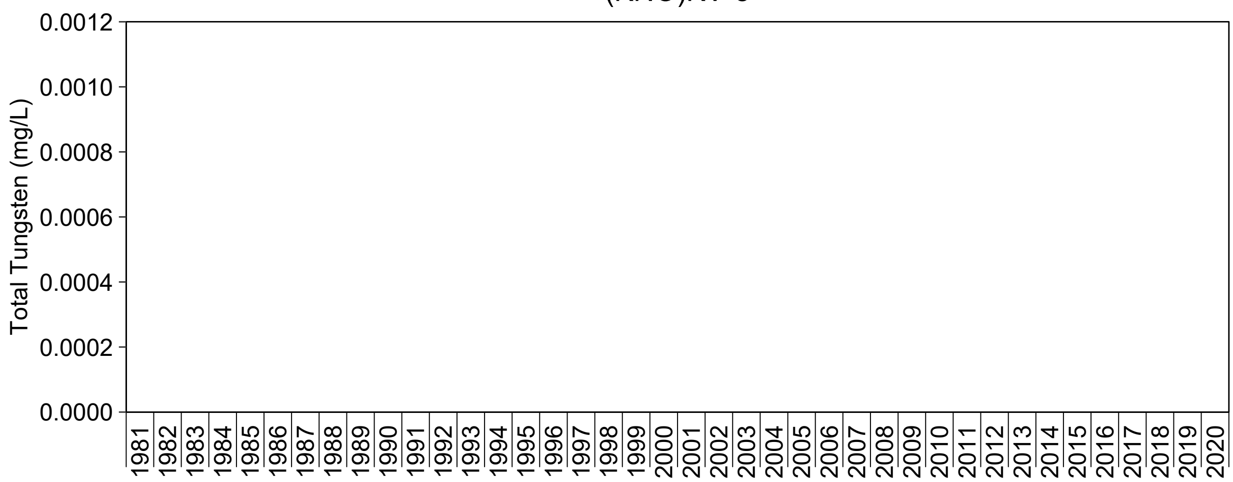


Figure A.89: Time Series Plots for Total Tungsten Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

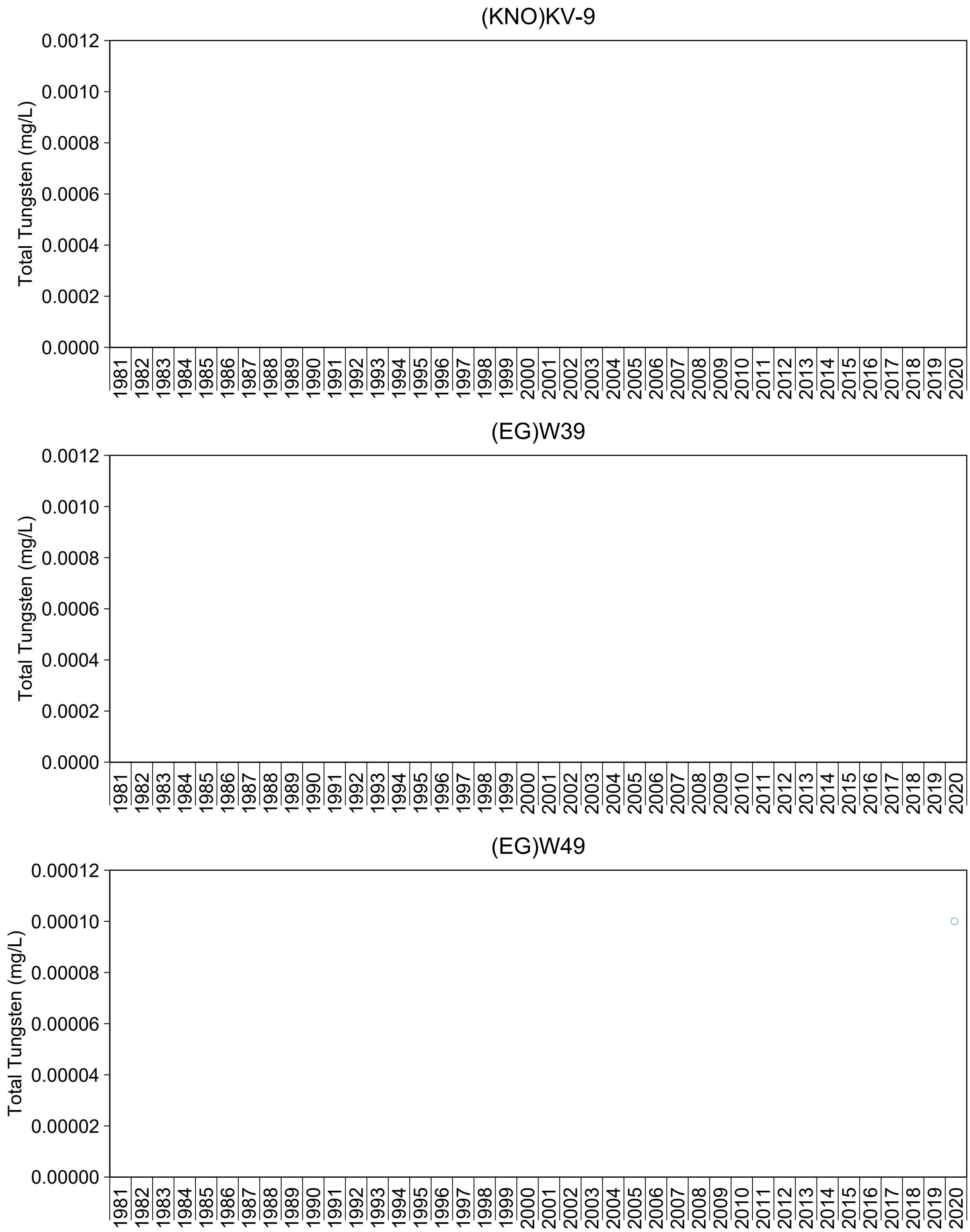


Figure A.89: Time Series Plots for Total Tungsten Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

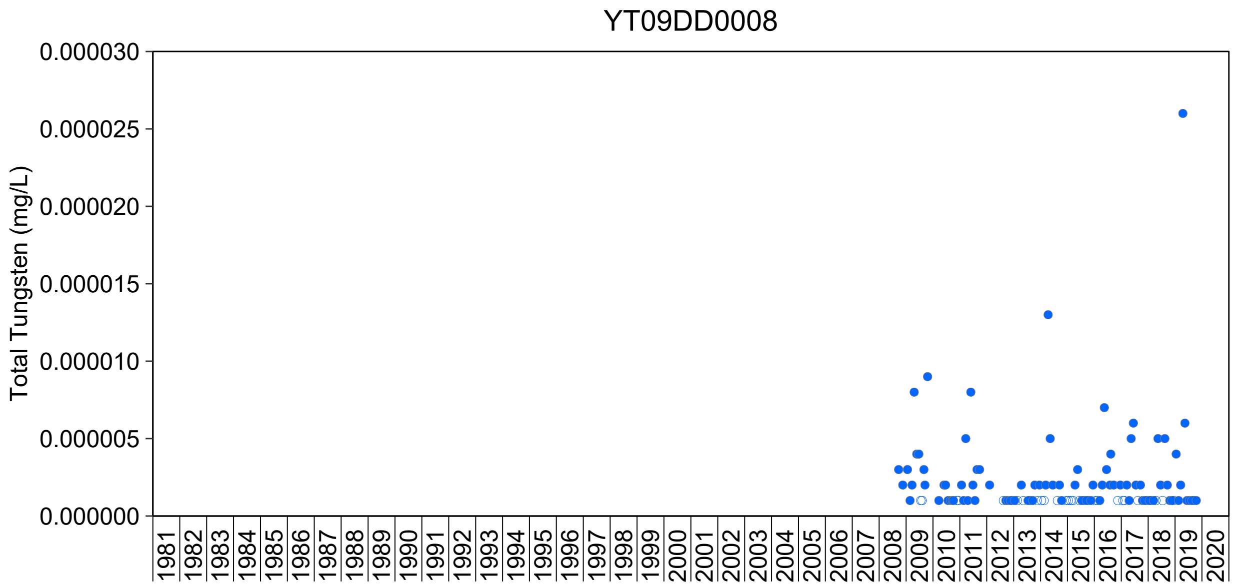
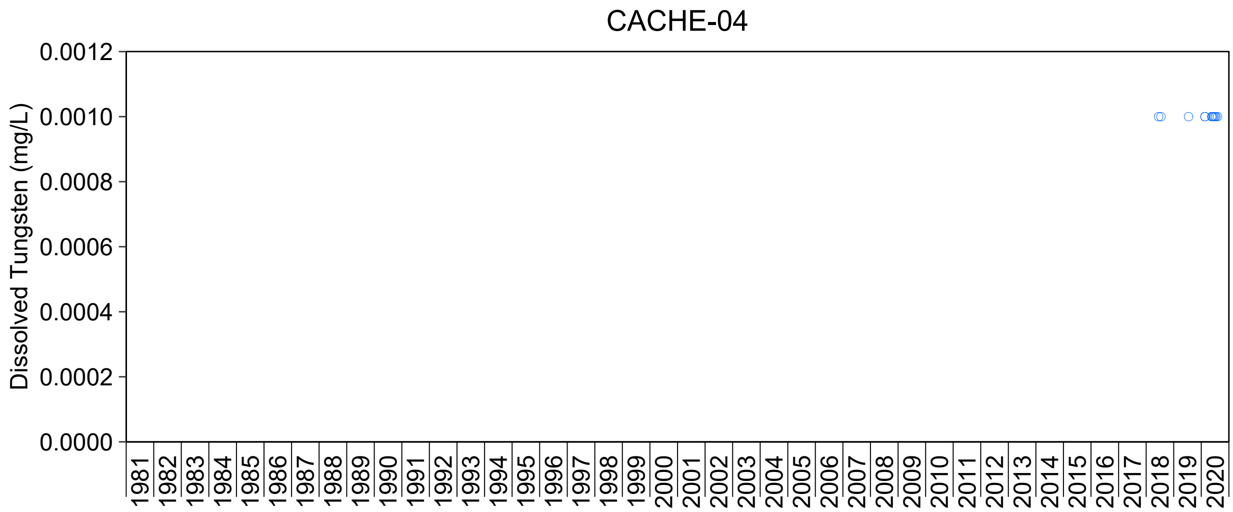
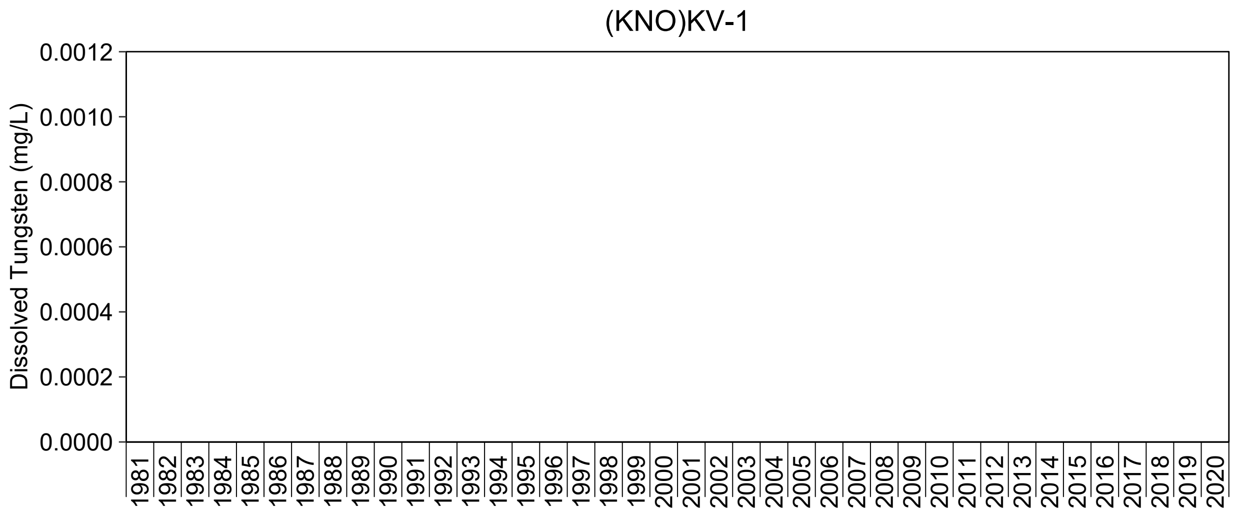


Figure A.89: Time Series Plots for Total Tungsten Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.





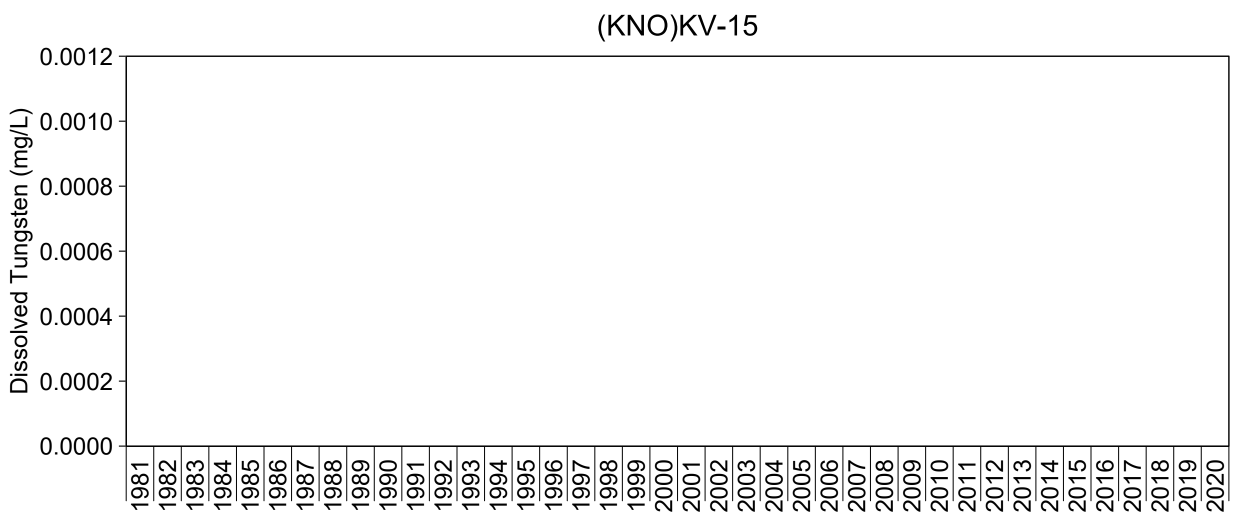


Figure A.90: Time Series Plots for Dissolved Tungsten Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

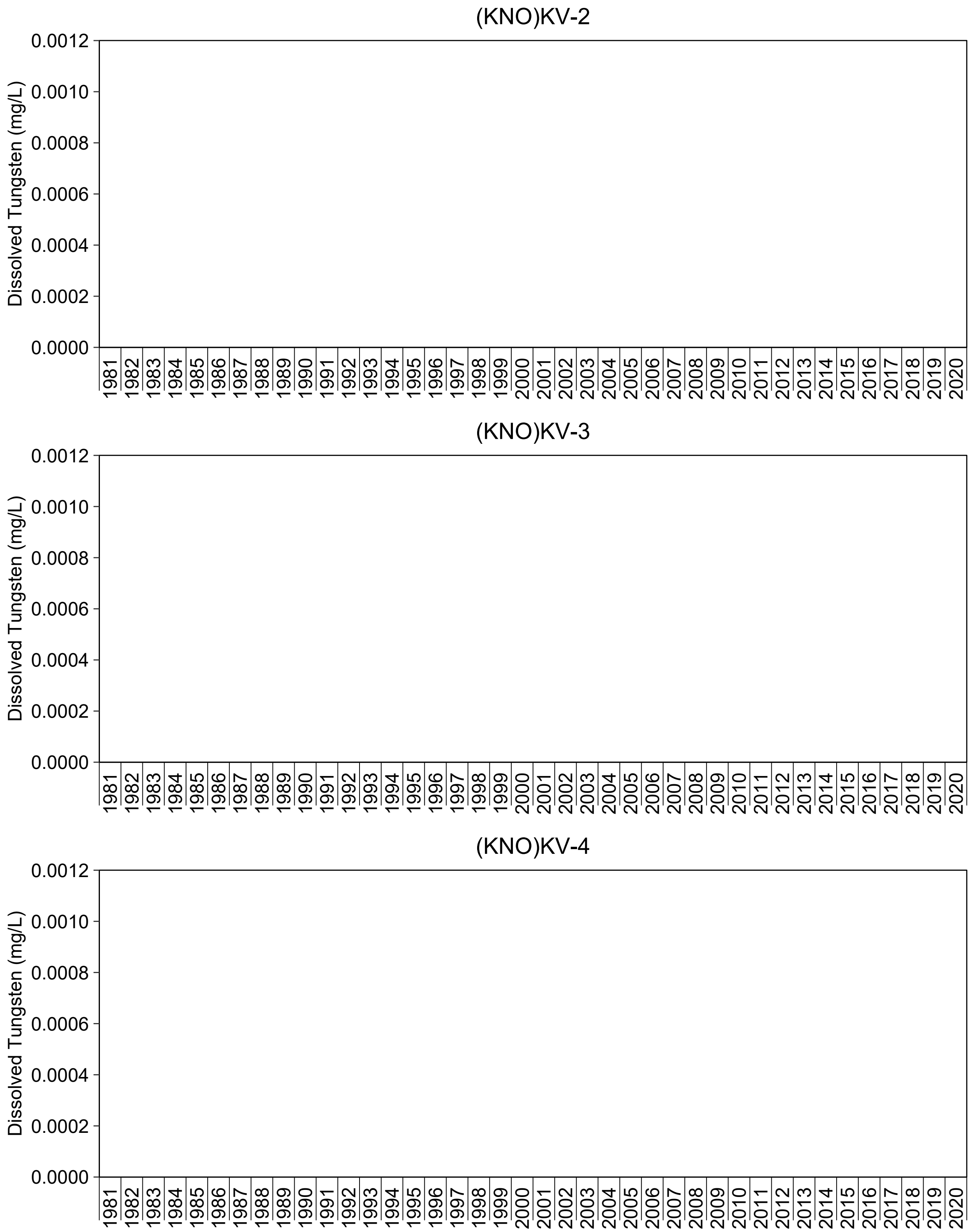
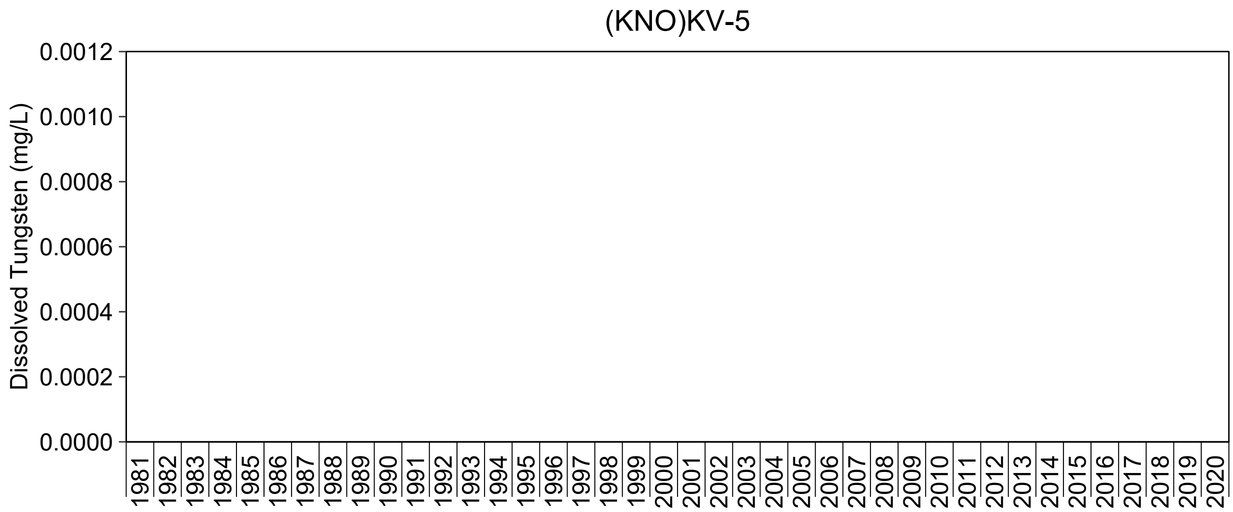
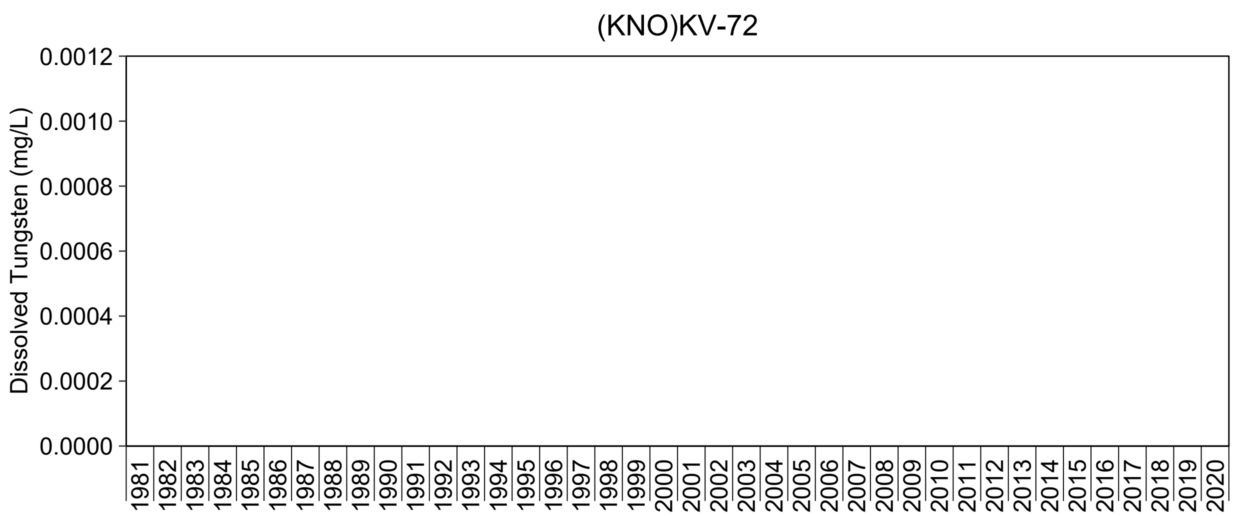


Figure A.90: Time Series Plots for Dissolved Tungsten Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.





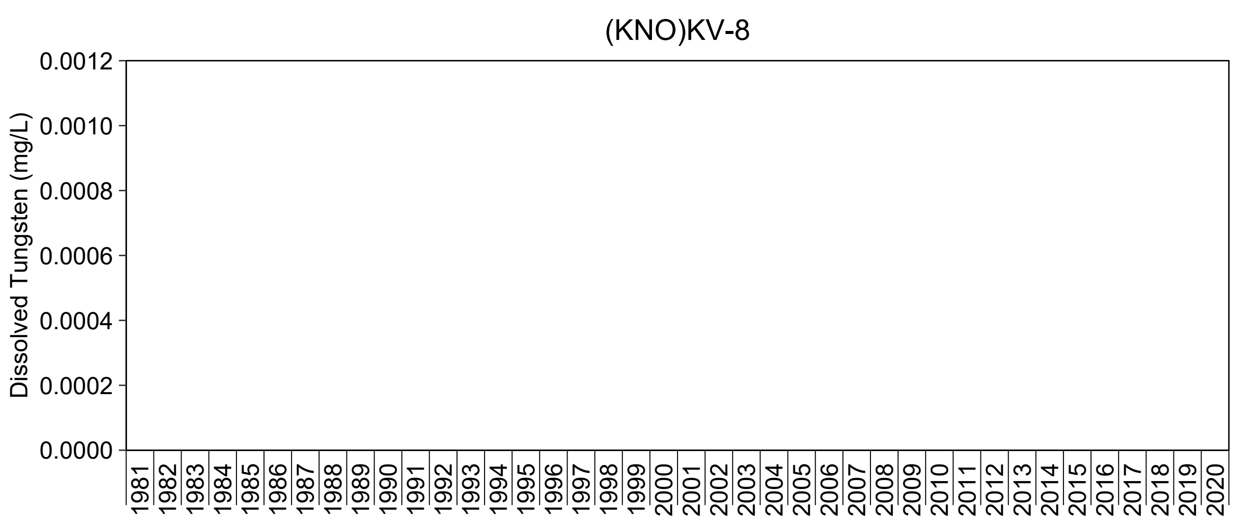


Figure A.90: Time Series Plots for Dissolved Tungsten Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

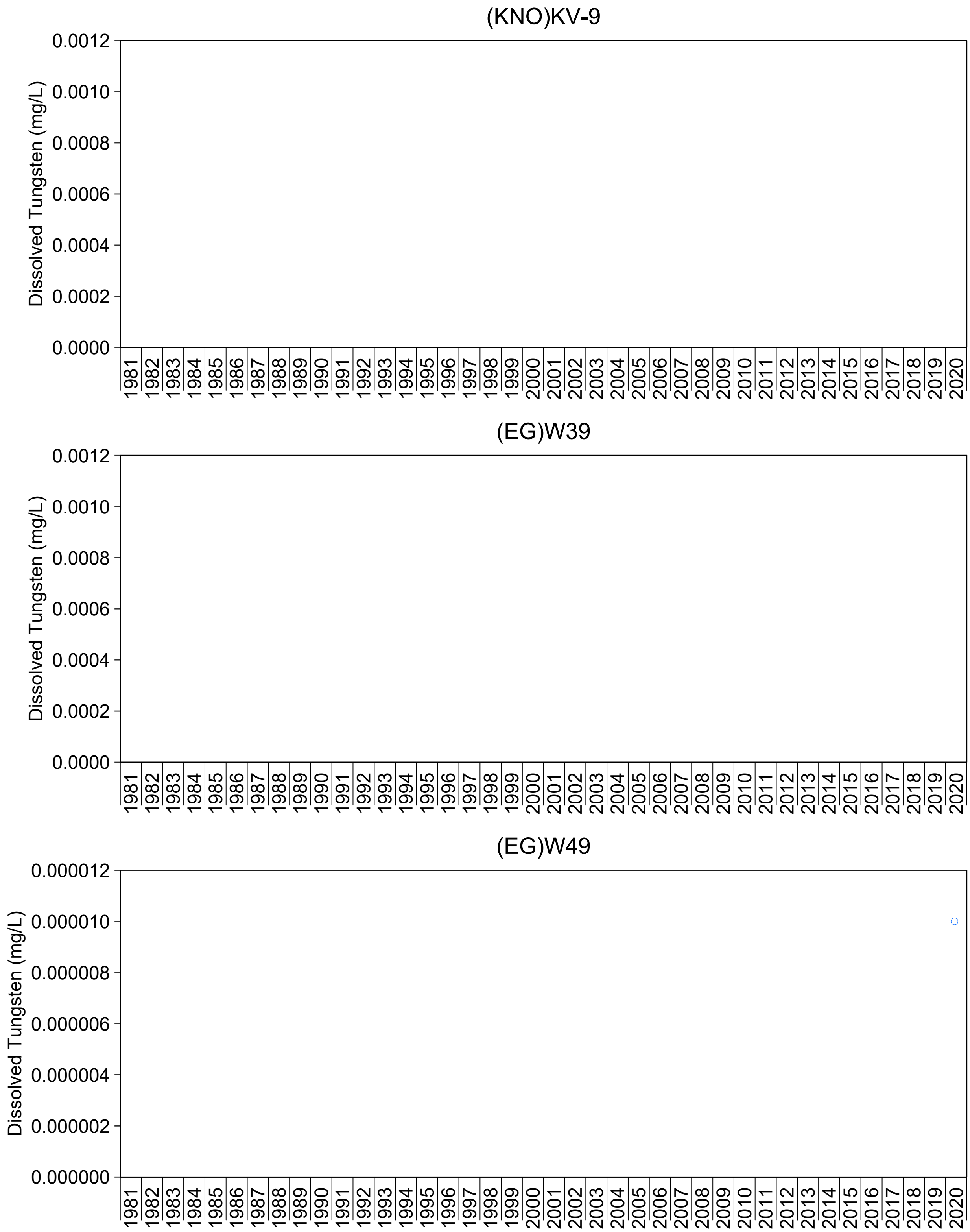


Figure A.90: Time Series Plots for Dissolved Tungsten Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

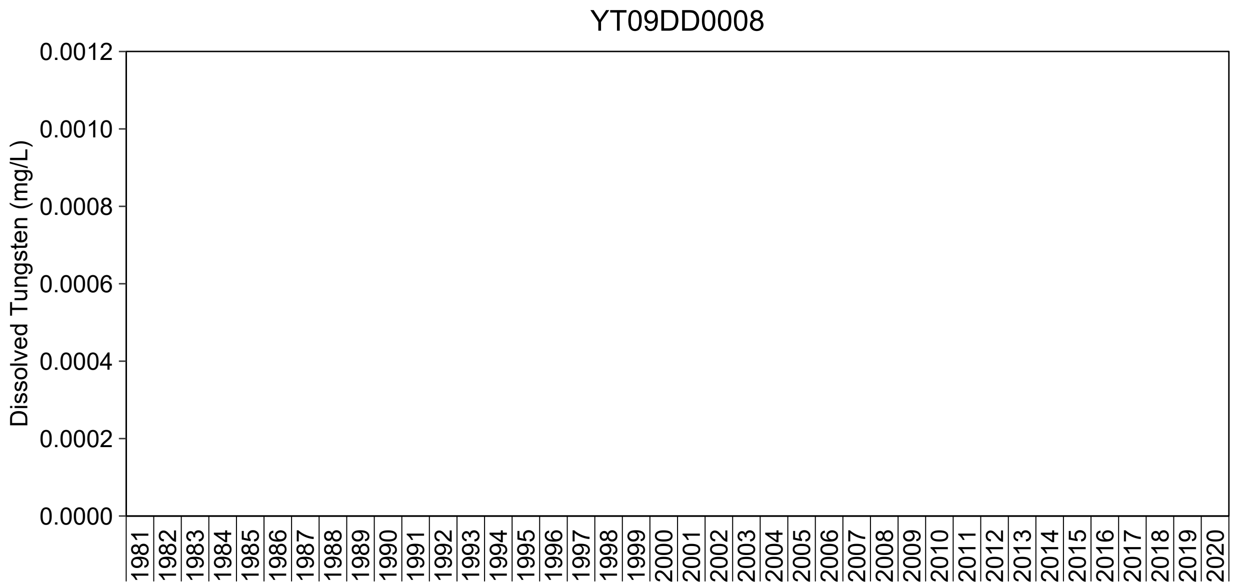
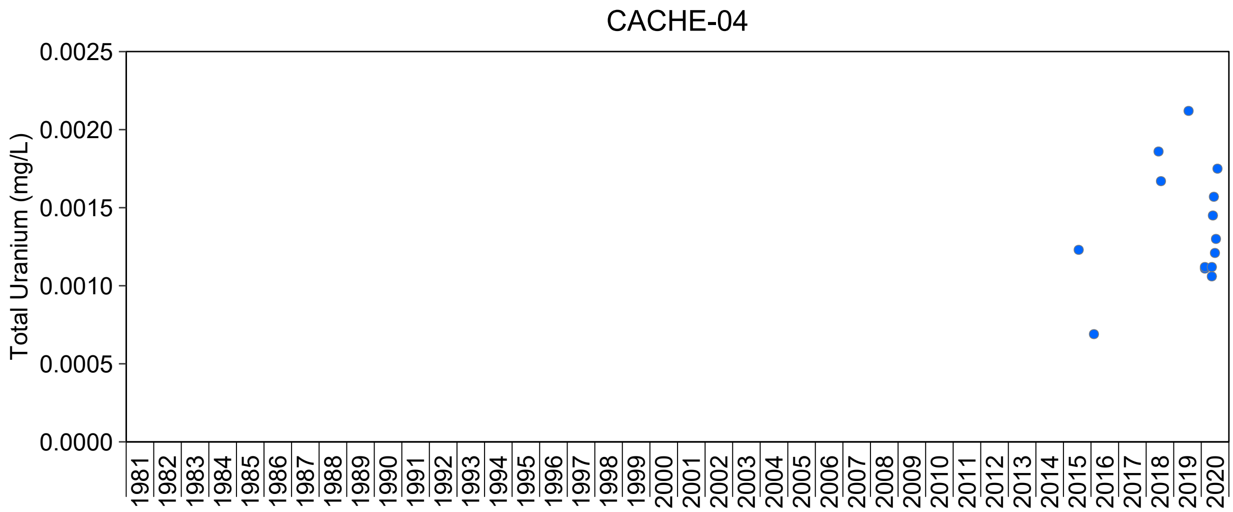
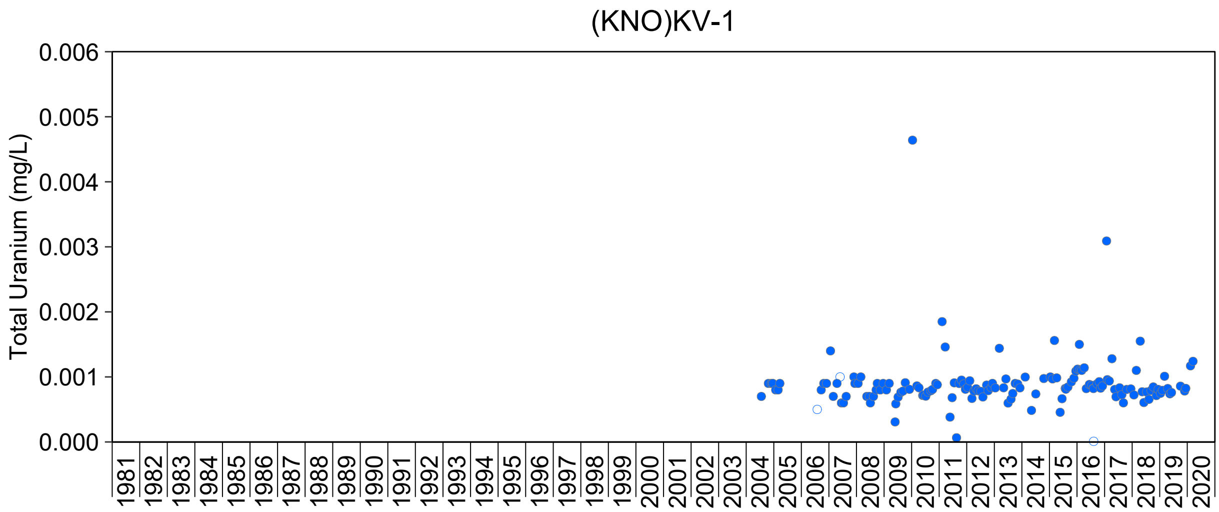


Figure A.90: Time Series Plots for Dissolved Tungsten Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.





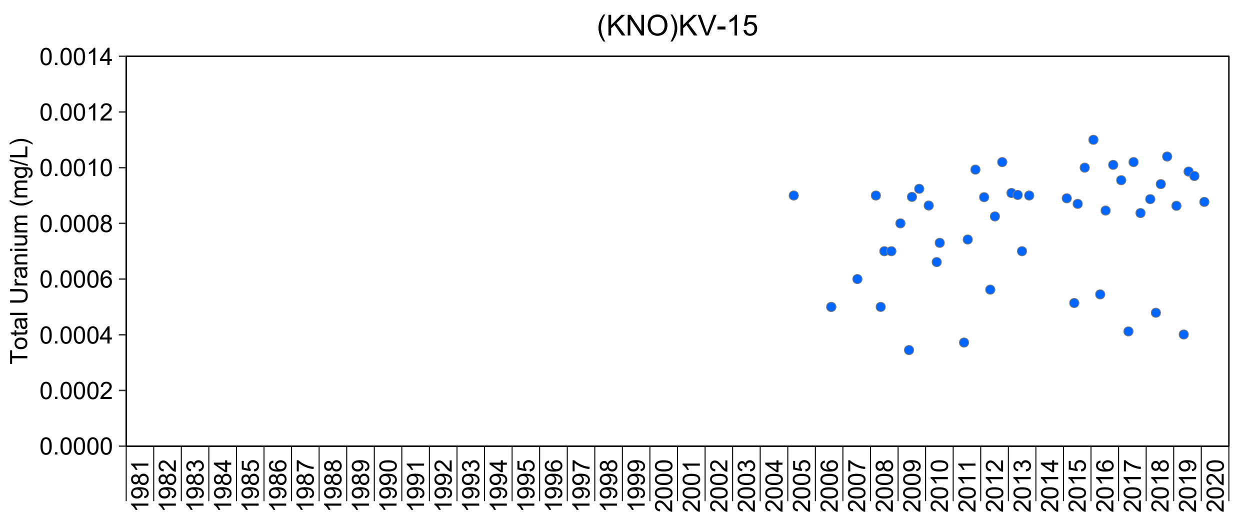


Figure A.91: Time Series Plots for Total Uranium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

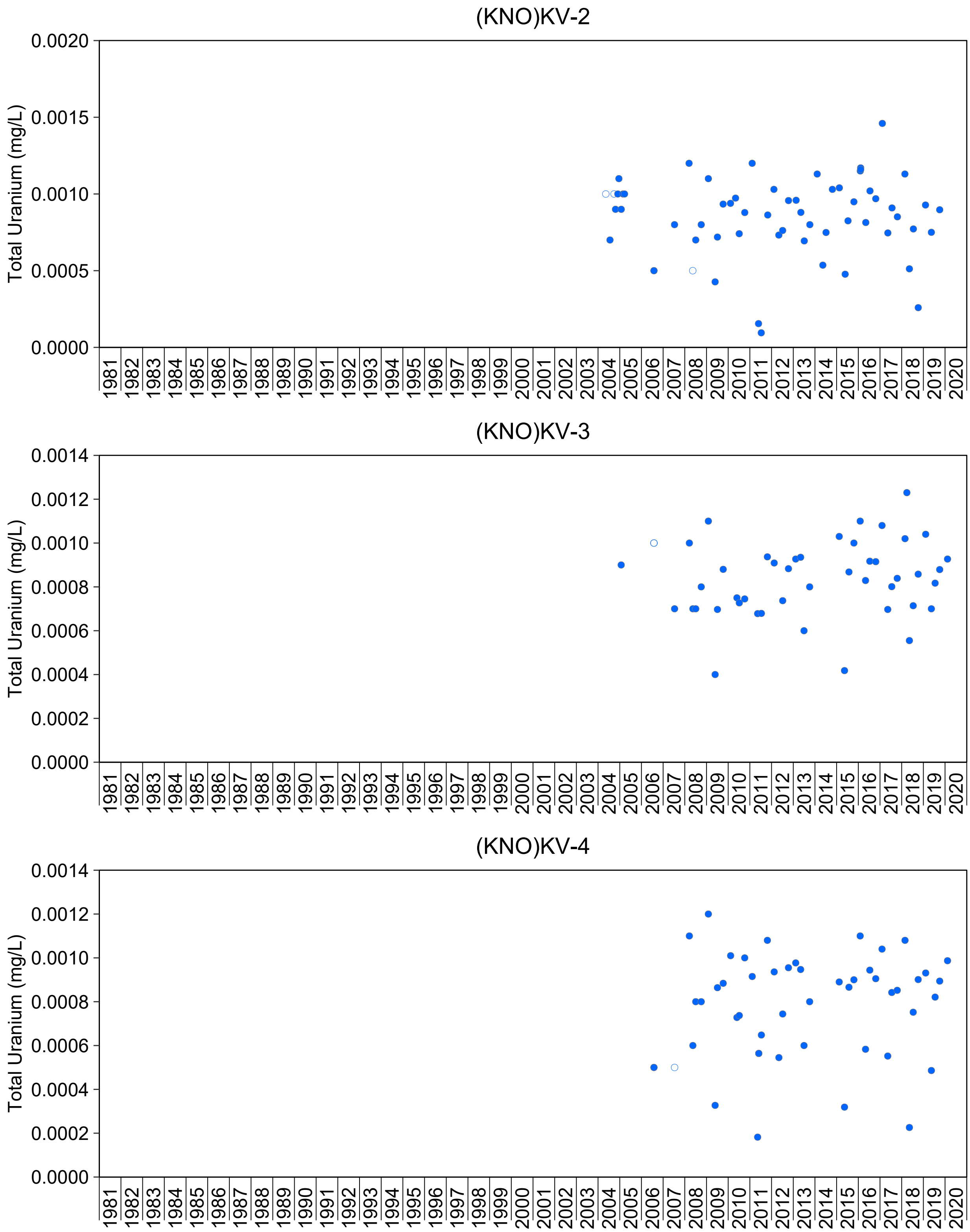


Figure A.91: Time Series Plots for Total Uranium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

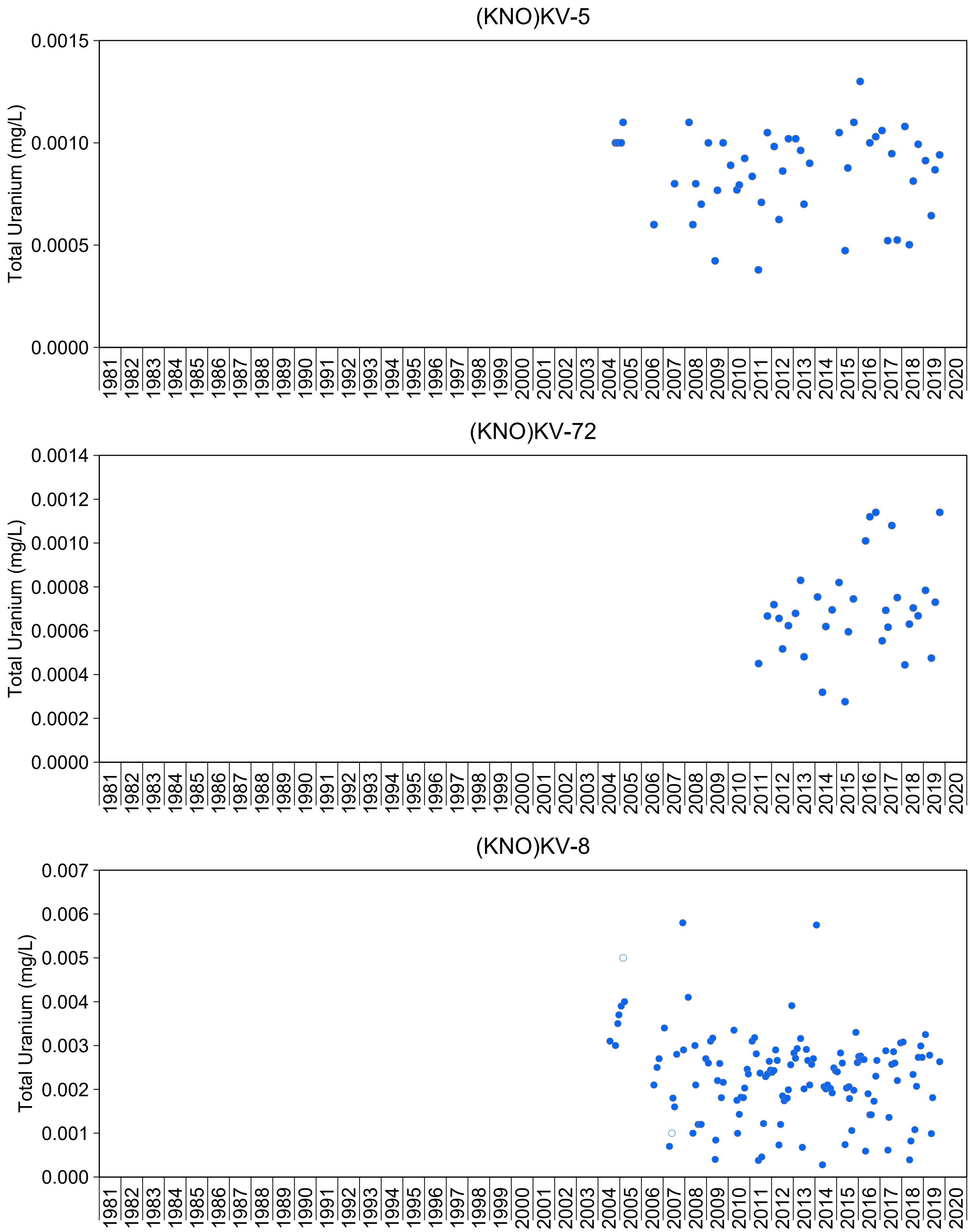


Figure A.91: Time Series Plots for Total Uranium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

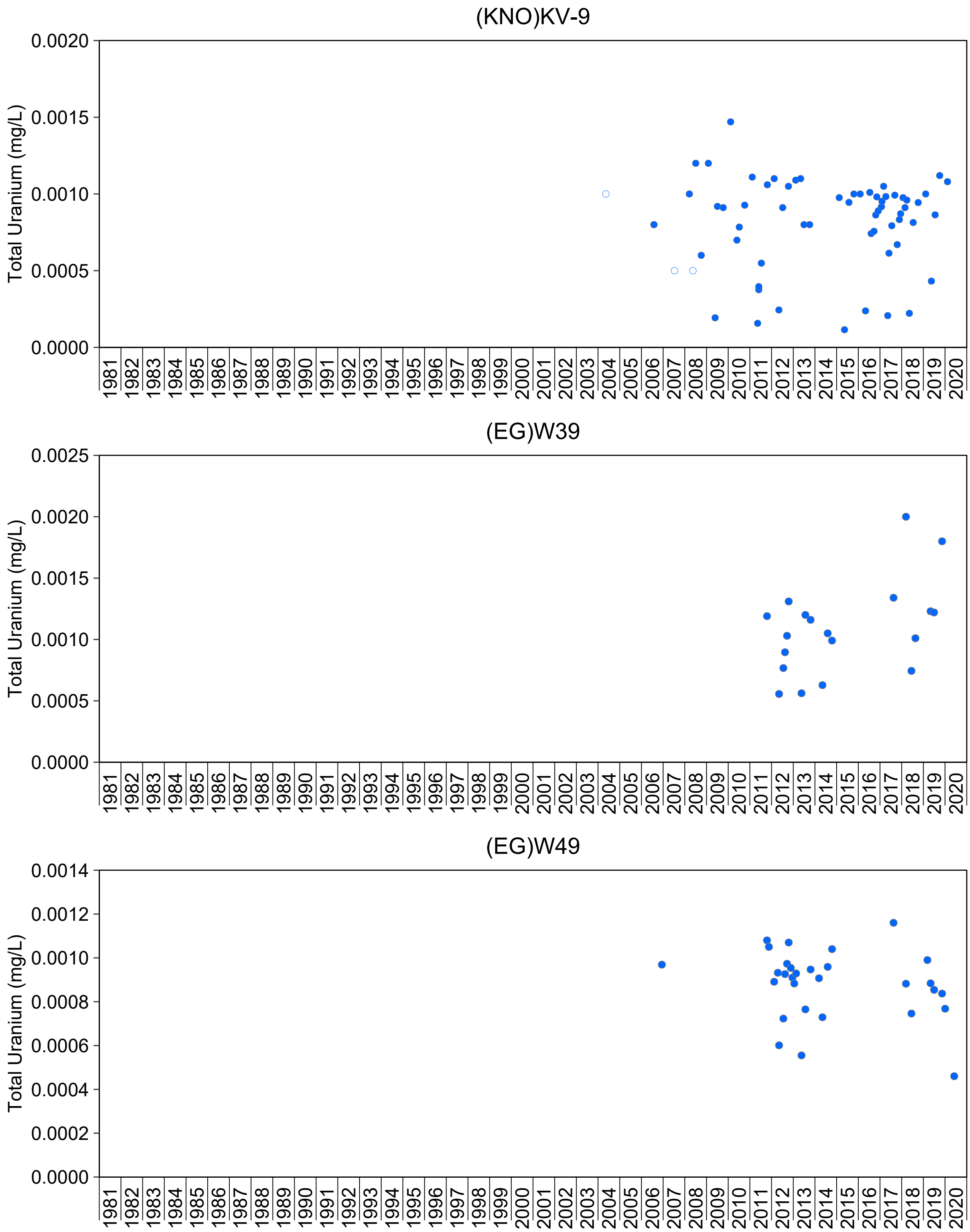


Figure A.91: Time Series Plots for Total Uranium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

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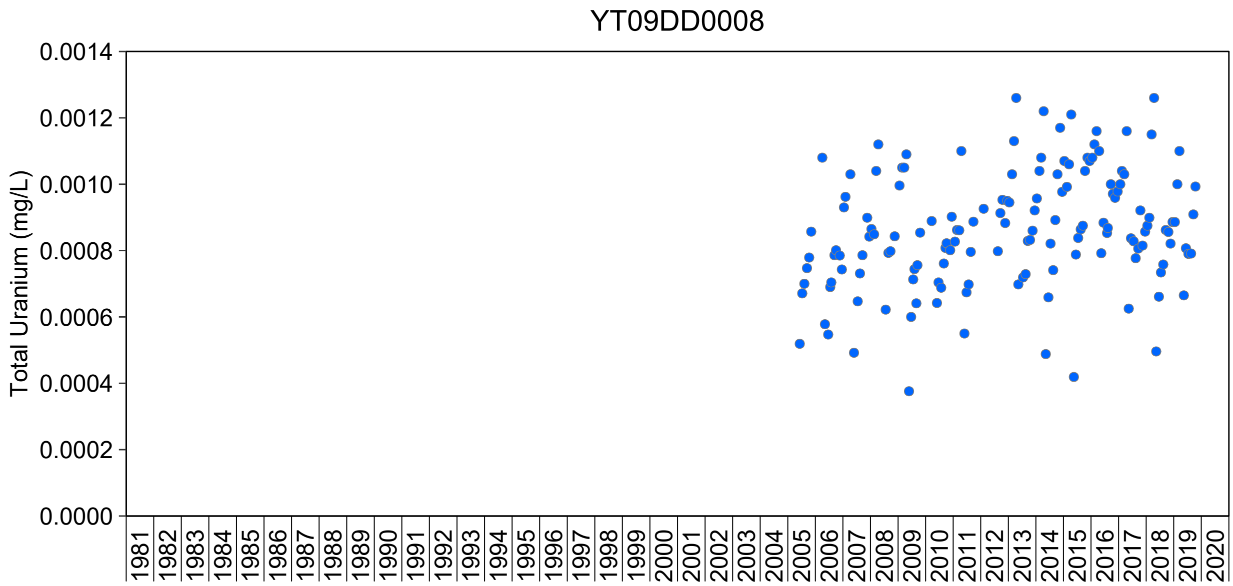


Figure A.91: Time Series Plots for Total Uranium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

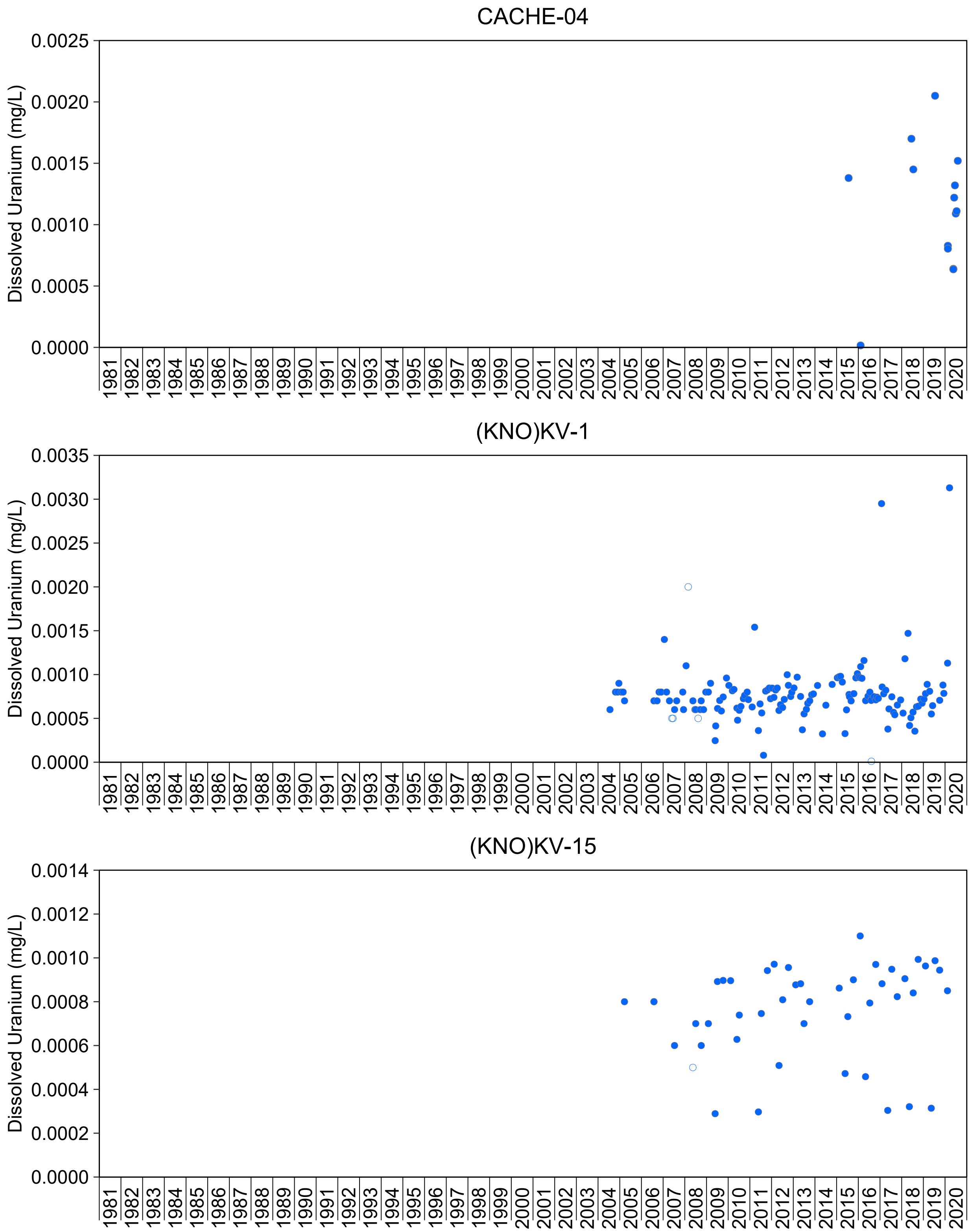


Figure A.92: **Time Series Plots for Dissolved Uranium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020**

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

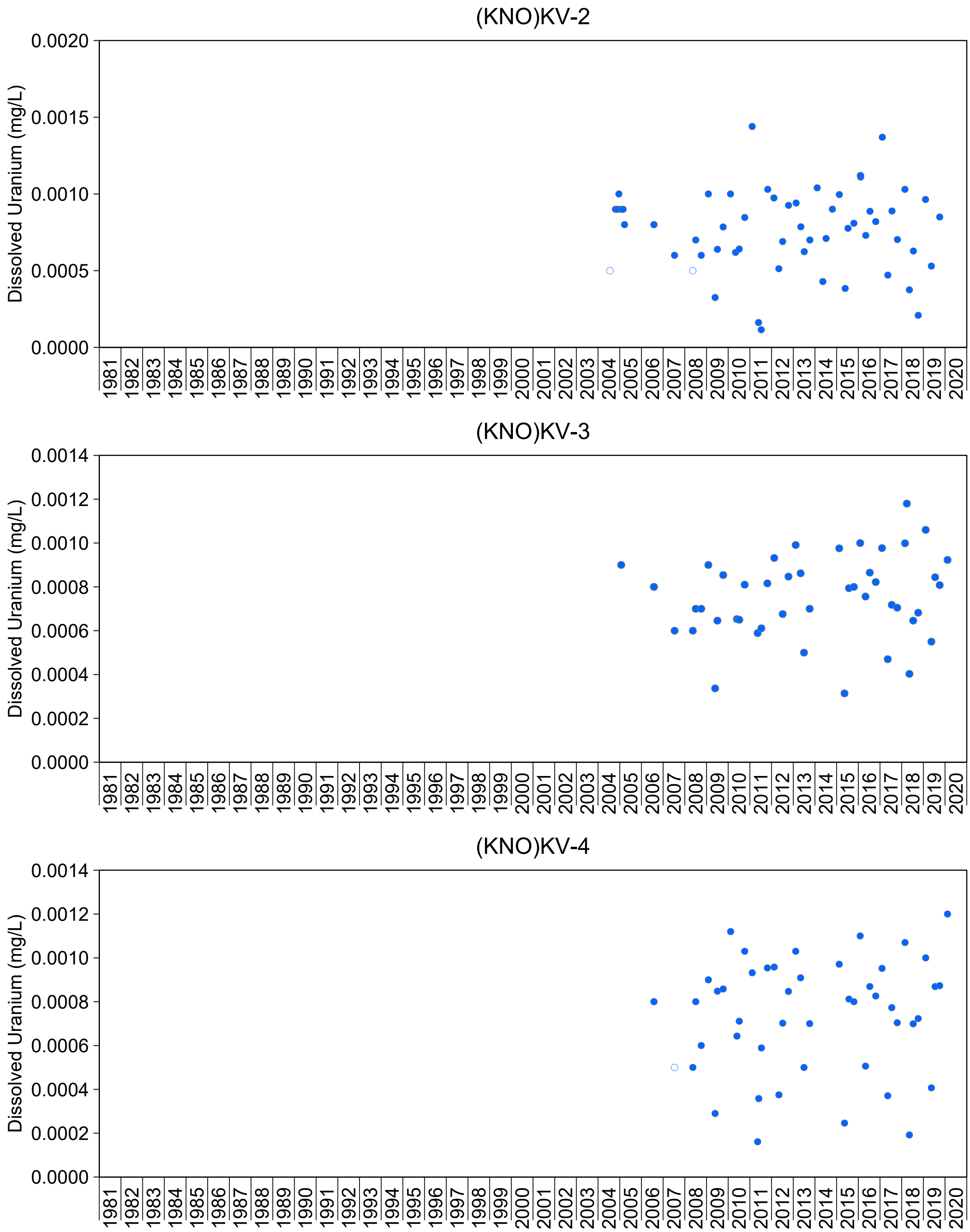


Figure A.92: Time Series Plots for Dissolved Uranium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

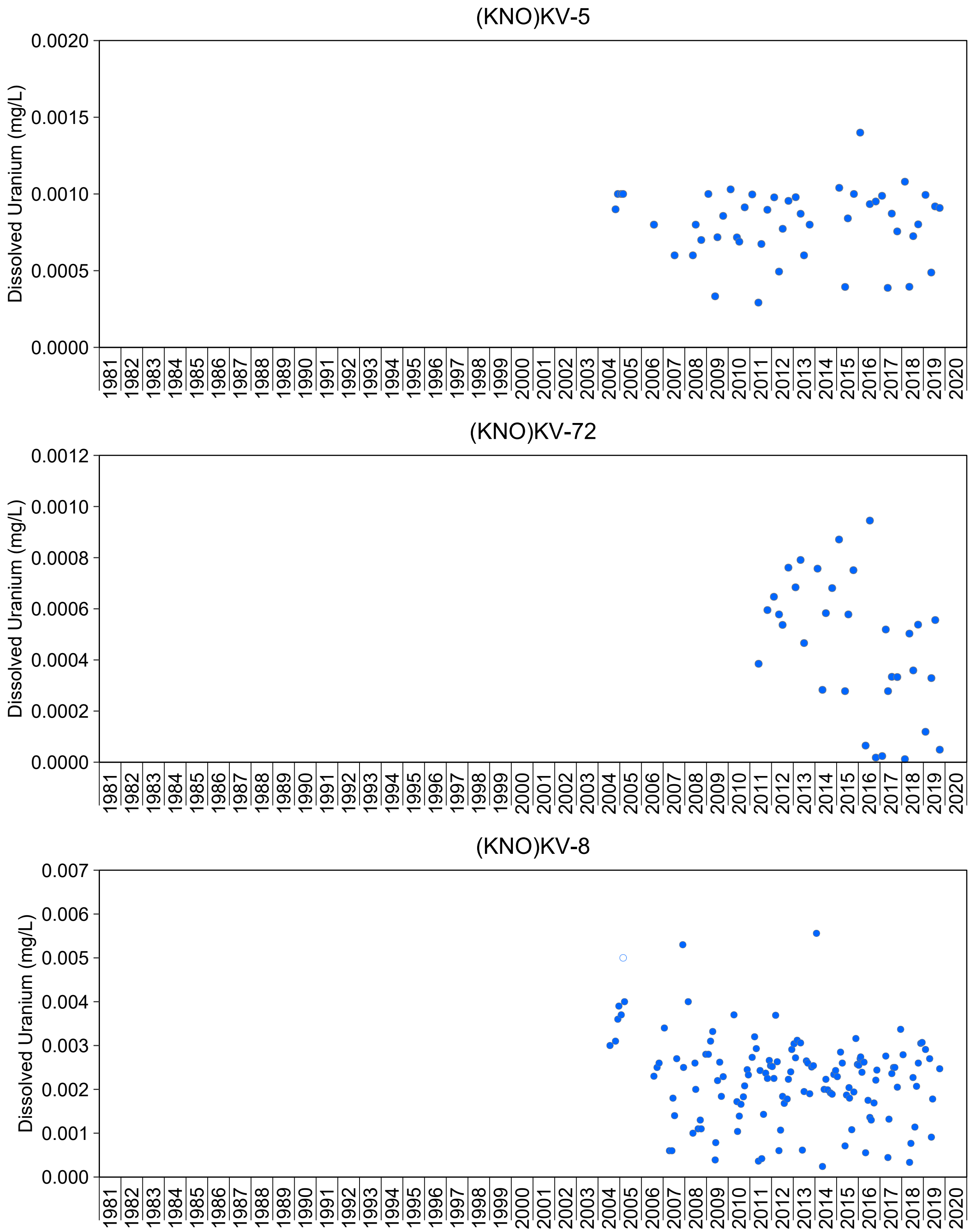


Figure A.92: **Time Series Plots for Dissolved Uranium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020**

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

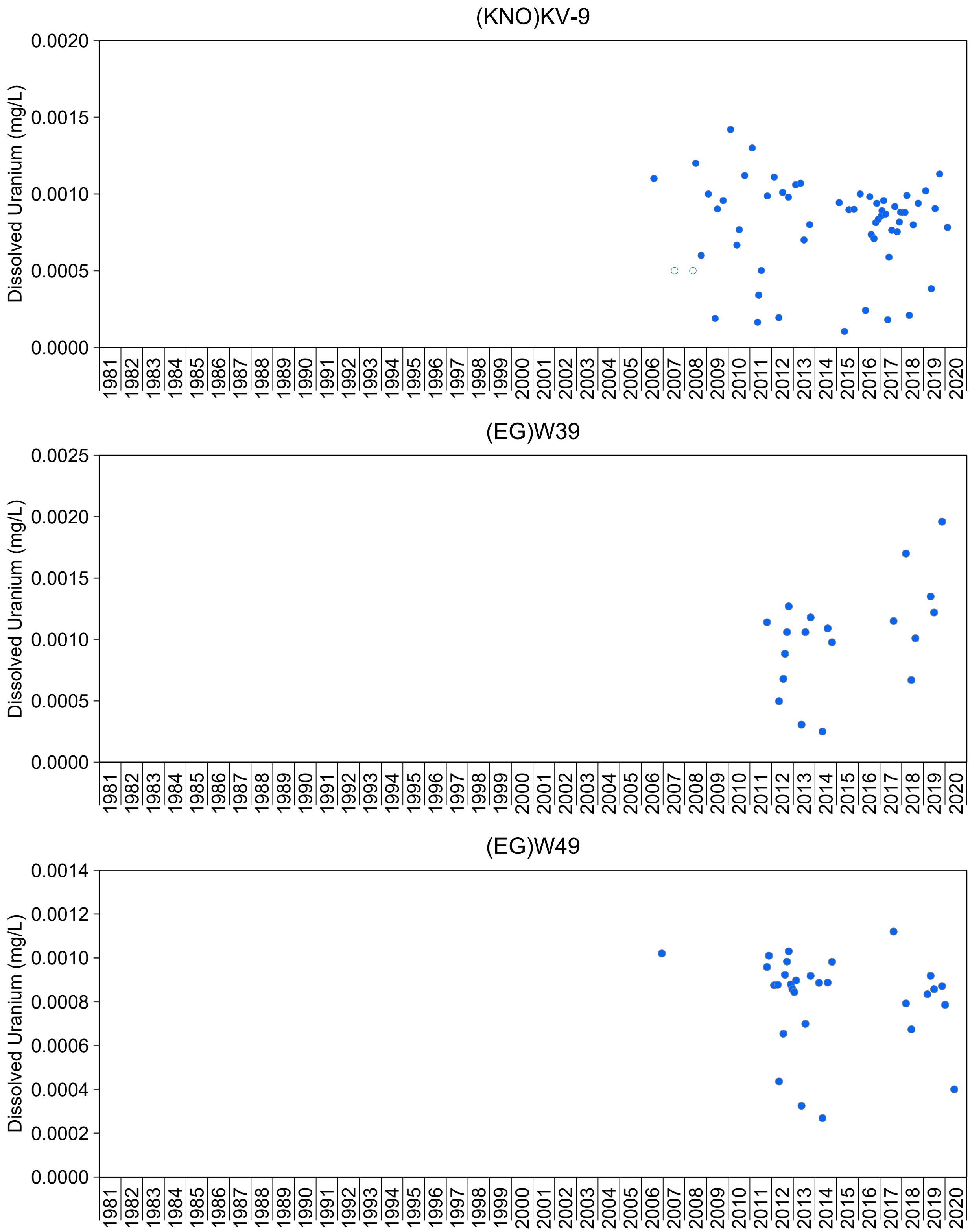


Figure A.92: Time Series Plots for Dissolved Uranium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

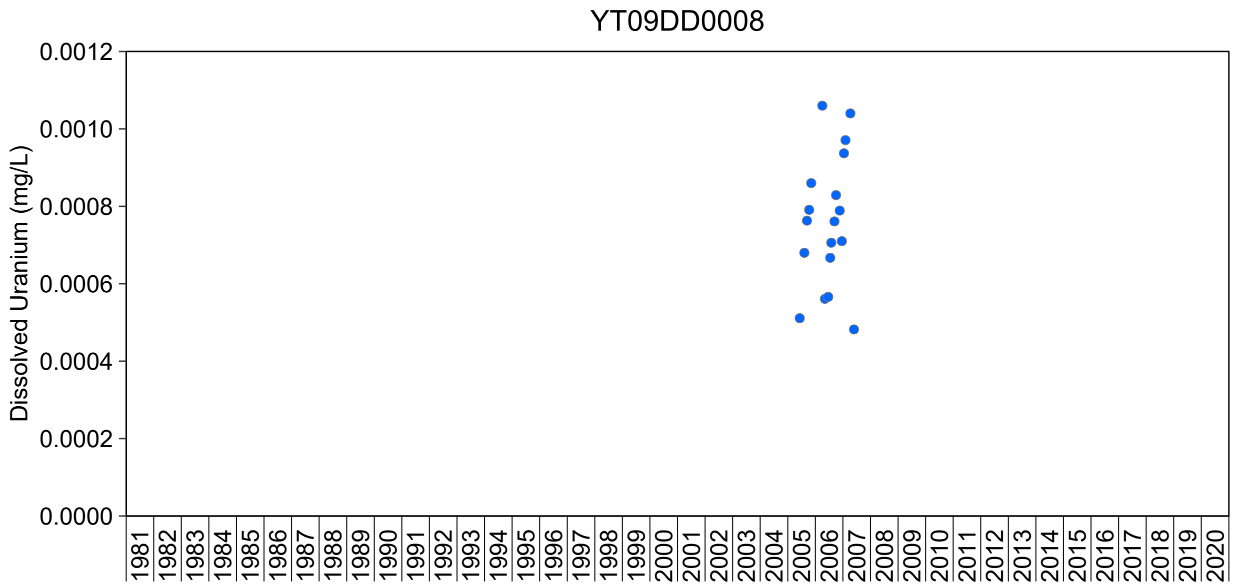


Figure A.92: Time Series Plots for Dissolved Uranium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

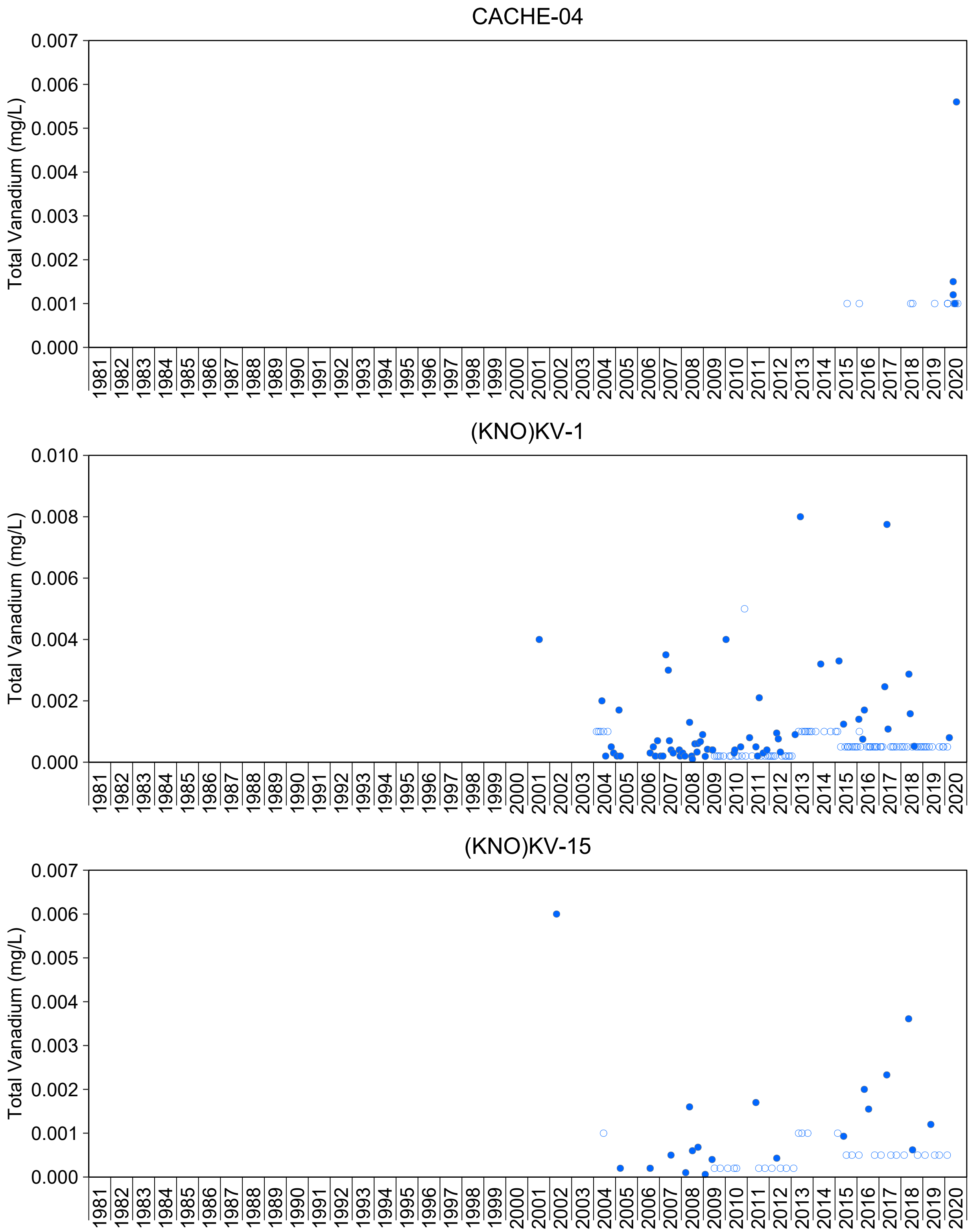


Figure A.93: Time Series Plots for Total Vanadium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

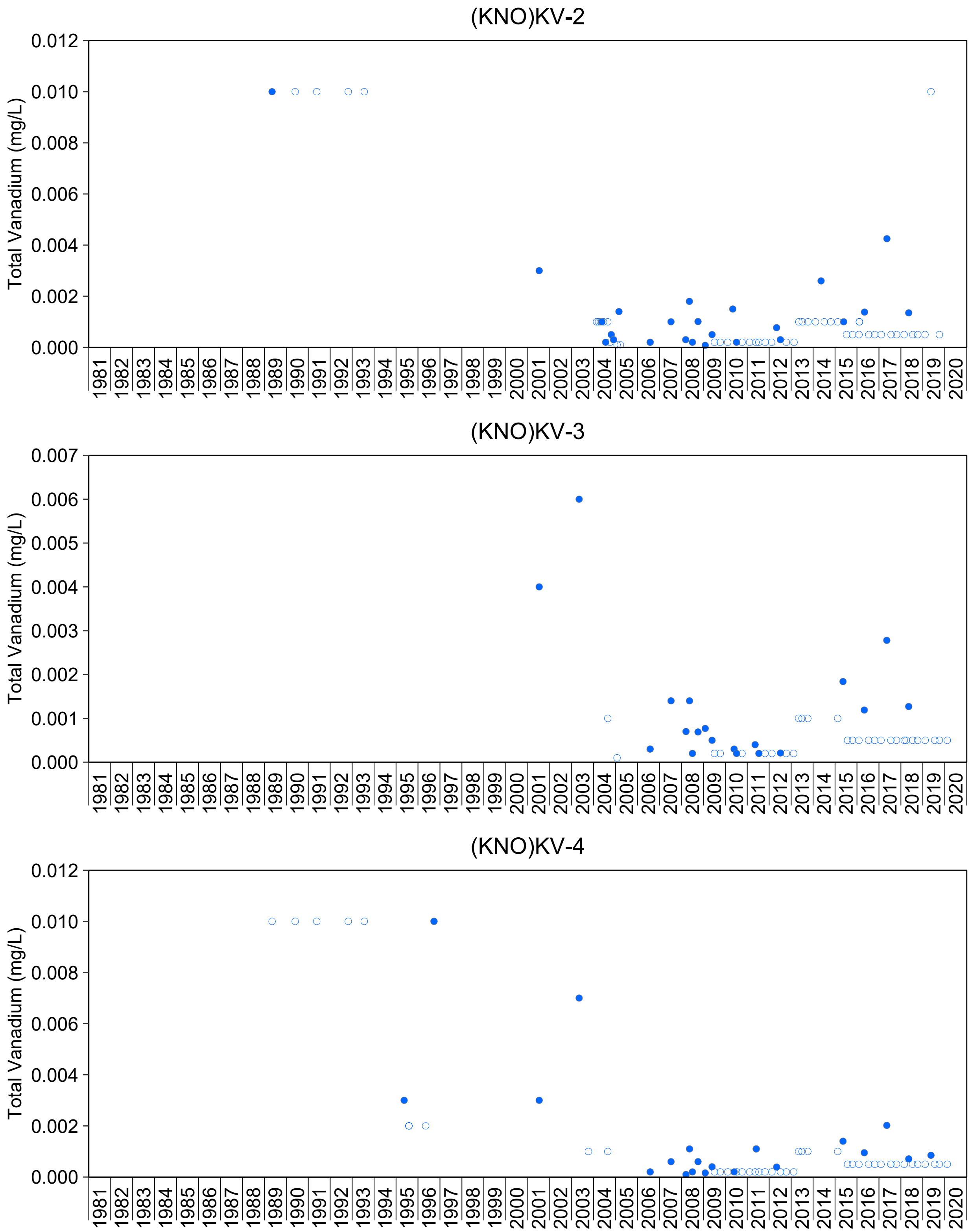


Figure A.93: Time Series Plots for Total Vanadium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

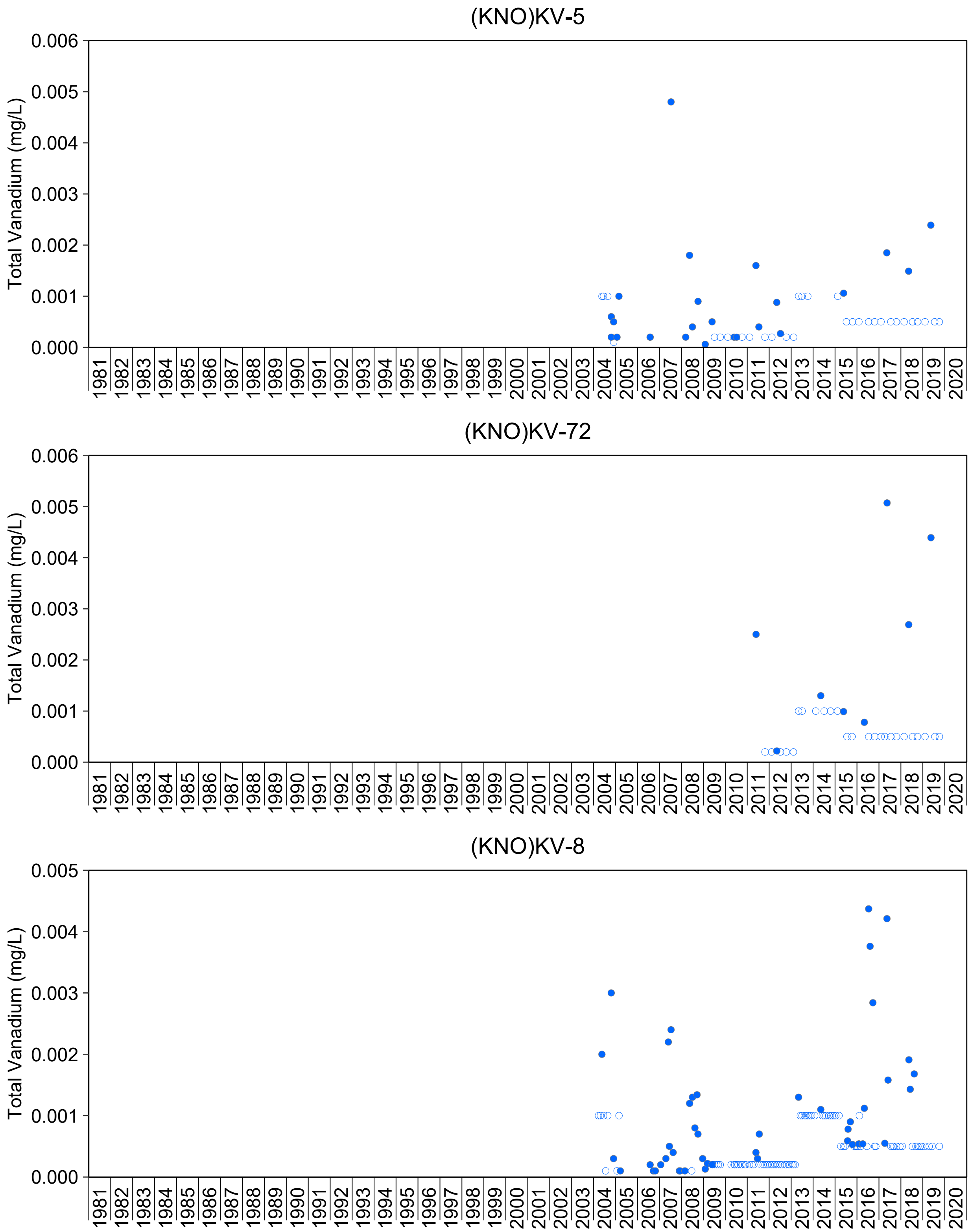


Figure A.93: Time Series Plots for Total Vanadium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

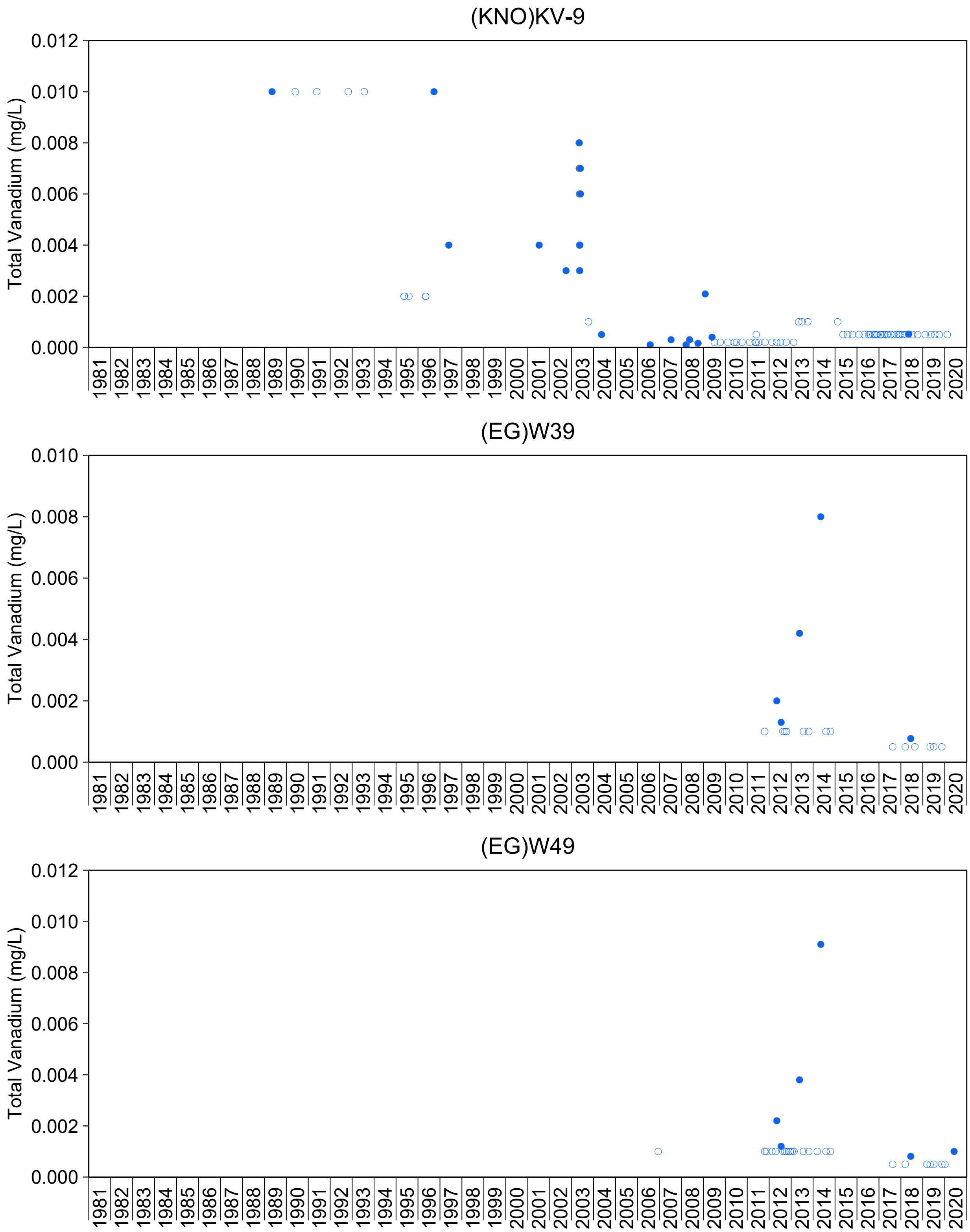


Figure A.93: Time Series Plots for Total Vanadium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

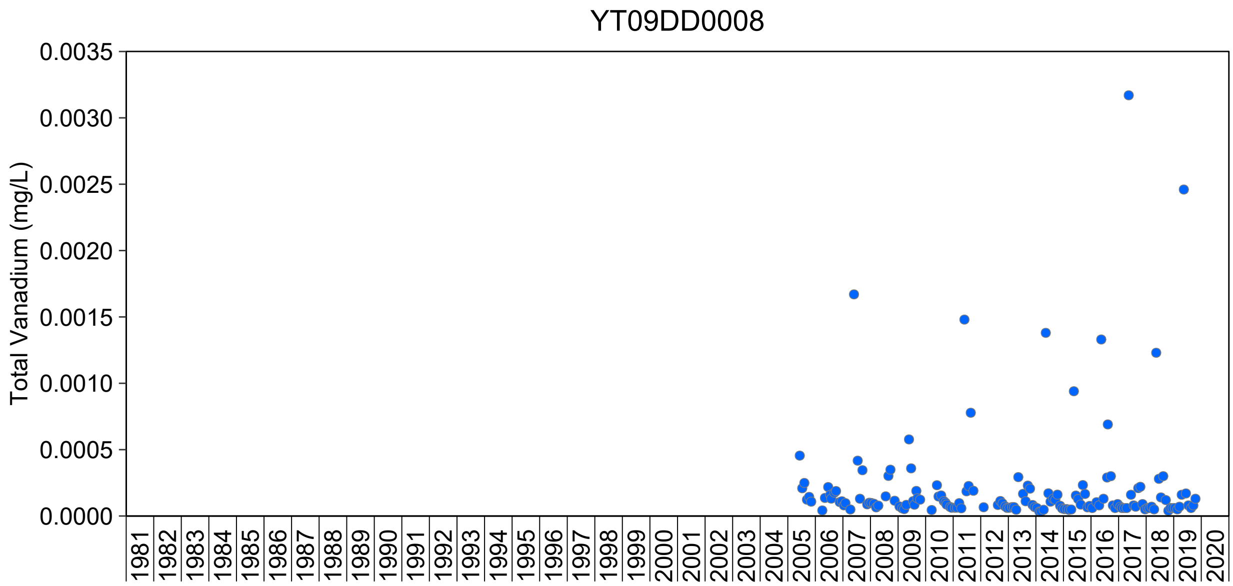


Figure A.93: Time Series Plots for Total Vanadium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

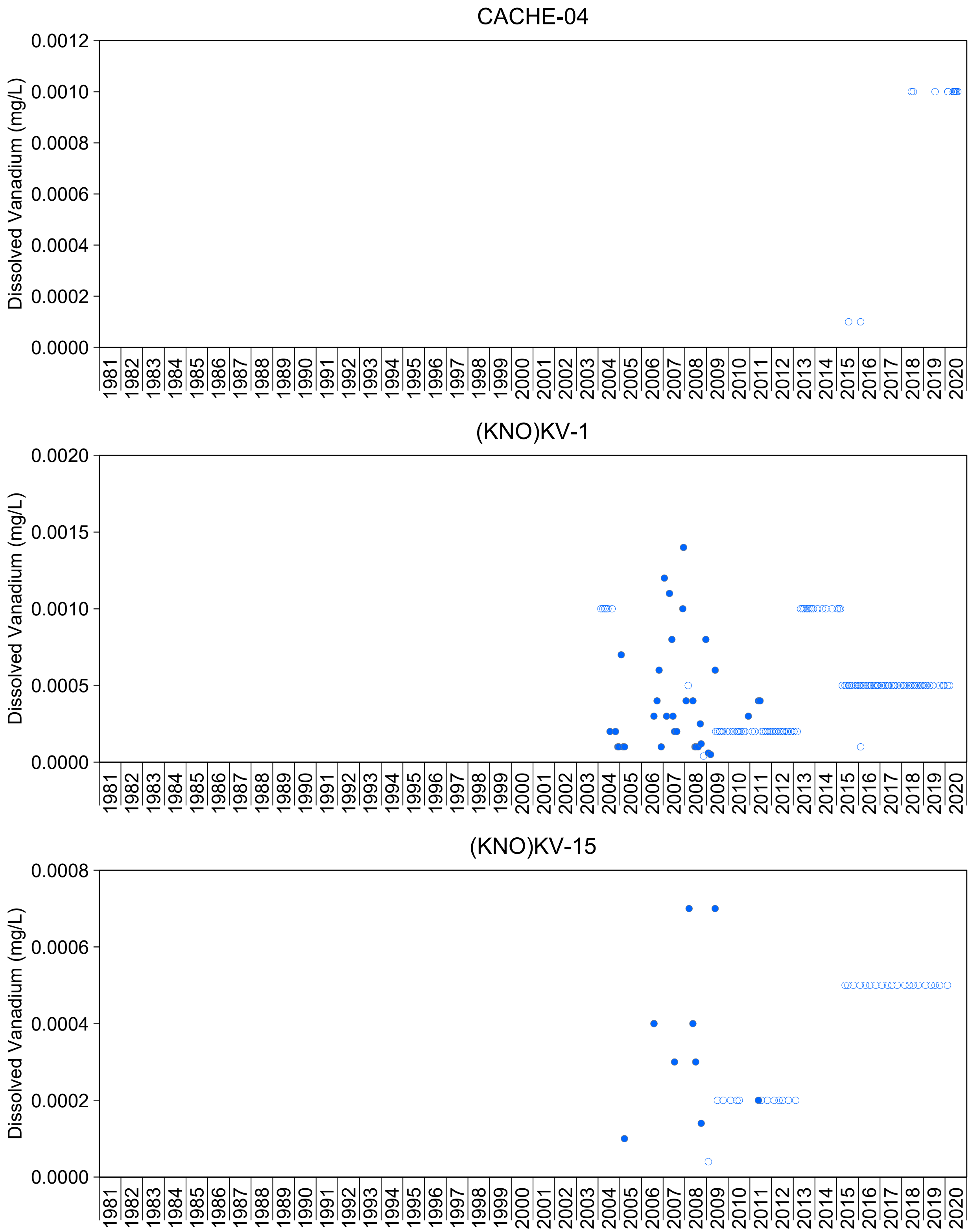


Figure A.94: Time Series Plots for Dissolved Vanadium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

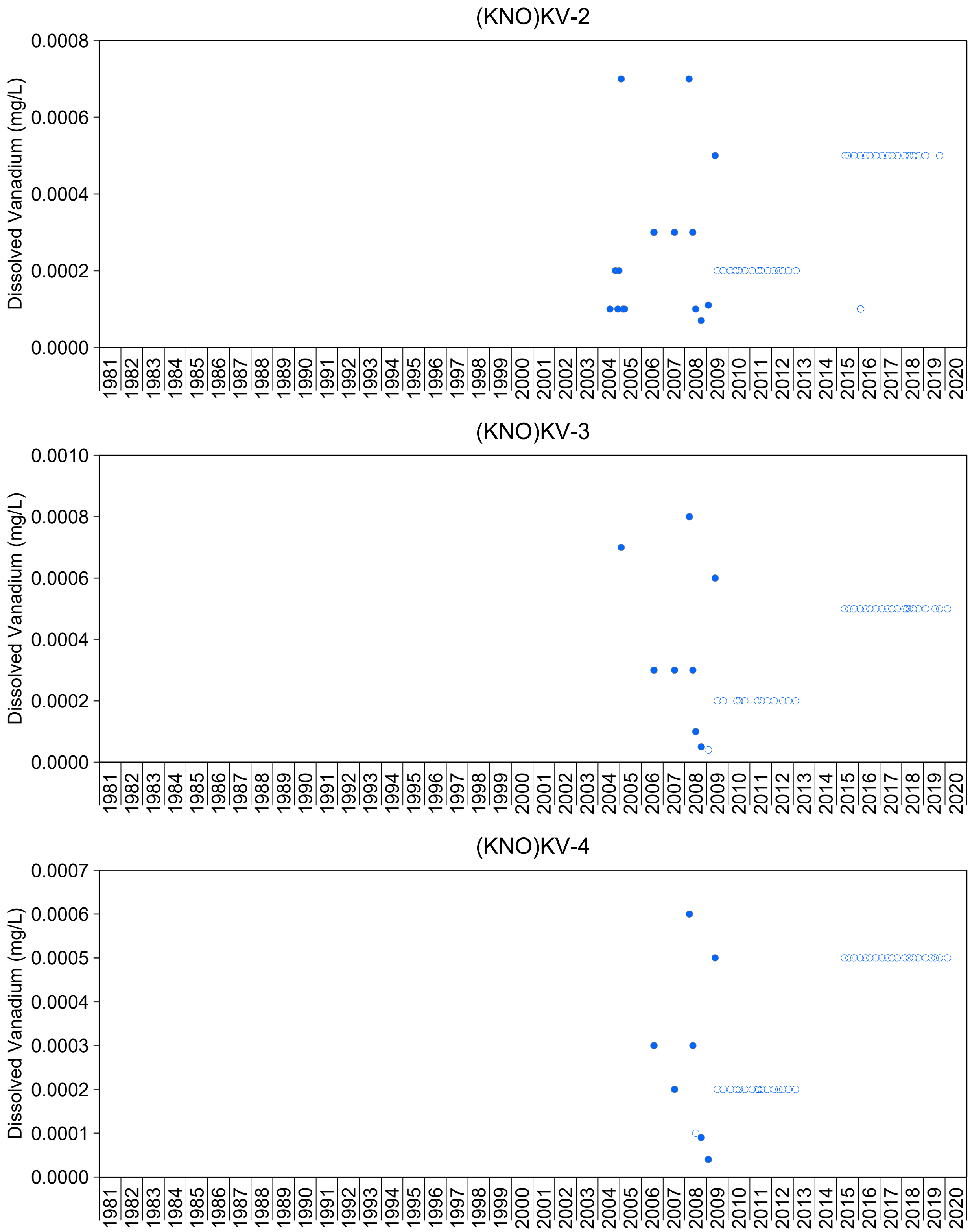


Figure A.94: Time Series Plots for Dissolved Vanadium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

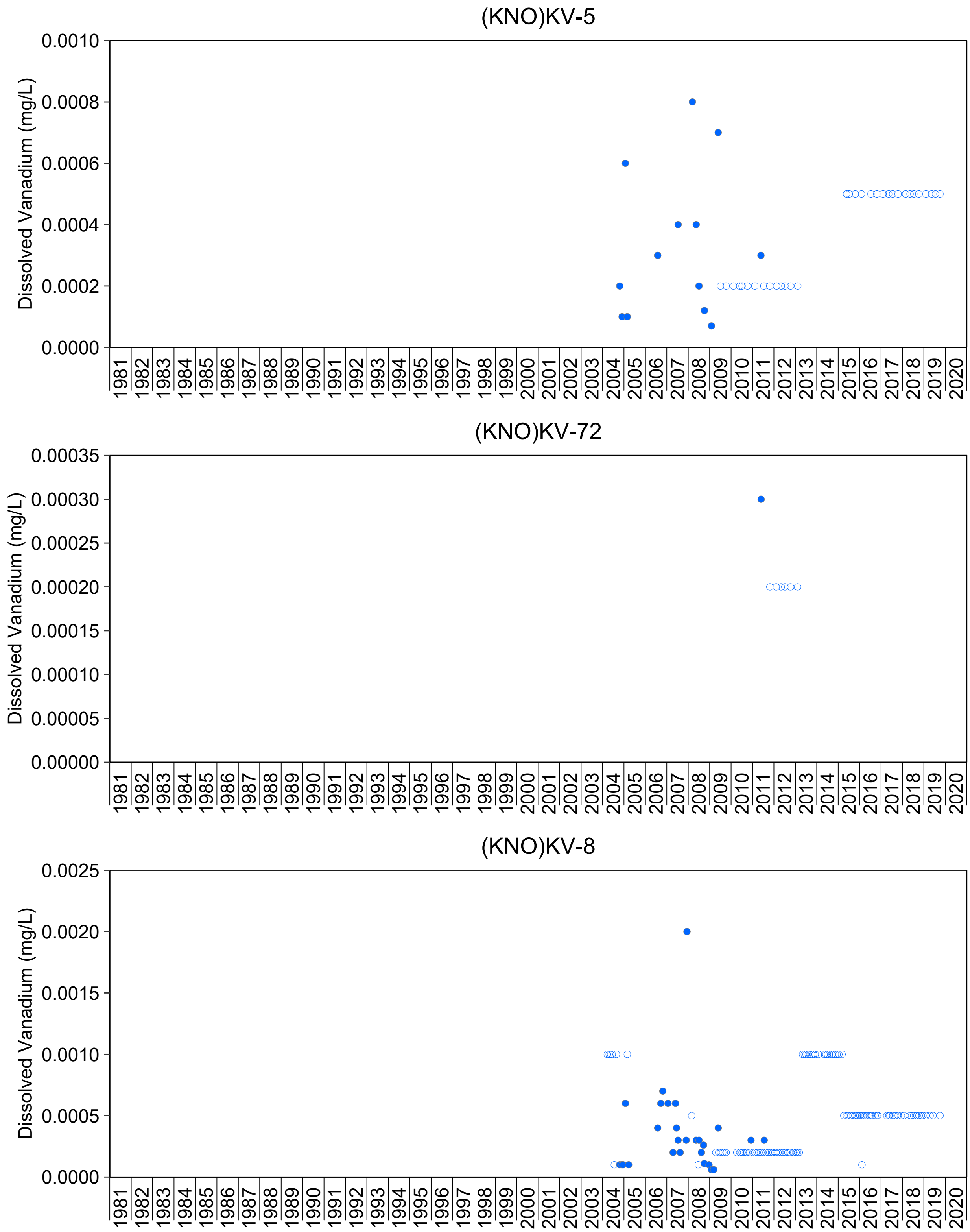


Figure A.94: Time Series Plots for Dissolved Vanadium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

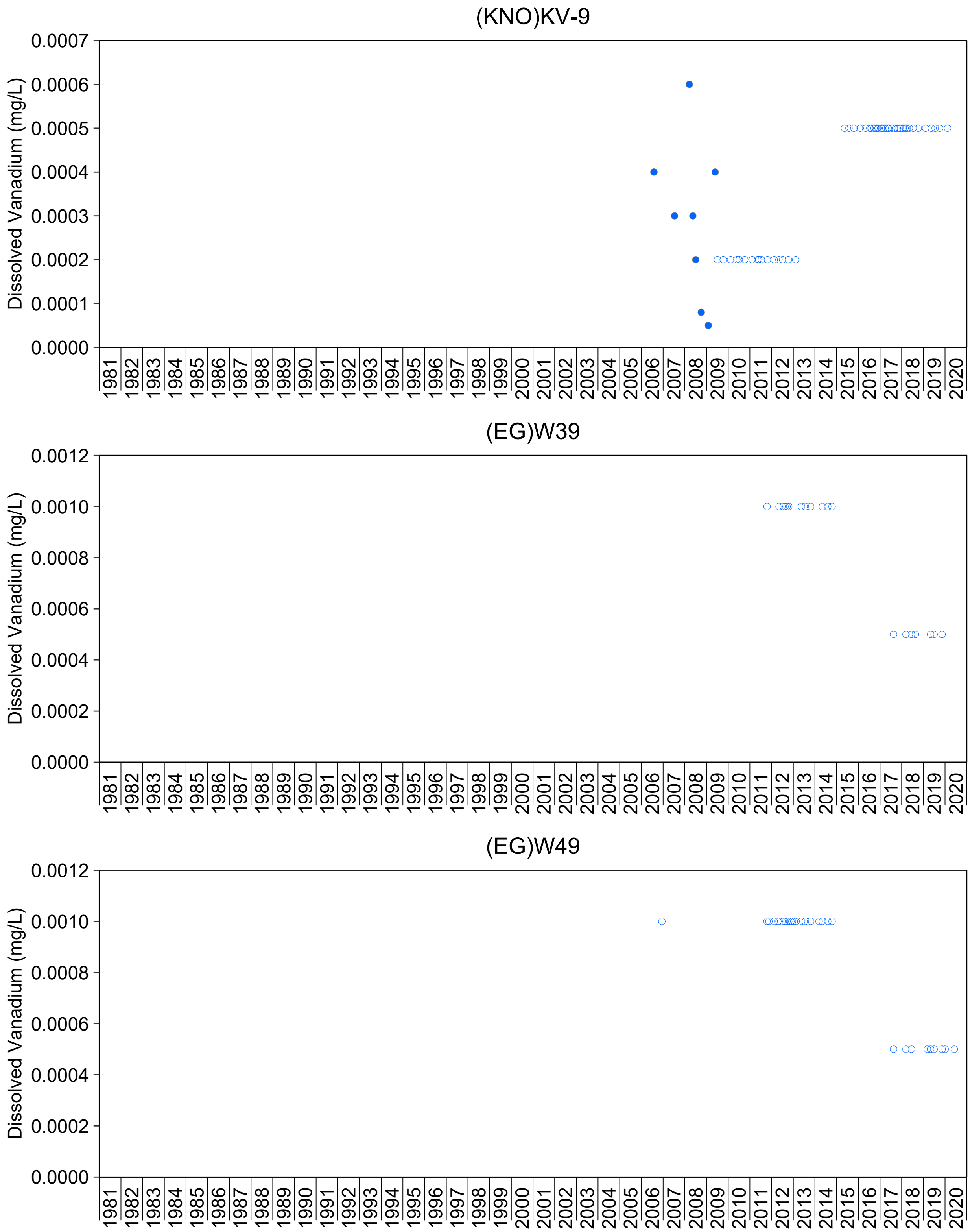


Figure A.94: Time Series Plots for Dissolved Vanadium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

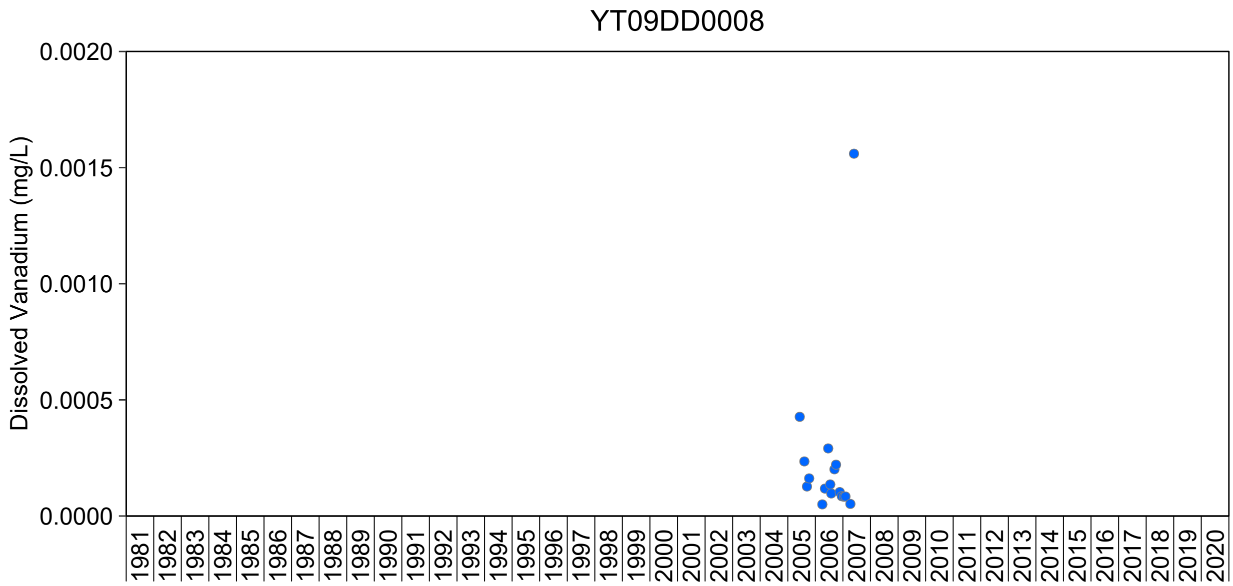


Figure A.94: Time Series Plots for Dissolved Vanadium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

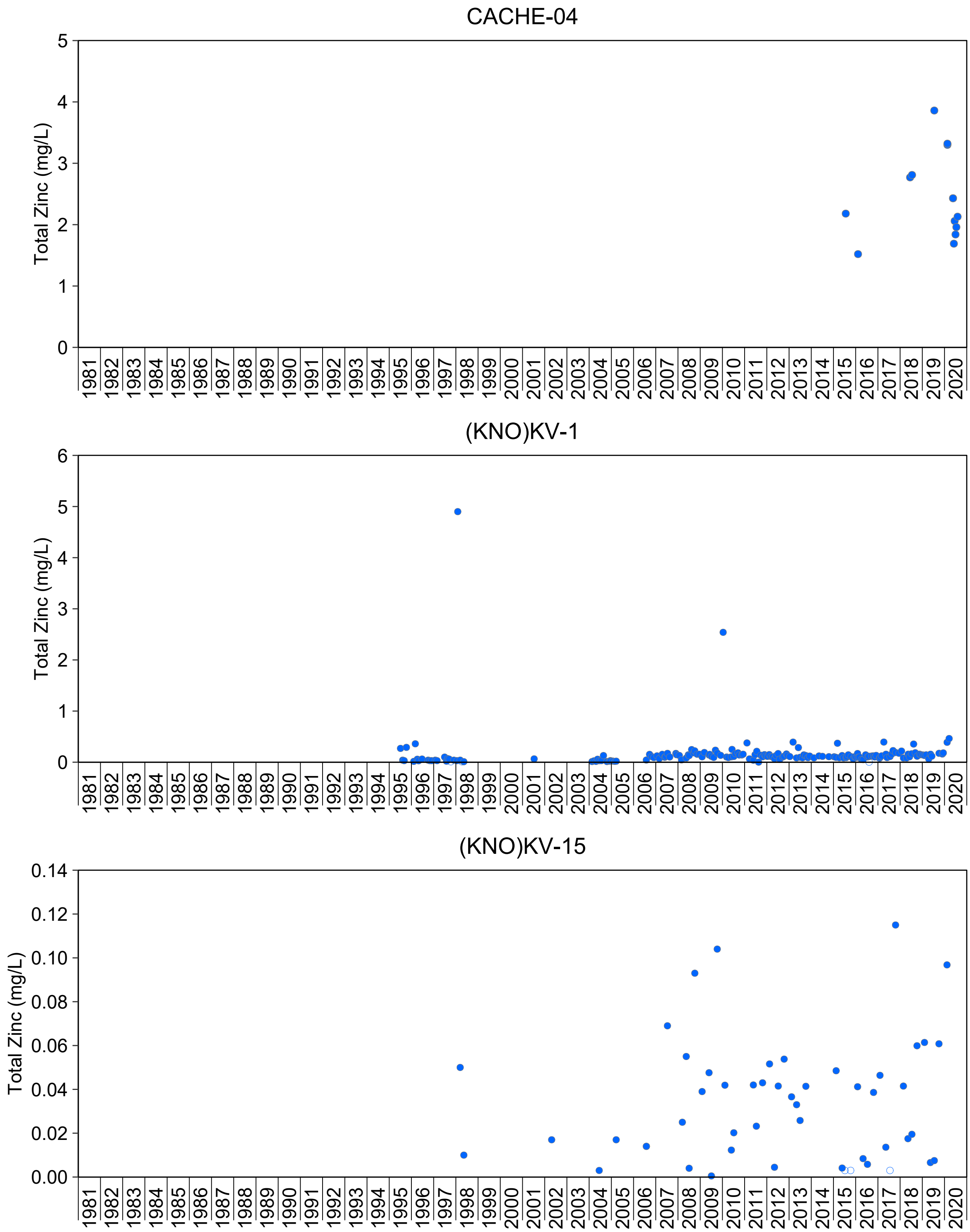


Figure A.95: Time Series Plots for Total Zinc Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

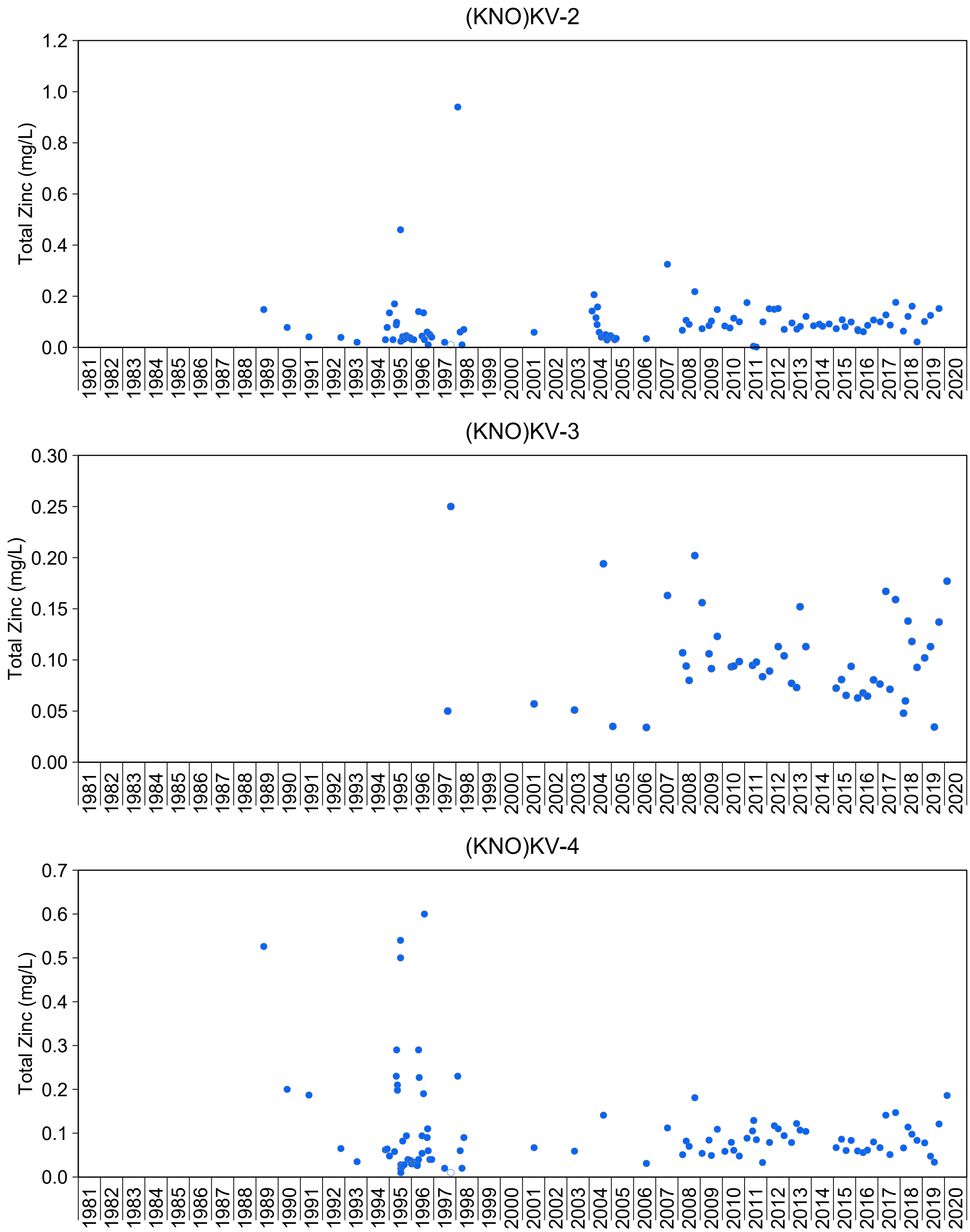
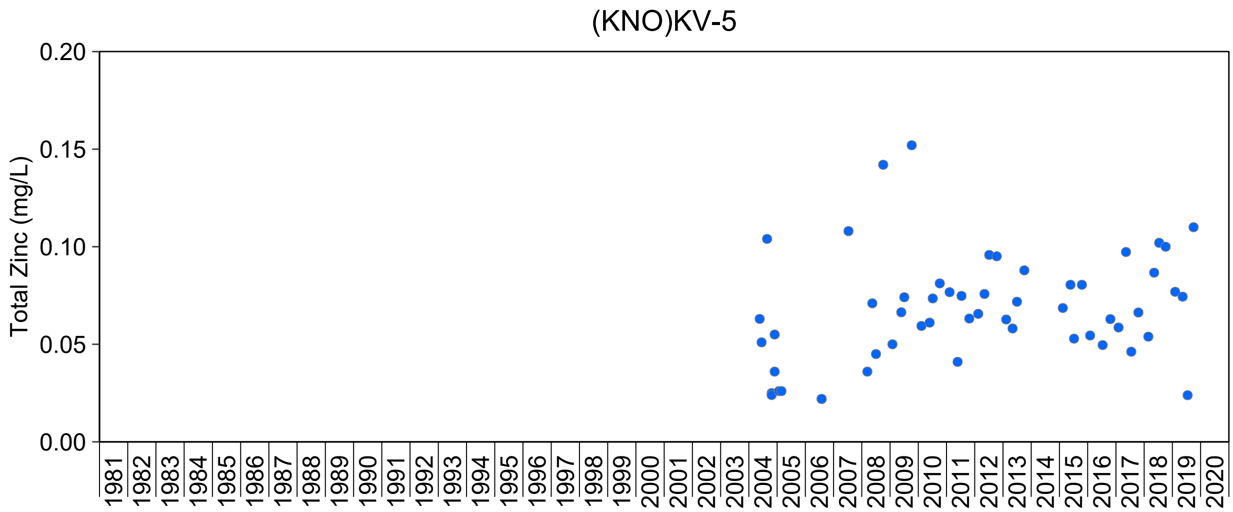
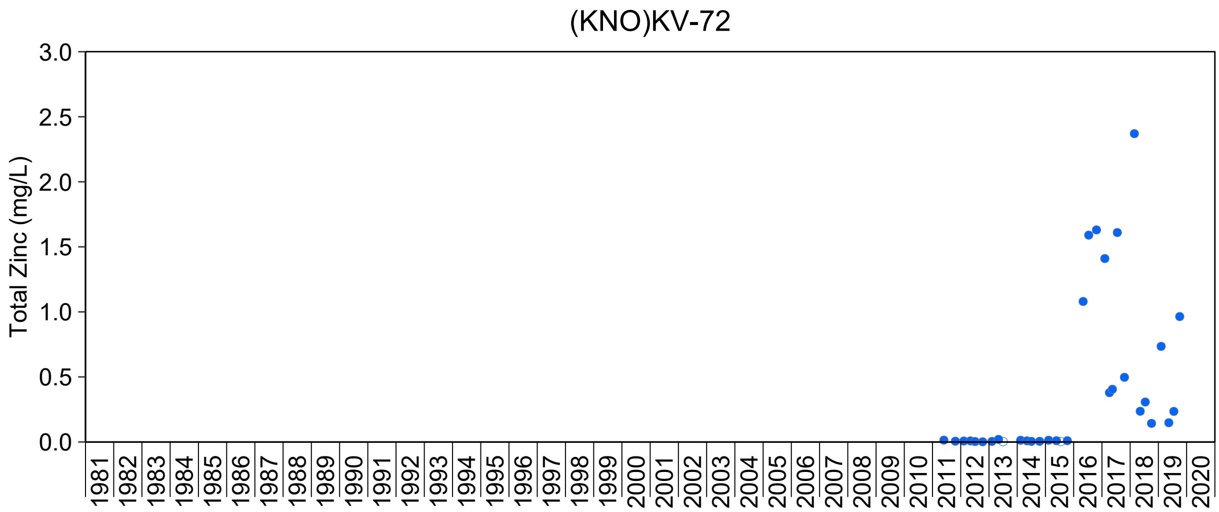
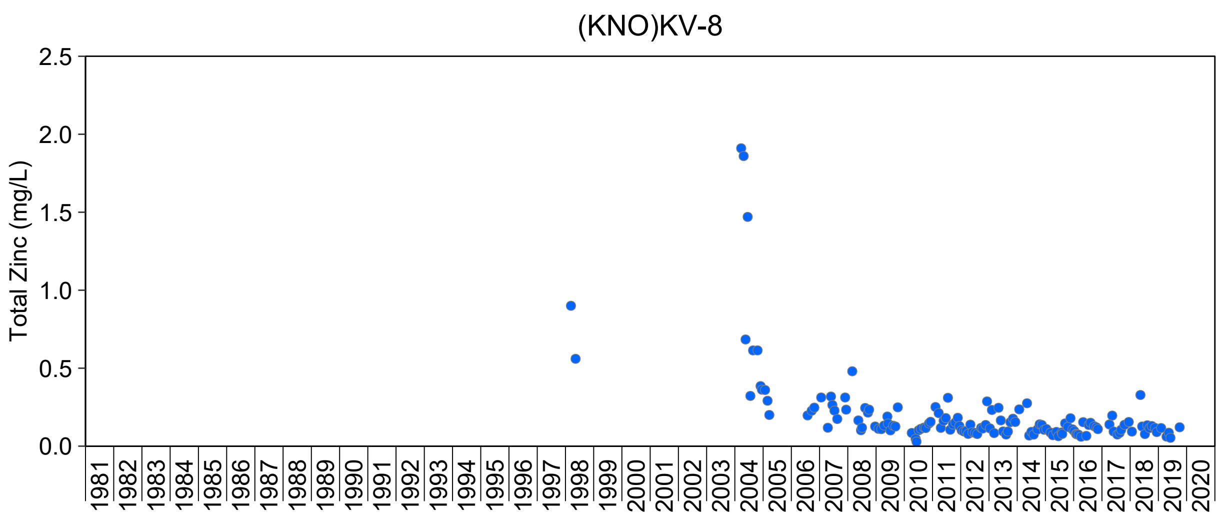


Figure A.95: Time Series Plots for Total Zinc Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.







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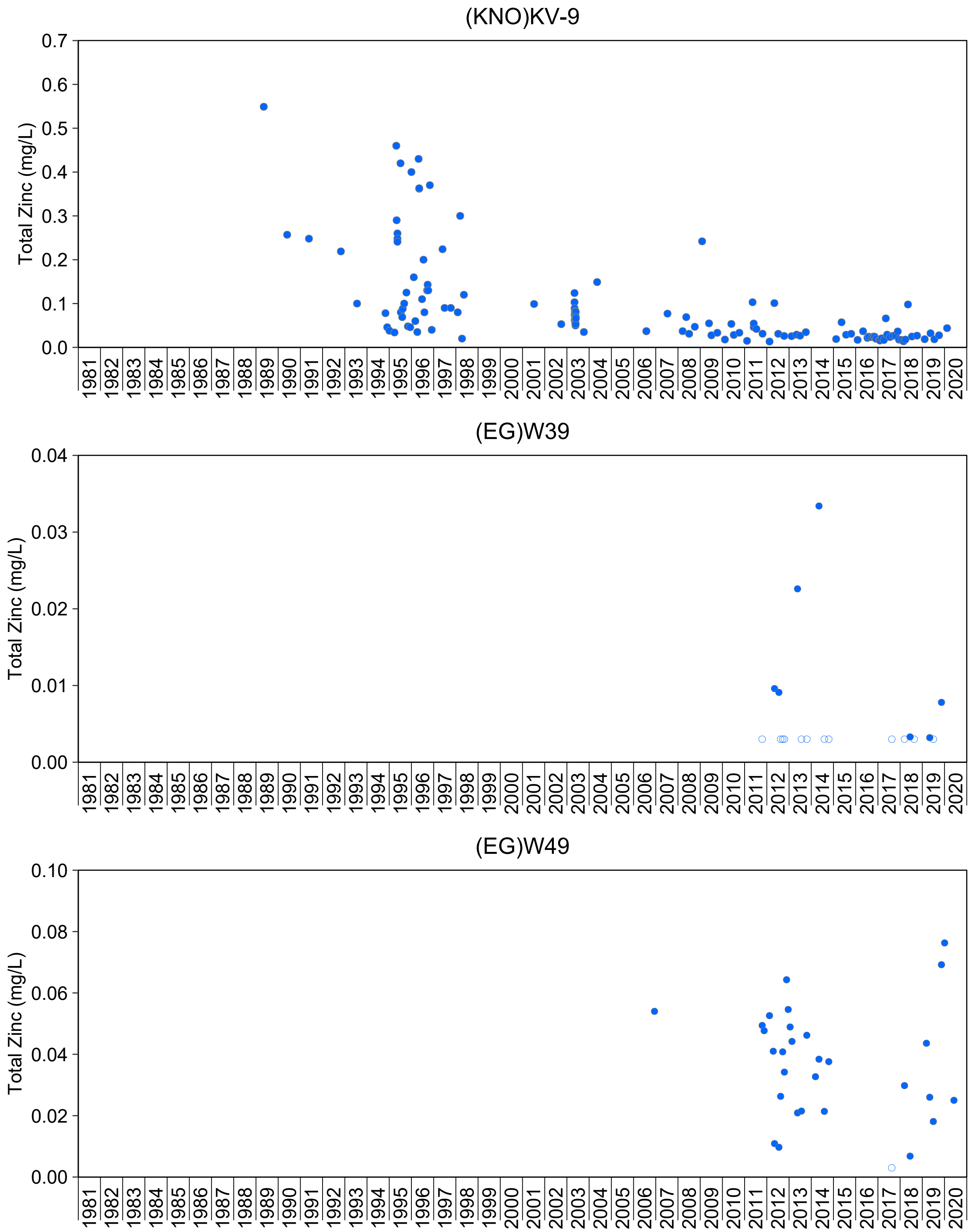

Figure A.95: Time Series Plots for Total Zinc Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

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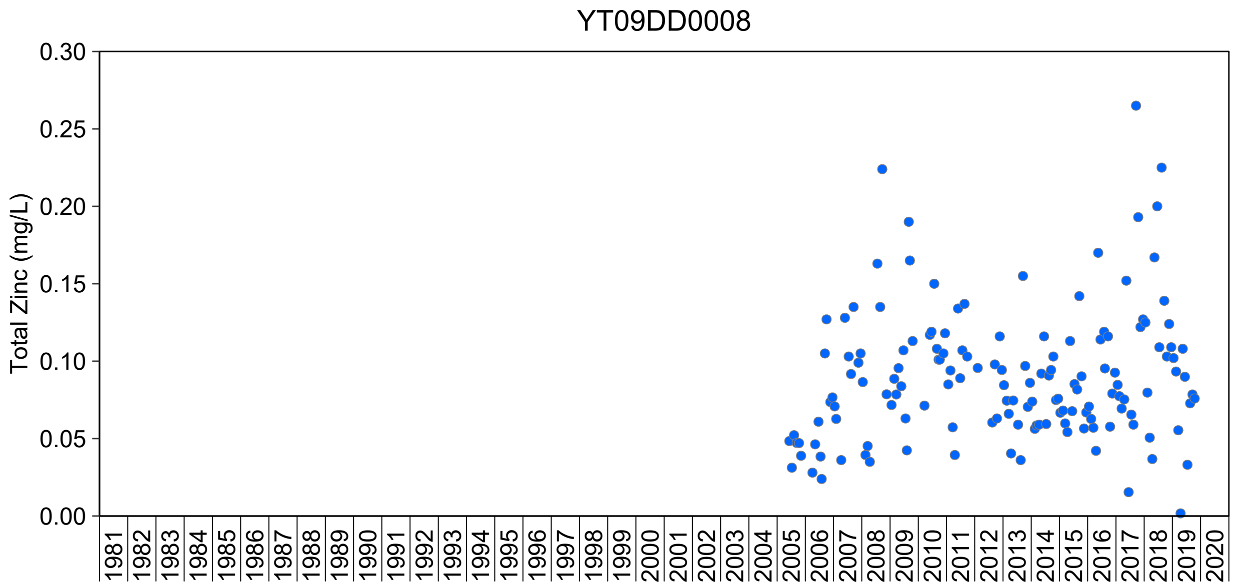

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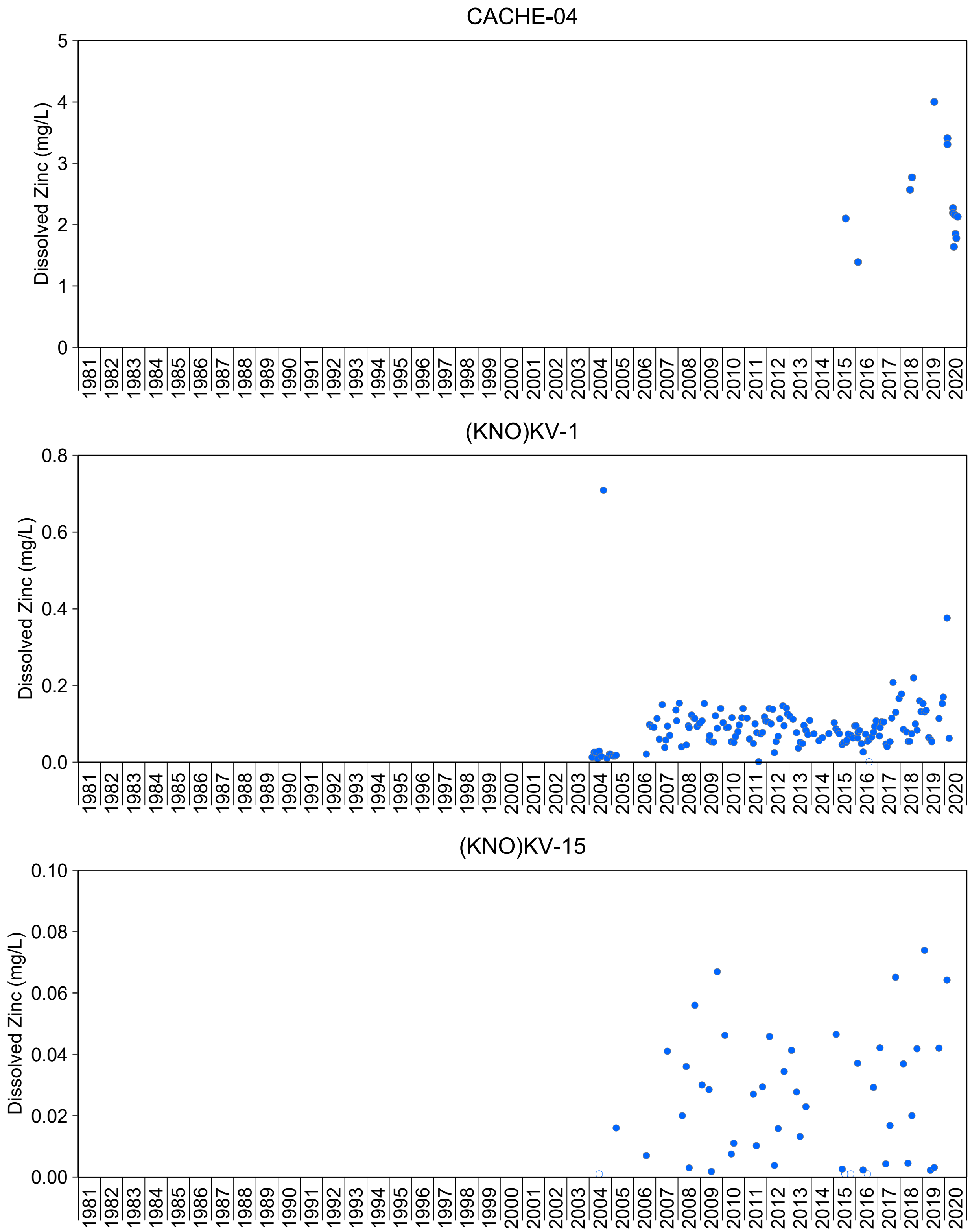

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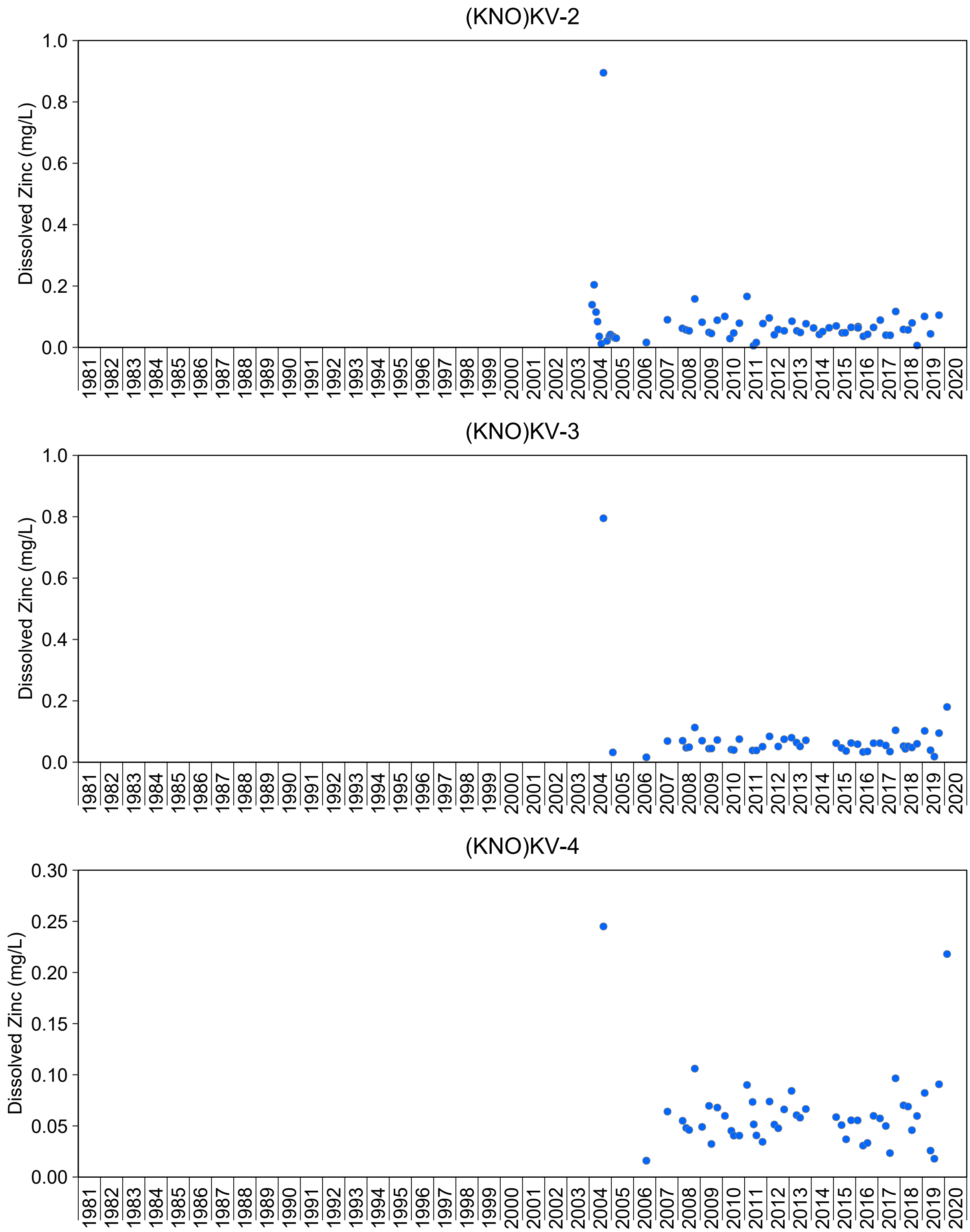

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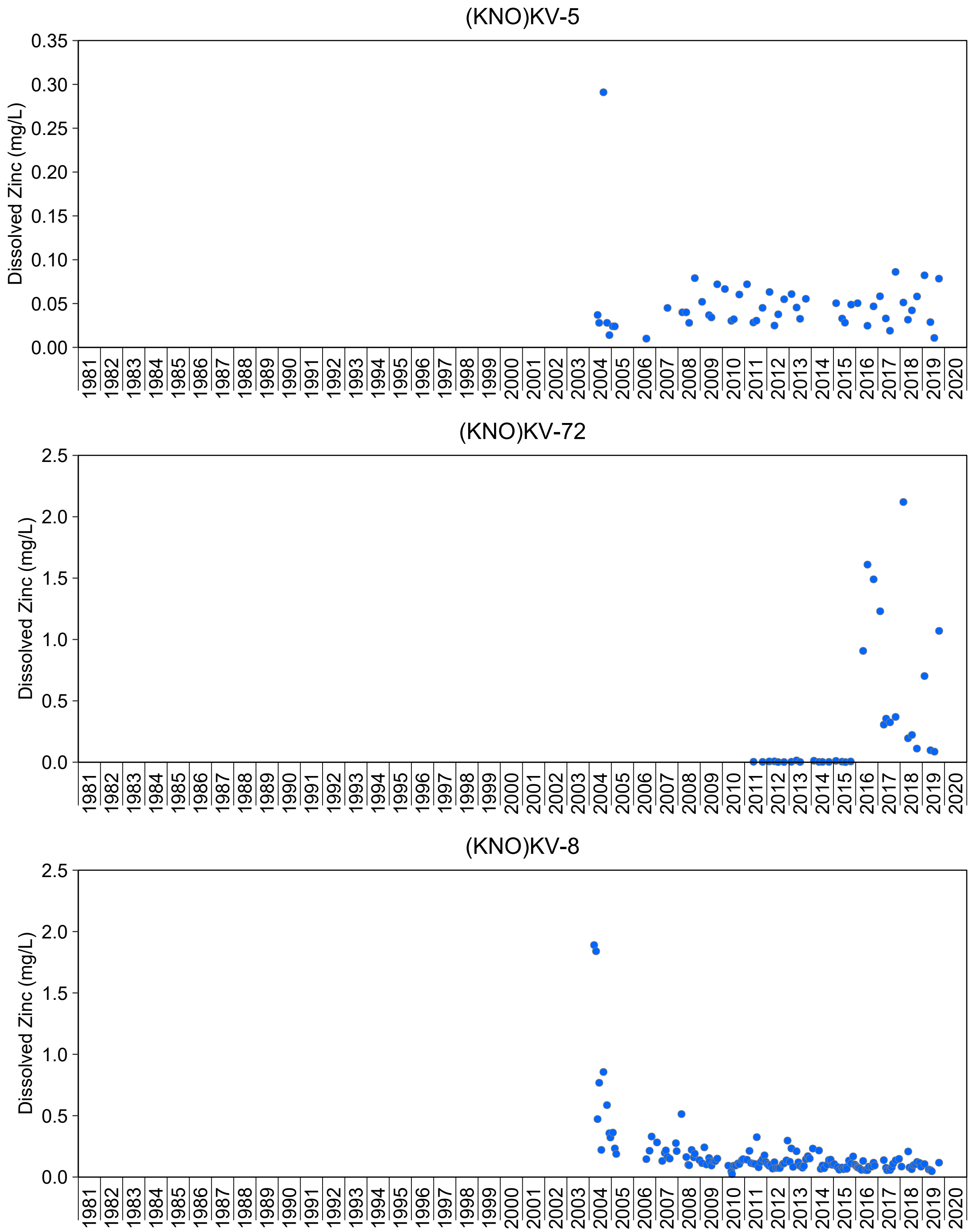

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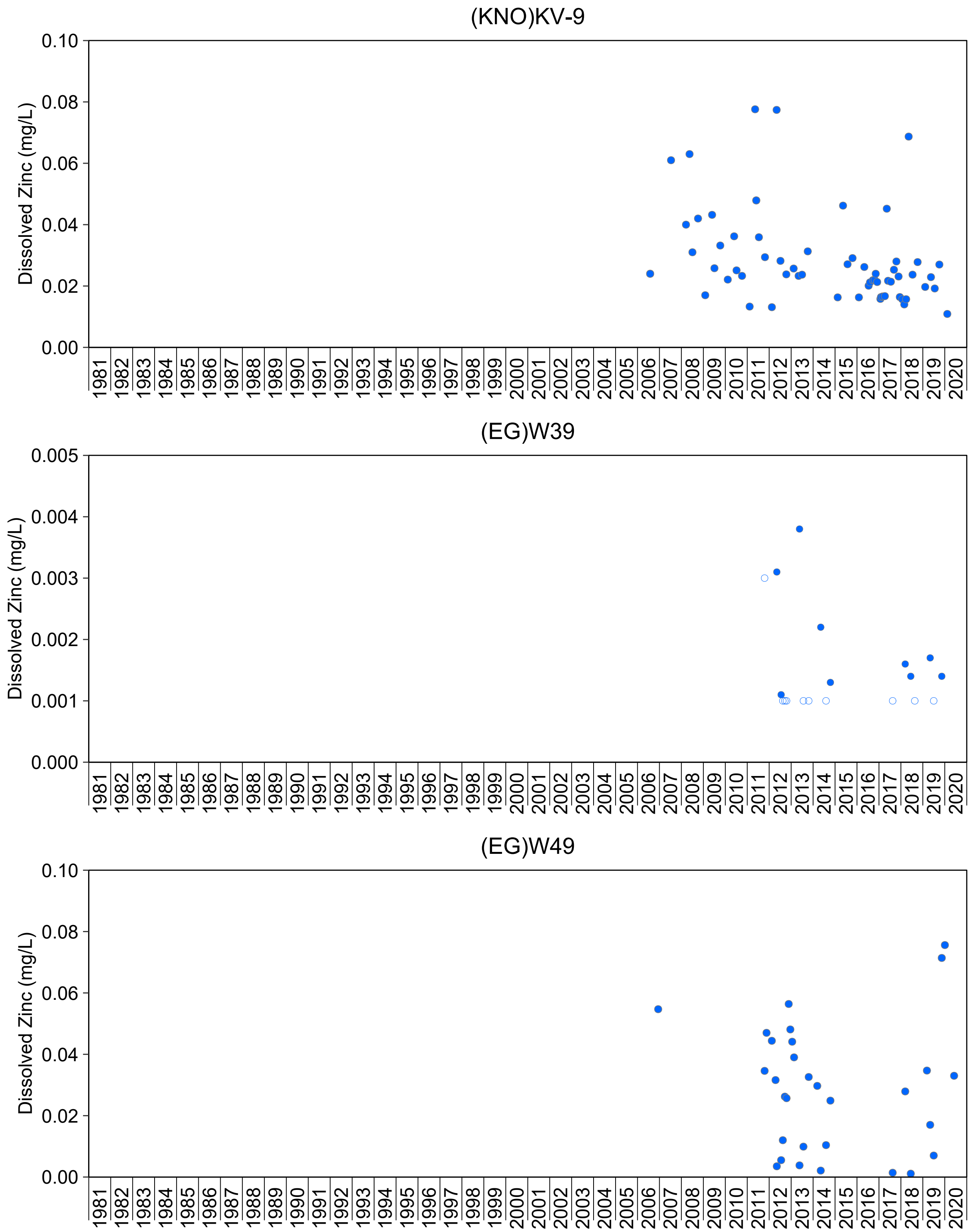

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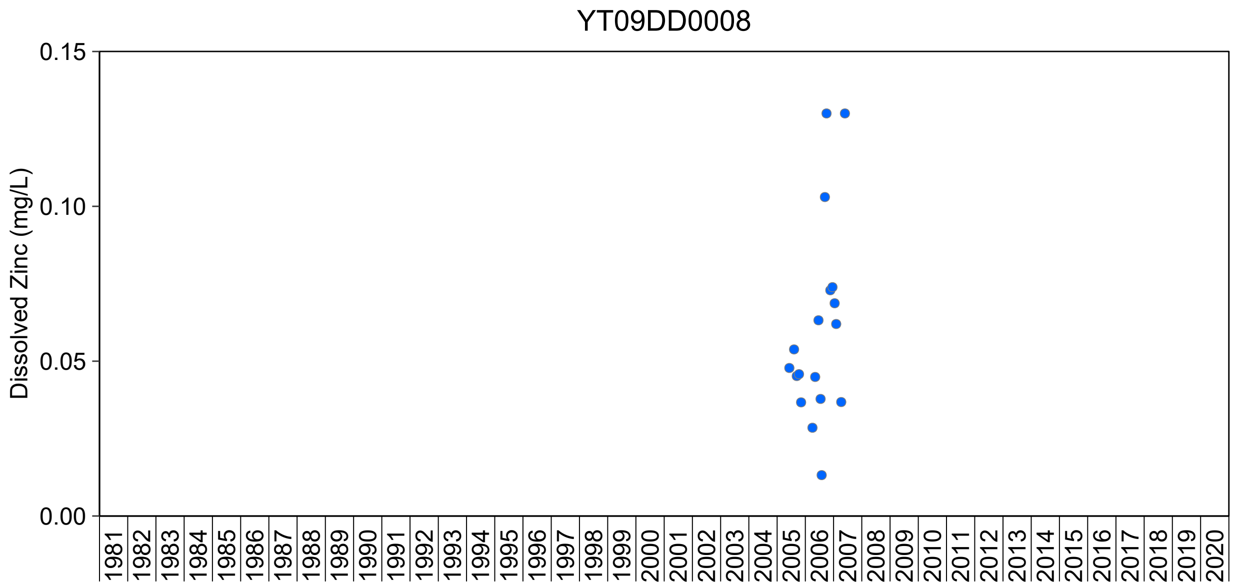

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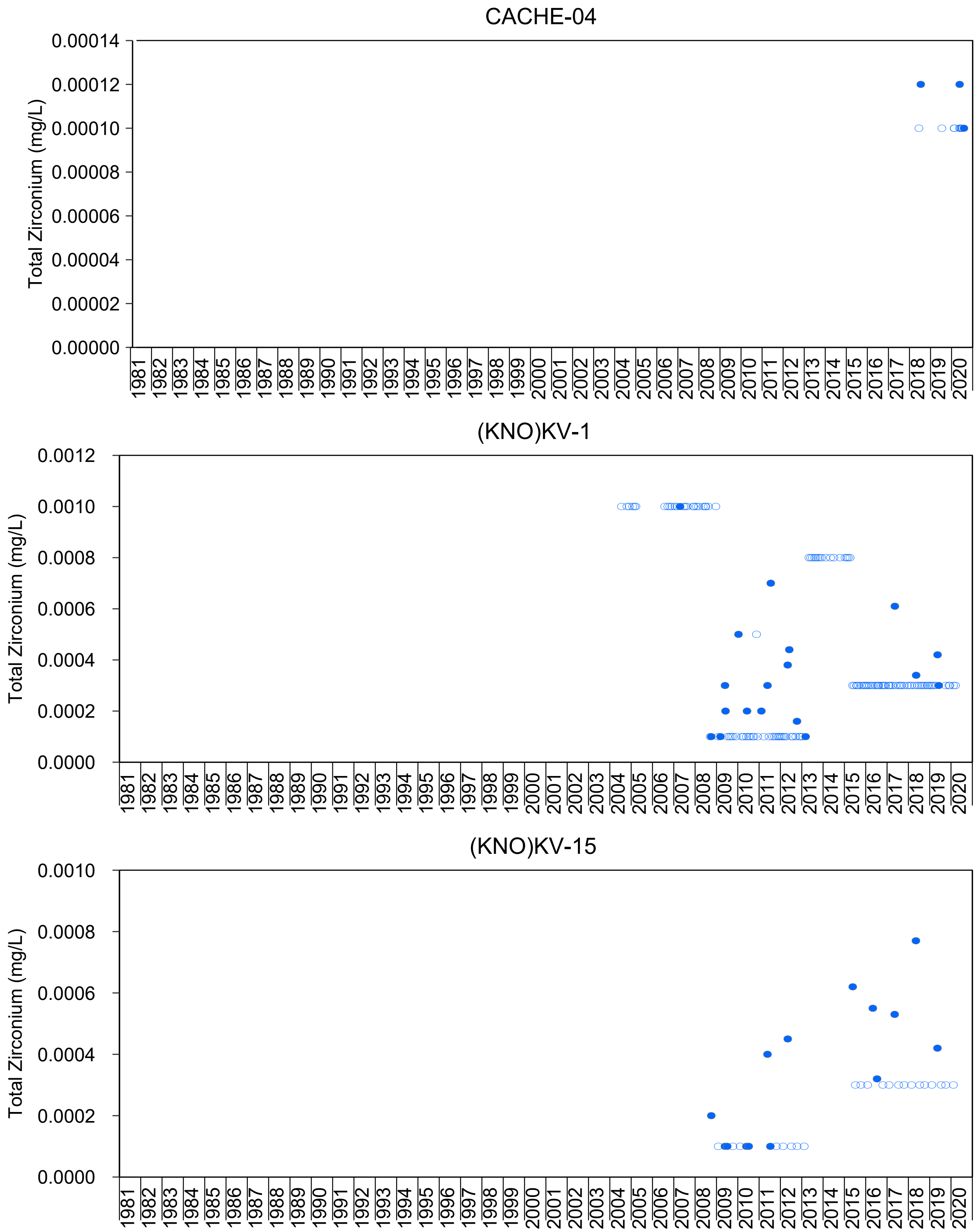


Figure A.97: Time Series Plots for Total Zirconium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.

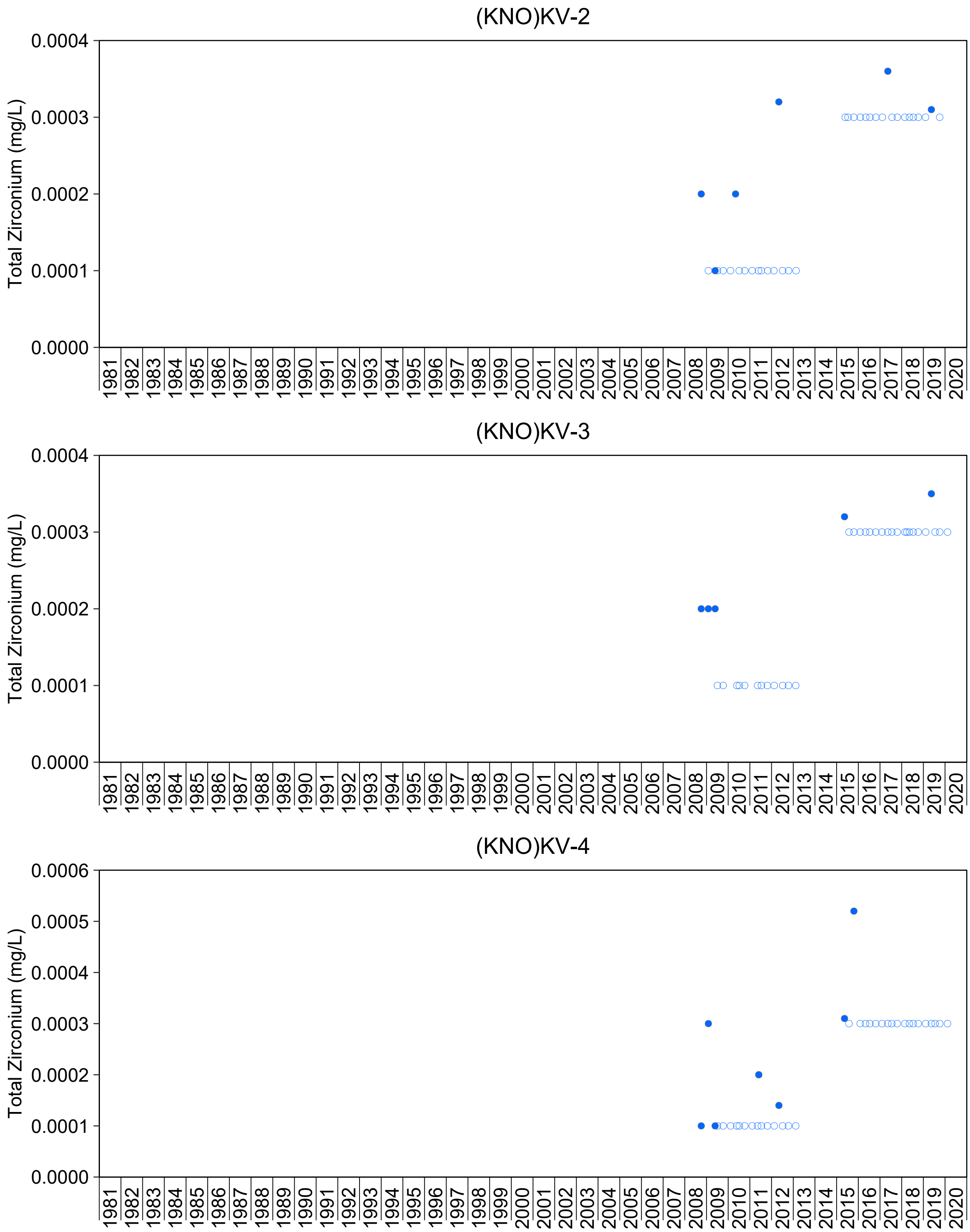
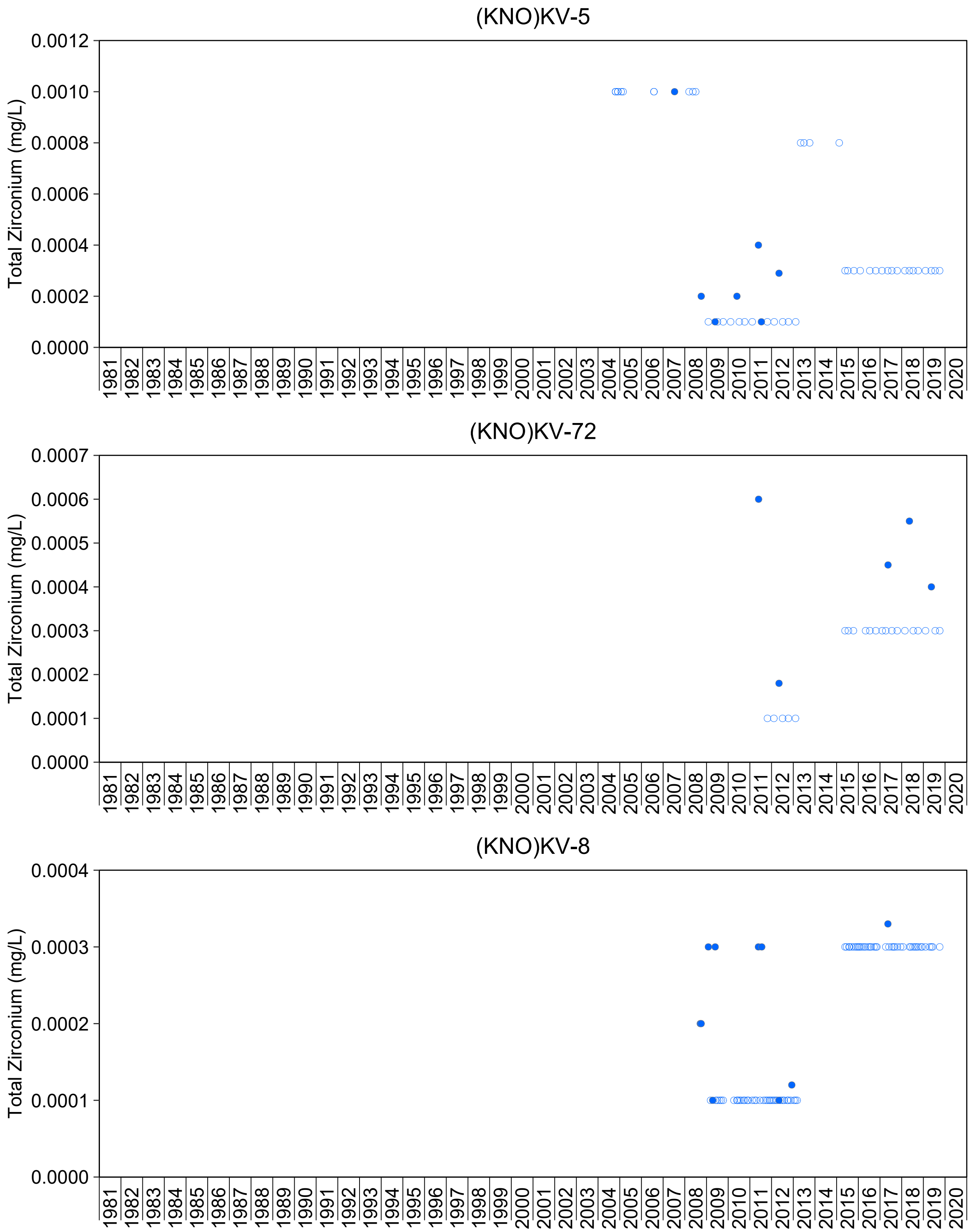


Figure A.97: Time Series Plots for Total Zirconium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

Notes: mg/L = milligrams per litre. Concentrations reported below the laboratory reporting limit (LRL) are plotted as open symbols at the LRL.



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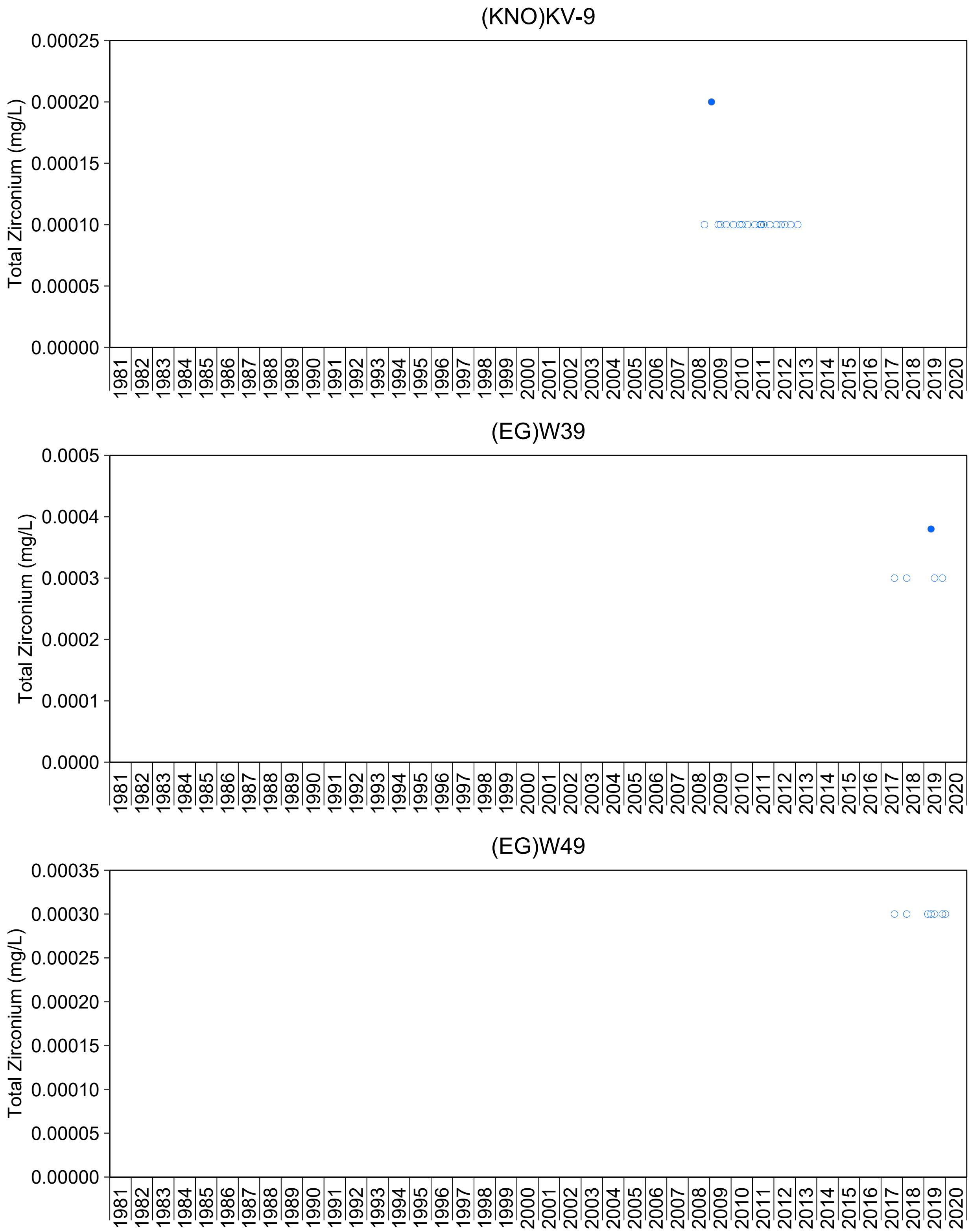

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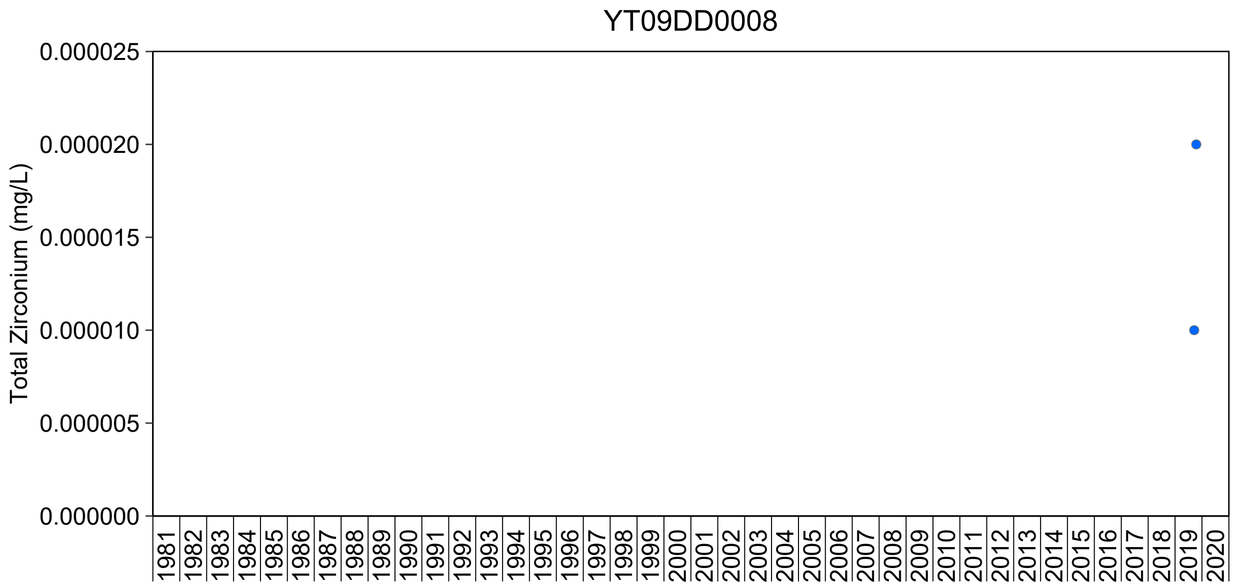

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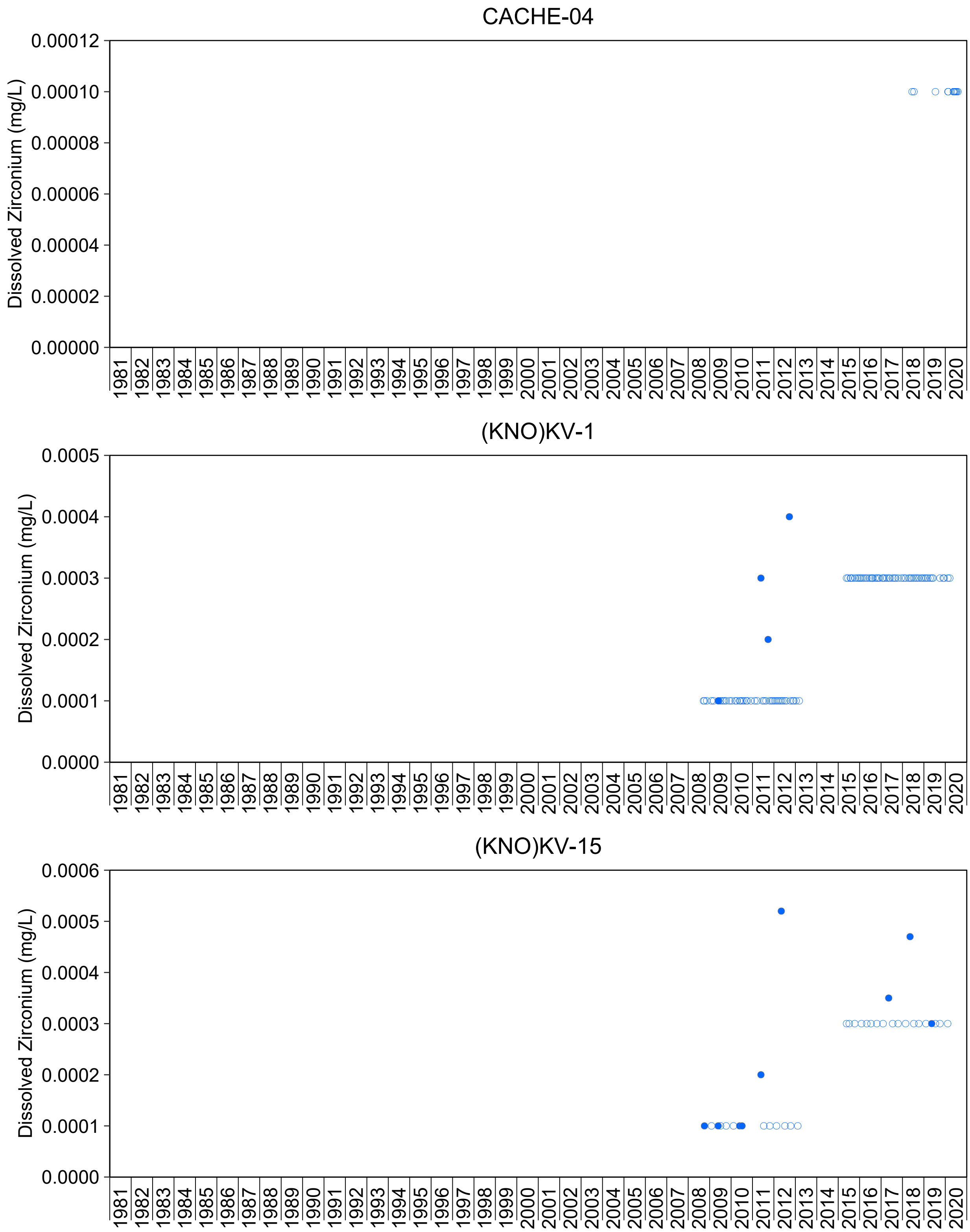

Figure A.98: Time Series Plots for Dissolved Zirconium Concentrations (mg/L) in the South McQuesten River, 1981 to 2020

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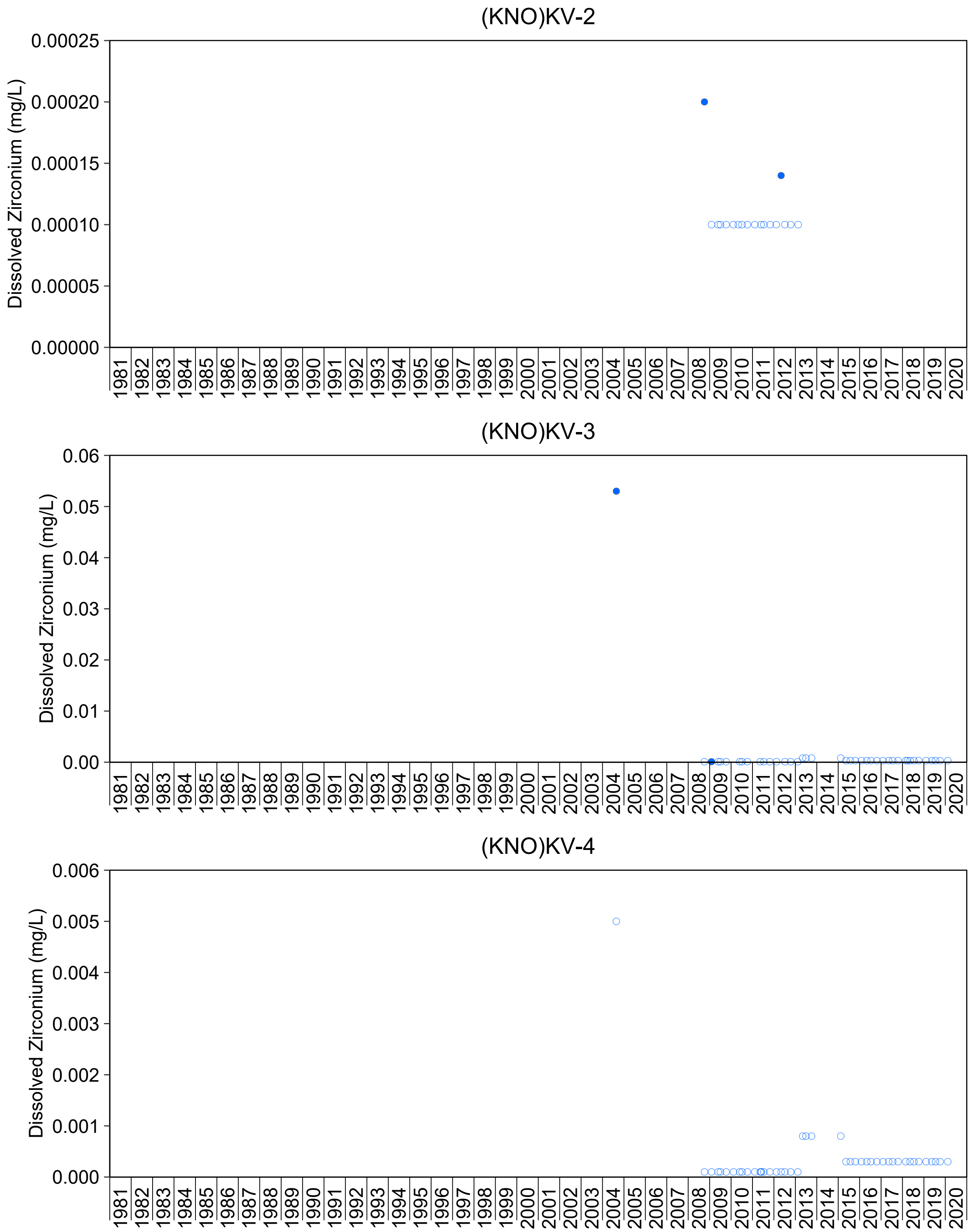

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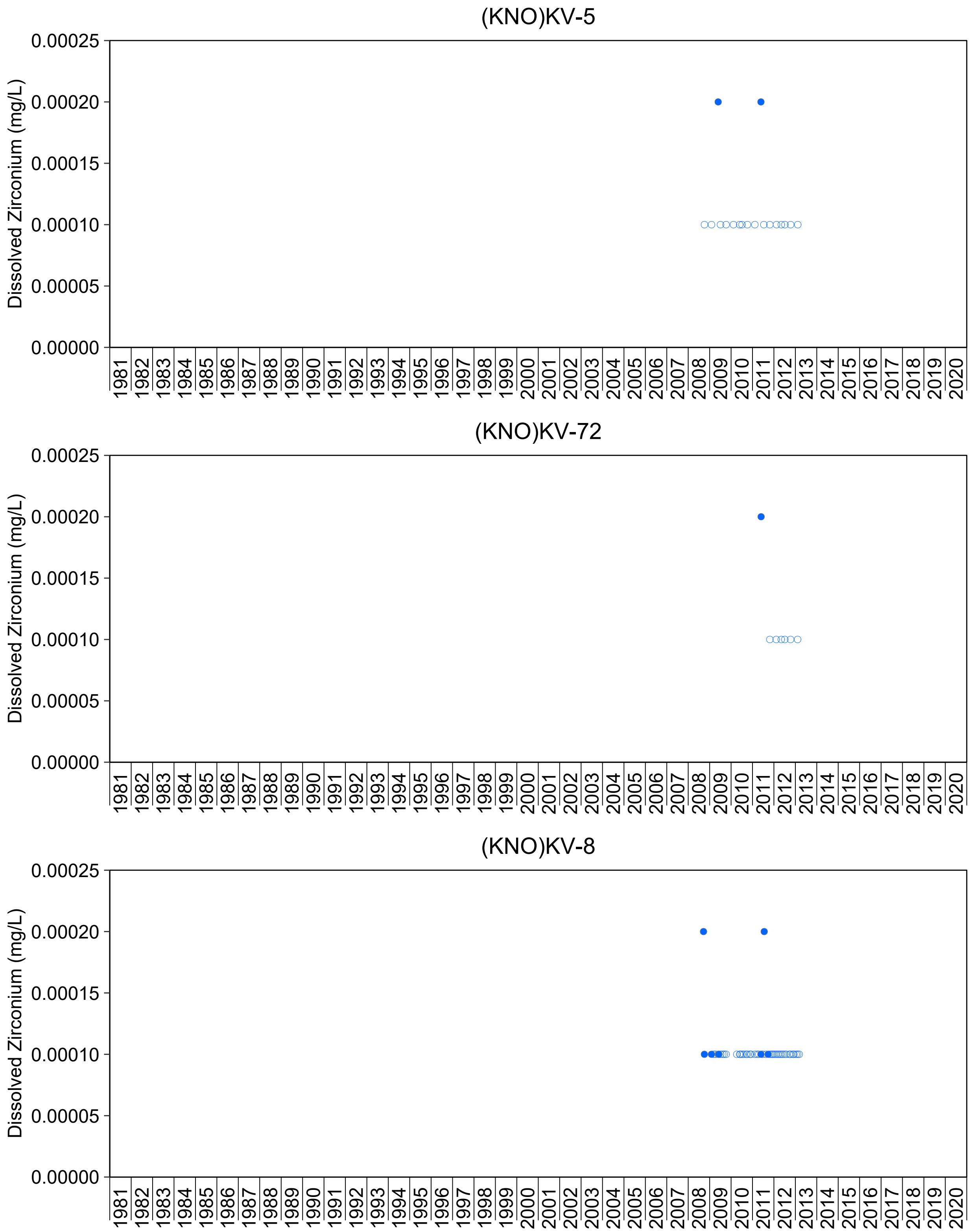

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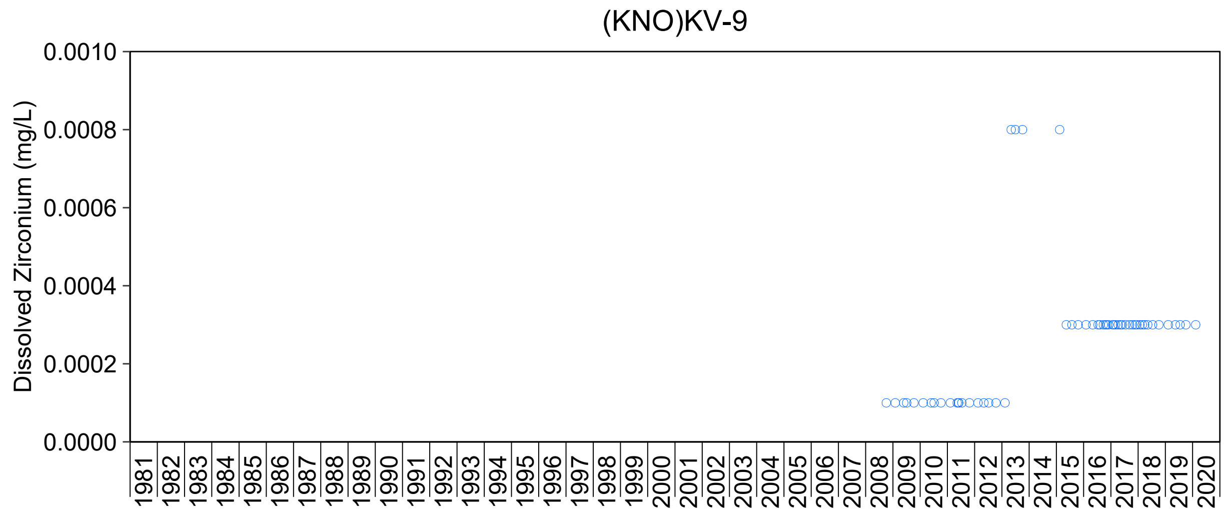

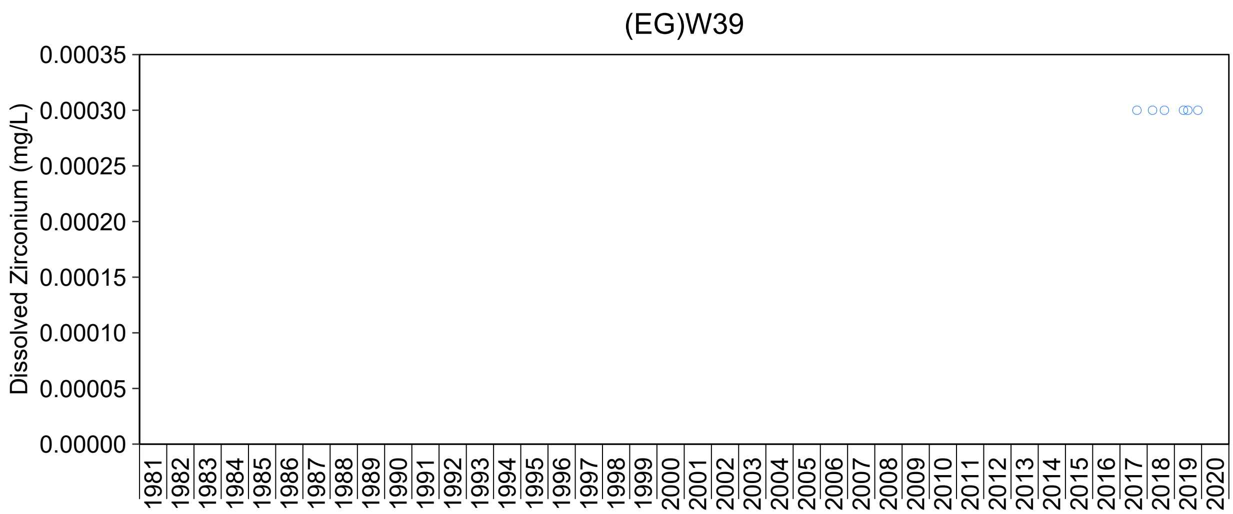

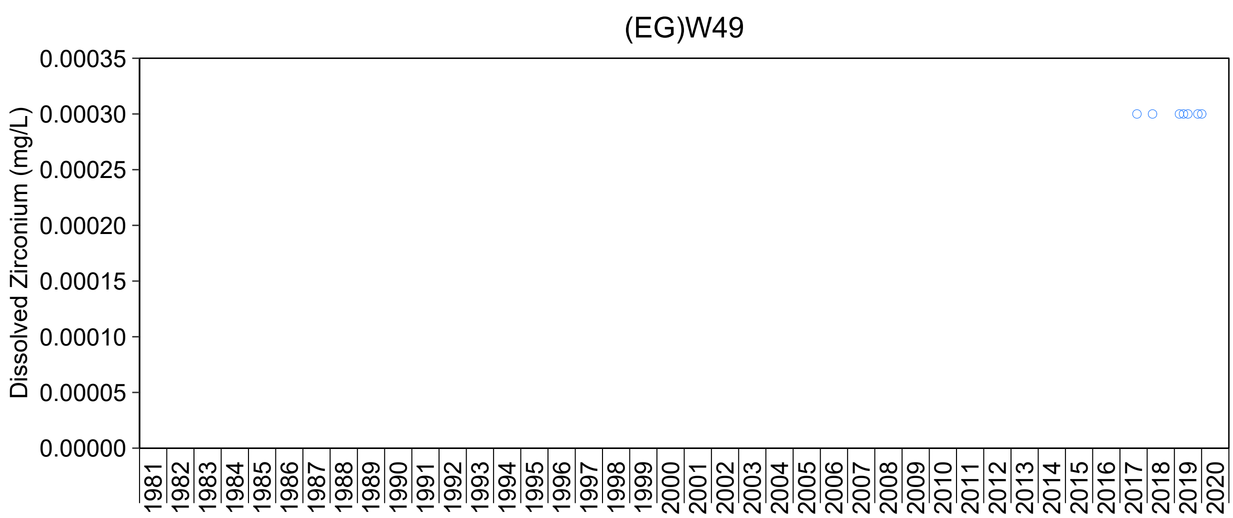

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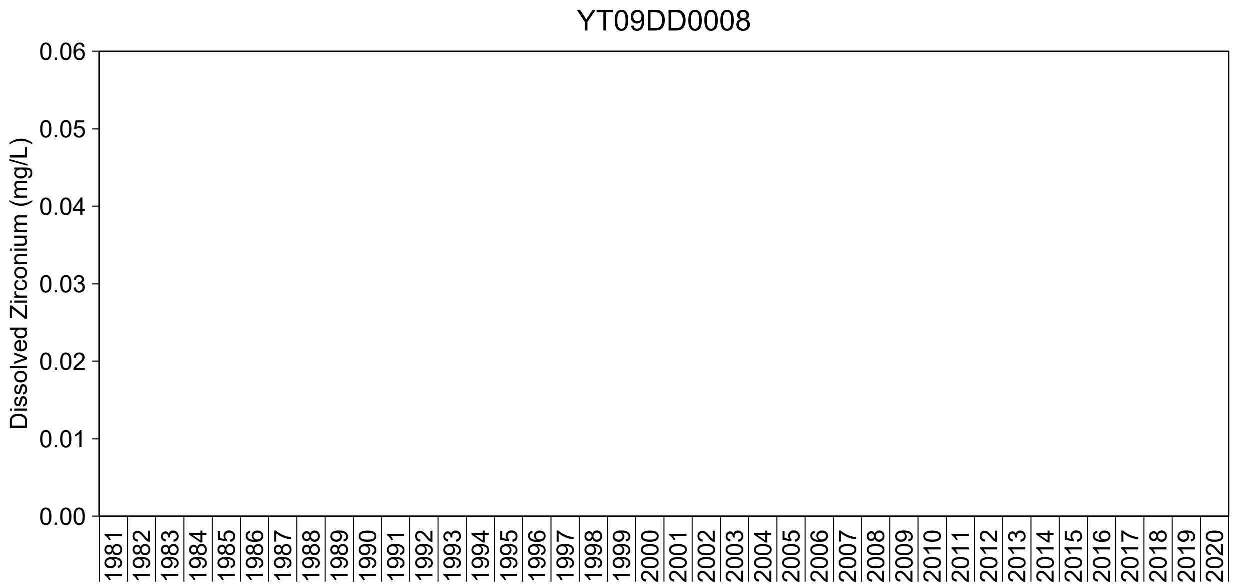

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